# ACADEMIC CURRICULA

# 2020-2024

## BACHELOR'S DEGREE PROGRAMME
## B.Tech

**Course Structure and Detailed Syllabi**
**for students admitted in**
**2020-2021**
**Academic Session**

Kalinga Institute of Industrial Technology (KIIT)
Deemed to be University U/S 3 of UGC Act, 1956
Bhubaneswar, Odisha, India

All the precautions have been taken to print the Course Curriculum accurate. However, mistakes if any will be corrected as and when noticed. The University reserves the right to include/exclude any content at any point of time during the progression of the course.

## SCHEME-I

- **Mechanical Engineering**
- **Mechanical Engineering (Automobile)**
- **Mechatronics Engineering**
- **Aerospace Engineering**
- **Electronics and Telecommunication Engineering**
- **Electronics and Electrical Engineering**
- **Electronics and Instrumentation Engineering**
- **Electronics and Computer Science Engineering**
- **Electronics and Control System Engineering**
- **Computer Science and Communication Engineering**
- **Computer Science and System Engineering**
- **Information Technology**

## SCHEME-II

- **Computer Science and Engineering**
- **Civil Engineering**
- **Electrical Engineering**

## SCHEME-I
## FIRST SEMESTER

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1. | MA 1003 | Mathematics – I | 3 | 1 | 0 | 4 | 4 |
| 2. | PH 1007 | Physics | 3 | 1 | 0 | 4 | 4 |
| 3. | EE 1003 | Basic Electrical Engineering | 3 | 0 | 0 | 3 | 3 |
| 4. | ME 1003 | Engineering Mechanics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **14** | **14** |
| **Practical** | | | | | | | |
| 1. | PH 1097 | Physics Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2. | EE 1093 | Basic Electrical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1. | ME 1083 | Basic Manufacturing Systems | 0 | 1 | 2 | 3 | 2 |
| 2. | CH 1081 | Environmental Science | 0 | 0 | 2 | 2 | 1 |
| 3. | YG 1081 | Yoga and Human Consciousness | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **12** | **6.5** |
| **Semester Total** | | | | | | **26** | **20.5** |

## SECOND SEMESTER

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1. | MA 1004 | Mathematics – II | 3 | 1 | 0 | 4 | 4 |
| 2. | CH 1007 | Chemistry | 3 | 0 | 0 | 3 | 3 |
| 3. | HS 1005 | Professional Communication | 2 | 0 | 0 | 2 | 2 |
| 4. | LS 1001 | Biology | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **11** | **11** |
| **Practical** | | | | | | | |
| 1. | CS 1093 | Computer Programming | 0 | 2 | 4 | 6 | 4 |
| 2. | CH 1097 | Chemistry Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1. | HS 1085 | Language Lab | 0 | 0 | 2 | 2 | 1 |
| 2. | CE 1083 | Engg. Graphics | 0 | 1 | 2 | 3 | 2 |
| **Total of Practical & Sessional** | | | | | | **14** | **8.5** |
| **Semester Total** | | | | | | **25** | **19.5** |
| | EAA- 1 | Extra Academic Activity | | | | | P/NP |

**N.B. For B. Tech Programmes in Electronics and allied branches, Mechanical and allied branches**

## SCHEME-I
## FIRST SEMESTER

| Theory | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
| 1. | MA 1003 | Mathematics – I | 3 | 1 | 0 | 4 | 4 |
| 2. | PH 1007 | Physics | 3 | 1 | 0 | 4 | 4 |
| 3. | EE 1003 | Basic Electrical Engineering | 3 | 0 | 0 | 3 | 3 |
| 4. | EC 1004 | Analog Electronic Circuits | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **14** | **14** |
| **Practical** | | | | | | | |
| 1. | PH 1097 | Physics Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2. | EE 1093 | Basic Electrical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 3. | EC 1094 | Analog Electronic Circuits Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1. | ME 1083 | Basic Manufacturing Systems | 0 | 1 | 2 | 3 | 2 |
| 2. | CH 1081 | Environmental Science | 0 | 0 | 2 | 2 | 1 |
| 3. | YG 1081 | Yoga and Human Consciousness | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **14** | **7.5** |
| **Semester Total** | | | | | | **28** | **21.5** |

## SECOND SEMESTER

| Theory | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
| 1. | MA 1004 | Mathematics – II | 3 | 1 | 0 | 4 | 4 |
| 2. | CH 1007 | Chemistry | 3 | 0 | 0 | 3 | 3 |
| 3. | HS 1005 | Professional Communication | 2 | 0 | 0 | 2 | 2 |
| 4. | LS 1001 | Biology | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **11** | **11** |
| **Practical** | | | | | | | |
| 1. | CS 1093 | Computer Programming | 0 | 2 | 4 | 6 | 4 |
| 2. | CH 1097 | Chemistry Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1. | HS 1085 | Language Lab | 0 | 0 | 2 | 2 | 1 |
| 2. | CE 1083 | Engg. Graphics | 0 | 1 | 2 | 3 | 2 |
| **Total of Practical & Sessional** | | | | | | **14** | **8.5** |
| **Semester Total** | | | | | | **25** | **19.5** |
| | EAA- 1 | Extra Academic Activity | | | | | P/NP |

**N.B. For B. Tech Programmes in Computer Science and Communication Engineering, Computer Science and System Engineering and Information Technology**

## SCHEME-II
## FIRST SEMESTER

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1. | MA 1003 | Mathematics – I | 3 | 1 | 0 | 4 | 4 |
| 2. | CH 1007 | Chemistry | 3 | 0 | 0 | 3 | 3 |
| 3. | HS 1005 | Professional Communication | 2 | 0 | 0 | 2 | 2 |
| 4. | LS 1001 | Biology | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **11** | **11** |
| **Practical** | | | | | | | |
| 1. | CS 1093 | Computer Programming | 0 | 2 | 4 | 6 | 4 |
| 2. | CH 1097 | Chemistry Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1. | HS 1085 | Language Lab | 0 | 0 | 2 | 2 | 1 |
| 2. | CE 1083 | Engg. Graphics | 0 | 1 | 2 | 3 | 2 |
| **Total of Practical & Sessional** | | | | | | **14** | **8.5** |
| **Semester Total** | | | | | | **25** | **19.5** |

## SECOND SEMESTER

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1. | MA 1004 | Mathematics – II | 3 | 1 | 0 | 4 | 4 |
| 2. | PH 1007 | Physics | 3 | 1 | 0 | 4 | 4 |
| 3. | EE 1003 | Basic Electrical Engineering | 3 | 0 | 0 | 3 | 3 |
| 4. | ME 1003 | Engineering Mechanics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **14** | **14** |
| **Practical** | | | | | | | |
| 1. | PH 1097 | Physics Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2. | EE 1093 | Basic Electrical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1. | ME 1083 | Basic Manufacturing Systems | 0 | 1 | 2 | 3 | 2 |
| 2. | CH 1081 | Environmental Science | 0 | 0 | 2 | 2 | 1 |
| 3. | YG 1081 | Yoga and Human Consciousness | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **12** | **6.5** |
| **Semester Total** | | | | | | **26** | **20.5** |
| | EAA – 1 | Extra Academic Activity | | | | | P/NP |

**N.B. For B. Tech Programmes in Civil and Electrical Engineering**

## SCHEME-II
## FIRST SEMESTER

| Theory | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
| 1. | MA 1003 | Mathematics – I | 3 | 1 | 0 | 4 | 4 |
| 2. | CH 1007 | Chemistry | 3 | 0 | 0 | 3 | 3 |
| 3. | HS 1005 | Professional Communication | 2 | 0 | 0 | 2 | 2 |
| 4. | LS 1001 | Biology | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **11** | **11** |
| **Practical** | | | | | | | |
| 1. | CS 1093 | Computer Programming | 0 | 2 | 4 | 6 | 4 |
| 2. | CH 1097 | Chemistry Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1. | HS 1085 | Language Lab | 0 | 0 | 2 | 2 | 1 |
| 2. | CE 1083 | Engg. Graphics | 0 | 1 | 2 | 3 | 2 |
| **Total of Practical & Sessional** | | | | | | **14** | **8.5** |
| **Semester Total** | | | | | | **25** | **19.5** |

## SECOND SEMESTER

| Theory | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
| 1. | MA 1004 | Mathematics – II | 3 | 1 | 0 | 4 | 4 |
| 2. | PH 1007 | Physics | 3 | 1 | 0 | 4 | 4 |
| 3. | EE 1003 | Basic Electrical Engineering | 3 | 0 | 0 | 3 | 3 |
| 4. | EC 1004 | Analog Electronic Circuits | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **14** | **14** |
| **Practical** | | | | | | | |
| 1. | PH 1097 | Physics Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2. | EE 1093 | Basic Electrical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 3. | EC 1094 | Analog Electronic Circuits Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1. | ME 1083 | Basic Manufacturing Systems | 0 | 1 | 2 | 3 | 2 |
| 2. | CH 1081 | Environmental Science | 0 | 0 | 2 | 2 | 1 |
| 3. | YG 1081 | Yoga and Human Consciousness | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **14** | **7.5** |
| **Semester Total** | | | | | | **28** | **21.5** |
| | EAA – 1 | Extra Academic Activity | | | | | P/NP |

**N.B. For B. Tech Programme in Computer Science and Engineering**

## Basic Frame work for B.Tech Curricula and Guidelines for Minor and Honours Scheme

- Starting from 2018 Admitted batch, the total credits for B.Tech Program for any Branch of Engineering is between 150 - 160 credits.

  The structure of the B.Tech Programs for different Branches of Engineering have courses from Basic Science (BS), Humanities & Social Science (HS), Engineering Sciences (ES), Program Core (PC), Program Elective (PE) and Open Elective (OE).

- With effect from 2018 Admitted batch, a Major - Minor Scheme has been introduced. A student having a Major in a Branch of Engineering can opt for a Minor in a different Branch of Engineering from another School. For example, a student doing B.Tech in Mechanical Engineering (his/her parent branch) can choose to have a Minor in Computer Science Engineering. Therefore the Course Curricula also contains Minor courses offered by each School of Engineering, which include their Core Branch of Engineering and also in selected niche areas (such as VLSI & Embedded System offered by School of Electronics Engineering and so on).

  To get Minor in a discipline, a student has to complete 20 credits in that area (Six Theory subjects @ 3 credits each and Two Labs @ 1 credit each / a Minor Project of 2 credits, as advised by the Course Advisor).

  The Minor courses will start from 6th semester onwards.

  In the B.Tech Curriculum of 2018 batch, there are two Open Elective courses (amounting to 6 cr), which is mandatory for a student to obtain the B.Tech Degree. This is offered in 6th & 7th sem. However a student can opt for the Minor in lieu of the Open Elective courses.

  Students having no backlogs till the end of 5th sem and a minimum CGPA of 7.0 will only be allowed to opt for the Minor scheme.

  Students opting for Minor have to mandatorily attend a minimum of 75% Theory and Lab classes (as the case may be) failing which the Minor option will be withdrawn.

- Further, from 2018 Admitted batch, provision for getting B.Tech Honours by a student has also been included. For this, a student has to undertake additional Three Advanced level courses (to the tune of 9 cr) to get a B.Tech Honours Degree in his/her parent Branch of Engineering.

  A student will be allowed to opt for the Honours scheme only if he/she has a minimum CGPA of 8.00 at the end of 5th sem and which is to be maintained constantly in the 6th, 7th and 8th sem and a minimum attendance of 75% (in all the three Honours subjects) to retain the Honours criteria and also should complete all his/her courses in the first attempt.

## COURSE STRUCTURE FOR B. TECH IN CIVIL ENGINEERING

### SEMESTER-III

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CE 2101 | Fluid Mechanics | 3 | 1 | 0 | 4 | 4 |
| 2 | CE 2103 | Mechanics of Material | 3 | 1 | 0 | 4 | 4 |
| 3 | CE 2105 | Environmental Engineering-I | 3 | 0 | 0 | 3 | 3 |
| 4 | CE 2107 | Surveying & Geomatics | 3 | 0 | 0 | 3 | 3 |
| 5 | CE 2109 | Civil Engineering Materials & Construction | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | CE 2191 | Environmental Engineering Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CE 2193 | Surveying Field Work | 0 | 0 | 3 | 3 | 1.5 |
| 3 | CE 2195 | Material Testing Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 2 | 0 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **29** | **24.5** |

### SEMESTER IV

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2005 | Mathematics –III (Civil & Mechanical) | 3 | 1 | 0 | 4 | 4 |
| 2 | CE 2100 | Geotechnical Engineering-I | 3 | 0 | 0 | 3 | 3 |
| 3 | CE 2102 | Surface Hydrology & Hydraulics | 3 | 0 | 0 | 3 | 3 |
| 4 | CE 2104 | Structural Analysis | 3 | 1 | 0 | 4 | 4 |
| 5 | CE 2106 | Environmental Engineering-II | 3 | 0 | 0 | 3 | 3 |
| 6 | CE 2108 | Construction Planning & Management | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | CE 2190 | Geotechnical Engineering Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 2 | CE 2192 | Fluid Mechanics Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | CE 2180 | Structural Analysis Applications | 0 | 2 | 0 | 2 | 1 |
| 2 | CE 2182 | Hydraulics & Hydrologic Design | 0 | 2 | 0 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **29** | **24.5** |

## SEMESTER-V

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CE 3101 | Transportation Engineering-I | 3 | 0 | 0 | 3 | 3 |
| 2 | CE 3103 | Design of Concrete Structures | 3 | 1 | 0 | 4 | 4 |
| 3 | CE 3105 | Water Resources Engineering | 3 | 0 | 0 | 3 | 3 |
| 4 | CE 3107 | Geotechnical Engineering-II | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | CE 3191 | Transportation Engg. Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | CE 3181 | Structural Design (RCC) | 0 | 2 | 0 | 2 | 1 |
| 2 | CE 3183 | Geotechnical Design | 0 | 2 | 0 | 2 | 1 |
| 3 | CE 3185 | Water Resources Design | 0 | 2 | 0 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

## SEMESTER-VI

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CE 3100 | Design of Steel Structures | 3 | 0 | 0 | 3 | 3 |
| 2 | CE 3102 | Transportation Engineering-II | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective-I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | CE 3190 | Structural Engg. Lab. | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | CE 3180 | Estimating & Costing | 0 | 2 | 0 | 2 | 1 |
| 2 | CE 3182 | Computer Aided Building Drawing | 0 | 2 | 0 | 2 | 1 |
| 3 | CE 3184 | Structural Design (Steel) | 0 | 2 | 0 | 2 | 1 |
| 4 | CE 3082 | Minor Project | 0 | 4 | 0 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **12** | **6** |
| **Semester Total** | | | | | | **30** | **24** |

## SEMESTER-VII

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| 1 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-I) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **5** | **5** |
| **Sessional** | | | | | | | |
| 1 | CE 4081 | Project – I / Internship | | | | | 3 |
| 2 | CE 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project-Minor/Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER-VIII

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (M1-5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (M1-6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | CE 4082 | Project-II / Internship | - | - | - | - | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

**HS Elective- I**

| Sl. No. | Course Code | Course Title | Credit |
|---|---|---|---|
| 1 | HS 2002 | Engineering Economics | 3 |
| 2 | HS 2008 | Economic Environment of India | 3 |
| 3 | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4 | HS 2012 | Development Economics | 3 |

**HS Elective- II**

| | | | |
|---|---|---|---|
| 1 | HS 3006 | Entrepreneurship | 3 |
| 2 | HS 3008 | Management Concepts & Practices | 3 |
| 3 | HS 3002 | Organizational Behaviour | 3 |
| 4 | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

**Dept. Electives - I & II**

| | | | |
|---|---|---|---|
| 1 | CE 3021 | Advanced Solid Mechanics | 3 |
| 2 | CE 3023 | Concrete Technology | 3 |
| 3 | CE 6103 | Construction Finance Management | 3 |
| 4 | CE 3027 | Engineering Geology | 3 |
| 5 | CE 3035 | Hydraulic Machines | 3 |
| 6 | CE 3039 | Pavement Materials | 3 |
| 7 | CE 6136 | Building Services Planning | 3 |
| 8 | CE 4057 | Drainage Engineering & Design | 3 |
| 9 | CE 6134 | Project Quality and Safety Management | 3 |
| 10 | CE 3131 | Transport of Water and Wastewater | 3 |
| 11 | CE 3133 | Air and Noise Pollution Control | 3 |
| 12 | CE 6443 | Rock Mechanics | 3 |
| 13 | CE 6303 | Open Channel Hydraulics | 3 |
| 14 | CE 6431 | Soil Exploration and Field test | 3 |

**Dept. Electives- III, IV & V**

| | | | |
|---|---|---|---|
| 1 | CE 6449 | Advanced Foundation Engineering | 3 |
| 2 | CE 4069 | Cost Effective Housing | 3 |
| 3 | CE 6241 | Design of Bridges | 3 |
| 4 | CE 4077 | Earth & Earth Retaining Structures | 3 |
| 5 | CE 4061 | Earthquake Engineering | 3 |
| 6 | CE 6435 | Finite Element Method in Geo-mechanics | 3 |
| 7 | CE 4051 | Flood and Drought Estimation and Management | 3 |
| 8 | CE 6437 | Geo-synthetics & Reinforced Earth Structures | 3 |
| 9 | CE 4065 | Infrastructure Planning | 3 |
| 10 | CE 4067 | Offshore Geotechnical Engineering | 3 |
| 11 | CE 6248 | Pre-stressed Concrete | 3 |
| 12 | CE 4059 | Reinforced Concrete Repairs and Maintenance | 3 |
| 13 | CE 6235 | Soil-Structure Interaction | 3 |

| | | | |
|---|---|---|---|
| 14 | CE 4053 | Solid and Hazardous Waste Management | 3 |
| 15 | CE 4033 | Structural Dynamics | 3 |
| 16 | CE 6445 | Pavement Analysis & Design | 3 |
| 17 | CE 6238 | Composite Structures | 3 |
| 18 | CE 6446 | Geotechnical Earthquake Engineering | 3 |
| 19 | CE 4044 | Ground Improvement Engineering | 3 |
| 20 | CE 4030 | Machine Foundation Engineering | 3 |
| 21 | CE 6436 | Tunnel Engineering | 3 |
| 22 | CE 6342 | Water Power Engineering | 3 |
| 23 | CE 6332 | River Engineering & Sediment Transport | 3 |
| 24 | CE 6142 | Contract Laws & Regulations | 3 |
| 25 | CE 6306 | Groundwater Engineering | 3 |
| 26 | CE 6347 | Advanced Irrigation Engineering | 3 |
| 27 | CE 3130 | Water and Air quality Models | 3 |
| 28 | CE 3041 | Traffic Engineering & Transportation Planning | 3 |
| 29 | CE 6307 | Remote Sensing & GIS | 3 |
| 30 | CE 3134 | Deep Excavation Planning and Design | 3 |

## HONORS COURSES OFFERED BY SCHOOL OF CIVIL ENGINEERING

### Area: Construction Planning & Management

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 6102 | Construction Engineering Practices | Civil Engineering Materials and Construction, Concrete Technology |
| 2 | CE 6113 | Construction Contract Management & Quantity Surveying | Civil Engineering Materials and Construction, Construction Planning and Management |
| 3 | CE 6106 | Construction Methods & Equipment | Construction Planning and Management |

### Area : Transportation Engineering

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 4131 | Fundamentals of Traffic Flow | Transportation Engineering-I |
| 2 | CE 4020 | Pavement Management System | Transportation Engineering-I |
| 3 | CE 4132 | Urban Transportation Systems and Planning | Transportation Engineering-I |

### Area : Geotechnical Engineering

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 6405 | Advanced Soil Mechanics | Geotechnical Engineering I and Geotechnical Engineering II |
| 2 | CE 6407 | Foundation Engineering: Principles and Practices | Geotechnical Engineering I and Geotechnical Engineering II |
| 3 | CE 6412 | Geotechnical Stability Analysis | Geotechnical Engineering I and Geotechnical Engineering II |

### Area: Structural Engineering

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 6209 | Advanced Structural Analysis | Mechanics of Materials and Structural Analysis |
| 2 | CE 6211 | Finite Element Method | Engineering Mechanics & Mechanics of Materials |
| 3 | CE 6208 | Stability of Structures | Structural Analysis |

**Area: Environmental Engineering**

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 6501 | Physico-chemical Processes for Water and Wastewater Treatment | Environmental Engineering-I and Environmental Engineering-II |
| 2 | CE 6503 | Biological Process Design for Wastewater Treatment | Environmental Engineering-I and Environmental Engineering-II |
| 3 | CE 6500 | Environmental Impact Assessment and Auditing | Environmental Engineering-I and Environmental Engineering-II |

**Area: Water Resources Engineering**

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 6309 | Advanced Hydrology | Fluid Mechanics, Surface Hydrology & Hydraulics |
| 2 | CE 6305 | Advanced Fluid Mechanics | Fluid Mechanics, Mathematics-I, Mathematics-II |
| 3 | CE 6310 | Water Resources Systems Analysis | Water Resources Engineering |

## LIST OF OPEN ELECTIVES OFFERED BY CIVIL ENGINEERING

**Open Elective : I**

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 3070 | Fundamentals of Project Management | Nil |
| 2 | CE 3072 | Bio-remediation | Nil |
| 3 | CE 3074 | Construction Materials & Specifications | Nil |
| 4 | CE 3076 | Tropical Hydrology & Water Resources | Nil |
| 5 | CE 4092 | Global Warming & Climate Change | Nil |
| 6 | CE 4094 | Green Buildings | Nil |
| 7 | CE 4096 | Environmental Chemistry | Nil |

**Open Elective : II**

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 4029 | Disaster Management | Nil |
| 2 | CE 4089 | Coastal Management | Nil |
| 3 | CE 4071 | Basic Transportation Engineering | Nil |
| 4 | CE 4073 | Fundamentals of RCC Structure | Nil |
| 5 | CE 4075 | Fundamentals of Soil Physics | Nil |
| 6 | CE 4079 | Water Resources Management | Nil |

## MINOR IN CIVIL ENGINEERING

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 3150 | Fundamentals of Structural Analysis & Design | Nil |
| 2 | CE 4151 | Theory & Applications of Soil Mechanics | Nil |
| 3 | CE 4153 | Hydraulics & Water Resources Engineering | Nil |
| 4 | CE 4155 | Fundamentals of Environmental Engineering | Nil |
| 5 | CE 4150 | Transportation & Traffic Engineering | Nil |
| 6 | CE 4152 | Construction & Management of Projects | Nil |
| 7 | CE 4191 | Civil Engineering Laboratory | Nil |

## MINOR IN WATER RESOURCES DEVELOPMENT & MANAGEMENT

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CE 3152 | Surface & Groundwater Hydrology | Nil |
| 2 | CE 4157 | Systems Approach in Water Resources Management | Nil |
| 3 | CE 4159 | Soil Mechanics in Water Resource Projects | Nil |
| 4 | CE 4161 | RS & GIS For Water Resources | Nil |
| 5 | CE 4154 | Gender & Legal Aspects In Water Resources | Nil |
| 6 | CE 4156 | Environmental Impact Assessment of Water Resource Projects | Nil |
| 7 | CE 4193 | GIS Laboratory on Water Resources | Nil |

## COURSE STRUCTURE FOR B. TECH IN COMPUTER SCIENCE & ENGINEERING

### SEMESTER-III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 3 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| 4 | MA 2013 | Discrete Mathematics | 3 | 0 | 0 | 3 | 3 |
| 5 | IT 2005 | Object Oriented Programming | 3 | 0 | 0 | 3 | 3 |
| 6 | MA 2011 | Probability & Statistics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | CS 2091 | Data Structures Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | IT 2095 | Object Oriented Programming Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **4** | **2** |
| **Semester Total** | | | | | | **23** | **21** |

### SEMESTER – IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2002 | Operating Systems | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 2010 | Automata and Formal Languages | 3 | 1 | 0 | 4 | 4 |
| 3 | IT 2004 | Web Technology | 3 | 0 | 0 | 3 | 3 |
| 4 | CS 2004 | Database Management System | 3 | 1 | 0 | 4 | 4 |
| 5 | CS 2006 | Computer Architecture | 3 | 1 | 0 | 4 | 4 |
| 6 | EC 2004 | Principle of Digital Communication | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **22** | **22** |
| **Practical** | | | | | | | |
| 1 | CS 2094 | Database Management System Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2092 | Operating Systems Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | IT 2094 | Web Technology Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Theory & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **30** | **26** |

## SEMESTER - V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 3010 | High Performance Computing | 3 | 1 | 0 | 4 | 4 |
| 2 | IT 3005 | Computer Networks | 3 | 0 | 0 | 3 | 3 |
| 3 | CS 2012 | Design and Analysis of Algorithms | 3 | 0 | 0 | 3 | 3 |
| 4 | IT 3003 | Software Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | IT 3095 | Networks Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2098 | Algorithms Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **4** | **2** |
| **Semester Total** | | | | | | **24** | **22** |

## SEMESTER – VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 3008 | Compiler Design | 3 | 0 | 0 | 3 | 3 |
| 2 | IT 3022 | Cloud Computing | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | CS 3096 | Tools and Techniques Laboratory | 0 | 0 | 4 | 4 | 2 |
| 2 | IT 3098 | Cloud Computing Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | CS 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

## SEMESTER -VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | CS 4081 | Project-I/Internship | | | | | 3 |
| 2 | CS 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER -VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | CS 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl.No. | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | CS 3027 | Real Time Systems | 3 |
| 2. | CC 3021 | Principles of Cryptography | 3 |
| 3. | CS 3011 | Artificial Intelligence | 3 |
| 4. | IT 3039 | Human Computer Interaction | 3 |
| 5. | IT 3033 | Image Processing | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | IT 3031 | Data Mining and Data Warehousing | 3 |
| 2. | CS 3029 | Advanced Database Management System | 3 |
| 3. | CS 3022 | Design and Analysis of Parallel Algorithms | 3 |
| 4. | CS 3031 | Computational Intelligence | 3 |
| 5 | CS 3033 | Computer Graphics | 3 |
| 6 | CS 3032 | Big Data | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | CS 3035 | Machine Learning | 3 |
| 2. | CS 3028 | Parallel Architectures and Programming | 3 |
| 3. | IT 3007 | Internet of Things | 3 |
| 4. | CC 3024 | Network Security | 3 |
| 5 | IT 3034 | Multimedia Systems and Architecture | 3 |

**Dept. Elective - IV**

| | | | |
|---|---|---|---|
| 1. | IT 3035 | Natural Language Processing | 3 |
| 2. | CM 3022 | Principles of Processor Design | 3 |
| 3. | IT 3006 | Data Analytics | 3 |
| 4. | EC 3066 | Principle of Microprocessors and Microcontrollers | 3 |
| 5 | IT 3024 | Mobile Applications Development | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | IT 3040 | Mobile Computing | 3 |
| 2. | CS 3024 | Wireless Network Systems | 3 |
| 3. | CS 3026 | Randomized Algorithms | 3 |
| 4. | IT 3032 | Software Project Management | 3 |
| 5 | CM 3026 | Programming for Embedded Systems | 3 |

## COURSE STRUCTURE FOR B. TECH IN INFORMATION TECHNOLOGY

### SEMESTER - III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2004 | Principles of Digital Communication | 3 | 1 | 0 | 4 | 4 |
| 3 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| 4 | MA 2013 | Discrete Mathematics | 3 | 0 | 0 | 3 | 3 |
| 5 | IT 2005 | Object Oriented Programming | 3 | 0 | 0 | 3 | 3 |
| 6 | MA 2011 | Probability & Statistics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | CS 2091 | Data Structures Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | IT 2095 | Object Oriented Programming Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **4** | **2** |
| **Semester Total** | | | | | | **24** | **22** |

### SEMESTER – IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2002 | Operating Systems | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 2010 | Automata and Formal Languages | 3 | 1 | 0 | 4 | 4 |
| 3 | IT 2004 | Web Technology | 3 | 0 | 0 | 3 | 3 |
| 4 | CS 2004 | Database Management System | 3 | 1 | 0 | 4 | 4 |
| 5 | CS 2006 | Computer Architecture | 3 | 1 | 0 | 4 | 4 |
| 6 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | CS 2094 | Database Management System Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2092 | Operating Systems Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | IT 2094 | Web Technology Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **29** | **25** |

## SEMESTER - V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3007 | Internet of Things | 3 | 0 | 0 | 3 | 3 |
| 2 | IT 3005 | Computer Networks | 3 | 0 | 0 | 3 | 3 |
| 3 | CS 2012 | Design and Analysis of Algorithms | 3 | 0 | 0 | 3 | 3 |
| 4 | IT 3003 | Software Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | IT 3095 | Networks Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2098 | Algorithms Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **4** | **2** |
| **Semester Total** | | | | | | **23** | **21** |

## SEMESTER – VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3006 | Data Analytics | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 3011 | Artificial Intelligence | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | CS 3096 | Tools and Techniques Laboratory | 0 | 0 | 4 | 4 | 2 |
| 2 | IT 3096 | Data Analytics Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | IT 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

## SEMESTER - VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | IT 4081 | Project-I/Internship | | | | | 3 |
| 2 | IT 4083 | PracticalTraining | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER – VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | IT 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | IT 3031 | Data Mining and Data Warehousing | 3 |
| 2. | IT 3025 | Enterprise Resource Planning | 3 |
| 3. | CC 3021 | Cryptography | 3 |
| 4. | IT 3039 | Human Computer Interaction | 3 |
| 5. | CS 3008 | Compiler Design | 3 |

**Dept. Elective - II**

| | | | |
|---|---|---|---|
| 1. | CS 3027 | Real Time Systems | 3 |
| 2. | IT 3036 | Virtual Reality | 3 |
| 3. | CS 3032 | Big Data | 3 |
| 4 | CS 3033 | Computer Graphics | 3 |
| 5 | CS 3031 | Computational Intelligence | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | IT 3038 | Object Oriented System Design | 3 |
| 2. | CS 3024 | Wireless Network Systems | 3 |
| 3. | CS 3035 | Machine Learning | 3 |
| 4. | IT 3028 | Information Storage Management | 3 |
| 5 | CC 3024 | Network Security | 3 |

**Dept. Elective - IV**

| | | | |
|---|---|---|---|
| 1. | CC 3026 | Cyber Security | 3 |
| 2. | IT 3034 | Multimedia Systems and Architecture | 3 |
| 3. | IT 3022 | Cloud Computing | 3 |
| 4. | IT 3024 | Mobile Applications Development | 3 |
| 5 | IT 3033 | Image Processing | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | IT 3035 | Natural Language Processing | 3 |
| 2. | IT 3040 | Mobile Computing | 3 |
| 3. | IT 3032 | Software Project Management | 3 |
| 4. | CM 3026 | Programming for Embedded Systems | 3 |
| 5 | CS 3039 | Optimization Technique | 3 |

## COURSE STRUCTURE FOR B. TECH IN COMPUTER SCIENCE & COMMUNICATION ENGINEERING

### SEMESTER - III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 3 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2023 | Principles of Signals and Systems | 2 | 0 | 0 | 2 | 2 |
| 5 | IT 2005 | Object Oriented Programming | 3 | 0 | 0 | 3 | 3 |
| 6 | MA 2011 | Probability and Statistics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | CS 2091 | Data Structures Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | IT 2095 | Object Oriented Programming Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2093 | Digital Electronics Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **24** | **21** |

### SEMESTER –IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2002 | Operating Systems | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 2010 | Automata and Formal Languages | 3 | 1 | 0 | 4 | 4 |
| 3 | EC 2016 | Communication Engineering | 3 | 1 | 0 | 4 | 4 |
| 4 | IT 2004 | Web Technology | 3 | 0 | 0 | 3 | 3 |
| 5 | CS 2006 | Computer Architecture | 3 | 1 | 0 | 4 | 4 |
| 6 | MA 2013 | Discrete Mathematics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | IT 2094 | Web Technology Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2092 | Operating Systems Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2094 | Communication Engineering Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **30** | **25.5** |

## SEMESTER -V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3003 | Software Engineering | 3 | 1 | 0 | 4 | 4 |
| 2 | IT 3005 | Computer Networks | 3 | 0 | 0 | 3 | 3 |
| 3 | CS 2012 | Design and Analysis of Algorithms | 3 | 0 | 0 | 3 | 3 |
| 4 | CS 2004 | Database Management Systems | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | IT 3095 | Networks Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2098 | Algorithms Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | CS 2094 | Database Management System Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **26** | **23** |

## SEMESTER –VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3022 | Cloud Computing | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 3036 | Cellular Communication | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | EC 3094 | Wireless Communication and Networking Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 2 | CS 3096 | Tools and Techniques Laboratory | 0 | 0 | 4 | 4 | 2 |
| **Sessional** | | | | | | | |
| 1 | CC 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **11** | **5.5** |
| **Semester Total** | | | | | | **29** | **23.5** |

## SEMESTER- VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | CC 4081 | Project-I/Internship | | | | | 3 |
| 2 | CC 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER - VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | CC 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

## HS Elective – I

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

## HS Elective – II

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

## Dept. Elective – I

| | | | |
|---|---|---|---|
| 1. | CS 3011 | Artificial Intelligence | 3 |
| 2. | CC 3021 | Cryptography | 3 |
| 3. | CS 3031 | Computational Intelligence | 3 |
| 4. | CS 3027 | Real Time Systems | 3 |

## Dept. Elective – II

| | | | |
|---|---|---|---|
| 1. | EC 3013 | Principle of Digital Signal Processing | 3 |
| 2. | EC 3066 | Principle of Microprocessors and Microcontrollers | 3 |
| 3. | EC 3064 | Information Theory & Coding | 3 |
| 4 | EC 6313 | Optimization Techniques in Engineering | 3 |

## Dept. Elective - III

| | | | |
|---|---|---|---|
| 1. | IT 3034 | Multimedia Systems and Architecture | 3 |
| 2. | CC 3024 | Network Security | 3 |
| 3. | CS 3035 | Machine Learning | 3 |
| 4. | IT 3007 | Internet of Things | 3 |

## Dept. Elective - IV

| | | | |
|---|---|---|---|
| 1. | IT 3024 | Mobile Applications Development | 3 |
| 2. | IT 3006 | Data Analytics | 3 |
| 3. | IT 3039 | Human Computer Interaction | 3 |
| 4. | IT 3040 | Mobile Computing | 3 |

## Dept. Elective – V

| | | | |
|---|---|---|---|
| 1. | EC 3062 | Smart Antennas | 3 |
| 2. | EC 3035 | High Speed Digital System Design | 3 |
| 3. | EC 6122 | Satellite Communication Systems | 3 |
| 4. | EC 6128 | Wireless Sensor Network | 3 |

## COURSE STRUCTURE FOR B. TECH IN COMPUTER SCIENCE & SYSTEM ENGINEERING

### SEMESTER- III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 3 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2005 | Semi Conductor Devices | 3 | 0 | 0 | 3 | 3 |
| 5 | IT 2005 | Object Oriented Programming | 3 | 0 | 0 | 3 | 3 |
| 6 | MA 2013 | Discrete Mathematics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | CS 2091 | Data Structures Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | IT 2095 | Object Oriented Programming Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2093 | Digital Electronics Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **25** | **22** |

### SEMESTER – IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2002 | Operating Systems | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 2012 | Design and Analysis of Algorithms | 3 | 0 | 0 | 3 | 3 |
| 3 | EC 2020 | Microprocessors, Microcontrollers, and Interfacing | 3 | 1 | 0 | 4 | 4 |
| 4 | CS 2004 | Database Management System | 3 | 1 | 0 | 4 | 4 |
| 5 | CS 2006 | Computer Architecture | 3 | 1 | 0 | 4 | 4 |
| 6 | MA 2011 | Probability and Statistics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | CS 2094 | Database Management System Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2092 | Operating Systems Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | CS 2098 | Algorithms Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **29** | **25** |

## SEMESTER- V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3007 | Internet of Things | 3 | 0 | 0 | 3 | 3 |
| 2 | IT 3005 | Computer Networks | 3 | 0 | 0 | 3 | 3 |
| 3 | CS 3011 | Artificial Intelligence | 3 | 0 | 0 | 3 | 3 |
| 4 | IT 3003 | Software Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | IT 3095 | Networks Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 3097 | Advanced Programming Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **4** | **2** |
| **Semester Total** | | | | | | **23** | **21** |

## SEMESTER – VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3022 | Cloud Computing | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 3033 | Embedded Systems Design and Application | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | IT 3098 | Cloud Computing Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 3096 | Tools and Techniques Laboratory | 0 | 0 | 4 | 4 | 2 |
| **Sessional** | | | | | | | |
| 1 | CM 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

## SEMESTER - VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | CM 4081 | Project – I / Internship | | | | | 3 |
| 2 | CM 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER – VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | CM 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | CM 3021 | Systems Simulations and Modeling | 3 |
| 2. | CM 3023 | Network Processors Design | 3 |
| 3. | IT 3035 | Natural Language Processing | 3 |
| 4. | CS 3031 | Computational Intelligence | 3 |
| 5. | CS 3037 | Principles of Automata | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | CS 3027 | Real Time Systems | 3 |
| 2. | IT 2004 | Web Technology | 3 |
| 3. | CS 3035 | Machine Learning | 3 |
| 4 | CS 3008 | Compiler Design | 3 |
| 5 | CS 3012 | Parallel and Distributed Computing | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | IT 3024 | Mobile Applications Development | 3 |
| 2. | CM 3022 | Principles of Processor Design | 3 |
| 3. | CM 3024 | Performance Evaluation of Computer Systems | 3 |
| 4. | IT 3039 | Human Computer Interaction | 3 |
| 5 | CS 3032 | Big Data | 3 |

**Dept. Elective - IV**

| | | | |
|---|---|---|---|
| 1. | CS 3029 | Advanced Database Management Systems | 3 |
| 2. | CS 3033 | Computer Graphics | 3 |
| 3. | CC 3026 | Cyber Security | 3 |
| 4. | IT 3006 | Data Analytics | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | IT 3031 | Data Mining and Data Warehousing | 3 |
| 2. | EC 3013 | Principles of Digital Signal Processing | 3 |
| 3. | IT 3040 | Mobile Computing | 3 |
| 4. | CM 3026 | Programming for Embedded Systems | 3 |

## HONORS COURSES OFFERED BY COMPUTER SCIENCE & ENGINEERING

| Sl No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 4001 | Distributed Algorithms | |
| 2 | CS 4002 | High Speed Networks | |
| 3 | CS 4003 | Software Defined Network | |
| 4 | CS 4004 | Transaction Processing Systems | |
| 5 | CS 4005 | Pervasive Computing | |
| 6 | CS 4006 | Programming for Multi Core Systems | |
| 7 | CS 4007 | Soft Computing | |
| 8 | CS 4008 | Advanced Cryptography | |
| 9 | CS 4009 | Middleware Technologies | |
| 10 | CS 4010 | Game Theory | |

## HONORS COURSES OFFERED BY INFORMATION TECHNOLOGY

| Sl No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 4001 | Distributed Algorithms | |
| 2 | CS 4002 | High Speed Networks | |
| 3 | IT 4001 | Cognitive Science | |
| 4 | IT 4002 | Decision Support System | |
| 5 | CS 4005 | Pervasive Computing | |
| 6 | IT 4003 | Business Intelligence | |
| 7 | IT 4004 | Deep Learning | |
| 8 | IT 4005 | Software Testing | |
| 9 | IT 4006 | Distributed Database | |
| 10 | IT 4007 | Information Theory and Coding | |

## LIST OF OPEN ELECTIVES OFFERED BY SCHOOL OF COMPUTER SCIENCE & ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 3040 | Data Structures Using C | Computer Programming (CS 1093) |
| 2 | IT 2005 | Object Oriented Programming | Computer Programming (CS 1093) |
| 3 | IT 2004 | Web Technology | Object Oriented Programming (IT 2005) |
| 4 | CS 3042 | Computer Organization | NIL |
| 5 | IT 3044 | Fundamentals of Software Engineering | NIL |
| 6 | CS 3044 | Relational Database Management System | NIL |
| 7 | CS 2012 | Design & Analysis of Algorithm | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |

| | | | |
|---|---|---|---|
| 8 | IT 4005 | Software Testing | Fundamentals of Software Engineering (IT 3044) |
| 9 | CS 2002 | Operating Systems | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 10 | IT 3006 | Data Analytics | Relational Database Management System (CS 3044) |
| 11 | IT 3005 | Computer Networks | NIL |

## MINOR IN COMPUTER SCIENCE & ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 3040 | Data Structures Using C | Computer Programming (CS 1093) |
| 2 | IT 2005 | Object Oriented Programming | Computer Programming (CS 1093) |
| 3 | CS 2002 | Operating Systems | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 4 | IT 2004 | Web Technology | Object Oriented Programming (IT 2005) |
| 5 | CS 3042 | Computer Organization | NIL |
| 6 | IT 3044 | Fundamentals of Software Engineering | NIL |
| 7 | CS 3044 | Relational Database Management System | NIL |
| 8 | CS 2012 | Design & Analysis of Algorithm | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 9 | CS 2094 | Database Management System Laboratory | |
| 10 | IT 2094 | Web Technology Laboratory | |

## MINOR IN SOFTWARE ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 3040 | Data Structures Using C | Computer Programming (CS 1093) |
| 2 | IT 2005 | Object Oriented Programming | Computer Programming (CS 1093) |
| 3 | CS 2002 | Operating Systems | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 4 | IT 2004 | Web Technology | Object Oriented Programming (IT 2005) |
| 5 | IT 3044 | Fundamentals of Software Engineering | NIL |
| 6 | IT 4005 | Software Testing | Fundamentals of Software Engineering (IT 3044) |
| 7 | CS 3044 | Relational Database Management System | NIL |
| 8 | IT 3038 | Object Oriented System Design | Fundamentals of Software Engineering (IT 3044) |
| 9 | CS 2094 | Database Management System Laboratory | |
| 10 | IT 2094 | Web Technology Laboratory | |

## MINOR IN DATA ANALYTICS

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 3040 | Data Structures Using C | Computer Programming (CS 1093) |
| 2 | CS 2002 | Operating Systems | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 3 | CS 3044 | Relational Database Management System | NIL |
| 4 | IT 3006 | Data Analytics | Relational Database Management System (CS 3044) |
| 5 | IT 3031 | Data Mining and Data Warehousing | Relational Database Management System (CS 3044) |
| 6 | IT 3044 | Fundamentals of Software Engineering | NIL |
| 7 | CS 3031 | Computational Intelligence | Nil |
| 8 | IT 3096 | Data Analytics Laboratory | |
| 9 | CS 2094 | Database Management System Laboratory | |

## MINOR IN INFORMATION SECURITY

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | CS 3040 | Data Structure Using C | Computer Programming (CS 1093) |
| 2 | IT 2005 | Object Oriented Programming | Computer Programming (CS 1093) |
| 3 | CS 2002 | Operating Systems | Data Structures and Algorithms (CS 2001) / Data Structures Using C (CS 3040) |
| 4 | IT 3005 | Computer Networks | NIL |
| 5 | IT 2004 | Web Technology | Object Oriented Programming (IT 2005) |
| 6 | CC 3028 | Information Security | Computer Networks (IT 3005) |
| 7 | IT 3044 | Fundamentals of Software Engineering | NIL |
| 8 | CC 3024 | Network Security | NIL |
| 9 | IT 3095 | Networks Laboratory | |
| 10 | IT 2094 | Web Technology Laboratory | |

# COURSE STRUCTURE FOR B. TECH IN ELECTRICAL ENGINEERING

## SEMESTER III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2007 | Mathematics-III (Electrical) | 3 | 1 | 0 | 4 | 4 |
| 2 | EE 2015 | Electrical Circuits Analysis | 3 | 0 | 0 | 3 | 3 |
| 3 | EE 2017 | Transformers and Induction Motors | 3 | 0 | 0 | 3 | 3 |
| 4 | EE 2013 | Analog Electronic Circuits | 3 | 0 | 0 | 3 | 3 |
| 5 | EE 2019 | Electrical and Electronics Measurements | 3 | 0 | 0 | 3 | 3 |
| 6 | CS 2001 | Data Structure and Algorithm | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EE 2091 | Network and Electronics Circuit Laboratory | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2091 | Data structure Laboratory | 0 | 0 | 2 | 2 | 1 |
| 3 | EE 2092 | Electrical Measurements Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EE 2020 | DC Machines and Synchronous Machines | 3 | 0 | 0 | 3 | 3 |
| 2 | EE 2018 | Digital Circuits | 3 | 0 | 0 | 3 | 3 |
| 3 | EE 2028 | Linear Control System | 3 | 0 | 0 | 3 | 3 |
| 4 | EE 2022 | Signals and System | 3 | 0 | 0 | 3 | 3 |
| 5 | EE 2024 | Generation, Transmission and Distribution of Electric Power | 3 | 1 | 0 | 4 | 4 |
| 6 | EE 2026 | Power Electronics | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EE 2096 | Electrical Machines Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EE 2098 | Power Electronics Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 3 | EE 2094 | Digital Circuits Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EE 3017 | Renewable Energy Sources | 3 | 0 | 0 | 3 | 3 |
| 2 | EE 3013 | Microprocessors and Interfacing | 3 | 0 | 0 | 3 | 3 |
| 3 | EE 3002 | Power System Operation and Control | 3 | 1 | 0 | 4 | 4 |
| 4 | | HS Elective-1 | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EE 3095 | Control System Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EE 3093 | Microprocessor Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 3 | EE 3099 | PLC Laboratory | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | EE 3081 | Electrical System Modeling using MATLAB | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EE 3016 | Power Carrier Communication System | 3 | 0 | 0 | 3 | 3 |
| 2 | EE 3008 | Power System Protection | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | OE/(MI) | Open Elective-I / (MI – 1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | EE 3092 | Power Systems Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EE 3094 | Electric Drives Laboratory | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1 | EE 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

## SEMESTER VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS 4001 | Professional Practice, Law and Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **5** | **5** |
| **Sessional** | | | | | | | |
| 1 | EE 4081 | Project-I / Internship | | | | | 3 |
| 2 | EE 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (MI -6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | EE 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO – Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | EE 3004 | Electromagnetic Field | 3 |
| 2. | ME 3062 | Thermodynamics and Hydraulic Devices | 3 |
| 3. | EE 3023 | High Voltage Engineering | 3 |
| 4. | EE 3029 | IoT for Electrical Engineering | 3 |
| 5. | EE 3038 | Utilization of Electrical Power | 3 |
| 6. | EE 3027 | Electrical Engineering Materials | 3 |

**Dept. Elective - II**

| | | | |
|---|---|---|---|
| 1. | EE 3006 | Electric Drives and Control | 3 |
| 2. | EE 3035 | Energy Storage Technology | 3 |
| 3. | EE 3037 | Power Quality | 3 |
| 4. | EE 3031 | Neural Network and Fuzzy Logic | 3 |
| 5. | EE 3015 | Discrete Signal Processing | 3 |
| 6. | EE 3033 | Energy Conservation Techniques | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | EE 3048 | HVDC and FACTS | 3 |
| 2. | EE 3050 | Special Electrical Machines | 3 |
| 3. | EE 3052 | Power System Deregulation | 3 |
| 4. | EE 3054 | Bio-Inspired Algorithm | 3 |
| 5. | EE 3056 | Digital System Design using FPGA | 3 |
| 6. | EE 3058 | Energy Audit and Accounting | 3 |

**Dept. Elective - IV**

| | | | |
|---|---|---|---|
| 1. | EE 3036 | Discrete & Non linear Control Theory | 3 |
| 2. | EE 3060 | Industrial Automation | 3 |
| 3. | EE 3024 | Principle of Industrial Instrumentation | 3 |
| 4. | EE 3062 | Robotics and Control | 3 |
| 5. | EE 3064 | Bio-Medical Instruments | 3 |
| 6. | EE 3066 | Adaptive Control System | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | EE 3068 | Power Converter Analysis and Design | 3 |
| 2. | EE 3070 | Hybrid Electric Vehicle | 3 |
| 3. | EE 3072 | Computer Aided Power System | 3 |
| 4. | EE 3074 | Introduction to Machine Learning | 3 |
| 5. | EE 3076 | VLSI Circuit Design | 3 |
| 6. | EE 3078 | Energy Management and SCADA | 3 |

## HONORS COURSES OFFERED BY ELECTRICAL ENGINEERING

### Area: Power System

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 4053 | Digital Protection System | Microprocessor and interface (EE 3013), Power system Protection (EE 3008), |
| 2 | EE 4060 | Distribution System Planning and Automation | Generation, Transmission and Distribution of Electrical Power (EE 2024) |
| 3 | EE 4068 | State Estimation and Security | Power System Operation and Control (EE 3002) |

### Area: Smart Grid

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 4055 | Wide Area Measurement System | Signals and System (EE 2022), Power System Protection (EE 3008) |
| 2 | EE 4062 | Distributed Generation & Microgrid | Power Electronics (EE-2026), Generation, transmission and Distribution of Electrical power(EE 2024). |
| 3 | EE 4070 | Smart Grid Technology | Power System Operation and Control (EE 3002), Renewable Energy Sources (EE 3017) |

### Area: Power Electronics

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 4057 | Harmonics Elimination Techniques | Power Electronics (EE 2026) |
| 2 | EE 4064 | Advanced Power Converters | Power Electronics (EE 2026) |
| 3 | EE 4072 | Grid Integration and control | Power Electronics (EE 2026),Linear Control System (EE2028) |

### Area: Renewable

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 4059 | Solar Photovoltaic and Fuel Cell | Power Electronics (EE 2026), Renewable Energy Sources (EE 3017) |
| 2 | EE 4066 | Wind and Biomass | Transformers & Induction Motors (EE 2017) |
| 3 | EE 4074 | Small Hydro power and Tidal Energy | Generation, Transmission and Distribution of Electrical Power (EE 2024) |

## LIST OF OPEN ELECTIVES OFFERED BY SCHOOL OF ELECTRICAL ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering (EE 1003) |
| 2 | EE 3017 | Renewable Energy Sources | Basic Electrical Engineering (EE 1003), Physics (PH1003), Chemistry (CH 1003) |
| 3 | EE 3046 | Solar Power Technology | Basic Electrical Engineering (EE 1003), Physics (PH1003) |
| 4 | EE 3042 | Principles of Energy Conversion | Basic Electrical Engineering (EE 1003) |
| 5 | EE 3041 | Electrical Hazards and Safety | Basic Electrical Engineering (EE 1003) |
| 6 | EE 2028 | Linear Control System | Basic Electrical Engineering (EE 1003), Mathematics-II (MA 1004) |
| 7 | EE 4058 | Smart Illumination Technology | Basic Electrical Engineering (EE 1003), Physics (PH1003) |
| 8 | EE 3033 | Energy Conservation Techniques | Basic Electrical Engineering (EE 1003), Physics (PH1003) |
| 9 | EE 4047 | Electrical Instrumentation | Basic Electrical Engineering (EE 1003 |
| 10 | EE 4044 | Energy Audit and Management | Basic Electrical Engineering (EE 1003), Physics (PH1003) |

## MINOR IN ELECTRICAL ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering (EE 1003) |
| 2 | EE 2028 | Linear Control System | Basic Electrical Engineering (EE 1003), Mathematics-II (MA 1004) |
| 3 | EE 3042 | Principles of Energy Conversion | Basic Electrical Engineering (EE 1003) |
| 4 | EE 2013 | Analog Electronic Circuits | Physics (PH1007) |
| 5 | EE 2018 | Digital Circuits | Nil |
| 6 | EE 2019 | Electrical and Electronics Measurements | Basic Electrical Engineering (EE 1003) |
| 7 | EE 3013 | Microprocessor and Interfacing | Digital Circuits (EE 2018) |
| 8 | EE 3017 | Renewable Energy Sources | Basic Electrical Engineering (EE 1003), Physics (PH1007), Chemistry (CH 1003) |
| 9 | EE 3007 | Power Transmission and Distribution | Electrical Circuits Analysis (EE 2015) |
| 10 | EE 3028 | Power Electronics Circuits | Analog Electronic Circuits, Electrical Circuits Analysis |
| 11 | EE 3006 | Electric Drives and Control | Power Electronics Circuits, Linear Control System |
| 12 | EE 3008 | Power System Protection | Power Transmission and Distribution |
| 13 | EE 2099 | Energy Conversion Laboratory | |
| 14 | EE 2097 | Power Convertor Laboratory | |
| 15 | EE 3096 | Power System Protection Laboratory | |

## MINOR IN ENERGY MANAGEMENT

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering (EE 1003) |
| 2 | EE 2028 | Linear Control System | Basic Electrical Engineering (EE 1003), Mathematics-II (MA 1004) |

| | | | |
|---|---|---|---|
| 3 | EE 3042 | Principles of Energy Conversion | Basic Electrical Engineering (EE 1003) |
| 4 | EE 2019 | Electrical and Electronics Measurements | Basic Electrical Engineering (EE 1003) |
| 5 | EE 3017 | Renewable Energy Sources | Basic Electrical Engineering (EE 1003), Physics (PH1007), Chemistry (CH 1003) |
| 6 | EE 3033 | Energy Conservation Techniques | Basic Electrical Engineering (EE 1003) |
| 7 | EE 3058 | Energy Audit and Accounting (Mandatory) | Renewable Energy Sources |
| 8 | EE 3078 | Energy Management and SCADA (Mandatory) | Renewable Energy Sources, Linear Control System |
| 9 | EE 3007 | Power Transmission and Distribution | Electrical Circuits Analysis |
| 10 | EE 4058 | Smart Illumination Technology | Basic Electrical Engineering (EE 1003), Physics (PH1007) |
| 11 | EE 2099 | Energy Conversion Laboratory | |
| 12 | EE 2092 | Electrical Measurement Laboratory | |
| 13 | EE 4093 | Energy System laboratory | |

## MINOR IN CIRCUITS AND AUTOMATION

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering (EE 1003) |
| 2 | EE 2028 | Linear Control System | Basic Electrical Engineering (EE 1003), Mathematics-II (MA 1004) |
| 3 | EE 3042 | Principles of Energy Conversion | Basic Electrical Engineering (EE 1003) |
| 4 | EE 2022 | Signals and System | Nil |
| 5 | EE 2013 | Analog Electronic Circuits | Physics (PH 1007) |
| 6 | EE 3039 | Programmable Logic controllers | Basic Electrical Engineering (EE 1003) |
| 7 | EE 3043 | Inverter and SMPS | Analog Electronic Circuits |
| 8 | EE 4061 | Sensors for Engineering Applications | Electrical Circuits Analysis |
| 9 | EE 4063 | Process Instrumentation and Control | Linear Control System |
| 10 | EE 4065 | Components of Industrial Automation | Sensors for Engineering Applications, Signals and Systems |
| 11 | EE4092 | Drives Laboratory | |
| 12 | EE 3099 | PLC Laboratory | |
| 13 | EE 3098 | Control laboratory | |

## MINOR IN POWER ELECTRONICS

| Sl. No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering (EE 1003) |
| 2 | EE 2028 | Linear Control System | Basic Electrical Engineering (EE 1003), Mathematics-II (MA 1004) |
| 3 | EE 3042 | Principles of Energy Conversion | Basic Electrical Engineering (EE 1003) |
| 4 | EE 2013 | Analog Electronic Circuits | Physics (PH 1007) |
| 5 | EE 2018 | Digital Circuits | Nil |
| 6 | EE 3028 | Power Electronics Circuits | Analog Electronics Circuits, Electrical Circuits Analysis |
| 7 | EE 3006 | Electric Drives and Control | Power Electronics Circuits, Linear Control System |
| 8 | EE 3013 | Microprocessor and Interfacing | Digital Circuits |
| 9 | EE 3068 | Power Converter Analysis and | Power Electronics Circuits, Linear Control |

| | | | |
|---|---|---|---|
| | | Design | System |
| 10 | EE 3070 | Hybrid Electric Vehicle | Power Electronics Circuits |
| 11 | EE 4057 | Harmonics Elimination Techniques | Power Electronics Circuits |
| 12 | EE 4064 | Advance Power Converters | Power Electronics Circuits, Linear Control System |
| 13 | EE 2099 | Energy Conversion Laboratory | |
| 14 | EE 2097 | Power Convertor Laboratory | |
| 15 | EE 4092 | Drives Laboratory | |

**MINOR IN SMART ELECTRIC VEHICLES**

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1. | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering |
| 2. | EE 2028 | Linear Control System | Basic Electrical Engineering, Mathematics |
| 3. | EE 4061 | Sensors for Engineering Applications | Electrical Circuits Analysis , Analog Electronic Circuit |
| 4. | EE 3056 | Digital System Design Using FPGA | Digital circuit, Mathematics |
| 5. | EE 4067 | Special Machines, Drives and Smart Inverter | Basic Electrical Engineering, Analog Electronic Circuit. |
| 6. | EE 3070 | Hybrid Electric Vehicle | Basic Electrical Engineering, Analog Electronic Circuit, Mathematics |
| 7. | EE 3035 | Energy Storage Technology | Physics, Chemistry |
| 8. | EE 4071 | IoT in Electric Vehicles | Special Machines, Drives and Smart Inverter and Computer Programming |
| 9. | EE 4069 | Vehicle Charging Technology | Basic Electrical Engineering, Chemistry |
| 10. | EE 3017 | Renewable Energy Sources | Physics, Chemistry |
| 11. | EE 4095 | IoT Laboratory | |
| 12. | EE 4097 | Sensor and Control Laboratory | |
| 13. | EE 4099 | Electric Vehicles and Smart Inverter Laboratory | |

**MINOR IN INDUSTRIAL IOT**

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EE 2015 | Electrical Circuits Analysis | Basic Electrical Engineering |
| 2 | EE 2028 | Linear Control System | Basic Electrical Engineering, Mathematics |
| 3 | EE 4061 | Sensors for Engineering Applications | Electrical Circuits Analysis , Analog Electronic Circuit |
| 4 | EE 3056 | Digital System Design using FPGA | Digital Circuit, Mathematics |
| 5 | EE 3051 | OOPS with Python | Computer Programming |
| 6 | EE 4073 | IoT in Industry | Electrical Circuits Analysis, Analog Electronic Circuit and Computer Programming |
| 7 | EE 3053 | Database Security | Computer Programming |
| 8 | EE 3055 | Wireless network systems | Analog Electronic Circuit and Computer Programming |
| 9 | EE 3064 | Bio-Medical Instruments | Linear Control System, Biology |
| 10 | EE 4075 | IoT Sensors and Protocols | Sensors for Engineering Applications and Computer Programming |
| 11 | EE 4095 | IoT Laboratory | |
| 12 | EE 4097 | Sensor and Control Laboratory | |
| 13 | EE 3099 | PLC Laboratory | |

# COURSE STRUCTURE FOR B. TECH IN ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## SEMESTER - III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2009 | Mathematics-III (Electronics) | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2019 | Electronic Devices and Circuits | 3 | 1 | 0 | 4 | 4 |
| 3 | EC 2021 | Signals and Networks | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 5 | CS 2001 | Data Structure and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2091 | Electronic Circuits & Network Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EC 2093 | Digital Electronics Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | CS 2091 | Data Structures Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sesssional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **30** | **25.5** |

## SEMESTER - IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2024 | Advanced Electronic Circuits | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 2020 | Microprocessors, Microcontrollers & Interfacing | 3 | 1 | 0 | 4 | 4 |
| 3 | EC 2012 | Analog Communication Techniques | 3 | 0 | 0 | 3 | 3 |
| 4 | EI 2010 | Principle of Measurements and Instrumentation | 3 | 0 | 0 | 3 | 3 |
| 5 | EC 2022 | Electromagnetic Waves and Antennas | 3 | 1 | 0 | 4 | 4 |
| 6 | EL 2002 | Principle of Control System | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2092 | Analog Integrated Circuits Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EC 2098 | Simulation Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **26** | **23** |

## SEMESTER - V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 3015 | Microwave Engineering | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 3028 | Data Communication and Networking | 3 | 0 | 0 | 3 | 3 |
| 3 | EC 3007 | Digital Signal Processing | 3 | 1 | 0 | 4 | 4 |
| 4 | EC 3005 | Digital Communication Techniques | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2094 | Communication Engineering Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EC 3091 | Electronic Measurements and Instrumentation Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 3093 | Microwave and Antenna Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Total of Practical** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER - VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 3011 | VLSI Design | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 3036 | Cellular Communication | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | EC 3095 | VLSI Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EC 3099 | DSP Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 3094 | Wireless Communication and Networking Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Sessional** | | | | | | | |
| 1 | EC 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sesssional** | | | | | | **11** | **5.5** |
| **Semester Total** | | | | | | **29** | **23.5** |

## SEMESTER - VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | | **8** |
| **Sessional** | | | | | | | |
| 1 | EC 4081 | Project -I / Internship | | | | | 3 |
| 2 | EC 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER - VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | EC 4082 | Project - II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | EC 3023 | Optimization Techniques in Engineering | 3 |
| 2. | EC 3029 | Optical Communication and Networking | 3 |
| 3. | EE 3028 | Power Electronic Circuits | 3 |
| 4. | EI 3025 | Principle of Analytical Instrumentation | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | EC 3033 | Embedded System Design & Applications | 3 |
| 2. | EC 3031 | ARM and Advanced Processors | 3 |
| 3. | EL 3024 | Industrial Automation and Control | 3 |
| 4. | EC 3035 | High Speed Digital System Design | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | EC 3021 | Neural Networks and Machine Learning | 3 |
| 2. | EC 6122 | Satellite Communication Systems | 3 |
| 3. | EI 3032 | Principle of Sensors and Data Acquisition | 3 |
| 4. | EC 3062 | Smart Antennas | 3 |

**Dept. Elective – IV**

| | | | |
|---|---|---|---|
| 1. | EC 3050 | Internet of Things and its Applications | 3 |
| 2. | EC 3056 | Speech and Audio Signal Processing | 3 |
| 3. | EC 6112 | Communication and Network Security | 3 |
| 4. | EC 6108 | Digital Image Processing | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | EC 3058 | Nanoelectronics | 3 |
| 2. | EC 3068 | Real Time Systems and Application | 3 |
| 3. | EC 6128 | Wireless Sensor Networks | 3 |
| 4. | EC 3064 | Information Theory and Coding | 3 |

# COURSE STRUCTURE FOR B.TECH IN ELECTRONICS AND ELECTRICAL ENGINEERING

## SEMESTER - III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2007 | Mathematics-III (Electrical) | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2027 | Analog Electronics | 3 | 1 | 0 | 4 | 4 |
| 3 | EE 2015 | Electrical Circuits Analysis | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2023 | Principle of Signals and Systems | 2 | 0 | 0 | 2 | 2 |
| 5 | EE 2017 | Transformers and Induction Motors | 3 | 0 | 0 | 3 | 3 |
| 6 | EI 2003 | Electrical & Electronic Measurement Techniques | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EC 2091 | Electronic Circuits & Network Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EI 2095 | Electrical & Electronic Measurements Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sesssional** | | | | | | **7** | **3.5** |
| **Semester Total** | | | | | | **26** | **22.5** |

## SEMESTER - IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 2 | CS 2001 | Data Structure and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 3 | EE 2020 | DC Machines & Synchronous Machines | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2014 | Electromagnetic Theory | 3 | 0 | 0 | 3 | 3 |
| 5 | EE 2028 | Linear Control System | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EC 2096 | Digital & Linear IC Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 2096 | Electrical Machines Lab | 0 | 0 | 3 | 3 | 1.5 |
| 3 | CS 2091 | Data Structures Lab | 0 | 0 | 2 | 2 | 1 |
| 4 | EC 2098 | Simulation Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **28** | **23.5** |

## SEMESTER - V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2016 | Communication Engineering | 3 | 1 | 0 | 4 | 4 |
| 2 | EE 2024 | Generation, Transmission & Distribution of Electric Power | 3 | 1 | 0 | 4 | 4 |
| 3 | EE 3028 | Power Electronics Circuits | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2020 | Microprocessors, Microcontrollers & Interfacing | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 3098 | Control Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EE 2098 | Power Electronics Lab | 0 | 0 | 3 | 3 | 1.5 |
| **Total of Practical** | | | | | | **7** | **3.5** |
| **Semester Total** | | | | | | **28** | **24.5** |

## SEMESTER -VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | EC 3007 | Digital Signal Processing | 3 | 1 | 0 | 4 | 4 |
| 2 | EE 3002 | Power System Operation and Control | 3 | 1 | 0 | 4 | 4 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective-I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EE 3092 | Power System Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EC 3096 | DSP Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | EL 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sesssional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **29** | **24.5** |

## SEMESTER - VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | EL 4081 | Project-I / Internship | | | | | 3 |
| 2 | EL 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER-VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | EL 4082 | Project - II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | EE 3038 | Utilization of Electric Power | 3 |
| 2. | EE 3017 | Renewable Energy Sources | 3 |
| 3. | EI 3027 | Industrial Instrumentation | 3 |
| 4. | EL 3024 | Industrial Automation & Control | 3 |

**Dept. Elective - II**

| | | | |
|---|---|---|---|
| 1. | EL 3022 | Advanced Control System | 3 |
| 2. | EC 3021 | Neural Network & Machine Learning | 3 |
| 3. | EE 3035 | Energy Storage Technology | 3 |
| 4. | EC 3011 | VLSI Design | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | EE 3006 | Electric Drives & Control | 3 |
| 2. | EE 3068 | Power Converter Analysis & Design | 3 |
| 3. | EC 3023 | Optimization Techniques in Engineering | 3 |
| 4. | EC 3060 | Mobile Communication Engineering | 3 |

**Dept. Elective – IV**

| | | | |
|---|---|---|---|
| 1. | EE 3008 | Power System Protection | 3 |
| 2. | EE 3048 | HVDC & FACTS | 3 |
| 3. | EC 3028 | Data Communication & Networking | 3 |
| 4. | EI 3032 | Principle of Sensors & Data Acquisition | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | EE 3058 | Energy Audit and Accounting | 3 |
| 2. | EE 3072 | Computer Aided Power Systems | 3 |
| 3. | EC 3033 | Embedded System Design and Applications | 3 |
| 4. | EI 3022 | Biomedical Instrumentation | 3 |

## COURSE STRUCTURE FOR B. TECH IN ELECTRONICS AND INSTRUMENTATION ENGINEERING

### SEMESTER III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2009 | Mathematics-III (Electronics) | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2023 | Principle of Signals and Systems | 2 | 0 | 0 | 2 | 2 |
| 3 | EE 2015 | Electrical Circuits Analysis | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2027 | Analog Electronics | 3 | 1 | 0 | 4 | 4 |
| 5 | EI 2003 | Electrical & Electronic Measurement Techniques | 3 | 0 | 0 | 3 | 3 |
| 6 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2091 | Electronic Circuits & Network Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EI 2095 | Electrical & Electronic Measurements Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | CS 2091 | Data Structures Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **29** | **24.5** |

### SEMESTER IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 2 | EI 2012 | Sensors and Signal Conditioning | 3 | 0 | 0 | 3 | 3 |
| 3 | EE 2008 | Electrical Machines | 3 | 1 | 0 | 4 | 4 |
| 4 | ME 2017 | Thermodynamics & Fluid Mechanics | 3 | 1 | 0 | 4 | 4 |
| 5 | EL 2002 | Principle of Control System | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2096 | Digital & Linear IC Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 2096 | Electrical Machines Lab | 0 | 0 | 3 | 3 | 1.5 |
| 3 | EI 2098 | Simulation & Control System Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **7** | **3.5** |
| **Semester Total** | | | | | | **27** | **23.5** |

## SEMESTER V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2020 | Microprocessors, Microcontrollers and Interfacing | 3 | 1 | 0 | 4 | 4 |
| 2 | EI 3009 | Instrumentation Measurement Techniques | 3 | 0 | 0 | 3 | 3 |
| 3 | EC 3007 | Digital Signal Processing | 3 | 1 | 0 | 4 | 4 |
| 4 | EC 2016 | Communication Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EC 3096 | DSP Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EI 3091 | Instrumentation Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **27** | **24** |

## SEMESTER VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 3011 | VLSI Design | 3 | 0 | 0 | 3 | 3 |
| 2 | EI 3010 | Process Control | 3 | 1 | 0 | 4 | 4 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EC 3095 | VLSI Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EI 3092 | Process Control Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | EI 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |
| | | | | | | | |

## SEMESTER VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | EI 4081 | Project-I / Internship | | | | | 3 |
| 2 | EI 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | EI 4082 | Project - II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | EE 3028 | Power Electronic Circuits | 3 |
| 2. | EI 3021 | Material Science | 3 |
| 3. | EC 3023 | Optimization Techniques in Engineering | 3 |
| 4. | EI 3022 | Bio Medical Instrumentation | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | EI 3023 | Neural Network and Fuzzy Logic Control | 3 |
| 2. | EI 3025 | Principle of Analytical Instrumentation | 3 |
| 3. | EI 3026 | Fiber Optic Instrumentation | 3 |
| 4. | EI 3031 | Nonlinear Control Theory | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | EI 3032 | Principle of Sensors and Data Acquisition | 3 |
| 2. | EI 3024 | Virtual Instrumentation | 3 |
| 3. | EC 3033 | Embedded System Design and Applications | 3 |
| 4. | EC 3060 | Mobile Communication Engineering | 3 |

**Dept. Elective – IV**

| | | | |
|---|---|---|---|
| 1. | EC 6112 | Communication & Network Security | 3 |
| 2. | EI 3034 | Robotic Control | 3 |
| 3. | EC 3050 | Internet of Things and its Applications | 3 |
| 4. | EC 3070 | MANET and WSN | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | EI 3030 | Power Plant Instrumentation | 3 |
| 2. | EC 6108 | Digital Image Processing | 3 |
| 3. | EI 3028 | Instrumentation for Oil & Gas Industries | 3 |
| 4. | EC 6122 | Satellite Communication Systems | 3 |

## COURSE STRUCTURE FOR B. TECH IN ELECTRONICS AND COMPUTER SCIENCE ENGINEERING

### SEMESTER III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2009 | Mathematics-III (Electronics) | 3 | 1 | 0 | 4 | 4 |
| 2 | EC 2027 | Analog Electronics | 3 | 1 | 0 | 4 | 4 |
| 3 | EI 2010 | Principle of Measurements and Instrumentation | 3 | 0 | 0 | 3 | 3 |
| 4 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| 5 | EC 2021 | Signals and Networks | 3 | 0 | 0 | 3 | 3 |
| 6 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2091 | Electronic Circuits & Network Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | CS 2091 | Data Structures Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2096 | Digital & Linear IC Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **30** | **25.5** |

### SEMESTER IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2013 | Discrete Mathematics | 3 | 0 | 0 | 3 | 3 |
| 2 | IT 2005 | Object Oriented Programming | 3 | 0 | 0 | 3 | 3 |
| 3 | CS 2004 | Database Management Systems | 3 | 1 | 0 | 4 | 4 |
| 4 | EC 2020 | Microprocessors, Microcontrollers & Interfacing | 3 | 1 | 0 | 4 | 4 |
| 5 | CS 2006 | Computer Architecture | 3 | 1 | 0 | 4 | 4 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | IT 2095 | Object Oriented Programming Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 2094 | DBMS Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **27** | **24** |

## SEMESTER V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | CS 2012 | Design & Analysis of Algorithms | 3 | 0 | 0 | 3 | 3 |
| 2 | EC 3011 | VLSI Design | 3 | 0 | 0 | 3 | 3 |
| 3 | EC 2004 | Principle of Digital Communication | 3 | 1 | 0 | 4 | 4 |
| 4 | CS 2002 | Operating Systems | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EC 2094 | Communication Engineering Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | CS 2098 | Algorithms Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC 3095 | VLSI Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **7** | **3.5** |
| **Semester Total** | | | | | | **26** | **22.5** |

## SEMESTER VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | IT 3003 | Software Engineering | 3 | 1 | 0 | 4 | 4 |
| 2 | IT 3005 | Computer Networks | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | IT 3095 | Networks Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | CS 3096 | Tools & Techniques Lab | 0 | 1 | 2 | 3 | 2 |
| **Sessional** | | | | | | | |
| 1 | EM 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **9** | **5** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | EM 4081 | Project-I / Internship | | | | | 3 |
| 2 | EM 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | EM 4082 | Project - II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1 | IT 2004 | Web Technology | 3 |
| 2 | CS 3037 | Principles of Automata | 3 |
| 3 | CS 3029 | Advanced Database Management System | 3 |
| 4 | EC 3035 | High Speed Digital System Design | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1 | EC 3031 | ARM and Advanced Processors | 3 |
| 2 | EC 3033 | Embedded System Design and Applications | 3 |
| 3 | CS 3031 | Computational Intelligence | 3 |
| 4 | IT 3006 | Data Analytics | 3 |

**Dept. Elective – III**

| | | | |
|---|---|---|---|
| 1 | EC 6128 | Wireless Sensor Network | 3 |
| 2 | EC 3060 | Mobile Communication Engineering | 3 |
| 3 | EC 3064 | Information Theory and Coding | 3 |
| 4 | EC 6112 | Communication and Network Security | 3 |

**Dept. Elective - IV**

| | | | |
|---|---|---|---|
| 1 | IT 3007 | Internet of Things | 3 |
| 2 | CS 3012 | Parallel and distributed Computing | 3 |
| 3 | IT 3022 | Cloud Computing | 3 |
| 4 | CS 3032 | Big Data | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1 | EC 6224 | Low Power VLSI Design | 3 |
| 2 | EC 3058 | Nanoelectronics | 3 |
| 3 | EC 3029 | Optical Communication and Networking | 3 |
| 4 | EC 3068 | Real Time Systems and Application | 3 |

## COURSE STRUCTURE FOR B. TECH IN ELECTRONICS AND CONTROL SYSTEM ENGINEERING

### SEMESTER III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2009 | Mathematics-III (Electronics) | 4 | 0 | 0 | 4 | 4 |
| 2 | EC 2023 | Principle of Signals and Systems | 2 | 0 | 0 | 2 | 2 |
| 3 | EE 2015 | Electrical Circuits Analysis | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2027 | Analog Electronics | 3 | 1 | 0 | 4 | 4 |
| 5 | EI 2003 | Electrical & Electronic Measurement Techniques | 3 | 0 | 0 | 3 | 3 |
| 6 | CS 2001 | Data Structures and Algorithms | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2091 | Electronic Circuits & Network Lab | 0 | 0 | 3 | 3 | 1.5 |
| 2 | EI 2095 | Electrical & Electronic Measurements Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | CS 2091 | Data Structures Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **4.5** |
| **Semester Total** | | | | | | **29** | **24.5** |

### SEMESTER IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 2 | EI 2012 | Sensors and Signal Conditioning | 3 | 0 | 0 | 3 | 3 |
| 3 | EE 2008 | Electrical Machines | 3 | 1 | 0 | 4 | 4 |
| 4 | ME 2017 | Thermodynamics & Fluid Mechanics | 3 | 1 | 0 | 4 | 4 |
| 5 | EL 2002 | Principle of Control System | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | EC 2096 | Digital & Linear IC Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 2096 | Electrical Machines Lab | 0 | 0 | 3 | 3 | 1.5 |
| 3 | EC 2098 | Simulation Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **7** | **3.5** |
| **Semester Total** | | | | | | **27** | **23.5** |

## SEMESTER V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2020 | Microprocessors, Microcontrollers and Interfacing | 3 | 1 | 0 | 4 | 4 |
| 2 | EI 3009 | Instrumentation Measurement Techniques | 3 | 0 | 0 | 3 | 3 |
| 3 | EC 3007 | Digital Signal Processing | 3 | 1 | 0 | 4 | 4 |
| 4 | EC 2016 | Communication Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EI 3091 | Instrumentation Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EE 3098 | Control Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **27** | **24** |

## SEMESTER VI

| Sl.No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 3011 | VLSI Design | 3 | 0 | 0 | 3 | 3 |
| 2 | EL 3022 | Advanced Control Systems | 3 | 0 | 0 | 3 | 3 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | EC 3095 | VLSI Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EC 3096 | DSP Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EL 3092 | Advanced Control System Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | EN 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

## SEMESTER VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| 2 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI–4) | (3) | (0) | (0) | (3) | (3) |
| (6) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | EN 4081 | Project-I / Internship | | | | | 3 |
| 2 | EN 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **13** |

## SEMESTER VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| (1) | | (MI–5) | (3) | (0) | (0) | (3) | (3) |
| (2) | | (MI–6) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Sessional** | | | | | | | |
| 1 | EN 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **10** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS3006 | Entrepreneurship | 3 |
| 2. | HS3008 | Management Concepts & Practices | 3 |
| 3. | HS3002 | Organizational Behaviour | 3 |
| 4. | HS3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | EE 3028 | Power Electronic Circuits | 3 |
| 2. | EI 3021 | Material Science | 3 |
| 3. | EC 3023 | Optimization Techniques in Engineering | 3 |
| 4. | EI 3025 | Principle of Analytical Instrumentation | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | EI 3023 | Neural Network & Fuzzy Logic Control | 3 |
| 2. | EI 3026 | Fiber Optic Instrumentation | 3 |
| 3. | EI 3031 | Nonlinear Control Theory | 3 |
| 4. | EI 3029 | Process Dynamics and Control | 3 |

**Dept. Elective – III**

| | | | |
|---|---|---|---|
| 1. | EL 3024 | Industrial Automation and Control | 3 |
| 2. | EI 3036 | Optimal Control Theory | 3 |
| 3. | EC 3033 | Embedded System Design and Applications | 3 |
| 4. | EE 3006 | Electric Drives and Control | 3 |

**Dept. Elective – IV**

| | | | |
|---|---|---|---|
| 1. | EC 6112 | Communication & Network Security | 3 |
| 2. | EI 3034 | Robotic Control | 3 |
| 3. | EC 3050 | Internet of Things and its Applications | 3 |
| 4. | EC 3070 | MANET and WSN | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | EI 3030 | Power Plant Instrumentation | 3 |
| 2. | EC 6108 | Digital Image Processing | 3 |
| 3. | EI 3038 | Digital Control System | 3 |
| 4. | EI 3032 | Principle of Sensors and Data Acquisition | 3 |

## HONORS COURSES OFFERED BY ELECTRONICS AND TELECOMMUNICATION ENGINEERING

### Area: Communication Engineering

| Sl No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 4053 | Millimeter Wave and Terahertz Technology | Cellular Communication (EC 3036) |
| 2 | EC 4056 | Mobile Ad-Hoc Networks | Data Communication and Networking (EC 3028) |
| 3 | EC 4058 | Cognitive Radio and Cooperative Communications | Cellular Communication (EC 3036) |

### Area: VLSI and Embedded System

| SL No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 6203 | MOS Device Modeling | VLSI Design (EC 3011) |
| 2 | EC 6207 | Analog CMOS VLSI Circuits | VLSI Design (EC 3011) |
| 3 | EC 6248 | VLSI Signal Processing | Digital Signal Processing (EC 3007) |

### Area: Signal Processing

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 4047 | Biomedical Signal Processing | Digital Signal Processing (EC 3007), Math-III (Electronics) (MA 2009) |
| 2 | EC 4050 | Computer Vision & Pattern Recognition | Digital Signal Processing (EC 3007), Math-III (Electronics) (MA 2009) |
| 3 | EC 4052 | Machine learning for Digital Signal Processing | Digital Signal Processing (EC 3007), Math-III (Electronics) (MA 2009) |

## HONORS COURSES OFFERED BY ELECTRONICS AND INSTRUMENTATION ENGINEERING

### Area: Instrumentation Engineering

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EI 4041 | Design of Sensors and Transducers | Sensors and Signal Conditioning (EI 2012), Instrumentation Measurement Techniques (EI 3009) |
| 2 | EI 4042 | Instrumentation System Design | Sensors and Signal Conditioning (EI 2012) and Instrumentation Measurement Techniques (EI 3009) |
| 3 | EI 4044 | Control System Design | Principle of Control System (EL 2002) |

- Students belonging to B. Tech program in Electronics and Control System Engineering can opt for Honors course in the area of Instrumentation Engineering.
- Students belonging to B. Tech program in Electronics and Electrical Engineering can opt for Honors course in the area of Signal Processing as well as Honors courses offered by School of Electrical Engineering.
- Students belonging to B. Tech program in Electronics and Computer Science Engineering can opt for Honors courses from School of Computer Science Engineering.

## LIST OF OPEN ELECTIVES OFFERED BY SCHOOL OF ELECTRONICS ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 2011 | Digital Electronics | NIL |
| 2 | EC 2021 | Signals & Networks | Math-II (MA 1004) |
| 3 | EC 3044 | Introduction to Communication Engineering | NIL |
| 4 | EC 3066 | Principles of Microprocessors and Microcontrollers | Digital Electronics (EC 2011) |
| 5 | EI 3027 | Industrial Instrumentation | Basic Electrical Engineering (EE 1003) |
| 6 | EC 3013 | Principle of Digital Signal Processing | Math-II (MA 1004) |
| 7 | EL 2002 | Principle of Control System | Signals & Networks (EC 2021) |
| 8 | EC 3011 | VLSI Design | Digital Electronics (EC 2011) |
| 9 | EC 3033 | Embedded system Design and Applications | Microprocessors and Microcontrollers (EC 2020) /Principles of Microprocessors and Microcontrollers (EC 3066) |
| 10 | EL 3024 | Industrial Automation & Control | Principle of Control Systems (EL 2002) /Linear Control System (EL 2028) |
| 11 | EC 6108 | Digital Image Processing | Principle of Digital Signal Processing (EC 3013) / Digital Signal Processing (EC 3007) |
| 12 | EC 3060 | Mobile Communication Engineering | Communication Engineering (EC 2016) /Introduction to Communication Engineering (EC 3044) / Principle of Digital Communication (EC 2004) |
| 13 | EC 3050 | Internet of Things and its applications | Microprocessors and Microcontrollers (EC 2020) / Principles of Microprocessors and Microcontrollers (EC 3066) |

## MINOR IN ELECTRONICS & TELECOMMUNICATION ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 2025 | Principles of Electronics Engineering | Nil |
| 2 | EC 2011 | Digital Electronics | Nil |
| 3 | EC 3066 | Principle of Microprocessors and Microcontrollers | Digital Electronics (EC2011) |
| 4 | EC 2021 | Signals and Networks | Mathematics-II (MA1004) |
| 5 | EC 2014 | Electromagnetic Theory | Mathematics-II (MA1004) |
| 6 | EC 3011 | VLSI Design | Analog Electronic Circuits |
| 7 | EC 3031 | ARM and Advanced Processors | Principle of Microprocessors and Microcontrollers (EC3066) |
| 8 | EC 3035 | High speed Digital system Design | Digital Electronics (EC2011) |
| 9 | EC 3044 | Introduction to Communication Engineering | Nil |
| 10 | EC 3015 | Microwave Engineering | Nil |
| 11 | EC 3028 | Data Communication and Networking | Introduction to Communication Engineering (EC3044) |
| 12 | EC 3060 | Mobile communication Engineering | Introduction to Communication Engineering (EC3044)/Principle of Digital Communication (EC2004)/Communication Engineering (EC2016) |
| 13 | EC 3050 | Internet of Things and its Applications | Principle of Microprocessors and Microcontrollers (EC3066) |
| 14 | EC 6122 | Satellite Communication Systems | Introduction to Communication Engineering (EC3044)/Principle of Digital Communication (EC2004)/Communication Engineering (EC2016) |
| 15 | EC 3029 | Optical Communication and Networking | Introduction to Communication Engineering (EC3044)/Principle of Digital Communication (EC2004)/Communication Engineering (EC2016) |
| 16 | EC 3021 | Neural Networks and Machine Learning | Mathematics-I &II (MA1003 and MA1004) |
| 17 | EC 1094 | Analog Electronic Circuits Lab | |
| 18 | EC 2093 | Digital Electronics Lab | |
| 19 | EC 3095 | VLSI Lab | |

## MINOR IN ELECTRONICS & INSTRUMENTATION ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 2025 | Principles of Electronics Engineering | Nil |
| 2 | EI 2003 | Electrical & Electronic Measurement Techniques | Basic Electrical Engineering (EE 1003) |
| 3 | EC 2021 | Signals and Networks | Mathematics-II (MA 1004) |
| 4 | EL 2002 | Principle of Control System | Signals and Networks (EC 2021) |
| 5 | EI 2012 | Sensors and Signal Conditioning | Electrical and Electronic Measurement Techniques (EI 2003) |

| | | | |
|---|---|---|---|
| 6 | EI 3009 | Instrumentation Measurement Techniques | Electrical & Electronic Measurement Techniques (EI 2003) |
| 7 | EI 3029 | Process Dynamics and Control | Principle of Control System (EL 2002) |
| 8 | EI 3025 | Principle of Analytical Instrumentation | Chemistry (CH 1007) |
| 9 | EI 3030 | Power Plant Instrumentation | Instrumentation Measurement Techniques (EI 3009) |
| 10 | EI 3032 | Principle of Sensors and Data Acquisition | Electrical and Electronic Measurement Techniques (EI 2003) |
| 11 | EI 3023 | Neural Network & Fuzzy Logic Control | Mathematics-I (MA 1003), Mathematics-II (MA 1004) and Principle of Control System (EL 2002) |
| 12 | EI 2095 | Electrical & Electronic Measurements Lab | |
| 13 | EI 3091 | Instrumentation Lab | |
| 14 | EI 3092 | Process Control Lab | |

## MINOR IN VLSI AND EMBEDDED SYSTEM

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 2025 | Principles of Electronics Engineering | Nil |
| 2 | EC 2011 | Digital Electronics | Principles of Electronics Engineering (EC 2025) |
| 3 | EC 2005 | Semiconductor Devices | Principles of Electronics Engineering (EC 2025) |
| 4 | EC 3066 | Principle of Microprocessors and Microcontrollers | Digital Electronics (EC 2011) |
| 5 | EC 3011 | VLSI Design | Digital Electronics (EC2011) |
| 6 | EC 3035 | High Speed Digital System Design | Digital Electronics (EC2011) |
| 7 | EC3033 | Embedded System Design and Applications | Digital Electronics (EC2011) |
| 8 | EC 3031 | ARM and Advanced Processors | Microprocessors, Microcontrollers& Interfacing (EC 2020) / Principle of Microprocessors and Microcontrollers (EC 3066) |
| 9 | EC 3068 | Real Time Systems and Application | Digital Electronics (EC 2011) |
| 10 | EC 6224 | Low Power VLSI Design | VLSI design (EC 3011) |
| 11 | EC 3058 | Nanoelectronics | Principles of Electronics Engineering (EC 2025) |
| 12 | EC 2093 | Digital Electronics Lab | |
| 13 | EC 2090 | Microprocessor and Microcontroller Lab | |
| 14 | EC 3095 | VLSI Lab | |

## MINOR IN SENSORS & SIGNALS

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | EC 2025 | Principles of Electronics Engineering | Nil |
| 2 | EC 2011 | Digital Electronics | Nil |
| 3 | EC 2021 | Signals and Networks | Mathematics-II (MA1004) |

| | | | |
|---|---|---|---|
| 4 | EC 3066 | Principle of Microprocessors and Microcontrollers | Digital Electronics (EC 2011) |
| 5 | EI 2003 | Electrical & Electronic Measurement Techniques | Basic Electrical Engineering (EE 1003) |
| 6 | EI 2012 | Sensors & Signal Conditioning | Electrical and Electronic Measurement Techniques (EI 2003) |
| 7 | EC 3013 | Principle of Digital Signal Processing | Signals and Network (EC 2021) |
| 8 | EI 3032 | Principle of Sensors & Data Acquisition | Electrical & Electronic Measurement Techniques (EI 2003) |
| 9 | EC 3021 | Neural Networks &Machine Learning | Mathematics-I and Mathematics-II (MA1003 and MA1004) |
| 10 | EC 3050 | Internet of Things and its applications | Principle of Microprocessors and Microcontrollers (EC3066) |
| 11 | EC 6108 | Digital Image Processing | Principle of Digital Signal Processing (EC 3013) |
| 12 | EI 3024 | Virtual Instrumentation | Sensors and Signal Conditioning (EI 2012),Digital Electronics (EC 2011) |
| 13 | EC 3056 | Speech and Audio Signal Processing | Principle of Digital Signal Processing (EC 3013) |
| 14 | EC 2093 | Digital Electronics Lab | - |
| 15 | EI 2095 | Measurements and Instrumentation Lab | - |
| 16 | EC 3099 | DSP Lab | - |

# COURSE STRUCTURE FOR B. TECH IN MECHANICAL ENGINEERING

## SEMESTER- III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2005 | Mathematics-III (Civil & Mechanical) | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 2021 | Fluid Mechanics and Hydraulic Machines | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 2027 | Materials Science and Engineering | 3 | 0 | 0 | 3 | 3 |
| 4 | ME 2029 | Mechanics of Solids | 3 | 1 | 0 | 4 | 4 |
| 5 | ME 2031 | Engineering Thermodynamics | 3 | 1 | 0 | 4 | 4 |
| 6 | EC 2025 | Principles of Electronics Engineering | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **22** | **22** |
| **Practical** | | | | | | | |
| 1 | EC 2095 | Electronics Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 2091 | Material Testing Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | ME 2097 | Fluid Mechanics and Hydraulic Machines Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2083 | Machine Drawing and Computer Aided Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **30** | **26** |

## SEMESTER- IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | ME 2010 | Basic Manufacturing Processes | 3 | 0 | 0 | 3 | 3 |
| 2 | ME 2013 | Kinematics and Dynamics of Machines | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 2022 | Internal Combustion Engines and Gas Turbines | 3 | 0 | 0 | 3 | 3 |
| 4 | ME 2024 | Industrial Engineering and Operations Research | 3 | 0 | 0 | 3 | 3 |
| 5 | ME 2026 | Engineering Metrology | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME 2093 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 2092 | Metrology and Instrumentation Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2085 | Manufacturing Practices | 0 | 1 | 2 | 3 | 2 |
| 2 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **5** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER – V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | ME 3019 | Manufacturing Processes and Automation | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 3021 | Heat Transfer | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 3023 | Design of Machine Elements-I | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | ME 3093 | Computational Techniques Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 3095 | Heat Transfer Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | ME 3097 | Advanced Manufacturing Processes Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 3081 | Machine Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | ME 3014 | Refrigeration and Air Conditioning | 3 | 0 | 0 | 3 | 3 |
| 2 | ME 3016 | Metal Cutting and Tool Design | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 3018 | Design of Machine Elements-II | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective –I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME 3092 | ICE and RAC Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 3096 | Mechanical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| 2 | ME 3086 | Computer Aided Design and Analysis | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER- VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **5** | **5** |
| **Sessional** | | | | | | | |
| 1 | ME 4081 | Project –I/Internship | | | | | 3 |
| 2 | ME 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER- VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (MI – 5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (MI – 6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | ME 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO – Honors**

# LIST OF HS ELECTIVES

## HS Elective – I

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

## HS Elective – II

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

## Dept. Elective-I

| | | | |
|---|---|---|---|
| 1. | ME 3025 | Optimization Techniques | 3 |
| 2. | ME 3026 | Mecatronics | 3 |
| 3. | ME 3027 | Plant layout and Material Handling | 3 |
| 4. | ME 3071 | Renewable Energy Technology | 3 |
| 5. | ME 3073 | Mechanics of Composite Materials | 3 |

## Dept. Elective-II

| | | | |
|---|---|---|---|
| 1. | ME 3024 | Mechanical Vibration and Noise Engineering | 3 |
| 2. | ME 3028 | Supply Chain Management | 3 |
| 3. | ME 3043 | Power Plant Engineering | 3 |
| 4. | ME 3045 | Metal Forming Processes | 3 |
| 5. | ME 3047 | Production and Operations Management | 3 |

## Dept. Elective-III

| | | | |
|---|---|---|---|
| 1. | ME 3022 | Principles of Turbomachines | 3 |
| 2. | ME 3051 | Finite Element Analysis | 3 |
| 3. | ME 3055 | Additive Manufacturing | 3 |
| 4. | ME 3057 | Machine Maintenance and Condition Monitoring | 3 |
| 5. | ME 3059 | Computational Fluid Dynamics | 3 |

## Dept. Elective-IV

| | | | |
|---|---|---|---|
| 1. | ME 3061 | Advanced Mechanics of Solids | 3 |
| 2. | ME 3063 | Automobile Engineering | 3 |
| 3. | ME 3065 | Combustion Engineering | 3 |
| 4. | ME 3067 | Cryogenics | 3 |
| 5. | ME 3069 | Total Quality Management | 3 |

## Dept. Elective-V

| | | | |
|---|---|---|---|
| 1. | EE 2009 | Electrical Machines and Power Electronics | 3 |
| 2. | ME 3029 | Robotics and Flexible Manufacturing Systems | 3 |
| 3. | ME 3030 | Product Life Cycle Management | 3 |
| 4. | ME 3052 | Nano Technology | 3 |
| 5. | ME 3054 | Gas Dynamics and Jet Propulsion | 3 |
| 6. | ME 3056 | Tribology | 3 |

## COURSE STRUCTURE FOR B. TECH IN MECHANICAL ENGINEERING(AUTOMOBILE)

### SEMESTER - III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2005 | Mathematics-III (Civil & Mechanical) | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 2031 | Engineering Thermodynamics | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 2027 | Materials Science and Engineering | 3 | 0 | 0 | 3 | 3 |
| 4 | ME 2029 | Mechanics of Solids | 3 | 1 | 0 | 4 | 4 |
| 5 | ME 2021 | Fluid Mechanics & Hydraulic Machines | 3 | 1 | 0 | 4 | 4 |
| 6 | EC 2025 | Principle of Electronics Engineering | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **22** | **22** |
| **Practical** | | | | | | | |
| 1 | EC 2095 | Electronics Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 2091 | Material Testing Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | ME 2097 | Fluid Mechanics and Hydraulic Machines Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2083 | Machine Drawing and Computer Aided Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **30** | **26** |

### SEMESTER – IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | ME 2010 | Basic Manufacturing Processes | 3 | 0 | 0 | 3 | 3 |
| 2 | ME 2013 | Kinematics and Dynamics of Machines | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 2022 | Internal Combustion Engines and Gas Turbines | 3 | 0 | 0 | 3 | 3 |
| 4 | AE 2002 | Automotives, Suspension and Transmission System | 3 | 0 | 0 | 3 | 3 |
| 5 | AE 2004 | Automotive Mechatronics | 3 | 0 | 0 | 3 | 3 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME 2093 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AE 2092 | Automotive Electrical and Electronics Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2085 | Manufacturing Practices | 0 | 1 | 2 | 3 | 2 |
| 2 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **5** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | ME 3021 | Heat Transfer | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 3023 | Design of Machine Elements-I | 3 | 0 | 0 | 3 | 3 |
| 3 | ME 3019 | Manufacturing Processes and Automation | 3 | 1 | 0 | 4 | 4 |
| 4 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | ME 3095 | Heat Transfer Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 3093 | Computational Techniques Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 3081 | Machine Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **06** | **03** |
| **Semester Total** | | | | | | **26** | **23** |

## SEMESTER - VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | AE 3002 | Vehicle Maintenance | 3 | 0 | 0 | 3 | 3 |
| 2 | AE 3003 | Electrical and Hybrid Vehicle Technology | 3 | 0 | 0 | 3 | 3 |
| 3 | AE 3004 | Design of Automotive Components | 3 | 1 | 0 | 4 | 4 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | AE 3092 | IC Engine and Vehicle Maintenance Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 3096 | Mechanical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AE 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| 2 | ME 3086 | Computer Aided Design and Analysis | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **10** | **05** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER- VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **5** | **5** |
| **Sessional** | | | | | | | |
| 1 | AE 4081 | Project-I/Internship | | | | | 3 |
| 2 | AE 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER - VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | AE 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

## HS Elective – I

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

## HS Elective – II

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

## Dept. Elective-I

| | | | |
|---|---|---|---|
| 1. | ME 3071 | Renewable Energy Technology | 3 |
| 2. | ME 3073 | Mechanics of Composite Materials | 3 |
| 3. | ME 3025 | Optimization Techniques | 3 |
| 4. | ME 3065 | Combustion Engineering | 3 |
| 5. | AE 3011 | Fuels and Emission | 3 |
| 6. | ME 2024 | Industrial Engineering and Operations Research | 3 |

## Dept. Elective-II

| | | | |
|---|---|---|---|
| 1. | ME 3014 | Refrigeration and Air Conditioning | 3 |
| 2. | ME 3024 | Mechanical Vibration and Noise Engineering | 3 |
| 3. | ME 3051 | Finite Element Analysis | 3 |
| 4. | AE 3021 | Tractors and Farm Equipments | 3 |
| 5. | AE 3022 | Two and Three Wheelers | 3 |
| 6. | AE 3023 | Off Road Vehicles | 3 |

## Dept. Elective-III

| | | | |
|---|---|---|---|
| 1. | ME 3056 | Tribology | 3 |
| 2. | AE 3031 | Simulation of IC Engine | 3 |
| 3. | AE 3033 | Thermal Systems in Automotive | 3 |
| 4. | AE 3034 | Vehicle Dynamics | 3 |
| 5. | AE 3037 | Automotive Aerodynamics | 3 |
| 6. | AE 3039 | Battery Technology | 3 |

## Dept. Elective-IV

| | | | |
|---|---|---|---|
| 1. | ME 3028 | Supply Chain Management | 3 |
| 2. | ME 3069 | Total Quality Management | 3 |
| 3. | ME 3030 | Product Life Cycle Management | 3 |
| 4. | AE 3042 | Automotive Safety and Lighting | 3 |
| 5. | AE 3044 | Theory And Design of Jigs And Fixtures | 3 |

## Dept. Elective-V

| | | | |
|---|---|---|---|
| 1. | ME 3059 | Computational Fluid Dynamics | 3 |
| 2. | AE 3052 | Intelligent Vehicle Technology | 3 |
| 3. | AE 3054 | Design of Racing Car | 3 |
| 4. | AE 3056 | Fundamentals of Tyre Technology | 3 |
| 5. | AE 3058 | Assembly Line Automation | 3 |
| 6. | AE 3060 | Vehicle Life Cycle Management | 3 |

# COURSE STRUCTURE FOR B. TECH IN MECHATRONICS ENGINEERING

## SEMESTER- III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2005 | Mathematics-III (Civil & Mechanical) | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 2023 | Thermofluids | 3 | 1 | 0 | 4 | 4 |
| 3 | ME 2013 | Kinematics and Dynamics of Machines | 3 | 1 | 0 | 4 | 4 |
| 4 | EC 2025 | Principles of Electronics Engineering | 3 | 0 | 0 | 3 | 3 |
| 5 | EE 2011 | DC, AC and Special Electrical Machines | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME 2099 | Fluid Mechanics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 2095 | DC, AC and Special Machines Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | ME 2093 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2083 | Machine Drawing and Computer Aided Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

## SEMESTER- IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EI 2008 | Introduction to Instrumentation Engineering | 3 | 0 | 0 | 3 | 3 |
| 2 | ME 2027 | Materials Science and Engineering | 3 | 0 | 0 | 3 | 3 |
| 3 | MH 2002 | Principles of Machine Tools | 3 | 0 | 0 | 3 | 3 |
| 4 | EC 2011 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 5 | ME 2020 | Solid Mechanics and Machine Design | 3 | 1 | 0 | 4 | 4 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | EC 2096 | Digital and Linear IC Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EI 2096 | Measurement Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2085 | Manufacturing Practices | 0 | 1 | 2 | 3 | 2 |
| 2 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **9** | **5** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EC 2020 | Microprocessors, Microcontrollers and Interfacing | 3 | 1 | 0 | 4 | 4 |
| 2 | EE 2028 | Linear Control System | 3 | 0 | 0 | 3 | 3 |
| 3 | EI 3007 | Sensors and Actuators | 3 | 1 | 0 | 4 | 4 |
| 4 | EE 3011 | Power Electronics and Drives | 3 | 1 | 0 | 4 | 4 |
| 5 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | EC 2090 | Microprocessor and Microcontroller Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE 3097 | Power Electronics and Drives Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EI 3097 | Sensors and Actuators Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 3081 | Machine Design | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **29** | **25** |

## SEMESTER VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MH 3008 | Design of Mechatronic systems | 3 | 0 | 0 | 3 | 3 |
| 2 | MH 3010 | Industrial Automation and Robotics | 3 | 1 | 0 | 4 | 4 |
| 3 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective -I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | MH 3096 | PLC and Motion Control Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | MH 3092 | CIM and Robotics Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | MH 3094 | Mechatronics Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | MH 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER- VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| 3 | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **05** | **05** |
| **Sessional** | | | | | | | |
| 1 | MH 4081 | Project-I/Internship | | | | | 3 |
| 2 | MH 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER- VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | MH 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO - Honors**

## LIST OF HS ELECTIVES

**HS Elective – I**

| Sl. No. | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

**HS Elective – II**

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

## LIST OF DEPARTMENT ELECTIVES

**Dept. Elective – I**

| | | | |
|---|---|---|---|
| 1. | ME 3020 | Advanced Manufacturing Processes | 3 |
| 2. | EL 3022 | Advanced Control Systems | 3 |
| 3. | MH 3032 | Modeling and Simulation of Mechatronic Systems | 3 |
| 4. | MH 3034 | Product Design and Development | 3 |
| 5. | EC 6108 | Digital Image Processing | 3 |

**Dept. Elective – II**

| | | | |
|---|---|---|---|
| 1. | ME 3069 | Total Quality Management | 3 |
| 2. | MH 3035 | Process Planning and Cost Estimation | 3 |
| 3. | EI 3023 | Neural Network & Fuzzy Logic Control | 3 |
| 4. | MH 3037 | Micro and Nano Manufacturing System | 3 |
| 5. | MH 3039 | Artificial Intelligence for Mechatronics Systems | 3 |

**Dept. Elective - III**

| | | | |
|---|---|---|---|
| 1. | MH 3040 | Micro Electro Mechanical Systems | 3 |
| 2. | ME 3028 | Supply Chain Management | 3 |
| 3. | IT 4027 | Software Project Management | 3 |
| 4. | ME 3055 | Additive Manufacturing | 3 |
| 5. | MH 3042 | Mobile and Autonomous Robots | 3 |

**Dept. Elective – IV**

| | | | |
|---|---|---|---|
| 1. | ME 2024 | Industrial Engineering and Operations Research | 3 |
| 2. | MH 3044 | Virtual Reality and Haptics | 3 |
| 3. | ME 3057 | Machine Maintenance and Condition Monitoring | 3 |
| 4. | ME 3051 | Finite Element Analysis | 3 |
| 5. | AE 3001 | Automotive Mechatronics | 3 |

**Dept. Elective – V**

| | | | |
|---|---|---|---|
| 1. | MH 3046 | Intelligent Manufacturing Systems | 3 |
| 2. | ME 3047 | Production and Operations Management | 3 |
| 3. | E1 3022 | Bio-Medical Instrumentation | 3 |
| 4. | ME 3049 | Industrial Safety | 3 |
| 5. | MH 3048 | Internet of Things and Smart Manufacturing | 3 |

## COURSE STRUCTURE FOR B. TECH IN AEROSPACE ENGINEERING

### SEMESTER- III

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | MA 2005 | Mathematics-III (Civil & Mechanical) | 3 | 1 | 0 | 4 | 4 |
| 2 | ME 2015 | Manufacturing Technology | 3 | 0 | 0 | 3 | 3 |
| 3 | AS 2003 | Introductory Aerodynamics | 3 | 0 | 0 | 3 | 3 |
| 4 | AS 2005 | Aerospace Structures-I | 3 | 1 | 0 | 4 | 4 |
| 5 | AS 2007 | Aerospace Thermodynamics | 3 | 0 | 0 | 3 | 3 |
| 6 | AS 2010 | Aerospace Materials Technology | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | AS 2091 | Aerospace Thermodynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS 2092 | Aerospace Structures Lab-I | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME 2083 | Machine Drawing and Computer Aided Design | 0 | 0 | 2 | 2 | 1 |
| 2 | ME 2085 | Manufacturing Practices | 0 | 1 | 2 | 3 | 2 |
| **Total of Practical & Sessional** | | | | | | **9** | **5** |
| **Semester Total** | | | | | | **29** | **25** |

### SEMESTER- IV

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | AS 2002 | Automatic Control Theory | 3 | 0 | 0 | 3 | 3 |
| 2 | AS 2012 | Aerospace Structures-II | 3 | 1 | 0 | 4 | 4 |
| 3 | AS 2014 | Aircraft Systems & Instrumentation | 3 | 0 | 0 | 3 | 3 |
| 4 | AS 2016 | Aerodynamics - I | 3 | 1 | 0 | 4 | 4 |
| 5 | AS 2018 | Propulsion - I | 3 | 1 | 0 | 4 | 4 |
| 6 | | HS Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **21** | **21** |
| **Practical** | | | | | | | |
| 1 | ME 2091 | Material Testing Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS 2094 | Aerodynamics Lab - I | 0 | 0 | 2 | 2 | 1 |
| 3 | AS 2096 | Aerospace Structures Lab-II | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | HS 2081 | Business Communication | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **29** | **25** |

## SEMESTER- V

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | AS 3005 | Aerodynamics – II | 3 | 1 | 0 | 4 | 4 |
| 2 | AS 3007 | Propulsion – II | 3 | 1 | 0 | 4 | 4 |
| 3 | AS 3015 | Aircraft Performance | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-I | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-II | 3 | 0 | 0 | 3 | 3 |
| 6 | | Department Elective-III | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | AS 3093 | Aerodynamics Lab - II | 0 | 0 | 2 | 2 | 1 |
| 2 | AS 3095 | Propulsion Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | AS 3096 | Aerospace Measurement Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AS 3081 | Aircraft Systems | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- VI

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | AS 3010 | Aircraft Stability and Control | 3 | 0 | 0 | 3 | 3 |
| 2 | AS 3012 | Space Mechanics | 3 | 0 | 0 | 3 | 3 |
| 3 | AS 3014 | Avionics | 3 | 0 | 0 | 3 | 3 |
| 4 | | Department Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 5 | | Department Elective-V | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective –I / (MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | AS 3094 | Avionics Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AS 3082 | Minor Project | 0 | 0 | 4 | 4 | 2 |
| 2 | AS 3084 | FEM &CFD Analysis | 0 | 1 | 2 | 3 | 2 |
| 3 | AS 3086 | Aeroengine and Airframe | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **11** | **6** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER- VII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS 4001 | Professional Practice, Law & Ethics | 2 | 0 | 0 | 2 | 2 |
| 2 | | Open Elective-II / (MI-2) | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-1) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **5** | **5** |
| **Sessional** | | | | | | | |
| 1 | AS 4081 | Project-I / Internship | | | | | 3 |
| 2 | AS 4083 | Practical Training | - | - | - | - | 2 |
| (3) | | (Project – Minor / Lab) | (0) | (0) | (4) | (4) | (2) |
| **Semester Total** | | | | | | | **10** |

## SEMESTER- VIII

| Sl. No | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HS Elective-II | 3 | 0 | 0 | 3 | 3 |
| (2) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (3) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (HO-2) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (HO-3) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | AS 4082 | Project-II / Internship | | | | | 10 |
| **Semester Total** | | | | | | | **13** |

**MI – Minor** **HO - Honors**

# LIST OF HS ELECTIVES

## HS Elective – I

| Sl. No | Course Code | Course Title | Credit |
|---|---|---|---|
| 1. | HS 2002 | Engineering Economics | 3 |
| 2. | HS 2008 | Economic Environment of India | 3 |
| 3. | HS 2010 | Financial Institutions, Markets and Regulations | 3 |
| 4. | HS 2012 | Development Economics | 3 |

## HS Elective – II

| | | | |
|---|---|---|---|
| 1. | HS 3006 | Entrepreneurship | 3 |
| 2. | HS 3008 | Management Concepts & Practices | 3 |
| 3. | HS 3002 | Organizational Behaviour | 3 |
| 4. | HS 3004 | Human Resource Management | 3 |

# LIST OF DEPARTMENT ELECTIVES

## Dept. Elective-I

| | | | |
|---|---|---|---|
| 1. | AS 3032 | Theory of Aero-elasticity | 3 |
| 2. | AS 3038 | Aviation Fuels & Combustion | 3 |
| 3. | ME 3071 | Renewable Energy Technology | 3 |
| 4. | ME 3073 | Mechanics of Composite Materials | 3 |
| 5. | ME 3025 | Optimization Techniques | 3 |

## Dept. Elective-II

| | | | |
|---|---|---|---|
| 1. | AS 3031 | Computational Aerodynamics | 3 |
| 2. | ME 3024 | Mechanical Vibration and Noise Engineering | 3 |
| 3. | ME 3028 | Supply Chain Management | 3 |
| 4. | ME 3043 | Power Plant Engineering | 3 |
| 5. | ME 3047 | Production and Operations Management | 3 |

## Dept. Elective-III

| | | | |
|---|---|---|---|
| 1. | AS 3035 | Satellites& Space System Design | 3 |
| 2. | AS 3037 | Airframe Repair & Maintenance | 3 |
| 3. | ME 3022 | Principles of Turbo-machines | 3 |
| 4. | ME 3051 | Finite Element Analysis | 3 |
| 5. | ME 3059 | Computational Fluid Dynamics | 3 |

## Dept. Elective-IV

| | | | |
|---|---|---|---|
| 1. | AS 3040 | Rockets & Missiles | 3 |
| 2. | AS 3046 | Rotor Dynamics & Tribology | 3 |
| 3. | ME 3067 | Cryogenics | 3 |
| 4. | ME 3065 | Combustion Engineering | 3 |
| 5. | ME 3069 | Total Quality Management | 3 |

## Dept. Elective-V

| | | | |
|---|---|---|---|
| 1. | AS 3048 | Helicopter Aerodynamics | 3 |
| 2. | AS 3050 | Airport & Airlines Management | 3 |
| 3. | AS 3056 | Introduction to UAV Technology | 3 |
| 4. | ME 3030 | Product Life Cycle Management | 3 |
| 5. | ME 3052 | Nano Technology | 3 |

## HONORS COURSES OFFERED BY MECHANICAL ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/ s |
|---|---|---|---|
| 1 | ME 4010 | Metal Forming & Casting Processes | Manufacturing Processes and Automation(ME3019) |
| 2 | ME 4011 | Theory of Machining | Metal Cutting and Tool Design(ME3016) |
| 3 | ME 4012 | Non-Conventional Machining and Fabrication Processes | Manufacturing Processes and Automation(ME3019) |
| 4 | ME 4013 | Theory of Advanced Fluid Mechanics | Fluid Mechanics & Hydraulic Machines(ME2021) |
| 5 | ME 4014 | Theory of Advanced Thermodynamics | Engineering Thermodynamics(ME2031) |
| 6 | ME 4015 | Theory of Advanced Heat and Mass Transfer | Heat Transfer(ME3021) |
| 7 | ME 4016 | Mechanics of Solids and Structures | Mechanics of Solids(ME2029) |
| 8 | ME 4017 | Noise and Vibration Control Engineering | Kinematics and Dynamics of Machines(ME2013) |
| 9 | ME 4018 | Theory of Advanced Machines and Mechanisms | Kinematics and Dynamics of Machines(ME2013) |

## HONORS COURSES OFFERED BY MECHANICAL(AUTOMOBILE) ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | AE 4001 | Automotive Quality Management | Nil |
| 2 | AE 4002 | Auxiliary systems in Automotives | Internal Combustion Engines and Gas Turbines(ME2022) |
| 3 | AE 4003 | Turbochargers and Superchargers | Fluid Mechanics & Hydraulic Machines(ME2021) |

## HONORS COURSES OFFERED BY MECHATRONICS ENGINEERING

| Sl No. | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | MH 4001 | Robotics, Advanced Concepts and Analysis | Principle of Control Systems (EE 3009), Sensors & Actuators (EI-3007) |
| 2 | MH 4003 | Introduction to Biomechatronics | Principle of Control Systems (EE 3009), Sensors & Actuators (EI-3007) |
| 3 | MH 4005 | Computer Vision and Image processing | Digital Signal Processing (EC 3007) & Principle of Digital Signal Processing (EC 3013) |
| 4 | MH 4007 | Advance control and optimization | Control Systems (EL 3001) |
| 5 | MH 4009 | Sensors and Signals | Introduction to Instrumentation Engineering (EI 2008) |

## HONORS COURSES OFFERED BY AEROSPACE ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | AS 4001 | Composite Materials and Structures | Aerospace Materials Technology (AS 2010), Aerospace Structures-I (AS 2005) |
| 2 | AS 4002 | Advanced Aerospace Structure | Aerospace Structures-I (AS 2005), Aerospace Structures-II (AS 2012) |
| 3 | AS 4003 | Theory of Plates and Shells | Engineering Mechanics (ME 1003), Aerospace Structures-I (AS 2005), Aerospace Structures-II (AS 2012) |
| 4 | AS 4004 | Boundary Layer Theory | Introductory Aerodynamics (AS 2003) |
| 5 | AS 4005 | Turbulence in Fluid Flows | Introductory Aerodynamics (AS 2003) |
| 6 | AS 4006 | Viscous Fluid Flow | Introductory Aerodynamics (AS 2003) |
| 7 | AS 4007 | Hypersonic Air Breathing Propulsion | Propulsion - I (AS 2018), Propulsion – II (AS 3007) |
| 8 | AS 4008 | Radiative Heat Transfer | Aerospace Thermodynamics (AS 2007) |
| 9 | AS 4009 | High Temperature Gas Dynamics | Aerospace Thermodynamics (AS 2007), Aerodynamics - II (AS 3005) |

## LIST OF OPEN ELECTIVES OFFERED BY SCHOOL OF MECHANICAL ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | ME 3031 | Finite Element Method for Engineers | Mathematics-I (MA1003) |
| 2 | ME 3032 | Introduction to Fluid Mechanics and Heat Transfer | Mathematics –I (MA1003) |
| 3 | ME 3033 | Renewable Energy Sources | Nil |
| 4 | ME 3034 | Applied Thermodynamics | Mathematics –I (MA1003), Engineering Thermodynamics (ME2031) |
| 5 | ME 3035 | Biomechanics | Nil |
| 6 | ME 3036 | Strength of Materials | Engineering. Mechanics (ME1003) |
| 7 | ME 3037 | Quality Engineering and Management | Nil |
| 8 | ME 3038 | Kinematics and Dynamics of Machinery | Mathematics-I (MA1003), Engineering Mechanics (ME1003) |
| 9 | ME 3039 | Mechatronic Systems | Principles of Electronics Engineering (EC2025) |
| 10 | ME 3040 | Engineering Materials | Chemistry (CH1007) |
| 11 | ME 3042 | Computer Controlled Manufacturing Systems | Nil |
| 12 | ME 3044 | Robotics | Nil |
| 13 | ME 3046 | Introduction to Composite Materials | Nil |
| 14 | ME 3048 | Fundamentals of Computational Fluid Dynamics | Physics (PH1007), Chemistry (CH1007) |
| 15 | ME 3050 | Automobile Technology | Nil |

## MINOR IN MECHANICAL ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | ME 2013 | Kinematics and Dynamics of Machines | Nil |
| 2 | ME 2024 | Industrial Engineering and Operations Research | Nil |
| 3 | ME 3043 | Power Plant Engineering | Nil |
| 4 | ME 3062 | Thermodynamics and Hydraulic Devices | Nil |
| 5 | ME 3041 | Mechanical System Design | Nil |
| 6 | ME 4070 | Manufacturing Processes | Nil |
| 7 | ME 2085 | Manufacturing Practices | Nil |
| 8 | ME 4092 | Thermo fluids Lab | Nil |
| 9 | | Project(Minor) | Nil |

## MINOR IN MANUFACTURING ENGINEERING

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | ME 2007 | Materials Science and Engineering | Nil |
| 2 | ME 2026 | Engineering Metrology | Nil |
| 3 | ME 2024 | Industrial Engineering and Operations Research | Nil |
| 4 | ME 3055 | Additive Manufacturing | Nil |
| 5 | ME 4070 | Manufacturing Processes | Nil |
| 6 | ME 4072 | Industrial Automation and Robotics | Nil |
| 7 | ME 2085 | Manufacturing Practices | Nil |
| 8 | ME 2099 | Metrology and Instrumentation Lab | Nil |
| 9 | | Project(Minor) | Nil |

## MINOR IN INDUSTRIAL ENGINEERING AND MANAGEMENT

| Sl. No | Course Code | Course Title | Prerequisite/s |
|---|---|---|---|
| 1 | ME 3028 | Supply Chain Management | Nil |
| 2 | ME 3053 | Project Management | Nil |
| 3 | ME 4061 | Operations Research | Nil |
| 4 | ME 4074 | Quality Engineering | Nil |
| 5 | ME 4076 | Production, Planning and Control | Nil |
| 6 | ME 4078 | Work System Design | Nil |
| 7 | ME 4092 | Work System Design Lab. | Nil |
| 8 | ME 4094 | Operations Research Lab. | Nil |
| 9 | | Project(Minor) | Nil |

# APPLIED SCIENCES

**PH 1007** **PHYSICS** **Cr-4**

**Course Outcome :** At the end of the course, the students will be able to :

CO1. utilize the concept of waves and intensity modulation in day to day life through various applications.
CO2. apply the mechanism of LASER technology in different fields.
CO3. formulate and solve engineering problems of electricity and magnetism using Maxwell's electromagnetic equations.
CO4. apply the principles of quantum mechanics to related problems and device applications.
CO5. apply the knowledge of magnetic materials in fabrications and various device applications.
CO6. analyze the macroscopic behaviour of solids and utilize them in future applications.

**Prerequisite : NIL**

**Waves, Oscillations and Optics**

Simple Harmonic Oscillation, Damped Harmonic Oscillation (under damped, over damped and critically damped), Energy decay, Relaxation time, Forced Oscillation (Steady state Motion of Forced Damped Oscillator), Resonance, Coupled Oscillation. Harmonic waves, Wave equation.

Superposition of waves, Interference of light by wave front and amplitude splitting, Newton’s rings, Michelson’s interferometer, applications. Diffraction by a single slit, Plane Diffraction Grating, Absent spectra, Resolving Power and Dispersive power.

LASER, spontaneous emission and stimulated emission, Metastable state, population inversion, pumping, Ruby Laser, He-Ne Laser, applications.

**Electromagnetic Theory**

Vector calculus: gradient, divergence and curl, Maxwell's equations in differential and integral form with necessary derivations. Derivation of electromagnetic wave equations, transverse nature of EM waves. Scalar and vector potentials, Electromagnetic wave equations in terms of scalar and vector potentials, Poynting's theorem.

**Quantum Mechanics for Engineers**

Inadequacy of classical mechanics, de Broglie hypothesis for matter waves, phase velocity and group velocity, Heisenberg’s uncertainty principle, wave function and its interpretation, Postulates of Quantum mechanics, basic concepts of operators, Schrodinger’s equations, particle in one dimensional box, potential barrier, tunnelling, applications.

**Physics of Magnetic Materials**

Magnetic materials, Susceptibility, Permeability, Diamagnetic, Paramagnetic and Ferromagnetic materials, Langevin’s theory for Diamagnetic and Paramagnetic materials, Weiss theory for Ferromagnetic materials, Curie temperature.

**Mechanical properties of materials**

Stress, strain, Hooke's law, stress-strain diagram, elastic constants and their relations, torsional pendulum, bending moment, cantilever.

**Text Book :**

1. Engineering Physics, B. K. Pandey and S. Chaturvedi, Cengage Publication, New Delhi.

**Reference Books :**

1. Introduction to Electrodynamics, D J Griffiths, Pearson Education
2. Quantum Mechanics, L. I. Schiff, Tata McGraw-Hill Publications
3. Optics, A K Ghatak, Tata McGraw-Hill Publications
4. Concepts of Modern Physics, A. Beiser, Tata McGraw-Hill Publications
5. Engineering Physics, R K Gaur and S. L. Gupta, Dhanpat Rai Publications, New Delhi

## CH 1007 CHEMISTRY Cr–3

**Course outcome :** At the end of the course, the students will be able to :

CO1. rationalize bulk properties and processes using thermodynamic consideration and also apply the knowledge to decide the feasibility of a given process.
CO2. analyze the kinetics of simple and multistep reactions as well as theories of reaction rates.
CO3. evaluate some properties such as pH, solubility product etc. by using electrochemical cell and understand the working of modern batteries.
CO4. distinguish the different electromagnetic radiations used for exciting different molecular energy levels in various spectroscopic techniques so as to evaluate the structure of molecules.
CO5. get an exposure to different methods used for synthesis of nanostructured materials.

**Prerequisite : NIL**

**Chemical Equilibrium and Thermodynamics**

Internal energy, enthalpy, entropy and free energy, dependence of free energy on temperature and pressure, Gibbs Helmholtz equation, conditions of spontaneity and equilibrium, Free energy change and equilibrium constants, Van't Hoff isotherm and isochore, Clapeyron-Clausius equation , partial molar properties, Chemical potential, Gibbs Duhem equation.

**Electrochemistry**

Transport number, determination by Hitroff's method; Types of electrode, electrode/ cell potential; Nernst equation and application to: find electrode and cell potential, equilibrium constant, solubility product and pH; Frost and Predominance diagrams, Modern batteries: Fuel cells (AFCs, PEMFs, SOFCs, MCFCs), Zn-air battery, Li-ion battery, Ni-MH battery, Corrosion: Mechanism dry and wet corrosion, types of wet corrosion, prevention.

**Chemical Kinetics**

Rate of reaction and rate laws of multiple reactions (steady state approximation), parallel, opposing and consecutive reactions; theories of reaction rate: Collision theory, Lindemann modification, Absolute reaction rate; Catalysis: types, theories, kinetics of enzyme catalysis (Michaelis-Menten mechanism).

**Spectroscopy**

UV-Vis spectroscopy: Beer lamberts law, types of transition, concept of auxochrome and chromophores, factors affecting $\lambda_{max}$ and, Woodward-Fieser rules for calculation of $\lambda_{max}$ in diene systems; IR spectroscopy: types of vibration, Hooks law, detection of functional groups like C=C, -OH, $-NH_2$ and -C=O; NMR Spectroscopy: Basics of NMR Spectroscopy: Theory, Chemical shift, Shilding-deshilding effect, structural elucidation of simple compounds.

**Chemistry of Nano Materials**

Classification of nanostructured materials; Synthesis of nano-materials: CVD, Wet Chemical Synthesis, GPC, CVC and PLD; Applications.

**Text Book :**

1. Text book of Engineering Chemistry: Sashi Chawala, Dhanpat Rai and Co, 2016/17

**Reference Books :**

1. Elements of Physical chemistry-Samuel Glasstone; 2nd Edition, Macmillan
2. Principles of Physical Chemistry-B.R.Puri, L.R Sharma, M.S. Pathania; 42nd Edition, Vishal Publishing Co.
3. Spectrometric Identification of Organic compaunds,7th Edition -Robert M. Silverstein, Fransis X, Webster, Dravid j. Kiemle ; Jhon Wiley& Sons, INC.
4. Nanostructures & Nanomaterials: Synthesis, Properties and Applications- G. Cao and Y. Wang, World Scientific Pvt. Ltd.; 2nd Edition

**MA 1003** **MATHEMATICS-I** **Cr–4**

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the concept of modeling and formulation of Differential equation of physical problems.
CO2. apply different methods to solve ODE problems involving growth-decay, cooling effects and electrical circuits etc.
CO3. develop an ability to solve 2nd order ODEs.
CO4. get the concept of numerical solution of ODEs.
CO5. apply differential calculus in engineering problems.
CO6. the essential tool of matrices and linear algebra in a comprehensive manner.
CO7. apply the knowledge of Eigen value and Eigen vector in the field of engineering.
CO8. get the concept of complex matrices.

**Prerequisite : NIL**

**Ordinary Differential Equations :**

Basic concepts and definitions of $1^{st}$ order differential equations, solution of differential equations: variable separable, homogeneous, equations reducible to homogeneous form, exact differential equation, equations reducible to exact form, linear differential equation, equations reducible to linear form (Bernoulli's equation), Picard's iteration method to solve the 1st order ODE ,applications of differential equations.

**Linear Differential equations of $2^{nd}$ order :**

Second order linear homogeneous equations with constant coefficients; differential operators; solution of homogeneous equations; Euler-Cauchy equation; linear dependence and independence; Wronskian; Solution of non-homogeneous equations: general solution, complementary function, particular integral; solution by variation of parameters; undetermined coefficients.

**Differential Calculus and Numerics for ODEs:**

Taylor's Theorem (one and Two variables), Maxima and Minima (Two variables), Numerical solution of ODEs: Taylor's method, Euler's and Modified Euler's method.

**Vector Space and system of linear equations:**

Linear transformation, Linear system of equations; rank of matrix; consistency of linear systems; Solution of system of linear equations: Gauss elimination, Gauss Jacobi and Gauss Seidel methods; inverse of a matrix by Gauss Jordan method, Vector Space, Sub-space, Basis and dimension, linear dependence and independence.

**Matrix-Eigen value problems:**

Eigen values, Eigen vectors, Cayley Hamilton theorem, basis, complex matrices; quadratic form; Hermitian, Skew-Hermitian forms; similar matrices; diagonalization of matrices; transformation of forms to principal axis (conic section).

**Text Books :**

1. Kreyszig E., Advanced Engineering Mathematics, Wiley, $10^{th}$ edition.
2. Shanti Narayan and P. K. Mittal, Differential Calculus, S. Chand, reprint 2009

**References Books :**

1. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers,$36^{th}$ edition.
2. Dass H.K., Introduction to engineering Mathematics, S.Chand & Co Ltd, $11^{th}$ edition.
3. Ramana B.V., Higher Engineering Mathematics, TMH, 2007.
4. J.Sinha Roy and S Padhy, A course on ordinary & partial differential Equation, Kalyani Publication, 3rd edition.

## MA 1004 MATHEMATICS-II Cr-4

**Course Outcome :** At the end of the course, the students will be able to :

CO1. get the concept of Power series and solution of ODEs by using power series method.
CO2. acquire the knowledge of Power series solution of special type of ODEs such as Legendre and Bessel's equations.
CO3. achieve a comprehensive idea of Laplace transform and to solve IVPs by using it.
CO4. get the knowledge of periodic and non periodic functions and concept of finding Fourier series.
CO5. develop the geometrical/physical significance of Vector differential and integral calculus.
CO6. know the applications of Green's theorem, Gauss Divergence Theorem & Stoke's Theorem.
CO7. apply numerical techniques in interpolation.
CO8. evaluate definite integral by numerical methods.

**Prerequisite : Mathematics-I (MA 1003)**

**Series Solution of Differential Equations:**

Power series method, Legendre's equations, Legendre's polynomial and its properties, Frobenious method; Special functions: Gamma function, Beta function; Bessel's equations, Bessel's function and its properties .

**Laplace Transforms:**

Laplace Transform, Inverse Laplace Transform, Linearity, transform of derivatives and Integrals, Unit Step function, Dirac delta function, Second Shifting theorem, Differentiation and Integration of Transforms, Convolution, Solution of ODEs and Integral Equation by Laplace transform.

**Fourier series:**

Periodic functions, Even and Odd functions, Fourier series, Half Range Expansion.

**Vector Calculus:**

Gradient of a scalar field, Directional derivative, Divergence and Curl of a vector field, Line integral, Double Integral, Green's theorem, Surface Integral, Triple Integral, Divergence Theorem for Gauss, Stoke's Theorem.

**Interpolation and Numerical integration:**

Lagrange Interpolation, Newton's divided difference interpolation, Numerical integration by Trapezoidal rule and Simpson's rule.

**Text book :**

1. Kreyszig E., Advanced Engineering Mathematics, Wiley, 10$^{th}$ edition.

**Reference books :**

1. Grewal B.S., Higher Engineering Mathematics, Khanna Publishers, 36$^{th}$ edition
2. Dass H.K., Introduction to engineering Mathematics, S.Chand & Co Ltd, 11$^{th}$ edition
3. Ramana B.V., Higher Engineering Mathematics, TMH, 2007
4. J.Sinha Roy and S Padhy, A course on ordinary and partial differential Equation, Kalyani Publication, 3$^{rd}$ edition

**MA 2005 Mathematics-III (Civil & Mechanical) Cr-4**

**Course Outcome:** At the end of the course, the students will be able to :

CO1. know the concept of PDEs and their solution by separable method.
CO2. develop ability to solve one and two dimensional wave and heat equations.
CO3. find root of algebraic equations by different methods and obtain interpolating polynomials through Newton and Lagrange method.
CO4. evaluate differentiation and integration and solve ODE and PDE through numerical technique.
CO5. understand the technique of curve fitting by least square method and different concepts of regression and co-relation.
CO6. solve problems related to probability distribution and hypothesis testing.

**Prerequisite** : **Mathematics-I and II**

**Unit - I**
**Partial Differential Equations**:
Solution of PDE by separation method, Solution of one dimensional wave equation by separation method and D' Alembert's method, Solution of one and two dimensional heat equation, Solution of two dimensional wave equation
.

**Unit - II**
**Numerical Methods:**
Introduction to numerical methods, Numerical solution of algebraic equation (Bi-section, Newton-Raphson method), Newton's and Lagrange's interpolating polynomials, Numerical differentiation(using forward & backward difference formulae), Numerical integration( Simpson's rules), Solution of ODE by Runge-Kutta method of order two and four, Numerical solution of PDE.

**Unit - III**
**Statistics :**
Measures of central tendency (Mean, Median and Mode), Measures of dispersion(Standard deviation and variance), Curve fitting by method of Least square, Lines of regression, Coefficient of co-relation, Rank co-relation.

**Unit - IV**
**Probability :**
Introduction to Probability, Laws of probability, Random variable, Discrete probability distribution and continuous probability distribution, Testing of Hypothesis.

**Text Book :**
Higher Engineering Mathematics by B. S. Grewal
(18.2,3,4,5,6,7,9; 24.4,5; 25.5,6,7,8,12,13,14,16; 26.2,3,4,5,6,7,8,9,14,15,16,19;
27.2 - 7; 28.2; 29.1,4,6,10; 30.2,7,8; 32.7; 33.2-8

**Reference Book :**
Advanced Engineering Mathematics by E. Kreyszig (19.1)
Engineering Mathematics by S. Pal and S. C. Bhunia, Oxford University Press.

**MA 2007** **Mathematics-III (Electrical)** **Cr-4**

**Course Outcome:** At the end of the course, the students will be able to :

CO1. know the concept of Complex functions, their differentiability and integrability.
CO2. find series expansion of complex functions and evaluate real integrals by residue method.
CO3. find root of algebraic equations by different methods along with their convergence and solve the system of linear equations.
CO4. obtain eigen values and eigen vectors by power method and solve ODE numerically.
CO5. understand LPP and their solution by graphical and simplex method.
CO6. solve problems related to probability distribution and concepts of regression and co-relation.

**Prerequisite** : **Mathematics-I and II**

**UNIT-I**

**Complex Analysis:**

Basic concepts of Complex functions, Derivatives, Analyticity, Cauchy Riemman equations, Exponential, Trigonometric, hyperbolic, Logarithmic functions, general powers, Line integral, Line Integral of independent path, Cauchy's integral theorem, Cauchy's integral formula, Derivatives of analytic function. Taylor's series, Maclaurin's series, Laurent's series, Expansion of functions, singularities, Residues, Residue Integration method, Residue integration of Real Integrals.

**UNIT -II**

**Numerical Methods**:

Solutions of non linear algebraic equations by Fixed Point Iteration Method, Newton-Raphson Method and Secant Method, Rate of Convergence of Secant & Newton-Raphson Method . Solution of system of linear equations by LU- factorization(Crout, Dolittle & Cholesky methods), Largest eigen value and corresponding eigen vector by Power Method.
Runge-Kutta Methods of order 2 and 4, reduction of 2nd order ODE to 1st order ODE and its solution by R-K method of fourth order.

**UNIT -III**

**Linear programming :**

Introduction to Linear programming problem, solution by graphical method and simplex method.

**UNIT -IV**

**Probability**:

Experiments, Events, Outcomes, Probability, Conditional probability, Random variables, Mean and Variance of probability distributions, Discrete and Continuous distributions, Binomial and Poisson distributions, Normal distribution, Correlation & Regression analysis.

**Text Book:**
Advanced Engineering Mathematics(10th edition) by E. Kreyszig
(13.3,4,5,6,7,14.1,2,3,4,15.4,16.1,2,3,4
19.2; 20.2,8; 21.1,3; 22.1,2,3; 24.2,3,5,6,7,8; 25.9)

**Reference Book:**
Engineering Mathematics by S. Pal and S.C. Bhunia, Oxford University Press.

**MA 2009** **Mathematics-III (Electronics)** **Cr-4**

**Course Outcome:** At the end of the course, the students will be able to :

CO1. know the concept of PDEs and their solution by separable method.
CO2. develop ability to solve PDE by Laplace transform.
CO3. know the concept of Complex functions, their differentiability and integrability.
CO4. find series expansion of complex functions and evaluate real integrals by residue method.
CO5. find root of algebraic equations by different iterative methods along with their convergence
CO6. solve ODE numerically by single step and multi step method.
CO7. understand and solve problems related to probability distribution and concepts of regression and co-relation.

**Prerequisite** : **Mathematics-I and II**

**UNIT-I**

**Partial Differential Equation:**

Basic concepts, Wave equation, solution by separation of variables, solution by D' Alembert's method, Solution of Laplace equation in polar, cylindrical and spherical coordinate system, Application of Laplace Transform to solve PDE. Concept of error function.

**UNIT -II**

**Complex Analysis:**

Basic concepts of Complex functions, Derivatives, Analyticity, Cauchy Riemman equations, Line integral, Line Integral independent of path, Cauchy’s integral theorem, Cauchy’s integral formula, Derivatives of analytic function. Taylor’s series, Maclaurin’s series, Laurent’s series expansion of functions, singularities, Residues, Residue Integration method.

**UNIT -III**

**Numerical Methods:**

Solutions of non linear algebraic equation by Fixed Point Iteration Method and Newton-Raphson Method , Convergence of iterative methods.

Single step and multi step methods: Runge-Kutta Methods of order 2 and 4, reduction of 2nd order ODE to 1st order ODE and its solution by R-K method of fourth order, Adam- Bashforths and Adam- Moulton methods.

**UNIT -IV**

**Probability**:

Introduction to Probability, Mutually exclusive and independent events, Conditional probability, Joint probability, Random variables, Probability Distributions, Mean and Variance of distributions, Discrete and Continuous distributions, Binomial and Poisson distributions, Normal distribution, Distribution of several random variables, Regression and Correlation.

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**Text Book:**
Advanced Engineering Mathematics(10th edition) by E. Kreyszig , Wiley .
(12.1,3,4,7,9,10,11,12; 13.3,4; 14.1,2,3,4; 15.4;
16.1,2,3,4; 19.2; 21.1,2; 24.2,3,5,6,7,8,9; 25.9)

**Reference Book:**
Engineering Mathematics by S. Pal and S.C. Bhunia, Oxford University Press.

## MA 2011 Probability and Statistics Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the concept of probability and related terms, conditional probability and independent events.
CO2. get the idea of random variable and different discrete probability distribution..
CO3. know the concepts of continuous probability distribution, joint probability distribution of random variables and expected values.
CO4. solve problems related to co-variance and co-relation and know the methods of point estimation.
CO5. understand the concept of sampling, statistical intervals , confidence interval for population mean and normal population distribution.
CO6. test hypothesis based on single sample and deduce inferences based on two samples..

**Prerequisite** : **Nil**

**Unit - I**
Descriptive Statistics, Probability, Sample spaces, Events, Properties of Probability, Conditional Probability, Independent events.

Random variables, Probability distribution of discrete random variable, Binomial Probability distribution, Hyper geometric and Negative binomial Probability distribution, Poisson Probability distribution.

**Unit - II**
Probability distribution of continuous random variable, Other continuous Probability distributions. Jointly distributed random variables, Expected values, Co-variance and Co-relation. Distribution of sample mean. Point estimation, Methods of Point estimation.

**Unit - III**
Statistical intervals based on a single sample: properties of confidence intervals, Large sample confidence intervals for population mean and proportions. Intervals based on normal population distribution. Tests of hypothesis based on a single sample. Inferences based on two samples.

**Text Book** :
Probability and Statistics for Engineers and Sciences by J. L. Devore, CENGAGE Learning.
1.1,1.2; 2.1,2.2,2.4,2.5; 3.1 - 6; 4.1 - 5; 5.1 -4; 6.1,6.2; 7.1 - 4; 8.1 - 3; 9.1,9.2,9.4,9.5.

**Reference Book** :
Introduction to Probability and Statistics by William Mendenhall, Robert J, Beaver and Barbara M. Beaver, CENGAGE Learning.

## MA 2013 Discrete Mathematics Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. convert sentences in natural language into mathematical statements and understand predicate and quantifiers, rules of inference and prove results by principle of mathematical induction.
CO2. understand the principles of inclusion and exclusion of sets, concept of relations and functions and solve related problems.
CO3. know the concepts of partition of sets, partial ordering relation, Hasse diagram and Lattice.
CO4. solve problems on recurrence relations by substitution and method of generating functions.
CO5. understand the concept of algebraic structures, groups, semi group, subgroups and proof of Lagrange theorem.
CO6. gets the idea of homomorphism and isomorphism of groups, definition and examples of ring, integral domain and field.

**Prerequisite** : **Nil**

**Unit - I**

**Logic:**

Proposition, Truth values, Connectives, Logical equivalence of compound statement (using truth table & without truth table), Rules of Inference, Predicates and Quantifiers, Methods of Induction.

**Unit - II**

**Set, Relation & Function:**

Set, Operations on set, Principles of Inclusion and Exclusion, Relation and its representations through matrices and graphs, Types of relations, Properties on Binary Relation, Closures of relation, Equivalence relation and definition of function, Injection, Surjection, Bijection, Permutation functions. Partition of sets, Partial ordering relation, Hasse diagram, Lattice,

**Unit - III**

**Recurrence Relation and their solutions:**

Discrete numeric function, Generating Function, Concept of Linear Recurrence Relation with constant coefficients and its solution (Substitution Method and by using generating function).

**Unit - IV**

**Algebraic structure:**

Introduction to Algebraic structures, Semi group, monoid, Group, Abelian group. Properties of groups, Cyclic groups and its generator, Sub group, cosets, Normal subgroup, Lagrange's Theorem, Homomorphism and Isomorphism, Ring, Integral domain , Field(Definition with examples)

**Text Book :**
Discrete Mathematics and its Applications by Kenneth H Rosen (McGraw Hill 7th Edition)
1.1 - 3,1.5; 2.1 - 3; 4.1,4.2; 6.1,6.2,6.4,6.5; 7.1,7.3 - 6; 11.1 - 5.

**Reference Book :**
Elements of Discrete Mathematics. A Computer oriented approach by C.L Liu, D.P. Mohapatra (Tata McGraw Hill 4th Edition-2013)

## LS 1001 BIOLOGY Cr-2

**Course Outcome :** At the end of the course, the students will be able to :

CO1. comprehend the typical characteristics those distinguish life forms and analyze in life process at cellular level.
CO2. apply concepts on structure and function of simple biomolecules in life processes.
CO3. to comprehend the chemical reaction involved in life process and to analyze the effects of the factors governing the reactions.
CO4. to realize and relate biological phenomena with engineering application domains.
CO5. to comprehend the functions at neural level and relate to computer based techniques dependent on these.
CO6. to understand Biology and its relevance to Engineering and technology.

**Prerequisite : NIL**

**The Cellular Organization of a Living Organism**

The Living World: Biodiversity of Living World, Microorganisms. Cell as the Basic Unit of Life, Cell Theory, Structure and functions of Prokaryotic & Eukaryotic Cells, Cell division. Cell growth and reproduction, Cell Metabolism, Cell Differentiation, Homeostasis, Concept of Gene, Basic structure and function of Chromosomes.

**The Molecular and Biochemical Basis of an Organism**

Chemical Context of Life: Water, Carbon, Structure & Function, Bio-macromolecules (Protein, Carbohydrates, Amino Acids, Lipids, Nucleic Acids), Minerals, Types of Bonding, Protein Synthesis, Stem cells and their applications.

**Enzymes, Photosynthesis, Metabolism and Bioenergetics**

**Enzymes:** Introduction, Structure, Properties, Classification, Mechanism of Enzyme actions, Factors affecting Enzyme action, Strategies Utilized by Enzymes to effect catalysis. **Photosynthesis:** Introduction, History, Pigments, Process of Photosynthesis, Mechanism of Photosynthesis (Light Reaction and Dark Reaction), Factors affection Photosynthesis. **Metabolism and Bioenergetics:** Anabolism and catabolism.

**Molecular Machines, Biosensor and Bioremediation**

**Molecular Machines:** Introduction, Molecular Machines and Motors, F0F1-ATP Synthase Motors, Bacterial Flagellar Motor, Ctyoskeleton: Microtubules, Microfilaments and Intermediate Filaments, **Biosensor:** Basic Concept of Biosensor, working Principle, Types of Biosensors, Glucose Biosensors, Bio-detectors: DNA Detection, Biosensor Detection of Pollutants, Biosensor in Food Industry. **Bioremediation:** Introduction, Types, Role of Microorganisms, Advantages and Disadvantages, Factors Determining Bioremediation.

**Nervous System, Immune System and Cell Signaling**

**Nervous System:** Introduction, History of Neuroscience, Types of Glial Cells, Nerve Cells - Neurons, Action Potential, Organization of the Nervous System, Diseases of the Nervous System, Computer-Based Neural Networks. **Immune System:** Introduction, Innate Immunity, Adaptive or Acquired Immunity, Diseases of the Immune System, Immune Engineering. **Cell Signaling:** General Principles of Cell Signaling.

**Text Book :**


1. Biology for Engineers: S. ThygaRajan, N. Selvamurugan, M.P. Rajesh, R. A. Nazeer, Richard W. Thilagaraj, S. Barathi, M. K. Jaganathan, Mc Graw Hill Education (India) Edition, 2012.


**Reference Books :**


1. Biology (Indian Edition), P. H. Raven and G. B. Johnson, Mc Graw Hill Education (India) Private Limited.
2. Concepts of Biology, Eldon D. Enger, Feederick C. Ross and David B. Bailey, TMH publication.
3. Biology, Neil A. Campbell and Jane B. Reece, Pearson Education.
4. Biology Concepts and Application, Cecie Starr, Thomson Books.

# HUMANITIES

## HS 1005 PROFESSIONAL COMMUNICATION Cr-2

**Course Outcome :** At the end of the course, the students will be able to :

CO1. have a basic understanding of the communication process and to know the practical implementations in the workplace.
CO2. apply verbal and non-verbal modes of communication effectively in practical situations.
CO3. use English grammar correctly and unambiguously in technical writing.
CO4. bridge the gap between native language and target language.
CO5. retain a logical flow while drafting reports and other technical pieces of writing.
CO6. develop competence in reading and comprehension.
CO7. be familiar with English pronunciation and use neutral accent successfully.
CO8. develop active listening responses.

**Prerequisite : NIL**

### UNIT-I Communication

Process of Communication
Methods of Communication (Verbal & Non-Verbal)
Verbal Communication: Oral & Written
Non-Verbal Communication: Sign Language & Body Language
Kinesics; Proxemics; Chronemics
Oculesics; Olfactics; Gustorics; Haptics
Paralanguage; Sign Language
Flow of Communication (Formal & Informal); Grapevine
Levels of Communication
Barriers of Communication: Intrapersonal, Interpersonal & Organizational, Semantic

### UNIT-II Basics of Grammar

Time & Tense
Subject-Verb Agreement
Analogy
Active & Passive Voice
Error Detection in Sentences

### UNIT-III Writing Skills

Paragraph Writing- Techniques & Skills
Use of Punctuations
Business Letter: Enquiry, Claim/ Complaint, Order
Technical Reports: Importance & Objectives, Formats & Style
Comprehension Skills

### UNIT-IV Basic Sounds of English

Hearing & Listening
Introduction to Basic Sounds of IPA
Problem Sounds & MTI

**Text Book :**

1. Technical Communication: Principles & Practices. Meenakshi Raman & Sangeeta Sharma. OUP. 3rd ed. 2011.

**Reference Books :**

1. Communicative English Grammar. Geoffrey Leech & Jan Svartvik. Routledge. 3rd ed. 2013.
2. Effective Technical Communication. M. Ashraf Rizvi. TMH. 2005.
3. An Introduction to Linguistics: Language, Grammar & Semantics. Pushpinder Syal. Prentice Hall India. 2nd ed. 2007.
4. The Oxford Grammar (English). Sidney Greenbaum. OUP. 1st ed. 2005.
5. Technical Communication for Engineers. Shalini Verma. Vikas Publishing House. 2015.
6. Verbal Ability & Reading Comprehension for the CAT. Arun Sharma & Meenakshi Upadhyay. TMH. 2007.

## HS 2002 ENGINEERING ECONOMICS Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. learn the fundamentals of Engineering Economics.
CO2. understand and use Concepts of Economics in making business decisions.
CO3. use economic information to manage the organization.
CO4. use economic tools with respect to acceptance or rejection of investment proposals.
CO5. know the current issues related to economic environment.
CO6. optimize with resource constraints.

**UNIT I**

**Economics:** An Introduction to Economics and Engineering Economics.

Basic concepts of Economics: Demand and Supply Analysis, Demand and its Determinants , Demand Function, Law of Demand, Demand Schedule, Individual and Market Demand curve, Change in Quantity demanded and Change in Demand, Shift in Demand, Factors causing shift in demand curve.

Indifference Curve (IC): Properties of IC, Budget Line,. Equilibrium of the Consumer Classification of Goods: Normal, Inferior and Giffen Goods (to be explained through the concepts of Price effect, Income effect and Substitution effect).

Elasticity of Demand: Types-Price, Income and Cross Elasticity of demand. Methods-Point, Arc, Total Outlay method. Factors affecting elasticity of demand-Importance and Policy Implications of elasticity concept. Numerical Examples.

Demand Forecasting: Concepts and Methods- Ordinary Least Square method.

Revenue Concepts: Total, Average and Marginal Revenue, Relationship with price elasticity.

Supply Analysis: Supply and its Determinants, Law of Supply, Supply Schedule and Supply functions- Factors affecting supply.Market equilibrium and related numerical.

**UNIT II**

**PRODUCTION AND COST ANALYSIS:** Concept of Production and Production function. Producer’s Equilibrium condition.
Laws of production-Short Run and Long Run Production Functions. SRPF- The law of variable proportion-The 3 stages.

Concept of Isoquants and Iso-cost lines, properties of Isoquants.LRPF- Returns to Scale-Economies and Dis-economies of scale.Cobb-Douglas Production Function (Functional form).Numerical Examples.
Cost Concepts: Short Run and Long Run Cost curves. Average cost, Average fixed cost and Average variable cost- Relationship between Average and marginal cost ,Explanations of the U-shape of the Short run average cost curve. LAC.Numerical Examples.
Break-Even Analysis-Derive Breakeven point in terms of output sales .Margin of Safety, P/V ratio, Examples.

Market: Concepts and Types. Perfectly Competitive market-Characteristics Short run and Long run equilibrium. Monopoly Market: Characteristics. Short run and Long run equilibrium, Examples. Comparison of Competitive Solution with Monopoly Solution.

**UNIT III**

**Project Evaluation –**Meaning and Examples:Interest Formulas and their applications. The derivations of the interest formulas. Numerical Examples.
Evaluation of Investment Proposals-Present Worth method of comparison (Equal and Unequal lives with examples). Future worth method of comparison and Annual Equivalent Method of comparison with examples.
Economic Appraisal Techniques-Pay-Back Period criteria, Net Present Value(NPV), Internal Rate of Return(IRR) comparison with MARR, Cost Benefit analysis.

Depreciation calculation: Meaning and Definition. Methods: Straight Line Method, Declining Balance method, Sum-of-years digit method and Sinking Fund Method (Methods to be explained with illustrations).

Inventory control: Meaning, Type, objectives and benefits of Inventory control. Basic Inventory Model: Economic Order Quantity.

**UNIT IV:**
**Macroeconomic Concepts:** Theory of credit creation and methods to control it (OMO, Bank rate, Repo rate and reserve ratio approaches); Inflation: Its causes and control (Monetary and Fiscal measures).Fundamentals of Business cycle (Phases of Business cycle).Effectiveness of monetary and fiscal policies. National Income concepts and measurement with numerical examples.

**Text books :**


1. Managerial Economics: Principles and Worldwide Applications, 8th Edition. By Dominick Salvatore and Siddhartha K.Rastogi. Publisher: Oxford University Press,2016.ISBN:13-978-0019-946706-8.
2. Engineering Economics –James L.Riggs, DavidD.Bedworth and Sabah U.Randhawa,4$^{th}$Edition, McGraw Hill Education(India) Private Limited, New Delhi,2016.


**Reference Books :**


1. Engineering Economics – R.Panneerselvam, Pub: PHI Learning Private Limited, New Delhi, 9thEdition, 2008.
2. Micro ECON-A South-Asian Perspective-by William A. McEachern and Simrit Kaur, Cengage Learning, 2013.
3. Principles of economics, Deviga Vengedasalam and Karunagaran Madhavan, Oxford University Press, New York,3rd Edition,2013.
4. Economics for Engineers, H.L. Bhatia and S.N. Maheswari (Vikas Publishing House, New Delhi, 2012, check the current edition)
5. Engineering Economy-Zahid A.Khan, Arshad Noor Siddiquee, BrajeshKumar, Pearson Publication, 2012.
6. Monetary Economics-Institutions, Theory and Policy-S.B.Gupta, Pub: S.Chand, 1995.
7. Macro – Economics – R.D. Gupta, Publication: Kalyani Publication, 1994.

## HS 2008 ECONOMIC ENVIRONMENT OF INDIA Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. understand and analyze the economic situation of the country.
CO2. acquaint themselves with the economic crises in the past and the ways followed to get out of those.
CO3. know different institutions that chalk out different plans and policies related to economic affairs.
CO4. analyze the occupational structure of the country and sectoral contribution to growth.
CO5. ascertain the role of foreign sector in domestic economy.
CO6. have basic ideas about fiscal position of the country.

**UNIT I: Economic Crises and Way out**

Economic Crisis of early 1990s-Macro Economic Reforms since 1991-Structural Adjustment Programmes- Globalisation, Liberalisation and Privatisation- impact of 25 years of reforms on various sectors of the economy- Planning to markets - NITI Ayog and discontinuation of Central Planning- Demonetisation and its macro-economic impact - growth and inequality from regional perspective in India – Jobless growth, informal sector and employment

**UNIT II: Primary Sector and Secondary Sector**

Agriculture during the Reform Period- New Agricultural Policy- WTO and Indian Agriculture- Current Issues in Indian agriculture. Investments and subsidies in Indian agriculture- Agrarian distress and related issues.

New Industrial Policy 1991- Public Enterprises; Micro, Small and Medium Scale Industries (MSMEs)- Role, problems and remedies- Role of FDI in industrialization process- ICT based industrial development strategy- Make in India.

**UNIT III: Tertiary Sector and Foreign Sector**

Service sector as the engine of growth in India- Trade in services- Global technological change and Indian IT boom. Challenges of India’s Service sector .

External Sector- Foreign Trade:Salient features, composition and direction; Trade reforms- Balance of Payment; Exchange rate.
India and WTO

**UNIT IV: Public Finance**

Issues in Indian Public Finance- Fiscal reforms in India post 1991- Tax reforms and reforms in public expenditure management- Goods and Services Tax - Public Debt and Sustainability issues- Implementation of FRBM Act - Fiscal and Monetary Policy dynamics in India. Centre-State Fiscal relationship- cooperative and competitive federalism in India- Role of Finance Commission- Local Bodies in India.

**Text Book :**

1. Dutt and Sundaram.Indian Economy, Sultan Chand, latest edition

**Reference Books :**

1. Uma Kapila (2019), Indian Economy Since Independence, New Delhi, Academic Foundation
2. Babu, Suresh M. (2018): ‘Hastening Slowly: India’s Industrial Growth in the Era of Economic Reforms’. Orient Black Swan, Hyderabad.
3. Balakrishnan, P. (2010): ‘Economic Growth in India: History and Prospect’. Oxford University Press, New Delhi.
4. Bhagwati Jagdish and Arvind Panagariya( 2012): ‘ India’s Tryst with Destiny’. Collins Business, Noida, India.
5. Deaton, A. and V. Kozel (ed) (2005): ‘The Great Indian Poverty Debate’. New Delhi: Macmillan.

6. Eswaran Mukesh and Ahosk Kotwal (1994): ‘Why Poverty Persists in India’. Oxford University Press, New Delhi.
7. Jalan B (2017): ‘India: Priorities for the Future’. Penguin Random House, New Delhi.
8. Jean Dereze and Amartya Sen (1996): ‘An Uncertain Glory: India and its Contradictions’. Penguin Books Ltd. London.
9. Jean Dereze and Amartya Sen (1996): ‘Indian Development: Selected Regional Perspectives’. Oxford University Press, New Delhi.
10. Jeffrey Sachs, Ashutosh Varshney and Nirupam Bajpai (eds).(1999): India in the Era of Economic Reforms, Oxford University Press, New Delhi.
11. Mahendra Dev S. (ed)(2007): ‘ Inclusive Growth in India’. Oxford University Press, New Delhi.
12. Ajitava Raychaudhuri and Prabir De (2012), International Trade in Services in India, New Delhi: Oxford University Press

## HS 2010 FINANCIAL INSTITUTIONS, MARKETS AND REGULATIONS Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. have comprehensive understanding of the nature and functions of the several types of financial institutions that are present in the market.
CO2. develop critical skills in assessing the relevance of the principles of finance and financial inter-mediation to real world situations.
CO3. understand the role that financial markets play in the business environment that they will face in the future.
CO4. have essential background for decision making and analysis of security market transactions or policies.
CO5. have basic ideas on Indian financial markets, institutions, instruments and policies.
CO6. get accustomed with innovations in financial sector.

**UNIT I: Financial System**

Structure and Role of Financial System - Significance of Banking and Financial Institutions -Structure of the Financial System- Banks and Other Financial Institutions . Institutional structure in India- Commercial - Cooperative banks - Private sector banks - Non-Bank Financial Intermediaries - Institutional structure in India - Types and comparison of asset liability structures of various NBFCs - Finance Companies - Mutual Funds - Lease finance - Housing Finance - Venture Capital funds - Money Market Mutual Funds - Hedge Funds – Insurance companies - Infrastructure Finance Companies.

**UNIT II: Financial Innovation**

Financial Innovation -Function of Financial Markets - Overview of Structure of Financial Debt and Equity Markets Primary and Secondary Markets-Exchanges and Over-the-Counter Markets - Money and Capital Markets- Internationalization of Financial Markets- International Bond Market - Eurobonds - Eurocurrencies - World Stock Markets - Function of Financial Intermediaries -Transaction Costs.

**UNIT III: Monetary Authority**

Reserve Bank of India as a Financial regulator and Financial Authority - Regulation and supervision of banking system - Basel Norms - Early Warning Signals of Credit Deterioration and Failure in banks .
Subprime Crisis – Regulation of Non-Bank Financial Intermediaries - Mortgage Backed Securities and OTC market - Derivatives Markets - Foreign Exchange Derivatives and Swaps.

**UNIT IV: Capital Market Authority**

Regulation of Capital Market - Securities Exchange Board of India
Regulations - Securities and Exchange Board of India Act, 1992 - Securities Contract (Regulation) Act 1956 - Companies Act 1956 - Depositories Act 1996 - Prohibited Transactions - Insider Dealing - Market Abuse - Money Laundering -Corporate Governance and Management Guidance And Supervision - Role of stock exchanges and
NSDL.

**Text Book :**

1. Madura, Jeff (2008), Financial Markets and Institutions, 8th edition, Thomson Publications.

**Reference Books :**

1. Fabozzi, Frank, Modigliani, Franco, Jones, Frank (Feb 2009), Foundations of Financial Markets.
2. Eakins, Stanley G. (2005), Financial Markets and Institutions (5th Edition), Addison Wesley.
3. Howells, Peter, Bain, Keith (2007), Financial Markets and Institutions, 5th Edition.
4. Barth, James R., Caprio, Gerard, and Levine, Ross (2008), Bank Regulations are Changing: For Better or Worse?, Association for Comparative Economic Studies.
5. Goldstein, Morris (2006), Financial Regulation after the Subprime and Credit Crisis, Washington: Peterson institute.

## HS 2012 DEVELOPMENT ECONOMICS Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. differentiate between economic growth and economic development.
CO2. understand the quality of life.
CO3. analyze human development index.
CO4. compare the development paths across the countries of the Globe.
CO5. have the ability to analyze factors affecting long run economic growth.
CO6. analyse the growth models and their applicability.

**UNIT I: Development and Underdevelopment**

Difference between economic growth and economic development. Alternative measures of development –PQLI, HDI and its extensions, Development and growth- income as a measure of growth - Human development-Sens capability approach, development as freedom, Structural features of underdeveloped economies- International variations – development gap .

**UNIT II: Growth Models**

Models of Growth and Theories of Development: Big Push, Balanced and Unbalanced Growth, Harrod - Domar model, Solow model and its variants, Contribution and application of New Growth Theory - O Ring Theory - Endogenized Solow Model.

**UNIT III: Poverty and Inequality**

Perceptions about Development and Underdevelopment: Vicious circle of poverty, Dual economy models- Lewis model and its extensions, Harris- Todaro migration model - Poverty and Inequality: Definitions, Measures and Mechanisms - Concept of poverty and its measures - Inequality meaning – axioms - commonly used inequality measures, Kuznets curve - Impact of poverty and inequality on process of development .

**UNIT IV: Cross Country Perspectives of Development**

Cross Country Differences in Development Paths and New Development Challenges Asia with special reference to China and India, Africa, Latin America Millennium Development Goals. Sustainable Development Goals

**Text Books :**

1. Todaro, M. P. & Smith, S. C. (2015), Economic Development, Pearson ($12^{th}$ Edition).
2. Thirlwall A. P. Growth and Development ( 6 th and 7 th edition)

**Reference Books :**

1. Debraj Ray : Development Economics, Princeton University Press (1998)
2. Meier and Rauch,: Leading Issues in Economic Development, OUP, Latest Edition
3. Kaushik Basu :Analytical Development Economics , OUP
4. Human Development Reports, various years
5. Bagchi A. K. The Political Economy of Underdevelopment, Cambridge University Press 1982.

## HS 3002 ORGANISATIONAL BEHAVIOUR Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know about organisation, organizational behaviour its nature, scope and significance.
CO2. develop their personality as per industry requirement.
CO3. apply motivational techniques to make the employees work with confidence and satisfaction.
CO4. develop different leadership style to adjust themselves in different organisational situations.
CO5. improve the knowledge of group behaviour and techniques of group decision making.
CO6. apply the concepts for managing changes in organisation as well as the development of an organization's human resources

**UNIT-1- Introduction to Organisation and organisational behaviour**
Introduction to organisation and organizational behaviour. Nature and scope of OB, Human behaviour in Organizations, Employees' views of Work, Managerial Views of work.

**UNIT-2- Personality**
Meaning of personality, Personality Development, Determinants of Personality, Application of personality in Organization.
Motivation: Concept of motivation, motivation and behaviour, Theories of motivation, Elements of Sound motivational System, Motivation in Indian Organization.

**UNIT-3- Leadership and group dynamics**
Theories of leadership: Trait Theory, Behavioral theory, leadership styles, Leadership in Indian organization
Group Dynamics: Concept of Group Dynamics, Types of groups, group behaviour, Group decision making techniques to improve group decision, Merits and Demerits of group decision.

**UNIT-4- Organization structure, change and development**
Meaning and nature of organizational change, Factors of organizational change, Resistance to change, factors in Resistance, Overcoming Resistance to change, OD: Concept, objectives and process of organizational development

**Text Books :**
1. Organizational Behaviour, Stephen P. Robbins, Timothy A . Judg, S. Sanghi Pearson, 2013
2. Organizational Behaviour and work, F. M. Wilson, Oxford University Press, 2018

**Reference Books :**
1. Organisational behaviour, Dipak Kumar Bhattacharya, Oxford University Press, 2018
2. ORGB, Organizational Behaviour, Nelson, Quick, Khandelwal, Cengage, 2016
3. Organisational Behaviour. Dr. S. S Khanka, S. Chand, 2014.
4. Managing Organisational Behaviour, Moorhead & Griffin, Cengage Learning, 2014.

## HS 3004 HUMAN RESOURCE MANAGEMENT Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. develop personal and professional qualities of a manager in order to manage human resource of an organisation effectively.
CO2. meet the human resource requirement of the organisation for achieving its objective effectively.
CO3. follow different HR processes like recruitment, selection, training, performance appraisal effectively in organisational level.
CO4. inculcate the sense of inter personal relation required in professional front in handling employer-employee relation effectively for achievement of organisational objectives.
CO5. achieve strategic objectives of the organizations, by optimizing the potentiality of the human resource through workers participation in management.
CO6. know the technique of managing and being managed by the organisation.

**UNIT-1- Human Resource Management**

Meaning & Definition, Functions, Scope & Objectives, Qualities of a HR Manager.

**UNIT-2- Human Resource Planning**

Objectives, Meaning & Definition, Importance of HRP, HRP Process, Barriers of HRP, Factors of sound HRP.

Recruitment-Meaning & Definition, Sources of Recruitment, Recruitment Process, Effective recruitment. Selection- Meaning, Steps in selection process, Evaluation of selection process Wage & Salary administration : Meaning, importance, frienge benefits. Training & Performance Appraisal- Definition & Objectives, Areas of Training, Meaning & Definition of Performance Appraisal, Process, Effective principles of performance appraisal.

**UNIT-3- Industrial Relations**

Concept & Meaning, Objective & Importance, Reasons of poor Industrial Relation. Industrial Disputes-Meaning & Definition, Causes of Industrial Dispute, Conditions for good Industrial Relation.Trade Union-meaning, activities and trade union act, 2926.

Collective Bargaining : Meaning & definition, Objective & Importance, Process of Collective Bargain, Effective Condition.

**UNIT-4- Workers Participation in Management**

Meaning & Need, Forms of Participation, Scheme of participation, Merits & Demerits.
Employee Discipline- guidelines for action, Penalties & Punishment, Rewards of Discipline.

**Text Books :**

1. Human Resource Management, P. Jyoti & D. N. Venkatesh, Oxford Publication, 2016
2. Human Resource Management, B. Varkkey & G. Dessler, Pearson, 2017

**Reference Books :**

1. Human Resource Management, K. Aswathappa, Mc Graw Hill Education, 2013.
2. Human Resource Management, S. S. Khanka, S. Chand, 2019
3. Human Resource Management, P. Subba Rao, Himalaya Publishing House, 2018.

## HS 3006 ENTREPRENEURSHIP Cr-3

**Course outcome :** At the end of the course the students will be able to :

CO1. know the contribution of an entrepreneur and role of SSI units in growth and development of socio economic condition of our country.
CO2. learn market survey, sales promotions and management of working capital through costing and book keeping.
CO3. know different decision making technique and benefit of personal management system as well as motivational methods of an enterprise.
CO4. learn how to prepare a project report and knowledge about different tax system of an enterprise.

**UNIT-I :**

New Industrial Policy of 1991,Meaning and Definition of Entrepreneurship, Incentives and benefits available to SSI Units and New Entrepreneurs. Dearth of entrepreneurial talent in India, Growth of SSI in India. Procedures to start SSIs.

**UNIT-II :**

Market survey and research pricing and techniques, Distribution Channel, Sales promotion activities. Raising Finance and enterprise launching.

**UNIT-III** :

Financial Management, Working Capital Management, Costing,Book Keeping, Break-Even-Analysis. Taxation: Income Tax, Excise duty, Sales tax and VAT.

**UNIT-IV** :

Decision making – Types, Forecasting-Qualitative and Quantitative methods, Personal Management, Motivation and theories of motivation. Preliminary Project Report (PPR),Detailed Project Report (DPR) writing.

**Text Book :**

1. Entrepreneurial Development.S.S.Khanka. S.Chand, 2007.

**Reference Books :**

1. Industrial Organisation and Engg.Economics. Sharma & Banga.Khanna Publication, 2003.
2. Entrepreneurship New Venture Creation. David H.Holt.Prentice Hall .PHI, 2013.

## HS 3008 MANAGEMENT CONCEPTS AND PRACTICES Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. perform the critical management functions effectively and develop ideas about implementing principles and theories of management in organizations efficiently.
CO2. develop various marketing skills in order to be successful in corporate world.
CO3. utilize different financial techniques for better management and control of organisational financial resources.
CO4. take strategic decision for day to day operation through proper working capital management.
CO5. have competency in production planning as well as control measures will become easy in their professional career.
CO6. do strategy formulation of the organization and how to achieve that strategy within a stipulated time period.

**UNIT-1- Introduction to Management**
Meaning and Nature, Functions of management, Theories of management, classical theory, modern theory, Principles of management.

**UNIT-2- Marketing**
Identifying Market Segments, Market mix, product, price, Distribution and Promotion, Advertisement and market research, pricing strategies.

**UNIT-3- Finance**
Introduction, Scope & Functions, Financial statements, working capital management, capital budgeting decision.

**UNIT-4- Production**
Production planning and control, systems and procedure of inventory management, strategy management: firm and its environment, process of strategic planning.

**Text Books :**

1. Modern Business Organisation and Management. Sherlekar & Sherlekar, Himalaya Publishing House, 2018.
2. Business Organisation and Management. M. C. Shukla, S. Chand, 2014

**Reference Books :**

1. Principles & Practices of Management. L. M Prasad, 2015
2. A framework for marketing management, Philip Kotler, 2013
3. Financial Management. I. M Panday, 2015
4. Production and Operation Management, Everett E. Adam Jr. Ronald J. Ebert, 2013

## HS 3032 FOUNDATIONS OF MODERN MACROECONOMICS Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. introduce themselves to the basic principles of macro economics.
CO2. explain the circular flow model and use the concepts of aggregate demand and aggregate supply
CO3. understand the basic economic problems of inflation, unemployment, poverty and their remedies through macro insights.
CO4. evaluate the relevance of macro variables in policy making.
CO5. relate the corporate functioning to macroeconomic indicators.
CO6. define fiscal and monetary policies and how these affect the economy

**UNIT I: National Income and its measurement**

Introduction to National Income, Concepts of GDP, GNP, GDP Gap, GDP Deflator and national income, Comparison of GDP deflator with CPI, Rules and Methods of Measurement of GDP (Income, expenditure and Out Put method), Circular Flow of Income and expenditure both in close and open economy..

**UNIT II: General Equilibrium**

**Introduction of AD & AS.** Derivation of product market equilibrium (IS curve) and money market equilibrium (LM curve) – equilibrium in IS-LM Model, Effectiveness of Monetary and Fiscal Policy, Crowding-Out Effect.

**UNIT III: Inflation and Unemployment**

Measuring Inflation rate and Unemployment rate; The Phillips relation – The expectation augmented Philips curve – The natural rate of unemployment hypothesis The Relation between GDP Gap, Inflation rate and unemployment Gap, Okun's Law.

**UNIT IV: Theories of consumption and Investment:**

Keynesian and Post Keynesian**:** Consumption function, Marginal Efficiency of Capital, theories of consumption –Absolute, relative, permanent and life cycle income hypothesis.

Keynesian and Post Keynesian theories: The decisions to invest- Autonomous and Induced investment, MEI schedule. Multiplier and accelerator theories of Investment. Neo-classical theory of investment (Jorgensen)

**Text Books :**

1. N.Gregory Mankiw. Principles of Macro economics with course mate, 7th edition, Cengage Publishers.
2. Andrew Abel and Ben Bernanke ( 2016), *Macroeconomics, Publisher: Pearson.*

**Reference Books :**

1. Branson W.A , Macroeconomic Theory and Policy (latest Edition, Harper and Row New York.
2. Dornbusch, Fischer and Startz, *Macroeconomics*, McGraw Hill, 11th edition, 2010.
3. Shapiro, E. (1996), *Macroeconomic Analysis,* Galgotia Publications, New Delhi.
4. Ackley, G. (1976*), Macroeconomics: Theory and Policy*, Macmillan Publishing Company.
5. S.N.V.Siva Kumar, Macro Economics and Policy for Managers: An Indian Perspective ,Cengage publishers,2019.

## HS 3034 FINANCIAL SYSTEM AND RISK MANAGEMENT Cr-3

**Course Outcome:** At the end of the Course, the students will be able to:

CO1. introduce themselves to the financial concepts like money, stocks, wealth, assets, etc.
CO2. understand the basic operation of the financial system of the economy.
CO3. acquaint themselves with certain financial analytical tools.
CO4. accustom them with the financial market: money and capital market.
CO5. know the risk involved in financial market
CO6. have basic knowledge on how to manage the risk involved in financial instruments.

**UNIT I: Financial Market and Instruments**

Financial intermediaries: Indian Money Market –Indian Capital Market. Some selected financial instruments of both these markets: Equities,bonds,International Equities – GDRs – ADRs ,Euro Bonds – Repos – Euro Commercial Paper etc. Concepts of Options and Derivatives.

**UNIT II: Risk Management**

Risk and Return: Concepts; Relationship Between Risk and Return; Risk Diversification; Systemic and Unsystemic risk; Measuring the Risk-Variance and Standard Deviation, Efficient Market Hypothesis, Random Walk, Financial Securities: Bonds and Equities- Features; Types; Interest Rates and Yields, Current Yield; Yield to Maturity; Duration. Insurance.

**UNIT III: Manetary System**

Concept of Money and Finance, Difference between stock and flow (income, wealth, black money, investment) Monetary assets vs financial assets, Quantity Theories of Money- Fisher and Cambridge Approaches.
Demand for Money: Classical and Keynesian approaches to demand for money and the modern quantity theory.

RBI approach to money supply; High powered money and money multiplier. Money supply and open economy; Mechanistic and behaviour model of money supply; control of money supply.

**UNIT IV: Time Value of Money**

Time Value of Money: Why the time value of Money; Simple Interest and Compounded Interest; Nominal and Real Rates of Interest; Future Value- Single Cash Flow; Multiple Cash Flows and Annuity; Present Value- Single Cash flow, Multiple Cash Flows and Annuity; Growing Annuity, Perpetuity and Growing Perpetuity; Loan Amortization

**Text Books :**

1. Brigham,E.F.and M.C.Ehrhardt. Financial management. 14th edition. Cengage Publication.
2. Pandey, I.M (2018). Financial Management, 11th Edition, Vikas Publishers.

**Reference Books :**

1. Drake P.P and Fabozzi, F.J (2010). The Basics of Finance: An Introduction to Financial Markets, Business Finance, and Portfolio Management ( Frank J. Fabozzi Series), John Wiley & Sons.
2. Shim, J.K and Spiegel, J.G. (2009). Financial Management, 3rd Edition, Schaum's Outlines Graw-Hill Education.

## HS 4001 PROFESSIONAL PRACTICE, LAW AND ETHICS Cr-2

**Course Outcome :** At the end of the course, the students will be able to :

CO1. select appropriate engineering decisions in consideration of professional ethics in realization of more critical impact of engineering compared to general experiments.
CO2. evaluate and prescribe risk reducing measures
CO3. comprehend the dynamics in engineers' roles and responsibilities with emerging issues in global scene.
CO4. know the various compliance requirements and the regulatory bodies to protect environment
CO5. have a fair idea to protect their engineering inventions from unauthorised exploitation under Intellectual property rights system and laws relating to Information communication technologies
CO6. understand, analyze and prevent misuse of IT related transactions

**Pre-requisite :** Nil

**Morals and Ethics in Engineering**

Senses of 'Engineering Ethics' – Variety of moral issues- Moral Autonomy- Kohlberg's theory- Gilligan's theory- Professions and Professionalism.

**Engineering as Social Experimentation**

Engineering as Experimentation- Engineers as responsible Experimenters- Industrial Standards – Titanic disaster as Case Study.

**Engineer's Responsibility for Safety**

Safety & Risk- Assessment of Safety and Risk- Risk Benefit Analysis- Reducing Risk.

**Global Issues**

Computer Ethics, Role in Technological Development- Engineers as Managers – Engineers as Expert Witnesses and Advisors.

**Law of Contracts and Law of Torts**

Formation of Contract (Sections 2-6 of Indian Contract Act, 1872), Essentials of Contract (Sections 10-23 of Indian Contract Act, 1872), Liability for Defective Products: Product Liability, Consumer Protection Act 1986: Consumers: the concept, definition and scope, Rights of Consumers and Enforcement of Consumer Rights.

**Environmental Laws**

Environment Protection Act, 1986, Environmental Impact Assessment, 2006, Standards for Emission or Discharge of Environmental Pollutants from various Industries, Landmark cases - Bhopal Gas Tragedy, Taj trapezium case.

**Intellectual Property Law**

Basic Introduction to Intellectual Property Law, Protecting Engineering Invention: The Patent Approach, Protecting Engineering Invention: The Industrial Designs Approach, Protecting Engineering Invention: The U.S. Utility Model Approach and Need for Utility Model System in India.

**Information Technology Law**

Protecting Software and other engineering technologies in cyberspace, Maintaining Data Security, technological privacy in Cyberspace, E-Contracts, Electronic and Digital Signatures: Conceptual Analysis.

**Text book:**

1. R. Subramaniam, "Professional Ethics", Oxford University Press, 2013

**Supplementary Text materials**

To be compiled by course teachers in reference to the following legislations

1. Indian Contracts Act 1872
2. Patents Act 1970 (Unit 3)
   (Relevant Provisions: Chapter III- Section 6 to 11, Chapter IV- Section 11A to 24, Chapter V- Section 25 to 28)
3. Designs Act 2000 (Unit 3)
   (Relevant provisions: Chapter III- Section 3 to Section 9)
4. Information Technology Act 2000 (Unit 4)

**References :**


1. Mike Martin and Ronald Schinzinger, "Ethics in Engineering", McGraw Hill, New York, 2005.
2. Charles E Harris, Michael S Pritchard and Michael J Rabins, *" Engineering Ethics Oncepts and Cases"* Thompson Learning, 2000
3. Charles D Fleddermann, *"Engineering Ethics",* Prentice Hall, New Mexico, 1999.
4. Edmund G Seebauer And Robert L Barry, *" Fundamentals of Ethics for Scientists and Engineers*'', Oxford University Press, 2001
5. Rosencranz, "Environmental Law and Policy in India"
6. Gurdip Singh, "Environmental Laws"
7. V. K. Ahuja, "Law relating to Intellectual Property Rights"
8. Pavan Duggal, " CYBER LAW- Indian Perspective"
9. Howard B. Rockman "Intellectual Property Law for Engineers and Scientists" (ISBN-978-0471449980)
10. Mireille Hildebrant, "Smart Technologies and the End (s) of Law (ISBN- 9781786430229)
11. Avtar Singh, "Law of Contract"
12. Dr. R. K. Bangia, " Law of Torts"

# CIVIL ENGINEERING

# B. TECH IN CIVIL ENGINEERING

## Program Educational Objectives (PEOs):

The B. Tech program in Civil Engineering aims to prepare the graduates with the following objectives:

1. The graduates shall be able to provide to solutions to civil engineering problems and allied areas involving structural design, construction, geotechnical, environmental and water resources issues.
2. The graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical and multidisciplinary contexts.
3. The graduates shall demonstrate professional and ethical responsibilities and thrive to reinforce their knowledge being a part of higher educational programs.

## Program Outcomes (POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs)

The program specific outcomes are:

m) Ability to select and utilize sustainable low cost alternate materials contributing to environment friendly construction practices.
n) Ability to understand and adopt methodologies and actions for sustainable environment.
o) Ability to understand and develop strategies for sustainable water resources in the context of climate change.

## CE 2100 GEOTECHNICAL ENGINEERING-I Cr-4

**Course Outcome :** At the end of the course, the students will be able to:

CO1: identify the soil types and classify based on index properties.
CO2: evaluate the capillarity and permeability characteristics of soils.
CO3: determine the seepage pressure in soil.
CO4: estimate effective stress under various conditions to lead failures of hydraulic structures by piping.
CO5: determine various shear strength parameters of soil.
CO6: determine the long term settlement of foundations based on one dimensional consolidation theory.

**Pre-requisite : Mechanics of Materials ( CE 2103)**

Introduction and Classification: Definition of soil, origin & formation of soil, General types of soil and soil deposits, Cohesive and cohesion less soils. Basic definitions, Relationship & inter-relationships. Index properties of soils & their determination. Classification based on grain size and plasticity characteristics (IS 1498 & ASTM D2487).

Permeability of soils: Darcy's law, Discharge velocity, Seepage velocity Laboratory determination of Co-efficient of permeability (K): constant head permeability, Falling head permeability, Factors affecting permeability, Permeability of stratified soils.

Effective stress principle: Nature of effective stress, Effect of water table fluctuation on effective stress, Increase in effective stress due surcharge. Capillarity of soil and capillary zones. Effective stress in soils saturated by capillary action

Seepage analysis: Seepage pressure, Effective stress under steady seepage conditions, Quick Sand Condition. Laplace's equation, Stream and Potential Functions, flow net, characteristics of flow net, uses of flow net.
Shear strength: Basic concept, Mohr-Coulomb failure criteria. Methods of determination of shear strength parameters: Shear tests- Direct shear test, Triaxial compression test, Unconfined compression test, Vane shear test.
Compaction of Soils: Objects, Measurement of compaction: determination of OMC & MDD by standard & modified Proctor compaction test. Factors affecting compaction, Zero air voids line, field compaction method and control measures.

Consolidations of Soils: Introduction, Principles of consolidation, soil spring analogy, consolidation characteristics of laterally confined soil, pressure void ratio diagram, Normally consolidated and over consolidated soils, Estimation of preconsolidation pressure, Terzaghi's theory of one dimensional consolidation, Laboratory consolidation test, Determination of coefficient of consolidation, Consolidation settlement.

**Text Books :**

1. "Soil Mechanics & Foundation Engineering" by P. Purushothama Raj, Pearson Education India, 2013
2. "Soil Mechanics & Foundation Engineering" by B. C. Punmia, Ashok K. Jain & Arun Kumar Jain, 4th Edition, Laxmi Publication, New Delhi.
3. "Soil Mechanics & Foundation Engineering" by B.N.D Narasinga Rao, Wiley India Pvt Ltd, New Delhi, 1st Ed 2015.

**Reference Books :**

1. "Principle of Geotechnical Engineering" by B. M. Das & Khaled, 8th Edition, Global Engineering USA.
2. "Soil Mechanics and Foundation Engineering" by K. R. Arora, Standard Publisher, 2012
3. "Soil Mechanics and Foundation Engineering" by V.N.S. Murthy, CBS Publisher, 2012
4. Basic and applied soil mechanics" by Gopal Ranjan & A. S. R. Rao, New age international publication, 2012

**CE 2101** **FLUID MECHANICS** **Cr-4**

**Course Outcome** : At the end of the course, the students will be able to:

CO1: apply the basic equations of fluid statics to determine forces on planar and curved surfaces submerged in a static fluid; to manometers: to the determination of buoyancy and stability
CO2: know the concept of fluid kinematics, stream functions, velocity potentials and Laplace equation.
CO3: use Euler's and Bernoulli's equations and the conservation of mass to determine velocities, pressures and accelerations for fluids
CO4: perform dimensional analysis for problems in fluid mechanics.
CO5: apply the concepts of laminar and turbulent boundary layer.
CO6: determine minor and major head losses for flows through pipes and design simple pipe systems to deliver fluids under specific conditions.

**Pre-requisite: Engineering Mechanics (ME 1003)**

Introduction: Properties of Fluids, Concept of Shear Stress in Fluids, Newtonian, Non Newtonian & Ideal Fluids.
Fluid-Statics: Pressure at a Point, Pascal's Law, Pressure Head and Piezometric Head, Measurement or Pressure (Manometers), Pressure on Plane & Curved Surfaces, Buoyancy & Floating Bodies, Stability of Floating Bodies, Metacentre.
Fluid Kinematics: Fluid Motion, Fluid Acceleration, Types of Flows, Stream Lines, Path Lines, Streak Lines and Stream Tubes, Concept of Control Volume, Continuity Equation, Rotational & Irrotational Motion, Stream Function & Velocity Potential Function, Potential Flow & Laplace Equation.
Fluid Dynamics: Euler's Equation, Bernoulli's Energy Equation, Application Of Bernoulli's Energy Equation, Pitot Tube, Venturimeter, Orifice Meter, Flow Through Orifices And Mouth Pieces, Momentum Principles, Application Of Momentum Equation, Force On Pipe Bend.
Laminar Flow: Navier Stoke's Equation, Laminar Flow Through Circular Pipes, Stoke's Law, Measurement Of Viscosity.
Dimensional Analysis & Model Analysis: Dimensions, Physical Quantities In Fluid Flow, Dimensionally Homogeneous Equations, Buckingham's Π Theorem And Model Studies.
Boundary Layer Theory: Laminar & Turbulent boundary layer, momentum equation for Boundary layer, hydro-dynamically smooth & rough surfaces.
Pipe flow: Darcy-Weisbach formula, Laminar flow in pipes, velocity distribution & resistance to flow, resistance to flow in turbulent flow, Moody's diagram.
Pipe flow problem**:** Energy losses in transition, pipe fittings & valves

**Text Books :**

1. "Fluid mechanics" by Frank M. White, 7th Edition, Tata McGraw-hill Publication, New Delhi.
2. "Engineering Fluid Mechanics" by R. J. Garde & A.G. Mirajgaonker, Scitech Publications (India) Pvt. Ltd.
3. "Fluid Mechanics & Hydraulic Machines" by Sukumar Pati, 1st Edition, Tata McGraw-hill Publication.

**Reference Books :**

1. "Hydraulics & Fluid Mechanics" by P. N. Modi & S. M. Seth, 19th Edition, Rajsons Publication Private Limited.
2. "Fluid Mechanics" by V.L. Streeter, E.B. Wylie & K.M. Bedford, 9th Edition, Tata McGraw-hill Publication, New Delhi.
3. "Fluid Mechanics through problems" by R. J. Garde, 3rd Edition, Newage International Publishers, New Delhi.

## CE 2102 SURFACE HYDROLOGY & HYDRAULICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: check the consistency of rainfall data and calculate the probability of rainfall over a given return period.
CO2: explain the evaporation process, measurement and modeling of infiltration
CO3: estimate the runoff by various methods
CO4: understand the various aspects of hydrograph and to develop unit hydrograph
CO5: Explain the types of flows and analyze uniform flow calculations in open channels
CO6: solve problems for gradually varied flow in open channel

**Pre-requisite : Fluid Mechanics (CE 2101)**

Surface Hydrology
Introduction: Hydrologic cycle, Water-Budget Equation and Applications in Engineering
Precipitation: Forms and weather systems for precipitation, characteristics, Measurement, preparation & Presentation of rainfall data, Mean precipitation, DAD Curves and Frequency of point rainfall.
Abstractions from Precipitation: Overview on different types of abstractions, Evaporation, Infiltration-process, measurement, infiltration models, infiltration capacity and indices.
Runoff: Catchment and Stream characteristics, Yield, Curve Number method
Hydrograph: Factors affecting shape of Hydrograph, Components, Base flow, Effective rainfall, Unit hydrograph - Derivation, Method of superposition and S-curve. Applications of Unit hydrograph
Free Surface Hydraulics
Introduction, Uniform flow-Chezy's & Manning's formulae, Uniform flow problems, hydraulically efficient section, Energy & momentum equations, specific energy, Flow in transitions, Gradually varied flow - Differential equation of GVF, Flow profiles, GVF computation (Direct Step Method)

**Text Books :**

1. Engineering Hydrology by K. Subramanya, Tata McGraw Hill, 4$^{th}$ Ed. End reprint 2016.
2. Flow in Open Channels by K. Subramanya, 3rd Edition, TMH Education Pvt. Ltd, New Delhi

**Reference Books :**

1. Applied Hydrology by V.T. Chow, D.R. Maidment and L.W. Mays, Tata Mc. Graw Hill, 1$^{st}$ Ed., First Indian Reprint 2010.
2. Water Resources Engineering by L.W. Mays, Wiley Publication, 2nd Edition, First Indian Reprint 2001.
3. Irrigation and Water Power Engineering by B.C. Punmia, Pande B.B. lal, A.K. Jain and A.K. Jain, Laxmi Publishers, 16$^{th}$ Ed., End Reprint 2009.

## CE 2103 MECHANICS OF MATERIAL Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1: determine different stress and strain in materials under various loading conditions
CO2: select appropriate method to locate failure planes in materials for different loading condition.
CO3: analyze bending and shear stresses and draw SF and BM diagrams of simple beams
CO4: analyze torsion in solid and hollow circular shafts
CO5: estimate critical load of compression members for different support conditions
CO6: determine different stress and strain in cylinders & shells

**Pre-requisite : Engineering Mechanics (ME 1003)**

Simple Stresses and Strains: Concept of Stress, Stress and Strain in Materials Under Tension, Compression and Shear, Elastic Constants, Relation Between Elastic Constants, Thermal Stress and Strain, Stress & Strain of Composite Bars.
Compound Stresses and Strains: Two Dimensional Stress System, Principal Planes, Principal Stresses, Mohr's Stress Circle, Principal Strains, Mohr's Strain Circle, Principal Stresses Computed From Principal Strains.
S.F.D. & B.M.D.: Definition, type of supports, shears force and bending moment diagram of all determinate beams, frames etc.
Bending Stress &Shear Stresses in Beams: Theory of Simple Bending of Initially Straight Beams, Distribution of Normal & Shear Stresses. Introduction to shear centre.
Torsion: Torsion in Solid & Hollow Circular Shafts, Torque and Power Transmitted by Solid and Hollow Shafts, Strength of Shafts, Combined Bending & Torque.
Columns & Struts: Elastic Instability, Euler Theory-Column with One end Free & Other end Fixed, Column with Both ends Hinged, Column with both ends fixed, Column with one end fixed and the other end Hinged.
Cylinders & Shells: Stresses & Strains in Thin Cylinders and Thin Spherical Shell Under Internal Pressure.

**Text Books :**

1. "Strength of Material" by S. S. Ratan, Second Edition, TMH Education Pvt. Ltd, New Delhi
2. "Strength of Material" by R. K. Rajput, Fifth Edition, S. Chand and Co. Ltd.

**Reference Books :**

1. "Strength of Materials" by G. H. Ryder, Third Edition, Macmillan Publisher India Ltd
2. "Elements of strength of Materials" by S. Timoshenko & D. H. Yong, Fifth Edition, EWP an east-west edition
3. "Engineering Mechanics of Solids" by E. P. Popov, Second Edition, PHI Publisher Ltd
4. "Mechanics of Materials" by Gere & Timoshenko Second Edition CBS Publisher.

## CE 2104 STRUCTURAL ANALYSIS Cr-4

**Course outcome:** At the end of the course, the students will be able to :

CO1. determine slope and deflection of determinate and indeterminate beams and frames.
CO2. determine internal forces in members of plane, space truss, three, two hinged arches and suspension cables.
CO3. determine absolute maximum internal forces due to Influence line diagrams, rolling or moving loads.
CO4. determine the degree of static and kinematics indeterminacy of various types of structure and selection of method of analysis. .
CO5. determine the internal force components of beams and frames using slope deflection & moment distribution.
CO6. determine the internal force components of beams and frame using strain energy and consistent deformation method.

**Pre-requisites: Engineering Mechanics (ME 1003) , Mechanics of Materials (CE 2103)**

Introduction: Definition of determinate and indeterminate structures, Analysis Methods
Slope and Deflection of Beams: Double integration method. Macaulay's method. Moment area method. Conjugate beam method. Virtual work (Unit Load) method. Strain energy method. Castiglione's theorems of strain energy. Maxwell's and Betti's reciprocal theorem.
Analysis of Trusses: Definition of truss and determination of member forces in a truss by method of equilibrium.
Influence Lines and Rolling Loads: Definition of Influence Line. Influence Line at a particular section of a cantilever beam, simply supported beam or over hanging beam for shear force and bending moment. Position of UDL load for maximum S.F and B.M. Find absolute maximum S.F and B.M due to moving loads.
Analysis of Redundant Structures: Determine static and kinematic indeterminacy of 2D and 3D structures.

Consistent deformation method / Force method: Propped cantilever beam. Fixed beam, Continues beam by Theorem of three moments.
Slope Deflection Method: Analysis of beams and frames in 2D
Moment Distribution Method: Analysis of beams and frames in 2D.
Arches and Cables: Analysis of two and three hinged parabolic arches. Analysis of cables, Suspension bridge with two and three hinged stiffened girder.

**Text Books :**

1. Analysis of Structure Vol. I and Vol. II by V. N. Vazirani, M.M Ratwani and S.K Dugal, Khanna Publisher, New Delhi
2. Structural Analysis Vol. I and Vol. II by S.S. Bhavikatti, Fourth Edition, Vikas Publishing House Pvt, New Delhi.
3. Indeterminate Structural Analysis by C. K. Wang, 1st Eighth Edition, TMH Pvt Ltd. New Delhi.

**Reference Books :**

1. "Theory of Structure" by S Ramamrutham and R Narayan, Dhanpat Rai, 1993
2. "Structural Analysis Vol. I" by R C Hibbeler, Eighth Edition, Pearson Education India
3. "Indeterminate Structural Analysis" by J. S. Kenney, Oxford and IBH Publishing co Pvt Ltd. New Delhi.

## CE 2105 ENVIRONMENTAL ENGINEERING-I Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. estimate the water demand for a particular area
CO2. characterize physical and chemical parameters responsible for water pollution
CO3. characterize biological parameters of water and its significance
CO4. design various units of a water treatment plant
CO5. identify and control the parameters responsible for air pollution
CO6. identify and control the parameters responsible for noise pollution

### Pre-requisite : Nil

Water Supply Engineering:
Physical, chemical and biological characteristics of water and their significance, Water borne diseases. IS and WHO standards, General requirements of water supply, sources of water supply, Estimation of water demand. Intake structures, Pumping and Transportation of water, General description of water distribution system.
Engineered systems for water treatment:
Introduction to water treatment system, schematic of water treatment plant for groundwater and surface water, Aeration, coagulation, softening: lime-soda process and ion exchange process, flocculation, sedimentation, filtration, disinfection - chlorination and ozonation.
Air Pollution**:**
Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.
Noise Pollution:
Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

**Text Books :**

1. "Environmental Engineering (Vol. I) Water Supply Engineering" by S.K. Garg, Khanna Publishers, 2017.
2. "Environmental Engineering (Vol. II) Sewage Disposal and Air Pollution Engineering" by S.K. Garg, Thirty Seventh edition, Khanna Publishers, 2017.
3. "Environmental Engineering", H.S. Peavy, D.R. Rowe, & G. Tchobanoglous, Seventh Edition, McGraw Hill, 1985.

**Reference Books :**

1. "Process chemistry for water and wastewater treatment" by L.D. Benefield, J. F. Judkins and B.L. Weand, 1st edition, Prentice - Hall Series, 1981.
2. “Introduction to Environmental Engineering” by M.L. Davis & D.A. Cornwell, Fourth Edition, Tata McGraw Hill, 2010.
3. “Unit Operations and Processes in Environmental Engineering” by T.D. Reynolds & P.A. Richards, Second Edition, PWS Publishing Company, CENGAGE Learning, 2009.
4. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, GoI, New Delhi, 2009.
5. "Water Supply Engineering" by B.C. Punmia, A.K. Jain and A.K. Jain, Laxmi Publications (P)Ltd., 2016.
6. "Wastewater Engineering (including air pollution)" by B.C. Punmia, A.K. Jain and A.K. Jain, Laxmi Publications (P) Ltd., 2016.

## CE 2106 ENVIRONMENTAL ENGINEERING II Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: estimate sewage and storm water discharge for designing of sewers
CO2: explain essential features of various types of sewer appurtenances
CO3: characterize physical, chemical and biological parameters of wastewater
CO4: design modern and low cost wastewater treatment plants
CO5: assess the impact of sewage discharge on land and water bodies
CO6: characterize solid wastes and select proper methods for their collection, transportation and treatment

### Pre-requisite : Environmental Engineering-I (CE 2105)

Wastewater Engineering:
Generation and collection of wastewater, sanitary, storm and combined sewerage systems, Quantities of sanitary wastes and storm water. Design of sewerage system.
Treatment of sewage:
Physical, chemical and biological characteristics of sewage. Primary- screening, grit chamber, skimming tanks, sedimentation, Secondary- Basics of microbiology, classification of secondary treatments, activated sludge process, trickling filter, Tertiary- Removal of nitrogen and phosphorus, Miscellaneous treatments- oxidation ponds, Septic tank, Imhoff tank. Sludge digestion.
Disposal of effluent and sludge in land and water bodies:
Self-purification of rivers, oxygen sag curve, Streeter Phelps equation, Wastewater disposal standards.
Sewer Appurtenances:
Manholes, Drop manholes, Lampholes, street inlets, catch basins, flushing tanks, storm water regulators, grease and oil-traps, inverted siphons.
Municipal Solid Waste Management**:**
Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse, recycle, energy recovery, treatment and disposal.

**Text Books :**

1. “Environmental Engineering (Vol. II) Sewage Disposal and Air Pollution Engineering" by S.K. Garg, Thirty Seventh edition, Khanna Publishers, 2017.
2. “Environmental Engineering”, H.S. Peavy, D.R. Rowe, & G. Tchobanoglous, Seventh Edition, McGraw Hill, 1985.

**Reference Books :**

1. "Wastewater Engineering: Treatment and Reuse" by Metcalf & Eddy, Inc., 5th Edition, Tata McGraw-Hill, New Delhi, 2013
2. Process chemistry for water and wastewater treatment" by L.D. Benefield, J.F. Judkins and B.L. Weand, 1st edition, Prentice - Hall Series, 1981.

3. "Biological process design for wastewater treatment" by C.W. Randall and L.D. Benefield, 1st edition, Prentice - Hall Series, 1980.
4. “Unit Operations and Processes in Environmental Engineering” T.D. Reynolds & P.A. Richards, Second Edition, PWS Publishing Company, CENGAGE Learning, 2009.
5. “Introduction to Environmental Engineering” by M.L. Davis & D.A. Cornwell, Fourth Edition, Tata McGraw Hill, 2010.
6. “Manual on water supply and Treatment” by CPHEEO, Ministry of Urban Development, GoI, New Delhi, 2009.
7. "Wastewater Engineering (including air pollution)" by B.C. Punmia, A.K. Jain and A.K. Jain, Laxmi Publications (P) Ltd., 2016.

## CE 2107 SURVEYING AND GEOMATICS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. apply the basic principles of surveying and carry out the survey using chain, compass, plane table and theodolite in the field.
CO2. plan a survey for applications such as road alignment and height of the building
CO3. perform leveling and contouring of given ground.
CO4. employ appropriate survey methods in land survey, construction projects and to generate maps
CO5. develop skill to carry out tachometry, geodetic surveying wherever situation demands
CO6. invoke advanced surveying techniques over conventional methods in the field of civil engineering

### Pre-requisite : Nil

Introduction - Principles of surveying –Introduction to chain surveying – Chaining and ranging - Compass surveying –Prismatic compass only – Bearing of survey lines – systems and conversions – Local attraction – Latitude and departure – Traversing – Traverse adjustment of closing errors-Plane table Surveying- Two and Three Point Problems
Levelling – instruments – Temporary and permanent adjustments – Reduction to levels – Correction for Curvature and refraction – Classification of leveling – Profile Levelling – Differential levelling – Reciprocal levelling – longitudinal and cross sectioning.
Tacheometric surveying – Stadia Tachometry-Different Types of Tachometric Measurements– Analytic lens– Tangential method- Theodolite surveying – Vernier theodolite – Temporary and permanent adjustments– Measurement of horizontal and vertical angles – Methods of repetition and reiteration – errors in theodolite surveying –elimination of errors - Area and volume computation – area from latitude and departure – Simpson’s rule and Trapezoidal rule.
Trigonometrical levelling – Observations for heights and distances – Geodetic observations – Corrections for refraction, curvature, axis signal – Reciprocal observations-Errors – Types of errors.
Introduction to advanced surveying Equipment – Total station – GPS – Electronic theodolite.

**Text Books :**

1. “A Text book of Surveying and Leveling” by R. Agor; Khanna Publishers
2. “Surveying Vol. I” by S. K. Duggal; McGraw Hill Education (India) Private Limited.

**Reference Books :**

1. “Surveying Vol. I” by Dr. B. C. Punmia, Ashok K. Jain & Arun K. Jain; Laxmi Publications (P) Ltd.
2. “Surveying and Leveling” by R. Subramanian; 2nd Edition, Oxford publications, New Delhi.
3. ”Plane Surveying" by Dr. Alak De, Reprint 2016, S Chand & Company Pvt. Ltd.
4. “Surveying and Leveling (Part 1)” by T. P. Kanetkar & S. V. Kulkarni; Pune Vidyarthi Griha Prakashan.
5. “Surveying and Leveling” by N. N. Basak; Tata McGraw-Hill Private Limited.
6. “Surveying and Leveling” by S. C. Rangwal, K. S. Rangwala & P. S. Rangwala; Charotar Publishing House Pvt. Ltd.

## CE 2108 CONSTRUCTION PLANNING & MANAGEMENT Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: understand the different parameters of construction management
CO2: optimize the cost and time of a Project by using CPM & PERT
CO3: understand various aspects of contract
CO4: describe material procurement method and control for a project.
CO5: select appropriate construction equipment
CO6: identify different aspects of DPR preparation

### Pre-requisite : Nil

Construction Management- Objective and function of Construction Management, Stages in Construction, Work Break Down Structure, Construction planning, Scheduling & monitoring, Bar charts. Elements of Network, Network rules, Critical path analysis of CPM network, Activity times & floats, Optimization through CPM technique, Program Evaluation & Review Techniques (PERT) & its three time estimates. Resource levelling and allocation.
Contracts: Essentials of Contract, Various types of Contract, General conditions and principles, Methods of tendering, Earnest Money, Security Money, Arbitration, Arbitration case studies, Termination of Contract.
Construction Equipment: Selection of construction equipment, Cost of owning and operating, Engineering fundamentals of equipment, Excavating & transporting equipment, Hauling & conveying equipment.

**Text Books :**

1. "Construction Planning & Management", by U. K. Shrivastava, Galgotia Publications Pvt. Ltd, May 2010
2. "Construction Project Management" by Kumar Neeraj Jha, Pearson Education

**Reference Books :**

1. "Basics of Construction Management" by Ajay Kumar Singhal, Skill Enhancement Academy
2. "Construction Planning & Management", by P.S. Gahlot and B.M. Dhir, New Age International (P) Limited Publishers,2012
3. "Construction Planning & Management", by Dr. A. K. Jha, Pearson Publication.
4. "Estimating and costing", by Dr. B. N. Dutta, UBSPD, 2013
5. "Construction Management & Planning", by B. Sengupta & H.Guha, TMH Education (P) Ltd, New Delhi
6. "Construction Planning Equipment and methods", by R. L. Peurifoy, McGraw-Hill Education (India) Pvt. Ltd, Latest Ed.
7. "Construction Planning and Plant", by A. J. Ackerman & C. H. Locher, McGraw Hill Company,1940
8. "Construction Equipment and its Planning and application", by M. Verma, Metropolitan Book Co. 1975.
9. "Civil Engineering Contracts and Estimating", by B.S. Patil & Orient Longman Ltd New Delhi
10. "Construction Planning & Management", by B.C. Punmia, Laxmi Publications

## CE 2109 CIVIL ENGINEERING MATERIALS & CONSTRUCTION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the properties of stones and bricks
CO2. learn different properties of cement and concrete
CO3. acquire knowledge on properties of timber
CO4. learn about different types of foundations
CO5. identify different types of masonries
CO6. select different types of doors, windows and floors for construction

**Pre-requisite: Nil**

Stones: Classification, composition, characteristics, uses, method of quarrying and dressing.
Bricks: Brick earth, method of Brick manufacture, testing of bricks, classification.
Cement: Portland cement:-Classification, Chemical composition, hydration, tests for cement fineness test, normal consistency, setting time, soundness, tensile and compressive strength.
Concrete: Composition of concrete, W/C ratio, Workability, Compressive and tensile strength, Nominal Mix design, Pozzolanic concrete, Light weight and high density concrete, Elasticity, Shrinkage and creep of concrete.
Timber: Characteristics and suitability for different purposes, Defects and decay seasoning preservation of timber.
Foundation: Shallow foundation, Deep foundation, Description and types of spread foundation, Description and types of pile foundations, Methods of pile driving, Pile driving formulae (isolated and group of piles),Excavation and timbering of trenches, Well foundations, Caissons, Cofferdams.
Masonry: Definition of terms; classification of masonry; stone masonry; classification, dressing, joints, maintenance; Brick masonry; Types of bonds, brick laying, structures in brickwork; Partition walls.
Door & Windows: Criterion of size; types of doors and windows ventilators and fanlights sash and casement windows, skylights and lanterns; fixture and fastenings for doors and windows.
Floors: Ground flooring, upper flooring, types, preparation, advantages and disadvantages.

**Text Books :**

1. "Building Material" by M. L. Gambhir, 1st Edition, TMH Education, New Delhi.
2. "A Text Book of Building Construction" by S. K. Sharma, Revised Edition, S. Chand Publication, Latest Edition.
3. "Building Material" by S. S. Bhavikatti, Latest Edition, Vikas Publication.

**Reference Books :**

1. "Building Construction" by B. C. Punmia, Jain & Jain, 10th Edition, Laxmi Publication, New Delhi.
2. "Building Material" by P. C. Verghese, PHI Learning (P) Ltd., New Delhi, 2005
3. "Engineering Materials" by S. C. Rangwala, Charotar Publishing House, 2011.

## CE 3021 ADVANCED SOLID MECHANICS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand different theories of failure
CO2. determine stress at any point in cross section of unsymmetrical bending
CO3. determine Shear centre for symmetrical and un-symmetrical section
CO4. analyze curved beams and thin walled cylinders
CO5. understand Lame's theory of thick walled cylinders
CO6. determine stresses in beams due to thermal loading

**Pre-requisites: Mechanics of Materials (CE 2103), Structural Analysis (CE 2104)**

Theories of failures: Maximum principal stress theory, Maximum shearing stress theory, Maximum strain theory, Total strain energy theory, Maximum distortion energy theory, octahedral shear stress theory.

Unsymmetrical bending: Symmetrical and unsymmetrical bending, Stress at any point in cross section, Determination of stress in beams with unsymmetrical section.

Flexural and Shear Centre: Shear centre for symmetrical and un-symmetrical section.

Curved Beams: Bending of beams with small and large initial curvature, Statically indeterminate curved beams.

Thick Walled Cylinders: Lame's theory of thick walled cylinders.

Thermal Analysis: Thermo-elastic stress and strain relation, Equation of equilibrium, Stresses in beams due to thermal loading.

**Text Book :**

1. “Strength of Materials, Part 2”, by S. Timoshenko, 3rd Edition, CBS Publishers and Distributors Pvt. Ltd.

**Reference Book :**

1. “Advanced Mechanics of Material”, by A. P. Boresi & R. J. Schmidt, 6th ed., Wiley, 2003.

## CE 3023 CONCRETE TECHNOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. identify different types of concrete and its properties
CO2. determine the workability of concrete
CO3. determine strength and durability of concrete
CO4. design concrete mixes for the given conditions
CO5. perform destructive and non-destructive testing of hardened concrete
CO.: select types of admixture and special concrete for given condition.

### Pre-requisites: Civil Engineering Materials & Construction (CE 2109)

Concrete Materials: Types of material, cement types, testing of materials.
Concrete: Workability, Factors affecting workability, type of tests.
Strength of concrete: Water cement ratio, gain of strength with age, effect of maximum size of aggregate, relationship between compressive and tensile strength, high strength concrete, high performance concrete, Elasticity, shrinkage and creep of concrete.
Durability of concrete: permeability, carbonation, sulphate attack, alkali-aggregate reaction, chloride attack.
Concrete Mix design: concept & types, example.
Destructive and non-destructive testing of hardened concrete.
Admixtures
Special Concrete: Lightweight Concrete. High density concrete. Hot weather and cold weather concreting, Polymer concrete, Fibre reinforced concrete, Self compacting concrete.

**Text Books :**

1. “Concrete Technology” by M. S. Shetty, 4$^{th}$ Edition, S. Chand Publisher, New Delhi.
   “Properties of concrete”, A.M. Neville, 4th Edition, Pearson Education Pvt. Ltd., New Delhi.
   “Concrete Technology”, by M. L. Gambhir, McGraw Hill Education, New Delhi, 2013.

**Reference Books :**

1. “Construction Safety”, by Jimmy W. Hinze, Prentice Hall Inc 1997.
2. “Concrete Technology” by S. Bhavikatti, I. K. International Pvt. Ltd.

## CE 3027 ENGINEERING GEOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: acquire the knowledge about rocks and minerals
CO2: understand the process of rock formation
CO3: understand the role of geology in the design and construction process of underground opening in rocks.
CO4: apply geology concepts and approaches on rock engineering projects
CO5: select the sites for reservoirs and dams based on geological aspect
CO6: identify and classify soil and rock using basic geological classification system.

### Pre-requisite: Nil

General Geology: Branches and scope of geology, Earth, its position in the solar systems, surface features and internal structure, work of natural agencies like lakes, oceans, atmosphere, wind, streams, sea, glacier, earth movements. Types of weathering, mountains and mountain building.

Mineralogy: Definition of crystal and a mineral, the study of the physical properties and occurrence of quartz, Feldspar, Mica, Kyanitie, calcite, tale, corundum, gypsum, fluorite, biotite, mus, covite, graphite, realgar, magnetite, limonite, pyrite , galena, barite dolomite, garnet, tourmaline, chalcopyrite, opal, topaz, autite, hornblende, epidate, kaolinite, diamond.
Petrology: Formation and classification of rocks into three types, igneous, sedimentary and metamorphic rocks, description of physical properties for constructional purposes of granite, pegmatite, dolerite, gabbzo, basalt, sandstone, conglomerate, breccias, limestone, shale, schist, marble, quartzite, khondalite, slate, gneiss, and esite, stratigraphy of India(a general idea),principles of correlation, fossils, their preservation and significance.
Structural geology: strike and dip, out crops, volcanoes, overlaps, inliers and outliers, types classification of folds, faults, joints, unconformities, surface mapping, identification of potential zones of weakness or failure, analysis using stereonetes.
Earthquakes and landslides: Classification, causes and effects of earthquakes and landslides, seismic curve, seismographs, seismograms, accelograms, seismic problems of India, seismic zones of India, remedial measures to pr3event damage for engineering structures, case histories.
Geological investigation: Interpretation of geological maps, use of aerial maps in geological surveying, geophysical methods as applied to civil engineering for subsurface analysis (Electrical and seismic methods).
Geology of dams and reservoirs: Types of dams, requirements of dam site, preliminary and detailed geological investigations for a dam site, important international and Indian examples of failures of dams and their causes, factors affecting the seepage and leakage of the reservoirs and the remedial measures, silting of reservoirs.
Rock mechanics and tunneling: Purposes of tunneling and geological problems connected with tunneling, geological considerations in road alignment, roads in complicated regions problems after road construction, geology of bridge sites.

**Text Books :**

1. “Engineering Geology”, by Parbin Singh, S. K. Kataria and Sons, 2009
2. "An introduction to Geology" by V.S. Joji, I.K. International Publishing House Pvt. Ltd, Latest edition
3. "Engineering Geology" by S. K. Duggal, H. K. Pandey & N. Rawal, McGraw-Hill Education (India) Pvt. Ltd

**Reference Book :**

1 “Structural Geology”, by H. P. Billings, Prentice Hall Publishers, Third edition

## CE 3035 HYDRAULIC MACHINES Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: apply fundamental knowledge of effect of hydrodynamic force on various types of vanes.
CO2: develop basic knowledge on hydro-electric power stations.
CO3: introduce the concepts of the working and design aspects of hydraulic machines like turbines and pumps and their applications.
CO4: design various components turbines and study their characteristics.
CO5: design centrifugal and reciprocating pumps
CO6: understand the working principle of miscellaneous hydraulic machines like press, accumulator, crane etc. and their real life applicability.

**Pre-requisite: Fluid Mechanics (CE 2101)**

Impact of Jets: Force exerted by the jet on Stationary Vertical plate, Moving plates, Series of Vanes, Radial curved vanes.
Turbines: Introduction to turbines, General Layout of a Hydro-electric Power Plant, Classification of Heads and efficiency of a turbine, Pelton Wheel, Radial Flow Reaction Turbines, Francis Turbine, Axial Curves of flow Reaction Turbine, Draft tube, Specific Speed, Unit Quantities, Characteristic Curves of Hydraulic Turbines, Governing of Turbine.
Centrifugal Pumps: Parts of Centrifugal Pump, Work Done by the Centrifugal Pump on water, Head and efficiency of Centrifugal Pump, Multistage Centrifugal Pumps, Specific Speed, Priming, Characteristic curves of Centrifugal Pumps, cavitations, suction lift, net positive suction head.
Reciprocating Pumps: Parts Of Reciprocating Pump, Working of Reciprocating Pump, Slip of Reciprocating Pump, Classification, Variation of velocity and Acceleration in the suction and delivery pipe due acceleration of

the piston, effect of variation of velocity on friction in the suction and delivery pipe, Indicator diagram, air vessels, Comparison between centrifugal and reciprocating Pumps.
Fluid System: Hydraulic Press, Hydraulic accumulator, Hydraulic intensifier, Hydraulic Ram, Hydraulic Lift, Hydraulic Crane, Hydraulic Coupling, Hydraulic Torque converter, Air lift Pump, Gear-Wheel Pump.

**Text Books :**

1. "Hydraulics & Fluid Mechanics" by P. N. Modi & S. M. Seth, 19$^{th}$ Edition, Rajsons Publication Private Limited.
2. "Fluid Mechanics & Hydraulic Machines" by R.K. Bansal, 9$^{th}$ Edition, Laxmi Publications, New Delhi.

**Reference Books :**

1. "Fluid Mechanics & Hydraulic Machines" by Sukumar Pati, 1$^{st}$ Edition, Tata McGraw-Hill Publication.
2. "Fluid Mechanics & Hydraulic Machines: Problems and Solutions" by K. Subramanya, 1st Edition, Tata Mc Graw-hill Publication.
3. "A Text book of Hydraulic Machines" by R. K. Rajput, 5th Edition, S. Chand and company Ltd. 1999

## CE 3039 PAVEMENT MATERIALS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: understand the types and materials used in various types of pavements
CO2: know the basic soil properties related to pavement applications
CO3: identify properties of aggregate and bituminous binders used in pavement
CO4: design and evaluate bituminous mixes for non-stabilized and stabilized roads
CO5: explain cement concrete, semi rigid, non-conventional and new pavement materials
CO6: evaluate modern methods of testing of pavement materials

### Pre-requisite : Nil

Introduction: Types and Component Parts of Pavements, Highway And Airport Pavements, Materials Used In Pavements.
Soil Properties: Basic Soil Properties Relevant To Pavement Applications, Resilient Modulus, Modulus of Sub-Grade Reaction, Testing of Subgrade, Soil Stabilization.
Conventional aggregates: Source, Physical Properties of Aggregates, Preparation, Grading And Blending, Testing and Their Evaluation.
Bitumen & Bituminous binders: Basic Properties of Bitumen, Polymer and Rubber Modified Bitumen, Testing and Applications.
Bituminous mixes: Design, Testing and Evaluation, Dynamic Modulus, Flow Time and Flow Number of Bituminous Mixes, and Modeling of Bituminous Binders and Mixes.
Cement Concrete Pavement Materials: Materials For Cement Concrete And Semi-Rigid Pavements, Design Of Mixes For Stabilized Roads.
Flexible And Rigid Pavement Distresses: Distresses in Pavements, Distress Survey, Pavement Maintenance other than overlay, Fog spray, Slurry seal and micro surfacing, Treatments of cracks and joints in Rigid pavement, Mud Jacking.
Non-conventional and new pavement materials: Applications And Limitations of Non-Conventional Pavement Materials, Use of Geosynthetics and Other Materials In Pavements, Modern Methods of Testing and Evaluation Of Paving Materials.

**Text Book :**

1. "Principles of Transportation Engineering", by P. Chakraborty and A. Das, PHI Publication, 1st Ed. 2nd reprint 2005.

**Reference Books :**

1. "Principles of Transportation and Highway Engineering", by G. V. Rao, Tata Mc. Graw Hill, 1st Ed. 1995.
2. "Principles of Traffic and Highway Engineering" by N. J. Garber, L. A. Hoel and R. Sarkar, Cengage Learning India Pvt. Ltd., First Indian Reprint 2009.

3. "Pavement Engineering: Principles and Practice", Rajib B. Mallick, Tahar El-Korchi, Second Edition, CRC Press
4. "Highway Engineering" by S. K. Khanna & C. E. G. Justo, $10^{th}$ Edition, Khanna Publishers, New Delhi.
5. “Manual for Construction and Supervision of Bituminous works”, by Indian Roads Congress, New Delhi, 2005.
6. Relevant IRC, ASTM and AASHTO codes and specifications.

## CE 3041 TRAFFIC ENGINEERING AND TRANSPORTATION PLANNING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: identify the different aspects of traffic engineering.
CO2: determine traffic RU characteristics at various sections of road.
CO3: perform highway capacity analysis.
CO4: explain the concept of transportation planning.
CO5: understand about traffic control system
CO6: explain the economic evaluation of transportation plan.

**Pre-requisite: Transportation Engineering-I (CE 3103)**

Traffic Engineering: Traffic Engineering-Definition, Functions & Importance; Road User Characteristics, Human Factors Governing Road User Behavior, Vehicle Characteristics, Slow Moving Traffic Characteristics in Indian Conditions.
Traffic Engineering Studies: Traffic Volume & Occupancy Survey, Origin and Destination Studies, Speed, journey time and delay Measurements; Parking Studies, Use of Photographic methods in Traffic Survey, Fundamental relationships & diagrams in Traffic Engineering.
Highway capacity analysis: Cases of different types of highways, Highway capacity; Design of Intersection; Parking types; Off street parking; Facilities.
Traffic control devices: Channelization, rotary and Traffic signals, Traffic Signs and Road marking, Road Accidents.
Transportation Planning: Brief ideas about urban and regional transportation systems; Components of transportation system planning, Planning Surveys, Trip generation and distribution, Traffic assignment and modal split, Optimal scheduling, Computer applications in Traffic Engineering & Transportation Planning.

**Text Books :**

1. “Traffic Engineering & Transportation Planning”, by L. R. Kadyali, 4th Edition, Khanna Publishers
2. “Transportation Engineering and Planning”, by C. S. Papacostas and P. D. Prevedouros, 3rd Edition, PHI

**Reference Books :**

1. “Transportation Engg: An introduction”, by C. J. Khisty & B. K. Lall, 3rd Edition, PHI, 2006.
2. “Principles of Transportation Engg”, by P. Chakraborthy and A. Das, 1st Edition, 2nd reprint 2005. PHI
3. "Modelling Transport", Juan de Dios Ortúzar, Luis G. Willumsen, 4th Edition, Wiley
4. "Highway Engineering" by S. K. Khanna & C. E. G. Justo, $10^{th}$ Edition, Khanna Publishers, New Delhi.

## CE 3070 FUNDAMENTALS OF PROJECT MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. apply concepts to address specific management needs at the individual, team, division and/or organizational level
CO2. formulate strategies allowing organizations to achieve strategic goals and apply team-building skills
CO3. investigate complex business problems to propose project-based solutions and manage creative teams and project processes effectively and efficiently.

**Pre-requisite : Nil**

Introduction:

What is Project and Project Management, Role of a Project Manager, The Project Life Cycle, Characteristics of the Project Life Cycle, Project Phases.
Project Management Process:

Project Management Process Groups, Initiating Process, Planning Process, Executing Process, Monitoring and Controlling Process, Closing Process.
Project Management Knowledge Areas:

Introduction, Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Human Resource Management, Communications Management, Risk Management, Procurement Management.

**Text Book :**

1. A Guide to the Project Management Body of Knowledge *(Pmbok® Guide)*—Fourth Edition

**Reference Book :**

1. Project Management, the Managerial Process, the McGraw-Hill Company, Clifford F. Gray, Erik W. Larson

## CE 3072 BIOREMEDIATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of microbial bioremediation

CO2. analyze & identify the various aspects of bioremediation

CO3. design bioremediation systems or methods for soil, liquid and slurry phase remediation.

**Pre-requisite : Nil**

Bioremediation Principles:

Introduction about bioremediation, current bioremediation practices and its application to green environment. Advantages and disadvantages of bioremediation.

Bioremediation systems and Processes:

Solid, Liquid and Slurry phase bioremediation.

Factors influencing bioremediation:

Environmental, Physical and chemical factors Influencing Bioremediation Process.

Genetics of Bioremediation:

Genetic responses of microorganisms to the presence of pollutants: Plasmid coded inducible degradative enzymes; stages of biodegradation.

Microbial transformation reactions: Aerobic and Anaerobic Biotransformation.

Applications of Bioremediation:

Application of genetically engineered microorganisms for hazardous waste management; Microbial detoxification of specialty chemicals (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals); Microbial cleaning of gases: biofiltration and bioscrubbing. Phytoremediation.

In-situ Bioremediation:

Current advances on in-situ bioremediation techniques, Laboratory stage bio-treatability studies for in-situ and ex-situ bioremediation.

**Text & Reference Books :**


1. Baker, K H., and Herson, D. S., Bioremediation, McGraw-Hill Publishing Company, New York, 1994
2. Eweis, J. B., Ergas, S. J., Chang D. P. Y., and Schroeder E. D., Bioremediation Principles, McGraw-Hill Publishing Company, Singapore, 1998.
3. Cookson, J.T. Jr., Bioremediation Engineering – Design and Application, McGraw Hill Publishing Company, New York, USA, 1995.
4. Young, L.Y., and Cerniglia, C.E., Microbial Transformation and Degradation of Toxic Organic Chemicals, Wiley–liss Publishers, New York, USA, 1995.


## CE 3074 CONSTRUCTION MATERIAL AND SPECIFICATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the various type of construction materials used for construction purpose.

CO2. know and understand the necessities of specifications of the materials with respect to quality and quantity for a construction work.

CO3. know the engineering specifications containing detailed description of all workmanship and materials for a complete project in accordance with plan and drawings.

CO4. know the specifications regarding the quality of workmanship to be achieved during construction.

### Pre-requisite: Nil

Bricks: Classification, Methods of brick manufacture, Testing of bricks

Cement: Classification, Chemical Composition, Cement Manufacturing Process, Tests on Cement

Aggregates: Fine and Coarse Aggregate, Gradation of Sand, Tests on Aggregates

Concrete: Composition of Concrete, W/C ratio, Nominal Mix Design, Pozzolanic Concrete, Light Weight and High Density Concrete, Tests on Concrete

Bituminous Materials: Manufacturing of Bitumen, Tests on Bitumen, Grades of Bitumen, Use of Bitumen in road construction and water proofing.

Geosynthetics: Geotextiles, geogrids, geonets, geomembrane, geosynthetic clay liner, geocells, geocomposites, prefabricated vertical drains, Applications of geosynthetic materials.

Reinforcement and Structural Steel: Steel Manufacturing Process, Types of Reinforcement Steel and Application, Grades of Structural Steel, Various Types of Standard Sections.

Non Structural Materials: Thermal Insulation and acoustic absorption material, waterproofing materials, Flooring materials.

**Text Books :**


1. "Building Material" by M. L. Gambhir, 1st Edition, TMH Education, New Delhi
2. "Building Material" by P. C. Verghese, PHI Learning (P) Ltd., New Delhi, 2005.


**Reference Books :**


1. "A Text Book of Building Construction" by Dr. S. K. Sharma, Revised Edition, S. Chand Publication, 1987.
2. "Building Material" by S. S. Bhavikatti, 1st Edition, Vikas Publication.
3. "Building Construction" by B. C. Punmia, Jain and Jain, 10th Edition, Laxmi Publication, New Delhi.
4. "Building Material" by P. C. Verghese, PHI Learning (P) Ltd., New Delhi, 2005.
5. "Engineering Materials" by S. C. Rangwala, Charotar Publishing House, 2011.

## CE 3076 TROPICAL HYDROLOGY & WATER RESOURCES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. check the consistency of rainfall data and calculate the probability of rainfall period.
CO2. determine the evaporation evapo-transpiration and rate of infiltration.
CO3. apply the concept of various stream flow measurement methods and synthetic and instantaneous unit hydrograph.
CO4. determine flood discharge using probability distribution functions
CO5. analyze flood routing in reservoir and channel

**Pre-requisite : Nil**

Introduction:
Hydrologic cycle, Water-Budget Equation and Applications in Engineering.
Precipitation:
Forms and weather systems for precipitation, Characteristics of precipitation in India, Measurement, preparation and presentation of rainfall data, mean precipitation, DAD Curves and Frequency of point rainfall.
Abstractions from precipitation:
Evaporation, Evapotranspiration, Infiltration - process, measurement, infiltration capacity and indices.
Runoff:
Catchment characteristics, Runoff estimation methods, SCS-CN method for estimation of runoff
Hydrograph:
Components, Factors affecting runoff hydrograph, Base flow, effective rainfall, Unit hydrograph
Flood:
Methods of estimation, Flood frequency studies (Gumbel's method, Log Pearson type III method), Design flood, Risk and reliability.
Flood Routing:
Basic equation, Hydrologic storage routing - Modified Pul's and Goodrich method, Hydrologic channel routing - Muskingham method of channel routing.
Erosion and Reservoir Sedimentation:
Erosion process, Estimation, Channel Erosion, Reservoir Sedimentation, Trap Efficiency, Density Current, Life of reservoir.

**Text Book :**

1. Engineering Hydrology by K. Subramanya, Tata McGraw Hill, 4$^{th}$ Ed. End reprint 2016.

**Reference Books :**

1. Applied Hydrology by V.T. Chow, D.R. Maidment and L.W. Mays, Tata Mc. Graw Hill, 1$^{st}$ Ed., First Indian Reprint 2010.
2. Water Resources Engineering Vol. 2, Irrigation Engineering and Hydraulic Structures by S.K. Garg, Khanna Publishers, 33$^{rd}$ Ed. End reprint 2017.

## CE 3100 DESIGN OF STEEL STRUCTURES Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand the properties of different types of rolled steel structural members
CO2. design different types of connections (bolted & welded) as per Limit state design
CO3. design different types of steel structural members for axial (tension and compression) as per Limit state design
CO4. design of beams as per Limit state design
CO5. design beam-column and select appropriate column bases for steel columns
CO6. analyze beams and frames using plastic theory

**Pre-requisite : Structural Analysis (CE 2104)**

Introduction: Properties of structural steel, IS rolled section.
Plastic analysis: Plastic analysis of beams and frames.
Connections: Simple and moment resistant bolted and welded connections.
Tension members: Design of tension members.
Compression members: Design of compression members, single angle, column with cover plate, lacings and battens.
Beams: Design of laterally supported and unsupported beam.
Beam-column: Design of beam-column.
Column bases: Design of slab base, gusseted base, and grillage footing

**Text Books :**

1. "Design of Steel Structures", by S. K. Duggal, Mc Graw Hill Education Pvt. Ltd
2. "Design of Steel Structures", by N. Subramanian, Oxford University Press, 2012

**Reference Books :**

1. "Design of Steel Structures by Limit State Method as per IS 800-2007" by S. S. Bhavikatti, 2nd edition, I.K International publishing house pvt. Ltd.
2. "Design of Steel Structures V-II", by S. Ramchandra, Standard Pub.

## CE 3103 DESIGN OF CONCRETE STRUCTURES Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic concepts of working stress and limit state methods
CO2. determine strength of reinforced concrete beams and slabs at various support conditions as per Limit state design
CO3. design reinforced concrete beams and slabs at various support conditions for different loadings as per Limit state design
CO4. design staircases for different support conditions as per Limit state design
CO5. design different types of reinforced concrete compression members as per Limit state design
CO6. design different types of footings as per Limit state design

**Pre-requisites: Mechanics of Materials CE 2103), Structural Analysis (CE 2104)**

Introduction: Materials, Basic properties of concrete and reinforcement, Basic working stress and limit state design concepts.
Analysis & Design of R. C. Beams: Analysis of singly-doubly reinforced sections, flanged sections, Design of simply supported subjected to flexure, shear and torsion by limit state methods.
Design of Slabs: Design of one-way and two-way slab (simply supported & restrained) by limit state methods.
Design of staircases: Different components of Staircase, Design Of dog-legged staircase.
Design of column: Design of short Column with axial load, uniaxial & biaxial moment. Design of long column.
Design of Footing: Design of isolated footing.

**Text Books ;**

1. "Reinforced Concrete Limit State Design" by A. K. Jain, Nem Chand & Bros, 2002
2. "Design of Reinforced Concrete structure" by S. Ramamruthum, 17th Edition, Dhanpat Rai & sons, New Delhi.

**Reference Books :**

1. "Limit state design of reinforced concrete", by P C Varghese, Prentice Hall of India pvt. ltd. New Delhi 2002
2. "Design of Concrete Structures", U. Pillai & D. Menon, Tata Mcgraw Hill publishing company ltd. New Delhi 2003

## CE 3102 TRANSPORTATION ENGINEERING-II Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the function of various components of permanent way
CO2. understand the geometric design of railway track
CO3. know the layout and planning of airport
CO4. understand the geometric design of airport
CO5. know the components of ports and harbours
CO6. know the principles of layout of ports and harbours

**Pre-requisite : Nil**

Introduction to Railway Engineering: Role of Indian Railways in National Development – Railways for Urban Transportation – LRT & MRTS - Engineering Surveys for track alignment (Conventional and modern methods), Permanent way components – Cross section of Permanent Way – Function of various components like rails, sleepers and ballast, Gauge – Creep of rails – Theories related to creep – Sleeper density.
Geometric Design of Railway Track: Gradients – Grade compensation – Cant and negative super elevation – Cant deficiency – Degree of curve, Points and Crossing, Rail joints & welding of joints, Railway station & yards, Signalising & interlocking.
Airport Planning: Air transport characteristics, airport classification, airport planning: objectives, components, layout characteristics, and socio-economic characteristics of the catchment area, criteria for airport site selection and ICAO stipulations, typical airport layouts, Parking and circulation area.
Airport Design: Runway Design: Orientation, Wind Rose Diagram, Runway length, Problems on basic and Actual Length, Geometric design of runways, Configuration and Pavement Design Principles, Elements of Taxiway Design, Airport Zones, Passenger Facilities and Services, Runway and Taxiway Markings and lighting.
Port and Harbour Engineering: Definition of Basic Terms: Harbor, Port, Satellite Port, Docks, Waves and Tides – Planning and Design of Harbours: Requirements, Classification, Location and Design Principles – Harbour Layout and Terminal Facilities –Coastal Structures: Piers, Break waters, Wharves, Jetties, Quays, Spring Fenders, Dolphins and Floating Landing Stage –Inland Water Transport.

**Text Books :**


1. “Railway Engineering” by Satish Chandra and M. M. Agarwal; Oxford Higher Education, New Delhi.
2. "Airport Planing and Design", by S. K. Khanna , M. G. Arora , S. S. Jain, 6th edition, Nem Chand & Bros., Roorkee, India.
3. "A Course in Docks and Harbour Engineering", Bindra S P, Dhanpat Rai and Sons, New Delhi, 2013


**Reference Books :**


1. “A Textbook of Railway Engineering” by S. C. Saxena and S. P. Arora, Dhanpat Rai Publications, New Delhi.
2. "Planning and Design of Airports" by R. M. Horonjeff & F. X. Mckelvey, 5th Edition, McGraw-Hill Professional.
3. “Airport Systems - Planning, Design and Management” by Richard L. de Neufville and Amedeo R. Odoni, McGraw Hill Professional, New York, United States.
4. “Dock & Harbour Engineering” H.P. Oza & G.H. Oza; Charotar Publishers, Ahmedabad, 2013

## CE 3101 TRANSPORTATION ENGINEERING I Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know geometric design of highway
CO2. know characteristics of traffic flow required for transportation planning and design
CO3. know traffic control devices
CO4. know the characterization of various pavement materials
CO5. understand the principle of design of flexible and rigid pavements.
CO6. understand the methods for construction of highways.

### Pre-requisite : Nil

Introduction: Importance of various modes of Transportation, Road development plans and programs, PMGSY, Classification of roads.
Highway Geometric Design: Highway alignment & survey, Importance of geometric design, design control and criteria, Highway cross section element, Sight distance, Design of horizontal alignment, Design of vertical alignment, Grade compensation, Summit curve and Valley curve.
Traffic engineering
Fundamentals of Traffic flow: Road user and vehicle characteristics, Speed flow and density concepts, Microscopic and macroscopic parameters of traffic flow, fundamental relationships between speed flow and density, Traffic studies, PCU, peak hour factor, accident study and analysis
Traffic Operation and Control: Delay concepts, Highway capacity and level of service of different traffic facilities, Traffic control and regulation devices, Signal design by Webster's method, Types of intersections and channelization, Introduction to Intelligent Transportation System
Pavement Engineering
Pavement Materials: Subgrade soil, aggregates and bituminous materials, bituminous mix design, materials for paving concrete, modern materials in pavement.
Pavement Design: Flexible Pavement and Rigid Pavement, Basic Concept of Flexible, Review of CBR method, Design of Flexible pavement as per IRC: 37-2012 and Design of Rigid pavement as per IRC: 58-2011.
Highway Construction: Construction of Flexible Pavements, Construction of Rigid Pavements, Joints in rigid pavements, Surface and sub-surface and cross drainage system for road pavements, Pavement Distress and Maintenance.

**Text Books :**

1. "Principles of Transportation Engineering" By Partha Chakroborty & Animesh Das, 1st Edition, PHI Learning Private Limited-New Delhi.
2. "Highway Engineering" by S. K. Khanna, C. E. G. Justo & A. Veeraragavan, 10th Edition (revised), Nem Chand & Bros., Roorkee, India.

**Reference Books :**

1. "Principles, Practice and Design of Highway Engineering (Including Airport Pavements)" by S. K. Sharma, Revised Edition, S. Chand Publishers.
2. "Principles of Transportation Engineering" By Partha Chakroborty & Animesh Das, 1st Edition, PHI Learning Private Limited-New Delhi.
3. "Pavement Analysis and Design" by Y.H. Huang, Pearson Prentice Hall, New Jersey, USA, 2004.
4. "Transportation Engineering – An Introduction" by C.J. Khisty and B. K. Lall, 3rd Edition, Prentice Hall.
5. "Traffic Engineering and Transport Planning" by Kadiyali L.R., Khanna Publishers, New Delhi, India, 1997
6. "Guidelines for the design of plain jointed rigid pavements for Highways", Third Revision, IRC:58-2011, Indian Roads Congress 2011.
7. "Guidelines for the design of flexible pavements", Third Revision, IRC: 37-2012, Indian Roads Congress July 2012.

## CE 3105 WATER RESOURCES ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. classify the canals, design irrigation channels and apply the concept of Kennedy and lacey theory
CO2. explain the theories of seepage and design of weirs on permeable foundation
CO3. select appropriate sites for construction of reservoirs and dams.
CO4. design the gravity dam by considering various forces acting on it.
CO5. describe the types, causes of failure and criteria for safe design of earthen dam.
CO6. Study about different types of spillways and design of Ogee spillway

**Pre-requisites: Surface Hydrology & Hydraulics (CE 2102)**

Canal Irrigation Systems: Overview on Irrigation and various terminologies, Soil Water Relationship, Delta and Duty, Estimation of Design Discharge, Classification of canals, Alignment, Different types of canals, Distribution system, Design of stable channels in India, Regime Channel, Kennedy's Theory, Lacey's theory
Diversion Head Works: Concept of weir and barrage, Layout of diversion heads works and its components, Theory of seepage, Bligh's creep theory, Lanes weighted creep theory, Khosla's theory on permeable foundation.
Reservoirs: Types, Capacity-Elevation and Area-Elevation Curve of reservoir site, Storage zones, Designing and fixing of reservoir capacity, Reservoir sedimentation.
Dams: Classification, Problems, Site selection, Economical height of dam.
Gravity dams: Forces acting on gravity dam, Modes of failure and criteria for structural stability of gravity dam, Stability analysis, Elementary profile of a Gravity dam, High and low gravity dam, profile of a dam, fixing the section of dam, design of gravity dam, Galleries, and joints.
Earth Dams: Types of earthen dams, causes of failure of earth dams, seepage analysis, determination of phreatic line, measures to control seepage through earth dams and their foundations.
Spillways: Types and Description, Design aspects of Ogee spillway.

**Text Book :**

1. "Irrigation Engineering & Hydraulic Structures" by S. K. Garg, Khanna Publishers

**Reference Book :**

1. "Water Resources Engineering" by Larry W. Mays, Willy Student Edition-2001

## CE 3107 GEOTECHNICAL ENGINEERING-II Cr-3

**Course Outcomes :** At the end of the course, the students will be able to:

CO1. determine the vertical stress distribution on horizontal and vertical plane below the ground surface due to various shapes of footings.
CO2. evaluate the bearing capacity of shallow foundations.
CO3. determine the load carrying capacity of pile foundations.
CO4. identify type of earth pressures behind retaining structures and the intensity of earth pressure.
CO5. identify failure mechanisms of cuttings and embankment using slope stability analysis.
CO6: select appropriate soil exploration methods and field experimentation in geotechnical engineering.

**Pre-requisite: Geotechnical Engineering-I (CE 2100)**

Stresses Distribution: Introduction, Boussinesq's equation for determining vertical stress under point load, pressure bulb, Vertical stress distribution on horizontal and vertical plane, Vertical stress due to uniformly loaded line, circular, square and rectangular footings, Equivalent load method, soil contact pressure under rigid & flexible footing.
Bearing Capacity of Shallow Foundations: Introduction, Rankine's analysis for cohesion less soils, Terzaghi's bearing capacity equation, Factors influencing bearing capacity of soil including effect of water table , size of footings and eccentricity of loading, IS 6403:1981 method, Meyerhof's method, plate load test, Selection of type of foundations, Depth of foundation, Floating Foundation.

Pile Foundations: Classification of piles, Load carrying capacity of single piles by static and dynamic formulae (Hilley's and Engineering News formula) Group action of piles, Negative skin friction, Pile load test (Static and Dynamic method).
Earth Pressure and Retaining Structures: Active & passive earth pressure, Rankine's theory for active and passive earth pressure, Coulomb's theory Pressure against solid retaining walls without and with uniformly distributed load surcharge.
Stability of Slopes: Stability of infinite slopes, Swedish, slice method and friction circle method of analysis, stability of homogeneous finite earth slopes without surcharge with steady seepage and under sudden drawdown condition.

**Text Books :**

1. Foundation Engineering - Geotechnical Aspects" by P.C. Varghese, 11th Printing, 2014, PHI Learning Pvt. Ltd, New Delhi.
2. Principles of Foundation Engineering" by B. M. Das, 7th Edition, Cengage Learning India Pvt. Ltd, New Delhi.

**Reference Books :**

1. "Foundation Analysis and Design" by J. E. Bowls, TMH Education, New Delhi.
2. "Basic and applied soil mechanics" by Gopal Ranjan & A. S. R. Rao, New age international publication, 2012.
3. "Soil Mechanics and Foundation Engineering" by K. R. Arora, Standard Publisher, 2012.
4. "Soil Mechanics and Foundation Engineering" by V.N.S. Murthy, CBS Publisher, 2012.

## CE 3130 WATER AND AIR QUALITY MODELS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. appreciate the need for mathematical models in solving environmental problems
CO2. formulate and set-up different water quality models
CO3. solve different water quality models
CO4. formulate and set-up different air quality models
CO5. solve different air quality models

**Pre-requisites: Environmental Engineering-I ( CE 2105), Environmental Engineering-II (CE 2106)**

Introduction to Mathematical Modeling:
Introduction - need for mathematical modeling - types of models, formulation and analysis –computational methods;
Water quality Models:
Reactors - mass-balance analysis, modeling of ideal and non-ideal flows for different types of reactors, Dissolved oxygen model for streams, sources and sinks of dissolved oxygen, estimation of system parameters, Streeter Phelps model - 'oxygen 'sag' curve, determination of deoxygenation and re-aeration coefficients;
Physical, chemical and biological processes in estuaries;
Air quality models:
Micrometeorological processes, wind rose, dispersion, coefficients and stability classes, Gaussian and dispersion model, Stack height computation, Regional air quality models, Source inventories and significance.

**Text Books :**

1 "Wastewater Engineering Treatment and Reuse" by Metcalf & Eddy Inc., Fourth Edition, McGraw Hill Education India Private Limited, 2015.
2 "Foundation Course on Air Quality Management in Asia" by Haq, Gary & Schwela, Dietrich, Stockholm Environment Institute, 2008.

**Reference Books :**

1 "Surface water quality modeling" by Chapra, Steven C., McGraw Hill Book Company, New York, 1997.
2 "Introduction to Environmental Engineering and Science" by Gilbert M. Masters, 3rd Edition, Pearson Education, 2015.

## CE 3131 TRANSPORT OF WATER AND WASTEWATER Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. design water supply pipelines
CO2. understand the hydraulics of flow in sewers
CO3. design sewer network under various field conditions
CO4. explain the hydraulics of flow in storm water drains
CO5. design storm water drainage systems

**Pre-requisites: Environmental Engineering-I (CE 2105), Environmental Engineering–II (CE 2106)**

Water Supply Systems: Storage requirements, impounding reservoirs, intake structures, pipe hydraulics, design of distribution systems, distribution and balancing reservoirs, pipe materials, appurtenances, design for external loads, maintenance and operation.
Sanitary Sewerage Systems: Flow estimation, sewer materials, hydraulics of flow in sewers, sewer layout, sewer transitions, materials for sewers, appurtenances, manholes, sewer design, conventional and model based design, sewage pumps and pumping stations, corrosion prevention, operation and maintenance, safety.
Storm water Drainage Systems: Drainage layouts, storm runoff estimation, hydraulics of flow in storm water drains, materials, cross sections, design of storm water drainage systems, inlets, storm water pumping, operation and maintenance.

**Text Books :**
1. "Manual on water supply and treatment", CPHEEO, 2009.
2. "Manual on sewerage and sewage treatment systems", CPHEEO, 2013.

**Reference Books :**

1. "Practical Handbook on Public Health Engineering" by Bajwa, G.S., Deep Publishers, Shimla, 2003.
2. "Water and Wastewater Technology" by M.J.Hammer, Prentice Hall, New Jersey, 2001.

## CE 3133 AIR & NOISE POLLUTION CONTROL Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the importance of air quality and its impact on the environment and human health
CO2. evaluate the fate and transport of air pollutants
CO3. select different control methods and design principles for gaseous and particulate pollutant
CO4. explain the fundamentals of noise pollution
CO5. adopt suitable measures for noise pollution control

**Pre-requisite: Environmental Engineering –I (CE 2105)**

Introduction to Air Pollution:
Sources and Sinks of Air Pollution, Classification and Scales of the Air Pollution Problems, Indoor Air Pollution; Effects of air pollution on materials and structures, humans, animals and vegetation, global effects of air pollution - Acid rain, photochemical smog, global warming, ozone layer depletion;
Air pollution monitoring and analysis: Ambient air pollution monitoring, Stack monitoring, Experimental Analysis for Gaseous and Particulate matter.
Air Pollution Meteorology: Dispersion phenomenon of air pollutants, stability of atmosphere, plumes
Air Quality Modelling: Types and description of Gaussian based air quality models for point source
Fundamentals of Noise Pollution: Sources of Noise Pollution, Effects of Noise Pollution, Sound Propagation and Measurement–Noise Standards and Regulations.
Noise Control and Management: Noise Prevention and Mitigation Measures, Noise Pollution Control and Management

**Text Books :**

1. "Fundamentals of Air Pollution" by Daniel Vallero, 4th Edition, Elsevier's Science & Technology, 2008
2. "Environmental Noise Pollution: Noise Mapping, Public Health, and Policy" by Enda Murphy and Eoin A. King, 1st Edition, Elsevier's Science & Technology, 2014.

**Reference Books :**

1. "Air Pollution Control Technology Handbook" by Karl B. Schnelle, Jr. and Charles A. Brown, CRC Press, 2002.
2. "Air Pollution" by Jeremy Colls, 2nd Edition, SPON Press, 2003.

## CE 3134 DEEP EXCAVATION PLANNING AND DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the need of deep excavation and related health and safety issues
CO2. learn about the various stages of planning for deep excavation
CO3. learn various methods to analysis soil settlement due to the deep excavation
CO4. learn design of commonly use lateral support for deep excavation
CO5. learn to asses effect of deep excavation to the adjacent structures

**Pre-requisites: Geotechnical Engineering-I CE 2100), Geotechnical Engineering-II (CE 3107)**

Introduction: Excavation and their classification, basic excavation terminology, excavation health and safety issues
Excavation planning: Planning responsibility of design engineer and contractor, element of excavation plane, design standards for excavation and shoring system, standard practice for open cut excavation, short term soil loading
Methods and supporting system for excavation: full open cut method, braced excavation method, anchored excavation methods, island excavation methods, top down construction method, piles and diaphragm retaining wall, shutting system, selection of strut system.
Analysis: settlement induces due to the installation of diaphragm wall, wall and ground movement induced by excavation, time dependant ground surface settlement by the excavation,
Design of retaining wall: Preliminary design of sheet pile and diaphragm wall, anchor system
Protection of adjacent structures: excavation induces permissible settlement, soil improvement, other remedial measures for protection to adjacent structures, dewatering and its importance in deep excavation.

**Text Book :**

1. Change-Yu Ou, Deep excavation theory and practice, Taylor & Francis, New

**Reference Book :**

1. J. M. Turner, Excavation systems planning, design and safety, Mc Graw Hill, New York

## CE 3150 FUNDAMENTAL OF STRUCTURAL ANALYSIS AND DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. develop skills to idealize, formulate, and analyze determinate and indeterminate structures (beams, trusses, and frames) using structural analysis methods.
CO2. present methods to determine structural Forms, and basic shear and moment diagrams, deflected shape
CO3. develop skills in interpreting and predicting solutions from structural analysis.
CO4. determine strength of reinforced concrete beams and slabs at various support conditions as per Limit state design.
CO5. identify, formulate, and solve engineering problems.

**Pre-requisite: Engineering Mechanics (ME 1001)**

Energy Theorems:

Total potential energy, Complementary
Introduction: Structural Elements, Design Loads, Reactions, Free Body Diagrams, Bending stress.
Structural forms, and basic structural elements: Trusses, Beams and Frames, Shear, Moment Diagrams and deflection curves.
Methods to compute deflections
Deflection of Beams and Frames, Double integration, moment area, and virtual work. Methods of analysis for statically indeterminate structures including consistent deformation, slope deflection and moment distribution.
Design: Working stress method, Limit state method, Design flexure, shear and torsion,

**Text Books :**

1 "Structural Analysis-1" By S S Bhavikathi, 4th Edition, Vikas Publishing House Pvt Ltd-India.
2 "Reinforced Concrete Design" by N. Krishna Raju and R.N Pranesh, First Edition (revised), New Age International Publishers, India.

**Reference Books :**

1 “Structural Analysis” By T.S Thandavamoorthy, Oxford University Press, First Edition, New Delhi.
2 “Design reinforced Concrete Structures”, By N. Subramanian, First Edition, Oxford University Press, New Delhi.

## CE 3152 SURFACE AND GROUNDWATER HYDROLOGY Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. check the consistency of rainfall data and calculate the probability of rainfall over a given return period
CO2. determine the evaporation, evapo-transpiration and rate of infiltration.
CO3. estimate the runoff by various methods and derive the unit hydrograph
CO4. understand groundwater concept as well as properties.
CO5. analyze well hydraulics for steady and unsteady flow in aquifer.

**Pre-requisite : Nil**

Surface Water Hydrology
Hydrologic cycle, Water-Budget Equation and Applications in Engineering.
Precipitation: Forms and weather systems for precipitation, Measurement, preparation and presentation of rainfall data, Mean precipitation over an area, Frequency of point rainfall
Abstractions from Precipitation: Different types of abstractions, Evaporation, Evaporimeters, Transpiration, Evapo-transpiration, Interception and Depression storage, Infiltration-process, measurement, Modelling infiltration capacity.
Runoff and Hydrographs: Catchment characteristics, Runoff estimation methods, SCS-CN method for estimation of runoff, Factors affecting runoff hydrograph, Components, Effective rainfall and Unit Hydrograph
Ground Water Hydrology
Introduction, Forms of sub surface water, Saturated formation, Aquifer properties - Porosity, Specific yield, Darcy's law, Coefficient of permeability and Stratification.
Well Hydraulics: Steady flow into a well - Confined flow and Unconfined flow, Open wells, Unsteady flow in a confined aquifer, Well loss, Specific capacity, Sea-Water intrusion.

**Text Book :**

1 Engineering Hydrology by K. Subramanya, Tata Mc-Graw Hill, 4th Ed.

**Reference Books :**

1 Applied Hydrology by V.T. Chow, D.R. Maidment and L.W. Mays, Tata Mc. Graw Hill, 1st Ed., First Indian Reprint 2010.
2 Water Resources Engineering by L.W. Mays, Wiley Publication, 2nd Edition, First Indian Reprint 2001.
3 Groundwater Hydrology”, by D. K. Todd and L.W. Mays, 3rd Edition, John Wiley and Sons, 2011.
4 Ground Water”, by H. M. Raghunath, New Age International Publishers; 3rd edition, Dec 2007.

## CE 4020 PAVEMENT MANAGEMENT SYSTEMS Cr-3

**Course Outcomes :** At the end of the course, the students will be able to:

CO1. evaluate the surface condition of the pavement and its structural adequacy.
CO2. collect data and develop models for pavement deterioration
CO3. design PMS and implement them

**Pre-requisite : Transportation Engineering-I ( CE 3101)**

Pavement Surface Condition & Its Evaluation - Various Aspects of Surface and their Importance; Causes, Factors Affecting, Deterioration and Measures to Reduce Pavement Slipperiness, Unevenness, Ruts, Pot holes and Cracks; Methods of Measurement of Skid Resistance, Unevenness, Ruts and Cracks. Pavement Surface Condition Evaluation by Physical Measurements, by Riding Comfort and Other Methods; their Applications.
Pavement Structure & Its Evaluation - Factors affecting Structural Condition of Flexible and Rigid Pavements; Effects of Subgrade Soil, Moisture, Pavement Layers, Temperature, Environment and Traffic on Structural Stability, Pavement Deterioration; Evaluation by Non-Destructive Tests such as FWD, Benkelman Beam Rebound Deflection, Plate Load Test, Wave Propogation and other methods of Load Tests; Evaluation by Destructive Test Methods, and Specimen Testing
Pavement Management Process & Data Requirements - Establishing criteria – development of models for pavement deterioration – determining the future needs – rehabilitation and maintenance strategies – developing combined programmes for maintenance & rehabilitation
Project Level Design - Framework for pavement design, characterization of physical design inputs, basic structural response models – variability, reliability and risk – generating alternate design strategies – pavement analysis & design of AC & PC, - rehabilitation design procedures – economic evaluation of alternate pavement design strategies – selection of optimal design strategy.
Implementation - Major steps in implementing PMS – pavement construction management & pavement maintenance management – information's, research needs – cost and benefit of pavement management – future directions and need for innovations in pavement management.

**Text Book**

1. "Pavement Evaluation and Maintenance Management System", **R Srinivasa Kumar,** Universities Press (India)

**References Books :**

1. "Modern pavement management", Ralph Haas, W. Ronald Hudson, John P. Zaniewski, Krieger Pub Co
2. "Pavement Engineering: Principles and Practice", Rajib B. Mallick,Tahar El-Korchi, Second Edition, CRC Press
3. Pavement Management for Airports, Roads and Parking Lots, M. Y. Shahin, 2nd edition, Springer Publication.
4. "Pavement Analysis and Design", Y. H. Huang, 2nd edition, Pearson Education
5. "The Design and Performance of Road Pavements", D. Croney & P. Croney, 3rd Edition, McGraw Hill Professional.
6. "Deterioration and Maintenance of Pavements", Derek E. Pearson, ICE Publishing.
7. OECD, Pavement Management Systems, O E C D, 1987.
8. Relevant AASHTO/ IRC and other Codes and Specifications

## CE 4029 DISASTER MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. explain causes of different natural disasters.
CO2. identify appropriate rehabilitation and retrofitting technique for structures.
CO3. identify different management techniques during disasters.

**Pre-requisite : Nil**

Natural disaster management:

Fire disaster - challenges and management strategy; Flood disaster - its impact, challenges and its management; Earthquake hazard management.

Manmade disasters:

Temporal transport hazard , health disaster.

Role of technology in disaster management:

Developing appropriate technology for disaster mitigation**,** Applications of remote sensing & GIS in disaster management, case studies
Community preparedness:

Vulnerability analysis and mitigation, Role of management teams, importance of awareness, alertness and preparedness camp.

**Text Books :**

1. "Disaster Management - Future Challenges and Opportunities" by Jagbir Singh, IK International Publishing House Pvt. Ltd. Latest edition
2. "Disaster Management", Harsh K. Gupta, Universities Press (India) Pvt. Ltd.

**Reference Books :**

1 "Engineering Hydrology", K. Subramanian, Tata McGraw Hill, New Delhi.

2 "Elementary Hydrology", V. P. Singh, Prentice Hall of India.

3 "Disaster Mitigation, Preparedness, Recovery and Response", V. P. Singh, SBS Publishers & Distributors Pvt. Ltd. Heinemann.

4 "Practical Guide to Environmental Management", F. B. Friedman, McGraw Hill.

## CE 4030 MACHINE FOUNDATION ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand basic theory of vibrations of Single Degree of Freedom systems.
CO2. undertake design and analysis problems related to machine foundations.
CO3. calculate the stiffness and damping constants of different types of foundations.
CO4. calculate the response of machine foundations under the effect of different types of dynamic loading.
CO5. explain the guidelines for design and construction of machine foundation

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II (CE 3107)**

Vibration of elementary Systems: Vibration motion, vector representation of harmonic motion, Single degree of freedom system: Free Vibrations- damped and undamped, Forced Vibrations – damped and undamped.
Dynamics of soil-foundation System: types of machine foundation, design criteria, dynamic loads, physical modeling and response analysis, Barken's approach, Ford & Haddow's analysis, Hammer foundation, I. S. Codes.
Dynamic soil testing techniques: cyclic plate load test, block vibration test, shear modulus test, geophysical methods, Resonance-column test, Two & three borehole techniques, Model tests using centrifuge and shake table, recent developments.
Vibration isolation and control: vibration transmitted through soil media, active and passive isolation, vibration isolation – rigid foundation and flexible foundation, method of isolation, properties of material and media used for isolation, vibration control of existing machine, foundation isolation by barriers. Guidelines for design and construction of machine foundation: data required for design of reciprocating, impact and rotary type machines, guidelines for the design of different type machines, construction guidelines, guidelines for providing vibration absorbers.

**Text & Reference Books :**

1. "Foundation for Machine", by S. Prakash, Wiley, 1988.
2. "Soil Dynamics and Machine Foundations", by Swami Saran, Galgotic Pulbication Pvt Ltd, New Delhi.
3. "Vibrations of Soil and Foundations", by Richard, Hall & Wood, Prentice Hall, June 1970
4. "Dynamics of Structures", by Anil K. Chopra Prentice Hall, 4th edition 2012.
5. "Vibration Analysis and Foundation Dynamics", by N. S. V. Kameswara Rao, S. Chand New Delhi.

## CE 4033 STRUCTURAL DYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. analyze single degree of freedom (SDOF) system for damped and undamped free vibration systems
CO2. analyze single degree of freedom (SDOF) system for undamped free vibration systems
CO3. analyze single degree of freedom system for damped and undamped forced vibration for harmonic, periodic, impulse and general dynamic loads
CO4. analyze multi degree of freedom (MDOF) system for damped and undamped free vibration systems
CO5. analyze free vibration of distributed mass system of Beam
CO6. analyze forced vibration of distributed mass system of Beam

**Pre-requisites: Mechanics of Materials (CE 2103) and Structural Analysis (CE 2104)**

Single degree of freedom system: Equation of motion, Damped and undamped free vibration, Response to harmonic, Periodic, impulse load and general dynamic load, Duhamel's integral
Multi degrees of freedom system: Equation of motion, Free vibration analysis, Dynamic response and modal analysis.
Free and Forced vibration of distributed mass system: Beams

**Text Books :**

1. "Dynamics of Structures: Theory and Applications to Earthquake Engineering", by A. K. Chopra, Prentice Hall of India.
2. "Earthquake resistance design of structures", by Pankaj Agarwal & Manish Shikhande, Prentice hall (PHI).

**Reference Book :**

1. "Dynamics of structures", by R. W. Clough and J. Penzien, McGraw-Hill Inc.

## CE 4044 GROUND IMPROVEMENT ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. apply the ground improvement technique using admixtures and advanced technique using grouting.
CO2. identify the relevance of reinforcing elements to resist the lateral earth pressures.
CO3. apply suitable techniques for the deep compaction of granular soils and improvement of cohesive soils.
CO4. utilize ground anchors and soil nails for design of soil retained structures.
CO5. identify methods to accelerate the consolidation settlement of cohesive soil using preloading methods and vertical drains.

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II (CE 3107)**

Introduction: Need – methods – suitability – Mechanical modification: principle - Surface compaction: Field compaction and equipment, compaction specification and controls. Vibration methods: dynamic consolidation, vibratory rollers, Vibro floatation.
Drainage methods: Well point systems, deep well drainage, vacuum dewatering system, design of dewatering system – field permeability tests, dewatering by electro osmosis. Preloading, sand drains, wick drains- Thermal methods case studies.

Chemical stabilization: cement stabilization- factors affecting soil cement mixing-admixtures- lime stabilization-effect of lime on soil properties construction of lime stabilized bases-bituminous stabilization-thermal stabilization- electrical stabilization.
Grouting: Classification – Methods – Types – grouts – equipment, grouting design and layout, grout monitoring – applications – Case studies.
Earth Reinforcement: mechanism and concept- stress strain relationship of reinforced soil-design theories and stability analysis of retaining wall-tie back analysis-coherent gravity analysis- application areas of earth reinforcement.
Geotextiles: Soil reinforcement with geotextiles- classification- concepts geotextiles as separators, filters, and drainage media-damage and durability of geotextiles.

**Text Books :**

1. "Geotechnical Engineering", by Shashi K Gulhati and Manoj Datta, $9^{th}$ Reprint edition, TMH Education Pvt. Ltd.
2. "Ground Improvement techniques",by P. Purushothama Raj, Laxmi publications Pvt. L, 2005.
3. "Reinforced soil and its engineering application",by Swami Saran, Second Edition, I. K. International Publishing House Pvt. Ltd, 2011.
4. "Principle and Practice of Ground Improvement", by Jie Han,1st Edition, Wily Publication.

**Reference Books :**

1. "Foundation Analysis and Design" by J.E.Bowles, MCGRAW-HILL Higher Education, 5 Edition 1997
2. "Soil Improvement techniques and their evolution", by Van Impe, CRC Press, Jan1989.

## CE 4051 FLOOD AND DROUGHT ESTIMATION AND MANAGEMENT Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. estimate flood by various methods
CO2. explain different methods of flood control and management
CO3. understand various methods of flood monitoring and forecasting
CO4. learn about drought classifications
CO5. know various methods of drought assessment
CO6. explain about drought management

**Pre-requisites: Surface Hydrology & Hydraulics (CE 2102), Water Resources Engineering (CE 3105)**

Flood Estimation: Estimation of design flood- Empirical methods, envelope curve method, unit hydrograph method, flood estimation in small watersheds, urban catchment and influence of urban drainage.
Flood Control and Management: Detailed study of various methods of flood control- flood plain identification, flood disaster monitoring and mitigation procedures, various methods of forecasting data, communication and warning, flood fighting.
Drought Classification: Importance, definition-NCA classification, direct and indirect losses.
Drought Estimation: Drought severity assessment, methods in meteorological, hydrological and agricultural aspects.
Drought Monitoring: Supply and demand oriented measures, drought prone areas programme (DPAP), short term and long-term strategies, drought management.

**Text Books :**

1. "Irrigation Engineering & Hydraulic Structures" by S. K. Garg, Khanna Publishers
2. "Engineering Hydrology" by K. Subhrmanya, TMH Education Pvt. Ltd, New Delhi

**Reference Books :**

1. "Applied Hydrology", by VenTe Chow, David, R. Maidment, Lary, W. Mays., McGraw Hill Publications, 1995.
2. "Elementary Hydrology", by Vijay P. Singh, Prentice Hall of India, 1994.
3. "Hydrology", H.M. Ragunath, by Wiley Eastern Ltd. 1996.
4. "Handbook of Applied Hydrology", by VenTe Chow, et al, McGraw Hill Publications, 1995.

## CE 4053 SOLID AND HAZARDOUS WASTE MANAGEMENT Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. classify solid wastes and understand the functional elements of solid waste management
CO2. understand the aspects of waste generation and its effects on public health and environment.
CO3. identify the strategies for waste collection, storage, processing, transport and disposal.
CO4. identify proper ways of source reduction, product recycling and recovery of biological conversion products.
CO5. explain various incineration technologies, estimate the energy generation potential of wastes and assess the environmental impacts of incineration.
CO6: identify and classify hazardous wastes and select proper strategy for managing and treating them.

### Pre-requisite: Environmental Engineering-II (CE 2106)

Introduction to Solid and Hazardous waste management: Classification of solid waste – source-based and type-based. Functional elements of solid waste management.
Waste Generation aspects: Waste generation and composition, Waste characteristics, Effects on public health and environment.
Waste collection, storage, transport and disposal: Collection components, storage devices, collection operation, Transfer station, Waste collection system design, disposal options – sanitary landfill, landfill gas emission, leachate formation.
Waste Processing techniques: Mechanical volume and size reduction, component separation, drying and dewatering.
Source reduction, product recycling and recovery of biological conversion products: Basics of source reduction, Elements of recycling – source separation, drop-off, curbside programme, storage and collection of recyclables etc., Composting, Biogasification.
Incineration and energy recovery: Incineration technologies, Energy recovery, Air emission and its control.
Hazardous waste (HW): management and treatment. Identification and classification of HW, Management strategies of HW, HW treatment – physical, chemical and biological.
Integrated Waste Management (IWM): Characteristics of IWM, Planning for IWM, Implementation of IWM, and Benefits of IWM. Introduction to life cycle assessment tool and its application in IWM.

**Text Books :**

1. "Management of Municipal Solid Waste", by T.V. Ramachandra, Commonwealth of Learning, Canada and Indian Institute of Science, Bangalore, TERI Press, The Energy and Resources Institute, New Delhi, 2006.
2. "Integrated Solid Waste Management", by Tchobanoglous, Thisen & Vigil, McGraw Hill International.

**Reference Books :**

1. "Solid Waste Management in Developing Countries", by A.D. Bhide, Nagpur publications
2. "Environmental Pollution Control Engineering", C.S. Rao, Wiley Eastern, Manual of solid waste of management, CPHEEO
3. "Hazardous Waste Management" by Lagrega, Buckingham & Evans, McGraw Hill International

## CE 4057 DRAINAGE ENGINEERING AND DESIGN Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand drainage of agricultural land
CO2. plan the drainage of agricultural land
CO3. design the drainage of agricultural land
CO4. understand the urban drainage system
CO5. plan the urban drainage system
CO6. design the urban drainage system

**Pre-requisite: Nil**

Drainage of Agricultural Land: Nature and extent of Drainage Problems; drainage Investigation; Steady and transient state drainage equations; Design, alignment, construction and maintenance of surface and subsurface drainage systems; Design, construction and maintenance of mole drains; Guideline for the selection of envelope materials for subsurface drain; Design, construction and maintenance of well drains; Drainage machineries.
Urban Drainage: Introduction; Approaches to urban drainage – piped or natural systems, types of piped system, urban water system; Storm water – introduction, runoff generation, overland flow and storm water quality; System components and layout of urban drainage system – introduction, building drainage, system components and design; Hydraulics of urban drainage, Storm sewers, Structural design and construction – types of construction, site investigation, open-trench construction, tunneling and trenchless methods; Storm water management.

**Text Books :**

1. "Land and Water Management Engineering" by V.V.N Murthy and M.K. Jha; 6th Edition, Kalyani Publishers, Ludhiana, India.
2. "Urban Drainage" by D. Butler and J.W. Davis;3rd Edition, Spon Press, London and Newyork

**Reference Book :**

1. "Irrigation Engineering & Hydraulic Structures" by S.K. Garg, Khanna Publishers.

## CE 4059 REINFORCED CONCRETE REPAIRS & MAINTENANCE Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand condition Survey
CO2. evaluate and Assess damage detection methods concrete structures
CO3. perform repair analysis and design using different materials and methodologies
CO4. understand various methods of protection of concrete structures and rebar corrosion
CO5. understand maintenance of concrete structures

**Pre-requisites: Civil Engineering Materials & Construction (CE 2109)**

Introduction: Causes of deterioration of concrete structures. Effects of climate, moisture, temperature, chemicals, wear, erosion and loading on serviceability and durability. Design and construction errors. Causes of seepage and leakage in concrete structures. Formation of cracks including those due to corrosion.
Condition Survey, Evaluation and Assessment of Damage: Diagnostic methods and analysis. Destructive, Semi destructive and Non-Destructive methods including Core test, Carbonation test , Chloride test, Petrography, Corrosion Analysis, Cover meter test, Rebound Hammer test, Ultrasonic Pulse Velocity test, Crack measurement techniques, Concrete Endoscopy and Thermal imaging, Pull-off test and Pull-out test etc.
Materials and Methodology of Repairs: Repair analysis and design. Repair materials and their properties. Methodologies of crack and patch repair used of Polymer modified mortar, Polymer modified concrete, Polymer concrete. Injection grouting. Shortcreting. Joints and sealants. Rebar corrosion crack repair.
Protection of Concrete Structures: Protective materials and their properties for moisture barrier systems, Above-grade and below grade waterproofing of concrete structures. Systems like integral, crystalline, coatings, membranes etc,. Thermal protection coatings.
Rebar Corrosion Protection: Methods of Corrosion protection. Corrosion inhibitors, Corrosion resistant steels, Cathodic Protection, Pre-packaged zinc sacrificial anode, Snap-on zinc mesh anode CP system.
Maintenance of concrete structures: Facets of maintenance. Planned preventive maintenance. Maintenance cycles. Statutory legislation and obligation.

**Text & Reference Books :**

1. "Concrete Repair and Maintenance", by Peter H .Emmons & Gajanan M. Sabnis, Galgotia Publication.
2. "Repairs and Rehabilitation", by Compilation from Indian Concrete Journal-ACC Publication.
3. "Guide to Concrete Repair and Protection", HB84-2006, A joint publication of Australia.

4. "Concrete Repair Association", by CSIRO and Standards Australia.
5. "CPWD hand book on Repairs and Rehabilitation of RCC buildings" by DG (Works), CPWD, Government of India (Nirman Bhawan), http://www.cpwd.gov.in/handbook.pdf.
6. "Guide to Concrete Repair", by Glenn Smoak, US Department of the Interior Bureau of Reclamation, Technical Service Center , http://books.google.co.in.
7. "Management of Deteriorating Concrete Structures", by George Somerville, Taylor and Francis Publication.
8. "Concrete Building Pathology", by Susan Macdonald, Blackwell Publishing.
9. "Testing of Concrete in Structures", by John H. Bungey, Stephen G. Millard & Michael G. Grantham, Taylor & Francis Publication.
10. "Durability of concrete and cement composites", by C.L. Page & M.M. Page, Woodhead Publishing.

## CE 4061 EARTHQUAKE ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. identify the parameters of earthquake and seismic zones of India.
CO2. determine dynamic responses of free vibration and forced vibration (un-damped & damped) for single degree of freedom systems.
CO3. construct response spectra and select proper value for design from given dynamic properties.
CO4. determine dynamics responses of un-damped free vibration for multi degree of freedom systems.
CO5. use standard earthquake codes for design of structure.

**Pre-requisites: Mechanics of Materials (CE 2103), Structural Analysis (CE 2104)**

Single degree freedom system: Free and forced vibration.
Multi degree freedom systems: Free vibrations of un-damped systems, Determination of frequencies by Rayleigh’s method and Stodola method, Un-damped and damped free vibrations with viscous damping, Vibration isolation, Response spectra, India seismic zoning map.
Earthquake resistant design of RC multi story buildings and masonry buildings as per provision in IS code: India seismic zoning map.
Seismic retrofitting of RC and masonry buildings

**Text Book :**

1. “Earthquake resistance design of structures”, by Pankaj Agarwal & Manish Shikhande, Prentice hall (PHI).

**Reference Book :**

1. “Dynamics of structures (Theory and applications to Earthquake Engineering)”, by Anil K. Chopra PH (I) New Delhi.

## CE 4065 INFRASTRUCTURE PLANNING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand the fundamental characteristics of infrastructure
CO2. understand past and contemporary challenges and trends in the theories and practice of mega infrastructure planning, appraisal and delivery
CO3. acquire basic knowledge of the international, national and regional policies and legislative frameworks, plus market contexts that surround mega infrastructure development
CO4. understand the critical issues concerning sustainable infrastructure investment at all scales.
CO5. apply innovative methods and techniques to infrastructure planning, appraisal and monitoring.

**Pre-requisite: Construction Planning & Management (CE 2108)**

Definitions of infrastructure; Typical infrastructure planning steps; Planning and appraisal of major infrastructure projects. Screening of project ideas; Life cycle analysis; Multi-criteria analysis for comparison of infrastructure alternatives. Procurement strategies; Scheduling and management of planning activities.
Economic Analysis – Concepts and Applications, Principles of methodologies for economic analysis of public works, Social welfare function, indifference curves and tradeoffs, Demand curves and price elasticity; Benefit-cost ratio and internal rate of return; Shadow pricing; Accounting for risk and uncertainty.
Financial Evaluation - Time value of money, Investment criteria, Project cash flows – elements and basic principles of estimation, Financial estimates and projections, Cost of capital, Rate of return; Project risk analysis; Political and social perspectives of infrastructure planning; Case studies.

**Text Books :**

1. "Infrastructure planning handbook: Planning, Engineering, and Economics", by A. S. Goodman and M. Hastak, McGraw-Hill, New York, 2006.
2. Infrastructure planning, by J. Parkin and D. Sharma, Thomas Telford, London, 1999.

**Reference Books :**

1. P. Chandra, Projects Planning, analysis, selection, financing, implementation, and review, Tata McGraw-Hill, New Delhi, 2009.
2. J. D. Finnerty, Project financing - Asset-based financial engineering, John Wiley & Sons, New York, 1996.
3. L. Squire and H. G.van der Tak, Economic analysis of projects, John Hopkins University Press, London, 1975.
4. T. J. Webster, Managerial economics: Theory and practices, Elsevier, New Delhi, 2003.

## CE 4067 OFFSHORE GEOTECHNICAL ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. learn about equipment and standard soil investigation methods used in offshore constructions.
CO2. understand geotechnical problems related to offshore oil exploration and production
CO3. evaluate procedures relevant for foundations, piles and anchors subjected to cyclic loading.

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II (CE 3107)**

Classification; Consolidation and shear strength characteristics of marine sediments; Planning and site exploration of offshore drilling, sampling, laboratory testing, in-situ testing methods and geophysical methods.
Current design practice of pile-supported and gravity offshore structures.
Dynamic analysis of offshore structures.
Anchor design, breakout resistance analysis and geotechnical aspects of offshore pipe line and cable design.

**Text & Reference Books :**

1. Graham Dalton, Theory and Practice of Seamanship, Shroff Publishers Delhi..
2. B M Das, Principles of Geotechnical Engineering, Thomson Brooks/Cole.
3. Ramakrishna, T V, Marine and Offshore Engineering, Mahip Distributor Delhi

## CE 4069 COST EFFECTIVE HOUSING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. classify the population based on income.
CO2. identify the need and problems of lower income and economically weaker section regarding shelter.
CO3. identify different low cost materials and use them to build a low cost house.
CO4. describe the cost effective technologies used in building construction
CO5. understand the cost effective housing for natural disaster mitigation

**Pre-requisite: Nil**

Income based classification of population. High, Middle, Low Income group and economically weaker section. Basic shelter issues in India. Mindset of low income group and economically weaker section people. Problems associated with this group with relation to land, living condition and dwelling standards; Recommendation of housing and urban development corporation.
Traditional materials and techniques (rammed earth, sun dried bricks, wood, bamboo, jute); Alternate and developed methods / materials of construction: pressed soil blocks, use of stabilized soil, soil cement blocks, fly ash brick, by-product gypsum, foundation, arch foundation, walling- rat trap bond, roofing- filler slabs. Precast blocks and their use.
Laurie Baker's experiments in low cost housing. ; Modular constructions. Experimental observations/findings of CBRI.
Use of cost effective technologies (CECT) in building constructions, stub foundation, Rat trap bond (walls), brick arches (alternates to lintels) filler slab (roof). Use of Ferro cement.
Cost effective housing for natural disaster mitigation.

**Text Books :**

1. "Low cost Housing Technology", L. J. Goodman, R. P. Lama, R. Rajani, F. J. Burian, Pergamon Press, 1979.
2. International Association for Earthquake Engg. Guidelines for Earthquake Resistant Non-Engineered Construction.

**Reference Books :**

1. "Are slums inevitable", L. Baker, Centre of science & technology for Rural Development, (COSTFORD) Ayanthple, Thrissur, Kerala.
2. "Houses - How to reduce the building cost", L. Baker, Centre of science & technology for Rural Development, COSTFORD Ayanthple, Thrissur-68003, Kerala.

**CE 4071 BASIC TRANSPORTATION ENGINEERING Cr-3**

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand highway system & design
CO2. understand railway and airport system
CO3. understand other modes of transportation engineering

**Pre-requisite : Nil**

Course Content
Highway Engineering:
Introduction to Transportation Systems, Road Development in India, Highway Engineering – Classification of Roads, Highway Planning - Road cross section - camber, gradient, Super elevation - Sight distance - Horizontal and
Vertical curve, Highway Materials- Soil & Soil properties, Bitumen and bituminous mixes – sources, composition, characterization, various forms - Tests on bitumen- Aggregate test, mix design - Types of pavement - pavement construction and maintenance, Traffic engineering- various studies, Level of Service, Intersections, Road signs, markings & signals, Highway Parking
Railway Engineering:
Introduction, Development & Administration of Indian Railway, Railway surveying, Rolling Stock & track resistances, Tractive power & Tractive resistances, Permanent way, Railway gauges, Sleepers, Ballast, Track design, Stations & yards, Station Equipment, Signaling, High speed Trains, Train Accidents-Causes & Prevention.
Airport Engineering:
Administration, Advantages & Disadvantages of Air transport, Aircraft Characteristics, Airport Obstructions, Typical layout of Airports – Component parts – Objectives of components – Runways – Taxiways – Aprons – Landing, Helicopters, Air traffic control, Airport Marking & Lightning.

**Tunnel Engineering:**
Introduction-Advantages, disadvantages, economics & selection, Classification of tunnels, Design of shape & size of tunnels, Components of Tunnel, Methods of tunneling, Precautions, Tunnel Lining & drainage.
Docks & Harbor Engineering:
Introduction, Classification & Requirements of ports, harbor, docks, Maintenance of ports & harbours, advantages of docks, Transit shed & warehouse, Tides, wind & waves, Different components of docks, Navigational aids, Breakwater.

**Text Book :**

1. "A Textbook of Transportation Engineering", by S.P. Chandola, 1st Edition, S. Chand (G/L) & Company Ltd.

**Reference Books :**

1. "Transportation Engineering Vol. I & II", by V. N. Vazirani & S. P. Chandola, 5th edition & 8th edition, Khanna Publishers, New Delhi.
2. "Roads, Railways, Bridges, Tunnels & Harbour Dock", by Amit Gupta & B.L. Gupta, 5th edition, Standard Publications.
3. "Highway Engineering", by K. S. Rangwala, 10th edition, Charotar Publishing House Pvt. Limited
4. "Airport Engineering" by S. C. Rangwala, K. S. Rangwala and P. S. Rangwala, Charotar Publishing House
   Pvt. Ltd., Anand, Gujarat.
5. "Railway Engineering", by Rangwala, 25th edition, Charotar Publishing House Pvt. Ltd.
6. "Harbour, Dock and Tunnel Engineering" by R. Srinivasan, Charotar Publishing House Pvt. Ltd., Anand,
   Gujarat.

## CE 4073 FUNDAMENTALS OF RCC DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the different properties, types & test of cement.
CO2. know the different gradation of coarse aggregate, test of fine & coarse aggregate, types
CO3. know the manufacturing process & different grades of steel.
CO4. know the different behavior of concrete.
CO5. know about the concept of stress and strain.
CO6. design simple beams & columns.

### Pre-requisite: Nil

Materials for Concrete: Cement:
Physical and chemical properties of cement, Types of cements and their use, Tests on cement.
Fine aggregates and coarse aggregates:
Gradation of fine aggregate, Tests on sand, Tests on coarse aggregates Steel: Steel manufacturing process, grades of steel.
Concrete:
Composition of concrete, W/C ratio, Workability, Compressive and tensile strength, Nominal Mix design, Elasticity, Shrinkage and creep of concrete
Concept of Stress and strain: Simple stresses and strains:
Materials under tension, compression and shear stresses, Elastic constants.
Bending Stresses & Shear Stresses in Beams:
Bending Moment and Shear Force Diagram of Determinate Beams, Theory of Simple Bending of Initially Straight Beams.
Basic Design Concept:
Basic working stress and limit state design concepts. Design of singly-doubly reinforced sections Design of columns.

**Text Book**

1. "A Textbook of Transportation Engineering", by S.P. Chandola, 1st Edition, S. Chand (G/L) & Company Ltd.

## CE 4075 FUNDAMENTALS OF SOIL PHYSICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand soil basic relationship
CO2. understand soil-water relationship
CO3. understand soil-plant-water relationship

### Pre-requisite: Nil

Introduction & Basic Relationships:
Soil Physics and Soil Physical Characteristics, Water Properties In Relation To Porous Media.
The Solid Phase:
Particle Sizes, Shapes, and Specific Surface, Clay, the Colloidal Component, Soil Structure and Aggregation.
The Liquid Phase:
Water Content and Potential, Water Flow in Saturated Soil
The Field Water Cycle:
Water Entry into Soil, Surface Runoff and Water Erosion, Groundwater Drainage and Pollution, Evaporation from Bare Soil and Wind Erosion.
Soil–Plant–Water Relations:
Plant Uptake of Soil Moisture, Water Balance and Energy Balance in the Field, Irrigation and Water-Use Efficiency.

**Text Book :**

1. Environmental Soil Physics" by Daniel Hillel, 1st Edition, Academic Press, 2003.

## CE 4077 EARTH & EARTH RETAINING STRUCTURES Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. describe potential applications for Earth Retaining Structures (ERS)
CO2. explain the mechanical stability of Earth retaining walls
CO3. understand the applications, advantages and limitations of soil nailing
CO4. select appropriate material properties, soil design parameters, and earth pressure diagrams
CO5. perform design analysis and prepare conceptual designs

### Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II(CE 3107)

Earth and Rock Fill Dam: Choice of types, material, foundation, requirement of safety of earth dams, seepage analysis.
Mechanically Stabilized Earth retaining walls: General considerations, backfill and reinforced materials, construction details, design method, stability.
Soil nailing: applications, advantages, limitations, methods of soil nailing, case histories, analysis and design.
Reinforced Soil: Introduction, basic components, strength characteristics, soil-reinforcement interface friction.
Reinforced Earth wall: Stability analysis, construction procedure, drainage, design Procedure.
Foundation on Reinforced Soil Bed: Pressure ratio, analysis of strip, isolated, square and rectangular footing on reinforced soil bed, ultimate bearing capacity of footing on reinforced earth slab. Fiber reinforced soil.

**Text & Reference Books :**

1. “Reinforced Soil and its Engineering Application", by Swami Saran, Second Edition, I. K. International Publishing House Pvt. Ltd, 2011.
2. "Soil Mechanics and Foundation Engineering", by V N S Murthy, CBS Publisher, 2009.
3. "Analysis and Design of Foundation", by J. E. Bowles, TMH Education, New Delhi.

## CE 4079 WATER RESOURCES MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic concepts of surface and groundwater components of Hydrological cycle
CO2. estimate the surface runoff by various methods and idea about water for various sectors
CO3. demonstrate familiarity in urban water and water quality management
CO4. identify and critically review the conflicting interests to be considered in making water resource management decisions
CO5. integrate information from a range of disciplines into a comprehensive picture of a water resource management issue considering impact of climate change

**Pre-requisite: Nil**

**Introduction:**
Distribution of earth's water resources, fresh water on earth, rainfall distribution, river basins, land and water resources of India, Role of Water in the Constitution of India, National Water Policy and State Water Policies.
Surface water:
Hydrological cycle and its components, Precipitation and Abstractions, Estimation of water resources of a country, runoff estimation methods (Rainfall-Runoff, SCS-CN Method).
Ground water:
Ground water component in hydrologic cycle – Geological formations – Types of water bearing strata and their characteristics – Ground water movement – Darcy's Law – Flow through layered soils – Stream Lines and Equipotential Lines, Types of wells, Groundwater Uses in India, Conjunctive use of surface and groundwater.
Water for different sectors:
Water for drinking, irrigation, industrial and developmental needs – Emphasis on domestic and drinking water sector – Green, Blue and Grey water concepts – Virtual water and trade.
Urban water management:
Domestic water supply system, monitoring and conservation, Storm water management practices (Structural and Non-structural Management measures).
Management of water quality:
Water quality issues, types and sources of pollution, water quality monitoring, environmental guidelines for water quality, National and international standards of potable water.
Remote sensing and GIS applications:
Spatial data sources – GIS approach in water resources management, Uses in Thematic map - Rainfall-runoff – Groundwater and Water quality Analysis.
Water conflicts in India:
Water conflicts and Tribunals - Contending Water Uses – Equity, Access and Allocation - Water Quality Conflicts - Micro-level Conflicts, Dams and Displacement – Privatization.
Climate change and water resources:
Climate, Climate system, climate change – Drivers of Climate change – Characteristics of climate system components - Green house effect – Carbon cycle – El Nino, La Nina, Impact on Water Resources and its management

**Text Books :**


1. Engineering Hydrology by K. Subramanya, Tata McGraw Hill, and 4th Ed. End reprint 2016.
2. Water Resources Engineering Vol. 2, Irrigation Engineering and Hydraulic Structures by S.K. Garg, Khanna Publishers, and 33rd Ed. End reprint 2017.


**Reference Books :**


1. "Groundwater Hydrology", David Keith Todd, 2nd edition, 1976, John Wiley and Sons, New York.
2. "Ground Water", H. M. Raghunath., Third edition, 2009, Wiley Eastern Ltd.
3. Environmental Engineering. Howard Speedy.

## CE 4089 COASTAL MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. learn about estuaries, wetlands, lagoons, and of the uses of and stresses on the coastal zone.
CO2. study the classification, characteristics, and theories of waves, tides and currents.
CO3. learn about coastal erosion, sea level change, and coastal structures.
CO4. study sea water intrusion, desalination, and anthropogenic impacts on wetlands, mangroves and coral reefs.
CO5. learn about coastal zone management and the applications of remote sensing and geographical information systems in coastal zone management.

**Pre-requisite : Nil**

**Introduction:**
Origin of coasts, wind, waves, ocean currents, tides, wave theories (basics), wave forces
Coastal process:
wave shoaling, wave refraction, wave diffraction, wave reflection, wave breaking, types of breakers, Wave run-up, beach profile, beach process
Coastal erosion & protection:
Erosion process, causes for erosion, littoral drift, protection works using seawall, Groins, Jetties, off-shore breakwaters, artificial beach nourishment, new technologies of shore protection
Coastal Zone Management and Remote Sensing & GIS Applications.
Coastal Zone Management:
Concepts and Development, Database for Coastal Zone Management
Remote Sensing Data for CZM, GIS:
Concepts and Models Used in Coastal Zone
Environmental impact assessment:
Concept of coastal eco-systems, coastal pollution and its implications.

**Text & Reference Books :**


1. "Harbour and Coastal Engineering", Volume I & II, 2002, Editors S. Narasimhan, S. Kathiroli, Nagendra Kumar B., National Institute of Ocean Technology, NIOT, Chennai, Ocean and Coastal Engineering Publications.
2. "Coastal Structures", 2002, Proceedings of short term course by the Department of Ocean Engineering, I.I.T. Madras, Chennai, India
3. "Coastal Erosion Areas–Protection and Management", 2003, Proceedings of short term course by the Dept. of Applied Mechanics and Hydraulics, N.I.T.K. Surathkal, India
4. "Hand Book of Coastal and Ocean Engineering", 1990, by Herbich, Gulf publishing Co.
5. "Coastal Engineering Manual", (CEM), 2006, U.S.Army Corps of Engineer, Vicksburg, Miss.
6. "Port Engineering", 1981, Brunn P., Gulf publishing Company


## CE 4092 GLOBAL WARMING & CLIMATE CHANGE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the importance of global warming
CO2. model and apply the techniques of 'measuring' the Earth's temperature
CO3. assess the 'best predictions' of current climate models
CO4. understand the concept of mitigation measures against global warming
CO5. explain the factors forcing climate change and the extent of anthropogenic influence.

**Pre-requisite : Nil**

Earth's Climate System:
Role of ozone in environment-ozone layer-ozone depleting gases-Green House Effect, Radiative Effects of Greenhouse Gases-The Hydrological Cycle-Green House Gases and Global Warming – Carbon Cycle.
Atmosphere and its Components:
Importance of Atmosphere, Physical Chemical Characteristics of Atmosphere, Vertical structure of the atmosphere, Composition of the atmosphere, Atmospheric stability, Temperature profile of the atmosphere, Lapse rates, Temperature Inversion, Effects of inversion on pollution dispersion.
Impacts Of Climate Change:
Causes of Climate change, Change of Temperature in the environment, melting of ice Pole, Sea level rise, Impacts of Climate change on various sectors, Agriculture, Forestry and Ecosystem, Water Resources, Human Health, industry, Settlement and Society, Methods and Scenarios, Projected Impacts for different regions, Uncertainties in the Projected Impacts of Climate Change, Risk of Irreversible Changes.
Observed changes and its causes:
Climate change and Carbon credits, CDM, Initiatives in India-Kyoto Protocol, Intergovernmental Panel on Climate change, Climate Sensitivity and Feedbacks, The Montreal Protocol, UNFCCC, IPCC, Evidences on changes in Climate and Environment on a Global scale and in India.
Climate change and mitigation measures:
Clean Development Mechanism, Carbon Trading, examples of Future Clean Technology, Biodiesel, Natural Compost, Eco- Friendly Plastic, Alternative energy, Hydrogen, Bio-fuels, Solar Energy, Wind, Hydroelectric Power, Mitigation Efforts in India and Adaptation funding, Key Mitigation Technologies and Practices, Energy Supply, Transport, Buildings, Industry, Agriculture, Forestry, Carbon sequestration, Carbon capture and storage (CCS), Waste (MSW and Bio waste), Biomedical, Industrial waste, International and Regional cooperation.

**Text Book :**

1. "Global Warming and Climate Changes Transparency and Accountability (Vol. 3)", Gopal Bhargava, Gyan Publishig House 2004.

**Reference Books :**

1. "Environmental Engineering Vol-II", S. K. Garg, Revised Edition, Khanna Publisher, New Delhi.
2. "Environmental Engineering", Peavy H.S., Rowe, D.R. and Tchobanoglous, G.. Seventh Edition, Tata
3. McGraw Hill, Latest Edition.
4. "Adaptation and mitigation of climate change-Scientific Technical Analysis", Cambridge University Press, Cambridge, 2006.

## CE 4094 GREEN BUILDINGS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand necessity and role of green buildings
CO2. design green buildings considering water, site and material parameters
CO3. understand passive solar design
CO4. handle construction and maintenance of green buildings
CO5. explain the factors forcing climate change and the extent of anthropogenic influence

**Pre-requisite : Nil**

Introduction to Green Buildings:
Green Buildings, Global warming, requirement of Green Building, Benefits of Green Buildings, Requisites for Constructing a Green Building, sustainable construction focus point: site, water, energy, material, indoor air quality, construction procedures.
Indian Green Building Council:
Introduction to IGBC green homes, Benefits of IGBC, IGBC green home rating system, introduction to USGBC, LEED rating system, procedure to get IGBC certification.

Green Building Design Site issues:
Site analysis and design, site development and layout, Water issues: watershed protection, drainage of concentrated Runoff, water efficiency and conservation, rain water harvesting, water reclamation, Sustainable materials: Reduce / Reuse / Recycle, Natural Sources, concrete, masonry, metals, wood and plastic, finishes.
Passive Solar Design:
Passive solar design, Day lighting, Building envelope, Renewable energy, Construction Process and Maintenance of Green Building: Environmental construction guidelines, building operations and maintenance.
Indoor Environmental Quality:
Significance, design principle, ventilation control, occupant activity control, significance of acoustics.
Economics of Green Homes:
Economics of green buildings, Selecting environmentally and economically balanced building materials, Project cost, Income and expenses.

**Text Books :**

1 "Green homes" by R.K .Gautham, BS publications.
2 "Sustainable building technical manual- Green building design, constructions and operation", Produced by Public Technology Inc., US Green Building Council.
3 "IGBC Green homes rating system" Version 1.0 – A bridged reference guide

**Reference Books :**

1 "Green Building a Basic Guide to Building and Remodeling Sustainably" Tree Hugger Consulting.
2 "Green Building Handbook", Volume 1, Tom Woolley, Sam Kimmins, Paul Harrison and Rob Harrison; E & FN Spon, an imprint of Thomson Science & Professional.

## CE 4096 ENVIRONMENTAL CHEMISTRY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. demonstrate knowledge of global biogeochemical cycles
CO2. understand the basic principles of atmospheric chemistry
CO3. understand the principles of soil chemistry
CO4. understand the physico-chemical properties of water

**Pre-requisite : Nil**

Introduction to environmental chemistry: Global biogeochemical cycles
Atmospheric chemistry: gases, particulate matter; Air pollution and its health effects; Climate change.
Soil chemistry: Physico-chemical properties of soil, Classification of soils and their characteristics, Major nutrients of soil, Biofertiliser and their types, Significance of C: N ratio.
Water chemistry: Physico-chemical properties of water and their significances.

**Text Books :**

1 "Environmental Chemistry", by V. Subramanian, IK International Publishing House Pvt. Ltd., 2011.
2 "Environmental Chemistry", by De, A.K., New Age International (P) Ltd, Publishers, 4$^{th}$ Edition, 2001.
3 "Chemistry for Environmental Engineering and Science", by Sawyer, C.N., MacCarty, P.L. and Parkin, G.F., Tata McGraw-Hill, 5$^{th}$ edition, 2003.

**Reference Books :**

1 "Environmental Chemistry– A Global perspective", by vanloon, G.W. and Duffy, S.J., Oxford University Press, 1999.
2 "Chemistry Theory and Practice", Anastas, P.T. and Warner, J.C., Green Oxford University Press: New York, 1998.

## CE 4131 FUNDAMENTALS OF TRAFFIC FLOW Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. describe the main characteristics of traffic flow
CO2. represent traffic phenomena using different methods and tools
CO3. recognize how traffic congestion starts and propagates
CO4. select and apply appropriate methods and techniques for analyzing traffic-related problems
CO5. interpret and elaborate different type of traffic data

### Pre-requisite: Transportation Engineering-I (CE 3101)

Introductory concepts of traffic engineering, road user and vehicle characteristics, Traffic stream characteristics (Volume, speed, and density), and traffic flow theory basics. Greensheild's and Greenberg's equations. Statistical theories of traffic flow (Poisson arrivals, binomial and negative binomial distributions). PCU concept. Traffic data collection methods - speed, volume, travel time and delay studies. Parking studies. Headway distributions, gap acceptance, critical gap estimation, queuing theory, shock wave. Capacity and LOS of freeway and multilane highways - fundamental concepts, freeway segment analysis, two-way highways. Analysis of signals ansignal design by Webster's method.

**Text Book :**

1 L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers.

**Reference Books :**

1 Khisty & Lal, *Transportation Engineering*, Prentice Hall India.
2 Khanna S.K. and Justo C.E.G. Highway Engineering, Nem Chand & Bros.
3 C. S. Papacostas and P. D. Prevedouros, Transportation Engineering & Planning
4 Introduction to Traffic Engineering by R Srinivasa Kumar, Universities Press
5 P. Chakroborty and A. Das, Principles of Transportation Engineering, PHI.

## CE 4132 URBAN TRANSPORTATION SYSTEMS AND PLANNING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. Justify the need for urban transportation system planning
CO2. Undertake transport surveys followed by a report
CO3. Plan the process of trip generation and distribution
CO4. Justify the need of a modal split
CO5. Prepare the transportation plans for urban mass rapid transit systems

### Pre-requisite : Transportation Engineering-I ( CE 3101)

Introduction: Transport and socio-economic activities, historical development of transport, transportation in cities, freight transportation system, future development of transportation system: BRTS, MRTS, ITS. Urban structure: urban activity system, urban movement hierarchies. Goods movement: broad classes of urban goods movement demand, classification of urban goods movement, methodology of approach to analysis of goods movement, modeling demands for urban goods transport

Classification of roads: arterial roads, secondary or sub-arterial roads, local road, other road: bypass road, outer and inner ring road, express way, freeway types of urban or road systems.

Urban transportation planning: Trip generation analysis, introduction, types of trip, methods of trip generation, trip production statistical analysis, category analysis or cross classification. Mode choice: modelling, influencing factors, socioeconomic characteristic of the trip makers, characteristics of the trip, characteristics of the transportation system, Trip distribution:

Trip distribution: methods of trip distribution, uniform constant factor method, average factor method, fractar method, furness method, growth factor model, gravity model model, tranner's model, opportunity model.

Route assignment: objective of traffic assignment, principle of traffic assignment, assignment technique, all-or-nothing assignment, multiple route assignment, capacity restrain assignment, application of route assignment.

Modal split: factor affecting modal split, modal split in transportation planning process: trip end type modal split modal, Rip interchange modal split modal. trip interchange modal split modal, binary choice model, logit model Land Use and Transport Model: introduction, selection of land use transport model, lowry derivative model, garin-lowry model, matrix operation for simplifying computations. application in india.

**Text Books :**

1. "Traffic Engg & Transportation Planning", by L. R. Kadyali, 4th Ed, Khanna Publishers, 2003
2. "Transportation Planning and Planning", by C. S. Papacostas and P. D. Prevedouros, 3rd Ed, PHI, 2002

**Reference Books :**

1. "Transportation Engg: An introduction", by C. J. Khisty & B. K. Lall, 3rd Edition, PHI, 2006.
2. "Principles of Transportation Engg", by P. Chakraborthy and A. Das, 1st Edition, 2nd reprint 2005.PHI,
3. "Highway Traffic Analysis and Design", by R. J. Salter, ELBS Macmilan, 2nd Edition, 1990.

## CE 4150 TRANSPORTATION AND TRAFFIC ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the importance of geometric design of highway
CO2. know characteristics of traffic flow required for transportation planning and design
CO3. know the characterization of various pavement materials
CO4. understand the principle of design of flexible and rigid pavements.
CO5. understand the construction of highways.

### Pre-requisite : Nil

Introduction: Importance of various modes of Transportation, Road development plans and program, PMGSY, Classification of roads.
Highway Geometric Design: Highway alignment & survey, Importance of geometric design, Highway cross section element, Sight distance, Design of horizontal alignment, Design of vertical alignment, Grade compensation, Summit curve and Valley curve.
Traffic engineering: Road user and vehicle characteristics, Speed flow and density concepts, Microscopic and macroscopic parameters of traffic flow, Traffic studies, PCU, peak hour factor, accident study and analysis
Delay concepts, Highway capacity, Traffic control and regulation devices, Signal, Types of intersections and channelization, Introduction to Intelligent Transportation System
Pavement Materials: Sub-grade soil, aggregates and bituminous materials, materials for paving concrete, modern materials in pavement.
Pavement Design: Types of pavements, Flexible Pavement and Rigid Pavement, Basic Concept of Flexible pavement design, Basic concepts of rigid pavement design.
Highway Construction: Construction of Flexible Pavements, Construction of Rigid Pavements,

**Text Books :**

1 "Principles of Transportation Engineering" By Partha Chakroborty & Animesh Das, 1st Edition, PHI Learning Private Limited-New Delhi.
2 "Highway Engineering" by S. K. Khanna, C. E. G. Justo & A. Veeraragavan, 10th Edition (revised), Nem Chand & Bros., Roorkee, India.

**Reference Books :**

1 "Principles, Practice and Design of Highway Engineering (Including Airport Pavements)" by S. K. Sharma, Revised Edition, S. Chand Publishers.
2 "Principles of Transportation Engineering" By Partha Chakroborty & Animesh Das, 1st Edition, PHI Learning Private Limited-New Delhi.
3 "Pavement Analysis and Design" by Y H Huang, Pearson Prentice Hall, New Jersey, USA, 2004.
4 "Transportation Engineering – An Introduction" by C. J. Khisty and B. K. Lall, 3rd Edition, Prentice Hall.
5 "Traffic Engineering and Transport Planning" by Kadiyali L.R., Khanna Publishers, New Delhi, India, 1997
6 "Guidelines For The Design of Plain Jointed Rigid Pavements For Highways", Third Revision, IRC:58-2011, Indian Roads Congress 2011.
7 "Guidelines For The Design of Flexible Pavements", Third Revision, IRC: 37-2012, Indian Roads Congress July 2012.

## CE 4151 THEORY & APPLICATIONS OF SOIL MECHANICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify the soil types and classify based on index properties
CO2. evaluate the capillarity and permeability characteristics of soils
CO3. determine the seepage pressure in soil
CO4. understand the concept of shear strength of soil
CO5. understand the compaction parameters of soil
CO6. evaluate the bearing capacity of shallow foundations

### Pre-requisite: Engineering Mechanics (ME 1001)

Introduction and Classification: Definition of soil, origin & formation of soil, General types of soil and soil deposits, Cohesive and cohesion less soils. Basic definitions, Relationship & inter-relationships. Index properties of soils & their determination. Classification based on grain size and plasticity characteristics.
Seepage analysis: Introduction to Permeability of soils, Laplace’s equation, Stream and Potential Functions, flow net, characteristics of flow net, graphical method.
Shear strength: Basic concept, Mohr-Coulomb-failure criteria. Methods of determination of shear strength parameters using laboratory and field methods.
Compaction of Soils: Objectives, Measurement of compaction: Determination of OMC & MDD by standard & modified proctor compaction test. Factors affecting compaction, field compaction control.
Types of Foundation & determination of Bearing Capacity of Shallow Foundations: Introduction, Selection of type of foundations, Methods to determine the bearing capacity of soil, Factors influencing bearing capacity of soil including effect of water table, size of footings and eccentricity of loading, plate load test, Floating Foundation

**Text Books :**

1. “Basic & Applied Soil Mechanics” by Gopal Ranjan & ASR Rao, Latest Edition, New Age International Publishers.
2. “Soil Mechanics & Foundation Engineering” by B.N.D Narasinga Rao, Wiley India Pvt Ltd, New Delhi, 1st Ed 2015

**Reference Books :**

1. “Principle of Geotechnical Engineering” by B. M. Das & Khaled, 8th Edition, Global Engineering USA.
2. “Soil Mechanics and Foundation Engineering” by K. R. Arora, Standard Publisher, 2012
3. “Soil Mechanics and Foundation Engineering” by V.N.S. Murthy, CBS Publisher, 2012

## CE 4152 CONSTRUCTION & MANAGEMENT OF PROJECTS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand and apply, basic project management concepts and techniques to achieve project goals.
CO2. learn the optimization of resources in a project
CO3. familiar with the project stakeholders and their roles
CO4. understand the risk assessment and risk analysis
CO5. understand the construction of highways

### Pre-requisite : Nil

Construction Management:
Modern scientific management(Contribution by Fayol , F.W. Taylor , Mayo), Management Functions, Management Styles, SWOT Analysis in construction, Project planning concepts including use of various management tools, Activities during construction mobilization phase including planning of site infrastructure.

Process of human resource management, preparation of project organization chart and staff schedule, duties and responsibilities of Project Manager.
Project Scheduling, Monitoring & Control:
Construction Scheduling, Work break down structure, Preparing resource based schedules including schedule of quantity & invoicing. Estimation & scheduling of construction materials, equipment & manpower. Schedule of direct & indirect cost, cash inflow & outflow including S-curve. Monitoring and Control, Crashing, Resource Leveling, Updating.
Introduction to Risk Management:
Definitions - Risk Management - Risk Assessment and Identification, Risk Analysis. Risk estimation – types of risk and classifications.

**Text & Reference Books :**

1 "Project Management" by K. Nagarajan, New Age International Pvt. Ltd. 2011
2 "Construction Project Management – Planning, Scheduling and Controlling" by Chitkara K.K. , Tata McGraw Hill, New Delhi, 2000.
3 "Construction Project Management" by Kumar Neeraj Jha, Pearson Publication, 2011
4 "Professional Construction Management", Barrie D.S. , McGraw Hill, New York , 1999.

## CE 4153 HYDRAULICS AND WATER RESOURCES ENGINEERING Cr 3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamental concepts of fluid mechanics and apply the basic equations of fluid statics to determine forces on planar and curved surfaces
CO2. know the concept of fluid kinematics, use Bernoulli's equations and estimate the energy losses in pipes
CO3. explain the types of flows and analyze uniform flow calculations in open channels
CO4. learn about various ways of presentation of rainfall data and understand the rainfall abstraction process
CO5. calculate the runoff by various methods, derive the unit hydrograph and importance of flood
CO6. estimate the reservoir capacity

### Pre-requisite: Engineering Mechanics (ME 1001)

Properties of Fluids, Newton's law of viscosity, Newtonian, Types of fluids
Fluid-Statics, Kinematics and Dynamics
Fluid Pressure, Pascal's Law, Manometers, Pressure on Plane and Curved Surfaces, Buoyancy and Float Bodies, Stability of Floating Bodies, Metacentre.
Fluid Motion, Types of fluid Flows, Continuity Equation, Rotational and Irrotational Motion
Bernoulli's Energy Equation, Application of Bernoulli's Energy Equation
Introduction, Types of channels, Classification of flows, energy equation, specific energy, critical depth, Uniform flow, Chezy's equation, Manning's formula, Hydraulically efficient channel section.
Hydrologic cycle, Water-Budget Equation and Applications in Engineering.
Precipitation: Forms and weather systems for precipitation, Measurement, preparation and presentation of rainfall data, Mean precipitation over an area, DAD curve
Abstractions from Precipitation: Different types of abstractions, Evaporation, Evaporimeters, Transpiration, Evapo-transpiration, Interception and Depression storage, Infiltration-process, measurement, Modeling infiltration capacity.
Runoff and Hydrographs: Catchment characteristics, Runoff estimation methods, SCS-CN method for estimation of runoff, Factors affecting runoff hydrograph, Components, Effective rainfall and Unit Hydrograph.

**Text Books :**

1 Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Publications (P) Ltd., 9th Edition, End reprint 2017.
2 Engineering Hydrology by K. Subramanya, Tata McGraw Hill, $4^{th}$ Ed. End reprint 2016.

**Reference Books :**

1 Applied Hydrology by V.T. Chow, D.R. Maidment and L.W. Mays, Tata Mc. Graw Hill, 1st Ed., First Indian Reprint 2010.
2 Water Resources Engineering by L.W. Mays, Wiley Publication, 2nd Edition, First Indian Reprint 2001.
3 Hydraulics & Fluid Mechanics" by P. N. Modi & S. M. Seth, 19th Edition, Rajsons Publication Private Limited.
4 Fluid mechanics" by Frank M. White, 7th Edition, Tata McGraw-hill Publication, New Delhi.
5 Water Resources Engineering Vol. 2, Irrigation Engineering and Hydraulic Structures by S.K. Garg, Khanna Publishers, 33rd Ed. End reprint 2017.

## CE 4154 GENDER & LEGAL ASPECTS IN WATER RESOURCES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. learn the basics of water law, in a context of historical development and evolving recognition of issues related to human and ecological needs of water.
CO2. understand how the policies, laws and judicial approaches tackle the recent water Issues.
CO3. help formulate recommendations/responses that could resolve/avoid disputes.
CO4. emphasize water as a finite common property resource that must be used in public interest.
CO5. understand the legal perspective of Water Resources Management
CO6. undertake critical analysis of water conflict

### Pre-requisite : Nil

Gender Approach to Water Management: Drinking and Domestic Water - Sanitation and Hygiene -Gender Policies in Water Management - Country Experiences
Historical Background and Current Challenges On Legal Aspects: Policy, Law, Bill, Act, Rules, Notifications – Nature of Rights: Natural Rights -Doctrine of Equality – Doctrine of Equitable Apportionment – Public Trust Doctrine -Challenges in Water Management – Physical and Technical Challenges – Social and Economic Challenges - Role of Law in Water Management, Conceptions of Water: Commodity, Service, Human Right
Water Legislation In India: Pre-Constitutional Water Laws – Constitutional Provisions: Article 14, Article 21, Directive Principles of State Policy, Fundamental Duties, Article 262 – Legislative Process: Legislative, Judicial, Executive – Natural Justice – Delegation of Powers - Tribunals – Post-Constitutional Water Laws – National-Level Enactments - Protection of Water Sources – Groundwater – Drinking and Domestic Water Supply – Industrial Use – Water Pollution – Torts and Crimes
Water Governance: Policies And Legal Frameworks: Water Governance and Water Policy – Legal Framework of Water – Substance of National Water Laws – Other key issues – Changing incentives through Regulation - National Water Policy – National-Level Commissions – Irrigation Management Transfer Policies and Activities –Legal Changes in Water Allocation,
Water Conflicts In India: Water conflicts and Tribunals - Contending Water Uses – Equity, Access and Allocation - Water Quality Conflicts - Sand Mining - Micro-level Conflicts, Dams and Displacement – Privatization – Case Studies

**Text & Reference Books :**

1 Singh, Chhatrapati "Water Rights in India," Ed: Chhatrapati Singh. Water Law in India*:* The Indian Law Institute, New Delhi,1992.
2 "Law for Water Management – A Guide to Concepts and Effective Approaches", Ed: Jessica Vapnek, Brace Aylward, Christie Popp and Jamie Bartram, FAO, Rawat Publications, New Delhi, 2011.
3 "Water Conflicts in India – A Million Revolts in the Making" , Ed: K. J. Joy, Biksham Gujja, Subas Paranjape, Vinod Goud, Shruti Vispute, Rourledge, New Delhi, 2008.
4 "Groundwater Management and Ownership‟ , Report of the Expert Group, New Delhi: Government of India, Planning Commission, http : // planning commission.nic.in / reports / genrep / rep_grndwat.pdf, 2007.
5 "Irrigation Management Transfer In India – Policies and Performance", Brewer, J., S. Kolavalli, A. H. Kalru, G. Naik, S, Ramnarayan, K.V. Raju and R. Sakthivadivel, Oxford and IBH Publishing Company, New Delhi,1999.
6 "The Politics of Irrigation Reform – Contested Policy Formulation and Implementation in Asia, Africa and Latin America", Mollinga, Peter P., and Alex Bolding, Ashgate, England, 2004,

7 “Commentaries on The Indian Easements Act, 1882 and Licences”, Row, Sanjiva, $5^{th}$ Edition, Delhi Law House, . New Delhi, 2006.

8 “The Politics of Water – A Survey”, Ed: Kai Wegerich and Jeroen Warner, Taylor and Francis Group, London, 2010.

## CE 4155 FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1. characterize physical, chemical and biological parameters of water and wastewater
CO2. prepare layout plan and design various units for treatment of water
CO3. select and design various units for treatment of wastewater
CO4. characterize solid wastes and select proper methods for their collection, transportation and treatment
CO5. categorize, identify and control the parameters responsible for air pollution
CO6. identify and control the parameters responsible for noise pollution

### Pre-requisite : Nil

Water and wastewater treatment
Physical, chemical and biological characteristics of water and wastewater;
Water Treatment: screening, aeration, coagulation, flocculation, water softening, settling, filtration, disinfection
Wastewater treatment: Primary - screening, grit chamber, skimming tanks, sedimentation; Secondary - Basics of microbiology, classification of secondary treatments, activated sludge process, trickling filter; Tertiary - Removal of nitrogen and phosphorus. Low cost wastewater treatments - oxidation ponds, Septic tank, Imhoff tank.
**Municipal Solid Waste Management**: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse, recycle, energy recovery, treatment and disposal).
**Air Pollution**: Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.
**Noise Pollution:** Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

**Text Books :**

1 “Environmental Engineering (Vol. I) Water Supply Engineering“ by S.K. Garg, Khanna Publishers, 2017.

2 “Environmental Engineering (Vol. II) Sewage Disposal and Air Pollution Engineering" by S.K. Garg, Thirty Seventh edition, Khanna Publishers, 2017.

3 “Environmental Engineering”, H.S. Peavy, D.R. Rowe, & G. Tchobanoglous, Seventh Edition, McGraw Hill, 1985.

**Reference Books :**

1 "Wastewater Engineering: Treatment and Reuse" by Metcalf & Eddy, Inc., 5th Edition, Tata McGraw-Hill, New Delhi, 2013

2 "Process chemistry for water and wastewater treatment" by L.D. Benefield, J.F. Judkins and B.L. Weand, 1st edition, Prentice - Hall Series, 1981.

3 "Biological process design for wastewater treatment" by C.W. Randall and L.D. Benefield, 1st edition, Prentice - Hall Series, 1980.

4 “Unit Operations and Processes in Environmental Engineering” T.D. Reynolds & P.A. Richards, Second Edition, PWS Publishing Company, CENGAGE Learning, 2009.

5 “Introduction to Environmental Engineering” by M.L. Davis & D.A. Cornwell, Fourth Edition, Tata McGraw Hill, 2010.

6 “Manual on water supply and Treatment” by CPHEEO, Ministry of Urban Development, GoI, New Delhi, 2009.

7 "Wastewater Engineering (including air pollution)" by B.C. Punmia, A.K. Jain and A.K. Jain, Laxmi Publications (P) Ltd., 2016.

## CE 4156 ENVIRONMENTAL IMPACT ASSESSMENT OF WATER RESOURCES PROJECTS Cr 3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. appreciate the importance of EIA for water resource projects
CO2. conduct EI studies for different water resource projects
CO3. formulate appropriate environment management plan for sustainable water resources management

### Pre-requisite : Nil

Introduction to EIA
Definition of EIA; History of EIA, Purpose and objectives of EIA, Process of EIA - Screening, Scoping, Impact analysis, Impact mitigation, Reporting, Review, Decision making and Monitoring.
Concept of EIA in water resource projects
Impact identification, Baseline studies, impact prediction and impact assessment for dams and reservoirs, channelization projects, irrigation projects.
Environmental Management Plan
In-stream ecological water requirements - Public participation in environmental decision making – Sustainable water resources development – Environmental monitoring programs.

**Text Books :**

1 "Environmental Impact Assessment of Water Resources Projects", by Canter, L., Lewis Publishers, 1986.
2 "Introduction to Environmental Impact Assessment: A Guide to Principles and Practice", by B.M. Noble, Oxford University Press, USA, 2005.

**Reference Books :**

1 "Methods of Environmental Impact Assessment (The Natural and Built Environment Series)", by P. Morris, 2nd edition, Spon Press, USA, 2001.
2 "Environmental Assessment", by R.K. Jain, L.V. Urban, G.S., Stacey, Harold, E. Balbach, 2 edition, McGraw-Hill Professional; 2001.

## CE 4157 SYSTEM APPROACH IN WATER RESOURCES MANAGEMENT Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO 1. check the consistency of rainfall data and calculate the probability of rainfall over a given return period
CO 2. determine the evaporation, evapo-transpiration and rate of infiltration.
CO 3. estimate the runoff by various methods and derive the unit hydrograph
CO 4. understand groundwater concept as well as properties.
CO 5. analyze well hydraulics for steady and unsteady flow in aquifer.

### Pre-requisite : Nil

System Concepts: Definition, classification, and characteristics of systems - Scope and steps in systems engineering, Need for systems approach to water resources and irrigation.
Financial Analysis of WR System: Basic economic concepts: Present worth future worth, annuities, discounting techniques depreciation, Benefit-cost analysis, Internal Rate of Return
Linear Programming: Introduction to operations research - Linear programming, problem formulation, graphical solution, solution by simplex method - Sensitivity analysis.
Dynamic Programming: Bellman's optimality criteria, problem formulation and solutions - Application to design and operation of reservoirs, Single and multipurpose reservoir development plans.
Simulation: Basic principles and concepts - Random variant and random process - Monte Carlo techniques - Model development - Inputs and outputs - Single and multipurpose reservoir simulation models.

**Text & Reference Books :**

1 "Water Resources Systems", Vedula S, Mujumdar P. P., Tata McGraw-Hill, 2005
2 "Water Resources Systems Planning & Management", Jain S. K., Singh V. P., Elsevirer B. V., 2003
3 "Operations Research CBS Publications and distributions", Hiller F.S and Liebermann G.J., New Delhi, 1992.
4 Lecture Notes to be Provided by the Course Teacher

## CE 4159 SOIL MECHANICS IN WATER RESOURCE PROJECTS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify the soil types and classify based on index properties.
CO2. evaluate the permeability and consolidation characteristics of soils.
CO3. determine the seepage pressure in soil.
CO4. understand the concept of shear strength of soil.
CO5. evaluate stability of earthen slope
CO6. determine the bearing capacity of shallow foundations and load carrying capacity of piles.

### Pre-requisite : Engineering Mechanics (ME 1001)

Formation of soils; origin & formation of soils, weathering process, geological cycles, classification and properties of soil. based on its formation.
Interrelationship and characterization of soil strata; basic soil classification using grain size, Cohesive and cohesion less soils, Relationship & inter-relationships, Index properties of soils and name of the tests used to determine these properties, plasticity chart, soil classification based on IS 1498:1970 , Darcy's law, Discharge velocity, Seepage velocity Laboratory tests to determine Co-efficient of permeability (K), Factors affecting permeability, soil compaction, determination of OMC & MDD by standard & modified proctor compaction test. Zero air void line, Factors affecting compaction, total and effective stress in soil mass, change in effective stress due to surcharge and water table, soil consolidation and soil consolidation soil properties

Seepage analysis: Laplace's equation, Stream and Potential Functions, flow net, characteristics of flow net, graphical method.
Shear strength: Basic concept, Mohr-Coulomb-failure criteria. Methods of determination of shear strength parameters using laboratory and field methods.
Stability of Slopes: Stability of infinite slopes, Swedish and slice method of analysis, stability of homogeneous finite earth slopes without surcharge with steady seepage and under sudden drawdown condition.

Foundation Engineering: Types of foundations, selection of foundation, Bearing capacity of shallow foundation using Terzaghi's equation and IS 6403:1981 method, depth of footing, settlement analysis of footing, introduction to pile foundation, classification of piles based on installation, load carrying capacity of single piles and pile group

**Text Books :**

1 "Basic & Applied Soil Mechanics" by Gopal Ranjan & ASR Rao, Latest Edition, New Age International Publishers.
2 "Soil Mechanics & Foundation Engineering" by B.N.D Narasinga Rao, Wiley India Pvt. Ltd., New Delhi, 1st Ed 2015

**Reference Books :**

1 "Principle of Geotechnical Engineering" by B. M. Das & Khaled, 8th Edition, Global Engineering USA.
2 "Soil Mechanics and Foundation Engineering" by K. R. Arora, Standard Publisher, 2012
3 "Soil Mechanics and Foundation Engineering" by V.N.S. Murthy, CBS Publisher, 2012

## CE 4161 REMOTE SENSING & GIS APPLICATIONS IN WATER RESOURCES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the concept, principle and application of remote sensing.
CO2. know about different types of remote sensing satellites and their features.
CO3. explain the fundamental operations of GIS.
CO4. manage GIS data files and also analyze the spatial and attribute data.
CO5. interpret the application of remote sensing and GIS in various water resources applications.

### Pre-requisite : Nil

**Remote Sensing:**
Introduction – Principle and Types of Aerial Photographs, Scale of a Vertical Aerial Photograph, Map Vs Aerial Photographs, Mosaic, Ground Control, Parallax Measurements for height, Basic concepts and foundation of Remote Sensing – Elements involved in Remote Sensing, Electromagnetic Spectrum, Physics of Remote Sensing, Energy Interactions with Earth Surface Features of Vegetation, Water and Soil, Energy Interactions with Atmosphere, Different types of Satellites

**Geographic Information System:**
Geographic Information System: Introduction, Components of GIS, Fundamental operations of GIS, A theoretical framework for GIS and GIS categories. Types of data representation - Data collection data input and output. Manual Digitizing and Scanning. GIS Data File Management; Layer based GIS, Feature based GIS mapping. Data storage – Raster, Vector and Attribute data storage, Overview of the Data Manipulation and Analysis. Integrated Analysis of the Spatial and Attribute Data.

**Water Resources Applications:**
Land use/Land cover, Rainfall – Runoff relations and runoff potential indices of watersheds, Flood and Drought impact assessment and monitoring. Watershed management for sustainable development and Watershed characteristics – Reservoir sedimentation, Identification of suitable sites for Ground water & identification of sites for artificial recharge structures, Drainage morphometry, water depth estimation and bathymetry.

**Text Books :**

1 "Remote Sensing and Geographical Information systems" by M. Anji Reddy, 3rd Edition, B.S. Publications, 2006.
2 "Remote Sensing and Geographical Information System" by A.M. Chandra, S.K. Ghosh, 1st Edition, Narosa Publishing house, 2007.
3 "Remote Sensing and Image Interpretation" by T.M. Lillesand, R.W. Kiefer and J.W. Chipman, 5th Edition, John Wiley and Sons, 2008.

**Reference Books :**

1 "Fundamental of GIS" by M.N. Demers, 3rd Edition, John Wiley & Sons, 2008.
2 "Concepts and Techniques of GIS" by C.P.Lo Albert and K.W.Yonng, 2nd Edition, Prentice Hall (India) Publications, 2008.
3 "Aerial Photography and Image Interpretation" by D.P. Paine, 2nd Edition, Wiley, Higher Education, 2006.
4 "Basics of Remote Sensing and its applications" by LRA Narayana, 1st Edition, Universities press, 2001.

## CE 6102 CONSTRUCTION ENGINEERING PRACTICES Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. explain concreting in different environment and design the formwork.
CO2. explain Fabrication and erection of structures by special construction methodology.
CO3. explain construction of special structures.

**Pre-requisites: Civil Engineering Materials & Construction (CE 2109), Concrete Technology(CE 3023)**

Concrete construction methods; form work design and scaffolding, slip form and other moving forms, pumping of concrete and grouting, mass concreting (roller compacted concrete), ready mixed concrete.
Various methods of placing and handling concrete, Accelerated curing, hot and cold weather concreting, under water concreting, pre-stressing.
Steel and composites construction methods; Fabrication and erection of structures including heavy structures, Prefab construction, industrialized construction, Modular coordination.
Special construction methods, Construction in Marine environments, high rise construction, Bridge construction including segmental construction.
Incremental construction and push launching techniques, River valley projects.

**Text Book :**

1. "Formwork for Concrete Structures", by Robert L Peurifoy & Garold D.Oberiender, McGraw-Hill, 1996.

**Reference Books :**

1. "Formwork for Concrete", by M.K Hurd, Fifth Edition, Special Publication No-4, (American Concrete Institute, Detroit, 1980).
2. "Guide for Concrete Formwork", American Concrete Institute. Box No 19150, Detroit, Michigan-48219.

## CE 6103 CONSTRUCTION FINANCE MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. make balance sheet of construction accounting.
CO2. choose best alternatives for financial investments and assess financial health of organization in a given environment.
CO3. explain the depreciation, taxation and inflation of any construction project.
CO4. explain the cost elements associated with the contract bidding and tendering.
CO5. understand capital budgeting and working capital management parameters, risks, financial ratios, international finance.
CO6. understand project cash flow

**Pre-requisite: Engineering Economics (HS 2002)**

Construction accounting, Profit & Loss, Balance sheet, Income statement, Ratio analysis, Depreciation and amortization, Engineering economics, time value of money, discounted cash flow, NPV, ROR, PI, comparison, incremental rate of return, benefit-cost analysis, replacement analysis, break even analysis, risks and uncertainty.
Management decision in capital budgeting, taxation and inflation.
Work pricing, cost elements of contract bidding and award, revision due to unforeseen causes, escalation.
Turnkey activities, project appraisal and project yield, working capital management finance. International finance.
Budgeting and budgetary control, Performance budgeting appraisal through financial statements.
Practical problems and case studies, project cash flow.

**Text Books :**

1. "Engineering Economics" by R. Pannerselvam P.H.I, N.D. 2012.
2. "Engineering Economics" by J.L. Riggs., Mc Graw Hill , 1976.

**Reference Books :**

1. "Construction Planning & Management" by U. K. Shrivastava, Galgotia N.D, 2012.
2. "Project Planning, Analysis, Selection, Implementation & Review" by Prasanna Chandra (Tata McGraw Hill Publishing Co Ltd.), 2010.
3. "Essentials of Management" by Harold Koontz and Heinz Weihrich (McGraw Hill).
4. "Principles of Management" by Dr. M.M. Verma and Agarwal, Himalaya Publisher, 2008.
5. "Essentials of Management" by B.P. Singh and J.N Chhabra, South Western College Publishing-1991.
6. "Industrial Engg and Management" by O.P. Khanna, Khanna Publisher - 2008.
7. "Construction Management and Planning" by B. Sengupta and H. Guha Tata Mc Graw Hill, ND 1995.
8. "Principle of Construction Management" by Pilcher, McGraw Hill, 1981.

## CE 6106 CONSTRUCTION METHODS & EQUIPMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. prepare owning and operating cost (rate analysis) of any construction equipment.
CO2. select appropriate construction equipment for different purpose and environments.
CO3. explain the output/ production of equipment.

### Pre-requisite : Construction Planning & Management ( CE 2108)

Construction Equipment: Factors affecting selection of equipment, Owning and Operating Cost.
Construction Equipment fundamentals: Classification of Construction Equipment, Earth moving Equipment, Hauling, Hoisting, Conveying Equipments, Aggregate and concrete production Equipment, Pile Driven Equipment, Cranes.
Analysis of production output and costs of Excavating Equipment, Characteristics and performances of equipment for Earth moving.
Deep excavation support systems: Diaphragm wall, sheet piling, secant pile, contiguous pile, strutting, ground anchors.

**Text Book :**

1. “Construction Planning, Equipment and Methods”, R. L. Peurifoy, P. E Clofford ,J Sehexnayder, P.E., Tata Mc Graw Hill Publishing ,N.D

**Reference Books :**

1. “Construction Equipment and Management” by S.C.Sharma, Khanna Publishers, New Delhi.
2. “Construction Equipment and its Planning and Application”, by Dr.Mahesh Verma ,Metro Politan Book Company, New Delhi.
3. “Construction Planning and Equipment”, by Satyanarayana & Saxena, Standard Publishers Distributors, Edition 3, 1985.
4. “Heavy Construction”, by Vazirani & Chandolu, Khanna Publisher Delhi.

## CE 6113 CONSTRUCTION CONTRACT MANAGEMENT & QUANTITY SURVEYING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the types of contract and common contract clauses.
CO2: understand the role and responsibility of employer, engineer/consultant and contractor.
CO3: learn the process of tendering including evaluation of the bid.
CO4: read working drawings and evaluate the quantity of major civil engineering items.
CO5: understand and carry out rate analysis of civil engineering item

**Pre-requisites: Civil Engineering Materials & Construction (CE 2109), Construction Planning & Management (CE 2108)**

Construction Contracts Management:
Definition, Essential elements of a valid contract, about Indian Contract Act, Classification of contracts, Types of construction contracts, Contract documents, Salient features of the contract, Various important clauses of contracts related to time extension & cost compensation stated in GCC, SCC, ITB, Minutes of pre-bid meeting, addendum etc., Important submittal, Employer's claim, Role & responsibility of Employer, Engineer / Consultant & Contractor, Settlement of disputes including ADR Mechanism, about Indian Arbitration & Conciliation Act, Types of construction claims & its origin, Basic functions of Contract & QS cell in the project.
Tendering (Bidding):
Definition, Tender submission methods : single envelope, two envelope, multiple envelope bidding, Types of tenders including its advantage and disadvantage, Typical stages of tendering process, Important terms in tendering, Presentation of bid & its evaluation. Registration of vendors of the required goods and services and their pre – qualification criteria, preparing prequalification documents. Preparation of tender documents and invitation to bid. Preparation and submission of bids. Procurement of tender documents. Pre- bid conference and site investigation.
Quantity Surveying:
Understanding the Basics of UNITS System, reading of drawings, More on UNITS and Dimensions with Practical Applications. Role of Quantity Surveyor in Pre-construction Stage, during Construction stage and post construction stage, Types of estimation, Steps in estimation process, Various types of date required for determining estimates, Methods of taking off quantities, Standard forms for entering detailed measurements, abstracting and billing. Quantity Calculation for Excavation Works, Footings or Underground works Quantity Calculation for above the Ground Works, Plinth Beams, Columns, SLAB Beams, fishing Works, Brick work calculation, Plaster Calculation (In and out), Painting, Wood Works calculation etc.
Rate Analysis, Rate Analysis for Various Items, Effects of Inflation On profitability. Design of project cost control system. Valuation of properties.

**Text & Reference Books :**


1 "Estimating and Costing in Civil Engineering – Theory and Practical", BY Dutta B. N., UBS Publishers Distributors Pvt. Ltd. , New Delhi, 2002.
2 "Civil Engineering Contracts And Estimates", Patil B. S., University Press , 4th Edition 2015
3 "Construction Contract Claims", Thomas R., Macmillan, London, 1993.
4 "Estimating, Costing Specification & Valuation in Civil Engineering", Chakraborti M., S. Chand Publisher, Calcutta 1999.


## CE 6134 PROJECT QUALITY AND SAFETY MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: identify different techniques of quality control and select the appropriate one for given conditions.
CO2: use different quality standards/ codes in design and construction
CO3: explain safety and various parameters of safety construction.
CO4: manage accident/injuries during construction according to safety standards.
CO5: understand the safety legislation, standards/codes with regard to construction

**Pre-requisite : Nil**

Introduction to quality planning and control of quality during design of structures, Quantitative techniques in quality control, Quality assurance during construction.
Inspection of materials and machinery in process inspection and test, Preparation of quality manuals, check list and inspection report, Establishing quality assurance system.
Quality standards/ codes in design and construction, Concept and philosophy of total quality management (TQM), Training in quality and quality management systems (ISO-9000).
Concept of safety, Factors affecting safety, Physiological, Psychological and Technological, Planning for safety provisions, Structural safety, Safety consideration during construction, demolition and during use of equipment.
Management of accidents/ injuries and provision of first aid, Provisional aspect of safety, Site management with regard to safety recommendations.

Training for safety awareness and implementation, Formulation of safety manuals, safety legislation, standards/ codes with regard to construction, Quality vs. Safety. Case studies.

**Text Books :**

1 "Construction Safety" by Jimmy W. Hinze, Prentice Hall Inc 1997.
2 "Safety Management in Construction" by S. K Bhattacharjee, Khanna Publishers, Latest edition

**References Books :**

1 "Construction Safety and Health Management" by Richard j. coffe, jimmie Hinze and Theo C. Haud, Prentiee Hall Inc 2001.Tamilnadu Factory Act.
2 "Construction Planning and Management" by U. K. Shrivastava, Golgotia Publication.

## CE 6136 BUILDING SERVICES PLANNING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: explain urban planning
CO2: explain functional planning of buildings
CO3: understand different techniques used for optimization of space
CO4: determine fire rating of building construction
CO5: prepare the layout plan of lift & escalator in building as per fire safety rules

**Pre-requisite : Nil**

Components of urban forms and their planning.
Concepts of neighborhood unit, Street system and layout in a neighborhood, Functional planning of buildings.
Optimization of space; Spatial Synthesis graphical techniques, heuristic procedures, formulation of linear and non-linear optimization problem.
Space requirements and relationships for typical buildings, like residential offices, hospitals, etc. Standard fire, fire resistance.
Classification of buildings, means of escape, alarms, Engineering services in a building as a systems, Lifts, escalators, cold and hot water systems, waste water systems, and electrical systems.

**Text Book:**

1. "Environmental Control Systems", by Mooref, McGraw Hill,Inc 1994

**Reference Books :**

1. "Building Services", by Peter R. Smith & Warren G. Jullian, Applied Science Publisher ltd, London.
2. "Hand book of Buildings and Enclosure", by A. J. Elder & Martix Vinder Bary, McGraw Hill Book Co, 1982.
3. "The fire Precautions Act in Practices 1987", by Jane Taylor & Gordon Cooke, Architectural Press, June 1978.

## CE 6142 CONTRACT LAWS AND REGULATIONS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand Contract, Contractual Procedures & Tendering
CO2: understand about claim, compensation, disputes
CO3: understand Arbitration and conciliation
CO4: understand claim settlement and dispute resolution
CO5: perform Estimates and Costing of any Civil Work

**Pre-requisite : Nil**

Definition of Contract, Essential Features of Contract, Types of Contract, their advantages and disadvantages, Conditions of Contract, Special Conditions of Contract. Termination of Contract Arbitration.
Tender, Notice Inviting Tender, Earnest Money Deposit, Security Money & Liquidated Damage,

‘Escalation of Price’ Clauses, Pre & Post Bid Meeting, Work Order, Contract Document, Step by step procedure followed by a Contractor in the preparation of Tender.
Breach of Contract’, Different remedies for breach of Contract, ‘Contingent Contract’, Litigation Void & Voidable Contract, Termination of Contract by Owner, Termination of Contract by Contractor, Procedure takes place after terminating the Contract? Status after the termination, FIDIC Laws, BOT advantages & disadvantages.
Estimate, Basic purposes of estimating, Different Types of Estimate, Steps for detailed estimating for bidding process, Progress Report of Site, Financial S-Curve, Additional Claim, Application for Extension of Time.

**Text & Reference Books :**

1. Contracts and the Laws environment for the Engineers and Architects by Joseph T. Bockrath.
2. Laws relating to Building & Engineering Construction in India by Gajaria G.T.
3. Construction Planning & Management by Dr.U.K.Shrivastava.
4. Construction, Planning & Management by P.S.Galhot.
5. Estimation, Costing & Valuation by B.N.Dutta.
6. Estimation, Costing, Specification & Valuation by M.Chakraborti.
7. Text Book on Estimation & Costing by G S Birde.

## CE 6208 STABILITY OF STRUCTURES Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: analyze and find the critical state of thin plates
CO2: determine critical state of the structural system
CO3: understand the enhance the design analysis process
CO4: evaluate the structural stability of columns, frames

**Pre-requisite : Structural Analysis (CE 2104)**

Torsion of thin walled open sections, warping displacements under pure torsion,-Warping constants for rolled steel section. Strain energy in bending and torsion of members of thin walled open section including the effects of warping. Torsional buckling including the effects of Wagner’s effect, flexural torsional buckling (with centroid and shear centres coincident).
Lateral buckling of beams under pure bending central point load through centre of gravity of the section. Cantilever beams with point load at the free end, Application of Rayleigh-Ritz method.
Beam-columns on rigid supports-concentrated and continuous lateral loads with simply supported and built in-ends. Continuous beam with as axial loads. Application of trigonometric series. In-plane buckling of bars.
Approximate calculation of critical loads for bar structures by energy method- a bar on elastic foundation, a bar with intermediate compressive forces, bar under distributed axial loads, a bar with changes in cross section.
Effects of shearing force on the critical load. Buckling of built-up columns. In-elastic in-plane buckling of columns. Tangent and reduced modulus concept, Shanley’s contribution, elastic critical loads for rigid frames and triangulated structures, stability functions. Bending of thin plate. Buckling of thin rectangular plates in compression, shear and bending.

**Text & Reference Books :**

1. Theory of Elastic Stability by S.P.Timosheko & Gere, McGraw-Hill, 1961
2. Structural Members and Frames by T.V Galambos Prentice-Hall INC, 1968.
3. The stability of Frames by M.R.Horns and W.Merchang Porgamon press, 1965.
4. Elastic Instability by M.Gregory, Spon’s Civil Engineering series,1967.
5. Buckling Strength of Metal structures by F.Bleich, Mc Graw Hill Book co.,1952
6. Structural Stability (Theory and implementation) by W.F. Chen and EM Lui, Elsevier NY

## CE 6209 ADVANCED STRUCTURAL ANALYSIS Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1: understand and apply the concept of energy theorems to solve practical problems
CO2: draw influence line diagrams for indeterminate structures
CO3: analyze beams, trusses and frames using Matrix methods
CO4: perform plastic analysis of frame structures

**Pre-requisite : Mechanics of Materials (CE 2103), Structural Analysis (CE 2104)**

Energy Theorems:
Total potential energy, Complementary Energy, Simple Examples,
Influence line for Redundant Structures:
Muller-Breslau Principle, Influence lines for reaction components, shear force and bending moment for single redundancy
Matrix Method of Analysis:
Introduction to Matrix Methods, Direct Flexibility and Stiffness Methods, Element Flexibility and Stiffness Methods, Problem to be solved for Beams, Pin and Rigid jointed structures, Influence coefficients, Substitute technique, Plane Grids
Plastic Analysis:
Rigid Plastic Theory, Evaluation of fully plastic moments for mono and double symmetric sections, Upper and Lower bound Theorems, Application of upper bound theorem for beams and frames, Combination of mechanisms for simple examples, Load interaction diagram, Characteristics of yield surface

**Text Books :**

1. "Matrix Analysis", by Pandit and Gupta, TMH Company Limited
2. "Matrix and Finite Element Analyses of Structures," by Madhujit Mukhopadhyay and Sheikh Abdul Hamid, ANE Books

**Reference Books :**

1. "Indeterminate Structures", by J. S. Kinney, Addition Wesley Publication Co.
2. "Fundamental of Limit Analysis of Structures", by Manick Selvam, Dhanpat Rai Publication.
3. "Matrix Analysis of Framed Structures", by W. Weaver and J. M. Gere, CBS Publishers

## CE 6211 FINITE ELEMENT METHOD Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the fundamentals of finite element method
CO2: derive and know various types of finite elements and its application
CO3: analyze various structures using finite element method.
CO4: apply finite element method to structural and geotechnical engineering
CO5: develop computer program for finite elements

**Pre-requisite : Engineering Mechanics (ME 2001), Mechanics of Materials (CE 2103)**

Fundamentals of finite element: Equations of Equilibrium, Elements, Degrees of freedom, Stiffness matrices, Different steps involved in finite element analysis, Finite Element modeling, Shape functions, Strain displacement relations, Constitutive relations, Boundary Conditions, Loading type, Solution technique, Convergence criteria
Formulation Techniques: Variation methods, Gelerkin method, Weighted residual methods
One Dimensional Element: Truss element and beam element
Two dimensional Elements: Constant strain triangular element and rectangular element
Three dimensional Element: Tetrahedral element

**Text Books :**

1. “Introduction to Finite Elements in Engineering”, T. R. Chandrupatla and A. D. Belegundu, 4th Edition, Pearson,2012
2. “Concepts and Applications of Finite Element Analysis”, by R. D. Cook, 4th Edition, John Wiley & Sons, 2003.

**Reference Books :**

1. “The Finite Element Method: Its Basics and Fundamentals ”, by O. C. Zienkiewicz, Elsevier; Seventh edition, 2013
2. “Finite Element Procedures”, by K. J. Bathe, Prentice Hall, Second edition, 2007

## CE 6235 SOIL-STRUCTURE INTERACTION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand various theories applicable to SSI
CO2: calculate Contact pressure and settlement under foundations
CO3: calculate earth pressure on different retaining structures
CO4: understand the theories and application methods for modelling the soil structure interaction for various typical field situations.
CO5: know the elastic analysis of pile

**Pre-requisite : Geotechnical Engineering-I (CE 2100)**

Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior.
Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.
Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap. Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis.

**Text Books :**

1. “Foundation Analysis and Design” by J E Bowles- Tata-McGraw Hill
2. “Elastic Analysis of Soil-Foundation Interaction” by Selvadurai, A. P. S Elsevier

**Reference Books :**

1. “Pile Foundation Analysis and Design” by Poulos H. G. and Davis E. H.- John Wiley,1980.
2. “Design Analysis of Beams, Circular Plates and Cylindrical Tanks on Elastic Foundation” by E.S.Melersk.
3. “Beams of Elastic Foundation” by M.Hetenyi, University Michigan Press 1946

## CE 6238 COMPOSITE STRUCTURES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: know the classifications of composite material and its applications.
CO2: know the method of manufacturing processes of composite
CO3: know macro and micro-mechanics of composite material.
CO4: learn the failure theories of composite material.
CO5: design a laminate based on the application

**Pre-requisites: Civil Engineering Materials & Construction(CE 2109), Mechanics of Materials(CE 2103)**

Introduction to composite materials: Definition, Isotropy, Orthotropy and Anisotropy, Lamina, Laminate, Advantages and limitations, Classification and characteristics of Composite materials, Mechanical behaviour of composite material, Manufacture of laminated fiber reinforced composite material.
Macromechanical behavior of lamina: Stress strain relations for anisotropic materials, Stress strain relations for a lamina of arbitrary orientation, Interlaminar stresses.
Micromechanical behaviour of lamina: Volume and mass fraction, Density and void content, Evaluation of elastic moduli: Mechanics of material approach to stiffness.
Micromechanical behavior of laminate: Classical lamination theory: Lamina stress-strain behavior, Stress and strain variation in laminate, Resultant laminate forces and moments, Special cases of laminate stiffnesses.
Strength criterion for an orthotropic lamina: Maximum stress failure criterion, Maximum strain failure criterion, Tsai-Hill failure criterion, Tsai-Wu failure criterion, Hoffman failure criterion.
Bending of laminated plate: Assumptions, Equilibrium equation, Solution technique.
Introduction to the design of composite structures: Design requirements, Material selection and Con figuration selection.

**Text Book :**

1. "Mechanics of Composite Materials", by Robert M. Jones, CRC Press, Second edition, 2015

**Reference Book :**

1. "Mechanics of Composite Materials", by A. K. Kaw, Taylor& Francis-India, Second edition, 2006

## CE 6241 DESIGN OF BRIDGES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand various requirements of bridge design
CO2: select appropriate site for Bridge
CO3: understand different types of sub structure for bridges
CO4: explain construction methods for different types of bridges
CO5: design bearings for bridges
CO6: understand different types of construction joints

**Pre-requisite: Structure Analysis (CE 2104), Design of Concrete Structures (CE 3103)**

Introduction, historical review, engineering and aesthetic requirements in bridge design. Introduction to bridge codes. Economic evaluation of a bridge project, Loading standard, IRC specification, Impact factor.
Site investigation and planning: Scour - factors affecting and evaluation.
Bridge foundations: Open, pile, well and caisson. Piers, abutments and approach structures-reinforced earth structure; Superstructure - analysis and design of right, skew and curved slabs.
Girder bridges: Types, load distribution, design. Orthotropic plate analysis of bridge decks. Introduction to long span bridges - cantilever, arch, cable stayed and suspension bridges. Methods of construction of R.C Bridges.
Various types of bearings and their design.
Pre-stressed concrete bridges and steel bridges Fabrication, Launching & creation. Design and construction of construction joints (use of relevant codes of practice are permitted in the examination).

**Text & Reference Books :**

1. "Design of Bridge Structures", by T. R. Jagadeesh & M. A. Jayaram, 2nd Edition, PHI Learning Pvt. Ltd.
2. "Design of Concrete Bridges", by M. G. Aswani, V. N. Vazirani & M. M. Ratwani, 2nd Edition, Khanna Publishers, New Delhi, 2004.
3. "Essentials of Bridge Engineering", D. J. Victor, Oxford and IBH.
4. "Design of Bridges", N. Krishna Raju, Oxford and IBH.
5. "Concrete bridge Practice: Analysis, Design and Economics", V. K. Raina, Tata McGraw Hill.
6. "Dynamics of Railway Bridges", L. Fryba, Thomas Telford Ltd, April 1996.
7. "Concrete Bridges" by P.E. Mondorf, Taylor & Francis.
8. "Bridge Engineering" by S. Ponnuswamy, Tata Mc Graw Hill.

## CE 6248 PRE-STRESSED CONCRETE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: determine the prestressing force required in beam for a prestressing systems.
CO2: compute losses and deflections of prestressed concrete members.
CO3: compute flexural strength & torsional resistance of prestressed concrete members.
CO4: design End Blocks of a post tensioned prestressed concrete member.
CO5: design continuous prestressed concrete beams.
CO6: design prestressed concrete pipes, mast and railway sleepers

**Pre-requisites: Structural Analysis (CE 2104), Design of Concrete Structures (CE 3103)**

Different systems of pre-stressing, Characteristics of concrete and steel, Other suitable materials, Losses in prestress.
Analysis and design of section for flexure, shear and torsion. Design of compressive member. Limit state design as per IS code. Introduction to Partial prestressing.
Stress distribution in end-block of post tensioned section: Magnel's method, Guyen's method, Rowe's method and IS code method.
Deflection of prestressed structures- short term as well as long term deflections of uncracked and cracked members.
Indeterminate structures- Principles of design of prismatic continuous beams of two and three equal, unequal spans with variable moments of inertia.
Composite construction of prestressed and in-situ concrete.
Design of special structures- Circular tanks, Pipes, Mast, and Railway sleepers.

**Text & Reference Books :**


1. "Prestressed Concrete", by N. Krishna Raju, TMH, New Delhi.
2. "Design of Prestressed Concrete Structure", by T.Y. Lin, Asia Publishing House.
3. "Limit State Design of Prestressed Concrete", by Y. Guyan, Applied Science Publishers.
4. "Prestressed Concrete", by Raja Gopala N., Narosa Publishing House, New Delhi.
5. "Design of Prestressed Concrete Structures" by T.Y. Lin & Ned H. Burns; John Wiley & Sons.


## CE 6303 OPEN CHANNEL HYDRAULICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: analyze uniform flow calculations in open channels
CO2: solve problems on dynamics of gradually varied flow
CO3: solve problems on spatially varied flow
CO4: analyze rapidly varied flow calculations in open channels
CO5: understand the dynamics of gradually varied unsteady flow
CO6: understand the dynamics of gradually and rapidly varied unsteady flow

**Pre-requisite : Fluid Mechanics (CE 2101)**

Uniform flow, determination of roughness coefficients and the factors affecting the roughness, computation of uniform flow, flood discharge, determination of normal depth and velocity, flow in composite roughness; Design of channels for uniform flow in non-erodible and erodible with grassed channels.
Dynamics of Gradually varied flow and classification of flow profile, methods of computation, Dynamics of spatially varied flow - analysis of flow profile and computation by method of numerical integration.
Rapidly varied flow, classification, flow over spillway, Hydraulic Jump, types with characteristics of jump, the surface profile and location of the jump, jumps as energy decapitator, rapidly varied flow through non-prismatic channels.
Unsteady flow, dynamics of gradually varied unsteady flow, solution of unsteady flow equations, rapidly varied unsteady flow, positive and negative surges, flood routing, principle and methods of flood routing.

**Text Books :**

1 "Open Channel Flow", by F. M. Henderson, MacMillan Publishing Company, 1996.
2 "Flow in Open Channel", by K. Subramanya, Tata McGraw Hill, New Delhi.

**Reference Books :**

1 "Flow through Open Channel", K. G. Rangaraju, Tata McGraw Hill, New Delhi.
2 "Open Channel Hydraulics", by V.T Chow, McGraw-Hill Publishing Company, New Delhi, 1993.
3 "The Hydraulics of Open Channel Flow An Introduction", by H. Chanson, Elsevier.
4 "River Hydraulics", Technical Engineering and Design Guides as adapted from the U.S. Army Corps of Engineers, No. 18, New York, ASCE Press.
5 "Engineering Hydraulics", by H. Rouse, John Wiley & Sons.

## CE 6305 ADVANCED FLUID MECHANICS Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1: determine magnitudes of various types of deformations of a fluid element
CO2: distinguish between flow properties and fluid properties
CO3: apply the potential flow theory to determine the lift force on an object (aerofoil)
CO4: obtain the velocity distribution in viscous flow through parallel plates, pipes and calculate the shear stress
CO5: solve laminar boundary layer equations for flow over a flat plate and compute the drag force experienced by the plate
CO6: prevent the boundary layer separation and thereby reducing the drag
CO7: carry out a linear stability analysis and can establish the criteria for a flow to be in stable condition
CO8: identify the causes of turbulence and control these factors; can determine the velocity distribution in turbulent flow and find the drag in turbulent boundary layer flow

### Pre-requisites: Fluid Mechanics (CE 2101)

Preliminary concepts:
Continuum hypothesis, Knudson number, definition of fluids, properties of fluids, kinematic properties or flow field properties ( linear velocity, angular velocity, acceleration, strain rate), transport properties ( viscosity, thermal conductivity, mass diffusivity), Reynolds transport theorem.
Potential flow theory
Types of flow like steady flow, uniform flow, one, two and three dimensional flow, circulation and vorticity, stream function and velocity, potential function, potential flow, standard flow patterns, combination of flow patterns, circulation, Kutta-Joukouski's equation, application of circulation in calculating the lift force.
Viscous flow
Mass conservation equation, momentum conservation equation (Navier-Stokes equation), significance of each term in Navier-Stokes equation, solution of Navier-Stokes equation for Poiseuille flow, Couette flow, and Couette-Poiseuille flow of Newtonian fluids through parallel plates and cylindrical geometry.
Boundary layer theory
Flow over a flat plate, Navier-Stokes equations, scaling analysis, boundary layer equations, similarity transformation, reduction of the PDE to ODE, Blasius solution, momentum-integral equation, solution of the momentum integral equation, drag force on the plate, condition for the boundary layer separation, means for avoiding boundary layer separation.
Stability analysis of laminar flow
Concept of small disturbance stability, outline of a typical stability analysis, wind generated waves, Kelvin-Helmholtz instability, linearized stability of parallel viscous flows, derivation of the Orr-Sommerfield equation, solution of the Orr-Sommerfield equation, comparison of results with experiments.
Turbulent flow
Physical description of turbulence, mathematical description, fluctuations and time averaging, The Reynolds equations of turbulent motion, turbulent kinetic energy equation, the Reynolds stress equation, two dimensional turbulent boundary layer equations, turbulent boundary layer integral relations, velocity profiles: the inner, outer and the overlap layers, dimensionless velocity profiles.

**Text Book :**

1 Viscous Fluid Flow, F. M. White, 2011, Third Edition,Tata Mc Graw Hill, New Delhi.

**Reference Book :**

1 Fluid Mechanics by V.L. Streeter, 1971, New York, McGraw-Hill Book, New York.

## CE 6306 GROUND WATER ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: know groundwater concept
CO2: analyze well hydraulics for steady and unsteady flow in aquifer.
CO3: explain the construction of shallow and deep wells.
CO4: identify modern methods of groundwater exploration.
CO5: describe various methods of artificial recharge of ground water
CO6: explain the concept of ground water management.

**Pre-requisite: Water Resources Engineering (CE 3105)**

Hydrologic cycle, Water balance, Occurrence of ground water: Origin, geological formations as aquifers, type of aquifers, groundwater basins, springs.
Darcy's Law, validity of Darcy's Law permeability, laboratory and field measurement of permeability, groundwater Flow lines.
Well Hydraulics, steady flow to a well, steady radial flow to a well in confined aquifer and unconfined aquifer, unsteady radial flow into a confined aquifer, Non equilibrium Theis equation, Theis method of solution, multiple well system.
Methods of constructions of deep and shallow wells: The percussion (or cable tool) method of drilling, Direct circulation hydraulic rotary method, Down the hole hammer method, well logs-receptivity logging, testing of wells for yield.
Surface and Subsurface investigations of groundwater, Geophysical exploration, Electrical resistivity method, aerial photo interpretation, remote sensing applications to ground water exploration, test drilling.
Artificial recharge by water spreading, through pits and shaft, recharge through other methods.
Groundwater management: Concepts of Basin management, Equation of hydrologic equilibrium, groundwater basin investigations, conjunctive use of surface and groundwater.

**Text Book :**

1. "Groundwater Hydrology", by D. K. Todd, John Wiley and Sons.

**Reference Books :**

1. "Groundwater and Tube Wells", by S. P. Garg, Oxford and IBH Publishing Co., New Delhi.
2. "Hand book of Applied Hydrology", by V. T. Chow, McGraw-Hill Publishing Company, New York.
3. "Ground Water", by H. M. Raghunath, New Age International Publishers; 3rd edition, Dec 2007.

## CE 6307 REMOTE SENSING & GIS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: Understand the concept, principle and application of remote sensing
CO2: know the various types of platforms and sensors used in remote sensing
CO3: interpret satellite images
CO3: Explain the fundamental operations of GIS
CO5: Manage GIS data files and also analyze the spatial and attribute data

**Pre-requisite : Surveying & Geomatics (CE 2107)**

Introduction to Remote Sensing system: data acquisition and processing, Applications, Multi concept in remote sensing.
Physical Basis of Remote Sensing: EMR nature, definition, nomenclature and radiation laws. Interaction in atmosphere-nature, its effects in various Wave-length regions, atmospheric windows; Interaction at ground surface soils Geometric basis of interaction.
Platform and Sensors: Terrestrial, aerial and space platforms, Orbital characteristics of space platforms, sun-and geo-synchronous; Sensor systems-radiometers, opto-mechanical and push broom sensor.
Resolution : spectral, spatial, radiometric and temporal; IFOV, FOV, GRE; geometric characteristics of scanners, V/H and S/N ratio; Data products from various air and space borne sensors-aerial photographs, LiDAR, Landsat, SPOT, IRS, ERS, IKONOS etc.
Image Interpretation: elements of interpretation; digital image processing and interpretation, Field verification.
Geographical Information systems: components of GIS-data acquisition, spatial and attribute data, pre-processing, storage and management; data structures raster and vector data.
GIS analysis functions: Errors and corrections; data presentation and generation of thematic maps.

**Text books :**

1. "Remote Sensing and GIS", by Basudev Bhatta, Oxford, 2013
2. "Remote Sensing and GIS", by M. Chandra and S. K. Ghosh, Narosa Pub, 2007.
3. "Surveying Volume -2" by S. K. Duggal, Third Edition, Tata Mecgraw Hill- 2011.

**Reference Books :**

1. "An Introduction to GIS", by I. Heywood, S. Cornelius and S. Carver, 2nd Ed, Pearson Education, 2002.
2. "Fundamentals of Remote Sensing", by George Joseph, Universities Press, Second Edition-2011.
3. " Advanced Surveying- Total station, GIS, Remote Sensing" by Satheesh Gopi, R. Sathikumar, N. Madhu, Peareson Eduction-2007
4. "Remote Sensing and Image Interpretation", by T. M. Lillisand, R. W. Kaifer & J. W. Chipman, 6th Edition, John Wiley and sons Inc, Nov 2007.
5. "Remote Sensing and its Applications", by LRA Narayan, Universities Press-2012

## CE 6309 ADVANCED HYDROLOGY Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1: gain an understanding of advanced hydrological processes and techniques necessary for tackling engineering and environmental problems, such as predicting design floods
CO2: apply techniques for hydrology study
CO3: measure and analyze the rainfall data
CO4: explain evaporation, transpiration and Infiltration
CO5: measure runoff
CO6: apply advanced computer models for hydrological prediction.

**Pre-requisites: Fluid Mechanics (CE 2101), Surface Hydrology & Hydraulics (CE 2102)**

Hydrologic Principles - hydrologic cycles and weather parameters, Atmospheric Water, hydrologic losses; Hydrologic Process, Reynold's transport theorem, continuity equation, momentum equation, and energy equation;, rainfall-runoff, hydrograph analysis, unit hydrograph theory, synthetic unit hydrograph, Flood, Methods of Flood Estimation, Flood Routing, Lumped Flow Routing, Hydrologic Reservoir Routing, Modified Pulse Method, Goodrich Method, Hydrologic Channel Routing, Muskingum method, Distributed Flow Routing, Hydraulic Flood Routing,; Saint-Venant Equations, Hydrologic Statistics - statistical parameter estimation, probability distribution, goodness of fit, concepts of probability analysis, frequency analysis, Markov process, Probability Distribution, Markov chain and reliability analysis; Philosophy of Mathematical Models of Watershed Hydrologic Simulation Models.

**Text & Reference Books :**

1. Applied Hydrology by Ven Te Chow, David R. Maidment and Larry W. Mays, Tata McGraw Hill Education (India) Private Limited
2. Engineering Hydrology by K. Subramanya, 4th Edition, Tata Mc-Graw hill, New Delhi.
3. Principles of Hydrology by R.C. Ward and M. Robinson, 4th Edition, Mc-Graw Hill, New Delhi.
4. "River Hydraulics, (Technical Engineering and Design Guides as adapted from the U.S. Army Corps of Engineers, No. 18) New York", ASCE Press.
5. "Engineering Hydraulics", by H. Rouse, John Wiley & Sons.

## CE 6310 WATER RESOURCES SYSTEMS ANALYSIS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: develop a simulation model related to water resources planning.
CO2: explain reservoir operation, planning and management of water resources projects.
CO3: explain economics for hydro-systems, water pricing and allocation policies.

**Pre-requisite : Water Resources Engineering (CE 3105)**

Water Resources System, Fundamentals of System Analysis: Financial Analysis of WR Projects, Optimization techniques; linear programming, non—linear programming, geometric programming, dynamic programming, Network flow algorithm and Goal programming. Introduction to modern heuristic methods like generic algorithm and simulated annealing, Sequencing and Scheduling, Systems concepts and its application in irrigation, flood control, hydropower generation, water supply and drainage storage-yield analysis, Rule curves, Reservoir sizing, Multi-reservoir systems, Real time operation, water conflicts.

**Text & Reference Books :**

1. Water Resources Systems Planning & Management, S. K. Jain & V. P. Singh, Elsevier Science B.V
2. Managing Water Resources: Methods and Tools for a Systems Approach by S. P. Simonovic, UNESCO Publishing, France, 2009.
3. Water Resources Systems: Modeling Techniques and Analysis by S. Vedula and and P. P. Mujumdar, Tata McGraw Hill, New Delhi, 2005.

## CE 6332 RIVER ENGINEERING & SEDIMENT TRANSPORT Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: know about river morphology in respect of engineering, sediment and river regulation systems
CO2: understand analytical and numerical modeling of river morphology and sediment transport
CO3: explain the design of stable channels and river engineering works
CO4: governing equations of sediment transport
CO5: explain about various models of sediment transport
CO6: understand sediment transport measurement, sedimentation in reservoirs and its computational methods

**Pre-requisites: Surface Hydrology & Hydraulics (CE 2102), Water Resources Engineering (CE 3105)**

River Flow hydrology, Flow Characteristics (Laminar and Turbulent Flows), Velocity Distribution, Bed Shear Stress, Depth — Discharge Relationship).
Sediment Sources and Sediment Characteristics: Initiation of Motion of Sediment Transport, Mode of Sediment Transport, Estimation of Sediment Transport and Alluvial Roughness: (Flow Regimes and Bed Forms, Sediment Transport Formulas for Bed Load and Total Load, Suspended Load Formula, Alluvial Channel Roughness.
Design of Stable Channels, Flow and Sediment Transport Measurements, Waterways Engineering Works: (River Engineering Works, Flow Regime Control Structures, Sediment Control Devices for Intake Structures).
Modeling of Sediment Transport and River Morphology: Governing Equations of Flow and Sediment Transport, Propagation of Bed Forms, Analytical Models of Sediment Transport and River Morphology. Numerical Models of Sediment Transport and River Morphology, Accuracy and Stability of Numerical Models.

Sedimentation in Reservoirs: Distribution of Sediment Deposition in Reservoirs, Erosion of Sediment Deposits in Reservoirs, Computation of Sedimentation Volume in Reservoirs, Sedimentation Distribution in Reservoirs.

**Text & Reference Books :**

1. K.D. Gupta, River Engineering, Vayu Education of India, 2014.
2. P.Y. Julien, River Mechanics, Cambridge University Press, 2002.
3. C.T. Yang, Sediment Transport: Theory and Practice, Mcgraw-Hill, 1996.
4. A.A. Khan and W. Wu, Sediment Transport: Monitoring, Modeling and management, Earth Sciences in the 21st Century, NOVA Science Publishers, 2013.

## CE 6342 WATER POWER ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: explain the classifications of water power plants based on various parameters
CO2: design different components of hydroelectric scheme effectively and economically
CO3: explain the construction process of hydro power development project
CO4: understand the theory of water hammer and types of surge tanks
CO5: select different types of turbines according to head, specific speed and casing

**Pre-requisites: Fluid Mechanics (CE 2101), Water Resources Engineering (CE 3105)**

Concept of water power Engineering, Different heads such as Gross head, Effective head, Design head, rated head, critical head, classifications of water power plants based on hydraulic characteristics, topography, head, capacity of plant, load etc. Major hydroelectric schemes in India.
Planning a site selection of hydropower projects according to availability of Quantity and head of water , estimating of power potential using Mass curve and flow duration curves Economics of water power plants load factor, capacity factor, load curve, effect of pondage on flow duration curve. Estimation of unit cost of hydro power and comparison with unit cost of stream power station, General planning of hydropower projects.
Various types of intake structures. Penstocks of steel pipes economic diameter, number of penstocks wall thickness of steel penstocks, shell theory of design, welded and riveted steel pipes, Accessories of penstocks. Expansion joints anchor blocks and pipe supports. Tunnels. Dimensions and shape economic size of tunnel, Tunnel lining.
Theory of water hammer, Arithmetic integration and graphical method of analysis, surge tanks and types of surge tanks theory of simple surge tank and design, Mathematical treatment f water surface oscillations including friction. Pressure relief valves stability of surge tank. Thoma formula, Balancing reservoir and fore bays Pressure.
Selection of type of turbines according to head & specific speed, various types casing of turbines. Determination of their shapes, main relative dimension of runner. Draft tube, its functions, draft tube theory. In take conduits, Preliminary power house dimensioning, general arrangement of power house.

**Text Book :**

1. “Water Power Engineering”, by M. M. Dandikar & K. N. Sharma, Vikas Publication, 1979.

**Reference Books :**

1. “Water Power Engineering”, by H.K. Barrows 2nd Edition, McGraw-Hill, London, 1934
2. “Irrigation Water Resource & Water Power Engineering”, by P. N. Modi, Standard Book House Dec 2008

## CE 6347 ADVANCED IRRIGATION ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the student will be able to:

CO1: understand and identify different types and methods of irrigation
CO2: design different surface and sub-surface irrigation methods
CO3: use different types of flow measurement instruments
CO4: explain the fundamentals of surface irrigation hydraulics
CO5: design drainage system
CO6: know salt and water balance within the root zone

**Pre-requisite: Water Resources Engineering (CE 3105)**

Introduction, objectives of irrigation, type of irrigation and suitability, selection of irrigation method

Irrigation requirement, water balance, soil water relationships, water storage zone, Flow of moisture through root zone, soil physical and chemical properties.
Crop evaporative and drainage requirements, irrigation efficiency and uniformity, Surface irrigation systems, types of surface systems, basin irrigation, border irrigation, furrow irrigation, sprinkler irrigation.
Field measurement techniques, flow measurement, flumes, weirs, irrigation events, advance, wetting, depletion and recession phases.
Infiltration, infiltrometer, ponding methods, soil water, tensiometers, neutron probe, time domain reflectometer, evapotranspiration, crop coefficient, leaf area index, evapotranspiration estimation.
Fundamentals of surface irrigation hydraulics, continuity equation, momentum equation, Hydrodynamic model, zero inertia model and kinematic wave model.
Drainage principles, need for drainage, steady state equations, Hooghoudt, Kirkham, Dagan and Ernst equations.
Salt balance, water and salt balance of the root zone, salt equilibrium equation and leaching requirement, leaching efficiency.

**Text Books :**

1. “Irrigation Engineering and hydraulics structures” by S. K. Garg, Khanna Publishers, 25$^{th}$ Edition.
2. “Irrigation theory and practice”, A.M. Michael, Vikas Publishing House Pvt. Ltd, 2$^{nd}$ Edition, 2009.
3. "Irrigation Water Management Principles and Practices", by Majumdar D. P., Prentice Hall of India, New Delhi, 2004.

## CE 6405 ADVANCED SOIL MECHANICS Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1: know the fundamental concepts of soil formation and its subsequent effect on geotechnical properties of soil.
CO2: understand clay behavior in terms of its mineralogy
CO3: understand cohesionless soil and its properties in terms of its composition.
CO4: perform seepage analysis
CO5: interpret consolidation test data and subsequent analysis of one dimensional vertical settlement

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II (CE 3107)**

Introduction: Origin of soil and its types, mineralogy and structure of clay minerals, X-ray and Differential Thermal Analysis; structure of coarse grained soil, behaviour of granular and cohesive soils with respect to their water content
Consolidation: Steady State flow, 2D and 3D seepage, transient flow; Compressibility and rate of consolidation, one, two, and three dimensional consolidation theories; Sand drains
Critical state soil mechanics: Critical State Line, Hvorslev Surface, Yield Surfaces: Modified Cam-clay and Original Cam-clay; Elastic and plastic analysis of soil: Constitutive relationships of soil; failure theories. Limit analysis-Upper bound theorems, lower bound theorems, limit equilibrium methods.
Soil Stabilization: Classification of stabilizing agents and various stabilization processes, Nature and surface characteristics of soil particles; Concepts of surface area and contact points; Inorganic stabilizing agents; Strength improvement characteristic of soft and sensitive clay, Marine clay and waste material.

**Text Books :**

1. Das & Sobhan, Principles of Geotechnical Engineering, 8th Edition, 2016

2 Holtz,Kovacs & Sheahan, An Introduction to Geotechnical Engineering, Second Edition,2011

**Reference Books :**

1 R.O. Davis and A.P.S. Selvadurai, Elasticity and Geomechanics, Cambridge University Press, New York, 2002
2 Mitchell, James K, Fundamentals of Soil Behaviour, John Wiley and Sons, 2005.
3 D.M. Wood, Soil Behaviour and Critical State Soil Mechanics, University of Glasgow, 1991 CE

## CE 6407 FOUNDATION ENGINEERING: PRINCIPLES AND PRACTICES Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1: understand the concepts of deformations and strains in a body when subjected to stresses
CO2: learn about stress and strain transformations in a 3D field
CO3: understand the results using theory of elasticity approach and compare with SOM approach for different types of structural problems
CO4: understand the fundamentals of plasticity theory

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II(CE 3107)**

Introduction to Foundation Design:
Motivation for using Different Foundation Types, Issues to Consider in Design**,** Shear Strength of Soils, and Application to Foundation Analysis, Subsurface Sampling and Characterization Methods, and Application to Foundation Design.
Shallow Foundations:
Bearing Capacity Analysis, Concept of upper and lower bound solutions, Undrained analyses (simple circular arc, theories of Prandtl and Reissner), Drained analyses (Terzaghi's theory), Special factors (for depth, slope, inclined load, shape, layered soils, anisotropy), Overview of settlement analysis methods on clay and sand, Induced stress beneath the foundations, Balancing bearing capacity and settlement in design, Strategies to mitigate the effects of expansive soils on foundations
Structural and Geotechnical design of spread footings and mat foundations, Design for eccentric or moment loads
Deep Foundations:
Types and their definition, Load transfer, Pile Foundations, Pile types and deterioration issues, Pile driving and allowable stresses, Axial load capacity by static and dynamic load tests, piles bearing on rock, downdrag of piles, uplift capacity of piles, lateral load capacity, group action in piled foundation, pile group in coarse-grained and fine grained soil, effect on pile groups of installation, Structural issues and design, Construction, inspection, specifications and case histories,
Other types of foundations (micro piles, helical anchors, anchors, soil nails, drilled shafts, caissions etc.)

**Text Book :**

1 P.C. Varghese, Foundation Engineering, Ninth Edition, 2012

**Reference Book :**

1 H. G. Poulos, E. H. Davis, Pile foundation analysis and design, Wiley, 1980.

## CE 6412 GEOTECHNICAL STABILITY ANALYSIS Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1: know the fundamentals of finite element method
CO2: derive and know various types of finite elements and its application
CO3: analyze various structures using finite element method
CO4: apply finite element method to structural and geotechnical engineering
CO5: develop computer program for finite elements
CO6: know commercial finite element software for engineering solutions

**Pre-requisites: Geotechnical Engineering-I(CE 2100), Geotechnical Engineering-II(CE 3107)**

Landslide phenomenon: Types and causes of slope failures, Practical applications, case studies
Analysis of slope stability: Stability analysis of infinite slopes with or without water pressures ; Stability analysis of finite and Infinite slopes: concept of factor of safety, pore pressure coefficients, important details of stability analysis, Mass analysis, Wedge methods, friction circle method ; Method of slices, Bishop's method, Janbu's method ; Effect of seepage, submerged and sudden draw down conditions
Seismic slope stability: pseudo-static screening analysis, determination of peak acceleration, shear strength for pseudo-static analysis, post-earthquake stability analysis
Slope stabilization: factors governing selection of method of stabilization, drainage, retaining structures, reinforcing piles and drilled shafts, injection methods, vegetation, repair of failed slopes.

**Text Books :**

1. Chowdhury R.& Bhattacharya, Geotechnical Slope Analysis, CRC press , 2009
2. L. W Abramson, T. S Lee, S Sharma and G M Boyce, Slope Stability and Stabilization Methods, Willey Inter science publications, 2002

**Reference Books :**

1. T W Lambe and R V Whitman, Soil Mechanics, John Wiley & sons, 1979
2. Soil Strength & slope Stability, Duncan, Wright & Brandon,2nd Edition,2016

## CE 6431 SOIL EXPLORATION AND FIELD TEST Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: identify sources of subsurface information
CO2: report relevant field reconnaissance information for soil investigation
CO3: perform all the relevant laboratory and field test on soil
CO4: prepare log soil samples and prepare bore-hole logs for civil engineering projects.

**Pre-requisite: Geotechnical Engineering-I (CE 2100)**

Course Content
General principles of exploration: Methods of exploration; Boring: Different types of borings.
Sampling methods: Surface sampling, sampling from boreholes and core boring in soils; Boring and sampling records.
Soil profile: Pore pressure measuring devices for laboratory and field use; Earth pressure cells.
Vibration-meters: Pickups and generators for vibration study of machine foundations; Load measuring devices; Settlement measurements in field.

**Text & Reference Books :**

1. V N S Murthy, Principles of Soil Mechanics and Foundation Engineering, UBS Publishers Private Ltd, 2002.
2. B M Das, Principles of Geotechnical Engineering, Thomson Brooks/Cole,

## CE 6435 FINITE ELEMENT METHOD IN GEO-MECHANICS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO 1: understand the importance of numerical modeling in geotechnical engineering
CO 2: learn to solve the solution of linear and non-linear systems of equations
CO 3: learn finite element formulation, discretization and meshing.
CO 4: model soil response
CO 5: model soil by considering compressibility, yielding, hysteresis

**Pre-requisites: Mechanics of Materials (CE 2103), Structural Analysis (CE 2104), Geotechnical Engineering-I (CE 2100)**

Introduction: The Continuum, Equations of Equilibrium, Boundary Conditions, Strain displacement relations, Stress strain Relations, Plane stress and plane Strain problems, Different methods of structural analysis including numerical methods. Basics of finite element method (FEM), different steps involved in FEM, Different approaches of FEM, Direct method, Energy approach, Weighted residual Method.
One and Two Dimensional Problems: Detail formulation including shape functions. stress strain relations, strain displacement relations and derivation of stiffness matrices using energy approach, Assembling of element matrices, application of displacement boundary conditions, Numerical solution of one dimensional problems using bar, truss, beam elements and frames. Derivation of shape function using Lagrange's interpolation, Pascal's triangle, Convergence criteria, Finite Element modelling of two dimensional problems using Constant strain Triangle(CST) elements, Stress strain relations for isotropic and orthotropic materials, Four nodded rectangular elements, axisymmetric solids subjected to axisymmetric loading.
Isoparametric Elements: Natural coordinates, iso-parametric elements, four nodes, eight node elements, Numerical integration, order of integration
Plate Bending: Bending of plates, rectangular elements, triangular elements and quadrilateral elements, Concept of 3D modelling

**Text Books :**

1. R. D. Cook, Concepts and Applications of Finite Element Analysis, John Wiley 2002(4th)
2. O. C. Zienkiewicz and R. L. Taylor, Finite Element Method, McGraw Hill- 1977

**Reference Books :**

1. D. L Logan, A First Course in the Finite Element Method, PWS Publishing, Boston-1997
2. C. S. Krishnamoorthy, Finite Element Analysis-Theory and Programming, Tata McGraw Hill-1995.

## CE 6436 TUNNEL ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: make investigation for tunnel work
CO2: design tunnels
CO3: understand tunneling techniques

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Design of Concrete Structures(CE 3103)**

Site investigations, Geotechnical Considerations of tunneling.
Design of Tunnels.
Construction & Excavation methods, soft ground tunnels, Rock tunnels.
Micro tunneling techniques, Tunnel support design.
Ventilation of tunnels, tunnel utilities, safety aspects.

**Text & Reference Books :**

1. "Tunnel Engineering Handbook" by J O Bickel & T R Kuesel, Chapman & Hall, New York,2$^{nd}$ edition,1996.
2. "Rock Mechanics Design in Mining & Tunneling" by Z T Bieniawski, Balkema Publication, Sept 1989.
3. Ramamurthy, T. Engineering in Rocks for Slopes, Foundations and Tunnels, PHI Learning Pvt. Limited, 2010.

## CE 6437 GEOSYNTHETICS & REINFORCED EARTH STRUCTURES Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: develop an understanding of the fundamental concepts that govern the behavior of soils reinforced with geosynthetics.
CO2: provide design guidance for allowable tensile strength, vertical reinforcement spacing, length of reinforcement, drainage, seismic loading issues, and different facing systems.
CO3: know the composition, properties and functions of Geosynthetics
CO4: understand the applications of Geosynthetics in reinforced earth structures
CO5: design geosynthetic-reinforced steep slopes and walls.

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II(CE 3107)**

Historical background; Principles, concepts and mechanism of reinforced earth
Design consideration for reinforced earth and reinforced soil structures
Geosynthetics-their composition, manufacture, properties, functions, testing and applications in reinforced earth structures
Design of reinforced soil structures like retaining walls, embankments, foundation beds etc.; Designing for Separation, Filtration, Drainage and Roadway Applications; Designing for Landfill Liners and Barrier Applications; Case histories of applications

**Text Books :**
1. Clayton, C.R.I., Milititsky, J. and Woods, R.I., Earth Pressure and Earth Retaining Structures, Blackie Academic & Professional, 1993.
2. Ingold, T, Reinforced Earth, Thomas Telford Ltd., 1982.
3. G. L. Sivakumar Babu, An Introduction to Soil Reinforcement and Geosynthetics, Universities Press, India, 2006
4. Swami Saran, Reinforced Soil and Its Engineering Applications, I. K. International Pvt Ltd, 2005

**Reference Books :**
1. Jones, C.J.F.P, Earth Reinforcement and Soil Structures, Butterworth, 1985.
2. Koerner, R.M, Designing with Geosynthetics , Prentice Hall, 1993

## CE 6443 ROCK MECHANICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: critically review rock mechanics principles and methods and their applications to engineering practices.
CO2: measure the physical characteristics of rock masses, including the engineering description of rocks, discontinuities and rock mass; the strength of rock substance, defects and rock mass; laboratory testing of rock, data presentation.
CO3: analyze stresses under gravitational and imposed loads for rock engineering applications.
CO4: predict the response of rock masses to loading (and unloading).
CO5: analyze rock slope stability and foundations on rock.

**Pre-requisite: Geotechnical Engineering-I (CE 2100)**

Introduction: Development of Rock Mechanics, Applications of Rock Mechanics
Laboratory Testing : Rock sampling, Determination of density, Porosity, Water absorption, Uniaxial compressive strength, Tensile strength, Shear strength, Flexural strength, Swelling and slake durability, permeability and point load strength, Triaxial compressive test. Factors affecting strength and deformation of rocks.
Classification: Rock mass classification, Rock Quality Designation, Rock Structure rating, Geomechanics and NGI classification systems.
Field Testing of Rock Masses: In-situ determination of shear strength, permeability and modulus of deformation, Plate load test, Radial jacket test, Goodman jack test, Dialometer test.
Geophysical methods - Seismic Refraction & Electrical Resistivity methods
Methods of Improving Rock Properties: Rock reinforcement & Rock bolting.

Stability of rock slopes: Modes of failure, Methods of analysis, Prevention and control of rock slope failure, Monitoring and maintenance.
Foundation on Rocks: Shallow foundations, Pile and Well Foundations, Basement Excavation, Foundation construction, Allowable bearing pressure.

**Text & Reference Books :**

1 "Introduction to rock Mechanics" by R .E .Goodman; John Wiley & Sons.
2 "Manual on Rock Mechanics" by Central Board of Irrigation and Power.
3 "Hand Book Mechanics properties of Rock" By R . D. Lama and V. S. Vulukuri Vol. I to IV.
4 "Rock Mechanics for Engineers" – B. P. Varma, Khanna Publications
5 "Rock Mechanics and Hydraulic Structures" – Obert and Duvall (1967) John Viley and Sons Ind.
6 "Rock Mechanics in Engineering Practice" – Stag and Zienkiewec (1968) John Viley and Sons Ind.
7 "Foundation Engineering Hand Book" by Winterkorn H.F. and Fang H.Y , Van Nostand Reinhold Company, 1975
8 Relevant Indian Standards

## CE 6445 PAVEMENT ANALYSIS AND DESIGN Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: explain the principles and factors affecting pavement design.
CO2: know the traffic considerations in pavement design
CO3: analyze and design flexible pavement using empirical and mechanistic empirical methods.
CO4: design rigid pavements using IRC, AASHTO and other important methods of design.
CO5: design overlay on existing pavement based on the structural evaluation BBD and FWD.

**Pre-requisites: Geotechnical Engineering-I (CE 2100) Transportation Engineering-I (CE 3101)**

Principles of Pavement Design: Types of Pavements, Concept of pavement performance, Structural and Functional failures of pavements, Different types of pavement performance criteria, Different pavement design approaches, General framework for pavement design.
Traffic Considerations in Pavement Design: Vehicle types, Axle configurations, Contact shapes and contact stress distributions, Concept of standard axle load, Vehicle damage factor, Axle load surveys, Lateral placement characteristics of wheels, Estimation of design traffic.
Analysis of Flexible Pavements: Selection of appropriate theoretical models for analysis of flexible and concrete pavements, analysis of layered flexible pavement systems using linear elastic layered theory, Discussion of the need for use of advanced analytical techniques for flexible pavements, Discussion of different softwares available for analysis of flexible pavements.
Flexible Pavement Design Methods: Detailed discussion of different methods of design of flexible pavements, Indian Roads Congress guidelines - IRC:37, American Association of State High and Transport Officials (AASHTO) - 1993 method, TRRL Design method, brief discussion of salient features of the AASHTO 2002 draft design guidelines for flexible pavements, Comparison of design concepts adopted in different approaches.
Analysis of Concrete Pavements: Discussion of different theoretical models for analysis of different types of concrete pavements, Analysis of wheel load stresses, curling/warping stresses due to temperature differential, critical stress combinations, Discussion of the need for use of advanced analytical techniques for concrete pavements.
Concrete Pavement Design Methods: Detailed discussion of different methods of design of concrete pavements, Indian Roads Congress guidelines - IRC:58, American Association of State High and Transport Officials (AASHTO) - 1993 method, PCA method, Concept of Continuously Reinforced Concrete Pavement, Brief discussion of salient features of the AASHTO 2002 draft design guidelines for concrete pavements, Comparison of design concepts adopted in different approaches.
Structural Evaluation and Strengthening: Structural evaluation of in-service pavements using Benkelman beam and Falling Weight Deflectometer methods, Overlay design as per Indian Roads Congress guidelines (IRC:115), Overlay design as per AASHTO-1993 guidelines.

**Text Book :**

1. "Pavement Analysis and Design" by Y. H. Huang, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India

**Reference Books :**


1. "Principles of Pavement Design" by E. J. Yoder and M. W. Witczak, Wiley and Sons, New York, USA, 1975.
2. "Specifications for Roads and Bridge Works", Ministry of Road Transport and Highways, Indian Road Congress, New Delhi, India.
3. IRC: 37 (2012) "Guidelines for Design of Flexible Pavements", Indian Road Congress, New Delhi.
4. IRC: 58 (2011) "Guidelines for Design of Plain Jointed Rigid Pavements for Highways", Indian Road Congress, New Delhi.
5. IRC: 81 (1997) "Guidelines for Strengthening of Flexible Road Pavements using Benkel man Beam Deflection Technique", Indian Road Congress, New Delhi.
6. IRC: 115 (2014) "Guidelines for Structural Evaluation and Strengthening of Flexible Road Pavements using Falling Weight Deflectometer (FWD) Technique", Indian Road Congress, New Delhi.


## CE 6446 GEOTECHNICAL EARTHQUAKE ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: know the concept of Geotechnical Earthquake Engineering
CO2: understand seismic design concepts and current practices for shallow and deep foundations, slopes and retaining walls to enable them to plan and direct the construction activity appropriately
CO3: understand the soil dynamic testing procedure and methodology of seismic design to be able to execute a proper design
CO4: explain design methodology and the interpretation in the seismic codes while designing foundations, slopes and retaining walls
CO5: know the performance of Earthquake Geotechnics

**Pre-requisites: Geotechnical Engineering-I (CE 2100), Geotechnical Engineering-II(CE 3107)**

Introduction to Geotechnical Earthquake Engineering. Seismology and Earthquakes, Strong Ground Motion: Parameters and Estimation
Seismic Hazard Analysis: Deterministic and Probabilistic Analyses, Wave Propagation: 1D and 3D
Dynamic Soil Properties: Lab and Field Determination. Ground Response Analysis. Local Site Effects and Design Ground Motions.
Liquefaction;
Seismic Response Analysis of Slopes, Retaining Walls and Shallow Foundations, Case Studies in Earthquake Geotechnics
Performance-based Earthquake Geotechnics – An Introduction, Usage of Softwares;

**Text Books :**


1. Kramer, S. L. (1996). Geotechnical Earthquake Engineering, Prentice Hall, New Jersey, Seventh Impression
2. Bolt, B. A. (2005). Earthquakes: 2006 Centennial Update, W. H. Freeman, New York.
3. Stein, S. and Wysession, M. (2003). An Introduction to Seismology, Earthquakes, and Earth Structure, Blackwell Publishing, Oxford.


**Reference Books :**


1. Towhata, I. (2008). Geotechnical Earthquake Engineering, Springer, Berlin.
2. Ishihara, K. (1996). Soil Behaviour in Earthquake Geotechnics, Clarendon Press, Oxford.
3. Srbulov, M. (2008). Geotechnical Earthquake Engineering Simplified Analyses with Case Studies and Examples, Springer, Dordrecht.
4. Srbulov, M. (2011). Practical Soil Dynamics Case Studies in Earthquake and Geotechnical Engineering, Springer, Dordrecht.

## CE 6449 ADVANCED FOUNDATION ENGINEERING Cr-3

**Course outcome :** At the end of the course, the student will be able to:

CO1: know the concept of machine foundation
CO2: determine the soil parameters for foundations subjected to dynamic loads and its control measures.
CO3: assess the liquefaction potential of soil strata under earthquake condition.
CO4: identify the swelling potential of cohesive soil and its effect on the building, measures to prevent the swelling using various ground improvement and design methods.
CO5: identify the ground improvement techniques to make the soil suitable for the construction of structures.

**Pre-requisites: Geotechnical Engineering-I(CE 2100), Geotechnical Engineering-II(CE 3107)**

Machine Foundations: Types of Machine Foundations, Basic Definitions, Degree of Freedom of a Block Foundation, General criteria for design of Machine Foundations, Free Vibration, Forced Vibration, Vibration analysis of a Machine Foundation, Determination of Natural Frequency, Design Criteria for Foundations of Reciprocating machines, Reinforcement and construction Details, Mass of Foundation, Vibration Isolation and Control.
Liquefaction of foundation soils under earthquakes: Introduction, Liquefaction Phenomenon, Effect of Liquefaction on Build environment, Factors Affecting Liquefaction, Assessment of Susceptibility of a Soil to Liquefaction, Prevention of Liquefaction.
Foundations on Expansive soils: Expansive soils, Identification of Expansive soils, Classification of Expansive soils, Causes of moisture changes in soils, Effects of swelling on buildings, Preventive measures for expansive soils Modification of Expansive soils, Design of foundation in swelling soils, Drilled piers, Belled drilled pier, Under reamed piles, construction of under reamed piles.
Foundation Soil Improvement: Stabilization of soil with granular skeleton, chemical, cement, lime , ash, slag & bitumen, Thermal stabilization, Electrical stabilization, Vibration methods of ground improvement, Drainage methods of ground improvement, Pre-compression and vertical drains, Grouting and injection, Reinforced earth, Use of geotextile & modern materials Ground anchors & soil nails.

**Text Books :**

1. "Advanced Foundation Engineering", by V. N. S, Murthy, First Edition, CBS Publishers & Distributors.
2. "Foundation Analysis and Design", by J.E.Bowles, 5th Edition, McGraw Hill Higher Education, 1997.

**Reference Books :**

1. "Soil mechanics and foundation Engineering", by K.R.Arora. Standard Publisher, 2005.
2. "Geotechnical engineering handbook" by B.M.Das, J.Ross Publishing, Cengage learning.
3. "Principles Of Foundation Engineering" by B.M.Das, 7th Edition, Cengage Learning India Pvt. Ltd, New Delhi.
4. "Reinforced soil and its engineering application" by Swami Saran, Second Edition, I. K. International Publishing House Pvt. Ltd, 2011.
5. "Geotechnical Engineering", by Shashi K. Gulhati & Manoj Datta, Tata Mcgraw Hill Publishing Co Ltd, 2014.
6. "Foundation Engineering", by P.C.Verghese, PHI Learning Private Limited, July 2013.
7. "Ground Improvement Techniques" by P. Purushothama Raj, Laxmi publications Pvt. L, 2005.

## CE 6500 ENVIRONMENTAL IMPACT ASSESSMENT & AUDITING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: identify the roles of EIA and environmental audits
CO2: prepare an EIA Report required to evaluate the environmental sustainability of any project
CO3: conduct an environmental audit and evaluate its result

**Pre-requisites: Environmental Engineering-I(CE 2105), Environmental Engineering-II(CE 2106)**

Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA.
Specialized areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties; Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical, biological and socio-economic environment.
Environmental management plan; Post project monitoring, EIA report and EIS; Review process.
Case studies on project, regional and sectoral EIA; Legislative and environmental clearance procedures in India and other countries, Sating criteria; CRZ; Public participation.
Resettlement and rehabilitation. Environmental auditing.

**Text Books :**

1. "Introduction to Environmental Impact Assessment: A Guide to Principles and Practice", by B. M. Noble, Oxford University Press, USA, 2005.
2. "Introduction to Environmental Impact Assessment: Principles, and Procedures, Process, Practice and Prospects (The Natural and Built Environment Series"), by J. Glasson, Routledge; 3rd edition, 2005.

**Reference Books :**

1. "Methods of Environmental Impact Assessment (The Natural and Built Environment Series)" , by P. Morris, 2nd edition, Spon Press, USA, 2001.
2. "Environmental Assessment", by R. K. Jain, L. V. Urban, G. S., Stacey, Harold, E. Balbach, 2 edition, McGraw-Hill Professional; 2001.

## CE 6501 PHYSICO-CHEMICAL PROCESSES FOR WATER AND WASTEWATER TREATMENT Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1: identify various physical, chemical and biological parameters responsible for water pollution
CO2: know the potable water and wastewater effluent standards
CO3: categorize various unit operations and processes required for water purification
CO4 evaluate physical and chemical treatment options for treatment of water and wastewater
CO5: explain the mechanism behind the treatment processes and their advantages and disadvantages
CO6: design various physico- chemical units for the treatment of water and wastewater

**Pre-requisites: Environmental Engineering-I (CE 2105), Environmental Engineering-II(CE 2106)**

Water Quality - Physical, chemical and biological parameters of water - Water Quality requirement - Potable water standards-Wastewater Effluent standards.
Water purification systems in natural systems - Unit operations - unit processes.
Mixing, clarification – sedimentation; Aeration and gas transfer; Coagulation and flocculation, coagulation processes-stability of colloids- destabilization of colloids- destabilization in water and wastewater treatment-transport of colloidal particles, Clariflocculation.
Filtration processes- slow sand filtration- rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration.
Adsorption, adsorption equilibria- adsorption isotherms, Disinfection – chlorine dioxide; chloramines; ozonation; UV radiation. Ion Exchange-processes, Application Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodialysis..

**Text & Reference Books :**

1 Weber, W.J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 1983.
2 Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.
3 Metcalf and Eddy, Wastewater engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi, 2003.

## CE 6503 BIOLOGICAL PROCESS DESIGN FOR WASTEWATER TREATMENT Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1: identify conventional and advanced biological treatment processes for the treatment of wastewater
CO2: design the biological reactors based on biokinetics
CO3: select and design appropriate aerobic treatment unit for removal of BOD
CO4: select and design appropriate anaerobic unit for removal of BOD
CO5: design proper biological nitrogen and phosphorus removal system.
CO6: adopt and design proper sludge treatment and disposal process

**Pre-requisites**: **Environmental Engineering-I (CE 2105), Environmental Engineering-II(CE 2106)**

Basic principles of biological wastewater treatment: Principles and determination of wastewater biodegradability, Principles of aerobic and anaerobic biological treatment, Principles of biological nitrogen and phosphorus removal.
Aerobic active sludge process: Concept, growth rule of activated sludge, kinetics of activated sludge, designing of activated sludge process.
Aerobic biofilm process: Basic principle of biofilm, Biofilter process, Biodisk process, Biological contact oxidation process, Aerobic biological fluidized bed process
Other aerobic biological wastewater treatment process: Oxidation ditch process, Adsorption-Biodegradation process, Sequential Batch Reactor process, Membrane Biological Reactor process.
Anaerobic biological wastewater treatment process: Anaerobic digester, Anaerobic contact process and anaerobic biofilter, UASB process.
Biological nitrogen and phosphorus removal process: Biological nitrogen removal process and technology, Biological phosphorus removal process and technology, Simultaneous nitrogen and phosphorus removal process.
Sludge treatment and disposal process: Source, nature and treatment of sludge, Sludge thickening and digestive stability, Sludge conditioning, dewatering and drying incineration.

**Text Books :**

1. "Wastewater Engineering Treatment and Reuse" by Metcalf & Eddy Inc., Fourth Edition, McGraw Hill Education India Private Limited, 2015.
2. "Biological Processes Design for wastewaters" by Benefield, L.D. and Randall C.W., Prentice-Hall, Inc. Eaglewood Cliffs, 1989.

**Reference Books :**

1. "Introduction to Environmental Engineering and Science" by Gilbert M. Masters, 3rd Edition, Pearson Education, 2015.
2. "Environmental Engineering" by Peavy, H.S., Rowe, D.R., Tchobanoglous, G., McGraw Hills, New York, 2013.

# COMPUTER SCIENCE & ENGINEERING

## B.TECH IN COMPUTER SCIENCE AND ENGINEERING

**Program Educational Objectives (PEOs):**

The B. Tech program in Computer Science and Engineering aims to prepare the graduates with the following objectives:

1. The graduates shall be able to provide solutions to Computer Science & Engineering problems involving design, simulation, and analysis of algorithms for theory and applications of computing.
2. The graduates can perceive the limitations and impact of engineering solutions in social, legal, ethical, environmental, economical, and multidisciplinary contexts.
3. The graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal educational programs.

**Program Outcomes (POs):**

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

The program specific outcomes are:

m) Ability to design and develop hardware and software in emerging technology environments like cloud computing embedded products and real-time systems.

n) Ability to work in multidisciplinary teams in small and large scale projects by utilizing modern software engineering tools and emerging technologies.

o) Ability to develop complex products for the societal and engineering needs with skills to communicate effectively in group discussions and report writing.

## CS 2001 DATA STRUCTURES AND ALGORITHMS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the concepts of data structure, data type, abstract data type (ADT) and compute the complexity of different algorithms.
CO2. understand, distinguish and implement Array and Linked data structure on different types of problems.
CO3. understand and implement different linear data structures such as Stack and Queue to solve various problems.
CO4. understand and implement different non-linear data structures such as Tree and Graph on various computing problems.
CO5. understand and apply standard algorithms for searching, sorting and hashing
CO6. effectively choose the data structure that efficiently models the information in a problem.

**Pre-requisites: Computer Programming(CS 1093), Mathematics for Computer Science**

**Introduction:** Structures and Unions, Pointers, Dynamic Memory Allocation, Algorithm Specification, Space and Time Complexity
**Arrays:** Arrays, Abstract Data Type, Dynamically Allocated Arrays, Polynomials, Two-dimensional Array, Address Calculation, Sparse Matrix, Upper & Lower Triangular Matrix, Tridiagonal Matrix
**Linked List:** Singly Linked Lists and Chains, Representing Chains in C, Polynomials, Sparse Matrix, Doubly Linked Lists, Circular & Header Linked lists
**Stacks and Queues:** Stacks, Stacks using Dynamic Arrays and Linked List, Queues, Queue using Dynamic Arrays and Linked List, Circular Queues using Dynamic Arrays and Linked List, Evaluation of Expressions, Priority Queue, Dequeue
**Trees:** Introduction, Binary Trees, Binary Tree Traversals, Threaded Binary Trees, Binary Search Trees, AVL Trees, m-way Search Trees, B-Trees, Introduction to B+-Trees, Tree Operation, Forests
**Graphs:** Graph ADT, Graph Operation – DFS, BFS
**Sorting:** Insertion Sort, Quick Sort, Merge Sort, Heap Sort, Bubble Sort, Selection Sort, Radix Sort
**Searching:** Linear Search, Binary Search, Hashing – Hash Function, Collision Resolution Techniques

**Text Book :**

1. Fundamentals of Data Structures in C, 2nd edition, Horowitz, Sahani, Anderson-Freed, Universities Press.

**Reference Books :**

1 Data Structures, Schaum's OutLines, Seymour Lipschutz, TATA McGRAW HILL
2 Data Structures using C by Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein. Pearson, 1st Edition
3 Data Structures A Pseudocode Approach with C, 2nd Edition, Richard F. Gilberg, Behrouz A. Forouzan, CENGAGE Learning, India Edition
4 Data Structures Using C, Second Edition, Reema Thereja, Oxford University Press
5 Data Structures and Algorithm Analysis in C, Mark Allen Weiss, Pearson Education, 2nd Edition.

## CS 2002 OPERATING SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students should be able to :

CO1. understand the difference between different types of modern operating systems, virtual machines, their structure with implementation and applications.
CO2. understand the difference between process & thread, issues in scheduling of user-level processes/threads.
CO3. understand and analyze use of locks, semaphores, monitors for synchronization in multiprogramming/multithreaded systems and design solutions for multithreaded programs.
CO4. understand the concepts of deadlock in operating systems and how they can be managed/avoided.
CO5. understand the design and management concepts along with issues and challenges of main memory, virtual memory and file system.
CO6. understand I/O management, disk scheduling in operating systems and analyze the protection and security problems faced by operating systems for designing methods to minimize these problems.

**Prerequisites: Data Structures and Algorithms (CS-2001)**

**Introduction:** Operating system and functions, types of operating systems, structure and components.

**Process and threads:** Process and threads, process scheduling, scheduling criteria, scheduling algorithms, algorithm evaluation.

**Concurrent Processes:** Critical section problem, semaphores, classical problems in synchronization, high level synchronization tools.

**Deadlock:** System model, deadlock characterization, deadlock prevention, avoidance and detection, recovery from deadlock.

**Memory Management:** Memory management in multiprogramming by creating partitions, paging, segmentation, virtual memory implementation through demand paging, thrashing.

**File System:** File concept, access methods, directory structures, file system mounting, file system Implementation, allocation methods, free space management.

**Input / Output Management:** I/O devices, device controller, device drivers, application I/O interface, disk structure, disk scheduling.
Operating System Protection & Security

**Text book :**

1. Operating System Concepts by A. Silberschatz, P. B. Galvin and G. Gagne, John Wiley & Sons, Inc., ISBN 978-1-118-06333-0

**Reference books :**

1 Operating Systems by M. Deitel, P.J. Deitel and D.R. Choffnes, Pearson, ISBN: 9780131453159.
2 Operating Systems Concepts and Design by Milan Milenkovic, Tata McGraw-Hill Education India, ISBN: 9780074632727.
3 Operating Systems Design and Implementation by Andrew S. Tanenbaum, Albert S. Woodhull, Prentice-Hall,ISBN: 9780131429383.

## CS 2004 DATABASE MANAGEMENT SYSTEM Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamental elements of relational database management systems and its applications.
CO2. conceptualize and depict a database system using ER diagram.
CO3. query database using relational algebra, relational calculus and SQL.
CO4. understand the functional dependencies and design the database using normalization.
CO5. understand the Transaction processing system and concurrency control mechanisms.
CO6. understand basic database storage structures and access techniques: file organizations, indexing methods including B-tree, and hashing.

**Prerequisite: Data Structures and Algorithms (CS-2001)**

**Introduction:** Introduction to database systems; Characteristics of databases, File system V/s Database system, Users of Database system, approaches to building a database, data models, database management system, Data Independence, DBMS system architecture, challenges in building a DBMS, various components of a DBMS.

**E/R Model:** Conceptual Data Modeling – motivation, entities, entity types, various types of attributes, relationships, relationship types, Entity set types, Participation constraints, E/R diagram notation, Extended E/R Model, Case studies.

**Relational Data Model:** Concepts of relations, schema-instance distinction, keys, referential integrity & foreign keys, converting the database specification in E/R notation to the relational schema, Relational algebra operators: selection, projection, cross product, various types of joins, division, set operations, example queries, tuple relational calculus, domain relational calculus, Fundamentals of SQL.

**Relational Database Design:** Importance of a good schema design, problems encountered with bad schema designs, motivation for normal forms, dependency theory - functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, minimal covers, Normalization, Normal Forms - 1NF, 2NF, 3NF and BCNF, decompositions and desirable properties of them, multi-valued dependencies and 4NF, join dependencies and 5NF, Concept of Denormalization.

**Transaction Processing:** Transaction processing and Error recovery - Concepts of transaction processing, ACID properties, concurrency control, Serializability, locking based protocols, Timestamp based protocols, recovery and logging methods.

**Data Storage & Indexing:** Data Storage and Indexes - File organizations, primary, secondary index structures, various index structures – hash-based, dynamic hashing techniques, multi-level indexes, B and B+ trees.

**Text Book :**

1. Fundamentals of Database System By R. Elmasari & S.B. Navathe, $7^{th}$ Edition, 2018, Pearson Education

**Reference Books :**

1. Database System Concepts by A. Silberschatz, H.F. Korth & S. Sudarshan, $6^{th}$ Edition, 2019, McGraw-Hill Education
2. Database Management Systems by R. RamaKrishna & J. Gehrke, $3^{rd}$ Edition, 2018, McGraw-Hill Education
3. Database System Concepts by P. Rob & C. M. Coronel, Indian Edition, 2011, Cengage Learning
4. Fundamentals of Relational Database management Systems by S. Sumathi & S. Esakkirajan, 2007, Springer.

## CS 2006 COMPUTER ARCHITECTURE Cr-4

**Course Outcome:** At the end of the course, the students will be able to :

CO1: remember the functions of each components of computer, and how each components of computer hardware has evolved to meet the requirements of the execution of instructions.
CO2: understand Instruction Set Architecture (ISA): Instruction format, types, various addressing modes.
CO3: apply the basic components to design the CPU: the ALU and control unit.
CO4: analyze the different levels of memory organization: SRAM, DRAM, Cache memory, Virtual Memory.
CO5: design the ALU and it's operations: Addition, Subtraction, Multiplication, and Division.
CO6: understand the I/O Organization and types of I/O Transfer.

**Prerequisite: Fundamentals of Computer Programming, Digital Logic Circuits.**

**Basic Structure of Computers:** Computer Types, Functional Units, Basic Operational Concepts, Bus Structures, Machine Instructions and Programs: Memory Locations and Addresses, Memory Operations, Encoding of Machine Instructions, Addressing Modes, Instruction Types, Instruction Format, Instruction Length, Assembly Language, Subroutines, Additional Instructions, RISC vs CISC.

**Basic Processing Unit:** Fundamental Concepts, Execution of a Complete Instruction, Single and Multiple Bus CPU Organization, Hard-wired Control, Micro programmed Control unit.

**Memory System:** Basic Concepts, Semiconductor RAM Memories, Read Only Memories, Speed, Size, and Cost, memory module design, Memory Hierarchy, Cache Memories – Mapping Functions, Replacement Algorithms, Memory Performance Considerations, Memory interleaving, Virtual Memories.

**Arithmetic:** Design of fast adders, Multiplication of Positive Numbers, Signed Operand Multiplication, Fast Multiplication, Integer Division, Floating-point Numbers and Operations.
**Input/ Output Organization:** Accessing I/O Devices, Modes of I/O Transfer, Program Controlled I/O, Interrupts – Interrupt Hardware, Enabling and Disabling Interrupts, Handling Multiple Devices, Controlling Device Requests, Exceptions, Direct Memory Access.

**Case Study**: IA-32 Register Structure, IA-32 Addressing Modes,IA-32 Instructions, Machine Instruction Format, IA-32 Assembly Language, Program Flow Control, Logic and Shift/Rotate Instructions, Subroutines for IA-32, Programming examples.

**Text Book :**

1. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Computer Organization, TMH, 5th Edition, 2002.

**Reference Books :**

1. M. Morris Mano, Computer System Architecture, Pearson Education India, 3rd Edition
2. Computer Organization & Architecture, William Stallings, 7th Edition, PHI, 2006.

## CS 2010 AUTOMATA AND FORMAL LANGUAGES Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. acquire a fundamental understanding of the core concepts in automata theory and formal languages
CO2. demonstrate knowledge of basic mathematical models of computation and describe how they relate to formal languages.
CO3. design grammars and automata (recognizers) for different language classes.
CO4. acquire a fundamental understanding of core concepts relating to the theory of computation and c computational models.
CO5. understand limitations on what computers can do, and learn examples of undecidable problems.
CO6. learn that certain problems do not admit efficient algorithms, and identify a few such problems.

**Prerequisite of the course:** NIL

**Regular Languages:** Basic Concepts, Deterministic Finite Automata, Non-deterministic Finite Automata, Equivalence of DFA and NFA, Minimization of number of states in a DFA, Regular Expressions, Equivalence of Regular Expressions and Finite State Automata, Closure Properties of Regular Languages, Pumping Lemma for Regular Languages, Myhill-Nerode Theorem, Identification of some non-Regular languages, Decision Problems on Regular Languages, Regular grammars: right linear and left linear grammars, Equivalence of regular languages and regular grammars.

**Context-Free Languages:**Context-Free Grammars, Leftmost and Rightmost derivations, Sentential Forms and Derivation Trees, Parsing and Membership, Parse Trees, Ambiguity in Grammars and Languages, Simplification of Context-Free Grammars, Chomsky Normal Form, Greibach Normal Form, Pushdown Automata, Equivalence of PDA and Context-Free Grammars, Closure Properties of Context-Free Languages, Pumping Lemma for Context-Free Languages, Identification of some Languages that are not Context-Free.

**Turing Machines and other relevant Topics:** Turing Machines, Turing Machines as Language Accepters, Church-Turing Thesis, Models of Turing Machines -- Multiple Tape, Multiple Tracks, Non-determinism, etc., Equivalence of TM Models, Recursive and Recursively Enumerable languages, Chomsky Hierarchy of Formal Languages, Computability and Decidability, Halting Problem, Undecidability of the Halting Problem, Examples of some other undecidable problems.

**Text Book :**

1. An Introduction to Formal Language and Automata, Peter Linz, Jones & Bartlett Publishers, 5th Edition.

**Reference Books :**

1. Introduction to automata theory, languages and computations, John E.Hopcroft, Jeffery D.Ullman, Pearson Education, 3rd Edition.
2. Elements of the theory of computation, Lewis, Harry R. and Christos H. Papadimitriou Prentice-Hall Englewood, 2nd Edition.
3. The Theory of Computation, Bernard M. Moret, Pearson Education, 1st Edition.

4. Introduction to the Theory of Computation, Michel Sipser, Thomson Brooks/Cole, 2nd Edition.
5. Theory of computer science by KLP Mishra & N. Chandra Sekharan, PHI, 3rd edition.

## CS 2012 DESIGN AND ANALYSIS OF ALGORITHMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. analyze the asymptotic performance of algorithms.
CO2. understand different algorithm design techniques.
CO3. apply important algorithmic design paradigms and methods of analysis.
CO4. demonstrate familiarity with major algorithms and data structures.
CO5. modify existing algorithms to apply in common engineering design situations.
CO6. understand different classes of problems: P, NP , NP Complete and NP Hard.

**Prerequisite: Data Structures and Algorithms (CS-2001)**

**Introduction:** Notion of an algorithm. Time and space complexity, Asymptotic notations and their properties. Insertion sort. Recurrence equations, Master theorem. Complexity analysis of recursive and non-recursive algorithms. Heaps & Priority queues.

**Divide-and-Conquer Method:** Basic concepts, Binary search, Merge sort, quick Sort, Randomized version of quick-sort.

**Dynamic Programming:** Basic concepts, Matrix-chain multiplication, Longest common subsequence.
**Greedy Techniques:** Basic concepts, Activity selection problem, Huffman codes, Fractional knapsack problem, Job sequencing with deadlines.

**Graph Algorithms:** Graph representations, Breadth-First Search, Depth-First Search. Single-Source Shortest Paths: Dijkstra's algorithm. All-Pairs Shortest Paths: Floyd-Warshall algorithm. Minimum Spanning Trees: Kruskal's algorithm, Prim's algorithm.

**Complexity Classes:** Basic concepts, problem classes: P, NP, NP-Complete and NP-Hard .

**Text Books :**
1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to Algorithms", Printice Hall of India,3rd Edition.
2. E. Horowitz & S Sahni, "Fundamentals of Computer Algorithms", Galgotial publication; Second edition.

**Reference Books :**
1. J.Kleinberg and E. Tardos, Algorithm Design, Pearson International Edition, 1st Edition.
2. Michael T Goodrich and Roberto Tamassia, "Algorithm Design: Foundations, Analysis, and Internet Examples", Wiley, Students Edition.

## CS 3008 COMPILER DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the design of a compiler and the phases involved in program translation from source code to executable code along with the intermediate files produced by the phases.
CO2. understand lexical analysis phase and its underlying formal models to design lexical analysers through regular expressions and finite automaton.
CO3. understand syntax analysis phase, identify the similarities and differences among various parsing techniques to design parsers for any context free grammar.
CO4. understand formal attributed grammars for specifying semantics of programming languages and design semantic rules to facilitate translation process.

CO5. identify the effectiveness of optimization and learn various machine independent and machine dependent optimization techniques.
CO6. Learn register allocation and target code generation algorithms used by the compiler.

**Prerequisites: Computer Programming (CS-1093), Data Structures & Algorithms (CS-2001)**

**Overview of Compilation:** Introduction to Compiler, Phases of Compilation, Grouping of Phases.
**Lexical Analysis**: Role of Lexical Analyzer, Input Buffering, Specification of Tokens, Finite state machines and their applications to lexical analysis.

**Syntax Analysis:** Context Free Grammar, Top-down Parsing- Recursive descent parsing, Table driven predictive parsing, LL(1), Bottom-up Parsing- Shift-reduce parsing, Efficient Bottom-up parsers (LR parsers), LR and LALR parsing, Error recovery in parsing, handling ambiguous grammar. compiler construction tools.

**Semantic Analysis:** Intermediate forms of source programs- Syntax tree and three address code (Quadruples, Triples), attributed grammar, syntax directed translation . Evaluation and flow of attributes in a syntax tree, conversion of programming language constructs into intermediate code forms. Symbol table organization, DAG representation.

**Code Optimization:** Machine dependent and machine independent optimization. Local Optimization-common sub-expression elimination, Constant folding, replacing expensive operations. Loop Optimization- Basic Block, Flow Graphs, Inner loops, Code Motion, Induction Variable.

**Code Generation:** Design of Code Generator. Machine dependent code optimization, register allocation and assignment, Code generation algorithm.

**Text Book :**
1. Compilers Principles, Techniques and Tools by Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffery D. Ullman, Pearson Education, 2009.

**Reference Books :**
1. Compiler construction principles and practice by K. C. Louden, Brooks/Cole - Thomson Learning.
2. Engineering a Compiler by Keith Cooper, Linda Torczon, ISBN: 978-0-12-088478-0, Elsevier, Inc.
3. Introduction to Compiler Construction With Unix by Axel T. Schreiner, H. George Friedman, ISBN: 978-0134743967, Prentice-Hall software series.
4. The Compiler Design Handbook by Y.N. Srikant , Priti Shankar, ISBN:978-1420043822, Taylor and Francis.

## CS 3010 HIGH PERFORMANCE COMPUTING Cr-4

**Course Outcome**: At the end of the course the students will able to :

CO 1. understand about different quantitative techniques used to measure performance of system with various criteria like CPI, CPU time, speed up, throughput, efficiency etc.
CO 2. understand the concept of different types of hazards along with their structural implementation and applications.
CO 3. identify the criteria to enhance the performance of a pipelined processors.
CO 4. understand memory hierarchy and to analyze various Cache optimization techniques.
CO 5. understand ILP and the techniques to exploit ILP in scalar, super scalar, super pipelined processor and VLIW processor.
CO 6. classify various parallel architecture like centralized and distributed memory architecture

**Prerequisite: Computer Architecture (CS-2006)**

**Introduction:** Review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors.

**Pipelining:** Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques. Compiler techniques for improving performance.

**Hierarchical memory technology:** Introduction, Coherence and locality of reference properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.

**Instruction-level parallelism:** Basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors.

**Multiprocessor architecture:** Taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture.

**Text Book :**

1. John L. Hennessy and David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann.

**References Books :**

1. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw-Hill.
2. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House.
3. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill.

## CS 3011 ARTIFICIAL INTELLIGENCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. have a broad understanding of the fundamental concepts, applications, achievements and the theory underlying those achievements of AI.
CO2. have an appreciation for the engineering issues underlying the design of AI systems.
CO3. have a basic proficiency in a traditional AI language including an ability to write the intermediate programs and an ability to understand the code written in that language.
CO4. have an understanding of the basic issues of knowledge representation and search techniques, as well as an understanding of other topics such as min-max, resolution, etc. that play an important role in AI programs.
CO5. apply AI techniques to develop programs to solve real life problems in different domains.
CO6. have basic understanding of some of the more advanced topics of AI such as learning, natural language processing, agents, robotics, expert system and planning.

### Prerequisite: NIL

**UNIT-1: Introduction:** Overview; Foundation of AI ; History of AI; The State of Art of AI.
**Intelligent Agents:** Agents and environment; Rationality; The nature of environment; The structure of agents.

**UNIT-II: Solving Problems by Searching**: Problem-solving agents; Example problems; Searching for solution;

**Uninformed search, informed Search and Exploration**: Uninformed and Informed search strategies; Heuristic functions; On-line search agents and unknown environment.

**UNIT-III: Constraint Satisfaction Problems:** Constraint satisfaction problems; Backtracking search for CSPs.
**Adversial search**: Games; Optimal decisions in games; Alpha-Beta pruning.

**UNIT-IV: Logical Agents**: Knowledge-based agents; The wumpus world as an example world; Logic; Propositional logic Reasoning patterns in propositional logic; Effective propositional inference; Agents based on propositional logic.

**First-order Logic:** Representation revisited; Syn.tax and semantics of first-order logic; Using first-order logic; Knowledge engineering in first-order logic.

**UNIT-V: Knowledge Representation**: Ontological engineering; Categories and objects, Actions, situations, and events; Mental events and mental objects; The Internet shopping world; Reasoning systems for categories; Reasoning with default information; Truth maintenance systems.

**Planning:** The planning problem; Planning with state-space approach; Planning graphs; Planning with propositional logic.

**Text Book:**

1. Artificial Intelligence: A Modern Approach – Stuart Russel, Peter Norvig, 3rd Edition, Pearson Education, 2018.

**Reference Books:**

1. Artificial Intelligence - Elaine Rich, Kevin Knight and Shivashankar B Nair, 3$^{r}$ Edition, Tata McGraw Hill.,2008
2. Principles of Artificial Intelligence – Nils J. Nilsson,1$^{st}$ Edition, Elsevier, 1982.

## CS 3012 PARALLEL AND DISTRIBUTED COMPUTING Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand a number of different models of parallel and distributed computing and understand the basic techniques for designing algorithms in these models.
CO2. learn and apply knowledge of parallel and distributed computing techniques and methodologies
CO3. design, develop, and analysing performance of parallel and distributed applications.
CO4. use the application of fundamental Computer Science methods and algorithms in the development of parallel applications.
CO5. explain the design, testing, and performance analysis of a software system, and to be able to communicate that design to others.
CO6. gain experience in the design, development, and performance analysis of parallel and distributed applications

**Pre-requisites: Data Structures and Algorithms (CS-2001), Design and Analysis of Algorithms (CS-2012), Knowledge of Computer Architecture and Operating System, Knowledge of Mathematics for Computer Science**

**Introduction to Parallel Computing:** Scope, issues, applications and challenges of Parallel and Distributed Computing

**Parallel Programming Platforms:** Implicit Parallelism, Trends in microprocessor Architectures, Dichotomy of parallel Computing platforms, Physical Organization of parallel platforms, communication costs in parallel Machines, Routing Mechanisms for interconnection Network, Impact of Process Processors mapping and mapping Techniques.

**Principles of Parallel Algorithm Design:** Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for load Balancing, Methods for containing interaction overheads, Parallel Algorithm Models.

**Basic Communication Operations:** One-to-All Broadcast and All-to-One Reduction, All-to-All Broadcast and reduction All-Reduce and Prefix sum operations, scatter and Gather, All-to-All personalized communication, circular shift, improving the speed of some communication operation.

**Analytical Modeling of Parallel Programs:** Performance Metrics for Parallel systems, Effect of Granularity of Performance, scalability of parallel system, Minimum Execution Time and Minimum Cost-optimal execution Time, Asymptotic Analysis of parallel Programs, other scalability Metrics.

**Programming Using the Message Passing Paradigm:** Principle of Message – Passing Programming, Send and receive Operations, The message passing Interface, Topologies and Embedding, Overlapping communication with computation, collective communication and computation Operations, Matrix-Vector Multiplication, Matrix-Matrix Multiplication.

**Sorting & Searching Algorithms:** Sequential Search Algorithms, Parallel Depth-First Search, Parallel Best-First Search, Speedup Anomalies in Parallel Search Algorithms, Issues in Sorting on Parallel Computers, Bubble Sort and Variants, Quick Sort

**Graph Algorithms:** Minimum Spanning Tree (Prim's Algorithm) shortest path (Dijkstra's Algorithm)

**Text Books :**

1. Introduction to Parallel Computing, Second Edition, Ananth Gram, Anshul Gupta, George Karypis, Vipin Kumar, Person Education.
2 Parallel programming in c with MPI and Open MP, M.J. Quinn, TMH.

**Reference Books :**

1. Parallel Computer Architecture and Programming, D.E.Culler,J.P Singh & A Gupta, Morgan Kaufman
2. Designing and Building Parallel Programs, I.Foster. Addison-Wesley.

## CS 3022 DESIGN AND ANALYSIS OF PARALLEL ALGORITHMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand different parallel programming platforms and communication cost, routing mechanism of interconnection networks

CO2. understand different decomposition techniques, mapping techniques, parallel algorithm models of hypercube, square mesh.

CO3. analyse parallel algorithms for PRAM machines and various interconnection networks

CO4. apply parallel algorithm to different graph algorithms

CO5:. design and develop cost optimal parallel algorithms for specific problems

CO6. comprehend and apply parallel algorithms to real world applications.

**Prerequisites: Design and Analysis of Algorithms (CS-2012), Data Structure and Algorithms (CS-2001), Computer Architecture and Operating System**

Unit–I: Introduction to Parallel Computers - SIMD - EREW, CREW - SM-SIMD algorithms -Shared memory SIMD - Tree and mesh interconnection computers - Classifying MIMD Algorithms - Hypercube SIMD Model.

Unit–II: Selection and Sorting – Sequential algorithm - Algorithm for parallel selection – Sorting on a linear array – broadcasting a datum- Computing all sums- Sorting on a mesh - Sorting on EREW SIMD computer - enumeration sort – parallel quick sort – hyper quicksort Sorting on other networks - Sorting on other networks.

Unit–III: Matrix operations - Mesh transpose – Shuffle transpose - EREW transpose – Mesh multiplication - Cube multiplication - Matrix by vector multiplication - Tree multiplication.

Unit–IV: Numerical problems - Linear equations - SIMD algorithm - Roots of nonlinear equations MIMD algorithm - Partial differential equations - Computing Eigen values. Monte Carlo methods – parallel random number generators – random number distributions.

Unit–V: Graph problems –Definitions - Graph coloring - Computing the connectivity matrix -Finding connected components - Traversal - Minimal alpha-beta tree - Minimum Cost Spanning Tree Addition tree-Multiplication tree.

**Text Book :**

1. S. G. Akl, "The Design and Analysis of Parallel Algorithms", Prentice Hall of India, 1989

**Reference Books :**

1. B. Wilkinson and M. Allen, "Parallel Programming – Techniques and applications using networked workstations and parallel computers", 2nd Edition, Pearson Education, 2005

2. Michael J. Quinn, “Parallel Computing : Theory & Practice”, Tata McGraw Hill, 2003
3. S. Lakshmivarahan and S. K. Dhall, "Analysis and Design of Parallel Algorithms - Arithmetic and Matrix Problems", Tata McGraw Hill, 1990

## CS 3024 WIRELESS NETWORK SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basics of Wireless Communication Networks.
CO2. motivate the students to pursue research in the area of wireless communication.
CO3. Understand the transmission of voice and data through various networks.
CO4. familiar with contemporary issues in networking technologies
CO5. master the concepts of protocols, design/performance issues in wireless networks

**Prerequisite**: **NIL**

**Introduction to Wireless Networks:** Introduction, Technology and service trends of Emerging Wireless technologies, The Amazing Growth of Mobile Communications, A Little History, Mobile Communications Fundamentals, Mobile Data, WiFi, Bluetooth, Cable Systems, Wireless Migration Options, Harmonization Process.

**WiFi and Next Generation WLAN:** WiFi (802.11), 802.11 Standards, WiFi Protocols, Frequency Allocation, Modulation and Coding Schemes, Network Architecture, Typical WiFi Configurations, Security, 802.11 Services, HotSpots, Virtual Private Networks (VPNs), Mobile VPN, VPN Types, WiFi Integration with 3G/4G, Benefits of Convergence of WiFi and Wireless Mobile.

**Third Generation Mobile Services:** Introduction, Universal Mobile Telecommunications Service (UMTS), UMTS Services, The UMTS Air Interface, Overview of the 3GPP Release 1999 Network Architecture, Overview of the 3GPP Release 4 Network Architecture, Overview of the 3GPP Release 5, All-IP Network Architecture, Overview CDMA2000, TD-CDMA, TD-SCDMA, Commonality among WCDMA, CDMA2000, TD-CDMA, and TD-SCDMA

**LTE:** LTE Ecosystem, Standards, Radio Spectrum, LTE Architecture, User Equipment (UE), Enhanced Node B (eNodeB), Core Network (EPC), Radio Channel Components, TD-LTE, Multiple Input Multiple Output, LTE Scheduler, Carrier Aggregation, Cell Search, Cell
Reselection, Attach and Default Bearer Activation, Handover (X2, S1, Inter-MME), Self-
Organizing Networks (SONs), Relay Cells, Heterogeneous Network (HetNET), Remote Radio Heads (RRH), VoLTE, LTE Advanced

**WiMAX:** Introduction, Standards, Generic WiMAX Architecture, Core Network, Radio Network, WiMAX Spectrum, Modulation, Channel Structure, Mixed Mode, Interference Mitigation Techniques,Frequency Planning, Features and Applications, Security, QoS, Profiles, Origination, Handover, Femto and SON.

**VOIP:** Why VoIP?, The Basics of IP Transport, VoIP Challenges, H.323, The Session Initiation Protocol (SIP), Distributed Architecture and Media Gateway Control, VoIP and SS7, VoIP,Quality of Service.

**Text Books :**

1. Clint Smith, P.E., Daniel Collins, “Wireless Networks: Design and Integration for LTE, EVDO, HSPA, and WiMAX”, McGrawHill Education, Third Edition
2. EldadPerahia, Robert Stacey, “Next Generation Wireless LANs”, Cambridge University Press, Second Edition.

**Reference Books :**

1. Yi-Bang Lin, ImrichChlamtac, “Wireless and Mobile Network Architecture”, Wiley India Edition.
2. Dipankar Raychaudhary, Maria Gerla, “Emerging Wireless Technologies and the Future Mobile Internet”, Cambridge University Press..

## CS 3026 RANDOMIZED ALGORITHMS Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1: apply basics of probability theory to analyse algorithms
CO2: comprehend randomized algorithms.
CO3: understand the advantages of randomized algorithms over traditional algorithms
CO4: design and analyse efficient randomized algorithms
CO5: apply randomized techniques in solving real world problems.
CO6: design, develop, and analyze performance randomized algorithms.

**Prerequisites: Design and Analysis of Algorithms (CS-2012), Data Structures and Algorithms (CS-2001), Knowledge of Mathematics for Computer Science, Knowledge of Probability Theory**

**Introduction to Randomization:** Introduction to probability theory, Verification of strings, poly identities, matrix multiplication Las Vegas and Monte Carlo algorithms, Expectations, Jensen's Inequality, geometric distribution.

**Sorting and Searching:** Randomized Quick Sort and its expected run-time, Variance and moments, Chebyshev's inequality, Coupon collector's problem, randomized median finding analysis

**Derivation and Application:** Derivation and application of Chernoff's bounds, Sum of Poisson Trials, Coin flips, Set balancing, Packet routing in sparse networks, permutation routing on the hypercube, butterfly.

**Graph Models:** Birthday paradox, balls and bins model, application to bucket sort, Poisson distribution, Application to hashing, Hamiltonian cycles in random graphs, random graph models
**Probabilistic Tools and Techniques:** Markov chains, classification of states, gambler's ruin, random walks on undirected graphs, S-T connectivity algorithm.

**Text Books :**

1. M. Mitzenmacher and E. Upfal, "Probability and computing: Randomized algorithms and Probabilistic analysis", Cambridge, 2005
2. Randomized Algorithms, by Motwani and Raghavan, Cambridge University Press, 1995.
3. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, by Mitzenmacher and Upfal, Cambridge University Press, 2nd edition, 2017.

**Reference Books :**

1. Computational Geometry: Algorithms and Applications, by Mark de Berg, Otfried Cheong, Marc van Kreveld, and Mark Overmars, 3rd edition, Springer-Verlag, 2008.
2. Algorithmic and Analysis Techniques in Property Testing, by Dana Ron. Found. Trends Theor. Comput. Sci. 5, 2 (February 2010), 73-205.

## CS 3027 REAL TIME SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand real-life applications of real-time systems
CO2. understand characteristics and features of real-time system
CO3. understand the application of various strategies to handle the functioning of various real-time features such as resources, tasks etc.
CO4 know about the working of commercial real-time operating systems, real-time communications and real-time database.
CO5: compare various real-time systems.
CO6: analysis & compare real-time communications.

**Prerequisites**: **NIL**

**Introduction:** Introduction to Real-Time systems, applications of Real-Time systems, basic model of Real-Time systems, Characteristics of Real-Time systems, types of Real-Time systems: hard, firm, soft, timing constraints, modeling timing constraints.

**Real-Time Task scheduling:** Basic concepts, clock driven scheduling, table driven scheduling, Cyclic Schedulers, hybrid schedulers, Event driven scheduling, EDF Scheduling, RMA, DMA, resource sharing among RT tasks, Priority inversion, Priority Inheritance Protocol, Highest Locker Protocol, Priority Ceiling Protocol, Scheduling Real-Time tasks in multiprocessor and distributed systems.

**Fault-Tolerant:** Fault-tolerant scheduling of tasks, clocks in distributed Real-Time systems, Commercial Real-Time Operating Systems, Timers, UNIX and Windows as RTOS, POSIX, PSOS, VRTX, QNX, RT Linux, Other RTOS, benchmarking RTOS, RT communications, QoS framework, models

**Real-Time Communication:** Real-Time Communication in a LAN, IEEE 802.4, RETHER, Communication over Packet Switched Networks, Routing algorithms, RSVP, rate control, RT databases, Applications, Characteristics of temporal data, Concurrency control, Commercial RT databases.

**Text book :**

1. Real-Time Systems, R. Mall, Pearson, 2007

**Reference books :**

1. Real-Time Systems, C. M. Krishna and K. G. Shin, McGraw Hill, reprinted 2004.
2. Real-time Systems, J. W. S.Liu, Pearson Education, 6th impression, 2008.
3. Real-Time Systems Design & Analysis, P. A. Laplante, Willey, 3rd Ed, 2004.

## CS 3028 PARALLEL ARCHITECTURES AND PROGRAMMING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand different parallel programming platforms and communication cost, routing mechanism of interconnection networks

CO2. understand different decomposition techniques, mapping techniques, parallel algorithm models of hypercube, square mesh.

CO3. learn basic communication operations like One to All Broadcast and All to One Reduction, All to All Broadcast and Reduction, All Reduce and prefix sum operations

CO4. design and implement parallel programs in modern environments such as CUDA, OpenMP, etc.

CO5. comprehend and apply parallel algorithms to real world applications.

**Prerequisites: Computer Architecture and Operating System, Parallel Programming**

**Introduction:** The need for parallelism, Forms of parallelism (SISD, SIMD, MISD, MIMD), Moore's Law and Multi-cores, Fundamentals of Parallel Computers, Communication architecture, Message passing architecture, Data parallel architecture, Dataflow architecture, Systolic architecture, Performance Issues

**Large Cache Design:** Shared vs. Private Caches, Centralized vs. Distributed Shared Caches, Snooping-based cache coherence protocol, directory-based cache coherence protocol, Uniform Cache Access, Non-Uniform Cache Access, D-NUCA, S-NUCA, Inclusion, Exclusion, Difference between transaction and transactional memory, STM, HTM

**Graphics Processing Unit:** GPUs as Parallel Computers, Architecture of a modern GPU, Evolution of Graphics Pipelines, GPGPUs, Scalable GPUs, Architectural characteristics of Future Systems, Implication of Technology and Architecture for users, Vector addition, Applications of GPU

**Introduction to Parallel Programming:** Strategies, Mechanism, Performance theory, Parallel Programming Patterns: Nesting pattern, Parallel Control Pattern, Parallel Data Management, Map: Scaled Vector, Mandelbrot, Collative: Reduce, Fusing Map and Reduce, Scan, Fusing Map and Scan, Data Recognition: Gather, Scatter, Pack, Stencil and Recurrence, Fork-Join, Pipeline

**Parallel Programming Languages:** Distributed Memory Programming with MPI: trapezoidal rule in MPI, I/O handling, MPI derived data type, Collective Communication, Shared Memory Programming with Pthreads: Conditional Variables, read-write locks, Cache handling, Shared memory programming with Open MP: Parallel for directives, scheduling loops, Thread Safety, CUDA: Parallel programming in CUDA C, Thread management, Constant memory and Event, Graphics Interoperability, Atomics, Streams Programming assignments are mandatory.

**Text Book :**


1. D. E. Culler, J. P. Singh, and A. Gupta, “Parallel Computer Architecture”, Morgan Kaufmann, 2004


**Reference books :**


1. Rajeev Balasubramonian, Norman P. Jouppi, and Naveen Muralimanohar, “Multi-Core Cache Hierarchies”, Morgan & Claypool Publishers, 2011
2. Peter and Pach Eco, “An Introduction to Parallel Programming”, Elsevier, 2011
3. James R. Larus and Ravi Rajwar, “Transactional Memory”, Morgan & Claypool Publishers, 2007
4. David B. Kirk, Wen-mei W. Hwu, “Programming Massively Parallel Processors: A Hands-on Approach”, 2010
5. Michael McCool, James Reinders, Arch Robison, “Structured Parallel Programming: Patterns for Efficient Computation”, 2012
6. Jason Sanders, Edward Kandrot, “CUDA by Example: An Introduction to General Purpose GPU Programming”, 2011


## CS 3029 ADVANCED DATABASE MANAGEMENT SYSTEM Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand Database Management Systems and construct simple and moderately advanced database queries using Structured Query Language (SQL).
CO2. understand the detail query processing and techniques involved in query optimization.
CO3. understand the database storage structures and access techniques such as file organizations, indexing methods.
CO4. understand the details of distributed database design process, concept of a distributed database transaction and related facilities, including concurrency control, backup and recovery.
CO5. understand the concept of parallel database design process.
CO6. understand contemporary issues and emerging technologies such as On-Line Analytical Processing (OLAP), Data Warehouse and Data mining.

**Prerequisite: Database Management System (CS-2004)**

**DBMS & SQL:** DBMS, Data Abstraction, Constraints, Relational Algebra, Querying multiple Relations, SQL, Aggregate Functions, Join, Sub query, Views, PL/SQL, Cursors, Functions & Procedures, Triggers.

**Query Evaluation:** Operator Evaluation, Query Optimization, Alternative Plans, Translation of SQL Queries into Algebra, Cost Estimation of Query Plans, Relational Algebra Equivalences, Enumeration of Alternative Plans, Nested subqueries, The System R Optimizer.

**Physical Database Design & Tuning:** File Organization & Indexing, Index Data Structures, Comparison of File Organizations, Indexes & Performance Tuning, Introduction to Physical Database Design, Clustering & Indexes, Overview of Database Tuning, Tuning in Conceptual Schema, Tuning Queries & Views.

**Parallel & Distributed Databases:** Architectures for Parallel Databases, Parallel Query Evaluation, Parallel Query Optimization, Introduction to Distributed Databases, Distributed DBMS Architectures, Distributed Catalog Management, Distributed Query Processing, Distributed Transactions & Concurrency Control, Distributed Recovery.

**Data Warehousing & Data Mining:** Decision Support, OLAP, Multidimensional Aggregation Queries, Data Warehousing, Views & Decision Support, View Materialization, Introduction to Data Mining, Mining for Rules, Tree-Structured Rules, Clustering.

**Text Book :**

1. Database Management Systems by RamaKrishna & Gehrke, 3rd Edition, 2018, McGraw-Hill Education

**Reference Books :**

1. Fundamentals of Database System By Elmasari & Navathe, 7th Edition, 2018, Pearson Education
2. Database System Concepts by Silberschatz, Korth & Sudarshan, 6th Edition, 2019, McGraw-Hill Education

## CS 3031 COMPUTATIONAL INTELLIGENCE Cr-3

**Course Outcome**: At the end of the course, the students will be able to :

CO1 understand the basic concepts and characteristics of soft computing and also its associated methodologies.
CO2 apply various set theoretic operations in fuzzy sets.
CO3 understand and analyse fuzzy rules, fuzzy reasoning and various fuzzy inference systems.
CO4 understand derivative free optimization and apply genetic algorithms to optimization problems.
CO5 understand concepts of artificial neural networks and apply neural networks to various classification problems.
CO6 analyse some hybrid models such as adaptive Neuro-fuzzy inference systems.

### Prerequisite: Nil

**Introduction**

Introduction, Soft Computing constituents and Conventional AI, Neuro-Fuzzy and Soft Computing characteristics

**Artificial Neural Networks**

Introduction to ANN, Perceptrons and MLP, Adaline and Madaline, Back-propagation Multilayer Perceptrons (BPMLP), Radial Basis Function Networks (RBF), Kohonen Self-Organizing Networks, Learning Vector Quantization, Hebbian Learning, Hopfield networks

**Fuzzy Set Theory**

Fuzzy sets, Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation and Parameterization, More on Union, Intersection and Complement

**Fuzzy Rules, Fuzzy Reasoning and Fuzzy Inference System**

Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning, Fuzzy Inference Systems, Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models

**Neuro-Fuzzy Models**

Adaptive Neuro-Fuzzy Inference Systems(ANFIS), ANFIS Architecture, Hybrid Learning Algorithm

**Optimization**

Derivative-based Optimization, Derivative-free Optimization, Genetic Algorithms, Simulated Annealing

**Text Book :**

1. Neuro-Fuzzy and Soft Computing, Jang, Sun, Mizutani, PHI/Pearson Education

**Reference Books :**

1. Introduction to Soft Computing, Roy and Chakraborty, Pearson Education
2. Fuzzy Logic with Engineering Applications, Timothy J. Ross, McGraw-Hill, 1997.
3. *Genetic Algorithms: Search, Optimization and Machine Learning, Davis E. Goldberg, Addison Wesley,* N.Y., 1989.

4. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall
5. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning, Vikash Publishing House
6. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran and G.A.V. Pai, PHI, 2003

## CS 3032 BIG DATA Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand the concet of data management and evolution of Big Data.
CO2. implement and understand various big data technology foundations.
CO3. apply the fundamentals of Hadoop ecosystem and its components for data analysis.
CO4. analyze the optimization and storage of data in data bases.
CO5. explore the understanding of analytics and big data.
CO6. implementation of deep learning approches in real life application.

**Prerequisite: Database Managment System (CS-2004)**

**UNIT I: Getting an Overview of Big Data**
What is Big Data, History of Data Management – Evolution of Big Data, Structuring Big Data, Elements of Big Data, Big Data Analytics, Future of Big Data, Use of Big Data in Social Networking, Use of Big Data in Preventing Fraudulent Activities, Use of Big Data in Detecting Fraudulent Activities in Insurance Sector, Use of Big Data in Retail Industry.

**UNIT II: Understanding Big Data Technology Foundations**
Exploring the Big Data Stack, Data Sources Layer, Ingestion Layer, Storage Layer, Physical Infrastructure Layer, Platform Management Layer, Security Layer, Monitoring Layer, Analytics Engine, Visualization Layer, Virtualization and Big Data, Virtualization Approaches, Distributed and Parallel Computing for Big Data, Introducing Hadoop, Cloud Computing and Big Data, In-Memory Computing Technology for Big Data.

**UNIT III: Understanding Hadoop Ecosystem**
Hadoop Ecosystem, Hadoop Distributed File System, MapReduce, Hadoop YARN, Introducing HBase, Combining HBase and HDFS, Hive, Pig and Pig Latin, Sqoop, ZooKeeper, Flume ,Oozie, The MapReduce Framework, Techniques to Optimize MapReduce Jobs, Uses of MapReduce, Role of HBase in Big Data Processing.

**UNIT IV: Storing Data in Databases and Data Warehouses**
RDBMS and Big Data, Non-Relational Database, Polyglot Persistence, Integrating Big Data with Traditional Data Warehouses, Big Data Analysis and Data Warehouse, Changing Deployment Models in Big Data Era. Introduction to NoSQL, Types of NoSQL Data Models, Schema-Less Databases, Materialized Views, Distribution Models, Sharding.

**UNIT V: Understanding Analytics and Big Data**
Comparing Reporting and Analysis, Types of Analytics, Points to Consider during Analysis, Developing an Analytic Team, Understanding Text Analytics, Introducing Social Media
Introducing Key Elements of Social Media, Introducing Text Mining, Understanding Text Mining Process, Sentiment Analysis, Performing Social Media Analytics and Opinion Mining on Tweets,

**Text books :**
1. Big Data, Black Book, DT Editorial Services, Dreamtech Press, 2015
2. Big Data and Analytics, Seema Acharya, Subhashini Chellappan, Infosys Limited, Publication: Wiley India Private Limited,1st Edition 2015

**Reference books :**
1. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analystics, John Wiley & sons, 2012.
2. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007 Pete Warden, Big Data Glossary,O'Reilly, 2011.
3. Big Data For Dummies, Judith Hurwitz, Alan Nugent, Fern Halper, Marcia Kaufman, Wiley 2013

## CS 3033 COMPUTER GRAPHICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: learn the basics of the components of a graphics system and to become familiar with its components, hardware and applications of computer graphics.
CO2: analyze and implement various algorithms to scan, convert the basic geometrical primitives, transformations, Area filling
CO3: understand the mapping of world coordinates to device coordinates and clipping.
CO4: learn the basics of three dimensional graphics, 3D geometric transformations, projections and how detect the visible surfaces.
CO5: familiar with the concept of curve fitting
CO6: design and develop of modeling, rendering, shading and animation.

**Prerequisite: NIL**

**Introduction:** Introduction to Computer Graphics, Use of computer graphics, Elements of picture creation, Display technologies, Graphics display devices, Graphics input primitives and devices.

**Two Dimensional Graphics:** Two dimensional output primitives, Different forms of line drawing algorithms, Circle generating algorithms, Ellipse generating algorithm, Filled area primitives.

**Two Dimensional Geometric Transformations:** Translation, Scaling, Rotation, Reflection, Shear, Homogeneous coordinates, Composite transformations.

**Two Dimensional Viewing**: Window to view port transformations, Line clipping: Cohen Sutherland algorithm, Polygon clipping: Sutherland-Hodgeman algorithm,

**3D Geometric Transformations:** Translation, Scaling, and Rotation in space, Projections: Parallel and Perspective projections.

**Visible surface detection**: Depth Buffer Method, Depth Sorting method. Area Subdivision Algorithm
**Three Dimensional Graphics:** Three dimensional shapes representations: Splines, Interpolation and Approximation spline Curves, Bezier curves and surfaces.

**Illumination model and surface rendering:** Basic illumination models, Goraud shading, Phong shading and Animation.

**Text Book :**
1. Computer Graphics with openGL, Donald D. Hearn and M. Pauline Baker, Prentice Hall, 3rd Ed, 2003.

**Reference Books:**
1. Computer Graphics - Principles and Practice, J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, Second Edition in C, Addison Wesley, 2nd Ed, 2003.
2. Mathematical Elements for Computer Graphics, D. F. Rogers, J. A. Adams, McGraw Hill, 2nd Ed, 2001

## CS 3035 MACHINE LEARNING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: have a good understanding of the fundamental issues and challenges of machine learning.
CO2: develop an appreciation for what is involved in learning from data.
CO3: have an understanding of the strengths and weaknesses of many popular machine learning approaches.
CO4: appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.
CO5: apply the concept of regression methods, classification methods and clustering methods.
CO6: design and implement various machine learning algorithms in a range of real-world applications.

**Prerequisites: Knowledge in probability, linear algebra, calculus and Programming .**

**Unit 1:** Machine Learning and AI, Motivations for Studying ML, Supervised Learning, Regression, Classification, Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naı̈ve Bayes, Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods.

**Unit 2:** Unsupervised learning, Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA

**Unit 3:** Theoretical ML: Identification in the Limit, Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting Bayesian Learning: Maximum Likelihood Estimates, Parameter Estimation, Bayesian Belief Networks.

**Unit 4:** Assorted Topics: Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Modellin Sequence /Time-Series Data, Deep Learning and Feature Representation Learning, Scalable Machine Learning (Online and Distributed Learning)

**Text Book:**

1. Tom Mitchell, Machine Learning, McGraw Hill, 1997 (new chapters on line, 2006)

**Reference Books:**

1. Christopher M. Bishop, Pattern Recognition and Machine Learning,Springer, 2006
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
3. Duda, Hart and Stork, Pattern Classification (2nd ed.), Wiley Interscience, 2000

## CS 3037 PRINCIPLES OF AUTOMATA Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the concepts formal languages and finite automata.
CO2: develop an understanding of equivalence in finite automata and its minimization.
CO3: acquire the knowledge of regular languages and their properties.
CO4: understand the concepts of context-free grammars and their properties.
CO5: understand the concepts of context-free languages and pushdown automata.
CO6: be familiar with Turing machines and Chomsky hierarchy of formal languages.

**Prerequisite: Discrete Mathematics**

**Formal Languages and Finite Automata:** Alphabet, Strings, Formal Languages and their Operations, Deterministic Finite Automata , Non-Deterministic Finite Automata, Equivalence between Deterministic Finite Automata and Non-Deterministic Finite Automata, Minimization of Finite Automata.

**Regular Languages and their Properties:** Regular Expressions, Regular Languages, Equivalence between Regular Expressions and Regular Languages, Regular Grammars, Closure Properties of Regular Languages, Pumping Lemma for Regular Languages.

**Context-Free Grammars and their Properties:** Left-most Derivation, Right-most Derivation, Ambiguous Grammars, Context-Free Grammars, Simplification of Context-Free Grammar, Chomsky Normal Form.

**Context-free Languages and Pushdown Automata:** Context-Free Languages, Pushdown Automata and its Variants, Closure Properties of Context-Free Languages, Pumping Lemma for Context-Free Languages.

**Turing Machines and Relevant Topics:** Introduction to Turing Machines, Turing Machines as Language Acceptors, Recursive and Recursively Enumerable Languages, Chomsky Hierarchy of Formal Languages.

**Text Book :**

1. Introduction to Automata Theory, Languages, and Computation, 3e, John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Pearson Education India, 2008.

**Reference Books :**

1. An Introduction to Formal Languages and Automata, 6e. Peter Linz. Jones & Bartlett, 2016.
2. Introduction to Languages and the Theory of Computation, 3e, John C. Martin. Mcgraw-Hill Education, 2009.
3. Languages and Machines, 3e, Thomas A Sudkamp, Pearson Education India, 2007.

## CS 3039 OPTIMIZATION TECHNIQUE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. design of decision making problem formulation.
CO2. understand the theory of optimization methods and its algorithms developed for solving various types applications.
CO3. apply dynamic programming and game Theory.
CO4. identify decision making solution alternatives.
CO5. evaluate and measure the performance of an algorithm.
CO6. develop and promote research interest in applying optimization techniques in problems of Engineering and Technology.

**Prerequisite: Fundamentals of Engineering Mathematics**

**Module – I:** Formulation of optimization problems: Decision variables, objective function and constraints, Graphical solution and optimization outcomes, Linear and non-linear programs, Linear Programming Problem: Formulation, Simplex method, Duality theory, Dual simplex method .

**Module – II:** Sensitivity Analysis, Transportation Problem, Assignment Problem, Traveling Salesperson Problem. Network Models: Minimal Spanning Tree Problem, Maximal Flow Problem, Shortest Route Problem, Minimum Cost Flow Problem.

**Module – III:** Integer Linear Programming Problem, Branch and Bound and Cutting Plane Methods, Zero-one Programming Problem, Knapsack Problem, Set covering Problem, Set Partitioning Problem, Deterministic Dynamic Programming Problems.

**Module – IV:** Game theory, Sequencing Problem, Unconstrained Non linear programming, constrained linear programming, Multi-objective optimization models .

**Text Book** :

1. H. A. Taha – Operations Research, $8^{th}$ Edition ,Prentice Hall of India, 2007

**Reference Books :**

1. Frederick S. Hillier and Gerald J. Lieberman - Introduction to Operations Research, $10^{th}$ Edition McGraw-Hill Higher Education, 2015
2. Ronald R. Rardin - Optimization in Operations Research, 1St Edition Prentice Hall, 1998.
3. D. T. Phillips, A Ravindran and J.J. Solaberg - Operation Research: Principles and practice, 2nd Edition John Wiley and Sons, 1976.

## CS 3040 DATA STRUCTURES USING C Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: understand the concepts of data structure, data type, abstract data type (ADT) and compute the complexity of different algorithms.
CO2: understand, distinguish and implement Array and Linked data structure on different types of problems.
CO3: understand and implement different linear data structures such as Stack and Queue to solve various problems.
CO4: understand and implement different non-linear data structures such as Tree and Graph on various computing problems.
CO5: understand and apply standard algorithms for searching, sorting and hashing
CO6: effectively choose the data structure that efficiently models the information in a problem.

**Prerequisites: Computer Programming (CS-1093), Mathematics for Computer Science**

**Introduction:** Structures and Unions, Pointers, Dynamic Memory Allocation.

**Arrays:** Arrays, Abstract Data Type, Dynamically Allocated Arrays, Polynomials, Two-dimensional Array, Address Calculation, Matrix Addition and Multiplication, Sparse Matrix

**Linked List:** Singly Linked Lists , Polynomials, Sparse Matrix, Doubly Linked Lists, Circular & Header Linked lists

**Stacks and Queues:** Stacks, Stacks using Dynamic Arrays and Linked List, Queues, Queue using Dynamic Arrays and Linked List, Circular Queues using Dynamic Arrays and Linked List, Evaluation of Expressions, Priority Queue.

**Trees:** Introduction, Binary Trees, Binary Tree Traversals, Threaded Binary Trees, Binary Search Trees, AVL Trees.

**Sorting:** Insertion Sort, Quick Sort, Merge Sort, Heap Sort, Bubble Sort, Selection Sort.

**Searching:** Linear Search, Binary Search

**Text Book :**

1. Data Structures: A Pseudocode Approach with C, 2nd edition, Richard F. Gilberg, Behrouz A. Forouzan, cengage.

**Reference Books :**

1. Data Structures, Schaum's OutLines, Seymour Lipschutz, TATA McGRAW HILL
2. Data Structures using C by Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein. Pearson, 1st Edition
3. Data Structures A Pseudocode Approach with C, 2nd Edition, Richard F. Gilberg, Behrouz A. Forouzan, CENGAGE Learning, India Edition
4. Data Structures Using C, Second Edition, Reema Thereja, Oxford University Press
5. Data Structures and Algorithm Analysis in C, Mark Allen Weiss, Pearson Education, 2nd Edition.

## CS 3042 COMPUTER ORGANIZATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand how computer hardware has evolved to meet the needs of multiprocessing systems.
CO2. understand instruction Set Architecture: Instruction format, types, various addressing modes.
CO3. understand the basic components and design of the CPU: the ALU and control unit.
CO4. understand the memory organization: SRAM, DRAM, concepts on cache memory, Memory. interleaving, Associative memory, Virtual memory organization.

CO5. understand the parallelism both in terms of a single processor and multiple processors.
CO6. understand the I/O Organization: Basics of I/O, Memory-mapped I/O & I/O mapped I/O, Types of I/O transfer: Program controlled I/O, Interrupt-driven I/O, DMA.

## Prerequisite: NIL

**Introduction:**
Functional units, Basic operational concepts, Bus structures, Performance and metrics, Instructions and instruction sequencing, Hardware – Software Interface, Instruction set architecture, Addressing modes, RISC & CISC. ALU design, Fixed-point arithmetic: Addition, Subtraction, Multiplication and Division,

**Basic Processing Unit:**
Fundamental concepts, Execution of a complete instruction, Single and Multiple bus organization, Hardwired control & Micro programmed control unit.

**Pipelining:**
Basic concepts, Flynn's Classification, Types of different hazards, Performance considerations.

**Memory System:**
Basic concepts, Semiconductor RAM – ROM, Speed, Size and cost, Cache memories, Improving cache performance using mapping, Virtual memory, Associative memories, Secondary storage devices.

**I/O Organization:**
Programmed I/O, DMA control and Interrupt based I/O, Serial transmission, Synchronization, Bus arbitration techniques, Bus architectures.

**Text Book:**
1. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, "Computer Organization", Fifth Edition, Tata McGraw Hill, 2002.

**Reference Books :**
1. William Stallings, "Computer Organization and Architecture – Designing for Performance", Sixth Edition, Pearson Education, 2003.
2. John P. Hayes, "Computer Architecture and Organization", Third Edition, Tata McGraw Hill, 1998.
3. V.P. Heuring, H.F. Jordan, "Computer Systems Design and Architecture", Second Edition, Pearson Education, 2004.

## CS 3044 RELATIONAL DATABASE MANAGEMENT SYSTEM Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the basic concepts & applications of database systems.
CO2. construct an Entity-Relationship (E-R) model from specifications and to perform the transformation of the conceptual model into corresponding logical data structures.
CO3. construct queries using relational algebra .
CO4. construct queries and maintain a simple database using SQL.
CO5. distinguish between good and bad database design, as well as apply data normalization principles.
CO6. apply database transaction management and database recovery.

## Prerequisite : NIL

**Introduction :**
Introduction to Database Systems; Database – DBMS Definition, Approaches to building Database, Data Models, Three – Level Data Abstraction, Various components of DBMS.

**Relational Data Model:**
Concept of Relations and its characteristics, Schema – instance, Integrity Constraints, E/R Model, Entities, Entity Types, Attribute Types, Relationship and types, E/R Diagram Notations, Extended E/R Model, Converting E/R Diagram to Relational Schema.

**Relational Query Language:**
Relational Algebra Operators: Selection, Projection, Cross product, Types of joins, Division. Introduction to SQL, Data definition in SQL, Table, Primary key and Foreign key definitions, Data manipulation in SQL. Nested queries.

**Relational Database Design:**
Dependencies and Normal forms – Importance of a good schema design, Problems encountered with bad schema designs, Motivation for normal forms, Dependency theory – functional dependencies, Armstrong's axioms for FD's, closure of a set of FD's, Minimal covers, 1NF, 2NF, 3NF and BCNF, Denormalization.

**Transaction Processing:** Introduction to transaction, ACID property, Serializability, Concurrency control protocol.

**Text Book :**

1. Fundamentals of Database System By R. Elmasari & S.B. Navathe, $7^{th}$ Edn,2018, Pearson Education

**Reference Books :**

1. Database Management Systems by R. RamaKrishna & J. Gehrke ,$3^{rd}$ Edn, 2018, McGraw-Hill Education
2. Fundamentals of Relational Database management Systems by S. Sumathi & S. Esakkirajan, 2007 Springer.
3. Database System Concepts by A. Silberschatz, H.F. Korth & S. Sudarshan, $6^{th}$ Edn, 2019, McGraw-Hill Education

## CS 4001 DISTRIBUTED ALGORITHMS Cr- 3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand different models of distributed systems and understand the basic techniques for designing algorithms in these models.
CO2. learn and apply knowledge of distributed techniques and methodologies
CO3. explain the design, testing, and performance analysis of distributed algorithms.
CO4. identify faults and failures in distributed systems.
CO5: design and develop stabilized distributed algorithms for specific problems.
CO6 design and develop distributed algorithms for real world problems.

**Prerequisites : Design and Analysis of Algorithms (CS-2012), Data Structures and Algorithms (CS-2001), Knowledge of Computer Architecture and Operating System, Mathematics for Computer Science**

**Unit - I**
Introduction, Synchronous Network Model, Leader election in a synchronous ring, Algorithms in general synchronous networks, Distributed consensus with link failures, Distributed consensus with process failures.

**Unit - II**
Asynchronous system model, Asynchronous shared memory model, mutual exclusion, resource allocation, consensus and atomic objects

**Unit - III**
Asynchronous network model, basic asynchronous network algorithms and synchronizers

**Unit - IV**
Shared memory versus networks, logical time, global snapshots and stable properties, network resource allocation, partially synchronous system models.

**Unit - V**
Fault Tolerance in distributed systems, Fault Tolerance in asynchronous systems, Fault Tolerance in asynchronous systems, failure detection - stabilization

**Text Books :**

1. Nancy A Lynch, "Distributed Algorithms", Morgan Kaufman Publishers 1996
2. Gerard Tel, "Introduction to Distributed Algorithms", Cambridge University Press, 2nd edition, 2000

## CS 4002 HIGH SPEED NETWORKS Cr- 3

**Course Outcome**: Upon completion of this course, students will be able to :

CO1: understand the basics of high speed networking technologies
CO2: understand traffic and congestion Management .
CO3: understand resource allocation and service management approach.
CO4: demonstrate the knowledge of network planning and optimization
CO5: apply the concepts learnt in this course to optimize performance of high-speed networks
CO6: design and configure networks to support a specified set of applications

### Prerequisites: Computer Networks (IT-3005)

**Unit – I**
Frame Relay Networks –Asynchronous transfer mode –ATM Protocol Architecture, ATM logical Connection, ATM Cell –ATM Service Categories –AAL, High Speed LANs: Fast Ethernet, Gigabit Ethernet, Fiber Channel

**Unit – II**
Queuing Analysis-Queuing Models –Single Server Queues –Effects of Congestion –Congestion Control –Traffic Management –Congestion Control in Packet Switching Networks –Frame Relay Congestion Control.

**Unit – III**
Retransmission Timer Management –Exponential RTO back off –KARN's Algorithm –Window management –Performance of TCP over ATM. Traffic and Congestion control in ATM –Requirements –Attributes –Traffic Management Frame work, Traffic Control –ABR traffic Management –ABR rate control, RM cell formats, ABR Capacity allocations –GFR traffic management.

**Unit – IV**
Integrated Services Architecture –Approach, Components, Services-Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ –Random Early Detection, Differentiated Services.

**Unit – V**
RSVP –Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms –Multiprotocol Label Switching –Operations, Label Stacking

**Text Book :**

1. William Stallings, High-speed networks and Internets – Performance and Quality of Service, PHI

**Reference Books :**

1. Mahoob Hassan, Raj and Jain, High Performance TCP/IP Networking: Concepts, issues and solutions,PHI
2. William Stallings, High-speed networks: TCP/IP and ATM design principles, PHI
3. Marc Boisseau, Michel Demange, Jean-Marie Munier, High speed networks, Wiley
4. Abhijit S. Pandya, Ercan Sea, "ATM Technology for Broad BandTelecommunication Networks", CRC Press, New York, 2004.

## CS 4003 SOFTWARE DEFINED NETWORK Cr- 3

**Course Outcome**: Upon completion of the course, the students will be able to :

CO1: differentiate between traditional networks and software defined networks
CO2: understand advanced and emerging networking technologies

CO3: apply the SDN abstractions over the networks
CO4: obtain skills to do advanced networking research and programming
CO5: learn how to use software programs to perform varying and complex networking tasks
CO6: expand upon the knowledge learned and apply it to solve real world problems

**Prerequisite: Computer Networks (IT-3005)**

**UNIT I: Introducing SDN**
SDN Origins and Evolution – Introduction – Why SDN? - Centralized and Distributed Control and Data Planes - The Genesis of SDN

**UNIT II: SDN Abstractions**
How SDN Works - The Openflow Protocol - SDN Controllers: Introduction – General Concepts - VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight - Layer 3 Centric - Plexxi - Cisco OnePK

**UNIT III: Programming SDN'S**
Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing

**UNIT IV: SDN Applications and Use Cases**
SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3

**UNIT V: SDN'S Future and Perspectives**
SDN Open Source - SDN Futures - Final Thoughts and Conclusions

**Reference Books :**

1. Cosma Rohilla Shalizi, Advanced Data Analysis from an Elementary Point of View, 2015.
2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.
4. Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.


## CS 4004 TRANSACTION PROCESSING SYSTEMS Cr- 3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: describe Transaction Processing System and understand ACID (atomicity, consitency, isolation, durability) properties of transactions and their implications on system correctness and performance.
CO2: understand various transaction processing models and how these models influence the design of applications involving transactional access to a database.
CO3: identify and discuss the procedures to safeguard Transaction Processing System.
CO4: implementation and support of ACID properties in modern relational and non-relational database transaction processing systems.
CO5: modern architectures of distributed transaction processing systems and their influence on security, replication and ACID properties.
CO6: discuss the practices that can be applied to test Transaction Processing System.

**Prerequisites - Database Management System (CS-2004)**

**Unit – I**
Consistency, Atomicity, Durability, Isolation, Flat Transactions, Providing Structure within a Transaction, Structuring an Application as Multiple Transactions.

**Unit – II**
Schedules and Schedule Equivalence, Recoverability, Cascaded Aborts and Strictness, Models for Concurrency Control, A Strategy for Immediate-Update Pessimistic Concurrency Controls,Design of an Immediate-Update Pessimistic Concurrency Control, Objects and Semantic Commutativity, Atomicity, Recoverability and

Compensating Operations, Isolation in Structured Transaction Models, Conflicts in a Relational Database, Locking and the SQL Isolation Levels,Granular Locking: Intention Locks and Index Locks, Tuning Transactions, MultiversionConcurrency Controls.

**Unit – III**
Crash, Abort and Media Failure, Immediate-Update Systems and Write-Ahead Logs, Recovery in Deferred-Update Systems, Recovery from Media Failure.

**Unit – IV**
Transaction Processing in a Centralized System, Transaction Processing in a Distributed System,The TP Monitor: An Overview, Global Atomicity and the Transaction Manager, Remote Procedure Call, Pear-to-Pear Communication, Event Communication, Storage Architectures,Transaction Processing on the Internet, Implementing the ACID Properties, Atomic Termination,Transfer of Coordination, Distributed Deadlock, Global Serialization, When Global Atomicity cannot be Guaranteed, Replicated Databases, Distributed Transactions in the Real world.

**Unit – V**
Authentication, Authorization and Encryption, Digital Signatures, Key Distribution and
Authentication, Authorization, Authenticated Remote Procedure Call, Electronic Commerce, The Secure Sockets Layer Protocol: Certificates, Passport: Single Sign-On, Keeping Credit Card Numbers Private, The Secure Electronic Transaction Protocol: Dual Signatures, Goods Atomicity, Certified Delivery, and Escrow, Electronic Cash: Blind Signatures.

**Text Books :**

1. Michael Kifer, Arthur Bernstein and Philip M. Lewis, "Database Systems: An Application Oriented
2. Approach", 2nd Edition, Addison-Wesley, 2006.
3. Philip A. Bernstein and Eric Newcomer, "Principles of Transaction Processing", 2nd Edition,Morgan Kaufmann, Elsevier, 2009.

## CS 4005 PERVASIVE COMPUTING Cr- 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the fundamentals of pervasive computing
CO2. familiarize with architectural elements of pervasive computing system
CO3. know about several wireless and web-based protocols for device connectivity and security
CO4. understand WAP and use of pervasive computing for voice technology
CO5. understand PDA and pervasive web application
CO6. develop applications of pervasive computing

**Prerequisite – NIL**

**Introduction**
Introductory concepts, brief history, fundamental aspects of pervasive computing, pervasive computing market, various case studies (retail, air-line check-in and booking, health care, car information system, sales force automation), device technologies (hardware, human machine interaction, operating system, bio metrics), device types, device characteristics

**Device connectivity and web applications**
Wireless protocols, mobile phone technology, mobile internet protocol, synchronization and replication protocols, distributed services, message and transaction protocols, security, device management, WWW architecture and protocol, transcoding, client authentication via internet

**WAP and voice technology**
Introduction and components of WAP architecture, WAP infrastructure and security issues, wireless markup language, WAP Push, products, i-mode, basics of speech recognition, voice standards, speech applications and security

**PDA and pervasive web application**

Device Categories, PDA operation Systems, Device Characteristics, Software Components,Standards, Mobile Applications, PDA Browsers, Pervasive Web Application architecture: Background, Scalability and availability, Development of Pervasive Computing web applications, Pervasive application architecture

**Applications**

User Interface Issues in Pervasive Computing, Architecture, Smart Card- based Authentication via internet and ordering goods, Access from WAP, Access from personal digital assistants, Access via voice

**Text Book :**

1. JochenBurkhardt, Horst Henn, Stefan Hepper, Thomas Schaech & Klaus Rindtorff, "Pervasive Computing, Technology and Architecture of Mobile Internet Applications", Pearson Education, 2012. ISBN-13: 978-0201722154

**Reference Books :**

1. Stefen Poslad: Ubiquitous Computing: Smart Devices, Environments and Interactions, Wiley, London, 2009, Indian reprint, 2014.
2. UweHansmann, L. Merk, M. Nicklous, T. Stober, U. Hansmann, "PervasiveComputing (Springer Professional Computing) ", 2003, Springer Verlag,ISBN:3540002189
3. Frank Adelstein, Sandeep KS Gupta, Golden Richard III, Loren Schwiebert, "Fundamentals of Mobile and Pervasive Computing", McGraw Hill edition, 2006. ISBN-13: 978-0071412377

## CS 4006 PROGRAMMING FOR MULTI CORE SYSTEMS Cr- 3

**Course Outcome:** Upon completion of this course, students will be able to :

CO1: understand the fundamentals of multi-core architecture.
CO2: know the basic concepts of multi core programming using threads
CO3: understand various programming constructs in multi-core architecture
CO4: comprehend the programming constructs of multi-core systems
CO5: exploit the benefit of parallel programming
CO6: design and develop APIs for Multi threaded Applications

### Prerequisites – NIL

**Unit – I**

Fundamentals of Multi core : Fundamentals of Quantitative Design and Analysis Dependability - Measuring, Reporting and Summarizing Performance-Quantitative principles of computer Design, Instruction Level Parallelism-Data level and Thread level Parallelism. Multi core Architecture-Motivation for Concurrency - Parallel Computing in Micro processors Gustafson's law.

**Unit – II**

Introduction to Threads: Defining threads-System View of threads-Threading above the OS Inside the OS-Threads inside the Hardware-What happened When a thread is created Application Programming models and threading- VMs and Platforms-Run time Virtualization, System Virtualization.

**Unit –III**

Thread Programming Types and APIs: Synchronization-Critical Section-Deadlock Synchronization Primitives-Semaphores-Locks-Condition Variables-Flow Control based Concepts-Implementation based Threading Features-Threading APIs for Microsoft Windows Threading API for .NET framework, POSIX Threads-Programming with Pthreads, OpenMP Challenges in threading a loop-Minimizing threading overhead-Performance oriented programming - Java Threads.

**Unit – IV**

Thread Handling and Debugging: Too many threads-Data Races, Deadlock and Live locks Heavily Contended Locks-Non-blocking algorithms-Thread safe functions and libraries-Memory Issues –Cache Related Issues-Avoiding Pipeline Stalls in IA-32-Data Organization for High Performance, Multithreaded Debugging Techniques: General Debugging Techniques.

**Unit – V**

Implementation of the Programming Constructs: Foundations of Shared Memory, Spin Locks and Contention-Monitors and Blocking Synchronization- Concurrent Queues and the ABA Problem- Concurrent Stacks and Elimination-Counting, Sorting, and Distributed Coordination Concurrent Hashing and Natural Parallelism- Skip lists and Balanced Search Futures, Scheduling, and Work Distribution- Barriers-Transactional Memory -Software Transactional Memory-hardware Transactional Memory –Threading on Intel Multicore Processors.

**Text Books :**

1. Shameem Akhter and Jason Roberts, “Multi-Core Programming: Increasing Performance through Software Multi Threading”, Intel Press, 2006
2. Maurice Herlihy and NirShavit, “The Art of Multiprocessor Programming“,Revised First Edition, Elsevier Publication, 2012

**Reference Books :**

1. John L. Hennesy, and David E. Patterson, “Computer Architecture: A Quantitative Approach”, 5th Edition, Elsevier Publication, 2012
2. Thomas Rauber and GudulaRünger, “Parallel Programming: for Multi-core and Cluster Systems” , 2nd Edition, Springer Publication, 2010

## CS 4007 SOFT COMPUTING Cr- 3

**Course Outcome:** At the end of this course, students should be able to :

CO1: use the concepts soft computing and its associated methodologies.
CO2: understand and analyze fuzzy rules, fuzzy reasoning and various fuzzy inference systems.
CO3: comprehend and derivative free optimization and apply genetic algorithms to optimization problems.
CO4: understand concepts of artificial neural networks and apply neural networks to various classification problems.
CO5: analyze some hybrid models such as adaptive neuro-fuzzy inference systems.
CO6: apply soft computing techniques to solve modern real-world problems.

**Prerequisites – NIL**

**Unit – I :** Introduction of soft computing - soft computing vs. hard computing- various types of soft computing techniques- applications of soft computing-Neuro-Fuzzy and Soft computing characteristics.

**Unit – II :** Fuzzy sets, basic definition and Terminology, set-theoretic operations, member function formulation and parameterization, extension principle and fuzzy relations, fuzzy if-then rules, Fuzzy Reasoning, Fuzzy Inference systems, Mamdani Fuzzy models, sugeno Fuzzy models, Tsukamoto Fuzzy Models.

**Unit – III :** Neuron- Nerve structure and synapse-Artificial Neuron and its model-activation functions- Neural network architecture- single layer and multilayer feed forward networks-perceptron model-Adaline and Madaline-multilayer perception model- back propagation algorithm- Radial Basis function networks, adaptive Neuro-Fuzzy inference systems(ANFIS)Architecture .

**Unit – IV :** Derivative-free Optimization-basic concept of Genetic algorithm and detail algorithmic steps-Solution of typical control problems using genetic algorithm-Concept on some other search techniques for solving optimization problems.

**Text Book :**

1. Neuro-Fuzzy and Soft Computing, Jang, Sun, Mizutani, PHI/Pearson Education .

**Reference Books :**

1. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, Wiley India, 3rd edition, 2012
2. Zimmermann H. J. "Fuzzy set theory and its Applications" Springer international edition, 2011
3. David E. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009
4. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms, And
5. Applications”, Pearson Education, 1st edition, 1993
6. W. T. Miller, R. S. Sutton and P. J. Webros, “Neural Networks for Control”, MIT Press, 1996

## CS 4008 ADVANCED CRYPTOGRAPHY Cr- 3

**Course Outcome:** At the end of this course, students should be able to :

CO1. understand the relevance of number theory, group, ring, finite fields and modular arithmetic in various contexts of Cryptography
CO2. understand the basic concepts of cryptography and various attack models
CO3. understand the ideas of asymmetric key cryptosystems, entity authentication, message digest algorithms and digital signature schemes
CO4. break cryptosystems that are not provably secure
CO5. derive simple provable security proofs for cryptographic schemes
CO6. design and implement cryptographic protocols

**Prerequisites – NIL**

**Unit – I**
Review of number theory, group, ring and finite fields, quadratic residues, Legendre symbol, Jacobi symbol,

**Unit – II**
Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack(IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model.

**Unit – III**
Public key cryptography, RSA cryptosystem, probabilistic encryption, homomorphic encryption, Elliptic curve cryptosystems, Blum-Goldwasser cryptosystems, identity based encryption, Cryptographic hash functions.

**Unit – IV**
Digital signatures and the notion of existential unforgability under chosen message attacks, ElGamal digital signature scheme, Schnorr signature scheme, blind signature, electronic voting.

**Unit – V**
Zero Knowledge Proofs and Protocols, lattice based cryptography

**Text Books :**

1. W. Mao, “Modern Cryptography: Theory & Practice”, Pearson Education, 2010
2. Jeffrey Hoffstein, Jill Pipher, and Joseph H. Silverman, **“**An Introduction to Mathematical Cryptography”, Springer publication


**Reference Books :**

1. Koblitz, N., “Course on Number Theory and Cryptography”, Springer Verlag, 1986
2. Menezes, A, et.al., “Handbook of Applied Cryptography”, CRC Press, 1996
3. Thomas Koshy, “Elementary Number Theory with applications”, Elsevier India, 2005


## CS 4009 MIDDLEWARE TECHNOLOGIES Cr- 3

**Course Outcome-** At the end of the course the students will able to:

CO1: have fundamental knowledge on client server programming.
CO2: understand middleware architecture and distributed applications.
CO3: design applications using JSP with database connectivity through JDBC drivers
CO4: design and create the distributed applications using Remote Method Invocation(RMI)
CO5: design and develop middleware components using EJB framework
CO6: design IT applications and business processes using middleware architecture.

**Prerequisite : Web Technology (IT-2004), Object Oriented Programming (IT-2005)**

**Unit – I**

Introduction to client server computing-client server models, Benefits of client server computing, pitfalls of client server programming, Middleware − Client / server building blocks, RPC.

**Unit – II**

Middleware – Objects, Elements, Architecture, Middleware distributed applications, middleware types, transaction oriented middleware. Fundamentals of Webservices.

**Unit – III**

Java , JSP - request response cycle, elements, tag, directives, expression and implicit objects.
Database connectivity :Types of JDBC drivers, JDBC/ODBC architecture, Loading a driver, making connection, SQL statement execution
ResultSet generation Statement & Prepared Statement classes, ResultSetMetaData Interface.

**Unit – IV**

Introduction to RMI and RPC, Component of RMI, The RMI Architecture, RMI stub, skeleton and RMI Registry, Designing and RMI Application

**Unit – V**

Introduction to EJB Component Architecture, EJB container frame work, Types of EJB – Entity Bean, Session Bean and Message Driven Bean, Life Cycle of all the Beans, Implementing EJB – J2EE SDK Architectue, Deployment Descriptor, JNDI, Different types of Exceptions in EJB, Deploying all Types of Beans

**Text Books :**


1. Chris Britton, "IT Architectures and Middleware: Strategies for Building Large, Integrated Systems", Pearson Education, 2 nd Edition , 2004
2. Professional Java Server Programming: J2EE 1.3ed Paperback – 2007 by Cedric Buest Subrahmanyam Allamaraju


## CS 4010 GAME THEORY Cr- 3

**Course Outcome-** At the end of the course the students will able to :

CO1: identify strategic situations and represent them as games.
CO2: solve simple games using various techniques.
CO3: analyse economic situations using game theoretic techniques.
CO4: recommend and prescribe which strategies to implement.
CO5: apply the awareness of life-long learning of Game Strategy.
CO6: understand the perfect and imperfect information in competitive world .

**Prerequisites: Knowledge in Algebra, Probability, Optimization techniques and Economics**

**Unit –I**

Game in strategic form: Game frames , strict and dominance, Nash equilibrium, Prisoner's Dilemma, Stravinsky, Market Equilibrium and Pricing.

**Unit-II**

Perfect Information Games, strategies, games with two players. Electoral Competition: Median Voter Theorem. Imperfect Information Games, strategies, games with chance moves.

**Unit-III.**

Bayesian Games ,Cournot's Duopoly with Imperfect Information, public goods, auction.
Static games, one sided complete information, two sided incomplete information, multi sided incomplete information.

**Unit-IV**
Signaling Games Bargaining: Rubinstein Bargaining Model with Alternating Offers
Nash Bargaining Solution,Relation of Axiomatic and Strategic Model ,Two Illustrations:
a. Trade in market
b. Bargaining in Wireless Network Auction and Mechanism Design with Applications

**Recommended Book :**
Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2004

**Reference Book :**
Giacono Bonaanno, Game Theory, 2$^{nd}$ edition, 2018, ISBN: 978-19833604638.

# INFORMATION TECHNOLOGY

# B. Tech in Information Technology

### Program Educational Objectives (PEOs):

The B. Tech program in Information Technology aims to prepare the graduates with the following objectives:

1. The graduates shall be able to exhibit core competence in mathematical, scientific, and fundamentals of engineering to formulate, analyze, and solve real-life computational problems.
2. The graduates shall perceive the sound knowledge in core areas of Information Technology to comprehend engineering trade-offs and technical skill inclined towards product development, higher study, and research.
3. The graduates shall be inculcated with high professionalism, ethical standards, and effective communication skills to work as an individual or part of a team in diverse professional environments related to social, economical, and emerging technologies.

## Program Outcomes (POs):

The program outcomes are:

a) Engineering knowledge: Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) Problem analysis: Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) Design/Development of solutions: Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) Conduct investigations on complex problems: Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) Modern tool usage: Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) The engineer and society: Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) Environment and sustainability: Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) Ethics: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) Individual and team: Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) Communication: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) Project management and finance: Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) Life-long learning: Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

#### Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Impart knowledge of data management system like data acquisition, big data so as to enable students in solving problems using the techniques of data analytics, pattern recognition and knowledge discovery.
n) Acquire basic knowledge in hardware/software methods and tools for solving real-life and R&D problems with an orientation to lifelong learning.
o) Acquire sound knowledge base and skill sets to develop and expand professional careers in fields related to human-computer interaction and management of industrial processes for the design and implementation of intelligent systems.

**IT 2004** **WEB TECHNOLOGY** **Cr-3**

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand and design interactive web page(s) using HTML, CSS.
CO2. understand Basic Concepts of OOP, introduction to classes and objects through Java Language and apply
CO3. understand the concepts of constructors, Overloading, parameter passing, access control, Inheritance and apply
CO4. understand Packages, Interfaces, and Exception Handling .
CO5. understand I/O Streams & apply
CO6. understand basics and design of an applet.

**Prerequisites: Object Oriented Programming**

**Web Development:** HTML, Structure, Tags, Lists, Table, Link and it's types ,Images, Form, Frame, Style sheets .

**Introduction to Java:** Java and Java applications, Java Virtual Machine(JVM), Java Runtime Environment(JRE)Java Development Kit(JDK,) Byte code, Java characteristics, Object oriented Programming, Simple java programs, Data types, Operators, Expressions, control statements, Selection statements, Iteration statements, Jump statements

**Classes, Inheritance:** Classes in java, Declaring a class, Creating instances of class, Constructors, Argument Passing, use of static keyword, Innner class. Method overloading, Inheritance, use of super keyword ,Method overriding, Abstract class, Dynamic method dispatch, use of final keyword

**Interface, Package:** Package, Acesss control mechanism, Interface, Dynamic Method look up

**Exception Handling:** Java Exception Handling Mechanism, try, catch, throw, throws and finally, Exception types, Built in Exceptions: checked and unchecked exceptions, User defined Exceptions

**String Handling:** String and String Buffer, Constructors, String operations : character extractions, String comparisons, searching strings, modifying a string. To String() and valueOf() methods, String Buffer operations

**Java I/O Stream:** I/O basics, Byte stream, Character stream, Reading console input, Writing console output, Reading and writing files

**Applet:** Applet class, Applet architecture, Applet Skeleton, Life cycle methods, setForeground() and setBachground() methods,Using the status window,HTML Applet tag, Passing parameters to an applet, getCodebase() and getDocumentbase() methods.

**Text Book :**

1. Java Programming for Core and Advanced Learners, Sagayaraj, Denis, Karthik and Gajalakshmi, 1st Edition, Universities Press 2018

**Reference Books :**

1. Java-The Complete Reference,Herbert Schildt, 9th Edition, McGraw Hill Education 2014
2. HTML- Complete Reference,Powell, 3rd Edition, TMH 2007
3. Introduction to JAVA Programming, Y.Daniel Liang, 6th Edition, Pearson Education 2007

## IT 2005 OBJECT ORIENTED PROGRAMMING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the difference between structure-oriented programming and object-oriented programming.
CO2: use object-oriented programming language like C++ and associated libraries to develop object-oriented programs.
CO3: apply various object-oriented features like class, object, inheritance, data abstraction, encapsulation polymorphism to solve various computing problems using C++ language.
CO4: understand and apply concepts of operator-overloading, contracture and destructtor
CO5: understand the and apply exception handling and use built-in classes from STL
CO6: implement, test and debug solutions in C++.

**Prerequisite: Computer Programming (CS-1093)**

**Introduction to Object Oriented Programming:** Object oriented programming concepts: Objects, classes, encapsulation and abstraction, inheritance, polymorphism, dynamic binding, message passing; C++ Programming basics: Character set, Keyword, Constant, Variable, Data types, operator & expression, control structure (branching & looping), typecasting, array & strings, Streams based I/O, Type conversions and casting, name space, scope resolution operator (::); Function: Parameter passing (i) by value, (ii) by address, (iii) by reference, inline function, function overloading, default arguments.

**Class and Object:** Class and Object: Defining class with functions and data members, Creating & deleting objects by using new and delete operators respectively, Array of Objects, Objects as function argument, Static Data members and member functions, Function with default arguments, function overloading; Constructor and Destructors: Definition of constructors and its uses, Types of constructors: default constructor, parameterized constructor, copy constructor, constructor with dynamic allocation, Dynamic Constructors, Constructor Overloading, Destructors.

**Inheritance:** Concept of inheritance: defining derived and base classes, Class hierarchies, public, private, and protected derivations; Types of Inheritance: Single Inheritance, Multilevel Inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance, Virtual base class: Function overriding, Constructors/Destructors in derived classes: Constructors invocation and data members initialization in derived classes, Member classes: classes within classes

**Polymorphism:** Operator overloading: Overloading unary operators, binary operators, overloading binary operators using friend function and member function, Rules for overloading operators; Polymorphism: Introduction to pointers: Pointers to objects, pointer to derived class object, this pointer, Compile time polymorphism: Review of Function Overloading and Operator overloading; Run time polymorphism: virtual functions, pure virtual functions, abstract class, virtual constructors and destructors

**Exception Handling, Templates, Files and Streams:** Exception Handling: Basics of Exception Handling, Exception Handling Mechanism: The keyword try, throw and catch. Templates: Need of template, Class Templates: Definition, Class Template with multiple parameters, Function Templates: Definition, Function Template with multiple parameters. Files and Streams: Introduction to file handling: text file Vs. binary file, Hierarchy of file stream classes: Functions of File Stream classes, Steps to process a File in a program. Different functions used in file, File modes(Sequential and random), File pointers and their Manipulations, Error handling during file operation

**Text Books :**

1. Object Oriented Programming with C++, Reema Thareja, OXFORD University Press, Revised First Edition, 2018.
2. Object Oriented Programming with C++, E.Balaguruswamy, McGraw Hill Education; Seventh edition 2017.

**Reference Books :**

1. C++ completes reference, Herbert Schildt, TMG Hill, 4th Edition, 2002.
2. C++ How to Program, Deitel and Deitel, Pearson Education Asia, 8th Edition, 2011.
3. Object Oriented Programming with Ansi and Turbo C++, Ashok N Kamthane, Pearson Education, 1st Edition,2003

## IT 3003 SOFTWARE ENGINEERING Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1: differentiate different software process models and understand their applicability in real life projects.
CO2: gather and specify requirements of the software projects.
CO3: understand and apply the basic project management practices in real life projects.
CO4: translate the baseline requirement specifications into design & development process.
CO5: distinguish and apply different testing methodologies.
CO6: work ethically in a team as well as independently on software projects and be prepared for the ever changing dynamic real world situations.

**Course Prerequisite: Nil**

**Software Process Models:** Software product, Software crisis, Handling complexity through Abstraction and Decomposition, Overview of software development activities. Process Models: Classical waterfall model, iterative waterfall model, prototyping model, evolutionary model, spiral model, RAD model. Agile models: Extreme programming and Scrum. Software Requirement Engineering

**Software Requirement Engineering:** Requirement Gathering and analysis, Functional and non functional requirements, Software Requirement Specification(SRS) , IEEE 830 guidelines, Decision tables and trees.

**Software Project Management:** Responsibilities of a Software project manager, project planning, Metrics for project size estimation, Project estimation techniques, Empirical estimation techniques, COCOMO models, Scheduling, Organization & team structure, Staffing, Risk management, Software configuration management.

**Structural Analysis & Design:** Overview of design process: High level and detailed design, Cohesion & coupling, Modularity and layering, Function–Oriented software design: Structural Analysis, Structural Design (DFD and Structured Chart), Object Oriented Analysis & Design, Command language, menu and iconic interfaces.

**Testing Strategies:** Coding, Code Review, Documentation, Testing: - Unit testing, Black-box Testing, White-box testing, Cyclomatic complexity measure, Coverage analysis, Debugging, Integration testing, System testing, Regression testing.

**Software Reliability Software Maintenance:** Software reliability, reliability measures, reliability growth modelling, Quality SEI CMM, Characteristics of software maintenance, software reverse engineering, software re engineering, Software reuse

**Emerging Topics:** Client-Server Software engineering, Service Oriented Architecture (SOA), Software as a Service (SaaS)

**Text book :**

1. Fundamentals of Software Engineering, Rajib Mall , PHI, Latest edition.

**Reference books :**

1. Software Engineering, A Practitioner's Approach, Roger S. Pressman ,TMG Hill, Latest edition.
2. Software Engineering, I. Sommerville, Pearson Education, Asia.

## IT 3005 COMPUTER NETWORKS Cr - 3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand different models used for study of computer networks and ability to identify different designs.

CO2: understand how information transforms while moving through network and understand different technologies used to improve efficiency of communication.
CO3: understand how to preserve the integrity of data communication on network.
CO4: design and engineer routes to create interconnect of nodes.
CO5: understand working of world wide web and electronic mail technologies.

**Prerequisites: NIL**

**Introduction:** Internet, Protocol, Packet and circuit switching, Delay and throughput in Packet-switched Network, Protocol layers and service model.

**Application Layer:** Architecture and principles of network applications, Web, HTTP, Email and DNS.

**Transport Layer:** Introduction and services, Multiplexing and de-multiplexing of data, Connection less transport, Principles of reliable data transfer(Flow Control), Connection oriented transport, Principles of congestion control, TCP flow and congestion control

**Network Layer:** Introduction and services, Virtual circuit and datagram networks, IPv4 datagram format, IPv4 addressing, DHCP, ICMP, NAT, Routing Algorithms.

**Link-layer:** Introduction and services , Error detection and correction techniques, Multiple access protocols, Link-Layer Addressing, ARP, Ethernet Frame format, GIGABIT Ethernet, Link Layer Switching & VLANs.

**Text Book :**
1. Computer Networks: A top-down approach by Forouzan, McgrawHill .

**Reference Books :**
1. Computer Networking: A top-down approach", by Kurose and Ross, *5th Edition, Pearson*
2. Computer Networks", by A.S. Tannenbaum, 5th Edition, Pearson
3. Computer Networks: A systems approach", by Peterson and Daive, 5th Edition, Morgan Kaufmann

## IT 3006 DATA ANALYTICS Cr- 3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: understand and classify the characteristics,concepts and principles of big data.
CO2: apply the data analytics techniques and models.
CO3: implement and analyze the data analysis techniques for mining data streams.
CO4: examine the techniques of clustering and frequent item sets.
CO5: analyze and evaluate the framework and vizualization for big data analytics.
CO6: formulate the concepts, principles and techniques focusing on the applications to industry and real world experience.

**Prerequisite: NIL**

Introduction to Big Data: Introduction to Data, Big Data Characteristics, Types of Big Data, Challenges of Traditional, Systems, Web Data, Evolution of Analytic Scalability, OLTP, MPP, Grid Computing, Cloud Computing, Fault Tolerance, Analytic Processes and Tools, Analysis Versus Reporting, Statistical Concepts, Types of Analytics.

**Data Analysis:** Introduction to Data Analysis, Importance of Data Analysis, Data Analytics Applications, Regression Modelling Techniques: Linear Regression, Multiple Linear Regression, Non Linear Regression, Logistic Regression, Bayesian Modelling, Basian Networks, Support Vector Machines, Time Series Analysis, Rule Induction, Sequential Cover Algorithm.

**Mining Data Streams:** Introduction to Mining Data Streams, Data Stream Management Systems, Data Stream Mining, Examples of Data Stream Applications, Stream Queries, Issues in Data Stream Query, Processing, Sampling in Data Streams, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Querying on Windows − Counting Ones in a Window, Decaying Windows, Real-Time Analytics Platform (RTAP).

Frequent Itemsets and Clustering: Introduction to Frequent Itemsets, Market-Basket Model, Algorithm for Finding Frequent, Itemsets, Association Rule Mining, Apriori Algorithm, Introduction to Clustering, Overview of Clustering Techniques, Hierarchical Clustering, Partitioning Methods, K- Means Algorithm, Clustering High-Dimensional Data.

Frameworks and Visualization: Introduction to framework and Visualization, Introduction to Hadoop, Core Components of Hadoop, Hadoop Ecosystem, Physical Architecture, Hadoop Limitations, Hive, MapReduce and The New Software Stack, MapReduce, Algorithms Using MapReduce, NOSQL, NoSQL Business Drivers, NoSQL Case Studies, NoSQL Data Architectural Patterns, Variations of NoSQL, Architectural Patterns, Using NoSQL to Manage Big Data, Visualizations

**Text Book :**

1. Data Analytics, Radha Shankarmani,M. Vijayalaxmi, Wiley India Private Limited, ISBN: 9788126560639.

**Reference Books :**


1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data by EMC Education Services (Editor), Wiley, 2014
2. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analystics, John Wiley & sons, 2012.
3. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007 Pete Warden, Big Data Glossary,O'Reilly, 2011.
4. Jiawei Han, MichelineKamber "Data Mining Concepts and Techniques", Second Edition, Elsevier, Reprinted 2008.
5. Stephan Kudyba, Thomas H. Davenport, Big Data, Mining, and Analytics, Components of Strategic Decision Making, CRC Press, Taylor & Francis Group. 2014
6. Big Data, Black Book, DT Editorial Services, Dreamtech Press, 2015


## IT 3007 INTERNET OF THINGS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand basics of IoT
CO2: understand the application areas of IoT ·
CO3: understand building blocks of Internet of Things and characteristics
CO4: understand the State of Art IoT Architecture.
CO5: understand the working of sensors and embedded systems
CO6: understand how to communicate with other mobile devices using various communication platforms such as Bluetooth and Wi-Fi.

**Prerequisites: Computer Networks (IT-3005)**

**Introduction to Internet of Things:** Definition & Characteristics of IoT, **Physical Design of IoT** - Things in IoT , IoT Protocols , **Logical Design of IoT. IoT Enabling Technologies -** Wireless Sensor Networks ,Cloud Computing ,Big Data Analytics ,Communication Protocols ,Embedded Systems .**IoT Levels & Deployment Templates.**

**Application of Domain Specific IoTs: Home Automation** -Smart Lighting ,Smart Appliances, Intrusion Detection ,Smoke/Gas Detectors**. Cities -** Smart Parking , Smart Lighting ,Smart Roads ,Structural Health Monitoring ,Surveillance ,Emergency Response. **Environment -**Weather Monitoring ,Air Pollution Monitoring ,Noise Pollution Monitoring ,Forest Fire Detection ,River Floods Detection.**Energy**-Smart

Grids ,Renewable Energy Systems , Prognostics. **Retail**-Inventory Management ,Smart Payments ,Smart Vending Machines.**Logistics** -Route Generation & Scheduling , Fleet Tracking ,Shipment Monitoring ,Remote Vehicle Diagnostics. **Agriculture** -Smart Irrigation , Green House Control.**Industry** - Machine Diagnosis & Prognosis , Indoor Air Quality Monitoring.**Health& Lifestyle** -Health & Fitness Monitoring.

**IoT and M2M: Introduction, M2M , Difference between IoT and M2M .**
**IoT Platform Design Methodlogy:** Introduction ,IoT Design Methodology.Case Study on IoT System for Weather Monitoring,Case Study on IoT System for Home Automation, Case Study on IoT System for Industry Automation.

**IoT Physical Devices & Endpoint:** IoT Device, Exemplary Device: Arduino, About the Arduino Uno input and output Control an LED with Arduino , Interfacing an LED with Switch with Arduino, Interfacing Relay with Arduino. Analog to Digital Converter , Reading value from potential meter, DHT-11 temperature sensor, LDR, Interfacing of various sensors with Arduino, Raspberry Pi, Intel, BeagleBone Black , Cubieboard.

**IoT Physical Server and Cloud Offering:** Introduction to Cloud Storage Models & Communication APIs ,(8.1)Client-Server model for IoT, Different server side web technologies for IoT-PHP ,JSP ,Servlet ,Node JS Different Client side web technologies for IoT -HTML Java script and JSON , AJAX .MVC architecture for IoT, Web socket and HTTP ,Arduino as a web-client ,Dweet ,Thingspeak,freebord.io .

**Case Studies Illustrating IoT Design:** Introduction, Home Automation- Smart Lighting, Home Intrusion Detection , Cities -Smart Parking, Environment -Weather Monitoring System ,Weather Reporting Bot ,Air Pollution Monitoring , Forest Fire Detection ,Agriculture - Smart Irrigation , Productivity Applications - IoT Printer .

**Advanced Topics:** Mobile Application Development using Android and IoT- Introduction ,Basics of Android System,Design mobile app using IOT. Data Analytics and Big data for IoT, Wireless Technology for IoT.

**Text Book :**

1. Arshadeep Bahga,Vijay Madisetti, "Internet of Things -A Hands-on Approach", Universities Press, 1st Edition, ISBN:9788173719547.

**Reference Books :**

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wiley Publication, 1st Edition, November 2013,ISBN:9781118430620.
2. Harry Fairhead ,"Raspberry Pi IOT in C", IO Press Publication, 1st Edition, ISBN:9781871962468

## IT 3022 CLOUD COMPUTING Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: understand the basic concepts of Distributed System and Cloud Computing
CO2: analyze the different cloud models
CO3: compare the various cloud services and cloud platforms
CO4: analyze various scheduling techniques applied in cloud platform.
CO5: appraise VM provisioning and migration techniques used in cloud environment.
CO6: examine various cloud applications and issues.

**Prerequisites: Nil**

**Introduction :** Introduction to Cloud Computing, Roots of Cloud Computing: Fundamental concepts of Distributed Systems, Cluster Computing, Grid Computing, and Mobile Computing.

**Cloud Models:** Basics of Cloud Computing Concepts, Characteristics of Cloud Computing, Need for Cloud, Cloud Deployment models: private, public, hybrid and community cloud, Cloud Services: Resource-as-a-

Service (RaaS), Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS), Examples of each services.

**Cloud Services:** RaaS: Usage of Physical resources like servers, networks, data center etc, IaaS: Virtualization, Virtual Machine provisioning and Migration Services, Scheduling techniques of Virtual machines for resource reservation. PaaS: Integrated lifecycle platform: Google App Engine, Microsoft Azure, Anchored life cycle platform: Salesforce platform, SaaS: Characterizing SaaS, Salesforce's software environment.

**Cloud Application: Cloud** Application, Cloud challenges, Cloud Security and privacy issues, Mobile Cloud, Integration of Cloud with Wireless Sensor Network and its application.

**Text Book :**

1. Cloud Computing by Shailendra Singh, Oxford University Press, 2018

**Reference Books :**

1. Cloud Computing Principles and Paradigms, edited by Rajkumar Buyya, James Broberg and Andrzej Goscinski, Wiley Publication, 2013
2. Cloud Computing for Dummies, Judith Hurwitz, Robin Bloor, Marcia Kaufman and Fern Halper, Wiley Publication, 2009

## IT 3024 MOBILE APPLICATIONS DEVELOPMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: expose to technology and business trends impacting mobile applications
CO2: understand the characterization and architecture of mobile applications.
CO3: understand the enterprise scale requirements of mobile applications.
CO4: understand the data base connectivity for mobile application.
CO5. competent with designing and developing mobile applications using one application development framework.
CO6. gain knowledge about connectivity of multimedia & wireless application using mobile

**Prerequisite: Programming skill, Java programming**

**Introduction:** What is Android, Android versions and its feature set. The various Android devices on the market, The Android Market application store, Android Development Environment - System Requirements, Android SDK, Installing Java, and ADT bundle - Eclipse Integrated Development Environment (IDE), Creating Android Virtual Devices (AVDs).

**Android Architecture Overview and Creating an Example Android Application:** The Android Software Stack, Android Runtime – Core Libraries, Java Interoperability Libraries, Android Libraries, Application Framework, creating a New Android Project, Defining the Project Name and SDK Settings, Project Configuration Settings, Configuring the Launcher Icon, creating an Activity, Running the Application in the AVD, Stopping a Running Application.

**User Interface and Application Components:** Basic UI Design; Fragments; Widget Toolbox; Understanding Android Views, View Groups and Layouts; Graphical User Interface Screen with views; Displaying Pictures; Introduction to Intents; Intent Filters and broadcast Receivers; Activities; Services; Content Providers; Application Widgets; Processes, Android Threads and Thread handlers.

**Files and Database Handling:** Saving Application Data; Shared Preferences; Preference Framework and Activity; Static File as Resource; File System; Introduction to SQLite Database; Querying SQLite; Storage options; Data backup

**User Experience Enhancement:** Action Bar; Menus and Action Bar Items; Settings; Dialogs; Customizing Toast; Notifications; Search; Drag and Drop.

**Messaging and Location-Based Services:** Sending SMS Messages Programmatically, Getting Feedback after Sending the Message Sending SMS Messages Using Intent Receiving, sending email, Introduction to location-based service, configuring the Android Emulator for Location-Based Services, Geocoding and Map-Based Activities.

**Multimedia, Wireless Connectivity and Telephony:** Audio and Video Handling; Manipulating Raw Audio; Sound Effects; Camera Programming; Video Recording; Managing Wireless Connectivity: Wi-Fi, Bluetooth, Near Field Communication; Hardware Support for Telephony; Telephony Management; SMS and MMS

**Text Book :**

1. Reto Meier, "Professional Android 4 Application Development", Wrox, 2012

**Reference Books :**

1. Matt Gifford, "Phone Gap Mobile Application Development Cookbook", PACKT, 2012
2. Adrian Kosmaczewski, "Mobile JavaScript Application Development", O'RELLY, 2012

## IT 3025 ENTERPRISE RESOURCE PLANNING Cr-3

**Course Outcome:** At the end of the course, the student will be able to:

CO1. comprehend the technical aspects of ERP systems.
CO2. understand concepts of reengineering and how they relate to ERP system implementations.
CO3. map business process using process mapping techniques.
CO4. understand the steps and the activities in the ERP life cycle.
CO5. identify and describe typical functionality in an ERP system.
CO6. have practical hands-on experience with one of the COTS ERP software e.g. SAP, Oracle

**Prerequisite : NIL**

**Introduction to ERP:** Enterprise - An overview, Integrated Management Information , Business modeling, Integrated Data Modeling, Risks & benefits of ERP.

**ERP & Related Technologies:** Business Process Reengineering (BPR), Data Warehousing, Data Mining, On-Line Analytical Processing (OLAP). Supply Chain Management (SCM), Customer Relationship Management (CRM), Management Information System (MIS), Decision Support System (DSS), Executive Information System (EIS).

**ERP Implementation:** Lifecycle , Implementation Methodology, Hidden costs, Organizing the Implementation, Vendors, Consultants and Users, Contracts with Vendors, Consultants & Employees, Project Management and Monitoring.

**ERP Modules:** Business Modules in an ERP Package- Finance, Manufacturing, Human Resources, Plant Maintenance, Materials Management, Quality Management, Sales and Distribution.

**ERP Planning:** ERP & Ecommerce, Future Directives in ERP and Internet, Critical success and failure factors, Integrating ERP into Organizational culture, Performance measurement of ERP system, Maintenance of ERP system.
**ERP Market:** ERP market place, SAP AG, Peoplesoft, Baan, JD Edwards, Oracle, QAD,SSA

**Text Book :**

1. Alexis Leon, "ERP Demystified", Tata McGraw Hill

**Reference Books :**

1. Vinod Kumar Garg and Venkita Krishnan N K, “Enterprise Resource Planning —Concepts and Practice” , PHI

## IT 3028 INFORMATION STORAGE MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the concept of information storage management including storage subsystems, RAID and intelligent storage systems
CO2: analyze the storage networking technologies such as FCSAN, IP-SAN, FCoE, NAS and object-based, and unified storage
CO3: evaluate the architectures of CAS and Virtualization
CO4: understand and articulate business continuity solutions – backup and replications, along with archive for managing fixed content
CO5: assessing the risk triads and security requirements and solutions using the storage security framework
CO6: develop ideal storage solutions for adaptive architectures and storage systems.

**Prerequisite: Computer Architecture, Operating Systems, Networking, and databases**

**Unit-1:Introduction to Information Storage and Management:** Information Storage, Evolution of Storage Technology and Architecture, Data Center Infrastructure, Key Challenges in Managing Information, Information Lifecycle. Storage System Environment: Components of a Storage System Environment, Disk Drive Components, Disk Drive Performance, Fundamental Laws Governing Disk Performance, Logical Components of the Host, Application Requirements and Disk Performance. Data Protection: RAID: Implementation of RAID, RAID Array Components, RAID Levels, RAID Comparison, RAID Impact on Disk Performance, Hot Spares. Intelligent Storage System: Components of an Intelligent Storage System, Intelligent Storage Array.

**Unit-2:Storage Network Technologies:** Types of DAS, DAS Benefits and Limitations, Disk Drive Interfaces, Introduction to Parallel SCSI, SCSI Command Model. Storage Area Networks: Fiber Channel: Overview, The SAN and Its Evolution, Components of SAN, FC Connectivity, Fiber Channel Ports, Fiber Channel Architecture, Zoning, Fiber Channel Login Types, FC Topologies. Network-Attached Storage: General-Purpose Servers vs. NAS Devices, Benefits of NAS, NAS File I/O, Components of NAS, NAS Implementations, NAS File-Sharing Protocols, NAS I/O Operations, Factors Affecting NAS Performance and Availability.

**Unit-3: Content Addressed Storage & Virtualization:** Content-Addressed Storage: Fixed Content and Archives, Types of Archives, Features and Benefits of CAS, CAS Architecture, Object Storage and Retrieval in CAS. Storage Virtualization: Forms of Virtualization, SNIA Storage Virtualization Taxonomy, Storage Virtualization Configurations, Storage Virtualization Challenges, Types of Storage Virtualization.

**Unit-4: Business Continuity:** Introduction to Business Continuity, Information Availability, BC Terminology, BC planning lifecycle, Failure Analysis, Bussiness Impact Analysis, Backup Purpose, Backup Considerations, Backup Granularity, Recovery Considerations, Backup Methods, Backup Process, Backup and Restore Operations, Backup Topologies, Backup in NAS Environments, Backup Technologies. Local Replication: Source and Target, Uses of Local Replicas, Data Consistency, Local Replication Technologies, Restore and Restart Considerations, Creating Multiple Replicas, Management Interface. Remote Replication: Modes of Remote Replication, Remote Replication Technologies, Network Infrastructure.

**Unit-5: Securing the Storage Infrastructure**: Storage Security Framework, Risk Triad, Storage Security Domains, Security Implementations in Storage Networking. Managing the Storage Infrastructure: Monitoring the Storage Infrastructure, Storage Management Activities, Storage Infrastructure Management Challenges, Developing an Ideal Solution.

**Text Book :**

1. Information Storage and Management: Storing, Managing, and Protecting Digital Information, G. Somasundaram; Alok Shrivastava, John Wiley & Sons, 2$^{nd}$ Edition, 2009

**Reference Books :**

1. Robert Spalding, “Storage Networks: The Complete Reference”, Tata McGraw Hill, Osborne, 2003.
2. Marc Farley, “Building Storage Networks”, Tata McGraw Hill, Osborne, 2001.

## IT 3031 DATA MINING AND DATA WAREHOUSING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the basic principles, concepts & applications of data mining and familiar with mathematical foundations of data mining tools.
CO2: understand the fundamental concepts, benefits, problem areas associated with data warehousing along with various architectures and main components of a data warehousing.
CO3: characterize the kinds of patterns that can be discovered by association rule mining algorithms.
CO4: understand various classification and prediction algorithms to solve the real problems.
CO5: understand various clustering algorithms to solve the real problems.
CO6: develop ability to design various algorithms based on data mining tools to solve web, spatial, temporal, text and multimedia data.

### Prerequisite: Database Management System (CS-2004)

**Introduction:** Basic Data Mining Tasks, Data Mining Issues, Data Mining Metrics, Data Mining from a Database Perspective, A Statistical Perspective on Data Mining.

**Data Warehousing and Preprocessing**: Data Warehousing, Data Warehousing Architecture, OLTP, OLAP, Preprocessing Techniques A Statistical Perspective on Data Mining, Similarity Measures

**Association Rules:** Basic Algorithms for Association Rule, Incremental Association Rules, Measuring the Quality of Rules, Advanced Association Rule.

**Classification**: Statistical-Based Algorithms, Distance-Based Algorithms, Decision Tree-Based Algorithms, Advanced Classification methods (Genetic, Rough Set, Fuzzy Set), Neural Network.

**Clustering:** Data Types, Similarity Measure, Hierarchical Algorithms, Partitional Algorithms, Clustering Large Databases, Clustering with Categorical Attributes.

**Advanced Techniques:** Web Mining, Spatial Mining, Temporal Mining, Text Mining, Multimedia Mining.

**Text Book :**

1. J. Han and M. Kamber, “Data Mining: Concepts and Techniques”, 4$^{th}$ Edition, Morgan Kaufman,2015.

**Reference Books :**

1. M. H. Dunham, “Data Mining: Introductory and Advanced Topics”, Pearson Education, 2006.
2. I. H. Witten and E. Frank, “Data Mining: Practical Machine Learning Tools and Techniques,” Morgan Kaufmann, 2000.
3. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining. Prentice-Hall. 2001.

## IT 3032 SOFTWARE PROJECT MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understands job roles of an IT project manager and conduct project planning activities.
CO2. determine an appropriate process model for an IT project.
CO3. estimate project costs, timelines and quality.
CO4: implement, monitor and control processes for successful resource, communication, risk and change management.
CO5: form the organization structure for the IT project and manage the contract, people and team.
CO6: define the metrics and measure quality and reliability.

**Prerequisite: Software Engineering (IT-3003)**

**Introduction to Software Project Management:** Software Project Management, Software projects vs other types of projects, activities, Plan Methods, Methodologies, Categorization, Management Control.

**Project Evaluation and Programme Management:** Project Portfolio Management, Evaluation, Cost-Benefit Evaluation, Risk Evaluation, Managing allocation of Resources, Benefits Management.

**An Overview of Project Planning:** Stepwise Project Planning

**Selection of Project Approach:** Choosing Methodologies and Technologies, Agile Methods, Dynamic System Development Method, Managing iterative process, Selecting Process Model.

**Software Effort Estimation:** Estimates, Effort Estimation, Top-down, Bottom -up, Function Points, COCOMO

**Activity Planning and Resource Allocation:** Project Schedules, Network Planning Models, Sequencing & Scheduling, Resource Allocation, Scheduling Resources, Cost Schedules.

**Risk Management Monitoring and Control:** Risk, Categories of Risk, Identification, Assessment, Planning, Management and control, Creating Framework, Cost Monitoring, Prioritizing Monitoring, Change control.

**Managing Contracts & People and Team Working:** Types of Contract, Contract management, Understanding Behavior, Organization behavior, Motivation, Oldham-Hackman job characteristics Model, Some ethical and professional concerns, Decision making, Organization Structure, Dispersed and Virtual Teams, Leadership.

**Software Quality:** Defining software quality, ISO-9126, Product vs Process Quality Management System, Process Capability Models, Testing, Quality Plans.

**Text Book :**

1. Bob Hughes and Mike Cotterell, Rajib Mall, “Software Project Management “, TMH-5e, 2011

**Reference Books :**

1. Henry.J, Addison, Software Project Management,-A Real-World Guide to Success, Wesley,2004.
2. Pankaj Jalote, Software Project Management in Practice, Pearson Education, 4e,2011.
3. S.A. Kelkar, Software Project Management, A Concise Study, Prentice -Hall , India, 3e, 2010.
4. Jerome D, Wiest, Ferdinand K Levy, A Management Guide to PERT/CPM, PHI,2e, 2008
5. Ince D, Sharp H, and Woodman M., Introduction to Software Project Management and Quality Assurance, McGraw-Hill, 1993

## IT 3033 IMAGE PROCESSING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: apply the theory and algorithms that are widely used in digital image processing
CO2: implement a proper image enhancement technique for given a set of noisy images.
CO3: distinguish and implement different image segmentation and compression techniques.
CO4: formulate solutions using morphological concepts.
CO5: understand the object recognition technologies.
CO6: develop various applications using different image processing techniques.

**Prerequisites: Mathematics, Programming language.**

**Digital Image Fundamentals** Different fields of DIP**,** The digitized image and its properties – Image sampling and quantization ,image types, spatial Intensity and resolution, basic relationship between pixels, Mathematical tools used in DIP

**Image Enhancement & Restoration**– Basic Intensity transformation functions, Histogram processing, smoothing and sharpening filters in spatial and frequency domain , Periodic noise, Image Degradation/ restoration Process, Noise Models, Mean filters, order statistics filters, Adaptive filters, and Notch filters.

**Morphological Image Processing** – Erosion & Dilation, Opening & Closing , Hit or Miss Transformation, Boundary Extraction, Pruning, Textural segmentation, morphological smoothing.

**Image Segmentation** – Fundamentals, Point, line & Edge Detection, Thresholding, multivariable thresholding, region growing, region splitting and merging.

**Image Compression**- Coding redundancy, measuring image information, fidelity criteria, image compression models, Huffman coding, Arithmetic coding, run length coding, symbol based coding, bit plane coding, digital image watermarking.

**Object recognition** –Object recognition system, automated Process of recogintion, patterns and pattern class, representation of pattern class, selection of measurement parameters, relationship between image processing and object recognition, approaches to object recognition, Bayes' parametric classification, Structural method-shape numbers, string matching, Face recognition.

**Text Book :**

1. Digital Image Processing, by R.C. Gonzales , R.E. Woods, $4^{th}$ Edition, Pearson Education, 2018 .

**Reference Books :**

1. Fundamental of Digital Image Processing by Anil K. Jain, PHI , India .
2. Image Processing, Analysis and Machine Vision, by Milan Sonka, Vaclav Hlavac, Roger Boyle Cengage Learning 3rd Edn, 2007, C L Engineering .
3. Fundamentals of Digital Image Processing, Annadurai , Pearson Publication

## IT 3034 MULTIMEDIA SYSTEMS AND ARCHITECTURE Cr- 3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: demonstrate knowledge on the concepts of multimedia systems.
CO2: understand the audio and Video concepts used.
CO3: differentiate between different compressions techniques and formulate new compression technique
CO4: understand the transmission and distribution of Multimedia content
CO5: gain knowledge on Multimedia Database and Content-based storage and retrieval
CO6: understand the hypermedia and virtual reality concept and Design using VRML

### Prerequisites: Computer Networks (IT-3005), Digital Electronics.

**Introduction to Multimedia:** Fundamentals of multimedia, Components of Multimedia, Image Data Representation, Image Processing, Color Models, Advantages of Graphics, Components of Graphics System.

**Audio and Video Concepts:** Properties of Audio, Digital Audio, Synthesizer, MIDI, Types of Video Signals, Analog Video, Digital Video.

**Compression:** Basic Concepts, Lossless Compression Techniques, Lossy Compression Techniques, Image Compression, Audio Compression, Video Compression, MPEG Standards.

**Multimedia Communication and Retrieval:** Quality of Multimedia and Data Transmission: Quality of Service (QoS), Protocols of Transmission and Streaming, Distributed Multimedia Applications, Multimedia Database, Content-based Storage & Retrieval.

**Advance Concepts in Multimedia:** Hypermedia Concepts & Design, Digital Copyrights, Virtual Reality, VRML.

**Text Book :**

1. Principles of Multimedia by Ranjan Parekh, $2^{nd}$ Edition, 2018, McGraw-Hill Education

**Reference Books :**

1. Multimedia: Computing Communications & Applications by Ralf Steinmetz & Klara Nahrstedt, 1st Edition, 2002 , Pearson
2. Multimedia Systems by John F. Koegel Buford, 1st Edition, 2002, Pearson

## IT 3035 NATURAL LANGUAGE PROCESSING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the concept of NLP and its algorithms.
CO2: evalute different computing architectures for natural language processing for various parameters.
CO3: apply the different modeling and tagging concepts for language processing.
CO4: analyze the various grammars & parsing algorithms.
CO5: explore the role of statistical parsing & machine translation.
CO6: implementation of the role of naltural languaue processinh in real life application.

### Prerequisite: Artificial Intelligence (CS-3011)

**UNIT-I: Introduction:** Basic Probability & Information Theory: Introduction to NLP, Main Issues, Basics on Probability Theory, Elements of Information Theory, Language Modeling in General and Noisy Channel Model, Smoothing and EM Algorithm. Linguistics: Phonology and Morphology, Syntax (Phrase Structure vs. Dependency).

**UNIT-II: Words & Lexicon:** Word Classes and Lexicography, Mutual Information, The t-score, The Chi-square Test, Word Classes for NLP Tasks, Parameter Estimation, Partitioning Algorithm, Complexity Issues of Word Classes, Programming Tricks &Tips.

**UNIT-III: Hidden Markov Models & Tagging:** Markov Models, Hidden Markov Models (HMMs), Trellis Algorithm, Viterbi Algorithm. Estimating the Parameters of HMMs, The Forward-Backward Algorithm, Implementation Issues, Task of Tagging, Tag sets, Morphology, Lemmatization, Tagging Methods, Manually Designed Rules and Grammars, Statistical, Methods, HMM Tagging (Supervised, Unsupervised), Evaluation Methodology (examples from tagging), Precision, Recall, Accuracy, Statistical Transformation Rule-Based Tagging, Maximum Entropy, Maximum Entropy Tagging, Feature Based Tagging, Results on Tagging, Various Natural Languages.

**UNIT-IV: Grammars & Parsing Algorithms:** Introduction to Parsing, Generative Grammars, Properties of Regular and Context-free Grammars, Overview on Non-statistical Parsing Algorithms, Simple Top-Down Parser with Backtracking, Shift-Reduce Parser, Tree banks and Tree banking, Evaluation of Parsers, Probabilistic Parsing. PCFG: Best Parse, Probability of String.

**UNIT-V: Statistical Parsing & Machine Translation:** Lexicalized PCFG, Statistical Machine Translation (MT), Alignment and Parameter Estimation for MT.

**Text Book :**

1. Foundations of Statistical Natural Language Processing, Manning, C. D. and H. Schutze, TheMIT Press.

**Reference Books :**

1. Speech and Language Processing, Jurafsky, D. and J. H. Martin, Prentice-Hall.
2. Natural Language Understanding, Allen, J., The Benajmins/Cummings Publishing Company Inc.
3. Elements of Information Theory, Cover, T. M. and J. A. Thomas, Wiley.
4. Statistical Language Learning, Charniak, E., The MIT Press.
5. Statistical Methods for Speech Recognition, Jelinek, F., The MIT Press.

## IT 3036 VIRTUAL REALITY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the fundamentals and I/O components of the virtual reality system.
CO2: evalute different computing architectures for virtual reality
CO3: apply the different modeling concepts to visual virtualization
CO4: analyze the varous human factors in virtual reality
CO5: explore the role of virtual reality in traditioanal & emerging applications
CO6: develop prototypes using the concepts for virtual reality

**Prerequisites: Object Oriented Programming (IT-2005),
Data Structures and Algorithms (CS-2001)**

**UNIT-I : Introduction to Virtual Reality**
Three I's of Virtual Reality, A Short History of Early Virtual Reality, Early Commercial VR Technology, VR Becomes an Industry, The five Classic Components of a VR System. Input Devices: Trackers, Navigation, and Gesture Interfaces: Three-Dimensional Position Trackers, Tracker Performance Parameters, Navigation and Manipulation Interfaces, Tracker-Based Navigation/Manipulation Interfaces, Trackballs, Three-Dimensional Probes, Gesture Interfaces. Output Devices: Graphics, Three-Dimensional, Sound, and Haptic Displays: Graphics Displays, Sound Displays, Haptic Feedback

**UNIT – II: Computing Architectures for VR**
The Rendering Pipeline, The Graphics Rendering Pipeline, The Haptics Rendering Pipeline PC Graphics Architecture, PC Graphics Accelerators, Graphics Benchmarks, Workstation-Based Architectures, The Sun Blade 1000 Architecture, The SGI Infinite Reality Architecture. Distributed VR Architectures, Multi-pipeline Synchronization, Co-located Rendering Pipelines, Distributed Virtual Environments.

**UNIT – III: Modeling**
Geometric Modeling, Virtual Object Shape, Virtual Object Appearance, Kinematics Modeling, Homogeneous Transformation Matrices, Object Position, Transformation Invariants, Object Hierarchies, Viewing the Three-Dimensional World, Physical Modeling, Collision Detection, Surface Deformation, Force computation, Force Smoothing and Mapping, Haptic Texturing, Behavior Modeling, Model Management, Level-d-Detail Management, Cell Management,

**UNIT – IV: Human Factors in VR**
Human Factors: Methodology and Terminology, Data Collection and Analysis, Usability Engineering Methodology, User Performance Studies, Testbed Evaluation of Universal VR Tasks, Influence of System Responsiveness on User Performance, Influence of Feedback Multimodality, VR Health and Safety Issues, Direct Effects of VR Simulations on Users, Cybersickness, Adaptation and After effects, Guidelines for Proper VR Usage, VR and the Society, Impact on Professional Life, Impact on Private Life, Impact on Public Life

**UNIT – V: Virtual Reality Applications**
Traditional Applications: Medical Applications of VR, Education, Arts, and Entertainment, Military VR Applications, Emerging Applications of VR, VR Applications in Manufacturing, Applications of VR in Robotics, Information Visualization, Oil Exploration and Well Management, Volumetric Data Visualization.

**Text Books :**
1. Virtual Reality Technology, Second Edition, Gregory C. Burdea & Philippe Coiffet, John Wiley & Sons, Inc. 2003
2. Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann, 2002.

**Reference Books :**
1. 3D Modeling and surfacing, Bill Fleming, Elsevier (Morgan Kauffman).
2. 3D Game Engine Design, David H.Eberly, Elsevier.
3. Virtual Reality Systems, John Vince, Pearson Education.

## IT 3038 OBJECT-ORIENTED SYSTEM DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: analyze and compare the advantages and disadvantages of traditional software development with object- oriented software development.
CO2: analyze the different system modeling techniques and understand the need for unified modelling.
CO3: implement the users' view and behavioral view of object-oriented systems using UML.
CO4: implement the structural view, implementation view and environmental view of object-oriented systems using UML.
CO5: understand the O-O design process and design axioms with applications of object-oriented analysis and design for solving real world problems.
CO6: understand the access layer and apply the mapping with object relational systems.

### Prerequisite: Software Engineering (IT-3003)

**Overview of Object-Oriented Development**: Introduction, Two Orthogonal Views of the Software, Object-Oriented Systems Development Methodology, Object Orientation, Overview of the Unified Approach.

**Object Basics:** An Object-Oriented Philosophy, Objects Grouped in Classes, Attributes, Object State and Properties, Object Behavior and Methods, Object Respond to Messages, Encapsulation and Information Hiding, Class Hierarchy, Polymorphism, Object Relationships and Associations, Aggregations and Object Containment, Object and Identity, Static and Dynamic Binding, Object Persistence, Meta-classes.

**Object-Oriented Systems:** The Software Development Process, Building High Quality Software, Object-Oriented Systems Development: A Use Case Driven Approach, Reusability.

**Object-Oriented Methodologies**: Introduction Towards Unification-Too Many Methodologies, Survey of Some of the Object-Oriented Methodologies, Rumbaugh et al.'s Object Modeling Technique, The Booch Methodology, The Jacobson et al. Methodologies, Patterns & Frameworks, The Unified Approach.

**Unified Modeling Language (UML):** Static and Dynamic Models, Introduction to the Unified Modeling Language, UML Diagrams, UML Dynamic Modeling, Model Management: Packages and Model Organizations, UML Extensibility, UML Meta-Model.

**Object-Oriented Analysis Process**: Identifying Use Cases : Why Analysis is a Difficult Activity, Business Object Analysis: Understanding the Business Layer, Use-Case Driven Object-Oriented Analysis: The Unified Approach, Business Process Modeling, Use-Case Model Developing Effective Documentation, Case Study: Analyzing the ViaNet Bank ATM – The Use-Case Driven Process.

**Object Classification** : Classifications Theory, Approaches for Identifying Classes, Noun Phrase Approach, Common Class Pattern Approach, Use-Case Driven Approach: Identifying Classes and their Behaviors through Sequence/Collaboration Modeling, Classes, Responsibilities and Collaborators, Naming Classes.

**Identifying Object Relationships, Attributes and Methods**: Associations, Super-Sub Class Relationships, A-Part-of Relationships-Aggregation, Case Study: Relationship Analysis for the ViaNet Bank ATM System, Class Responsibility: Identifying Attributes and Methods, Class Responsibility: Defining Attributes by Analyzing Use Cases and Other UML Diagrams, Defining Attributes for VianNet Bank Objects, Object Responsibility: Methods and Messages, Defining Methods for ViaNet Bank Objects.

**The Object-Oriented Design Process and Design Axioms:** The Object-Oriented Design Process, The Object-Oriented Design Axioms, Corollaries, Design Patterns.
**Designing Classes**: The Object-Oriented Design Philosophy, UML Object Constraint Language.

**Object Relational Systems**: Object-Relation Mapping, Table-Class Mapping, Table-Multiple Classes Mapping, Table-Inherited Classes Mapping, Tables- Inherited Classes Mapping, Keys for Instance Navigation.

**View Layer**: Designing interface objects, designing view class layer, macro and micro level process, purpose of a view layer, case studies, Quality assurance test, Testing strategies, Test cases and plans continuous testing.

**Text Book:**

1. Ali Bahrami, "Object Oriented Systems Development", Tata McGraw-Hill Publisher, Tata McGraw-Hill Edition 2008.

**Reference Books:**


1. Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development, Craig Larman, Third Edition, Addison Wesley, 2004.
2. Introduction to Object Oriented Analysis and Design, Stephen R Schach, Tata McGraw-Hill, 2003.
3. Unified Modeling Language Reference Manual, James Rumbaugh, Grady Booch, Addison Wesley, 1999.
4. Practical Object-Oriented Design with UML, Mark Priestley, 2nd Edition, Tata McGraw-Hill, 2003.
5. Object-Oriented Design with UML and JAVA, K Barclay, Elsevier, 2004.


## IT 3039 HUMAN COMPUTER INTERACTION Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: understand the importance of Human Computer Interaction and its fundamentals.
CO2: analyze various design methododlogies for HCI.
CO3: evaluate the implemented interaction styles used in HCI.
CO4: apply the HCI fundamentals for interface communications.
CO5: experiment for developement of new and efficient human computer interfaces.
CO6: build the application oriented human computer interface for solving real life problems.

### Prerequisite: Artificial Intelligence (CS-3011)

**Unit 1 Human**:
History of User Interface Designing, Hardware, Software and Operating Environments, The Psychopathology of Everyday Things, Psychology of Everyday Actions, Goal Directed Design, Mistakes Performed While Designing a Computer System, Design: Software Evolution Process, Method to Achieve Success, Recognize the Goals, Goal Directed Design Process, Implementation Model and Mental Model, Beginners, Experts and Intermediates

**Unit 2 Designing** :
The Graphical User Interface, The Web User Interface, The Merging of Graphical Business Systems and the Web, Principles of User Interface Design, Design Guidelines: Designing with Mind in Mind, Perception, Gestalt Principles, Visual Structure, Reading is Unnatural, Color, Vision, Memory, Six Behavioral Patterns, Recognition and Recall, Learning, Factors Affecting Learning.

**Unit 3 Interaction Styles :**
Menus: Structures of Menus, Functions of Menus, Content of Menus, Formatting of Menus, Phrasing the Menu, Selecting Menu Choices, Navigating Menus, Kinds of Graphical Menus.Windows: Window Characteristics, Components of a Window, Window Presentation Styles, Types of Windows, Window Management, Organizing Window Functions, Window Operations, Web Systems. Device-Based Controls: Characteristics of Device-Based Controls, Selecting the Proper Device-Based Controls. Screen-Based Controls, Operable Controls, Text Entry / Read-Only Controls, Selection Controls, Combination Entry / Selection Controls, Custom Controls, Presentation Controls, Selecting the Proper Controls

**Unit 4 Communication:**
Text Messages, Words, Sentences, Messages and Text, Text for Web Pages. Feedback and Guidance, Providing the Proper Feedback, Guidance and Assistance. Graphics, Icons and Images, Icons, Multimedia, Colors, Color—What Is It?, Color Uses, Possible Problems with Color, Color—What the Research Shows, Color and Human Vision, Choosing Colors, Choosing Colors for Textual Graphic Screens, Choosing Colors for Statistical Graphics Screens, Choosing Colors for Web Pages, Uses of Color to Avoid .

**Unit 5 Experiments:**
An Application to Teach Math, Digital Diary for Young Teens, Online, Payment Portal for Older Generation, ATVM for Train Ticketing in Rural Area, Redesign Interfaces of Home Appliances, Heuristic Evaluation Using Design Principles, Website Redesign for Better Navigation, Service Design – Connect Humans, Statistical

Graphics – Expense Tracker, Graphics – Way Finding, Icon Designing, Colors and Animation, Concept Generation – Input Method

**Textbook:**
1. Galitz's Human Machine Interaction, Dhananjay R. Kalbande, Prashant Kanade, Sridari Iyer Wiley India 2015, ISBN: 9788126558681.

**Reference Books :**
1. The Essential Guide to user Interface Design, Third Edition by Wilbert O. Galitz, Wiley.
2. Interaction Design: Beyond Human-Computer Interaction, Second Edition by Jenny Preece et al., John Wiley & Sons Ltd.
3. Designing the User Interface: Strategies for Effective Human Computer Interaction, Second Edition by B. Sheiderman et al., Addison Wesley.

## IT 3040 MOBILE COMPUTING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the necessary knowledge of cellular communication, infrastructure-less networks.
CO2. analyze TCP, MAC protocols and their technical feasibility.
CO3. work as a part of team on multidisciplinary and device independent application projects.
CO4. acquire knowledge about the basic concepts and principles in mobile computing.
CO5. understand techniques involved, in networks & systems issues for the design and implementation of mobile computing systems and applications.
CO6. apply the awareness of the life-long learning, business ethics, professional ethics and current marketing scenarios.

**Prerequisite: Nil**

**Basics Of Communication Technologies:** Mobile Handsets-Wireless Communications and server Applications-Cell Phone System-Types of Telecommunication Networks-Computer Networks-Traditional LAN- LAN Architecture-Components of Wireless Communication System-Architecture of a Mobile Telecommunication System-Wireless Networking Standards-Wireless Local Area Networks-Bluetooth Technology.
**MAC Protocols:** Mobile Computing – Mobile Computing Vs. wireless Networking – Mobile Computing Applications – Characteristics of Mobile computing – Structure of Mobile Computing Application. MAC Protocols – Wireless MAC Issues – Fixed Assignment Schemes – Random Assignment Schemes – Reservation Based Schemes-Cognitive Radio ad-hoc network.

**Mobile internet protocol and transport layer:** Overview of Mobile IP – Features of Mobile IP – Key Mechanism in Mobile IP – route Optimization. Overview of TCP/IP – Architecture of TCP/IP- Adaptation of TCP Window – Improvement in TCP Performance.

**Mobile telecommunication system:** Global System for Mobile Communication (GSM) – General Packet Radio Service (GPRS) – Universal Mobile Telecommunication System (UMTS).

**Mobile ad-hoc networks:** Ad-Hoc Basic Concepts – Characteristics – Applications – Design Issues – Routing – Essential of Traditional Routing Protocols –Popular Routing Protocols – Vehicular Ad Hoc networks ( VANET) – MANET Vs VANET – Security.

**Text Books :**
1. Mobile Communications, Jochen Schiller, PHI/Pearson Education, Second Edition, 2003.
2. Fundamentals of Mobile Computing, Rajib Mall, PHI, Second Edition, 2015.
3. Wireless Communications and Networks, William Stallings, PHI/Pearson Education, 2002.

**Reference Books :**
1. Principles of Wireless Networks, KavehPahlavan, PrasanthKrishnamoorthy, PHI/Pearson Education, 2003.

2. Principles of Mobile Computing, Uwe Hansmann, LotharMerk, Martin S. Nicklons and Thomas Stober, Springer,New York, 2003.
3. Mobile Communication Systems, HazysztofWesolowshi, John Wiley and Sons Ltd, 2002.

## IT 3044 FUNDAMENTALS OF SOFTWARE ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: differentiate different software process models and understand their applicability in real life projects.
CO2: gather and specify requirements of the software projects.
CO3: understand and apply the basic project management practices in real life projects.
CO4: translate the baseline requirement specifications into design & development process.
CO5: distinguish and apply different testing methodologies.
CO6: work ethically in a team as well as independently on software projects and being prepared for the ever changing dynamic real world situations.

**Prerequisite: NIL**

**Software Process Models:** Software product, Software crisis, Handling complexity through Abstraction and Decomposition, Overview of software development activities. Process Models: Classical waterfall model, iterative waterfall model, prototyping model, evolutionary model, spiral model, RAD model. Agile models: Extreme programming and Scrum. Software Requirement Engineering

**Software Requirement Engineering:** Requirement Gathering and analysis, Functional and non functional requirements, Software Requirement Specification(SRS) , IEEE 830 guidelines, Decision tables and trees.

**Software Project Management:** Responsibilities of a Software project manager, project planning, Metrics for project size estimation, Project estimation techniques, Empirical estimation techniques, COCOMO models, Scheduling, Organization & team structure, Staffing, Risk management, Software configuration management.

**Structural Analysis & Design:** Overview of design process: High level and detailed design, Cohesion & coupling, Modularity and layering, Function–Oriented software design: Structural Analysis, Structural Design (DFD and Structured Chart), Object Oriented Analysis & Design, Command language, menu and iconic interfaces.

**Testing Strategies:** Coding, Code Review, Documentation, Testing: - Unit testing, Black-box Testing, White-box testing, Cyclomatic complexity measure, Coverage analysis, Debugging, Integration testing, System testing, Regression testing.

**Text book :**
1. Fundamentals of Software Engineering, Rajib Mall , PHI, Latest edition.

**Reference books :**
1. Software Engineering, A Practitioner's Approach, Roger S. Pressman ,TMG Hill, Latest edition.
2. Software Engineering, I. Sommerville, Pearson Education, Asia.

## IT 4001 COGNITIVE SCIENCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the concept of cognitive science and its representation.
CO2: analyze the different philosophical approaches of cognitive science.
CO3: apply the psychological approach as Profusion of Theories.
CO4: obtain skills for vision and attention based on history of cognitive approach.
CO5: know the use memory, imagery, and problem solving for cognitive approach
CO6: expand upon the knowledge learned and apply it to solve real world problems.

**Prerequisite: Artificial Intelligence (CS-3011)**

**UNIT I: Introduction: Exploring Inner Space**
What Is Cognitive Science, Representation, Digital Representations , Analog Representations, The Dual-Coding Hypothesis, Propositional Representations, Computation, The Tri-Level Hypothesis, The Classical and Connectionist Views of Computation, The Interdisciplinary Perspective, The Philosophical Approach, The Psychological Approach, The Cognitive Approach, The Neuroscience Approach, The Network Approach, The Evolutionary Approach, The Linguistic Approach, The Artificial Intelligence Approach, The Robotics Approach,

**UNIT II: The Philosophical Approach**
What Is Philosophy, The Mind-Body Problem, Flavors of Monism, Flavors of Dualism, Evaluating the Dualist Perspective, Functionalism, The Knowledge Acquisition Problem, Evaluating the Knowledge Acquistion Debate, The Mystery of Consciousness, The What-It's-Like Argument, Mind as an Emergent Property, Evaluating the Emergent View of Mind, Consciousness and Neuroscience, Consciousness and Artificial Intelligence, Overall Evaluation of the Philosophical Approach.

**UNIT III: The Psychological Approach: A Profusion of Theories**
What Is Psychology, Psychology and the Scientific Method, Mental Atoms, Mental Molecules, and a Periodic, Table of the Mind: The Voluntarist Movement, Evaluating the Voluntarist Approach, Structuralism: What the Mind Is, Evaluating the Structuralist Approach, Functionalism: What the Mind Does, The Whole Is Greater Than the Sum of Its Parts:Mental Physics and the Gestalt Movement, Evaluating the Gestalt Approach, Mini-Minds: Mechanism and Psychoanalytic Psychology, Evaluating the Psychoanalytic Approach, Mind as a Black Box: The Behaviorist Approach, Evaluating the Behaviorist Approach, Overall Evaluation of the Psychological Approach.

**UNIT IV :The Cognitive Approach I: History, Vision, and Attention**
Some History First: The Rise of Cognitive Psychology, The Cognitive Approach: Mind as an Information Processor, Modularity of Mind, Evaluating the Modular Approach, Theories of Vision and Pattern Recognition, Template Matching Theory, Evaluating Template Matching Theory, Feature Detection Theory, A Computational Theory of Vision, Feature Integration Theory, Theories of Attention, Broadbent's Filter Model, Treisman's Attenuation Model, The Deutsch-Norman Memory Selection Model, The Multimode Model of Attention, Kahneman's Capacity Model of Attention

**UNIT V The Cognitive Approach II: Memory, Imagery, and Problem Solving**
Types of Memory, Sensory Memory, Working Memory, Long-Term Memory, Memory Models, The Modal Model, The ACT* Model , The Working Memory Model, Visual Imagery The Kosslyn and Schwartz Theory of Visual Imagery, Image Structures, Image Processes . The Imagery Debate, The General Problem Solver Model, The SOAR Model

**Reference Books :**


1. Jay Friedenberg, Gordon Silverman, Cognitive Science: An Introduction to the Study of Mind, SAGE Publications
2. José Luis Bermúdez, Cognitive Science: An Introduction to the Science of the Mind, 2nd Edition, Cambridge University Press
3. Ronald T Kellogg, Fundamentals of Cognitive Psychology, SAGE Publications


## IT 4002 DECISION SUPPORT SYSTEM Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: recognize the role of Decision (and other Management) Support Systems and their potential for assisting in organizational and individual decision making.
CO2: identify potential effects of cognitive biases and groupthink, which affect individual and groups of decision makers.
CO3: identify the types of problems that may be addressed effectively through the use of Decision Support Systems and Intelligent Systems.
CO4: recognize user interface issues in the development of systems to aid decision makers.
CO5: develop critical thinking, analytical reasoning, and problem solving skills.
CO6: create models of Decisions using a variety of notations and techniques.

## Prerequisites: Database Management System (CS-2004)

**Decision Making and Computerized Support**

**Management Support Systems: An Overview:** Managers and Decision-Making; Managerial Decision-Making and Information Systems; Computerized Decision Support and the Supporting Technologies; A Framework for Decision Support; The Concept of Decision Support Systems; Group Support Systems; Enterprise Information Systems; Knowledge Management Systems.

**Decision-Making Systems, Modeling, and Support:** Decision-Making Systems; Phases of the Decision Making Process; The Intelligence Phase; The Design Phase; The Choice Phase; The Implementation Phase; How Decisions Are Supported; The Decision-Makers

**Decision Support Systems: An Overview:** DSS Configurations; Characteristics and Capabilities of DSS; Components of DSS; The Data Management Subsystem; The Model Management Subsystem; The User Interface (Dialog) Subsystem; The Knowledge-Based Management Subsystem; The User; DSS Hardware; DSS Classifications.

**Modelling and Analysis:** MSS Modelling; Static and Dynamic Models; Certainty, Uncertainty, and Risk; Influence Diagrams; MSS Modeling with Spreadsheets; Decision Analysis of a Few Alternatives (Decision Tables and Decision Trees); The Structure of MSS Mathematical Models; Mathematical Programming Optimization; Multiple Goals, Sensitivity Analysis, What-If, and Goal Seeking; Problem-Solving Search Methods; Heuristic Programming; Simulation; Visual Interactive Modeling and Visual Interactive Simulation; Quantitative Software Packages; Model Base Management.

**Decision Support System Development:** Introduction to DSS Development; The Traditional System Development Life cycle; Alternative Development Methodologies; Prototyping: The DSS Development Methodology; Change Management; DSS Technology Levels and Tools; DSS Development Platforms; DSS Development Tool Selection; Team-Developed DSS; End User Developed DSS; Putting The DSS Together

**Knowledge Management:** Introduction to Knowledge Management; Organizational Learning and Transformation; Knowledge Management Initiatives; Approaches to Knowledge Management; Information Technology in Knowledge Management; Knowledge Management Systems Implementation; Roles of People in Knowledge Management; Ensuring Success of Knowledge Management

**Intelligent Decision Support Systems**

**Artificial Intelligence and Expert Systems: Knowledge-Based Systems:** Concepts and Definitions of Artificial Intelligence; Evolution of Artificial Intelligence; The Artificial Intelligence Field; Basic Concepts of Expert Systems; Applications of Expert Systems; Structure of Expert Systems; How Expert Systems Work; Problem Areas Suitable for Expert Systems; Benefits and Capabilities of Expert Systems; Problems and Limitations of Expert Systems; Expert System Success Factors; Types of Expert Systems.

**Knowledge Acquisition, Representation, and Reasoning:** Concepts of Knowledge Engineering; Scope and Types of Knowledge; Methods of Knowledge Acquisition from Experts; Knowledge Acquisition from Multiple Experts; Automated Knowledge Acquisition from Data and Documents; Knowledge Verification and Validation; Representation of Knowledge; Reasoning in Rule-Based Systems; Explanation and Metaknowledge; Inferencing with Uncertainty; Expert Systems Development; Knowledge Acquisition and the Internet

**Text Book :**

1. Decision Support Systems and Intelligent Systems by Efraim Turban, Jay E. Aronson, Richard V. McCarthy, Seventh Edition, Prentice-Hall of India, 2007

**Reference Books :**

1. Decision Support and Business Intelligence Systems by Efraim Turban, Ramesh Sharda, Dursun Delen, Pearson Education, 9th Edition, 2013.
2. Real-World Decision Support Systems: Case Studies by Jason Papathanasiou, Nikolaos Ploskas, Isaballe Linden, Springer, 1st Edition, 2016
3. Decision Support Systems: In the 21st Century by George M. Marakas, PHI, 2nd Edition, 2003.

## IT 4003 BUSINESS INTELLIGENCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: explain the fundamentals of business intelligence.
CO2: link data mining with business intelligence.
CO3: apply various modeling techniques.
CO4: explain the data analysis and knowledge delivery stages.
CO5: apply business intelligence methods to various situations.
CO6: decide on appropriate technique.

**Prerequisites: Database Management System (CS-2004)**

**Business Intelligence**
Effective and timely decisions – Data, information and knowledge – Role of mathematical models – Business intelligence architectures: Cycle of a business intelligence analysis – Enabling factors in business intelligence projects – Development of a business intelligence system – Ethics and business intelligence.

**Knowledge Delivery**
The business intelligence user types, Standard reports, Interactive Analysis and Ad Hoc Querying, Parameterized Reports and Self-Service Reporting, dimensional analysis, Alerts/Notifications, Visualization: Charts, Graphs, Widgets, Scorecards and Dashboards, Geographic Visualization, Integrated Analytics, Considerations: Optimizing the Presentation for the Right Message.

**Efficiency**
Efficiency measures – The CCR model: Definition of target objectives- Peer groups – Identification of good operating practices; cross efficiency analysis – virtual inputs and outputs – Other models. Pattern matching – cluster analysis, outlier analysis
Business Intelligence Applications & Future of Business Intelligence
Marketing models – Logistic and Production models – Case studies; Future of business intelligence – Emerging Technologies, Machine Learning, Predicting the Future, BI Search & Text Analytics – Advanced Visualization – Rich Report

**Text book :**

1. Efraim Turban, Ramesh Sharda, Dursun Delen, “Decision Support and Business Intelligence Systems”, 9th Edition, Pearson 2013.


**Reference books :**

1. Larissa T. Moss, S. Atre, “Business Intelligence Roadmap: The Complete Project Lifecycle of Decision Making”, Addison Wesley, 2003.
2. Carlo Vercellis, “Business Intelligence: Data Mining and Optimization for Decision Making”, Wiley Publications, 2009.
3. David Loshin Morgan, Kaufman, “Business Intelligence: The Savvy Manager‟ s Guide”, Second Edition, 2012.
4. Cindi Howson, “Successful Business Intelligence: Secrets to Making BI a Killer App”, McGraw-Hill, 2007.
5. Ralph Kimball , Margy Ross , Warren Thornthwaite, Joy Mundy, Bob Becker, “The Data Warehouse Lifecycle Toolkit”, Wiley Publication Inc.,2007.


## IT 4004 DEEP LEARNING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the concept of deep learning.
CO2: implement various deep learning models.
CO3: realign high dimensional data using reduction techniques.
CO4: analyze optimization and generalization in deep learning.
CO5: explore the deep learning applications.
CO6: implement deep learning approches in solutions of real life applications.

**Prerequisite: Machine Learning (CS-3035)**

**UNIT I: Introduction**
Introduction to machine learning- Linear models (SVMs and Perceptrons, logistic regression)- Intro to Neural Nets: What a shallow network computes- Training a network: loss functions, back propagation and stochastic gradient descent- Neural networks as universal function approximates

**UNIT II Deep Networks**

History of Deep Learning- A Probabilistic Theory of Deep Learning- Back propagation and regularization, batch normalization- VC Dimension and Neural Nets-Deep Vs Shallow Networks Convolutional Networks- Generative Adversarial Networks (GAN), Semi-supervised Learning

**UNIT III Dimensionality Reduction**
Linear (PCA, LDA) and manifolds, metric learning - Auto encoders and dimensionality reduction in networks - Introduction to Convnet - Architectures – AlexNet, VGG, Inception, ResNet - Training a Convnet: weights initialization, batch normalization, hyper parameter optimization

**UNIT IV Optimization and Generalization**
Optimization in deep learning– Non-convex optimization for deep networks- Stochastic Optimization, Generalization in neural networks- Spatial Transformer Networks- Recurrent networks, LSTM - Recurrent Neural Network Language Models- Word-Level RNNs & Deep Reinforcement Learning - Computational & Artificial Neuroscience

**UNIT V Case Study and Applications**
Imagenet- Detection-Audio WaveNet-Natural Language Processing Word2Vec - Joint Detection BioInformatics- Face Recognition- Scene Understanding- Gathering Image Captions

**Text Book :**
**1.** Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.

**Reference Books :**
1. Cosma Rohilla Shalizi, Advanced Data Analysis from an Elementary Point of View, 2015.
2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.
3. Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.

## IT 4005 SOFTWARE TESTING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the basic terminologies and need for software testing and generate test cases for a given software application.
CO2: analyze the different dynamic and static testing techniques and apply the same for testing software applications.
CO3: understand the importance of regression testing and apply the appropriate regression testing strategies to test the software under modification and understand different factors of prioritization and prioritize the test cases.
CO4: analyze different test plans and understand the test process management.
CO5: understand the benefits of test automation and its challenges.
CO6: apply the software testing techniques to different specialized environments.

**Prerequisites: Fundamentals of Software Engineering (IT-3044)**

**Testing Methodology**
Introduction to Effective Software Testing, Evolution of Software Testing, Software Testing Myths, Goals of Software Testing, Psychology for Software Testing, Software Testing Definitions, Model for Software Testing, Software Failure Case Studies.

**Software Testing Terminology and Methodology**
Definitions, Life Cycle of a Bug, Bug Classification based on SDLC, Testing Principles, Software Testing Life Cycle (STLC), Software Testing Methodology, Software Testing Strategy, Test Strategy Matrix, Verification and Validation, Verification and Validation Activities.

**Testing Techniques Dynamic Testing:**
Black Box Testing Techniques, Boundary Value Analysis, Boundary value checking, Equivalence Class Testing, Identification of Equivalence classes, State Table based Testing, Finite State Machine, State table based testing, Decision Table based Testing, Cause Effect Graphing based Testing, Error Guessing

**White Box Testing:**
Need of White box testing, Logic Coverage Criteria, Basis Path Testing, Control Flow Graph, Flow graph notations of different programming constructs, Path Testing, Terminology, Cyclomatic Complexity, Formulae based on Cyclomatic complexity Guidelines for Basis Path Testing, Applications of Path Testing, Data Flow Testing, Static Data flow testing, Dynamic Data flow testing, Mutation Testing, Mutation Testing Process

**Static Testing**
Inspections, Inspection Process, Walkthroughs, Technical Reviews, Unit Validation Testing, Integration Testing, Types of Incremental Integration Testing, Pair-wise Integration, Path Based Integration, Function Testing, System Testing, Performance Testing, Usability Testing, performing the system tests, Acceptance Testing.

**Regression Testing**
Progressive vs Regression Testing, Regression testing produces quality software Regression Testability, Objectives of Regression Testing, Regression Testing Types Regression Testing Techniques, Selective Retest Techniques, Strategy for Test Case Selection, Regression Test selection Techniques, Evaluating Regression Test Selection Techniques, Minimization Technique, Regression Test Prioritization, Types of Test case Prioritization, Prioritization Techniques, Prioritization Techniques, Code based test case prioritization vs coverage based test case prioritization.

**Managing the Test Process**
Test Management, Test Organization, Test Planning, Test Plan Hierarchy, Master Test Plan, Verification Test Plan, Validation Test Plan, Unit Test Plan, Integration Test Plan, Function Test Plan, System Test Plan, Acceptance Test Plan, Detailed Test Design and Test Specifications, Test Log, Test Reports, Software Metric, Testing Metrics for Monitoring and Controlling the Testing Process, Testing Process MaturityModels.

**Test Automation**
Automation and Testing Tools, Need of Automation, Categorization of Testing Tools Static and Dynamic Testing Tools, Testing Activity Tools, Selection of Testing Tools Costs incurred in Testing Tools, Guidelines for Automated Testing, Overview of some commercial TestingTools.

**Testing for Specialized Environment**
Testing Object Oriented Software, OOT and Structured Approach, Object Oriented Testing, Differences between Conventional testing and Object oriented Testing Issues in OO Testing, Testing of OO Classes, UML based OO Testing Introduction to Testing Web based Systems and Real Time Systems.

**Text Book :**

1. Software Testing Principles : Practices, Naresh Chauhan, Oxford University Press, New Delhi, 2010.

**Reference Books :**

1. Foundation of Software Testing, Aditya P Mathur, Pearson Education, 2008.
2. Software Testing and Analysis Process Principles and Techniques, Mauro Pezze, Michal Young, WiIley India, 2008.
3. Software Testing Principles and Practices, Srinivasan Desikan, Gopalaswamy Ramesh, 2nd Edition, Pearson, 2007.

## IT 4006 DISTRIBUTED DATABASE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand distributed database concepts and its structures.
CO2: understand alternative design strategies and distributed design issues.
CO3: understand the transaction management and query processing techniques in DDBMS.
CO4: relate the importance and application of emerging database technology.
CO5: understand the fundamentals of distributed object management.
CO6: understand the concept of transaction management in distributed environment .

**Prerequisite: Database Management System (CS-2004)**

**Introduction:** Distributed data processing, DDBMS: Advantages and disadvantages, Architecture, Transparencies in a distributed DBMS, Global directory issues.

**Distributed Database Design:** Alternative design strategies, Distributed design issues, Fragmentation, Data allocation

**Query Processing Issues:** Objectives of query processing, Characterization of query processors, Layers of query processing, Query decomposition, Localization of distributed data. Optimizing Distributed Queries Factors governing query optimization, Centralized query optimization, ordering of fragment queries, optimization algorithms for a distributed query processing environment.

**Distributed Object Management:** Object model features, Fundamental object management issues, DOM architectures, Object caching, Object clustering, Object migration, Distributed object base systems

**Transaction Management:** The transaction concept, Goals of transaction management, Characteristics of transactions, Taxonomy of transaction models. Concurrency Issues in a distributed environment.

**Text Book :**
1. Distributed Databases Principles and Systems, S. Ceri and G. Pelagatti, McGraw Hill.

**Reference Book :**
1. Principles of Distributed Database Systems, M. Tamer Ozsu, Patrick Valduriez, 3rd Edition,2011, Sprinjer .

## IT 4007 INFORMATION THEORY AND CODING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand entropy and its uses.
CO2: understand error–control coding.
CO3: understand encoding and decoding of digital data streams.
CO4: familiarize with the methods for the generation of these codes and their decoding techniques.
CO5: aware of compression and decompression techniques.
CO6: learn the concepts of multimedia communication.

**UNIT I:**
Information Entropy Fundamentals
Uncertainty, Information and Entropy – Source coding Theorem – Huffman coding –Shannon Fano coding – Discrete Memory less channels – channel capacity – channel coding Theorem – Channel capacity Theorem.

**UNIT II:**
Data and Voice Coding
Differential Pulse code Modulation – Adaptive Differential Pulse Code Modulation – Adaptive subband coding – Delta Modulation – Adaptive Delta Modulation – Coding of speech signal at low bit rates (Vocoders, LPC).

**UNIT III : Error Control Coding**
Linear Block codes – Syndrome Decoding – Minimum distance consideration – cyclic codes – Generator Polynomial – Parity check polynomial – Encoder for cyclic codes – calculation of syndrome – Convolutional codes.

**UNIT IV : Compression Techniques**
Principles – Text compression – Static Huffman Coding – Dynamic Huffman coding – Arithmetic coding – Image Compression – Graphics Interchange format – Tagged Image File Format – Digitized documents – Introduction to JPEG standards, MPEG video standards.

**Text Books :**

1. Information Theory, Coding & Cryptography, Ranjan Bose , Mcgrawhill, 3rd Edition 2016 .
2. Mark Nelson, "Data Compression Book", BPB Publication 1992.

**Reference Books :**

1. Watkinson J, "Compression in Video and Audio", Focal Press, London, 1995.
2. Simon Haykin, "Communication Systems", 4th Edition, John Wiley and Sons, 2001.
3. Fred Halsall, "Multimedia Communications, Applications Networks Protocols and Standards", Pearson Education, Asia 2002; Chapters: 3,4,5.

# COMPUTER SCIENCE & COMMUNICATION ENGINEERING

## B. TECH IN COMPUTER SCIENCE AND COMMUNICATION ENGINEERING

### Program Educational Objectives (PEOs):

The B. Tech program in Computer Science and Communication Engineering aims to prepare the graduates with the following objectives:

1. The graduates will be able to provide sound theoretical and practical knowledge in the domain of Computer Science & Communication Engineering for leading successful career in industries, pursuing higher studies or entrepreneurial endeavors.
2. The graduates will be able to perceive the limitations and impact of engineering solutions in social, legal environmental, economical and multidisciplinary contexts.
3. The graduates will be able to demonstrate professional and ethical responsibilities, imbibe lifelong learning, embrace global challenges and make positive impact on environment and society.

### Program Outcomes (POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

### Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Ability to design and develop hardware and software in emerging technology environments like Data Analytics, Mobile Computing and Smart Antennas.
n) Ability to carry out research in the field of multidisciplinary engineering such as Artificial Intelligence, Machine Learning, Real Time Systems, Internet of Things and Wireless Sensor Networks.
o) Ability to utilize the knowledge in solving practical real life technological problems in the field of Computer Science & Communication Engineering.

## CC 3021 CRYPTOGRAPHY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: gain knowledge about the Mathematics of Symmetric and Asymmetric Key Cryptography.
CO2: understand the basic concepts and goals of the security.
CO3: understand the fundamentals of symmetric key cryptosystems and their applications
CO4: understand the fundamentals of public key cryptosystems and their applications.
CO5: understand the requirement of Key management.
CO6: evaluate a range of access control and authentication mechanisms.

**Prerequisite: Algebra and Basic Mathematics**

**Mathematical Foundations for Cryptography:** Group, Ring, Field, Galois Fields, Fermat's theorem, Chinese remainder theorem, primality testing algorithms, Factorization, Euclid's algorithm, extended Euclid's theorem, quadratic residues, discrete logarithm problems.

**Introduction to Computer Security:** Security Goals and principles, Cryptographic Attacks, Substitution Ciphers, Transpositions, Stream and Block Ciphers.

**Symmetric Key Cryptography:** Modern Block Ciphers, Modern Stream Ciphers, Data Encryption Standard (DES), Blowfish, Advanced Encryption Standard (AES), Diffie-Hellman Key Exchange Algorithm.

**Asymmetric Key Cryptography:** RSA Cryptosystem, Rabin Cryptosystem, ElGamal Cryptosystem, Elliptic Curve Cryptosystems.

**Integrity, Authentications, and Key Management:** Message Authentication Code (MAC), Message Digest (MD), Secure Hash Algorithm (SHA), Digital Signature, Digital Signature Standard (DSS), Entity Authentication, KDC, Kerberos.

**Textbook :**

1. Cryptography and Network Security: Behrouz A Forouzan and Debdeep Mukhopadhyay, McGraw Hill Education, 3rd edition 2018.

**Reference Books :**

1. Cryptography and Network security: Principles and Practice, William Stallings, Pearson Education, 5th edition, 2011.
2. Introduction to Cryptography with Coding Theory: W. Trappe and L. C. Washington, Pearson Education, 2nd edition 2011.
3. Elementary Number Theory with applications: Thomas Koshy, Elsevier India, 2008.
4. Cryptography and Network Security: Atul Kahate, Tata McGraw Hill Education, 3rd edition, 2013.

## CC 3024 NETWORK SECURITY Cr-3

**Course Outcomes**: At the end of the course, the student should be able to:

CO1: understand fundamentals of networks security, principles and its architecture.
CO2: detect common threats and vulnerabilities.
CO3: understand various cryptographic operations used for both symmetric and asymmetric cryptographic algorithms
CO4: understand different ways to distribute keys over the network along with satisfying user authentication.
CO5: understand secure protocols that provide security at different layers of OSI model over the Internet.
CO6: understand the importance of secure communication in wireless medium and security mechanisms used in Wireless LAN.

**Prerequisite: NIL**

**Introduction:** Computer Security Concepts, Security Attacks, Security Services, Security Mechanisms, A Model for Network Security

**Cryptography:** Symmetric Encryption Principles, Symmetric Block Encryption Algorithms, Random and Pseudorandom Numbers, Stream Ciphers and RC4, Cipher Block Modes of Operation, Approaches to Message Authentication, Secure Hash Functions, Message Authentication Codes, Public-Key Cryptography Principles, Public-Key Cryptography Algorithms, Digital Signatures

**Key Distribution and User Authentication:** Symmetric Key Distribution Using Symmetric Encryption, Kerberos, Key Distribution Using Asymmetric Encryption, X.509 Certificates, Public-Key Infrastructure
**IP Security:** IP Security Overview, IP Security Policy, Encapsulating Security Payload, Combining Security Associations, Internet Key Exchange

**Transport-Level Security:** Web Security Considerations, Secure Socket Layer and Transport Layer Security, Transport Layer Security

**Application-Level Security:** Pretty Good Privacy, S/MIME, DomainKeys Identified Mail, HTTPS, Secure Shell (SSH)

**Wireless Network Security:** IEEE 802.11 Wireless LAN Overview, Wireless Application Protocol Overview, Wireless Transport Layer Security, WAP End-to-End Security

**Text Book :**

1. Network Security Essentials: Applications and Standards, William Stallings, 4th Edition, Pearson, 2011

**Reference Books :**

1. Cryptography and Network Security: Behrouz A Forouzan and Debdeep Mukhopadhyay, McGraw Hill Education, 3rd edition, 2018.
2. William Stallings, Cryptography and Network Security: Principles and Practice, Pearson, 7th Edition, 2017.

## CC 3026 CYBER SECURITY Cr-3

**Course Outcomes**: At the end of the course, the student should be able to:

CO1. understand cyber security and various technical aspects related with cyber security.
CO2. understand the evolution of cyber security and its challenges.
CO3. identify and realize the objectives of cyber security.
CO4. analyze the performance of decision making for a secured cyber world.
CO5. identify the cyber security policy taxonomy
CO6. acquire knowledge on cyber security policies.

**Prerequisites: Nil**

**Introduction:** What is Cyber Security, What is Cyber Security policy, Domains of Cyber Security Policy, Laws and Regulation, Enterprise Policy, Technology Operation, Technology Configuration, Strategy Vs Policy

**Cyber Security Evolution:** Productivity, Internet, e-Commerce, Countermeasures, Challenges.

**Cyber Security Objectives:** Cyber Security Metrics; Security Management Goals; Counting Vulnerabilities; Security Frameworks- e-Commerce Systems, Industrial Control Systems, Personal Mobile Devices; Security Policy Objectives.

**Guidance for Decision Makers:** Tone at the Top; Policy as a Project; Cyber Security Management- Arriving at Goals, Cyber Security Documentation; Using the Catalog.

**The Catalog Approach:** Catalog Format; Cyber Security Policy Taxonomy.

**Cyber Security Policy Catalog:** Cyber Governance Issues- Net Neutrality, Internet Names and Numbers, Copyrights and Trademarks, Email and Messaging; Cyber User Issues- Malvertising, Impersonation, Appropriate Use, Cyber Crime, Geolocation, Privacy; Cyber Conflict Issues- Intellectual Property Theft, Cyber Espionage, Cyber Sabotage, Cyber Warfare; Cyber Management Issues- Fiduciary Responsibility, Risk Management, Professional Certification, Security Principles, Research and Development; Cyber Infrastructure Issues- Banking and Finance, Health Care, Industrial Control System.

**Text Book :**

1. Cyber Security (Policy Guidebook): Bayuk, Healey, Rohmeyer, Sachs, Schmidt, Weiss , Wiley (Student Edition), 2017

**Reference Books :**

1. Computer Security Fundamentals: Chuck Easttom ,3rd Edition, 2016 ,Pearson
2. Cyber Security and Threats: Concepts, Methodologies, Tools, and Applications 1st Edition by Information Resources Management Association (Author, Editor), 2018, USA

## CC 3028 INFORMATION SECURITY Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the common threats faced in day to day life .
CO2. understand the foundational theory behind information security, the basic principles and techniques in designing a secure system,
CO3. distinguish between symmetric and asymmetric crypto systems.
CO4: understand the access control and authorization mechanisms .
CO5: find the software flaws and malwares and provide the solutions.
CO6: understand the security issues over the network.

### Prerequisite: Computer Networks (IT-3005)

**Introduction:**
Principles of Security, Classic Crypto, Modern Crypto History, Taxonomy of Cryptography, Information Hiding.

**Symmetric- and Asymmetric- Key Crypto:**
Stream Cipher, Block Cipher, Fiestel Cipher, DES and Variations, AES, RSA, Diffie-Hellman Key Exchange, Uses of Public Key Crypto, Public Key Infrastructure.

**Hash Functions & Cryptanalysis:**
Birthday Problem, Non-Cryptographic Hashes, Tiger Hash, HMAC, Uses of Hash Functions, Linear and Differential Cryptanalysis.

**Access Control & Authorization**:
Authentication Methods, Passwords, Biometrics, Captcha, Firewall, Intrusion Detection.

**Software Flaws & Malwares:**
Software Flaws, Malware, Software-based Attacks, Software Reverse Engineering, Software Tamper Resistance, Digital Rights Management.

**Network Security:**
TCP/IP Vulnerability, Concept of Hacking for Penetration Testing, Port Scanning, Packet Sniffing, MAC Flooding, Session Hijacking, IP Spoofing, Denial of Service Attack, Web Server Vulnerabilities, Network Operating System Vulnerabilities, SQL Injection Techniques, Wireless Network Security.

**Text Book :**

1. Information Security, Principles and Practices –Mark Stamp – 2nd Edition, 2018, Wiley.

**Reference Books :**

1. Cryptography and Network Security – Behrouz A. Forouzan, Debdeep Mukhopadhyay, 3rd Edition, 2018, McGraw Hill Education .
2. Cryptography and Network Security, Principles and Practice – William Stallings – 5th Edition, 2011, Pearson.

# COMPUTER SCIENCE & SYSTEMS ENGINEERNG

## B. TECH IN COMPUTER SCIENCE AND SYSTEM ENGINEERING

### Program Educational Objectives (PEOs):

The B. Tech program in Computer Science and System Engineering aims to prepare the graduates with the following objectives:

1. The graduates will be able to provide sound theoretical and practical knowledge in the domain of Computer Science & System Engineering for leading successful career in industries, pursuing higher studies or entrepreneurial endeavors.
2. The graduates will be able to perceive the limitations and impact of engineering solutions in social, legal environmental, economical and multidisciplinary contexts.
3. The graduates will be able to demonstrate professional and ethical responsibilities, imbibe lifelong learning, embrace global challenges and make positive impact on environment and society.

### Program Outcomes (POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**l)** **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

The program specific outcomes are:

m) Ability to design and develop hardware and software in emerging technology environments by using the concepts on Network Processors Design and Performance Evaluation of Computer Systems.

n) Ability to carry out research in the field of multidisciplinary engineering such as Artificial Intelligence, Machine Learning, Real Time Systems, Internet of Things and Embedded Systems.

o) Ability to utilize the knowledge in solving practical real life technological problems in the field of Computer Science & System Engineering.

## CM 3021 SYSTEMS SIMULATION AND MODELLING Cr- 3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: give an overview of the course (Modeling & simulation).
CO2: define important terminologies.
CO3: classify systems/models
CO4: know about simulation language like GPSS:
CO5: use the probability concepts in simulation
CO6: focus on the simulation languages, analysis and testing of simulation outputs and recent trends.

**Prerequisite: Numerical methods, probability and statistic**

**Introduction**-Systems, System types, System Modeling, Types of system modelling, Classification and comparison of simulation models, attributes of modelling, Comparison of physical and computer experiments, Application areas and Examples.

**Mathematical and Statistical Models-** Probability concepts, Queuing Models, Methods for generating random variables and Validation of random numbers.

**Languages-** System modelling, programming languages, comparison of languages, Identifying and selection of programming language, feasibility study of programming language for the given application.

**Experiments-** Simulation of different systems, Analysis, validation and verification of input and output simulated data, study of alternate techniques.

**Case study-** Developing simulation model for information centers, inventory systems and analysis of maintenance systems.

**Text Books :**

1. Geoffrey Gordon, “System Simulation”, Second edition, Prentice Hall, India, 2002.
2. Jerry Banks and John S.Carson, Barry L.Nelson, David M.Nicol, “Discrete Event System Simulation”, Third edition, Prentice Hall, India, 2002.

**Reference Books :**

1. Robert E. Shannon, “System Simulation The art and science”, , Prentice Hall, New Jersey, 1995.
2. D.S. Hira, “System Simulation”, S.Chand and company Ltd, New Delhi, 2001.

## CM 3022 PRINCIPLES OF PROCESSOR DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1: understand the different components of digital design flow, design validations, simulations and their timing analysis using Verilog HDL.
CO2: understand different digital design perspectives using hardware definition language (HDL) in Verilog.
CO3: understand the functional and behavioral difference between combinational and sequential circuits.
CO4: understand the design of bus structure, timers, primary memory, digital filters and pipeline architectures using different case studies.
CO5: understand the register transfer logic needed for computations and test them during design of CPU data paths.
CO6: understand the intricacies in processor design and develop processor circuits using Verilog.

**Prerequisites: Nil**

**Digital Design Flow in Verilog** –Design entry –Test bench in Verilog - Design validation - Compilation and synthesis –Post synthesis simulation - Timing analysis - Hardware generation- Verilog HDL –Verilog evolution- Verilog attributes -Verilog language RT level design – Control/data partitioning - Data part- Control part- Elements of Verilog –Hardware modules - Primitive instantiations- Assign statements - Condition expression - Procedural blocks- Module instantiations- Component description in Verilog – Test benches.

**Verilog Language Concepts** – Hardware languages-Timing- Concurrency- Timing and concurrency example – Module basics – Verilog simulation model –Continuous assignments-
Procedural assignments- Compiler directives – System task and function.

**Combinational and Sequential Circuits Description** - Module wires – Gate level logic – Hierarchical logic- Describing Expressions with Assign Statements- Behavioural Combinational Descriptions- Sequential models – Basic memory components – Functional registers – State machine coding – Combinational and sequential synthesis – Latches – Flip flops – Counters.

**Design Examples** – Bus structure – Simple processor – Timer – SRAM – Cache – Clock synchronization, Digital filters and signal processors-Pipelined Architectures-Halftone Pixel
Image Converter.

**Register Transfer Level Design and Test** – Sequential multiplier –Shift-and-add multiplication process- Sequential multiplier design-Multiplier testing-Von Neumann computer model–Processor and memory model- Processor model specification- Designing the adding CPU Design of data path - Control part design- Adding CPU Verilog description- Testing adding CPU- CPU design and test.

**Text Books :**

1. ZainalabedinNavabi, "Verilog Digital System Design", 2nd Edition, McGraw Hill, 2008
2. Michael D. Ciletti, "Advanced Digital Design with the Verilog HDL" 2nd edition, Pearson Edition, 2009

## CM 3023 NETWORK PROCESSORS DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: understand the basics of network processor architecture
CO2: understand basic concepts of processor scheduling and other parameters used for measuring performance of network processor
CO3: comprehend the network processor and its communication mechanisms
CO4: implement various programming aspects of network processors
CO5: design and develop optimal Network Processor
CO6: analyze the various memory interfaces and its components

### Prerequisite: Computer Networks (IT-3005), Computer Organization and Architecture

**Introduction**: Traditional protocol processing Systems, Network processing Hardware, Basic Packet Processing Algorithms and data Structures, Packet processing functions, Protocol Software, Hardware Architectures for Protocol processing, Classification and Forwarding, Switching Fabrics.

**Network Processor Technology:** Network Processors: Motivation and purpose, Complexity of Network Processor Design, Network Processor Architectures architectural variety, architectural characteristics Peripheral Chips supporting Network Processors: Storage processors, Classification Processors, Search Engines, Switch Fabrics, Traffic Managers.

**Commercial Network Processors**: Multi-Chip Pipeline, Augmented RISC processor, Embedded Processor plus Coprocessors, Pipeline of Flomogeneous processors. Configurable Instruction set processors, Pipeline of Electrogeneous processors, Extensive and Diverse processors, Flexible RISC plus Coprocessors, Scalability issues, Design Tradeoffs and consequences.

**Network Processor Architecture**: Architecture: Intel Network Processor: Multithreaded Architecture Overview, Features, Embedded EISC processor, Packet Processor Hardware, Memory interfaces, System and Control Interface Components, Bus Interface.

**Text Books :**
1. Douglas E.Comer "Networks Systems Design using Network Processors" Prentice Hall, 2003
2. Ran Giladi, "Network Processors Architecture, Programming, and Implementation", Morgan Kaufmann Publishers, 2008

**Reference Books :**

1. Patric Crowley, Mark A. Franklin , Haldun Hadimioglu, and Peter Z. Onufryk, "Network Processors Design: Issues and Practices (Volume-2)", 2004
2. Hill Carlson, "Intel Internet Exchange Architecture & Applications a Practical Guide to Intel‟ s network Processors" Intel press. www.cisco.com

## CM 3024 PERFORMANCE EVALUATION OF COMPUTER SYSTEMS Cr- 3

**Course Outcome:** At the end of this course the students will be able to:

CO1: understand the concept of evaluating the performance of machine, models, parameters for evaluating the performance.
CO2: understand the basic concepts of different types of evaluating models with case study of different server based on Queuing model.
CO3: understand the concepts of data center, stochastic process, business model
CO4: implement simulation modeling and different techniques for measurement.

**Prerequisites: Mathematics, Programming language**

**Module 1:** Overview Of Performance Evaluation , Random variables and common distributions Computer System Lifecycle and From Systems to Descriptive Models, Quantifying Performance Models, Performance Engineering Methodology and Case Study I: A Database Service.

**Module 2 :** Multiclass Open Queuing Network Models , Case Study II: A Web Server and Multiclass Closed Queuing Network Models.

**Module 3:** Data Center, Stochastic processes Markov Models, E-Business Service and Case Study V: A Help-Desk Service.

**Module 4 :** Queuing Networks with Load Dependent Devices, Non-Product Form Queuing Network Models

**Text Book :**

1. D. A. Menascé, V. Almeida, and Larry W. Dowdy, Performance by Design: Computer Capacity Planning by Example, Prentice Hall, 2004.

**Reference Books :**

1. Raj Jain,"The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement,Simulation, and Modeling", WileyInterscience, 1991.
2. K.S. Trivedi,"Probability and Statistics with Reliability, Queueing and Computer Science Applications", John Wiley and Sons, 2001.

## CM 3026 PROGRAMMING FOR EMBEDDED SYSTEMS Cr- 3

**Course Outcome:** At the end of the course, the students will be able to :

CO1: understand the embedded system design process.
CO2: understand the working of 8051 Micro controller.
CO3: write basic assembly language programs using 8051.
CO4: interface with keyboard, display, A/D and D/A converters.
CO5: understand the scheduling in real-time systems.
CO6: understand the implementation of embedded system.

**Prerequisite: Computer Organization and Architecture, Microprocessors and Interfacing**

Embedded Computing: Introduction, Complex Systems and Microprocessor, Embedded System Design Process, Formalisms for System Design, Design Examples.

The 8051 Architecture: Introduction, 8051 Micro controller Hardware, Input/Output Ports and Circuits, External Memory, Counter and Timers, Serial data Input/Output, Interrupts.

Basic Assembly Language Programming Concepts: The Assembly Language Programming Process, Programming Tools and Techniques, Programming the 8051. Data Transfer and Logical Instructions, Arithmetic Operations, Decimal Arithmetic. Jump and Call Instructions, Further Details on Interrupts.

Applications: Interfacing with Keyboards, Displays, D/A and A/D Conversions, Multiple Interrupts, Serial Data Communication.

Architecture and Performance Analysis: Architecture, Coordination, Communication, Prediction of execution times, Scheduling in real-time systems, Real-time operating systems, Middleware.

Implementation: Task level concurrency management, Hardware/software partitioning, Compilers for embedded systems, Design flows and tools.

**Text Books :**

1. Computers as Components-Principles of Embedded Computer system Design, Wayne Wolf, Elseveir.
2. The 8051 Microcontroller, Third Edition, Kenneth J.Ayala, Thomson.

**Reference Books :**

1. P. Marwedel, Embedded System Design. Springer Verlag, 2006.
2. Embedded Systems - Architecture, Programming and Design, Raj Kamal, TMH.

# ELECTRICAL ENGINEERING

# B. Tech in Electrical Engineering

## Program Educational Objectives(PEOs):

The B. Tech program in Electrical Engineering aims to prepare the graduates with the following objectives:

1. Graduates will be able to address complex problems and apply learned skills in wide range of career opportunities in industries and academics.
2. Graduates will be able to fulfill the needs of society in solving technical problems using engineering principles, tools and practices, in an ethical and responsible manner.
3. Graduates will develop leadership skills in the workplace and function professionally in a globally competitive world.

## Program Outcomes(POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Demonstrate knowledge and hands-on competence in the area of characteristics, operations, analysis, design of electrical machines and their applications in industry and other fields.
n) Demonstrate knowledge of analysis, design and implementation of electrical circuits, electronic circuits, power electronic circuits, measurements, control systems in different electrical systems.
o) Enhance the knowledge in generation, transmission, distribution, protection of electric power, installation, operation and maintenance of power system components with respect to competitive tariff for economic project viability and climate change issues and to understand the need for renewable energy systems for developing clean energy and sustainable technologies.

## EE 1003 BASIC ELECTRICAL ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand the basics of electric supply systems and safety measures.
CO2. provide knowledge about the DC circuits.
CO3. determine the different elements of AC circuits.
CO4. realize the behavior of magnetic circuits.
CO5. know the operation and application of transformer and induction motors.
CO6. measure different electrical quantities and to know the usage of different lamps.

**Prerequisite: Physics (PH 1007)**

**Module-1: Introduction**
Electrical Energy Scenario in India, power system layout, Comparison: overhead transmission lines and underground cable; generating stations (Thermal, Hydro, Nuclear and Solar PV Stations), AC and DC distribution System; Safety measures in electrical system) Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wiring, Types of Batteries, necessity of earthing and fuse.
**Activity:** IE Rules for Domestic wiring.

**Module-2: DC Circuits**
Basic terminology- circuit, network, mesh, loop, node, junction, active network, passive network, lumped network, distributed network, bilateral element and unilateral element, linear and non linear network, Kirchhoff's law, star-delta transformation, mesh analysis, nodal analysis, Superposition theorem, Thevenin's Theorem, Norton's Theorem, DC transients (RL, RC series circuits).
**Activity:** Problems on DC Circuits and DC transients.

**Module-3: AC circuits**
Basic terminology-Amplitude, time period, frequency, phase, phase difference, average value, R.M.S value, form factor, peak factor, phasor representation of alternating quantities, Phasor Algebra, AC Series circuit, Resonance in AC series Circuit, Three phase AC circuits- voltage and current relations in star and delta connections, Measurement of power and power factor by two-wattmeter method.
**Activity:** Problems on AC Circuit.

**Module-4: Magnetic circuits**
Basic terminology-magnetizing force, reluctance, Permeance, magnetic field, magnetic permeability, analogy between electric circuit and magnetic circuits, analysis of series magnetic circuit, B-H curve, hysteresis and eddy current loss, leakage flux, Faraday's laws of electromagnetic induction, self and mutual inductance.
**Activity:** Problems on Magnetic circuit.

**Module-5: Transformer and Induction Motors**
Single Phase transformer: principle, construction, Uses, E.M.F equation, Auto transformer, Three Phase Induction Motor: Principle, types and uses and Torque-Slip characteristics,
**Activity:** Single Phase Induction Motor: Working Principle, Types and applications.

**Module-6: Measuring Instruments and Illumination**
Principle and construction of Moving coil instruments, Extension of range; Moving iron instruments, Dynamometer Watt meter, 1-Phase induction type energy meter, Basic terminology-Luminous flux, luminous intensity, lumen, candela power, brightness; Different lamps: Fluorescent Lamp, Compact Florescent Light (CFL), Light Emitting Diode (LED).
**Activity:** Problems on Extension of range.

**Text Books :**
1. Basic Electrical Engineering by D.C. Kulshreshtha, Tata Mcgraw publication, 1st Edition 2011.
2. Principles of Electrical Engineering and Electronics- V K Mehta, Rohit Mehta,S Chand and Company, New Delhi(Revised Edition 2013)

**Reference Books :**
1. Basics Electrical Engineering Sanjeev Sharma, I.K. International, New Delhi.(Third Reprint 2010).
2. Basic Electrical Engineering, T.K. Nagasarkar and M.S. Sukhija, Oxford University press, 2nd Edition2011.

3. Basic Electrical Engineering Abhijit Chakrabarti, Sudip Nath, Chandan Kumar Chnada, Tata McGraw Hill Publishing Limited, New Delhi,2007

## EE 2011 DC AC AND SPECIAL ELECTRICAL MACHINES Cr-4

**Course Outcome :** At the end of the course, the students will be able to:

CO1. know the construction, basic principle of operation and performance characteristics of DC Machines.
CO2. understand the construction, basic principle of operation and testing of Transformer.
CO3. know the construction, principle of operation, types, use, starting and testing of three phase induction motor and three phase synchronous machines.
CO4. know the basic principle of operation and applications of single phase motors.
CO5. understand the basic principle, operation and applications of special electrical machines.
CO6. analyze the performance of various special electrical machines.

**Pre-requisite: Basic Electrical Engineering (EE 1003)**

**Module 1: DC Machines**

**DC Generator:** Construction, Principle of Operation, emf equation, Types of generators, load characteristics, Voltage build up of shunt generator, Applications.

**DC Motor:** Construction, Principle of operation, Back emf, Speed and Torque formula, Motor characteristics and performance curve, Speed control of DC shunt and series motor, Necessity of starter, 3-point starter, Losses and efficiency, Industrial Applications.

**Activity:** Different Parts of DC Machine, Connection Diagram, compensating winding, dummy coils, equalizer rings,3 point and 4 point starter, Laboratory method for Brake Test.

**Module 2: Transformer**
Single phase transformer, Construction , Principle of operation, emf equation, equivalent circuit and phasor diagram, Open circuit and Short circuit test, Regulation, Losses and Efficiency.
**Activity:** Explanation for origin of harmonics current and voltage, Harmonics techniques, Polarity Test,

**Module 3: Three-phase AC Machines**
**Three-phase synchronous Machines :**
Alternator: Introduction, Construction, Types and uses, Principle of operation, EMF equation of Alternator, Voltage regulation by synchronous impedance method.

Synchronous Motor: Construction, Principle of operation, V-curves, method of starting and applications.

**Three-Phase induction motor:**
Construction, Squirrel cage and Slip ring type, Principle of operation and equivalent circuit and phasor diagram, Torque-Slip characteristics, starting torque and maximum torque, starting and speed control and applications.

**Activity:**Construction, Laboratory Methods for Determination of $X_d$ and $X_q$ (Slip Test) of alternator, Applications of alternators and synchronous motors.Different parts of induction motor, Terminology: cogging, crawling, inching, jogging, Induction Generator

**Module 4:Single-Phase Induction Motors and Special Motors**
**Single-Phase Induction Motors:**
Types of Single-phase Motors, capacitor start motor, capacitor start and run motor.

**Special Motors:**
Stepper motor (Principle, operation and application), shaded pole motor, repulsion motor, Universal Motor, Reluctance Motor, Hysteresis Motor, Ratings and applications.

**Activity:** Application of single Phase induction motor, Backward slip, development of equivalent circuit, Applications of special motors.

**Text Books :**


1. Electrical Machinery, P. S Bimbhra, 7th Edition, Khanna Publishers, 2008.
2. Electrical Machines, by P. K. Mukherjee and S. Chakravorti, Dhanpat rai Publication, $18^{th}$ reprint 2013


**Reference Books :**


1. Electrical Machines, Ashfaq Hussain, Dhanpat Rai, Delhi, $2^{nd}$ Edition, 2008.
2. Electrical Technology, Volume -II. B. L. Theraja, S .Chand Publications. 2010.
3. Electric Machines, C. I. Hubert, , Pearson Education, 2003.
4. Electric Machines ,by Kothari. D P and I J Nagrath, , $3^{rd}$ Edn, Tata McGraw-Hill, New Delhi. 2004.


## EE 2013 ANALOG ELECTRONIC CIRCUITS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. draw the characteristics and applications of P-N Junction diode.
CO2. develop biasing circuits for BJT.
CO3. understand the characteristics of Field Effect Transistors.
CO4. know about different types of Amplifier circuits.
CO5. know about different types of Feedback circuits.
CO6. study electronics circuits using operational amplifiers.

**Prerequisites: Physics (PH 1007), Basic Electrical Engineering (EE 1003).**

**Module-1: Diode**
Characteristics of signal diode and Zener diode, applications: Limiters, clippers, clampers, Voltage stabilizers.
**Activity:** Voltage multipliers, half wave & full wave rectifier, LED, Photo diode, Shunt Regulator.

**Module-2: Bipolar junction transistor**
Transistors and characteristic, Biasing of BJT (Fixed, collector to base, emitter biasing), Analysis of transistor amplifier in CE configuration using BJT small signal model.
**Activity:** Stability & compensation of biasing circuit (Qualitative only), Parameter determination using small signal model in (CB, CC) mode.

**Module-3: Field Effect Transistors**
MOS structure & characteristics, MOS as a switch CMOS as an inverter.
**Activity:** MOSFET biasing circuit (CS & CD).

**Module-4: Power Amplifier and Feedback circuit**
Types of amplifier & their equivalent circuit (VA, CA, Trans conductance & Trans resistance amplifier), Class A, B amplifier, Concept & types of feedback topology, Analysis of practical feedback amplifiers, Barkhausen criterion, RC & LC phase shift oscillator( qualitative description), output frequency of the oscillator.
**Activity:** Class AB, C amplifier & their distortion, frequency response of amplifier with & without feedback.

**Module-5: Operational Amplifier:**
Characteristics of ideal & non ideal OP-AMP, Differential & common mode gain, Equivalent circuit for OP-AMP, inverting and non-inverting OP-AMP, differentiator and integrator circuit, OP-AMP as comparator, square wave generator using OP-AMP, Schmitt trigger, 555 timer.
**Activity:** Zero crossing detector, Triangular wave generator using OP-Amp, voltage controlled oscillator.

**Text Books :**


1. Integrated Electronics- Analog and Digital Circuits and Systems, J. Millman&Halkias, C.D. Parikh, Mc-Graw Hill India, $2^{nd}$ Edition, 2013 (10th Reprint).
2. Op-Amps and Linear Integrated Circuits - Ramakant A. Gayakward , Pearson, $4^{th}$ Edition, May 2015.

**Reference Books :**


1. Microelectronics circuits- A. S. Sedra and K. C. Smith- 5th Edition, 2011 - Oxford University Press.
2. Linear Integrated Circuits - D. Roy Choudhury and Shail B. Jain- 5th Edition- New Age International Publishers, 2018.
3. Foundations Of Analog and Digital Electronic Circuits:-Anant Agarwal, Elsevier India (2013)


## EE 2015 ELECTRICAL CIRCUITS ANALYSIS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. analyze different electrical circuits using network theorems.
CO2. understand the transients in AC/DC circuits.
CO3. evaluate different network parameters in networks.
CO4. know the concept of passive and active filters.
CO5. understand the magnetic couple circuits.
CO6. analyze the electrical circuits using network topology.

**Prerequisite: Basic Electrical Engineering (EE 1003)**

**Module-1: Network Theorems**
Independent and dependent source**,** Source transformation, Maximum Power Transfer theorem (Both AC and DC Network), Reciprocity Theorem, Millman's Theorem and Tellegen's Theorem, Analysis of circuit with one nonlinear network.
**Activity:** Thevenin's, Norton's and superposition theorem for AC circuits.

**Module-2: Magnetic coupled circuits**
Self and Mutual Inductance, Dot convention for coupled circuits and coefficient of coupling, Single Tuned coupled circuit.
**Activity:** Double Tuned coupled circuits.

**Module- 3: Transient Response**
Duality of circuits, Transient response for R-L, R-C and R-L-C circuits with both DC and AC excitation in time domain and Laplace transformation method.
**Activity:** Analyze RLC transient behavior using MATLAB/P-Spice/Multisim.

**Module-4: Two-Port Networks**
Network Configurations, Open Circuit, Short circuit, transmission and hybrid parameters, Condition of symmetry and reciprocity in two port network, Interconnection of two port networks (Series, Parallel &Cascade).
**Activity:** Inter-relationship between parameters of two port network, Image parameters.

**Module-5: Network Topology**
Concepts of Network graph, Tree, Co-Tree, Links and Twigs, Formation of incidence matrix [A] and loop matrix [B] Formation of Fundamental Cut-Set Matrix [QF], Tie-Set Matrix.
**Activity:** Relation between branch voltage and current, loop current network topology analysis.

**Module-6: Filter Design**
Passive filters, Design of low pass, high pass, band pass, and band elimination filter.
**Activity:** Application of different electric filters, Concept of Active filter.

**Text Books :**


1. Network Analysisby M. E. Van Valkenburg, Pearson Education, 3rd Edition, 2006.
2. Networks and systems by D.Roy Choudhury, New Age Publication, 2nd Edition, June 2013.


**Reference Books :**


1. Circuits and Networks Analysis and Synthesis (Second Edition) A Sudhakar ShyammohanS Palli, Tata McGraw-Hill, 2011.

2. Basic Circuit Analysis(Second Edition), John O'Malley, Schaum'sOutlines, Tata McGraw-Hill, 2010(Reprint).
3. Fundamentals of Electric Circuits, Charles K. Alexander, Matthew N.O. Sadiku, McGraw Hill Education; 5 edition (1 July 2013).

## EE 2017 TRANSFORMERS AND INDUCTION MOTORS Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. know the construction, principle, losses, efficiency and Phasor diagram of transformers and induction motors.
CO2. perform the different testing to develop the equivalent circuit of transformer and induction motor.
CO3. know the parallel operation of single phase and three phase transformers.
CO4. know the different connections and conversions of three phase transformers.
CO5. know the performance characteristics, different methods of starting and speed control of three phase induction motor.
CO6. know the construction and principle of operation of different single phase induction motors.

**Prerequisite: Basic Electrical Engineering (EE 1003)**

**Module 1: Single Phase Transformer**
Principle of operation, Construction, Types, emf equation and Phasor diagrams of transformer at no load and load condition, Development of Equivalent Circuit, No Load Test, Short Circuit Test and Sumpner's Test. Voltage Regulation, Losses, Efficiency and all day Efficiency. Parallel operation of Transformer and applications.
Auto Transformer: Principle, Performance (Copper Saving, Phasor Diagram and equivalent circuit) and Applications.
**Activity:** Explanation for origin of harmonics current and voltage, Harmonics techniques, Polarity Test, Special purpose transformer(instrument, pulse ,audio frequency, earthing, welding and tap-changing transformer).

**Module 2: Three Phase Transformer**
Three Phase Transformer Connections and vector Group, open delta connection, Phase Transformation: 3 phase to 2 Phase, 3 phase to 6 phase and 3 phase to 12 phase, Parallel operation of three phase transformer.
**Activity:** Construction of three phase Transformer, Inrush current.

**Module 3: Three Phase Induction Motor**
Rotating Magnetic Field, Principle of operation and concept of slip, Comparison between transformer and induction motor, Types and Applications, Equivalent Circuit and Phasor Diagram, Torque, maximum torque, Torque-slip characteristics, Effects of variation of rotor resistance, Power stages of an induction motor, No load and Blocked rotor test, Circle Diagram, Methods of starting for squirrel cage and slip ring induction motor, Speed control of squirrel cage and slip ring induction motor.
**Activity:** Different parts of induction motor, Terminology: cogging, crawling, inching, jogging, Induction Generator, types of insulations used in an induction motor, Magnetic levitation.

**Module 4: Single Phase Induction Motor**
Types, Double field Revolving Theory, capacitor start motor, capacitor start and run motor.
**Activity:** Application of single Phase induction motor, Backward slip, development of equivalent circuit.

**Text Books :**
1. Electrical Machinery, P. S Bimbhra, 7th Edition, Khanna Publishers, 2008.
2. Electric Machines, by Kothari. D P and I J Nagrath, 3rd Edition, Tata McGraw-Hill, New Delhi. 2004.
3. Electric Machinery, by E. Fitzagerald, C. M. Kingsley (Jr) and S. D. Umans, Tata McGraw Hill, 6th Edition 2003.

**Reference Books :**
1. Electrical Machines, Ashfaq Hussain, Dhanpat Rai, Delhi, 2nd Edition, 2008.
2. Electrical Machines, by P. K. Mukharjee and S. Chakravorti, Danpat rai Publication, 18th reprint 2013.
3. Electrical Machines, by P. Purkait and I. Bandyopadhyay, Oxford University Press. 1st Edition, 2017.

## EE 2018 DIGITAL CIRCUITS Cr- 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the different types of number systems and logic gates.
CO2. formulate Digital Circuits using Boolean algebra and K-Maps.
CO3. design Combinational Circuits.
CO4. understand Flip-Flops based design for Counters and Shift registers.
CO5. apply the fundamental knowledge of Analog and Digital Electronics to get different types ADC and DAC
CO6. compare different Logic Families of Digital Circuits and their characteristics.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module-1: Introduction to Digital Circuits**
**Introduction:** Digital and Analog systems, Logic levels and pulse waveforms, Elements and functions of Digital Logic, Applications of Digital Electronics.
**Number Systems:** The Binary Number system, Representation of signed numbers.

**Binary Codes:** 8421 BCD, Gray, Excess-3.
**Logic Gates:** Basic Gates, Universal Gates, Special Gates.

**Boolean Algebra:** Logic operations**,** Axioms and Laws of Boolean Algebra, Duality, Reducing Boolean Expressions, Boolean Functions and their representation, Expansion of a Boolean Expression in SOP form and POS form.

**Minimization of Switching Functions:** Introduction, Two-variable K-Map, Three-variable K-Map, Four Variable K-Map, Don’t care Combinations.
**Activity:** Reduction of Boolean Expressions using Boolean Algebra and K-Map representation, Representation using Logic Gates, Error Detecting Codes.

**Module-2: Combinational Logic Design**
Introduction, Adders (Half and Full adders, Binary Parallel Adder), Subtractors (Half and Full Subtractors, 4-bit parallel Subtractor), Encoders (Octal to Binary Encoder, Decimal to BCD Encoder), Decoders (3-Line to 8-Line, BCD to Decimal, BCD to SSD, Priority Encoder, Multiplexer, Demultiplexer.
**Activity:** Applications of Multiplexer (Logics Function Generator), Demultiplexer tree, Design circuits using Universal Gates, 2’s complement addition and subtraction using parallel adders, Look-Ahead Carry Adder, Serial Adder, 4-bit Magnitude Comparator.

**Module-3: Sequential Logic Design**
**Introduction:** Classification of Sequential Circuits, Level Mode and Pulse Mode Asynchronous Sequential Circuits.

**Flip Flops:** Latches and Flip Flops, Race Around Condition, Master Slave (Pulse-Triggered) Flip Flops, Flip Flop Excitation tables.

**Shift Registers:** SISO, SIPO, PIPO, PISO.
**Counter:** Ripple, Synchronous and mode n counter.
**Activity:** Analysis of Clocked Sequential Circuits, Digital circuit conceptualization, synthesis, verification and optimization using FSM, Conversion of Flip Flops, Application of Flip- Flops, Ring and Johnson Counter.

**Module-4: ADC and DAC**
Introduction, Digital to Analog converter (Weighted Resistor type & R-2R ladder type), Analog to Digital converter (Flash type, Counter type & Successive approximation type).
**Activity:** The Switched Current-Source type DAC, The Switched Capacitor Type DAC, Tracking type ADC, Dual Slope type ADC.

**Module-5: Logic Families**
Introduction, Digital Specification Terminology (Threshold Voltage, Propagation delay, Speed-power product, Noise margin, Fan-in, Fan-out), Standard logic families (TTL, ECL, CMOS), Analysis of TTL and CMOS chips

**Activity:** TTL Subfamilies, Dynamic MOS Logic, Interfacing.

**Text Books :**

1. Digital Logic and Computer Design – M. Morris Mano – PHI, 2011
2. Fundamentals of Digital Logic – Anand Kumar - PHI, 4th Edition, 2017

**Reference Books :**

1. Digital Principles and Applications – Malvino & Leach –TMH, 7th edition, 2011
2. Digital Fundamentals – T. L. Floyd & Jain – Pearson Education, 10th edition, 2011

## EE 2019 ELECTRICAL AND ELECTRONICS MEASUREMENTS Cr-3

**Course Outcomes :** At the end of the course, the students will be able to:

CO1. measure the different electrical quantities.
CO2. determine the unknown electrical circuit elements using different AC/DC bridges.
CO3. measure power, energy, frequency and phase angle.
CO4. use instrument transformer and potentiometer in Electrical system.
CO5. know the use of transducers and electronic instruments for measurement.
CO6. know the recent trends of measurement system.

### Prerequisites : Basic Electrical Engineering (EE 1003)

**Module 1: Measurement of Different Electrical Quantities:**
Errors in measurements, Moving Iron type instrument, Induction type wattmeter, VAR meter, Induction type energy meter, Electrical resonance type frequency meter, Electrodynamometer type power factor meter, Current transformers: Ratio and phase angle errors, phasor diagrams, uses. Potential transformer and Testing of Instrument Transformers
**Activity:** Deflecting, Controlling and Damping Torques in Indicating Instruments, extension of range, Electrodynamometer type meter.

**Module 2: DC/AC Bridge**
General equation of bridge balance, Maxwell's inductance, Owen's bridges, Wagner's earthling device, Maxwell's inductance-capacitance bridge, Hay's Bridge, Anderson's bridge, Schering bridge, Errors.
**Activity**: Wheatstone bridge, Kelvin's double bridge.

**Module 3: Transducers**
Definition and Classification of transducers, Capacitance Transducers, Variable Inductance Transducers, Encoders. Thermocouples, Synchros, Piezoelectric Transducers, Hall effect Transducers, Tachometer. Thermistors, LVDT, AC potentiometer
**Activity**: Advantages of Electrical transducers, Characteristics and choice of transducers, Strain Gauge, DC potentiometer,

**Module 4: Electronic Instruments**
Electronic voltmeter: Block diagram, principle of operation, CRO: Block Diagram, Sweep Generator, use of CRO for measurement of frequency, phase, amplitude and rise time.
**Activity**: Digital Frequency meter, Digital Multi-meter.

**Module 5: Recent trends of measurement system.**
Digital Energy Meter, Biometrics, Megger, Biomedical Instruments: ECG, Blood Pressure, Sonography.
**Activity:** Report of CT scan, MRI: Case study.

**Text Books :**

1. Electronic Instrumentation and Measurement Techniques, By William David Cooper, PHI, 2010.
2. Electrical Measurements and Measuring Instruments, By Edward William Golding, F. C. Widdis, 5th Edition, Pitman, reprint 2012.

**Reference Books :**

1. Electronics Instruments and Measurements – David A. Bell – PHI, 2012.
2. A Course in Electrical and Electronics Measurement and Instrumentation by A. K. Sawhney, $10^{th}$ edition, Dhanpat Rai, 1994.
3. Electrical Measurement and Measuring Instruments by Arthur Harris, Intelliz press,
4. ISBN: 978-1-6825/-382-8/2018.

## EE 2020 DC MACHINES AND SYNCHRONOUS MACHINES Cr -3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the Construction, principle and efficiency of synchronous machines and different DC machines.
CO2. understand the armature reaction and characteristics of DC machines and Synchronous machines.
CO3. understand the power flow diagram of DC machines and Synchronous machines.
CO4. develop the different winding diagrams of DC machines and Synchronous machines.
CO5. determine the voltage regulation of Synchronous machines.
CO6. know the starting, testing and speed control of DC machines and Synchronous machines.

### Prerequisite: Transformers and Induction Motor (EE 2017)

**Module 1: DC Generator**
Principle of operation, Types of DC Machines. Armature Winding and emf equation, Armature Reaction, Brush shift and its Effects, Methods to improve commutation, Interpoles, Commutation. Power Flow Diagram, Losses and Efficiency. Characteristics of different DC Machines. Applications of separately and self excited DC Generator.
**Activity:** Different Parts of DC Machine, Connection Diagram, Developed diagram, Equivalent ring diagram, compensating winding, dummy coils, equalizer rings.

**Module 2: DC Motor**
Principle of operation, Back emf, Characteristics of different motors, Losses and Efficiency, Speed control of DC Motor, Necessity of starters, Testing : Swinburne's Test and Hopkinson's Test. Applications of different DC motors.
**Activity:** 3 point and 4 point starter, Laboratory method for Brake Test, Rating of DC Machine.

**Module 3: Synchronous Generator**
Principle of operation, Different armature windings, Pitch factor, distribution factor, winding Factor, EMF equation, Armature Reaction, Phasor Diagram of a cylindrical alternator, Voltage Regulation: EMF Method, MMF Method and Zero power factor method, Short Circuit Ratio, Power angle characteristics of cylindrical alternator, Blondel's two reaction theory, Direct and quadrature axis reactance, Phasor Diagram of salient pole Machine, Power angle Characteristics of salient pole alternator, Excitation systems for synchronous machines.
**Activity:** Construction, Laboratory Methods for Determination of $X_d$ and $X_q$ (Slip Test), Ratings and Applications, Parallel operation of Alternators and load sharing, Synchronizing power.

**Module 4: Three Phase Synchronous Motor**
Principle of operation, Method of Starting, Equivalent Circuit and Phasor Diagram of cylindrical rotor, Power flow diagram, Construction of V curve and inverted V curves, Synchronous condenser and power factor correction, Power angle equation for both salient and cylindrical rotor synchronous motor.
**Activity:** Effect of load changes on a synchronous motor, Hunting, rating and applications.

**Text Books :**

1. Electrical Machinery, P. S Bimbhra, 7th Edition, Khanna Publishers, 2008.
2. Electrical Machines, by P. Purkait and I. Bandyopadhyay, Oxford University Press, $1^{st}$ Edition 2017.
3. Electric Machinery, by E. Fitzagerald, C. M. Kingsley (Jr) and S. D. Umans, Tata McGraw Hill, 2003.

**Reference Books :**

1. Electrical Machines, Ashfaq Hussain, Dhanpat Rai, Delhi, $2^{nd}$ Edition, 2008.
2. Electric Machines, C. I. Hubert, , Pearson Education, 2003.
3. A Text Book of Electrical Technology, Vol. –II, AC & DC Machines, By B. L Theraja, A. K Theraja, S. Chand and Sons, 2006.

## EE 2022 SIGNALS AND SYSTEM Cr- 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know various types of signals.
CO2. understand continuous and discrete linear time invariant system .
CO3. apply the signals through convolution and correlation techniques
CO4. analyze the time domain responses of LTI systems.
CO5. apply the Fourier Transform of continuous-time signals
CO6. determine Z-transform for the continuous signal.

### Prerequisite: Mathematics II (MA 1004)

**Module-1: Introduction**

Definition of signal, Continuous time and discrete time signal, Classification of signals as even, odd, periodic and non-periodic, deterministic and non-deterministic, energy and power. Elementary signals/Functions: exponential, sine, impulse, step and its properties, ramp, rectangular, triangular, signum, sync functions.
Systems: Definition, Classification: linear and nonlinear, time variant and invariant, causal and non- causal, static and dynamic, stable and unstable, invertible.
**Activity:** Operations on signals: Amplitude scaling, addition, multiplication, differentiation, integration (Accumulator for DT), time scaling, time shifting and time folding.

**Module-2: Continuous and Discrete Linear Time Invariant System**
Time domain representation of LTI System: System modeling: Input-output relation, definition of impulse response, convolution sum, convolution integral, Properties of convolution, Cross Correlation and Auto Correlation of signals.
**Activity:** Computation of convolution integral and convolution sum using graphical method.

**Module-3: Fourier Series and Fourier Transform**
Fourier series representation of continuous time periodic signals, properties of Fourier series, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series, Fourier transform of arbitrary signal, Fourier transform of standard signals, properties of Fourier transforms.
**Activity:** Derive Fourier transform from Fourier series, Fourier transform of periodic signals.

**Module-4: SAMPLING:** Representing a continuous signal by samples, Sampling theorem, Zero-order hold, Aliasing and its effect.
**Z Transforms:** Z–Transforms, Properties of Z-transforms, Region of Convergence in Z-Transform, Constraints on ROC for various classes of signals, Inverse Z-transform, Distinction between Laplace, Fourier and Z Transforms.

**Activity:** Applications of Sampling Theorem.

**Text Books :**

1. Signals and Systems – A.V. Oppenheim, A.S. Willsky and S.H. Nawab, 2nd Edition, Pearson, 2015.
2. Signals & Systems – Simon Haykin and Van Veen, Wiley, 2nd Edition,2002

**Reference Books :**

1. R.E.Zeimer, W.H.Tranter and R.D.Fannin, "Signals & Systems– Continuous and Discrete", Pearson, 2007.
2. John Alan Stuller, "An Introduction to Signals and Systems", Thomson, 2007.
3. M.J.Roberts, "Signals & Systems Analysis using Transform Methods & MATLAB", Tata McGraw Hill, 2007.
4. Principles of Linear Systems and Signals, 2nd Edition, B. P. Lathi, 2009, Oxford.
5. Signals and Systems by J B Gurung, PHI, 2009.
6. Signals and Systems by T K Rawat, Oxford, 2010.

## EE 2024 GENERATION, TRANSMISSION AND DISTRIBUTION OF ELECTRIC POWER Cr-4

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand the operation of conventional generating stations.
CO2. determine the electrical circuit parameters of transmission line.
CO3. analyze transmission line performance.
CO4. learn mechanical design of transmission line.
CO5. solve voltage drops in different distribution system.
CO6. understand the economic aspects of power plants and components of substation.

### Prerequisites: Electrical Circuit Analysis (EE 2015)

**Module-1: Generation of Electric Power**
Thermal Power plant : Selection of site for a Thermal station, Main Parts and working of Boilers, Economizer, Air Pre-heater, Super-heaters and Re-heaters, Steam Prime mover, Condenser, Spray pond, Cooling Towers, Fuels and Coal handling plant, ESP.
Hydro Power Plant: Factors for Selection of site, Classification of hydro electric plant, General arrangement and operation of Hydro Electric power plant, Construction and Operation of Different Components: catchment area, Head, surge tank, Penstock, spillway, Tail Race, Types of turbine (i) Pelton turbine, (ii) Francis turbine, (iii) Kaplan turbine.
Nuclear Power Plant: Location, Layout of nuclear power plant, Fission, Fusion, Controlled chain reaction, Classification of Nuclear reactors, Pressurized Water Reactor, Boiling Water Reactor, Fast Breeder Reactor, and CANDU reactor.
**Activity:** Layout of Thermal, Hydro and Nuclear power plant.

**Module-2: Transmission of Electric power**
Single and 3-phase transmission, Comparison of AC and DC transmission, Per Unit system
**Line constants:**
Resistance, Inductance and capacitance of single phase and three phase line with symmetrical and unsymmetrical spacing, GMD and GMR calculation, Transposition of power line, Effect of earth on line capacitance, Charging current due to capacitance effect, Bundle conductors, Skin effect and Proximity effect.

**Performance of Transmission line:**
Analysis of short, medium and long Transmission Line, ABCD constants and its calculation for Short, Medium and Long Transmission Line, Ferranti effect, proximity effect surge Impedance and Surge Impedance Loading.

**Mechanical Design of over head transmission lines:**
Types of conductor and insulator, Potential distribution over a string of suspension Insulators, String Efficiency, Methods of equalization of the potentials, Sag and Stress calculation, Effect of ice and wind loading, Vibration dampers.

**Corona:**
Critical disruptive voltage, Visual critical voltage, Corona Power losses, Factors affecting corona, Advantages and Disadvantages of Corona.
**Activity-** Advantage of high voltage transmission, Advantages and Disadvantage of EHV (AC) and HVDC Transmission system, Line compensators, Radio Interference between power and communication line, type of insulating material and their characteristics.

**Module-3: Distribution Systems**
Overhead line verses underground cables, Type and construction, Grading of cables, Insulation resistance of cable, Capacitance of three core cable, dielectric losses.

Classification of distribution system, Types of AC and DC distributors, Voltage drop and load calculation for concentrated and distributed loads, Feeder, Radial and ring main system, Economic choice of conductor, Kelvin's law.
**Activity-** Properties and uses of Underground cable

**Module-4: Economics Aspects and Substations**
**Economic Aspects:**
Load curve, Load duration curve, Connected load, Maximum demand, Demand factor, Average demand, Load factor, Diversity factor, Plant capacity Factor, Plant Use Factor, Tariffs-Types.

**Substations:** Classification and types of substation, equipment used, bus-bar arrangement.

**Activity:** Layout of 33/11kV substation and Power system layout and layout of Gas insulated substation.

**Text Books :**
1. Electrical Power System, C.L. Wadhwa, New Age International (P) Limited, Publishers, 2009.
2. A Text Book on Power System Engineering, A. Chakrabarti, M.L. Soni, P.V. Gupta and U.S. Bhatnagar, Dhanpat Rai and Co., Reprint 2012.

**Reference Books :**
1. A Course in Power System, J. B. Gupta, S K Kataria and Sons Publishers and Distributors, 2011.
2. Power System Analysis and Design- By B. R. Gupta, S. Chand Publications, 3rd Edition, Reprint, 2003.
3. Principle of Power System by V.K.Mehta, S.Chand Publishers, 2012.
4. Elements of Power System Analysis, W.D. Stevenson Jr, TMH, 1982.
5. Overhead Power lines planning, design and construction, by F Kiessling, P Nefzger, J F Nolasco and U Kaintzyk, Springer- Verlag

## EE 2026 POWER ELECTRONICS Cr-4

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the working principles of different power electronics devices.
CO2. analyze the concepts of single phase and three phase controlled rectifiers.
CO3. understand the control of single phase and three phase Inverters.
CO4. compare different topologies of DC to DC converters.
CO5. know the performance of various single-phase AC to AC converters.
CO6. choose a proper converter configuration suitable for industry.

**Prerequisites: Analog Electronic Circuits (EE 2013)**

**Module 1: Power Electronics Devices**
Elements of Power Electronics, Applications of Power Electronics, Thyristor characteristics, Turn on methods, Dynamic characteristics of thyristors, Ratings, Protection, Snubber circuit, Two Transistor model of thyristor, Power BJT, Power MOSFET and IGBT: Constructions, Characteristics and Applications, Latch up in IGBT, Safe operating area of IGBT, Comparison of IGBT with MOSFET, GTO - turn on and turn off methods. Heat sink calculations, SiC based power devices
**Activity:** Comparison between power MOSFET and power BJT, TRIAC, DIAC characteristics and applications.

**Module 2: AC to DC Converters**
Single phase controlled rectifiers: Half wave with R, R-L, R-L-E load and effect of freewheeling diode; Half and fully controlled full wave converters with R RL, RLE load and effect of freewheeling diode, Line commutated Inverters, performance parameters of single phase AC to DC converters, Single phase dual converters, Effect of source Inductance, 3-phase half wave and full wave controlled rectifiers.
**Activity:** Calculation of performance parameters of 1-phase and 3- phase AC to DC converters.

**Module 3: DC to DC Converters**
Principle of chopper operation, Buck, Boost and Buck-Boost converters, advantages of switch mode power supply over conventional power supply, fly back converter, commutation in DC to DC Chopper: voltage commutation, current commutation, load commutation.
**Activity:** Four Quadrant Chopper with DC Motor Load.

**Module 4: DC to AC Converters (Inverters)**
Single phase Half Bridge and Full bridge inverters, 3 phase inverters, $180^0$ and $120^0$ conduction, Voltage control of inverters: Single pulse and multiple pulse width modulation, Sinusoidal pulse width Modulation.
**Activity:** Concept of current source inverter operation and control.

**Module 5: AC to AC Converters**:
Single phase AC Voltage regulator with R and RL load, Single phase mid-point type cyclo-converter with R-L Load, concept of 3-phase cyclo-converter
**Activity:** Single phase bridge type cyclo-converter with R-L Load.

**Text Books :**

1. Power Electronics by M. H. Rashid, Pearson Education, 3rd Edition, 2009.
2. Elements of Power Electronics, by Philip T. Krein, Oxford University Press, 25 Sept 1997.
3. Power Electronics, by P S Bhimbra, Khanna Publishers, 5th Edition, 2011.

**Reference Books :**

1. Power Electronics, Converters, Applications and Design N. Mohan, Undeland and Robbins, John Wiley and Sons , 3rd Edition ,2009.
2. Modern Power Electronics by P. C Sen, S Chand Publisher- 2013.
3. Power Electronics K.R.Varmah and Chikku Abraham, Cengage Publications- 2014.
4. Power Electronics by M. D. Singh and K.B. Khanchandani, Tata McGraw - Hill publishers, 2nd edition, 2008.

## EE 2028 LINEAR CONTROL SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the terminology of control system.
CO2. compute the mathematical model of physical systems.
CO3. analyze the time domain response of different systems.
CO4. determine the stability of a system by classical methods.
CO5. analyze frequency domain response and different compensators.
CO6. understand the state space modeling of different systems.

**Prerequisites: Signals and System (EE 2022), Electric Circuit Analysis (EE 2015)**

**Module-1:**
**Introduction:** Basic concept of control system: open loop and closed loop control system, differential equations and transfer function, Effect of feedback on gain, stability, sensitivity and noise of the system, order and type of the system.

**Modeling of physical system:** Mathematical modeling of mechanical system and electrical system, Analogous system, Translational and rotational mechanical system, Transfer function by block diagram reduction technique, Developing block diagram from a mathematical model, Signal flow graph terminology, construction & procedure, Transfer function from signal flow graph using Mason's gain formula, Time delay control system.
**Activity:** Application of different control system components.

**Module-2:**
**Time domain analysis** : Time response of first order system, Response to the unit step input, unit ramp input, Time response of second order system for unit step input, Time response specification, steady state error & design specification, Error constant of second order system, Minimization of Errors through P, PI and PID controllers.

**Concept of stability**: The concept of stability, necessary condition for stability, Routh- Hurwitz stability criterion, Relative stability analysis.

**Root Locus Technique**: Root locus concept, construction of root locus, construction rules, Determination of gain from root locus.
**Activity:** Time response of first order system for unit impulse input, Application of Routh stability criterion to linear control systems

**Module-3:**
**Frequency domain analysis**: Introduction, Polar plots, Bode plots, Nyquist stability criterion, Stability analysis.
**Activity:** Correlation between time and frequency response, Computation of relative stability.
**Compensators**: Realization of basic compensators, Cascade compensation and Feedback compensation.

**Module-4:**
**State Space**: Concept of state, State variable, State model, State space model for LTI system, Computation of State transition matrix.
**Activity:** Design of Lag, Lead and lag lead compensators, Determination of state space model for physical system.

**Text Books :**

1. Control System Engineering by Noran S Nise, John Wiley Publication, 6th Edition, 2012.
2. Modern Control Engineering by K. Ogata PHI publication, 5th Edition, 2010.

**Reference Books :**

1. Control Systems Engineering by R. Anandnatarajan and P. Ramesh Babu, SCITECH,4th edition, 2016.
2. Control Systems: Theory and applications by Smarajit Ghosh, Pearson. Publication 2012
3. Automatic control system by Hasan Saeed, 6th revised edition 2008, S.K. Kataria and Sons.
4. Modern Control Engineering. By D. Roy Choudhury PHI publication, 5th Edition,2009.
5. Automatic Control Systems by Benjamin C. Kuo, Prentice-Hall,7th Edition,2009.
6. Control System Engg, by I. J. Nagrath and M Gopal ,New age international publication, 4th Edition,2011.
7. Control System by D N Manik, Cengage Learning India Pvt, 2012.
8. Automatic control systems by Prof. B.S. Manke and S. N. Verma , Khanna publication, 2012.

## EE 3002 POWER SYSTEM OPERATION AND CONTROL Cr-4

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the automatic generation control.
CO2. classify different Power system faults.
CO3. solve load flow problems.
CO4. find economic operation of power system generation.
CO5. understand power system stability
CO6. know concepts of generation control and voltage control.

**Prerequisites: Generation, Transmission and Distribution of Electrical Power (EE 2024) and Linear Control System (EE 2028)**

**Module-1**
**Load Flow Studies:**
Complex Power, Importance of load flow studies, Bus classification, Nodal Admittance matrix, Formulation of load flow problem, Difference between Gauss and Gauss Seidel Method, Approximate load flow solution by Gauss-Siedel Method with and without PV bus, acceleration of convergence, Newton-Raphson Method, Decoupled and Fast decoupled method.

**Economic Operation of Power System:**
Introduction, Optimal operation of generators, Distribution of load on various generating units, Penalty factor and Transmission loss as a function of plant generation.
**Activity-** Automatic load dispatch**,** Comparison of different load flow methods, Difference between Load Flow and Optimal power flow (OPF).

**Module-2**
**Symmetrical and Unsymmetrical Fault Analysis:**
Introduction, Transients in transmission line, Symmetrical components, Sequence analysis of power system, Symmetrical Fault analysis, Unsymmetrical Fault analysis: L-G, L-L, L-L-G.
**Activity-** Problem solving of Symmetrical and Unsymmetrical Fault, Short circuit of synchronous machine.

**Module-3**
**Automatic Generation and Voltage Control:**
Introduction, Load frequency control, Turbine speed governing system, Modeling of speed governing system, Turbine model, Generator load model, Integrated representation of various models, Steady state analysis, Dynamic response, Control area concept, Proportional plus integral control, Two area load frequency control.
**Activity-** Excitation system – DC Exciter, AC Exciter and Static Exciter, Automatic voltage regulator.

**Module-4**
**Stability Analysis:**
Introduction to stability, Dynamics of synchronous machines, Swing equation, Power angle curve and its equation, Steady state stability, Equal area criterion, Effect of clearing time on stability.
**Activity-** Calculation of critical clearing time using equal area criteria.

**Text Books :**

1. Modern Power System Analysis, I. J. Nagrath, D. P. Kothari, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 3rd Edition, 2003.
2. Power System Analysis- By John. J. Grainger & W. D. Stevenson, Jr., TMH, 2003 Edition, (15th Reprint).

**Reference Books :**

1. Power System Analysis by T K Nagsarkar and M S Sukhija, 1st Edition, Eighth impression 2012, Oxford University Press.
2. Power System Analysis Operation and Control, Abhijit Chakrabarti, Sunita Halder, Third Edition, 2010, PHI Learning Private Limited.

## EE 3004 ELECTROMAGNETIC FIELD Cr - 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the concept of different coordinate systems.
CO2. apply the different laws in Static Electric Field.
CO3. apply Maxwell's equation for both static and time varying fields.
CO4. derive the wave equation for lossless dielectric and determine Poynting vector.
CO5. determine Standing-Wave Ratio in plane wave for normal and oblique incidence.
CO6. calculate the parameters of transmission line.

**Prerequisites: Mathematics - II (MA 1004), Physics (PH 1007)**

**Module 1: Coordinate System and Vector Calculus**
Rectangular, Cylindrical and Spherical Coordinate Systems, Gradient, Divergence and Curl operation.
**Activity:** Coordinate Transformation, Application of Gradient, Divergence and Curl operation.

**Module 2: Static Electrical Field**
Coulomb's Law, Electric field intensity due to continuous line charge, surface charge and volume charge, method of images, Electric potential, equipotential surface , Gauss's law, Maxwell's Equation.
**Activity:** Application of Gauss's law, Maxwell's Equation, Boundary value problems, electric dipole.

**Module 3: Electric Field in Different Materials**
Continuity equation, Uniqueness Theorem, Poisson's and Laplace Equation.
**Activity:** Electric properties of materials, Conventional current, Conduction current.

**Module 4: Steady Magnetic Fields**
Magnetic scalar and vector potential, Energy stored in magnetic field, Magnetic forces, Biot-Savart's law, Ampere's circuital law.
**Activity:** Application of Ampere's circuital law and Biot-Savart's law, Boundary value problems.

**Module 5: Time Varying Fields**
Charged particle moving in a static magnetic field, Moving conductor in a static magnetic field, Faraday's law.
**Activity:** General case of induction, Displacement current, Application of Maxwell's equation.

**Module 6: Electromagnetic Waves and Transmission Line**
Helmholtz's wave equation, wave propagation in lossless dielectric, Plane wave in free space, Poynting vector, Reflection and Refraction in plane wave, normal and oblique incidence, Transmission-line equations.
**Activity:** Standing-Wave Ratio, Design of Transmission line.

**Text Books :**
1. Engineering Electromagnetic by W.H. Hayt & John A. Buck, 7$^{th}$ Edition TMH, 2006
2. Elements of Electromagnetic by M. N. O Sadiku, 4$^{th}$ Edition, Oxford, 2010.

**Reference Books :**
1. Electromagnetic waves and radiating Systems E.C Jordan & Balmin, 2$^{nd}$ Edition, PHI,2009
2. C. R. Paul, K.W. Whites, S. A. Nasor, Introduction to Electromagnetic Fields, 3$^{rd}$ Edition, TMH, 2011
3. Electromagnetic Field Theory by S. Salivahanan & S Karthie, Vikas Publisher 2016.
4. Electromagnetic Field Theory by Rohit Khurana, Vikas Publisher, 2015.

## EE 3006 ELECTRIC DRIVES AND CONTROL Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. learn the need of Electric Drives in the industry.
CO2. understand the various braking methods of electrical drives.
CO3. know the applications of different electric motors.
CO4. analyze the open loop and closed loop control techniques of different drives.
CO5. understand different speed control techniques for various industrial drives.
CO6. analyze the performance of Permanent Magnet Synchronous and Brushless DC motor drives.

**Prerequisites: DC Machines& Synchronous Machines (EE 2020), Transformers& Induction Motors (EE 2017), Power Electronics (EE 2026).**

**Module 1: Introduction**
Basic elements of an electric drive, Four quadrant operation of an electric drive, Dynamics of motor load combination, Types of loads, Stable operating condition of various motor load combinations, Fundamental load torque equation, Speed and current limit control, Load curve, load equalization, motor selection and rating calculations.

**Module 2: DC Motor Drives**
Review of characteristics of DC motors, Modification of characteristics of DC shunt and series motors, Concept of Electric Braking, Regenerative, Dynamic and Counter current braking of DC motors.
**Activity:** Demonstrate the state of art of Power Electronics and Drives in the perspective of various applications.

**Control of DC motor drives**
Open loop speed control, Closed loop Speed control, Closed loop speed and current control, Closed loop Torque control, Hysteresis controller, PI controller.

**Solid State Control of DC drive**
Chopper and rectifier based DC Separately excited motor and series motor drive control, four quadrant drive using dual converter.

**Activity:** Comparative analysis of various DC drive system with their characteristics, explanation with neat and suitable Schematic.

**Module 3: Induction Motor Drives**
Review of characteristics of three phase Induction motors, Modification of speed torque characteristics due to variation of stator voltage, Stator frequency and rotor resistance, Electric Braking of Induction Motors: Regenerative Braking, DC Dynamic braking and Plugging, Slip Power recovery.
**Activity:** Demonstration of various types of AC Drive system with specific application.

**Speed Control of Induction Motors:**
Control of IM by three phase AC-AC Voltage controller, PWM Voltage Source Inverter fed induction motor drives, Current source inverter fed induction motor drives, Comparison of VSI and CSI fed drives, slip compensation schemes, closed loop control (V/f control).
**Activity:** Modelling and design of a drive train system using digital circuit.

**Module 4: Synchronous and Brushless DC Motor Drives**
Synchronous motors, cylindrical rotor, salient pole synchronous motor, permanent magnet synchronous motor, synchronous reluctance motor, Transients due to load disturbances, Braking, Permanent magnet AC motor drives, Sinusoidal PMAC motor drives, Brushless DC motor Drives.
**Activity:** Industrial application of brushless DC Motor Drives.

**Text Books :**

1. G.K. Dubey, Fundamentals of Electric Drives, Second Edition, Narosa Publishers, 2007.
2. S. K. Pillai: A First Course On Electrical Drives, New Age International Publishers, 2nd Edition, 2007.

**Reference Books :**

1. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, Har/Cdr edition (13 September 2006).
2. N. K. De, P. K. Sen: Electric Drives, PHI Learning Pvt. Ltd., 7th Edition, 2004.
3. Modern Power Electronics and AC Drives by Bimal. K. Bose, PHI Publisher, 1st Edition, 2013.
4. S.A. Nasar, Boldea , Electrical Drives, CRC Press, Second Edition, 2006
5. M. A. El-Sharkawi , Fundamentals of Electrical Drives , Thomson Learning, 1st Edition, 2000.
6. R. Krishnan, Electrical Motor Drives, PHI, 2003

## EE 3007 POWER TRANSMISSION AND DISTRIBUTION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. describe different powers in power system.
CO2. evaluate the line constants in different configuration of overhead lines.
CO3. analyze the performance of transmission lines and underground cables..
CO4. describe different phenomenon of transmission line.
CO5. calculate the corona loss in transmission lines.
CO6. determine the current and voltage distribution in different distribution modules.

### Prerequisite: Electrical Circuit Analysis (EE 2015)

**Module 1:**
Introduction:
Single and 3-phase transmission, Concept of complex power, Per Unit system, Power System layout.

Supply System:
Comparison of AC and DC transmission, Advantage of high voltage transmission, Advantages and Disadvantages of EHV (AC) and HVDC Transmission.
Activity: Different types of topologies of HVDC transmission system.

**Module 2:**
Line constants:
Resistance, Inductance of Single phase and three phase line with symmetrical and unsymmetrical spacing, GMD and GMR calculation, Transposition of power line, Capacitance of Single phase line, Effect of earth on line capacitance, Charging current due to capacitance effect, Bundle conductors, Skin and Proximity effect.

**Performance of Transmission line:**
Analysis of short, medium and long Transmission Line, ABCD constants and its calculation for Short, Medium and Long Transmission Line, Ferranti effect, Surge Impedance and Surge Impedance Loading, Line compensators.

**Corona:**
Critical disruptive voltage, Visual critical voltage, Corona Power losses, Factors affecting corona, Advantages and Disadvantages of Corona, Problem Discussion, Radio Interference between power and communication line.

Activity: Line compensators, different types of FACTS Controllers, Radio Interference between power and communication line.

**Module 3:**
Mechanical Design of over head transmission lines:
Types of conductor and insulator, Insulating materials, Potential distribution over a string of suspension Insulators, String Efficiency, Methods of equalization of the potentials, Sag and Stress calculation, Effect of ice and wind loading, Vibration dampers.

**Underground Cable:**
Overhead line verses underground cables, Type and construction, Grading of cables, Insulation resistance of cable, Capacitance of three core cable, dielectric losses.

**Distribution Systems:**
Classification of distribution system, Types of AC and DC distributors, Feeder, Voltage drop and load calculation for concentrated and distributed loads, Radial and ring main system, Economic choice of conductor, Kelvin's law.
Activity- Properties and uses of Underground cable.

**Text Books :**
1. Electrical Power System, C.L. Wadhwa, New Age International (P) Limited, Publishers, 2009.
2. A Text Book on Power System Engineering, A. Chakrabarti, M.L. Soni, P.V. Gupta and U.S. Bhatnagar, Dhanpat Rai and Co., Reprint 2012.

**Reference Books :**
1. A Course in Power System, J. B. Gupta, S K Kataria and Sons Publishers and Distributors, 2011.
2. Power System Analysis and Design- By B. R. Gupta, S. Chand Publications, 3rd Edition, Reprint, 2003.
3. Principle of Power System by V.K.Mehta, S.Chand Publishers, 2012.
4. Elements of Power System Analysis, W.D. Stevenson Jr, TMH, 1982.
5. Overhead Power lines planning, design and construction, by F Kiessling, P Nefzger, J F Nolasco and U Kaintzyk, Springer- Verlag, 2003

## EE 3008 POWER SYSTEM PROTECTION Cr-3

**Course outcome :** At the end of the course, the students will be able to :

CO1. describe the need of protective devices in power system.
CO2. distinguish in different types of Circuit Breakers.
CO3. demonstrate the principle of operation of different relays.
CO4. realize the different scheme of protection for alternator, transformer.
CO5. understand the protection schemes of bus bar, feeder and transmission line.
CO6. know the protection against surges.

**Prerequisite: Generation, Transmission and Distribution of Electrical Power (EE 2024)**

**Module-1- Introduction:**
Protection system and its attributes, Philosophy of protection, requirement of ideal protective scheme, different terms in protective systems, Basic elements in protective scheme, Requirement of circuit breakers, characteristics of an electric arc, principle of AC and DC arc interruption, Recovery voltage, re-striking voltage, current chopping, resistance switching.

**Circuit Breakers:**
Types of AC and DC circuit breakers, Arc extinction methods, oil circuit breaker, air blast circuit breaker, vacuum and $SF_6$ circuit breaker, Principle of miniature circuit breaker and moulded case circuit breaker, determination of circuit breaker capacity, circuit breaker ratings.

**Protective Elements:**
Concept of Fuse, need, construction, principle, characteristics of H.R.C fuse.

**Earthing:**
Introduction, Methods of neutral grounding (solid earthing, resistance earthing and Peterson coil earthing and its effects on fault conditions), Construction, Principle of operations of Electromagnetic type, induction type: over current, directional, distance relays, Differential relay.
**Activity-**Bulk and minimum oil circuit breaker, control switch operation of circuit breaker, MCB, MCCB, RCCB, Relay characteristics.

**Module-2 - Alternator Protection:**
Different types of faults, differential protection with biasing, restricted earth fault protection, negative sequence protection, automatic field suppression and neutral circuit breakers.

**Transformer Protection:**
Buchholz relay, Biased differential protection, restricted earth fault protection, harmonic restraint, protection of combined alternator and transformer.

**Bus Bar Protection:** Differential scheme for both phase and line faults, introduction to digital protective relay and microprocessor based relays.
**Activity-** Frame leakage scheme of bus-bar protection, Fault detection in Alternator, Transformer, Bus bar using MATLAB.

**Module-3 - Feeder protection:**
Time graded protection: radial, parallel and ring feeders; over current and earth fault protection, calculation of graded time setting, split core protection of feeders, carrier current protection.

**Pilot Wire Protection:**
Circulating current differential protection (Merz-Price protection), Biased or percentage differential protection scheme, opposed (balanced) voltage differential protection system, Translay scheme; static relays.
**Protection against Surges:** Ground wire, Surge diverters: rod gap, horn gap lighting arresters, surge absorbers.
**Activity-**Introduction to microwave pilot system, arrangement of relay contacts, types of earthing and earthing impedance instruments.

**Text Books :**

1. Fundamentals of Power System Protection", Y. G. Paithankar, S. R. Bhide, 2nd edition, Prentice Hall of India Private Limited, New Delhi, 2011.
2. Power System Protection and Switchgear by B Rabindranath and M Chander , Wiley Eastern 2017, 2nd Edition.

**Reference Books :**

1. A Course in Power Systems, J. B. Gupta, S. K. Kataria and Sons Publishers and Distributors, 2009.
2. Principles of Relaying", Van Warrington, Y. G. Paithankar. TMH, 2009.
3. Power system Switchgear and Protection N.Veerappan and S R Krishnamurthy, S Chand Publication, Revised edition 2013.

4. Power system Protection and Switchgear, Badri Ram and D N Vishwakarma Tata McGraw Hill, 2nd reprint 2012
5. Electrical Power System, C.L. Wadhwa, New Age International (P) Limited, Publishers, 2009.

## EE 3011 POWER ELECTRONICS AND DRIVES Cr- 4

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the working principles of different power electronics devices.
CO2. analyze the concepts of single phase and three phase controlled rectifiers.
CO3. know the control techniques and operation of DC to DC and DC to AC converters.
CO4. choose a proper converter configuration suitable for industry.
CO5. understand the dynamics of electrical drives.
CO6. know the use of solid state devices for speed control of DC and AC electrical drives.

### Prerequisites: DC AC and Special Electrical Machines (EE 2011)

**Module 1: Power Switching Devices**
Introduction to Power Electronics, Thyristor characteristics , Turn ON methods, Dynamic Characteristics of thyristors, Thyristor Ratings- Average, RMS & surge ratings, Thyristor Protection. Characteristics & construction of Power MOSFETS, Comparison between Power MOSFET & Power BJT, Characteristics & construction of IGBT, Forward & Reverse Blocking Capability, Switching characteristics, Safe operating area, snubber protection, GTO – turn on and turn off methods, TRIAC and DIAC Characteristics and applications.

**Activity:** Comparison between power MOSFET and power BJT, TRIAC, DIAC characteristics and applications

**Module 2: AC to DC Converters**
Single Phase Converters – Half Wave, with R, RL load, Single Phase Converters – Half Wave, with RLE load, Single Phase Converters – Half Wave, with RL load & Free Wheeling diode, 1 Phase Full Wave converters with R & RLE Load, concept of Line Commutated Inverters, Single Phase Semi Converters, 3 Phase converters, Single Phase Dual converters.
**Activity:** Calculation of performance parameters of 1-phase and 3- phase AC to DC converters.

**Module 3: DC to DC Converters**
Step up & Step down choppers, Buck-Boost Converter, 4 Quadrant Choppers. Concept of Switch Mode Power Supply, Flyback Converter.
**Activity:** Four Quadrant Chopper with DC Motor Load.

**Module 4: DC to AC Converters (Inverters)**
Single Phase Half Bridge & Full Bridge Inverters, Sinusoidal Pulse Width Modulation.
**Activity:** Concept of current source inverter operation and control.

**Module 5: AC to AC Converters**
Single phase AC to AC phase control, with R and RL load.
**Activity:** Single phase bridge type cyclo-converter with R-L Load.

**Module 6: Electric Drives**
Basic elements of electric drives, 4 quadrant operation of electric drives. Review of characteristics of DC motors, and induction motors, Calculation of equivalent moment of inertia of a drive system and load equalization, Phase controlled and Chopper controlled DC drive, Control of Induction Motor by AC –AC Voltage controller, PWM Inverter fed induction motor drives, Concept of V/f control, Concept of Stepper motors and control, AC and DC servo motors.
**Activity:** Demonstrate the state of art of Power Electronics and Drives in the perspective of various applications.

**Text Books :**
1. Power Electronics by P. S. Bimbhra, Khanna Publishers, 4th edition, 2012
2. Fundamentals of Electric Drives by G K Dubey, Narosa Publishers, 2nd edition 2007.

**Reference Books :**

1. Power Electronics By M. H. Rashid, Pearson Education, 3rd Edition, 2014.
2. Power Electronics, Converters, Applications and Design N. Mohan, Undeland and Robbins, John Wiely and Sons , Third Edition, 2002.
3. Fundamental of Power Electronics by S K Bhattacharya, Vikas Publishing, 1st edition-2005.
4. S. K. Pillai: A First Course On Electrical Drives, Second Edition, New Age International Publishers 2007.
5. N. K. De, P. K. Sen: Electric Drives, 7th Edition, PHI Learning Pvt. Ltd., 2004.
6. Modern Power Electronics and AC Drives by Bimal. K. Bose, PHI Publisher, 1st Edition, 2013

## EE 3013 MICROPROCESSORS AND INTERFACING Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the building blocks of 8085 and 8086 Microprocessors.
CO2. write different assembly language programs in 8085 and 8086 microprocessors.
CO3. learn the architecture and programming of 8051 microcontroller.
CO4. understand the building of AVR microcontrollers.
CO5. analyze the different programs of AVR microcontrollers.
CO6. learn the different applications of microprocessor and microcontrollers.

**Prerequisite: Digital Circuits (EE 2018)**

**Module-1: 8085 & 8086 Microprocessors**
History of microprocessor, 8085 microprocessor architecture, machine cycles, T states, addressing modes of 8085, 8085 instruction sets, Development of 8085 assembly language programs, 8085 interrupts, Memory and I/O interfacing, 8086 microprocessor architecture, minimum and maximum mode configurations, 8086 addressing modes, 8086 instructions, 8086 assembly language programming.
**Activity:** SIM, RIM instructions of 8085, Time delay programming in 8085, I/O ports, 8255 PPI, Rotate, shift, branch, string instructions of 8086.

**Module-2: 8051 Microcontrollers**
Introduction, architecture of 8051 microcontroller, instruction-sets, 8051 assembly language programming,
**Activity:** Timers and counters of 8051, I/O ports of 8051.

**Module-3: AVR Microcontrollers**
Overview of AVR family, AVR Microcontroller architecture, Register, ATmega328 pin configuration & function of each pin, Addressing modes of AVR, Data transfer Arithmetic, Logic and Compare, AVR assembly language programs.
**Activity:** AVR status register; rotate and shift, branch and call instructions, AVR data types and assembler directives, AVR I/O Port Programming, basic AVR programming in C.

**Module-4: Industrial Application of Microprocessors and microcontrollers**
ADC, DAC interfacing, digital PID controller implementation using microcontroller, microcontroller based stepper motor control.
**Activity:** Microcontroller based PWM control of a DC Motor, Traffic light control, Sensor interfacing with microcontroller.

**Text Books :**

1. B. Ram, “Fundamentals of Microprocessors and Microcontrollers ", 7th Edition, Dhanpat Rai publications, 2010.
2. Muhammad Ali Mazidi, Sepehr Naimi,"Sarmad Naimithe AVR Microcontroller And Embedded Systems Using Assembly and C" Pearson Education, Inc, 2017.

**Reference Books :**

1. R. Theagarajan "Microprocessors and Microcontrollers"-1st Edition, SCITECH publications (India) Private limited, 2004.
2. Desmukh , "Microcontrollers –Theory and Application"- 1st Edition, TMH Publication, 2005.
3. A. P. Mathur, "Introduction to microprocessors" e-TMH Publication – 3rd edition, 2011
4. Md. Rafiquzzaman, "Microprocessors & Microcomputer based System Design",2nd edition,1995.

5. Prof. S. K. Venkat Rama, "Advanced Microprocessor & Microcontrollers" Laxmi Publications- 1st edition,2004.
6. Udayashankara & M Mallikarjunaswamy, "8051 Microcontroller - Hardware, Software & Applications "TMH – 1st edition,2009.
7. M. A. Mazidi, "The 8051 Microcontroller & Embedded Systems" Pearson – 2nd edition, 2011.

## EE 3015 DISCRETE SIGNAL PROCESSING Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand statistical analysis of various types of signals.
CO2. solve signals in discrete domain through convolution and correlation techniques.
CO3. determine the spectral coefficients and the Fourier series components of discrete-time signals.
CO4. calculate the frequency response and the Z-transform of discrete-time signals.
CO5. calculate discrete Fourier transform of Discrete-Time signals
CO6. design FIR and IIR Filters.

**Prerequisite: Signals and System (EE 2022)**

**Module-1:**
**Introduction:**

Terminology related to signals and systems, Analog and digital signals, signal processing (ASP and DSP), Advantages and Disadvantages of DSP.
**Activity:** Applications of DSP.

**Module-2:**

**Discrete time Signals & Systems:**
Discrete Time Signals and classification, Discrete Time Systems and classification, Operation on Discrete Time Signals, LTI systems Linear convolution sum and de-convolution, Properties of convolution, Applications of convolution, Interconnection of LTI systems, Correlation of two sequences and its Properties.

**Activity:** Graphical Method of Convolution by MATLAB.

**Module-3:**

**Discrete Fourier Transform:**
Introduction to Fourier Transform, Discrete Time Fourier Transform, DTFT of discrete time signal and its properties, Discrete Fourier Transform and its Properties, Inverse Discrete Fourier Transform, Circular convolution and its properties, Long duration sequences by digital filter method (Over-lap save and Over-lap add method).
**Activity:** Fast Fourier Transform and properties, DFT and IDFT and properties.

**Module-4:**

**Digital Filters:**
Introduction to Digital Filter, Design of IIR filter using Approximation of Derivatives method, Design of IIR filter using impulse invariance technique, Design of IIR filter using Bilinear transformation.

**Activity:** Design of FIR Filter using Rectangular window, Hamming window, Blackmann window, Kaiser Window and Bartlett window (Coding/Simulation).

**Text Books :**

1. Digital Signal Processing by T. K. Rawat, Oxford Publication 1st Edition
2. Signals & Systems: Alan V. Oppenheim & Schafer-2nd Edition 2011 Pearson, 1997.

**Reference Books :**

1. Digital Signal Processing – J.G.Proakis and D.G.Manolakis , 4th Edition-PHI,2014.
2. Principle of Signal Processing and Linear System: B. P. Lathi, First Edition, Oxford University Press.
3. Digital Signal Processing: P. Ramesh Babu: Scitech,
   4th Edition, 2009.

## EE 3016 POWER CARRIER COMMUNICATION SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to:

CO1. describe the importance of signal to noise ratio and properties of Fourier series transform in communication.
CO2. distinguish between analog and digital modulation techniques.
CO3. evaluate pulse modulation and demodulation technique.
CO4. analyze different digital modulation techniques.
CO5. demonstrate on the architecture of communication (Wide Area Network) Network in electric grid.
CO6 examine the basic techniques in wireless and wire line communication in electric grid.

**Prerequisite: Signals and System (EE 2022)**

**Module-1: Communication Signal properties**
Brief idea of mean, variance, noise and signal to noise ratio, Properties of Fourier transform and Fourier series.
**Activity**: Hilbert transform and its application.

**Module-2: Amplitude and Angle Modulation**
Principle of AM, Side Bands, Power Relationship, Assignable Frequency spectrum, Sideband Transmission, DSB, SSB, VSB, Balanced Modulation, Principle of FM, Frequency Deviation, Spectrum of FM wave, Power in Modulated Wave, Narrow band FM, Pre-emphasis, De-emphasis.
**Activity**: Block Diagram of FM transmitter, Reactance Modulator, Typical characteristics features.

**Module-3: Pulse Modulation and Demodulation**
Sampling Process, Pulse Amplitude Modulation, Time Division Multiplexing, Frequency Division Multiplexing the Quantization Process, Pulse Code Modulation.
**Activity**: Noise Consideration in PCM systems.

**Module-4: Digital Modulation**
Data Form, Principles involved in ASK, PSK (BPSK, QPSK,$\pi/4$ QPSK)
**Activity**: FSK.

**Module-5: Modern Communication in Electrical Grid**
Overview of network architecture, Wide area network, Standardization, Wireless personal area network, Wireless local area network, Satellite communication.
**Activity**: Co axial cable technology, Power line technology, Passive optical network.

**Text Books :**

1. Modern Digital And Analog Communication Systems by B P Lathi and Zhi Ding, Oxford publication, $4^{th}$ edition, 2017
2. Smart Grid Applications, Communications, and Security, by Lars T. Berger, Krzysztof Iniewski, John Willey publication 2012.

**Reference Books :**

1. Synchronized Phasor Measurements and Their Applications, by Arun G. Phadke and James S. Thorp, Springer international 2018.
2. The Smart Grid; Enabling Energy Efficiency and Demand Response, by Clark W. Gellings, CRC Press; $1^{st}$ edition (August 21, 2009).
3. Communication System, Simon Haykin, Wiley Publication; $4^{th}$edition (2006).

## EE 3017 RENEWABLE ENERGY SOURCES Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the need of renewable energy sources for future requirements globally.
CO2. reflect the concept of alternate energy sources.
CO3. demonstrate on various solar PV and thermal systems for energy efficiency.
CO4. analyze the scope of Geothermal and Ocean energy.
CO5. describe the process of extraction of power from wind and biomass energy.
CO6. study standalone Photovoltaic systems

**Prerequisite: Basic Electrical Engineering (EE 1003).**

**Module 1: Fundamentals of Energy**
Energy Consumption and standard of living, Classification of Energy Resources, Importance of Non-Conventional Energy Sources, Common Forms of Energy, Advantages and Disadvantages of Conventional energy Sources, Salient Features of Non-Conventional Energy Sources.
**Activity:** Environmental Aspects of Energy, World Energy Status, Energy Scenario in India

**Module 2 : Basics of Solar Energy, Solar Thermal and Photovoltaic Systems**
**Basics of Solar Energy**: Extraterrestrial and Terrestrial Radiations, Depletion of Solar Radiation, Solar Time, Solar Radiations Measurement.

**Solar Thermal Systems:** Solar Collectors, Solar Water Heater, Solar Passive Space – Heating and Cooling Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers, Solar Furnaces, Solar Green House, Solar Dryer, Solar Distillation.

**Solar Photovoltaic Systems:** Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell, Module, Panel and Array Construction, Maximizing the Solar PV Output and Load Matching, Maximum Power Point Tracker (MPPT).
**Activity:** Solar Thermo-Mechanical Systems, Balance of System Components, Solar PV Applications

**Module 3: Wind and Biomass energy**
**Wind Energy**: Origin of Winds, Nature of Winds, Wind Turbine Sitting, Major Application of Wind Power, Wind Turbine Types and Their Construction, Wind Energy Conversion Systems (WECS), Wind-Energy Storage, Wind – Energy.

**Biomass Energy**: Usable Forms of Biomass, their Composition and Fuel Properties, Biomass Resources, Biomass Conversion Technologies, Urban Waste to Energy Conversion, Biomass Gasification, Biomass Liquefaction, Biomass to Ethanol Production.
**Activity:** Various programmes on Wind energy and Biomass in India.

**Module 4: Geothermal and Ocean energy, Fuel cells**
**Geothermal Energy**: Applications, Origin, and Distribution of Geothermal Energy, Types of Geothermal Resources, Exploration and Development of Geothermal Resources, Geothermal Energy.

**Ocean Energy**: Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy, wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.
**Fuel cells:** Principle of working of various types of fuel cells and their working, performance and limitations, MHD (Magneto hydro dynamics) generation principles.
**Activity:** Applications and environmental impacts of Geothermal Energy, Ocean energy, Applications of Fuel cell.

**Text Books :**
1. B. H. Khan, "Non – Conventional Energy Resources" Tata Mc Graw Hill, 2nd edition 2009.
2. N. K. Bansal, Manfred Kleemann, Michael Meliss, "Renewable energy sources and conversion technology", Tata Mc Graw Hill, 1990.

**Reference Books :**


1. Kothari D.P., “Renewable energy resources and emerging technologies”, Prentice Hall of India Pvt. Ltd, 2006.
2. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, 4th Edition 2000.
3. Ashok V. Desai, "Nonconventional Energy", New Age International Publishers Ltd, Reprint 2003


## EE 3023 HIGH VOLTAGE ENGINEERING Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. describe the generation of high voltage and high current.
CO2. measure of high voltage and current.
CO3. test of high voltage electrical apparatus.
CO4. perform the Breakdown characteristics of different dielectrics.
CO5. reflect the effect of electromagnetic interference.
CO6. examine the scope of high voltage laboratory.

### Prerequisite: Electromagnetic Field (EE 3004)

**Module-1**

**Introduction:**

**Electric Field Strength (Electric Stress):** Levels of voltage Levels, Electrical Insulation and Dielectrics, Types of Electric Fields and Degree of Uniformity of Fields, Utilization of Dielectric Properties and Stress Control.

**Generation of High Voltage and Currents**:
Generation of High Voltage AC –By Tesla coil, Resonant Circuits and Cascade Transformers, Generation of High Voltage DC-voltage Double Circuits, Cockeroft Walton voltage multiplier circuit, Ripple voltage, voltage regulation, Van-de-Graff Generators, principle of series and shunt type voltage stabilizers, Generation of Impulse Voltage –Standard impulse wave shapes, Analysis of impulse Generator Circuit of series R-L-C type, Restriction on the ratio of the generator and load capacitances, Wave shape control, Multistage impulse Generators-Marx Circuit, Constructional details, tripping and synchronization, Generation of switching surge voltage, Generation of Impulse currents.

**Measurement of High Voltage and Currents:**
Measurement using Electrostatic voltmeters, Generating Voltmeters, Sphere gap, Potential Dividers, cathode Ray Oscilloscope, Peak reading A.C. Voltmeter-Chuub-Frotscue method.

**High Voltage Testing of Electrical Apparatus:**
Indian Standard Specification for DC, AC, Bushings, Isolators and Circuit Breakers, Cables Lighting Arrestor, Transformer.
**Activity-**Impulse and High frequency testing of Insulators, Introduction to Non-destructive testing materials and Electrical apparatus.

**Module-2**
**Conduction and Breakdown in Gases:**
Concept of Electrical stags, Ionization process, General Characteristics of Gaseous Insulation, Electrical Breakdown of gases, Townsend current growth Equation, Townsend’s criterion for breakdown, Experimental determination of ionization coefficients, Breakdown in Electronegative gases, Time lags for breakdown, Pashen’s law.
**Conduction and Breakdown in Liquid Dielectrics:**
Pure and Commercial Liquids, Conduction and Breakdown in Commercial liquids, Electronic, Cavitations and suspended particle theory.

**Breakdown in Solid Dielectrics:**
Intrinsic, Electromechanical, Thermal, Treeing and Tracking, Breakdown in composite dielectric.
**Activity-** Streamer theory of breakdown, Introduction to partial discharge phenomenon, lighting phenomenon.

**Module-3:**
**Operation of High Voltage Laboratories:**
Test facilities provided in High Voltage laboratories, Classification of High Voltage laboratories, Selection and rating of HV test equipment, Layout and Clearance, Shielding and grounding of high voltage Laboratories.

**Activity-** Introduction to the problem of Electromagnetic interference.

**Text Books :**

1. M. S. Naidu and V. Kamaraju, High voltage Engineering, Tata McGraw Hill, 1995.
2. J. Kuffel and W. S. Zaengl, High Voltage Engineering: Fundamentals, Newnes, 2000.

**Reference Books :**

1. C.L. Wadhwa : High Voltage Engineering, 2nd Edition, New Age International, 2007.
2. Ravindra Arora and Wolfgang Mosch: High Voltage Insulation Engineering, New Age International Publishers, 2011.

## EE 3024 PRINCIPLE OF INDUSTRIAL INSTRUMENTATION Cr-3

**Course Outcome :** At the end of the course, the students will able to :

CO1. describe the construction and working principle of different mechanical measurement systems.
CO2. explain transducers based measuring system using suitable calibration.
CO3. analyze instruments for gas analysis and liquid analysis.
CO4. examine the dynamic behavior (characteristics) of power plant instruments.
CO5. compare the operation of data logging systems, display methods and alarm annunciation.
CO6. know the application of telemetry system.

### Prerequisite: Electrical and Electronics Measurements (EE 2019)

**Module-1: Characteristics of Measurement system**
Functional units, classification and performance characteristics, dynamic calibration, Errors: An overview, statistical error analysis and reliability.
**Activity:** Case study of finding different measurement performance with sample reading data.

**Module-2: Pressure, Temperature and Flow Measurement**
Pressure Measurement by Electrical method, vacuum measurement, sound pressure level measurement, temperature measurement, Electrical type temperature sensor, Flow Measurement: Electrical type flow meters, open channel flow measurement, Level measurement: Hydrostatic type, thermal effect type, solid level measurement.
**Activity:** LVDT Characteristics and linearization, piezoelectric material modelling, eddy current transducers.

**Module-3: Instruments for Analysis**
Introduction, Gas Analysis, Different methods of gas analysis Liquid Analysers, X-ray method, Chromatography, Mass spectrography.
**Activity:** Linearizing electric bridge circuit for gas mixture conductivity measurement.

**Module-4: Telemetry**
Introduction, Pneumatic means, Frequency Telemetering Modulation, Modulation of Digital data, Transmission channels, Telemetry system in general.
**Activity:** High frequency amplitude modulation technique for communication.

**Module-5: Power Plant Instrumentation**
Introduction, Power plant scheme, Vibration and expansion, flue gas analysis, Turbine monitoring and control, Turbine measurements electrical, Mechanical and process parameters, Turbine control system, safety and process, Lubrication system for Turbo alternator, Turbo alternator cooling system.
**Activity:** Water treatment plant and water cycle in thermal power plant and monitoring.

**Module-6: Display, Recording, Alarm**
Introduction, Display methods, Alarm annunciation, Data logging system.
**Activity:** 8-bit LCD display unit calibration with temperature measurement.

**Text Books :**

1. Principle of Industrial Instrumentation, D Patranabis, Third Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2018.
2. Power Plant Instruments- K. Krishnaswamy, M. Ponnibala, PHI publication, 2009.

**Reference Books :**

1. Power plant engineering-P. K. Nag, Tata McGraw-Hill, 2010.
2. Electrical and Electronic Measurements and Instrumentation by R K Rajput, S Chand- 4th edition, 2015
3. Introduction to Instrumentation and Measurement, by Robert B. Northrop, 3rd Edition, CRC Press, 2014.

## EE 3027 ELECTRICAL ENGINEERING MATERIALS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO 1. compare in different dielectrics, insulators and conductors.
CO 2. examine the behavior of dielectric in AC fields.
CO 3. apply the dielectric properties of gases for various purposes.
CO 4. analyze the mechanism of semiconductor materials.
CO 5. demonstrate the various magnetic materials to find their suitability.
CO 6. examine the characteristics of conductors and their applications.

**Prerequisites: Basic Electrical Engineering (EE 1003) and Physics (PH 1003)**

**Module 1: Atoms and Aggregate of Atoms**
Introduction, crystallization of materials, Crystal symmetry and structure, Insulating materials: Dielectric properties of insulators in static fields, static dielectric constant, Polarization and dielectric constant, internal field in solid and liquids, static dielectric constant of solids, Spontaneous polarization, Piezoelectricity.

**Activity:**
The atomic interpretation of the dielectric constant of monoatomic gases, quantitative discussion of the dielectric constant of polyatomic molecules and gases.

**Module 2: Behavior of Dielectrics in Alternating Fields**
Frequency dependence of the electric polarization, Ionic polarization as function of frequency, the complex dielectric constant of non-polar solids, Dipolar relaxation, Dielectric losses.
**Activity:** Ferroelectric materials, properties, applications

**Module 3: Classification of Magnetic Materials**
Magnetic properties of Materials: Summary of concepts pertaining to magnetic fields, the magnetization from a microscopic view point, Lenz's Law and induced dipole moments, Magnetic dipole moment of a current loop, Orbital magnetic dipole moment and angular momentum of two simple atomic models, Diamagnetism, origin of permanent magnetic dipoles in matter, Paramagnetic spin system, Some properties of ferromagnetic materials, Spontaneous magnetization and the Curie-Weiss Law, Ferromagnetic domains and coercive force, Antiferromagnetic materials, Ferromagnetic materials, Semiconductors: Classifying materials as semiconductors.

**Activity:**
Density of carriers, intrinsic semiconductors, the energy gap, conductivity of intrinsic semiconductors, carrier densities in n-type semiconductors, P-type semiconductors, Hall effect and carrier density**.**

**Module 4: Conducting Materials**
General properties and specifications of pure copper and aluminum, factors affecting resistivity, Wiedemanm-Franz law, Materials and alloys for high conductivity, Characteristics of brass and different types of bronzes, Different types of solders, Metals and alloys for different types of fuses, fusing current and fuse ratings, Materials used for highly

loaded metal contacts, electrical carbon material, characteristics of different carbon and graphite brushes, Materials of high resistivity, alloys for use in electrical resistance, arc-lamps and electric furnaces, introduction to superconductivity.
**Activity:**
Nano materials: Introduction, synthesis and characterization, Description of basic energy carriers and nanostructures.

**Text Books :**

1. Electrical engineering Materials by R. K. Shukla & A. Singh, Tata Mc Grow-Hill Publishing Company Ltd, New Delhi, 2010.
2. A course in Electrical engineering Materials by R K Rajput, University Science Press, 2011.

**Reference Books :**

1. Electronic Properties of Materials, by Rolf E Hummel, Springer (India) Pvt Ltd, New Delhi,2010.
2. Electrical Engineering Materials, by A.J. Dekker, Prentice-Hall of India Pvt Ltd, New Delhi, 2009.
3. Material Science, by M.S. Vijay & G. Rangarajan, Tata McGrow-Hill Publishing Company Ltd New Delhi, 2011.

## EE 3028 POWER ELECTRONICS CIRCUITS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the working principles of different power electronics devices.
CO2. analyze the concepts of single phase and three phase controlled rectifiers.
CO3. understand the control of single phase and three phase Inverters.
CO4. compare different topologies of DC to DC converters.
CO5. know the performance of various single-phase AC to AC converters.
CO6. choose a proper converter configuration suitable for industry.

### Prerequisite: Analog Electronic Circuits (EE2013)

**Module 1 : Introduction to Power Electronics**
Comparison of power devices operating in the switch mode to those operating in the active region.
**Power Electronic Devices:**
Thyristor characteristics, Turn ON methods, Dynamic Characteristics of thyristors, Ratings, Protection, Two Transistor Model of thyristor, Characteristics and construction of Power MOSFETS, Comparison between Power MOSFET and Power BJT, Characteristics and construction of IGBT, GTO – turn on and turn off methods, SiC based power devices, TRIAC and DIAC Characteristics and applications.
**Activity:** Industrial applications of various power electronic devices.

**Module 2 : AC to DC Converters**
Single Phase Converters – Half Wave with R, RL, RLE load and effect of free Wheeling diode, Single Phase half and full controlled full Wave converters with R and RLE Load, Line Commutated Inverters, 3 Phase half and fully controlled rectifiers.
**Activity:** Effect of source Inductance on performance of single phase converters.

**Module 3: DC to DC Converters**
Step up and Step Down choppers, 2 and 4 quadrant choppers for control of DC motor.
**Switch Mode Power Supply SMPS :**
Advantage of Switch Mode Power Supply over Conventional Power Supply, Flyback converters.
**Activity:** Commutation in DC to DC Chopper.

**Module 4: Inverters**
Single Phase Half Bridge and Full Bridge Inverters, 3 Phase Inverters, 180° and $120^0$ conduction, Voltage Control of inverters, Sinusoidal Pulse Width Modulation, Concept of multi level inverters.
**Activity:** Concept of current source inverters.

**Module 5 :AC to AC Converters**
Single phase AC to AC Controllers with R and RL load, Single phase mid-point type Cycloconverters with R and RL load.
**Activity:** Single phase bridge type cyclo-converter with R-L Load.

**Text Books :**

1. Power Electronics By M. H. Rashid, Pearson Education, 3rd Edition, 2014.
2. Power Electronics by P S Bhimbhra, Khanna Publishers, 4th Edition, 2012.

**Reference Books :**

1. Power Electronics by M. D. Singh and K. B. Khanchandani, Tata McGraw-Hill publishers, Second Edition, 2007.
2. Power Electronics, Converters, Applications and Design N. Mohan, Undeland& Robbins, John Wiley and Sons, Third Edition, 2002.
3. Modern Power Electronics by P C Sen, S.Chand Publication 2013
4. Fundamental of Power Electronics by S K Bhattacharya, Vikas Publishing, 1st edition-2005.

## EE 3029 IoT FOR ELECTRICAL ENGINEERING Cr- 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. identify the components of IoT.
CO2. analyze various protocols of IoT.
CO3. apply internet of things in power sector.
CO4. examine schemes for the applications of IoT in home automation.
CO5. demonstrate embedded development platform.
CO6. create building blocks of Internet of Things and characteristics.

### Prerequisites: Digital circuit (EE 2018), Signals and System (EE 2022)

**Module 1: Introduction**
Definition, Components in internet of things, Sensing and Actuation Anywhere, Anytime, Genesis of the Internet of Things, Power Sources, Internet Principles, Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports.

**Activity:** Application Layer Protocols, Prototyping, Design thinking about prototyping, Sketching, Familiarity, Costs versus Ease of Prototyping, Prototypes and Production, Open Source versus Closed Source, Tapping into the Community.

**Module 2: The internet of things in the power sector**
Asset Performance Management, Operational Optimization, Comprehensive Customer Services and Experiences
**Activity:** The Internet of Things in the Power Sector in Asia.

**Module 3: Advanced Embedded Development Platforms**
System on Chip (SoC), ARM®, Raspberry Pi, Evolution of Pi and technical specification comparative study, GPIO Interfacing Cloud, Analytics & UI, Client Server Model, HTTP, Thingspeak, AWS, CloudMQTT.
**Activity:** Python programming for Digital I/O, I2C, SPI, UART, other platforms TI BeagleBone.

**Module 4: Home Automation**
Sensor based automated technologies, PIR Sensor, GSM module, Node MCU Module, Bluetooth module, Humidity sensor.
**Activity:** Automated home lighting system, automated home security system.

**Text Books :**

1. "Designing the Internet of Things", Adrian McEwen, Hakim Cassimally, Wiley publication, 1st Edition, November 2013.
2. The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, Ramamurthy, A. and Jain, P, 2017.

**Reference Books :**

1. "The Internet of Things: A Survey", Journal on Networks, Luigi Atzori, Antonio Lera, Giacomo Morabito, Elsevier Publications, October, 2010.
2. "The Internet of Things in the Cloud:A Middleware Perspective", Honbo Zhou, CRC Press-2012.
3. "Architecting the Internet of Things", Dieter Uckelmann, Mark Harrison, Springer, 2011.

## EE 3031 NEURAL NETWORK AND FUZZY LOGIC Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the basic model of Neural network.
CO2. examine the different types of Neural network and their learning rules.
CO3. demonstrate the feed forward neural network and application of BPA.
CO4. know the concept of unsupervised neural network and its application.
CO5. understand the concept of recurrent neural network and its application.
CO6. design a fuzzy logic controller for real world.

**Prerequisites: Engineering Mathematics - I (MA 1003) and Biology (LS 1001)**

**Module-1: Fundamentals of Artificial Neural Network**
Introduction, Biological Neuron model, Characteristics of ANN, Basic neuron model, Classification, Feed forward and Recurrent topologies, Activation functions, Types of Learning algorithms: Supervised, Un-supervised, Hebbian, Widrow-Hoff, Perceptron, Delta and winner-take-all learning rules, Regression Techniques**.**
**Activity:** Relation between biological neuron and artificial neuron, McCulloch-Pitts Model, Adaline, Madaline.

**Module-2: Feed forward Neural Network**
Perceptron representation, Linear inseparable problem, overcoming the linear inseparable problem, feed forward model, multilayer network model, back propagation learning methods, mathematical effect of learning rule co-efficient, back propagation algorithm (BPA), factors affecting back propagation training.
**Activity:** Learning difficulties and improvements, Application of back propagation algorithm.

**Module -3: Unsupervised Neural Network**
Introduction, Competitive Learning, Vector Quantization, clustering and classification, SOM learning algorithm, gross berg layer and its training, Adaptive Resonance Theory (ART), Instar, Outstar, ART1, ART2.
**Activity:** SOM and its properties, learning Vector Quantization and ART Applications, Radial Basis Function networks, counter propagation network.

**Recurrent Neural Network:**
Architecture of Hopfield Network, Recurrent network configuration, energy function, basic concept of dynamic system, Hopfield network algorithm, General Concepts of Associative Memory, Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms, Storage and Recall Algorithm, BAM Energy Function.
**Activity:** Discrete and Continuous versions, Storage and Recall Algorithm, Auto associative memory, Energy function reduction, stability of associative memory.

**Module -4: Fuzzy Logic**
Basic concept of fuzzy logic, Crisp set, Fuzzy set, crisp and fuzzy relation, crisp and fuzzy logic, Fuzzyfication, membership function, linguistic variable, universe of discourse, interference in fuzzy logic, fuzzy If-Then rule, defuzzyfication methods, fuzzy controller and applications.

**Activity:** Membership value assignment, development of rule based and decision making system, Representation and operation of type-2 fuzzy set, Fuzzy logic control application to load frequency control.

**Text Books :**

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai- PHI Publication. 2011
2. Introduction to Artificial Neural Systems- Jacek M.Zurada, Jaico Publishing House, 1997.

**Reference Books :**


1. Neural and Fuzzy Systems: Foundation, Architectures and Applications, – N. Yadaiah and S. Bapi Raju, Pearson Education
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications,” McGraw Hill, 1995.
3. B.Yegnanarayana, “Artificial Neural Networks,” PHI, India, 2006.


## EE 3033 ENERGY CONSERVATION TECHNIQUES Cr-3

**Course Outcome** : At the end of the course, the students will be able to :

CO1. understand various data analysis methodologies.
CO2. demonstrate the concept of energy conservation and audit.
CO3. apply the energy policies and understand its impact.
CO4. analyze combined heating and power system.
CO5. describe various applications and types of energy audit.
CO6. prepare energy audit report of a system.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module 1: Energy Scenario**
Introduction, world energy sources and their classification (Coal, oil natural gas), energy security, energy intensity, need for energy sector reforms in India, energy planning, utilization patterns, strategy for meeting future energy requirements, energy conservation acts 2001, role of energy manager under energy conservation acts.
**Activity:** Global scenario for non renewable energy sources, global scenario for renewable energy sources, Indian scenario for non renewable and renewable energy sources.

**Module 2: Energy Conservation**
Introduction, energy conservation verses energy efficiency, important of energy conservation, principles, planning, conservation of electrical energy, thermal energy, and human and animal mussel energy.
**Activity:** Energy conservation in various industry pumps, fans, boilers, refrigerator and air conditioning system.

**Module 3: Energy policy**
Energy policy: Introduction, energy policy for India, policy for conventional and non-conventional energy, availability of global energy sources, needs and cost benefits of energy sources, conflicting goals and decisions under uncertainty for energy.
Cogeneration:
Introduction, need for cogeneration, advantages, factor governing, classification of cogeneration system. Topping cycle, bottoming cycle, selection criteria for cogeneration, gas turbine, steam turbine and diesel engine cogeneration.
**Activity:** Energy technology assessment, control strategy for co-generation and performance comparison.

**Module 4: Electrical Energy and Energy Management**
Electrical Energy: Demand control, demand side management, power factor, load factor, demand factor, power factor correction and equipments, incentives for power factor improvement, load scheduling, load shifting load shedding, motor drives, motor efficiency and testing, power loss for motors, improvement of motor efficiency, energy efficient motors, conventional verses energy efficient motor, selection of motors for home appliances, motor speed control, adjustable ac drives and their applications. Electricity acts 2003.
Building energy management: Thermal performance of building, factors affecting thermal performance of building and its evaluation process, cooling load temperature difference, and cooling load factor, energy analysis of existing building.
**Activity:** Energy efficient lighting: terminology, types of lamps, lighting levels for various applications, lighting audit, guideline for energy efficiency in lighting.

**Text Books :**


1. Energy conservation and management, S.S Thipse, alpha science publication, 2014

2. Industrial Energy management; principle and applications, Glovanin and Petrecca, The Kluwer international series-2007.

**Reference Books :**

1. Guide to electric load management by Anthony J. Pansini, Kenneth D. Smalling, pennwell publication,1998.
2. Energy efficient electric motors and their applications, Howard E Jordan, Plenum Publication 1994
3. Energy management Hand book, Turner Wayne C Lillbun, The Fairmont press 2001

## EE 3035 ENERGY STORAGE TECHNOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. describe application of different energy storage systems.
CO2. understand the performance of different types of energy storage device.
CO3. analyze the principle of different types of fuel cell.
CO4. understand different types of battery technology.
CO5. solve the state of charge of batteries using different techniques.
CO6. know super capacitor, green house heating.

### Pre-requisite : Chemistry (CH 1007)

**Module 1: Introduction**
Energy availability, Demand and storage, Need for energy storage, Different types of energy storage; Mechanical, Chemical, Electrical, Electrochemical, Biological, Magnetic, Electromagnetic, Thermal, Comparison of energy storage technologies.
**Activity:** Different types of storage technologies and its applications.

**Module 2: Mechanical, Thermal Energy Storage**
Flywheel storage, Hydro storage, Capacitor, Principles and applications, Thermal energy storage, principles and applications, Phase change materials; Energy analysis of thermal energy storage, solar energy and thermal energy storage.
**Activity: Design** of super-capacitor.

**Module 3: Electrochemical Energy Storage**
Electrochemical energy storage: Battery fundamentals and technologies, characteristics and performance comparison of Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries, Voltages and Capacities of Electro-chemical Cells, Equivalent Circuit of an Electrochemical Cell, Charging and discharging operation of batteries, State-of-charge (SOC) of batteries, battery management systems.
**Activity:** Design of battery management systems for Solar PV systems and Electrical Vehicles.

**Module 4: Fuel Cells**
Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principles; Fuel cell types: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance; Fuel cell applications for power and transportation.
Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage: Greenhouse heating; Drying and heating for process industries.
**Activity:** Analyze different manufacturers and applications of commercially available fuel cells.

**Text Books :**

1. Huggins R. A., Energy Storage: Fundamentals, Materials and Applications, second edition, Springer International Publishing, 2015.
2. Dincer I., and Rosen M. A., Thermal Energy Storage: Systems and Applications, second edition, Wiley, 2011.

**Reference Books :**

1. Fuel Cell Fundamentals, O'Hayre R., Cha S., Colella W., and Prinz F. B., Wiley, Second Edition, 2009.

2. Chemical and Electrochemical Energy System, Narayan R. and Viswanathan B., Universities Press, (1998).
3. Battery Systems Engineering, Rahn C. D. and Wang C., First Edition, Wiley, 2013.
4. Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Moseley P. T., and Garche J., Elsevier Science, 2014.
5. Compressed Air Energy Storage, Miller F. P., Vandome A. F., and John M. B., VDM Publishing, 2010.

## EE 3036 DISCRETE AND NON LINEAR CONTROL THEORY CR-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand state space modeling.
CO2. check controllability and observability of the system and design state feedback observer.
CO3. know about discretization process.
CO4. analyze the stability of discrete time control system.
CO5. study the nonlinear behaviour of system by phase plane and describing function method.
CO6. carry out stability analysis of nonlinear control system

### Prerequisite: Linear Control System (EE 2028)

**Module-1:**
**State Space and State Solution:**
Transfer Function Decomposition, Controllable Canonical Form, Observable Canonical Form, Cascade Form, Parallel Form, Non Uniqueness of State Model, Diagonalization: Similarity Transformation, State Solution, Concept of Controllability, Kalman and Gilbert Test, Stability, Concept of Observability: Kalman and Gilbert Test, Pole assignment by state feedback using Ackermann's formula**.**
**Activity:** State space modelling of different physical systems.

**Observability and Stability:**
Duality between controllability and observability - Full order Observer based controller design. Reduced order observer design. Observability and observable canonical form - Design of full order observer using Ackermann's formula, Stability of a system.
**Activity:** Observer design of a practical system.

**Module-2:**
**Discrete Time Control Systems:**
Sampled Data Control Systems, Principle of Discretization: Impulse, Step Invariance Methods, Bilinear Transformation, Pulse transfer function, Relationship between s-plane and z-plane. Stability : Routh Hurwitz in Discrete Domain and Jury's Test.
**Activity:** Transient and steady state response analysis, design of control system in z plane.

**Module-3:**
**Nonlinear control system:**
Introduction, Difference between linear and nonlinear system, Common physical nonlinearities, the phase plane method: Basic concepts, Singular points, Limit cycle and Jump resonance, Construction of phase trajectories, The describing function method: basic concepts, derivation of describing function, stability of nonlinear system using Lyapunov technique.
**Activity:** Finding describing function of different non linear systems.

**Text Books :**
1. Advanced Control System, by B. N. Sarkar, PHI Learning, 2013
2. Control System Engg, by I.J. Nagrath and M Gopal, New age international publication, 2007.

**Reference Books :**
1. Digital Control and State Variable Methods, M. Gopal, TMH Publishers, 2012.
2. Discrete time control systems by K. Ogata (PHI), 2015.
3. Automatic Control Systems by Benjamin C Kuo, Prentice-Hall, 1991.
4. Modern Control Engg. by K. Ogata PHI publication, 2010.
5. Control systems Engineering by R. Ananda Natarajan and P. Ramesh Babu (SCITECH), 2010.

## EE 3037 POWER QUALITY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. familiar with different terminology of power quality as per IEEE standard.
CO2. describe different power quality issues.
CO3. calculate harmonics distortion for voltage and current signals for IEEE 6 Bus system.
CO4. analyze the effects of harmonics in power quality.
CO5. know various constraints for power quality mitigation.
CO6. examine compensation techniques during power system problems.

**Prerequisites: Generation Transmission and Distribution of Electrical Power (EE 2024), Power Electronics (EE-2026)**

**Module 1:**
**Introduction:**
Importance of Power Quality (PQ), terminology of PQ as per IEEE std. 1159 transients, short and long duration voltage variations, interruptions, Short and long voltage fluctuation, imbalance, flicker and transients, Symptoms of poor power quality.
**Activity:** Study of earthing in residential building, power plants, substation.

**Module 2:**
**Flicker & Transient over voltages:**
RMS voltage variations in power system and voltage regulation per unit system, complex power, Principles of voltage regulation, Basic power flow and voltage drop various devices used for voltage regulation and impact of reactive power management, various causes of voltage flicker and their effects, Short term and long term flicker.

**Voltage Sag, Swells and Interruption:**
Voltage sags versus interruptions, Economic impact of voltage sag, Areas of vulnerability, Assessment of equipment sensitivity to voltage sags

**Harmonics:**
Definitions of harmonics, causes and effect of harmonics, Triple harmonics, characteristics and non characteristics harmonics, harmonic series and parallel resonances, Consequences of harmonic resonance, Principles for controlling harmonics, Definitions of various powers, power factor under balanced, unbalanced and non-sinusoidal conditions.
**Activity:** Using MATLAB simulink model calculate harmonic distortion for voltage and current signal for IEEE 6 bus system by connecting 6 pulse converter, Simulation of voltage sags, Swell, CBEMA, ITIC, SEMI F 42 curves

**Module 3:**
**Power Quality Monitoring:**
Need of PQ monitoring and approaches followed in PQ monitoring, PQ monitoring objectives and requirement, Theories of load compensation, Introduction to custom power devices and their applications in power system. Power quality instrumentation, Selection of power quality monitors, Selection of monitoring location and period.
**Activity:** Detailed modeling, analysis and design aspects of custom power devices (DSTATCOM, DVR).

**Text Books :**

1. Electric Power Quality by Heydt, G T, Stars in circle Publications, Indiana 2nd edition-1994.
2. Electrical Power system Quality, by RC dugan, MF Mcgranaghan, S Santoso and H W Beaty, 2nd Edition TMH publication-2008.


**Reference Books :**

1. Arrillaga J and Watsone RN, Chen S, Power Quality Assessment, Wiley New York 2000
2. Bollen MHJ, Understanding Power Quality Problems; Voltage sag and instrumentations, IEEE press NY 2000 Power Quality C Sankaran CRC press

## EE 3038 UTILIZATION OF ELECTRICAL POWER Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. describe in applications of different motors.
CO2 . demonstrate on electric tariff.
CO3 . examine the characteristics and intensity of lightning systems for different types of lamps.
CO4 . analyze various electrolytic processes.
CO5. know the Process of different kinds of electric heating and electric welding.
CO6. know the application of different lamps.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module 1:**
**Motor power rating and selection:**
General considerations in selecting motor power rating, Selection of motor capacity for continuous duty, Equivalent current, torque and power methods, Selection of capacity for short term and intermittent periodic duty.
**Electric Tariff:**
Classification of costs, Formulation of Electric Tariff, Various kinds of Tariff, Economics of Generation, Load duration curve, Base load and peak load plants, Effect of Load Factor, diversity Factor and power factor on tariff.
**Activity:** Heating and cooling of motors, load equalization, fly wheel equalization, power factor improvement.

**Module 2:**
**Electric Heating and Welding:**
Advantages of electrical heating, Design of heating elements, Heating methods, Resistance Heating, Induction Heating, Dielectric Heating, Resistance furnace, Causes of failure of heating elements, Temperature control of resistance furnace, Arc furnace, Advantages of electric welding, Welding methods: Resistance welding, Electric arc welding, Atomic hydrogen welding, Modern welding techniques: Ultrasonic and Laser welding.
**Activity:** Generation of Dielectric heat, Dielectric heating principle, Comparison between dielectric and induction heating, Welding Accessories.

**Module 3:**
**Illumination:**
Introduction, terminology in illumination: luminous flux, luminous intensity, lumen candela power, illumination lux, lamp efficiency, Brightness glare, Space height ratio, Polar curve, Laws of illumination, Co-efficient of utilization, Maintenance factor, Depreciation factor, Solid Angle, Types of Lamps: Arc Lamp, Incandescent lamp, Sodium vapor lamp, Mercury Vapor Lamp, Fluorescent Lamp, Neon Lamp, Types of Lighting Scheme, Flood Lightning, Street lightning, Compact Lighting Characteristics.
**Activity:** Compact Fluorescent Lamp (CFL), Light Emitting Diode (LED), Design of choke and capacitor.
**Module 4**
**Electrolytic Processes:**
Fundamental principles, Faradays law of electrolysis, Extraction and refining of metals, Electro deposition.
**Activity:** Manufacture of chemicals, Power supply for electrolytic purposes, Electroplating, Anodizing.

**Text Books :**
1. Generation, Distribution and Utilization of Electrical Power by C.L. Wadhwa, Wiley Eastern Ltd, New Delhi, 2006.
2. Utilization of Electrical Power and Electric Traction by J B Gupta, S K Kataria and Sons, Delhi, 2011.

**Reference Books :**
1. Art & Science of Utilization of Electrical Energy by H. Pratab, Dhanpat Rai & Co.(P) Ltd. 2013.
2. Utilization of Electric power by Er. R K Rajput, Lakshmi publications Pvt. Ltd, 1st Edition 2006.
3. Electrical Technology volume – III, by B L Thereja, A.K Thereja, S Chand Publisher – 2013.

## EE 3039 PROGRAMMABLE LOGIC CONTROLLERS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. compare conventional sequential control with programmable logic control system
CO2. develop programs using different PLC programming languages for sequential and continuous process
CO3. interface analog and digital input/ output devices with PLC using different communication protocol
CO4. demonstrate on the PLC based system and troubleshoot the errors associated with it.
CO5. interface the HMI for industrial automation
CO6. develop the ladder diagram of process control for industrial automation

### Prerequisites: Digital Circuits (EE 2018), Signals and System (EE 2022)

**Module 1: INTRODUCTION TO FACTORY & PROCESS AUTOMATION**
Industrial Versions: Control elements of Industrial Automation, IEC/ISA Standards for Control Elements, Selection criteria for control elements, various input /output devices and its interfacing with PLC, Different types of Input devices.
**Switches:** Push button Switches, Toggle Switches, Proximity switches, Temperature Switch, Pressure Switch, and Level Switch.
**Activity:** Analysis of different types of relays and contactors (Industrial use).

**Module 2: PROGRAMMABLE LOGIC CONTROLLERS**
Architecture of PLC : Types of PLC , PLC modules, PLC Configuration PLC Hardware Components, The I/O section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O specifications, The CPU, Memory design, Memory Types, Programming Devices, Selection criteria for PLC, PLC Communication with PC and software , PLC Wiring – Installation of PLC and its modules.
**Activity:** Layout diagram of PLC by drawing sheet.

**Module 3: PROGRAMMING OF PLC**
Types of Programming, Construction of Relay, Ladder logic with different control elements, Need for PLC, PLC evolution, Bit Instructions, Timers and counters: ON delay timer instruction, Off-Delay timer instruction, Retentive Timer, Counter Instructions, Up-counter, down counter, Up-Down counter, Cascading counters, High Speed Counter, Incremental encoder, counter applications, Combining counter and timer functions, PLC arithmetic functions, PWM generation, Analog Scaling – Encoder Interfacing – Servo drive control, Stepper Motor Control.
**Activity:** Ladder diagram incorporating timer and counter using SIEMENS PLC.

**Module 4: HMI SYSTEMS AND NETWORKING**
Need for HMI in Industrial Automation, Types of HMI, Configuration of HMI, Screen development and navigation. Configuration of HMI elements /objects and Interfacing with PLC, PLC Networking – Networking standards & IEEE Standard, Protocols, Field bus, Process bus and Ethemet - CAN Open.
**Applications of PLC:** Case studies of manufacturing automation and Process automation.
**Activity:** Uses of HMI.

**Text Books :**

1. Programmable logic controller by Frank D. Petrusella, Tata McGraw-Hill publication.
2. Programmable Logic Controllers by W. Bolton, Elsevier Newnes publication.

**Reference Books :**

1. John R Hackworth and Fredrick D Hackworth Jr., “Programmable logic controllers: Programming Methods and Applications”, Pearson Education, 2006.
2. SIMATIC Programming with STEP 7, SIEMENS Manual, 2014.
3. Introduction to programmable logic controller by Gary dunning, Thomson Asia Pte Ltd.
4. Programmable Controllers An engineer’s guide by E.A.Parr, Elsevier Newnes publication.

## EE 3041 ELECTRICAL HAZARDS AND SAFETY Cr-3

**Course outcome** : At the end of the course, the students will be able to :

CO1. understand the effects and control of electrical hazards.
CO2. describe in the effects of industrial hazards.
CO3. apply different techniques to protect from electrical hazards.
CO4. select appropriate safety method for low, medium and high voltage equipment.
CO5. know the safety program structure and rescue techniques from electrical hazards.
CO6. apply the maintenance policy to electrical equipment based on standard procedure to avoid hazards.

### Prerequisite: Basic Electrical Engineering (EE 1003)

#### Module 1: Electrical Hazards

**Industrial Hazards:** Introduction, classification of hazards, Hazards management program (recognition, evaluation and control), Major industrial hazard.
**Electrical hazards:** Primary and secondary hazards, arc, blast, shocks-causes and effects-safety equipment, flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags.
**Activity:** Major industrial hazard, locking devices, voltage measuring instruments, proximity and contact testers, safety electrical one line diagram, safety kit of electricians.

#### Module 2: Grounding Techniques

General requirements for grounding and bonding, definitions, grounding of electrical equipment bonding of electrically conducting materials and other equipment, connection of grounding and bonding equipment, system grounding- purpose of system grounding, grounding electrode system, grounding conductor connection to electrodes, use of grounded circuit conductor for grounding equipment, Indian standards(IS2310).
**Activity:** Grounding of low voltage and high voltage systems.

#### Module 3: Safety Methods

The six step safety methods, pre job briefings, hot-work decision tree-safe switching of power system, lockout, tagout, flash hazard calculation and approach distances- calculating the required level of arc protection, safety equipment, procedure for low, medium and high voltage systems.
**Activity:** Preparation of safety audit.

#### Module 4: Safety Program and Policy implementation

Electrical safety program structure, development, company safety team, safety policy program implementation, employee electrical safety teams, safety audit accident prevention.
**Activity:** Safety meetings, first aid, rescue techniques, accident investigation.

#### Module 5: Safety related maintenance

Safety related case for electrical maintenance, reliability centered maintenance (RCM), eight step maintenance program, frequency of maintenance, maintenance requirement for specific equipment and location, regulatory bodies, national electrical safety code, standard for electrical safety in work place.

**Activity:** Occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.

**Text Books :**


1. 'Electrical Safety Handbook', John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, McGraw-Hill Education, 4thEdition, 2012.
2. 'Electrical Safety- a guide to the causes and prevention of electric hazards', Maxwell Adams. J, The Institution of Electric Engineers, IET 1994.

**Reference Books :**

1. Electrical Safety in the Workplace', Ray A. Jones, Jane G. Jones, Jones & Bartlett Learning, 2000.
2. Industrial safety and environment by Amit Gupta, Lakshmi publication private limited, 2006.
3. Handbooks of electrical Hazards and accidents by Leslie A Geddes, CRC press, 1995.
4. Risk reduction methods for occupational safety and health, by Roger C. Jensen, John wiley and sons, 2012.

## EE 3042 PRINCIPLES OF ENERGY CONVERSION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the principle of operation of different electrical machines.
CO2. understand the applications of different electrical machines.
CO3. analyze the performance characteristics of DC machines.
CO4. control the speed of a three phase induction motor for different applications.
CO5. develop the equivalent circuit of 3 phase induction motor.
CO6. describe on the starting methods of DC motors and induction motors.

**Prerequisite: Basic Electrical Engineering (EE 1003)**

**Module 1: Electromechanical Energy Conversion:**
Principle, Singly Excited Magnetic System and Doubly Excited Magnetic system, Physical concept of torque production, Electromagnetic torque and Reluctance torque.

**DC Machines:**
DC Generator: EMF equation of dc generator, methods of excitation, armature reaction, interpoles and compensating winding, commutation, characteristics of separately excited and self excited dc generator, losses, condition for maximum efficiency. DC Motor: Working principle, voltage equation, condition for maximum power, characteristics, operating characteristics of dc motor, torque developed, speed control methods.
**Activity:** Construction features of DC Machines, 3 point and 4 point starter.

**Module 2:Transformers**
Single Phase Transformer: Working principle, types, EMF equation, Transformer on no load and full load, vector diagram, exact and approximate equivalent circuit, O.C and S.C.test on transformer, Voltage regulation of transformer, losses and efficiency, condition for maximum efficiency, Auto transformer, 3 Phase transformers: connections(Y-Y, Y-Δ, Δ- Δ, Δ-Y).
**Activity:**
Construction of a single phase Auto transformer and Three phase transformer

**Module 3: 3 Phase induction motor**
Types, rotating magnetic field, principle of operation, slip, frequency of rotor current, rotor emf, rotor current, vector diagram and equivalent circuit, expression for torque, conditions for maximum torque, torque slip characteristics, starting torque in squirrel cage and slip ring motors, effect of change in supply voltage on torque, slip and speed , relation between full load torque and maximum torque, Power stages in induction motor, starting methods for 3 phase induction motor.
**Activity:** Construction and speed control of three phase Induction motor.

**Module 4: Synchronous Machine**
Alternator: Basic principle, pitch factor, distribution factor, emf equation, alternator on load, voltage regulation: Synchronous impedance method. Synchronous motor: Basic principle.
**Activity:** Construction of three phase synchronous machine, methods of starting, application.

**Text Books :**

1. Electrical Machines, Ashfaq Hussain, Dhanpat Rai, Delhi, 2nd Edition, 2008.
2. Electrical Machinery, P. S Bimbhra, 7th Edition, Khanna Publishers, 2008.

**Reference Books :**

1. Principles of Electrical power systems by J. B. Gupta
2. Text book of Electrical Machine by K R Sidhapura and D B Raval, Vikash, 1st edition, 2013.

## EE 3043 INVERTER AND SMPS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. Know various topologies of non-isolated DC-DC converters.
CO2. design the components of DC-DC Converters.
CO3. understand the operation of isolated DC-DC converter topologies.
CO4. model the isolated type DC-DC converters.
CO5. realize the operation and control of inverter and multilevel inverter topologies.
CO6. demonstrate on inverters in UPS system and dc-dc converter in battery charging system.

### Prerequisite: Power Electronics (EE 2026)

**Module 1: DC-DC converter**
DC-DC converter topology, Non isolated DC-DC converter: Buck, Boost, Buck-Boost, Cuk converter, Control topology: Time-Ratio control, Feedback control (Current-Limit Control), Effect of ESR on output voltage.
**Activity:** Estimation of inductor and capacitor value based on ripple analysis of the DC - DC converter.

**Module 2: Isolated DC-DC converter**
Fly-back converter, forward converter, bridge converter (Half & Full), Average modeling of converters, small signal analysis (state-space form) to determine control to output transfer function for the converters.
**Activity:** Modeling of Push Pull Converter

**Module 3: Inverter (DC-AC Converter)**
Single phase inverter and its control strategies to regulate the output voltage and frequency, Three phase inverter, 180 degree and 120 degree conduction, Sinusoidal unipolar and bipolar control technique.
**Activity:** Selective Harmonic Elimination Technique (SHE), Space Vector Modulation Techniques.

**Module 4: Introduction to multilevel inverter**
Cascaded type, diode-clamped and Capacitor clamped multilevel inverter. Control of cascaded multi level inverter: Phase - shifting, Level-shifting, On-line and Off-line UPS system. Charging Station for battery used for Electric Vehicle (EV).
**Activity:** Design and fabricate fast charging circuit for battery and EV.

**Text Books:**
1. Power Electronics: Circuits, Devices and Applications by M H Rashid, 3rd Edition, 2015, Pearson Education Power Electronics by MD Singh, K.B. Khanchandani, 2nd Edition, 2011, TMH Education Private Limited.
2. Elements of Power Electronics by Philip T. Krein, 2nd Edition, 2016, OXFORD University Press.

**Reference Books:**
1. Power Electronics: Converters, Application and Design by Mohan, Undeland, Riobbins, John Wiley and Sons, 3rd Edition, 2012.
2. Power Electronics by MD Singh, K.B. Khanchandani, TMH Education Private Limited, 2nd Edition, 2011.

## EE 3046 SOLAR POWER TECHNOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the need of solar energy technology.
CO2. describe operations of alternate energy sources.
CO3. apply the principle of solar thermal system for domestic applications.
CO4. analyze the various approaches of utilizing solar energy.
CO5. analyze power conditioning and MPPT operation.
CO6. understand standalone and grid connected PV system.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module 1: Introduction**
Basics of solar energy, Brief History of solar energy utilization, various approaches of utilizing solar energy, Blackbody radiation, Relation between radiation field energy density and radiation spectrum, Planck's formula in energy unit, Maximum spectral density, Planck's formula in wavelength unit, Wien displacement law, Stefan Boltzmann law, Photoelectric effect, Einstein's theory of photons.
**Activity:** Einstein's derivation of the black-body formula.

**Module 2: Solar Cells**
Formation of a p-n junction, Space charge and internal field, Quasi - Fermi levels, The Shockley diode equation - Structure of a solar cell, The solar cell equation, Fill factor and maximum power, Various electron, hole-pair recombination mechanisms.
**Activity:** Crystalline silicon solar cells, Thin film solar cells, organic solar cells**.**

**Module 3: Solar Photovoltaic System**
Solar PV modules from solar cells, Balance of solar PV system, Inverters (DC/DC, DC/AC), Power conditioning, Maximum power point operation Balance of System (BOS) for PV module installation, Concentrated solar power (CSP) systems.
**Activity:** Standalone PV system design, Grid-connected PV system.

**Module 4: Solar thermal systems**
Solar Collectors, Solar Water Heater, Solar Passive Space – Heating and Cooling Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers, Solar Furnaces, Solar Green House, Solar Dryer, Solar Distillation.
**Activity:** Solar Thermo-Mechanical Systems, Balance of System Components.

**Text Books :**
1. Solar Photovoltaics, fundamentals Technoloies and Applications, by Chetan Singh Solanki, PHI, 2nd edition 2012
2. Jui Sheng Hsieh, Solar Energy Engineering, Prentice-Hall, 2007.

**Reference Books :**
1. Micheal Boxwell , "Solar Electricity Handbook", Green Stream publishing (2010).
2. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, 4th Edition 2000.
3. Kothari D.P., "Renewable energy resources and emerging technologies", Prentice Hall of India Pvt. Ltd,2006.

## EE 3048 HVDC AND FACTS Cr- 3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the need of HVDC transmission systems
CO2 describe the control of HVDC transmission systems.
CO3. analyze the converter faults in HVDC transmission systems.
CO4. analyze the harmonic generation and elimination.
CO5. describe the application of FACTS devices in power system.
CO6. understand shunt and series compensation in a transmission system.

### Prerequisites: Generation, Transmission and Distribution of Electric Power (EE 2024), Power Electronics (EE 2026)

**Module 1: HVDC Transmission**
Introduction, Application of HVDC transmission, Choice of converter configuration, Converter bridge characteristics, Analysis of a twelve pulse converter.
**Activity:** Analysis of a voltage source converter for HVDC systems.

**Module 2: HVDC System Control**
Principles of DC Link control, Converter control characteristics, System control hierarchy, Firing angle control, current and extinction angle control, Power Control.
**Activity:** Higher level controllers for HVDC systems.

**Module 3: Reactive Power Control in HVDC**
Reactive power requirements in steady state, conventional control strategies, alternate control strategies, Sources of Reactive Power, harmonics and filters, Generation of harmonics, types of ac filters.
**Activity:** DC filters for HVDC system.

**Module 4: FACTS Controllers and Shunt Compensation**
Definition of FACTS, types of FACTS compensators. Principle of SVC scheme.. FACTS based shunt compensators: TCR, TSC, STATCOM.
**Activity:** FACTS based shunt compensators: SVC (Analysis-waveforms, Effective reactance, Compensator Current and Reactive power, VI characteristics).

**Module5: Principle of Series Compensation**
FACTS based series compensators: GCSC, TSSC and TCSC, Combined Series –shunt Compensator: Unified Power Flow Controller (UPFC).
**Activity:** Comparison of Shunt and Series compensation.

**Text Books :**

1. "HVDC Power Transmission Systems – Technology and System Interactions", K. R. Padiyar, Third Edition, New Age International Publishers, 2015.
2. "Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems" -Narain G. Hingorani, Laszlo Gyugyi-Wiley India publications 2011.


**Reference Books :**

1. Sang, Y.H. and John, A.T., Flexible AC Transmission Systems, IEEE Press (2006).
2. Ghosh, A. and Ledwich,G., Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers (2005).
3. *"FACTS* Controllers in Power Transmission and Distribution", *K. R. Padiyar,* New Age International Publishers, 2007.


## EE 3050 SPECIAL ELECTRICAL MACHINES Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the construction of special electrical machines.
CO2. know the principle of operation of special electrical machine including Servo Motor, Stepper Motor and Reluctance Motor.
CO3. identify the applications of special electrical machines.
CO4. analyse the performance of various special electrical machines.
CO5. develop the torque and emf expression of different special electrical machines.
CO6. know different control techniques for Permanent Magnet Brushless DC Motors.

**Prerequisites: DC machines and Synchronous Machines (EE 2020) & Transformers and Induction motors (EE 2017)**

**Module 1: Servo Motor**
Types of servomotor, DC Servo motor, Basic working principle and its classification, Field controlled and Armature controlled DC servomotor, Series Split field DC Servo motor, Permanent-magnet Armature controlled DC servo motor, AC Servomotor. Operating principle, two phase AC Servo motor, Shaded pole AC Servomotor, Equivalent circuit of A C servomotor.
**Activity:** Application of a DC Servo motor, Construction of AC Servo motor, Application of AC Servo motor, Servo motor torque speed curves.

**Module 2: Stepper and Linear Induction Motor**

Stepper Motor: Constructional features, Principle of operation, Step Angle, Types, Hybrid Stepper motor, Permanent Magnet Stepper Motor.

**Linear Induction Motor**: Construction, Working Principle, Comparison with Rotary Induction Motor, Thrust – speed Characteristics, Equivalent circuit.

**Activity:** Torque – Pulse rate Characteristics, Restraining torque, Applications of the stepper motor, Magnetic Levitation, Variable reluctance motor, Single and multi stack configurations.

**Module 3: Reluctance, Hysteresis and Universal Motors**

**Reluctance motor**: Construction, Principle of operation, Torque-Speed characteristics, Switched reluctance motor, SRM Drive System.

**Hysteresis Motors**: Construction, Principle of operation, Torque-speed characteristics.

**Universal motor**: Construction, Principle of operation, EMF due to main field and cross field, circuit model and Phasor Diagram, torque developed and performance characteristics.

**Activity:** Capacitor type reluctance motor, Synchronous Reluctance motor, Advantages of Hysteresis motor over reluctance motor, Applications of Reluctance, Hysteresis and Universal motors, Compensating and interpole windings.

**Module 4: Permanent Magnet Brushless DC Motors**

Permanent Magnets, Permittance coefficient, Magnetic circuit analysis, Principle of operation, modeling of a permanent magnet brushless DC Motor, EMF and torque equations.

**Activity:** Commutation, Closed loop control of PMBDC motor.

**Text Books :**

1. Krishnan R., “Permanent Magnet Synchronous and Brushless DC Motor Drives”, CRC Press, New York, 2010.
2. S K Sahadev, Electrical Machines, Cambridge University Press, 1st Edition, 2018.

**Reference Books :**

1. Krishnan R., “Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application”, CRC Press, New York, 2009.
2. Jacek F. Gieras, Jacek F. Gieras, Mitchell Wing, “Permanent Magnet Motor Technology: Design and Applications”, CRC Press, Second Edition, 2002.
3. Hendershot J. R. and Miller T. J. E., “Design of Brushless Permanent Magnet Machines”, Motor Design Books LLC, 2nd Edition, 2010.
4. Janardanan E.G., “Special Electrical Machines”, PHI Learning Private Limited, 2015.
5. Veinott, Fractional Horse Power Electric Motors, McGraw-Hill.
6. V.U Bakshi, U.A Bakshi, Electrical Circuits and Machines, Technical Publication, Pune.
7. Fitzgerald, Charles Kingsley, Stephen D Umans. Electric Machinery, TMH.

## EE 3051 OOPS with Python Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. understand the difference between structure-oriented programming and object-oriented programming.

CO2. use object-oriented programming language like Python and associated libraries to develop object oriented programs.

CO3. apply various object-oriented features like class, object, inheritance, data abstraction, encapsulation polymorphism to solve various computing problems using Python language.

CO4. understand and apply concepts of operator-overloading, contracture and destructtor.
CO5. understand the and apply exception handling and use built-in classes from STL
CO6. implement, test and debug solutions in Python.

**Prerequisite : Computer Programming (CS 1093)**

**UNIT 1:**

Introduction to Object Oriented Programming: Object oriented programming concepts: Objects, classes, encapsulation and abstraction, inheritance, polymorphism, dynamic binding, message passing; Python Programming basics: Character set, Keyword, Constant, Variable, Data types, operator & expression, control structure (branching & looping), typecasting, array & strings, Streams based I/O, Function: Parameter passing (i) by value, (ii) by address, (iii) by reference, inline function, function overloading, default arguments.

**UNIT 2:**

Class and Object: Defining class with functions and data members, Creating & deleting objects by using new and delete operators respectively, Array of Objects, Objects as function argument, Static Data members and member functions, Function with default arguments, function overloading; Constructor and Destructors: Definition of constructors and its uses, Types of constructors: default constructor, parameterized constructor, copy constructor, constructor with dynamic allocation, Dynamic Constructors, Constructor Overloading, Destructors.

**UNIT 3:**

Inheritance: Concept of inheritance: defining derived and base classes, Class hierarchies, public, private, and protected derivations; Types of Inheritance: Single Inheritance, Multilevel Inheritance, Multiple Inheritance, Hierarchical Inheritance, Hybrid Inheritance, Virtual base class: Function overriding, Constructors/Destructors in derived classes: Constructors invocation and data members initialization in derived classes, Member classes: classes within classes.

**UNIT 4:**

Polymorphism: Operator overloading: Overloading unary operators, binary operators, overloading binary operators using friend function and member function, Rules for overloading operators; Polymorphism: Introduction to pointers: Pointers to objects, pointer to derived class object, this pointer, Compile time polymorphism: Review of Function Overloading and Operator overloading; Run time polymorphism: virtual functions, pure virtual functions, abstract class, virtual constructors and destructors.

**UNIT 5:**

Templates, Files and Streams: Exception Handling: Basics of Exception Handling, Exception Handling Mechanism: The keyword try, throw and catch. Templates: Need of template, Class Templates: Definition, Class Template with multiple parameters, Function Templates: Definition, Function Template with multiple parameters. Files and Streams: Introduction to file handling: text file Vs. binary file, Hierarchy of file stream classes: Functions of File Stream classes, Steps to process a File in a program. Different functions used in file, File modes(Sequential and random), File pointers and their Manipulations, Error handling during file operation.

**Text Books :**

1. Python-3 Object Oriented Programming 3rd Edition,PactPub, ISBN9781789615852
**2.** Mastering Object-Oriented Python: Build powerful applications with reusable code using OOP design patterns and Python 3.7, 2nd Edition Kindle Edition

**Reference Books :**

**3.** Core Python Programming Paperback – 1 January 2018, by **R. Nageswara Rao**
**4.** Python Programming: Using Problem Solving Approach Paperback – 10 June 2017 by Reema Thareja.

## EE 3052 POWER SYSTEM DEREGULATION Cr-3

**Course outcome :**At the end of the course, the students will be able to :

CO1. analyze the challenges regarding deregulation of power system.
CO2. aware of the salient features of Electricity act 2003.
CO3 know the concept of Market Reform.
CO4. realize the model of Electricity Markets pricing and Non-Pricing Issues.
CO5. demonstrate on different aspects of energy market in recent times.
CO6. know the issues regarding transmission planning and pricing.

### Prerequisite: -Power System Operation and Control (EE 3002)

**Module 1:**
**Different Power Sectors**
Introduction to various institutions in Power sector of India such as CEA, Planning Commissions, Salient features of Electricity act 2003 PGCIL, PFC, Ministry of Power, state and central governments, REC, utilities and their roles, role of load dispatch center (SLDC/ RLDC), Critical issues / challenges faced by Indian power sector, Various national policies and guidelines under this act, Global experience with electricity reforms in different countries.
**Activity:** Different Electricity Acts and Indian Electricity Rule, Load Flow Analysis.

**Module 2:**
**Power Sector Restructuring and Market Reform**
Different industry structures , ownership and management models for generation, transmission and distribution, Competition in the electricity sector- conditions, barriers, types, Benefits, challenges, latest reforms, amendments, Different market and trading models / arrangements, Open access, key market entities- ISO, Genco, Transco, Disco, Retailco, types of Power market, Energy market, Ancillary service market, transmission market, Forward and real time markets, market power.
**Activity:** Key issues in Deregulation, Optimal Load Dispatch.

**Module 3:**
**Electricity Markets Pricing and Non-Price Issues**
Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs, Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow Spot prices for real and reactive power, Unconstrained real spot prices, constraints and real spot prices, Non price issues in electricity restructuring (quality of supply and service, Standards of performance by utility, environmental and social considerations).
**Activity:** Task Force on Measures for Operationalising Open Access in the Power Sector, Automatic Generation Control.

**Module 4:**
**Transmission Planning and Pricing**
Transmission planning, Different methods of transmission pricing, Different transmission services, Congestion issues and management, Transmission cost allocation methods, Locational marginal price, firm transmission right. Transmission ownership and control, Transco and ISO, Transmission pricing Model in India, Availability based tariff, Ancillary services for restructuring, Forward ancillary service auction, Power purchase agreements.

**Activity:** Provisions on Open Access in Sample two states, Load Frequency Control under Deregulated Environment.

**Text Books :**

1. Kankar Bhattacharya, Math H.J. Boller, Jaap E. Daalder, ‘Operation of Restructured Power System’ Klumer Academic Publisher,2010.
2. S. K. Gupta, “Power System Operation Control and Restructuring” I. K. International Publishing House Pvt. Ltd, New Delhi, 2015.

**Reference Books :**


1. Loi Lei Lai; "Power system Restructuring and Deregulation", Jhon Wiley & Sons Ltd., England.
2. Know Your Power", A citizens Primer On the Electricity Sector, Prayas Energy Group, Pune.
3. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc.
4. Mohammad Shahidehpour, and Muwaffaq alomoush, - "Restructured electrical Power systems" Marcel Dekker, Inc.,2009.


## EE 3053 DATABASE SECURITY Cr-3

**Course Outcomes:** At the end of the course, the students will be able to

CO1. analyze and evaluate the cyber security needs of an organization.
CO2. determine and analyze software vulnerabilities and security solutions to reduce the risk of exploitation.
CO3. measure the performance and troubleshoot cyber security systems.
CO4. implement cyber security solutions and use of cyber security, information assurance, using different tools.
CO5. comprehend and execute risk management processes, risk treatment methods, and key risk and performance indicators.
CO6. design operational and strategic cyber security strategies and policies.

**Prerequisite: Computer Programming (CS 1093)**

**UNIT 1:**
Introduction of Cyber Crime, Challenges of cyber crime, Classifications of Cybercrimes: E-Mail, Spoofing, Spamming, Internet Time Theft, Salami attack/Salami Technique,

**UNIT 2:**
Web jacking, Online Frauds, Software Piracy, Computer Network Intrusions, Password Sniffing, Identity Theft, cyber terrorism, Virtual Crime, Perception of cyber criminals: hackers, insurgents, and extremist group etc. Web servers were hacking, session hijacking.

**UNIT 3:**
Cyber Crime and Criminal justice: Concept of Cyber Crime and the IT Act, 2000, Hacking, Teenage Web Vandals, Cyber Fraud and Cheating, Defamation, Harassment and E-mail Abuse, Other IT Act Offences, Monetary Penalties, jurisdiction and Cyber Crimes, Nature of Criminality,Strategies to tackle Cyber Crime and Trends.

**UNIT 4:**
The Indian Evidence Act of 1872 v. Information Technology Act, 2000: Status of Electronic Records as Evidence, Proof and Management of Electronic Records; Relevancy, Admissibility and Probative Value of E-Evidence, Proving Digital Signatures, Proof of Electronic Agreements, Proving Electronic Messages.

**UNIT 5:**
Tools and Methods in Cybercrime: Proxy Servers and Anonymizers, Password Cracking, Key loggers and Spyware, virus and worms, Trojan Horses, Backdoors, DoS and DDoS Attacks , Buffer and Overflow, Attack on Wireless Networks, Phishing : Method of Phishing, Phishing Techniques.

**UNIT 6:**
Cloud and IoT are the latest emerging technologies and every other organization wants to implement it. Therefore, it is understandable to learn security measures under this category.

**Text Books:**
1. Principles of Cyber crime, Jonathan Clough Cambridge University Press
2. John R.Vacca, Computer Forensics:Computer Crime Scene Investigation, 2nd Edition, Charles River Media, 2005

**Reference Books**
3. Information Warfare: Corporate attack and defense in digital world, William Hutchinson, Mathew Warren, Elsevier.
4. Cyber Laws and IT Protection, Harish Chander, Pub:PHI.
5. Cryptography and Network Security: Principles and Practice, Global Edition, 7/E, William Stallings, Pearson,

## EE 3054 BIO-INSPIRED ALGORITHM Cr – 3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. understand the basic concept of evolutionary computation.
CO2. demonstrate swarm intelligence for existing systems
CO3. interpret the implementation issues of evolutionary algorithms.
CO4. calculate the appropriate parameter settings to make different evolutionary algorithms work well.
CO5. evaluate new evolutionary operators, representations and fitness functions.
CO6. identify different evolutionary algorithms for engineering applications

### Prerequisites: Mathematics - I (MA 1003), Biology (LS 1001)

**Module 1: Evolutionary computation**
Biological and artificial evolution, Evolutionary computation, Different historical branches of EC, Genetic Programming**:** Trees as individuals, Major steps of genetic programming, e.g., functional and terminal sets, initialization, crossover, mutation, fitness evaluation, etc. Search operators on trees, automatically defined functions, Issues in genetic programming, e.g., bloat, scalability, etc. Selection schemes: Fitness proportional selection and fitness scaling, Ranking, including linear, power, exponential and other ranking methods, Tournament selection, Selection and its impact on evolutionary search, Search Operators**:** Recombination/Crossover for strings (e.g., binary strings), e.g., one-point, multi-point, and uniform crossover operators, Mutation for real-valued representations, e.g., Gaussian and Cauchy mutations, self-adaptive mutations, etc., Generational cycle-convergence of Genetic Algorithm.
**Activity:** Genetic programming techniques for real-world problems such as Reactive power control, Speed control of DC and AC Motors, Load flow studies.

**Module 2: Introduction to swarm Optimization**
Conventional Computing versus Swarm Computing; Classification of meta-heuristic techniques- single solution based and population based algorithms – exploitation and exploration in population based algorithms; Properties of Swarm intelligent Systems;
Particle Swarm Optimization: PSO Model, global best, Local best, velocity update equations, position update equations, velocity clamping, inertia weight, constriction coefficients, synchronous and asynchronous updates, Binary PSO.
**Activity:** Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions-Control parameter, Application domain-discrete and continuous problems- single objective and multi-objective problems, Apply PSO techniques for electrical engineering problems such as economic load dispatch, automatic load frequency control

**Module 3: Different Evolutionary Algorithms**
Historical development, types of bees and their role in the optimization process, Introduction to Ant Systems, Ant Colony Optimization Technique, Pheromones and its Density as Deciding Factor. Artificial bee colony (ABC) algorithms binary ABC and continuous ABC algorithms; Bacterial foraging techniques-taxes-elimination-dispersals bacteria motility and swarming; Biological immune systems and artificial immune systems affinity measures-representations; Basic immune models and algorithms.

**Activity:**Differential search algorithms, harmony Search algorithms, cuckoo search algorithms, firefly algorithms, gravitational search Algorithms, Hybrid swarm intelligent systems; Applications of evolutionary Techniques in Load forecasting, Economic load dispatch, Load frequency control.

**Text Books :**

1. Genetic Algorithms in Search, Optimization & Machine Learning, D E Goldberg, Addison-Wesley, 1989
2. James Kennedy and Russel E Eberheart, 'Swarm Intelligence', The Morgan Kaufmann Series in Evolutionary Computation, 2001

**Reference Books :**

1. Eric Bonabeau, Marco Dorigo, and Guy Theraulaz, "Swarm Intelligence: From Natural to Artificial Systems", Oxford University Press, 1999
2. Engelbrecht, A.P. Computational Intelligence: An Introduction, Second Edition, John Wiley and Sons, 2007.
3. Dorigo, M., Stutzle, T., Ant Colony Optimization, MIT Press, 2004
4. Parsopoulos, K.E., Vrahatis, M.N., Particle Swarm Optimization and Intelligence: Advances and Applications, Information Science Reference, IGI Global, 2010
5. Clerc, M., Particle Swarm Optimization, ISTE, 2006 7. Nature Inspired Metaheuristic Algorithms, Xin-She Yang, Luniver Press, 2010.
6. Handbook on Evolutionary Computation, T. Baeck, D. B. Fogel, and Z. Michalewicz (eds.), IOP Press, 1997.
7. Andries P. Engelbrecht, "Computational Swarm Intelligence", Wiley, John & Sons, 2006.

## EE 3055 WIRELESS NETWORK SYSTEMS Cr-3

**Course Outcomes:**At the end of the course, the students will be able to

CO1. apply cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.
CO2. determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
CO3. analyse and design receiver and transmitter diversity techniques.
CO4. Determine the appropriate transceiver design of multi-antenna systems and evaluate the data rate performance.
CO5. design wireless communication systems with key 3G (e.g., CDMA) and 4G (OFDM) technologies.
CO6. describe and differentiate four generations of wireless standard for cellular networks.

**Prerequisites: Analog Electronic Circuits (EE 2013) and Computer Programming (CS 1093)**

**Unit-1:**
Overview of wireless communications and systems, Review of digital communications, Cellular systems from 1G to 3G Wireless 4G systems2.

**Unit-2:**
Radio propagation and propagation path-loss model
Free-space attenuation, Multipath channel characteristics, Signal fading statistics, Path-loss models.

**Unit-3:**
Fundamentals of cellular communications, Hexagonal cell geometry, Co-channel interference, Cellular system design, Sectoring using directional antennas.

**Unit-4:**
Multiple access techniques, Frequency division multiple access (FDMA), Time division multiple access (TDMA), Code division multiple access (CDMA), Space division multiple access (SDMA), Orthogonal frequency division

multiplexing (OFDM), Multicarrier CDMA (MC-CDMA), Random access methods.

**Unit-5:**
Wide-area wireless networks (WANs), GSM – IS-136, IS-95, UMTS, Cdma2000.

**Unit-6:**
Long Term Evolution Technologies (LTE), OFDM, MIMO channels, Space Time Codes, LTE Advanced, Other wireless systems IEEE 802.11 WLAN (WiFi), WiMAX.

**Text Books:**
1. Wireless Communications: Principles and Practice, 2nd Edition. Theodore S. Rappaport, Pearson publications

**Reference Books:**
2. Mobile Wireless Communications. Mischa Schwartz. Paperback (2013) ISBN:9781107412712. Cambridge University Press.
3. The evolution to 4G cellular systems: LTE-Advanced. Ian F. Akyildiz, David M. GutierrezEstevez, Elias Chavarria Reyes. Broadband Wireless Networking Laboratory, School of Electricaland Computer Engineering, Georgia Institute of Technology.
4. Vijay K. Garg, Wireless Communications and Networking, Morgan Kaufmann Publishers,2007, ISBN 978-0-12-373580-5.

## EE 3056 DIGITAL SYSTEM DESIGN USING FPGA Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. learn advanced design methodologies for high-performance FPGA applications.
CO2. analyze the implementation of a complete sophisticated digital system using FPGA.
CO3. apply translating software models of digital signal processing applications.
CO4. comprehend sophisticated optimization techniques for streaming applications.
CO5. understand design procedure and compare performance of FPGA based system.
CO6. synthesize VHDL based digital system.

**Prerequisites: Digital Circuits (EE 2018), Microprocessor and Interfacing ( EE 3013)**

**System Level Design:**
System- level architecture design for FPGAs. TMS322F series architecture.
**Activity:** Spartan-3E board architecture.

**VHDL:**
Review of VHDL programming basics, Synthesizable VHDL, synchronous and asynchronous processes, finite state machines, and memory.
**Activity:** VHDL coding for digital circuit both for combinational and sequential circuits.

**Programming Spartan-3E using VHDL**
Practical test bench design, performance testing.
**Activity:** Counter design using Spartan 3E.

**Design Optimization using FPGA interface in NI-CRIO-9082**
Design optimizations and performance comparison, FIFOs and streaming architectures
**Activity:** Analog signal processing using NI-CRIO FPGA interface.

**Synthesis of Design Using VHDL**

Design, optimize, simulate, and analyze the performance for a digital application, FPGA synthesis and iterative performance optimizations. (Xilinx software)
**Activity:** Circuit synthesis for delay circuit design.

**Text Books :**

1. The Designer's Guide to VHDL, Peter J. Ashenden; HDL Chip Design, Douglas J. Smith;
2. Advanced FPGA Design Architecture, Implementation, and Optimization, Steve Kilts

**Reference Books :**

1. "Digital System Design with FPGA", Implementation using Verilog and VHDL, Cem Unsalan, Bora Tar.1st Edition TMH publication.

## EE 3058 ENERGY AUDIT AND ACCOUNTING Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. learn the need of energy audit.
CO2. understand the concept of energy conservation and audit.
CO3. apply the concept of accounting in energy audit.
CO4. design the capacitor rating for power factor improvement.
CO5. evaluate the energy efficiency of furnace & CHP System.
CO6. create a report for an Economic Evaluation.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module 1: General Aspects**
Indian Energy scenario, definition of energy conservation, management and audit,, Energy audit-need, Types of energy audit, Energy Audit Reporting Format ,Energy audit instruments, Energy Conservation schemes, Energy index, Cost Index, Representation of energy consumption.
**Activity:** Economic and ecological implications on management & auditing systems, auditing on emission, pollution, safety and reliability.

**Module 2: Energy Utilization and Conversion System**
Furnace: Classification of furnace, controlled atmosphere in furnace, furnace fuels, efficiency of energy in furnace, thermal efficiency, heat losses, reducing heat losses.

Combined heat and power systems: Characteristic of prime movers, heat and power requirement, economics of C.H.P. system

Industrial Heating: Resistance heating, Induction heating, arc Heating, dielectric and microwave atmosphere generators, radiant heating

Lighting: Lamp lifetime, efficient lighting

Motive power and power factor improvement: Cost of electrical Energy, Power factor improvement, Capacitor rating, sitting the capacitor, effect of power factor improvement.

**Activity:** Hydraulic power system, Electrical Measurement, Temperature measurement and optimal start control.

**Module 3: Economic Analysis**
Introduction, Basic Concepts, Interest Rate, Inflation Rate, Tax Rate ,Cash Flows, break even charts, Compounding Factors, Single Payment, Uniform-Series Payment, Economic Evaluation Methods Net, Present Worth, Rate of Return Benefit–Cost Ratio, Payback Period, Summary of Economic Analysis Methods, Life-Cycle Cost Analysis Method, General Procedure for an Economic Evaluation.
**Activity:** Financing Options, Direct Purchasing, Leasing, Performance Contracting.

**Text Books :**

1. W.R. Murphy and G. McKay, "Energy management", Butterworth & Co Publishers, Oxford, UK, 2001.
2. Energy Audit of Building systems: An Engineering approach, by: Moncefkrarti, CRC PRESS, Second Edition, 2009.

**Reference Books :**

1. A Workbook for Energy Management in building by: Tarik Al-Shemmeri, Wiley-Blackwell.
2. Energy audit: Thermal power, combined cycle, and co-generation plants, by: Y. Pabbi, TERI, 2011.
3. Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007) by WC Turner.
2. Bureau of Energy Efficiency (BEE) (2016); Study material for Energy managers and Auditors Examination: Paper I.

## EE 3060 INDUSTRIAL AUTOMATION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. describe in Industrial Measurement Systems.
CO2. determine the effect of parameters of controller on system performance.
CO3. demonstrate the controller using different tuning methods.
CO4. design the ladder logic of PLC according to the problem statement.
CO5. analyze DCS and SCADA and their merits/demerits in an industrial automation.
CO6. know application of controller in hydraulic and pneumatic systems.

**Prerequisite: Linear Control System (EE 2028)**

**Module-1:**
**Introduction**
Introduction, Architecture of Industrial Automation Systems, Measurement Systems Characteristics, Data Acquisition Systems.
Controller tuning:
Introduction to Automatic Control, PI controller, PD controller, PID controller tuning methods: Ziegler-Nichols tuning method, Cohen coon tuning method.
**Activity-** Implementation of PID controllers.

**Module-2:**
**Automation:**
PLC (Programmable logic controllers): Overview, operation and architecture, PLC programming, Application examples.
DCS (Distributed control systems): Overview, Advantages, Functional requirements of Distributed control systems, Communication for distributed control, Application examples.
SCADA (supervisory control and data acquisition): Introduction to SCADA, SCADA system components, architecture and communication, SCADA applications.
**Activity -** Implementation of ladder logic for a given system

**Module-3:**
**Controllers in Industrial Instruments:**
Flow Control Valves, Hydraulic Control Systems - I, Hydraulic Control Systems - II, Industrial Hydraulic Circuit, Pneumatic Control Systems - I, Energy Savings with Variable Speed Drives
**Activity -** Application of advanced control techniques in hydraulic system

**Text Books :**
1. Modern Control Engineering, 4th edition, Ogata, Prentice Hall of India, 2002.
2.Fundamentals of Industrial Instrumentation and Process Control, William C. Dunn, Tata McGraw Hill, 2009.

**Reference Book :**

1. Chemical Process Control – Theory and Practice, Stephanopoulous, Prentice Hall of India Ltd, 1984.

## EE 3062 ROBOTICS AND CONTROL Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. gain knowledge towards configuring of robot.
CO2. analyze the kinematics and dynamics of robot.
CO3. understand the trajectory planning of robot.
CO4. familiarize the interfacing of robot with various sensors, actuators and camera.
CO5. control the robot through AI Techniques
CO6. design of robot for various applications.

**Prerequisite:Linear Control System (EE 2028)**

**Module 1:**
**Introduction to Robotics:**
Definition of a Robot, Basic Concepts, Robot configurations, Types of Robot drives, Basic robot motions, Point to point control.

**Components and Operation**:
Basic control system concepts, Control system analysis, Robot actuation and feedback, Manipulators, direct and inverse kinematics, Coordinate transformation, Brief Robot dynamics, Types of Robot and Effectors, Robot/ End and Effectors interface.
**Activity:** Simulink model for path tracking of Robot.

**Module 2:**
**Control design for Robotic System:** Control Loops of Robotic Systems, Trajectory, velocity and force control, Computed Torque control.

**Robot Sensing & Vision:** Use of Sensors and Sensor Based System in Robotics, Machine Vision System: Description, Sensing, Digitizing, Image Processing and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors, visual servo-control.
**Activity:** Controller design for robot.

**Module 3:**
**Robot Programming Methods**:
Languages, Capabilities and limitation, Artificial intelligence, Knowledge representation, Search techniques in AI and Robotics.

**Industrial Applications**:
Application of robots in autonomous vehicles and other industrial areas.
**Activity:** AI based control for Industrial Robot

**Text Books :**

1. Robotic Engineering: An Integrated Approach- Richard D. Klafter, Thomas A. Chmielewski and Michael Negin , Prentice Hall of India,1989
2. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.

**Reference Books :**

1. Introduction to Robotics- John J. Craig, Addison Wesley Publishing, 3rd edition, 2010.
2. Foundation of Robotics: Analysis and Control -Yoshikawa, Prentice Hall of India, 2003.

## EE 3064 BIO-MEDICAL INSTRUMENTS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know about various biomedical signal sources.
CO2. understand cardiovascular system and related measurements.
CO3. know working principle of measurement instrument for respiratory and nervous system.
CO4. analyze non-invasive diagnostic parameters
CO5. distinguish procedures and types in laboratory work.
CO6. design report on measuring and recording instruments for medical applications.

**Prerequisite: Electrical and Electronics Measurements (EE 2019)**

**Module-1: Introduction of Bio-medical Instrumentation, Sources of Bioelectric Potentials and Electrodes**
Introduction to man-instrument system, components of the man-instrument system, Physiological system of the body, Problems encountered in measuring a living system. Resting and action potentials.
**Activity:** Propagation of action potentials, bioelectric potentials, Bio potential electrodes, Biochemical transducers. Review of transducers.

**Module-2: Cardiovascular System and Measurements**
The heart and cardiovascular system, ECG, blood pressure and its measurement, respiration and pulse rate, characteristics and measurement of blood flow meter.
**Activity:** Cardiac output, phethysmography, pacemaker, defibrillators, heart sounds and its measurement.

**Module-3**: **Respiratory and Neuro-muscular System**
The physiology of the respiratory system, test and instrument for the mechanics of breathing, the somatic nervous system.
**Activity:** EEG, EMG and GSR

**Module-4: Measurement and Recording of Noninvasive Diagnostic Instrumentation, Patient Care and Electrical Safety**
Principle of ultrasonic measurement, ultrasonic, thermography, elements of intensive care monitoring-ray.
**Activity:** CT – Scan and MRI, tonometer, dialysis**,** diathermy, Shock hazards from electrical equipment.

**Module-5: Laboratory work**
Study the variance in pulse rate of subject in a batch, use Spiro meter on the subject, auditory system check-up using Audiometer, Measurement of Heart Rate using Stethoscope, Blood pressure using Sphygmomanometer, Pulse Rate and SpO2 using Pulse Oximeter, Skin Conductance and Skin Potential using Galvanic Skin Response Module.
**Activity:** Pulse Rate using Polyrite machine, Respiration Rate using Polyrite, Electromygram test using EMG biofeedback Trainer.

**Text Books :**

1. Cromwell, L. and Weibell, F.J. and Pfeiffer, E.A., Biomedical Instrumentation and Measurement, Dorling Kingsley (2006) 2$^{nd}$edition.
2. Carr, J.J. and Brown, J.M., Introduction to Biomedical Equipment Technology, Prentice Hall India (PHI) (2000) 4$^{th}$edition.

**Reference Books :**
1. Geddes, L.A., and Baker, L.E., Principles of Applied Biomedical Instrumentation, Wiley InternationalScience (1989) 3rd edition.
2. Khandpur, R.S., Handbook of Biomedical Instrumentation, McGraw Hill (2003) 2ndedition.
3. Webster, J.G., Medical Instrumentation Application and Design, John Wiley (2007) 3rdedition.

## EE 3066 ADAPTIVE CONTROL SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. learn the parameters of different controllers.
CO2. understand the concept of parameter estimation of dynamic systems.
CO3. apply adaptive controllers for different nonlinear systems.
CO4. analyze the performance of indirect adaptive control techniques.
CO5. design model reference adaptive systems using Lyapunov Theory.
CO6. design gain scheduling controllers.

**Prerequisites: Linear Control System (EE 2028)**

**Module-1:**
**Introduction to Adaptive Control:**
Introduction, Linear feedback, Effect of process variations, Adaptive schemes, The adaptive control problem, Applications
**Real- time Parameter Estimation:**
Introduction, Least square and regression models, estimating parameters in dynamic systems, Experimental conditions.
**Activity:** Simulation of recursive estimation by MATLAB / LABVIEW.

**Module-2:**
**Deterministic Self-tuning Regulators (STRs):**
Introduction, Pole placement design, Indirect self tuning regulators (STR), Continuous time self-tuners, Direct STRs, Disturbances with known characteristics.
**Stochastic and Predictive Self-tuning Regulators (STRs)**:
Introduction , Design of Minimum Variance and Moving average Controllers, Stochastic STRs, Linear Quadratic STR, Adaptive Predictive Control
**Activity:** Analysis of Indirect Discrete time STRs, Analysis of Direct Discrete time STRs in MATLAB / LABVIEW.

**Module-3:**
**Model Reference Adaptive Systems:**
Introduction, The MIT Rule, Determination of Adaptation Gain, Lyapunov Theory, Design of MRAS using Lyapunov Theory, Application to Adaptive Control, Output Feedback, Relations between MRAS and STR, Non-linear System.
**Activity:** Application of adaptive feedback in nonlinear systems.

**Module-4:**
**Auto Tuning and Gain Scheduling:**
Introduction, PID control, Auto tuning techniques, Transient Response methods, Principle of gain scheduling, Design of gain scheduling controllers, Nonlinear transformations.
**Activity:** Application of gain scheduling.

**Text Books :**
1. K.J. Astrom and B. Wittenmark, *Adaptive Control*, Addison, Pearson,2008.
2. SSastry and M Bodson "Adaptive Control: Stability, Convergence and Robustness" Prentice-Hall, 2011.

**Reference Books :**


1. K.S. Narendra and A.M. Annaswamy, *Stable Adaptive Systems*, Prentice-Hall, 2005.
2. Adaptive Control Algorithms, Analysis and Applications by Ioan Doré Landau Rogelio Lozano Mohammed M'Saad Alireza Karimi, Springer Publication, Second Edition, 2011.


## EE 3068 POWER CONVERTER ANALYSIS AND DESIGN Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. learn the design of power electronics converters for different applications.
CO2. design high frequency transformers and Inductors.
CO3. analyze the operation and application of inverters.
CO4. describe resonant converter and SMPS in various industrial applications.
CO5. know the power quality improvement strategies using power electronic converters.
CO6. design the gate driver circuit for different semiconductor devices.

### Pre-requisite: Power Electronics (EE 2026)

**Module 1: AC – DC Converters**
Single phase Rectifier Circuit: L-C filter design, performance parameter calculation, Heat Sink calculation.
**Activity:** Power factor improvement of rectifier circuits, 3 phase rectifier circuit design.

**Module 2: DC to DC Converters**
Non-isolated dc-dc converters: Design and operation of buck-boost, Cuk, SEPIC, Zeta in DCM and CCM.
**Activity:** Design of isolated dc-dc converters mentioned above/ Bidirectional dc-dc converters (half bridge and full bridge).

**Module 3: Switch Mode Power Supply**
Isolated dc-dc converters: Operation of Flyback Converter, Forward Converter andpush-pull Converters in CCM, Current Mode Control; Design of Magnetic Materials suitable for high frequency transformers.
**Activity:** Design of High Frequency transformers and Inductors.

**Resonant Converters**
Introduction to Soft switching, difference between hard and soft switching, basic resonant circuit concept; ZCS and ZVS resonant converters; Electronic Ballasts.
**Activity:** Series resonant converter, Parallel loaded resonant converter**.**

**Module 4: Inverters**
Review of Inverter circuits. Modulation Strategies: Bipolar and Unipolar switching scheme; Performance parameters of 3 phase Sinusoidal PWM Inverters; Harmonic reduction techniques, Multi-level inverters, advantages, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications.
**Activity:** Space Vector Modulation, SHE modulation.

**Gate drive Circuits:**
Gate drive circuits for Thyristor, MOSFET, IGBT, BJT, GTO.
**Activity:** Development of gate driver circuit for Thyristor/MOSFET/IGBT.

**Text Books :**


1. Power Electronics By M.H. Rashid Pearson Education, 3rd Edition, 2009.
2. Power Electronics, Converters, Applications and Design, by N. Mohan, Underland and Robbins, John Wiely and Sons, 3rd Edition,2011.

**Reference Books :**

1. Power Electronics By M.D. Singh and K.B. Khanchandani, Tata McGraw - Hill publishers, 2nd edition, 2008.
2. Modern Power Electronics, by P.C Sen, Wheeler publishing Co, First Edition, 2009.
3. Elements of Power Electronics, by Philip T. Krein, Oxford University Press, 25 Sept 1997.

## EE 3070 HYBRID ELECTRIC VEHICLE Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the modeling of Electric Vehicles and Hybrid Electric Vehicles.
CO2. know the mechanism of propulsion drive system.
CO3. control the output voltage and current of Traction Inverter.
CO4. analyze the control of the speed and torque of various traction motors.
CO5. explain the different energy storage systems.
CO6. know the design of Hybrid Electric Vehicle.

**Pre-requisites: DC Machines & Synchronous Machines (EE 2020), Power Electronics (EE 2026).**

**Module 1: Introduction**
History of hybrid and Electric vehicles, social and environmental importance of hybrid and electric vehicles.
**Electric Drive-trains:**
Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.
**Hybrid Electric Drive-trains**:
Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.
**Activity:** Demonstration of EV vs Conventional Vehicle with suitable schematic.

**Module2: Electric Propulsion unit**
Introduction to electric components used in hybrid and electric vehicles, configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switch Reluctance Motor drives, drive system efficiency.
**Activity:** Types of hybrid electric vehicle drive train with the suitable schematic of power flow arrangement.

**Module 3: Energy Storage**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems
**Activity:** Types of energy storage systems with their specific application, Discuss merits and demerits, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis

**Module 4: Energy Management Strategies**
Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, Comparison of different energy management strategies. concept of tariff management in charging stations.
**Case Studies:** Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).
**Activity:** Modelling and design of a HEV using multiple sources of energy.

**Text Books :**

1. Electric and Hybrid Vehicles: Design Fundamentals, by Iqbal Husain, CBC Press, Second Edition, 2010.

2. Vehicular Electric Power Systems by Ali Emadi, Willis Press, 2003

**Reference Books :**

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Electric Vehicle Technology by James and John, John Wiley & Sons, Ltd First Edition, 2004.

## EE 3072 COMPUTER AIDED POWER SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. formulate Bus admittance matrix during load flow study .
CO2. model power system components using graph theory.
CO3. formulate incidence and network matrix of 3-phase networks.
CO4. calculate the Bus impedance ($Z_{bus}$) using algorithm.
CO5. analyze the different fault study of 3-phase network using $Z_{bus}$.
CO6. know the transient stability analysis.

### Pre-requisite: Power System Operation and Control (EE 3002)

**Module-1**
**Load Flow Study using Computer Techniques:**
Formation of $Y_{bus}$ when regulating transformer present, Network matrices, Reference frame, Network graph, Tree, branch, Basic loop and Cut sets, Basic Incidence matrices, Augmented matrices, Primitive networks, Network matrices by Singular and Non-singular transformation with Bus frame of reference, Branch frame of reference, Loop frame of reference.
**Activity-** Review of bus admittance matrix, Review of load flow analysis methods, Network matrices by Singular and Non-singular transformation through Bus frame, branch and loop frame of reference.

**Module-2**
**Three Phase Networks:**
Elements in impedance and admittance form, Balance excitation, Un-balance excitation, Transformation matrices for symmetrical components, Incidence and network matrix for 3-phase elements, Formation of Z bus, Addition of branch, Addition of link problems.
**Activity-**Alteration of $Z_{.bus}$ by adding and removing an element, Formation of $Z_{bus}$ using MATLAB

**Representation of Three Phase Elements in Short Circuit Study**:
Short circuit study of balanced network by $Z_{bus}$, LG fault**,** L-L fault**,** 3-ph fault with and without fault impedance**,** Problems.
**Activity-** Short Circuit Analysis of any network through $Z_{bus}$ by MATLAB.

**Module-3**
**Transient stability Analysis:**
Load representation, Network performance equation, Swing equation, Machine equation, Solution techniques in transient stability study, RK $4^{th}$ order method, Problems.
**Activity-**Transient stability analysis using MATLAB.

**Text Books :**

1. Computer Methods in Power System Analysis by Glenn W. Stagg, Ahmed H. El-Abiad, McGraw-Hill Book Company, International Editions, 2009.
2. Advanced Power System Analysis and Dynamics by L. P. Singh, New Age International (P) Limited, Publishers, Revised 4th Edition, 2011.

**Reference Books :**

1. Power System Analysis by N.V.Ramana, Pearson Publication,2011
2. Computer application techniques in Power System by M.A.Pai, TMH, 2006.

## EE 3074 INTRODUCTION TO MACHINE LEARNING Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. understand the basic building blocks of machine learning algorithms
CO2. comprehend Big data and cloud computing
CO3. use the supervised and unsupervised learning techniques.
CO4. apply specific machine learning algorithms to solve real-world problems.
CO5. assess different Regression models
CO6. design Machine Learning Algorithm using its general principle

### Prerequisites: Mathematics - I (MA 1003), Data Structure and Algorithm (CS 2001)

**Module 1: Machine Learning, Big Data and Cloud computing**
Basic concepts of Machine learning, Techniques of Machine LearningSupervised learning (generative/discriminative learning, parametric/non-parametric learning, support vector machines),Unsupervised learning(clustering, dimensionality reduction, kernel methods), learning theory (bias/variance tradeoffs; VC theory; large margins), Introduction to Big Data Platform, Types of Data, Elements of Big Data, Big Data Analytics, Data Analytics Lifecycle, Fundamental concepts of cloud computing, Grid computing and mobile computing, h computing.
**Activity:** Semi-supervised and Reinforcement learning.

**Module 2: Simulated Annealing and Regression**
Simulated Annealing , Regression and its types Linear regression: Equations and algorithms,
**Activity**: Logistic regression K-Nearest Neighbor Classifiers (KNN) KNN with majority voting, KNN with distance-weighted voting.

**Module 3: Clustering**
Clustering algorithms, K-means clustering, hierarchical clustering, performance evaluation for clustering, applications, Density EstimationParametric and non-parametric density estimationapproaches, Dimension Reduction Principal component analysis (PCA), linear discriminant analysis (LDA).

**Activity**: Recent applications of machine learning, such as robotic control, data mining, autonomous navigation, bioinformatics, speech recognition, and text.

**Text Books :**

1. Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning From Theory to Algorithms, Cambridge University Press, 2014.
2. Machine Learning, Tom M. Mitchel , 1st edition Mc Graw hill 2018.

**Reference Books :**

1. Bishop. C M, Pattern Recognition and Machine Learning. Springer, 2006.
2. Duda, R O, Hart P E and Stork D G. Pattern Classification. Wiley-Interscience, 2nd Edition, 2000.

## EE 3076 VLSI CIRCUIT DESIGN Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. learn different steps involved in the fabrication of ICs using MOS transistor.
CO2. explain electrical properties of MOS and BiCMOS devices.
CO3. understand the design rules to be followed to draw the layout of any logic circuit.
CO4. analyze different types of logic gates using CMOS inverter.
CO5. design concepts to design building blocks of data path of any system using gates.
CO6. demonstrate basic programmable logic devices and testing of CMOS circuits.

**Prerequisites: Digital Electronics (EE 2018), Analog Electronics Circuits (EE 2013)**

**Module 1: MOS Transistor Principle**
PMOS, NMOS Transistors, Process parameters of PMOS and NMOS , Electrical Properties of CMOS circuits and device modeling, Scaling principle and fundamental limits, CMOS inverter scaling, propagation delays, stick diagram and layout diagram.
**Activity:** MOS transistor threshold Voltage, gm, gds, Figure of merit $\omega_o$; Pass transistor, NMOS Inverter, Various pull ups, CMOS Inverter analysis and design, Bi-CMOS Inverters.

**Module 2: Combinational Logic Circuits**
Example of combinational logic design, Elmore's Constant, Pass transistor logic, Transmission gates, Static and dynamic CMOS design, Power dissipation- low power design principle.
**Activity:** Contacts and Transistors Layout Diagrams for NMOS and CMOS Inverters and Gates, Scaling of MOS circuits.

**Module 3: Sequential Logic Circuit**
Static and dynamic latches and registers, Timing issues, Pipelines, Clock strategies, Memory architecture and memory control circuits, Low power memory circuit, Synchronous and asynchronous design.
**Activity:** Wiring capacitance, Fan – in, Fan – out, Choice of layers.

**Module 4: Designing Arithmetic Building Block**
Data path circuits, architectures of ripple carry adder, Carry look ahead adders, High speed adders, accumulators, multipliers, dividers, barrel shifters, and speed and area trade off.
**Activity:** Subsystem Design, Shifters, Adders, ALUs, Multipliers, Parity generators, Comparators, Zero/One Detectors, Counters. Array Subsystems: SRAM, DRAM, ROM, Serial Access Memories.

**Module 5: Implementation Strategies.**
Full custom and semi-custom design, Standard cell design and cell libraries, FPGA building block architectures.
**Activity:** PLAs, FPGAs, CPLDs, Standard Cells, Programmable Array Logic, Design Approach, Parameters influencing low power design. CMOS Testing: CMOS Testing, Need for testing, Test Principles, Design Strategies for test, Chip level Test Techniques.

**Text Books :**

1. Essentials of VLSI circuits and systems – Kamran Eshraghian, Eshraghian Dougles and A. Pucknell, PHI, 2005 Edition.
2. "Digital Integrated circuit –A design perspective", Jan Rabaey, Anantha Chandrakasan, B.Nikolic, Second Edition, PHI, 2003.

**Reference Books :**

1. CMOS logic circuit Design – John .P. Uyemura, Springer, 2007.
2. Modern VLSI Design – Wayne Wolf, Pearson Education, 3rd Edition, 1997.

## EE 3078 ENERGY MANAGEMENT AND SCADA Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know recent developments in Energy management System.
CO2. understand economic load dispatch and unit commitment.
CO3. analyze the economic aspect of energy production.
CO4. demonstrate the knowledge of energy management to existing system.
CO5. understand optimization and control of power systems.
CO6. describe SCADA system.

**Prerequisite: Power System Operation and Control (EE 3002)**

**Module 1: Introduction to Energy Management**
Energy Management Centers and Their Functions, Architectures, Characteristics of Power Generating Units and Economic Dispatch, Unit Commitment (Spinning Reserve, Thermal, Hydro and Fuel Constraints), Solution techniques of Unit Commitment, Generation Scheduling with Limited Energy, Energy management system.
**Activity:** Recent developments in Energy management System, Numerical Problems on Generation scheduling.

**Module 2: Economic Aspect**
Energy Production Cost – Cost Models, Budgeting and Planning, Practical Considerations, Interchange Evaluation for Regional Operations, Types of Interchanges.
**Activity:** Exchange Costing Techniques.

**Module 3: SCADA System**
Introduction to Supervisory Control and Data Acquisition, SCADA Functional requirements and Components, General features, Functions and Applications, Benefits, Configurations of SCADA, RTU (Remote Terminal Units) Connections, Power Systems SCADA and SCADA in Power System Automation.
**Activity:** SCADA Communication requirements.

**Text Books :**

1. Wood, A. J and Wollenberg, B. F, & sheble B.G."Power Generation Operation and Control", 2nd Edition John Wiley and Sons, 2003.
2. Handschin, Edmund, Petroianu& Alexandar. "Energy Management Systems", Springer Verlag, 1990.

**Reference Books :**

1. Green, J. N, Wilson, R, "Control and Automation of Electric Power Distribution Systems", Taylor and Francis, 2007.

## EE 4044 ENERGY AUDIT AND MANAGEMENT Cr-3

**Course Outcome** : At the end of the course, the students will be able to :

CO1. demonstrate various data analysis methodologies.
CO2. understand the concept of energy conservation and audit.
CO3. apply the energy policies and its impact.
CO4. analyze combined heating and power system.
CO5. realize the requirement of energy audit and management.
CO6. prepare an energy audit report of a system.

**Prerequisite: Basic Electrical Engineering (EE 1003)**

**Module 1:General Aspects**
Definitions of Energy Efficiencies, Estimation of Energy efficiencies in supply side and demand side, definition of energy conservation, management and audit, similarities and dissimilarities in financial audit and energy audit, approach, data collection and data analysis methodologies, demand and supply matching methodologies, optimization methodologies in input and output.
**Activity:** Economic and ecological implications on management & auditing systems, auditing on emission, pollution, safety and reliability.

**Module 2: Energy Utilization and Conversion System**
Classification of furnace, arc furnace, controlled atmosphere in furnace, furnace fuels, efficiency of energy in furnace, thermal efficiency, Heat losses, reducing heat losses in hydraulic power systems compressed air, heat recovery, drying and leak, operating conditions, steam turbine as alternatives to electric motors combined power and heating systems.
**Activity:** Characteristics of prime movers, heat and power requirements, economics of a C.H.P. system, energy conservation, district heating, factors affecting the choice of heating, district generation.

**Module 3 Applications of Energy Audit:**
Definition of energy audit, need for energy audit, energy audit and reporting format, financial audit. Peak load, average load, firm power, dump power, secondary power, load curve, load distribution curve, plant capacity factor, energy index, cost index, budgeting and standard costing, representation of energy consumption, energy economics.
**Activity:** Financial appraisal and profitability with numerical problems.

**Text Books :**
1. "Energy Management", by W.R. Murphy and G. McKay, Butterworth and co Publishers, Oxford, UK, 2003
2. Energy audit of Building systems: an Engineering approach by Moncefkrati, CRC PRESS, Second Edition, 2009.

**Reference Books :**
1. A workbook for Energy Management in building by Tarik Al-Shemmeri, Wilay-Blackwell,2011.
2. Energy audit: Thermal power, combined cycle and co-generation plants by Y. P. Abbi, TERI, 2012

## EE 4047 ELECTRICAL INSTRUMENTATION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. measure different electrical quantities.
CO2. find the unknown electrical parameters by different AC bridges.
CO3. know the characteristics and applications of transducers.
CO4. use instrument transformer in Electrical system.
CO5. demonstrate on choice of transducers
CO6. demonstrate on recent trends of measurement system

**Prerequisites: Basic Electrical Engineering (EE 1003)**

**Module 1: Measurement of Different Electrical Quantities:**
Errors in measurements, Moving Iron type instrument, Electrodynamometer type watt meters, Induction type energy meter, Electrical resonance type frequency meter, Current transformers, Potential transformer
**Activity:** Deflecting, Controlling and Damping Torques in Indicating Instruments, extension of range, Electrodynamometer type meter.

**Module 2: AC Bridge**
General equation of bridge balance, Maxwell’s inductance, Anderson's bridge, Schering bridge, Errors.

**Activity**: Wheatstone bridge, Kelvin's double bridge.

**Module 3: Transducers**
Definition and classification of transducers, Capacitance Transducers, Variable Inductance Transducers, Encoders. Thermocouples, Synchros, Piezoelectric Transducers, Hall effect Transducers, Tachometer. Thermistors, LVDT,
**Activity**: Advantages of Electrical transducers, Characteristics and choice of transducers, Strain Gauge, AC potentiometer,

**Module 4: Introduction to recent trends of measurement system.**
Digital Energy Meter, Biometrics, Megger, Biomedical Instruments: ECG, Blood Pressure, Sonography.
Activity: Report of CT scan, MRI: Case study, CRO.

**Text Books :**

1. Electronic Instrumentation and Measurement Techniques, By William David Cooper, PHI, 2010.
2. Electrical Measurements and Measuring Instruments, By Edward William Golding, F. C. Widdis, 5th Edition, Pitman, reprint 2012.

**Reference Books :**

1. Electronics Instruments and Measurements – David A. Bell – PHI, 2012.
2. A Course in Electrical and Electronics Measurement and Instrumentation by A. K. Sawhney, 10$^{th}$ edition, Dhanpat Rai, 1994.
3. Electrical Measurement and Measuring Instruments by Arthur Harris, Intelliz press, ISBN: 978-1-6825/-382-8/2018.

## EE 4053 DIGITAL PROTECTION SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the digital system for relaying and signal processing.
CO2. demonstrate the principle and communication protocol of numerical relay.
CO3. examine in different monitoring protocols and architecture of relay.
CO4. understand integrated digital substation control system.
CO5. describe in digital protection scheme of transmission line.
CO6. familiar with different digital protection of power apparatus.

**Prerequisites: Power system Protection (EE 3008), Microprocessor and interface (EE 3013)**

**Module-1**
**Principles of Numerical Relays:**
Introduction, block diagram of numerical relay, sampling theorem, correlation with a reference wave, least error squared (LES) technique, digital filtering, and numerical over current protection. Definition of a Numerical Protection System, Advantages of Numerical Relays, Procession Unit, Man-Machine Interface (MMI), Communication in Protection Relays, Information Handling with Sub-station Monitoring System (SMS), Digital / Numerical Relays, Different Types of Numerical Relays, Principles of Fault Locators.
**Activity-** Solution of Fault Locator Equation, Walsh Analysis

**Module-2**
**Protection and Coordinated Control**
Protection and Coordinated Control, Place of Personal Computer, Self-Monitoring and Post Fault Analysis, Workstations and Remote Communication, Alstom EPA Computer (Publication N.1.6918 B), PSCN 3020 Bay Module: Integrated Digital Sub-station Control System, Architecture, Interface to SCADA, Local Control Point: Man-Machine Interface, SPACE 2000-System for Protection and Automatic Control.

**Reliability, Testing, and Maintenance for Numerical Relays**

Reliability, Software Considerations, Redundancy, Privatization and Deregulation of Electrical Industry, Protective Relaying Capabilities, Maintenance, Opto-electronic Sensors.
**Activity**-Scheduling Problems, Relay Testing.

**Module-3**
Digital protection: Digital protection of Transmission line, Synchronous Generator and power transformer.
**Activity-** Software design of transmission line, Filtering schemes of power transformer, Field visit of substation.

**Text Books :**

1. Fundamentals of Power System Protection", Y. G. Paithankar, S. R. Bhide, 2nd edition, Prentice Hall of India Private Limited, New Delhi, 2011.
2. Digital Protection, L.P Singh, New age International Publisher, 2nd Edition, 1997.

**Reference Books :**

1. Protective Relaying: Principles and Applications, Fourth Edition, By J. Lewis Blackburn, Thomas J. Domin, CRC Press, Taylor and Francies.
2. Power System Protection Static Relays by T S M Rao, 2nd edition, Tata McGraw-Hill Education, 2005.

## EE 4055 WIDE AREA MEASUREMENT SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the principles of computer relaying.
CO2. use digital filters in computer relaying.
CO3. describe in PMUs and its behavior under transient conditions.
CO4. apply phasor measurement in wide area measurement systems.
CO5. demonstrate on architecture of wide area measurement systems.
CO6. familiar with WAMS based protection concept.

**Prerequisites-Signals and System (EE 2022), Power System Protection (EE 3008)**

**Module-1: Computer Relaying**

**Introduction:**
Historical background, benefits, Computer relay architecture, Anti-aliasing filter, Substation computer hierarchy.
**Filters in computer relaying:**
Walsh functions, Discrete Fourier Transform, Random process, Filtering of random processes, Kalman filtering, Digital filters , Windows and windowing , Linear phase, Approximation-Filter synthesis , Wavelets, Elements of artificial intelligence.
**Activity-** Derive Fourier series and exponential Fourier series of different signals.

**Module-2: Phasor measurement systems**
**Representation of phasors:**
Introduction, DFT and Phasor representation, Phasors of Nominal Frequency Signals, Formulas for updating phasors- Nonrecursive updates and recursive updates, Frequency Estimation.
**Phasor Measurement Units:**
Introduction, A generic PMU, GPS, Hierarchy for phasor measurement systems, Functional requirements of PMUs and PDCs.
**Transient Response of Phasor Measurement Unit**
Nature of transient, TR of Instrument transformers and filters.
**Activity-** Transient response during electromagnetic transients and power swings

**Module-3: Phasor measurement applications and WAMS**
**Phasor measurement applications:**
Static state estimation , State estimation with Phasors measurements, Linear state estimation, Protection system with phasor inputs: Differential and distance protection of transmission lines
**Activity-** Adaptive protection, Adaptive out-of-step protection.
**Wide area measurement systems:**
Introduction, adaptive relaying, WAMS architecture, WAMS based protection concept.

**Text Books :**

1. A.G. Phadke, J.S. Thorp, "Computer Relaying for Power Systems", John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008.

**Reference Books :**

1. Antonello Monti , Carlo Muscas , Ferdinanda Ponci ,`` Phasor Measurement Units and Wide Area Monitoring Systems", Elsevier, 1st edition, 2016.
2. J. Lewis Blackburn , Thomas J. Domin, ``Protective Relaying: Principles and Applications", 4th Edition, 2014

## EE 4057 HARMONICS ELIMINATION TECHNIQUES Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the various terms related to harmonics and their standards.
CO2. analyze the causes of harmonic generation from electrical loads.
CO3. apply the signal processing techniques for assessment of harmonics.
CO4. analyze the effects of harmonics on different electrical components and systems.
CO5. understand the nature of harmonics with different techniques.
CO6. design filters for elimination of harmonics.

**Prerequisite: Power Electronics (EE 2026)**

**Module 1:**

**Introduction**
Definition- RMS value, average power, True power factor, K-factor, Phase Shift, Phase Sequence, Standards- factors influencing the development of standards, concept of THD, existing harmonic standards (IEC, IEEE), General harmonics indices.
**Causes of Harmonics**
Transformer magnetization, machines, Power electronics loads such as line- commutated converters- typical current waveforms and THD, Switched mode power supplies- typical current waveforms and THD, non-characteristic and inter-harmonics.
**Activity:** Sources and Generation of Harmonics in SMPS: typical current waveforms and THD.

**Module 2: Effect of Harmonics**
Resonance, nuisance tripping, blown capacitor fuses and capacitor cells, degradation of internal capacitance, motor and torque pulsations, overheating, overloading neutrals, telephone interference.
**Activity:** Harmonics effects to neutral overloading.

**Harmonic Measurement Methods:**
Field measurements using voltage and current transducers, concept of harmonic phase angle displacement, harmonic symmetrical components, harmonic instrumentation.

**Module 3: Harmonics Elimination:**
Passive filter design methods, tuned filters, analysis of different analytical techniques: FFT and DFT, concept of

multi pulse converter, PWM for harmonic elimination
**Activity:** Design of different tuned filters for harmonic elimination.

**Text Books :**

1. Arrillaga J. and Waston N.R., "Power System harmonics", Wiley Second Edition, U.S.A., 2003.
2. Prof. Mack Grady, " Understanding Power System harmonics";Dept of Electrical & Computer Engineering University of Texas at Austin , U.S.A., 2012.

**Reference Books :**

1. "Power Systems Harmonics" by George J. Wakileh, Springer, 2001.
2. F. Z. Peng, "Harmonic sources and filtering approaches," IEEE Ind. Appl. Mag., vol. 7, pp. 18–25, 2001.
3. Power Electronics Converter Harmonics: Multipulse Methods for Clean Power, Derek A. Paice, Wiley-IEEE Press, 1999.

## EE 4058 SMART ILLUMINATION TECHNOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the different lighting system.
CO2. understand the design of interior lighting system.
CO3. apply lighting system for outdoor applications
CO4. analyze the various criteria for the selection of lighting systems.
CO5. perform calculations on photo metric performance of light sources and luminaries for lighting design.
CO6. design various types of lighting systems.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Module 1: Introduction of Light**
Types of Illumination, Quality of good lighting, Factors affecting the lighting-shadow, Lighting schemes, Terminologies, Laws of Illumination, Concept of image by eyes and glare.
**Activity:** Day lighting, Supplementary artificial lighting and total lighting.

**Module 2: Design of Interior Lighting**
Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors affecting it, Illumination required for various work planes, Space to mounting height ratio, selection of lamp and luminance, selection of utilization factor, reflection factor and maintenance factor, Determination of lamp lumen output taking into account voltage and temperature variations, calculation of wattage of each lamp and no. of lamps needed, lux measurement.
**Activity:** Layout, calculation of space to mounting height ratio, measurement of light by photodiode and calibration using a lux meter.

**Module 3: Design of outdoor lighting**
Street lighting: types of street and their level of illumination required, terminologies, Various arrangements in street lighting, requirements of good street lighting, selection of lamp and luminaire, calculation of their wattage, number and arrangement, calculation of space to mounting height ratio, calculation of illumination level available on road.
**Activity:** Street lighting: Types of fixtures used and their suitable application

**Module 4 : Computer Aided Lighting System Design**
Optical design of luminaire, construction, software design of luminaire optics, Advanced interior lighting design calculations, CSP (Comfort, Satisfaction, Performance) index, Study of various types of sensors, software design on interior lighting, road lighting and flood lighting.
**Activity:** Software tools on lighting design.

**Text Books :**

1. Jack L. Lindsey, Applied Illumination Engineering , PHI, 1991
2. John Matthews, Introduction to the Design and Analysis of Building Electrical Systems, Springer, 1993

**Reference Books :**

1. V. V, Meshkov, Fundamentals of Illumination Engineering, Mir Publication, Russia, 2008
2. Ronald N. Helms & M Clay Belcher, Lighting for energy efficient luminous environments, Pentice Hall, 2012
3. "Lamps and Lighting", M.A. Cayless, Routledge, 1996

## EE 4059 SOLAR PHOTOVOLTAIC AND FUEL CELL Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. learn basics of solar insolation.
CO2. understand the energy potential of renewable sources.
CO3. analyze the solar PV systems.
CO4. develop engineering approach for designing a Solar energy system.
CO5. understand the Life cycle costing of solar and Fuel cell system.
CO6. design of PV and fuel cell for standalone system.

### Prerequisites: Power Electronics (EE 2026),Renewable Energy Sources (EE 3017)

**Module 1: Solar resources**

Extra-terrestrial solar radiation, Solar spectrum at the earth surface, sun-earth movement, Seasonal and daily variation, Estimation of solar radiation, Local Apparent Time.
**Activity:**Measurement of solar radiation, Effect of Tilt Angle.

**Module 2: Solar Photovoltaic (PV) System**

The Photo voltaic effect, PN junction, PV cell characteristics, equivalent circuits**,** limits of cell parameter, losses in a solar cell, solar cell design, Analytical techniques. Solar PV modules, Mismatch in series and parallel connection, Design and structure of PV Modules, PV Module power output. Tracking Systems, Maximum power point tracking (P&O).
**Activity:** Effect of variation of temperature, insolation level & tilt angle on PV and IV characteristics.

**Module 3: PV System Design**

Introduction to Solar PV systems, Stand-alone PV system configurations, Design methodology PV systems, Sizing of PV system, Hybrid systems, Grid-connected PV systems, Simple payback period, Life cycle costing(LCC), Technical performance index like CUF,PR.
**Activity:**Balance of system.

**Module 4: Fuel cells**

Fuel cell definition, Comparison between fuel cells, Solar cells and batteries, Energy and Power Density, components of fuel cells, principle of working of fuel cell. Performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, Tafel Equation and Nernst Equations. Types of Fuel Cells: Alkaline fuel cell (AFC), polymer electrolyte membrane fuel cell (PEMFC), phosphoric acid fuel cell (PAFC), Molten carbonate fuel cell (MCFC), Solid-oxide fuel cell (SOFC).
**Activity:** Advantages and disadvantages of fuel cell, Environmental impact (LCA).

**Text Books :**


1. Solar Photovoltaics Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Publication, 2013.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).


**Reference Books :**


1. Micheal Boxwell , "Solar Electricity Handbook", Green Stream publishing, 2010.
2. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, 4th Edition, 2000.
3. Hand Book of Fuel Cells - Fundamentals and Technology and Application, Wiley & Sons Publishers, 2009.


## EE 4060 DISTRIBUTION SYSTEM PLANNING AND AUTOMATION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the concept of distribution planning.
CO2. understand load forecasting techniques.
CO3. identify appropriate substation location.
CO4. evaluate a distribution system for a given geographical service area.
CO5. determine the location and optimum size of capacitor for distribution system.
CO6. understand the concept of distribution system automation.

**Prerequisite : Generation, Transmission and Distribution of Electric Power (EE 2024)**

**Module-1**
**Distribution System Planning:**
Introduction, Factors affecting system planning, Planning Models – Present and future, Role of computers.

**Load Characteristics:**
Definitions, Load forecasting, methods of forecast, regression analysis, correlation analysis and time series analysis, Load management, tariffs and metering of energy.
**Sub transmission Lines and Distribution Substations:**
Sub transmission, distribution substations, Bus schemes, comparison of four and six feeder patterns, Substation location and rating.
**Activity-** Simulation of Load forecasting using ANN.

**Module-2**
**Design considerations of Primary Systems:** Types of feeders , voltage levels , radial feeder.
**Design considerations of Secondary Systems:** Secondary voltage levels, Secondary banking, Secondary network, spot network.
**Voltage Drop And Power Loss Calculations**: Three phase balanced primary lines, non three phase primary lines, Copper loss , Method to analyze distribution costs.
**Capacitors In Distribution Systems**: Effects of series and shunt capacitors, justification for capacitors, Procedure to determine optimum capacitor size and location.
**Activity-** Calculation of loss reduction and Voltage improvement in rural networks.

**Module-3**
**Distribution System Automation:**
Reforms in power sector, Methods of improvement, Reconfiguration, Reinforcement, Automation, Communication systems, Sensors, Automation systems, Basic architecture of Distribution automation system, software and open architecture, RTU and Data communication , SCADA requirement and application functions, GIS/GPS based mapping of Distribution networks, Communication protocols for Distribution systems , Integrated sub, station metering system , Revenue improvement , issues in multi–year tariff and availability based tariff.
**Activity-** Design a distribution system architecture in SCADA and Time synchronization with GPS clock.

**Text Books :**

1. Turan Gonen : Electric Power Distribution Engg., Mc-Graw Hill,1986.
2. A. S. Pabla : Electric Power Distribution, TMH, 2000.

**Reference books :**

1. **Shahnia**, Farhad, **Arefi**, Ali, **Ledwich**, ``Electric Distribution Network Planning",2018,Springer Nature Singapore Pte Ltd.
2. James Northcote-Green , Robert G. Wilson, ``Control and Automation of Electrical Power Distribution Systems", 1st Edition, September 22,2006 , Taylor and Francis Publisher

## EE 4061 SENSORS FOR ENGINEERING APPLICATIONS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the effect and application of strain gauge in sensors.
CO2. describe the measurement techniques of strain gauge for sensors and transducers.
CO3. analyze different motion sensors and their application.
CO4. demonstrate the effect of light radiation in sensor technology and application.
CO5. apply heat and temperature sensors.
CO6. use of sensors in electrical and non-electrical parameter measurement.

**Prerequisite:Electrical and Electronics Measurement (EE 2019)**

**Module 1: STRAIN AND PRESSURE MEASUREMENT**
Resistance strain gauge, piezoelectric pressure gauge, characteristics. Electronic circuits for strain gauge, load cells, Interferometer, fibre-optic methods. Pressure gauge: Aneroid capacitance pressure gauge, ionization gauge using transducers for applications.
**Activity:** Mathematical analysis of strain gauge.

**MOTION SENSORS:**
Capacitor plate sensor, inductive sensor, LDVT Accelerometer systems, rotation sensors, drag cup devices, piezoelectric devices, Rotary encoders.
**Activity:** Applications of motion sensors.

**Module 2: LIGHT RADIATION**
Color temperature light flux, photo sensors, photomultiplier, photo resistor and photoconductors, photodiodes, phototransistors, photovoltaic devices, fiber-optic applications, light transducer, solid –state transducers, liquid crystal devices.
**Activity:** Applications of Photo diodes and Photo transistors for control of power circuit.

**HEAT AND TEMPERATURE:**
Bimetallic strip, Bourdon temperature gauge, thermocouples, Resistance thermometers, thermostats, PTC thermistors, bolometer, Pyroelectric detector.
**Activity:** Use of thermostat in domestic washing machine.

**Module 3:**
**ELECTRONIC SENSORS**: Proximity detectors- inductive and capacitive, Ultrasonic photo beam detectors, Reed switch, magnet and Hall–effect units, Doppler detectors, liquid level detectors, flow sensors, smoke sensors.
**Activity:** Hall Effect sensors and its uses.

**Text Books :**

1. Doebelin E O," Measurement Systems, Application and Design", McGraw Hill, Fifth Edition, 2004.
2. Ian R Sinclair, "Sensors and transducers", Third Edition, Newness Publishers , 2001.

**References Books :**

1. Jack P Holman, “Experimental Methods for Engineers”, Seventh Edition, McGraw Hill, USA, 2001.
2. Robert G Seippel, “Transducers, Sensors and detectors”, Reston Publishing Company, USA, 1983.

## EE 4062 DISTRIBUTED GENERATION AND MICROGRID Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know about the different renewable energy sources.
CO2. implement distributed generation in power system.
CO3. understand the impact of grid integration.
CO4 know the concept and operation of micro grid system.
CO5. demonstrate the communication infrastructure related to micro grid.
CO6. analyze the power quality issues related to micro grid.

**Prerequisites: Power Electronics (EE-2026), Generation, transmission and Distribution of Electrical power(EE 2024).**

**Module 1**
**Introduction:**
Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems.
**Activity-**Fuel Cells, micro-turbines, biomass, and tidal sources.

**Module 2**
**Distributed Generations (DG):**
Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations.

**Impact of Grid Integration:**
Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, is-landing issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.
**Activity-**Energy storage elements: Batteries, ultra-capacitors, flywheels, Captive power plants.

**Module 3:**
**Micro grids:**
Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro-grids, Power Electronics interfaces in DC and AC micro grids, communication infrastructure, modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues.

**Power Quality Issues In Micro grids:**
Power quality issues in microgrids-Modelling and Stability analysis of Micro grid, regulatory standards, Micro grid economics, Introduction to smart micro grids.
**Activity-**Anti-islanding schemes: passive, active and communication based techniques.

**Text Books :**

1. Gevork B. Gharehpetian S. Mohammad Mousavi Agah ‘Distributed Generation Systems’ ,1st Edition, 2017.
2. Pat Wheeler ,Frede Blaabjerg,"DC Distribution Systems and Microgrids",Publisher Institution of Engineering and Technology, 2018

**Reference Books :**

1. M.S Mahmoud“ Microgrid advanced control method and Renewable energy system integration”,BH Publication, 2016.
2. Gevork B.Gharehpetian, S.Mohammad Mousavi Agah “Distributed Generation Systems”,1st Edition, Elsevier Publication,2017.

## EE 4063 PROCESS INSTRUMENTATION AND CONTROL Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. understand characteristics of batch and continuous process.
CO2. understand significance of process parameters in industrial processes.
CO3. measure process parameters by using different techniques.
CO4. analyze different control techniques for process control.
CO5. tune the control parameters of developed controller.
CO6 . embed intelligent methods in different industrial applications.

### Prerequisites: Basic Electrical Engineering (EE 1003), Linear Control System (EE 2028)

**Module 1: Process characteristics**
Various process schemes / unit operations, batch and continuous process –differences and characteristics. Description and characteristics like large time constants, time lag etc. of a few processes, such as, heat exchangers, furnaces, boilers and condensers, distillation columns, absorbers, reactors.
**Activity:** Measurement of process parameters for Mineral Processing industries –pH and blending processes.

**Module-2: Measurement of process parameters**
Radio isotope and ultrasonic methods of Instrumentation and its applications in process industries, Measurement and transmission of process parameters like flow, pressure, level and temperature –invasive and noninvasive techniques.
**Activity:** Imaging technique of measurement.

**Module-3: Process control methods and control action generation**
Different control techniques and interaction of process parameters –On – off control, feed forward, Cascade, Ratio, Override controls, Multivariable control, Optimal control, Adaptive control, Three term controller as the basic controller, Means of generation of control actions using electronic and pneumatic components, Digital P-I-D controller –scheme and simulation.

**Controller tuning :**
Tuning of controllers –Zeigler Nichols, Cohen Coon and other methods.

**Final control elements:**
Control valves, valve positioners, torque motors, step motors.

**Computer control of processes:**
Supervisory control, Direct digital control (DDC).
**Activity:** Implementation of distributed computer control for Industrial Process Control.

**Reference Books:**
1. Harriot, Process Control, TMH, New Delhi
2. Patranabis, D. Principles of Process control, TMH, New Delhi
3. Coughnower and Koppel Process system Analysis and Control .Mc Graw hill
4. Smith , L. Digital Computer process control .intext Education Publishers, 1972
5. Franklin Digital control of dynamic systems .3rd Edition Pearson, 2003
6. Johnson, C. Process control instrumentation technology, PHI, New Delhi

## EE 4064 ADVANCED POWER CONVERTERS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand the working principle, control and application of multilevel inverters.
CO2. know the various PWM techniques of multilevel inverters.
CO3. analyze the equivalent circuits, operating principle and control of Z-Source Inverters.
CO4. learn the equivalent circuits, operating principle and control of direct matrix converter, indirect matrix converter.
CO5. understand various Modulation Techniques for direct matrix converter and indirect matrix converter topology.
CO6. design Multilevel inverters, ZSI, matrix converter for industrial applications.

### Prerequisite: Power Electronics (EE 2026)

**Module 1: Multilevel Inverters**
Introduction; floating capacitor MLI, Diode-Clamped Multilevel Inverters; Capacitor-Clamped Multilevel Inverters; Multilevel Inverters Using H-Bridges (HBs) Converters- Cascaded Equal Voltage Multilevel Inverters (CEMI), Binary Hybrid Multilevel Inverter (BHMI), Trinary Hybrid Multilevel Inverter (THMI); Different PWM techniques for multilevel Inverters: POD, APOD and PD PWM techniques, Fundamental Frequency switching scheme.
**Activity:** Methods for Determination of Switching Angle: Half-Height (HH) Method.

**Module 2: Z-source Inverters**
Introduction; Equivalent Circuits of ZSI, Operating Principle; Circuit Analysis and Output Voltage, Control of ZSI-Simple Boost Control, Maximum Boost Control.
**Activity:** Control of ZSI- Maximum Boost Control with Third Harmonic Injection.

**Module 3: Matrix converters**
Introduction; Conventional (Standard) Inverter Based AC/DC/AC Converter Topology,Direct Matrix Converter Topology,Commutation Difficulties of the Direct Matrix Converter, Current and Voltage Commutation Methods, Modulation Technique for Direct Matrix Converter, Indirect Matrix Converter Topology.
**Activity:** Modulation Techniques of Indirect Matrix Converter Topology.

**Module 4: Application of converters**
Industrial applications of multilevel inverters, Application of ZSI in solar PV system, Application of matrix converter in wind energy conversion system.
**Activity:** Application of MLI and matrix converters in distributed energy system.

**Text Books :**


1. F. L. Luo and H. Ye, Advanced DC/AC inverters application in renewable energy, Boca Raton, FL: CRC press: Taylor and Francis, 2013
2. Elements of Power Electronics, by Philip T. Krein, Oxford University Press, 25 Sept 1997.
3. Power Electronics, Converters, Applications and Design, by N. Mohan, Underland and Robbins, John Wiely and Sons, 3rd Edition,2011.


**Reference Books :**


1. Bin Wu, High Power Converters and AC Drives,Publisher : John Willey & sons, second edition, 2017.
2. Power Electronics Converter Harmonics: Multipulse Methods for Clean Power, Derek A. Paice, Wiley-IEEE Press, 1999.

## EE 4065 COMPONENTS OF INDUSTRIAL AUTOMATION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. understand various applications of digital and analogue signals.
CO2. learn working principle of various types of Sensors, Actuators & Controllers.
CO3. analyze data acquisition system, serial Interfacing and signal conditioning process.
CO4. demonstrate architecture of industrial network orientation.
CO5. analyze the significance of different motors and input-output modules in industrial automation system.
CO6. design and Tune controller for Industrial Application.

### Prerequisite: Signals and System (EE 2022)

**Module 1: Signals & Conversion**
Digital and Analog Signals, Signal Sampling Process, Analog to Digital Conversion.
**Activity:** Sampling Theory

**Module 2: Industrial Electronics Controller**
Relays Contractors and Switches, Thermistor, RTD, LVDT, Synchro, Load Cells, Indicators, electronic controllers like Timers, Counters and PID type Temperature Controllers, two wire, three wire Sensors, inductive, capacitive, optical etc, Sensors and transducers, Interfacing signal conditioning, Signal analysis techniques, Networking methods and their applications in instrumentation.
**Activity:** Mathematical analysis of Strain guage.

**Module 3: Data Acquisition Methods and Communication System**
DAQ hardware, Instrumentation buses, IEEE 488.I and IEEE 488.2, Serial interfacing-RS 232C, RS 422, RS 423, RS 485, CAMAC, VXI, SCXI, PXI, Characteristic features of industrial networks, Low level networks and their features, Field bus architecture: Performance aspects of Industrial Automation Systems.
**Activity:** Various protocols of serial and parallel interfacing.

**Module 4: Industrial Automation and Control**
Structure & components Industrial Automation systems, Architectural levels of Industrial controls, Servomotors, Stepper motors, Process I/O systems. Local & remote I/O systems, Different types of controllers, Single loop and Multi-loop controllers and their tuning, Direct controllers and their tuning, Direct Digital Controllers, Software implementation of Multi-loop Controllers, Distributed Control Systems.
**Activity:** Comparison between push button, Toggle switch, Proximity switch, Principle of reactance motor.

**Text Books :**

1. Computer-Based Industrial Control, Krishna Kant, 2nd Edition, PHI
2. Fundamentals of Industrial Instrumentation and Process Control, W. C. Dunn, TMH, 2009.

**Reference Book :**

1. Modern Automation System, M. Abdelati, University Science Press, 2009.

## EE 4066 WIND AND BIOMASS Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. learn wind power and biomass potential at a particular location.
CO2. understand Government policies for Wind energy.
CO3. apply the Wind Energy Conversion System (WECS).
CO4. use of generators and variable speed drive for WECS.
CO5. demonstrate the benefits of Biomass energy.
CO6. create a report on the environmental and social impacts of Wind and Biomass power.

**Prerequisite: Transformers & Induction Motors (EE 2017)**

**Module 1: Introduction of Wind Energy**
Overview of Wind power in India, Speed and power relation, Power extracted from the wind, rotor-swept area, air density, Global wind patterns and wind speed distribution.
**Activity:** State Government Policy for Wind Power Project Investment.

**Module 2: Wind power Systems**
Components of Wind Energy Conversion System- Turbine rating, Power vs. speed and Tip Speed Ratio, Maximum energy capture, Maximum Power Operation, Wind turbine blades aerodynamic design, System design trade-offs, system control requirement.
**Activity:** Environmental aspects, IEC Standards for Wind Turbines.

**Module 3: Electrical Generators and Drives**
Electrical Generators for Wind Energy Conversion System, Self-Excited Induction Generator and Doubly Fed Induction Generator operation, Speed control regions, Generator drives: Fixed and variable speed drives, Drive selection, cut-out speed selection.
**Activity:** Issues related to Stand alone and grid connected WECS in various countrie

**Module 4 : Bio energy**
Biomass as energy resource: Bio fuels, classification, Biomass conversion technologies: Physical Method, Thermal conversion: pyrolysis, gasification and liquefaction, Types of Gasifiers, Classification of biogas plants, biogas digester and types.
**Activity:** Energy potentials of Biomass and its environmental and social impacts.

**Text Books :**
1. Wind and Solar Power system by Mukund R Patel, CRC Publication, 2005.
2. Donald L. K., “Biomass for Renewable Energy, Fuels and Chemicals”, Academic press, Elsevier, 2003.

**Reference Books :**
1. B. H. Khan, “Non – Conventional Energy Resources” Tata Mc Graw Hill, 2nd edition, 2009.
2. Wind Electrical Systems by S.N. Bhadra, D. Kastha, S. Banerjee, Oxford Higher Education, 2005.

## EE 4067 SPECIAL MACHINES AND SMART INVERTER Cr-3

**Course outcomes :** At the end of the course, the students will be able to :

CO1. understand the operation of different special machines.
CO2. select different special machines as part of control system components.
CO3. use special machines as transducers for converting physical signals into electrical signals.
CO4. design digital controllers for different machines.
CO5. extend these fundamental principles into a way of thinking for problem solving in real time applications.
CO6. select Smart Inverters Selection and Sizing for Grid Connection and Off Grid.

**Prerequisites: Basic Electrical Engineering (EE 1003), Analog Electronic Circuits (EE 2013)**

**UNIT1:**
Stepper Motors:Introduction-synchronous inductor (or hybrid stepper motor), Hybrid stepping motor, construction, principles of operation, energization with two phase at a time- essential conditions for the satisfactory operation of a 2-phase hybrid step motor – very slow – speed synchronous motor for servo control-different configurations for switching the phase windings-control circuits for stepping motors-an open-loop controller for a 2-phase stepping motor.

**UNIT2:**
Linear Induction Motor:Development of a double-sided LIM from rotary type IM- A schematic of LIM drive for electric traction development of one-sided LIM with back iron-field analysis of a DSLIM fundamental assumptions.

**UNIT3:**
Synchronous Motors:Construction- Principle of operation of Permanent Magnet Synchronous Motors – EMF and torque equations – Starting – Rotor configurations –Dynamic model, Synchronous Reluctance Motors: Constructional features–axial and radial flux motors – operating principle – characteristics.

**UNIT4:**
Smart Inverters: Types of solar inverter, Selection of string /central / off grid inverter, Selection of power conditioning unit (PCU), Sizing of solar inverter for roof top and grid connected projects, Passive and active protection, Anti- islanding protection, Mounting arrangement of string inverter, IEC/IEEE /Grid Compliance of inverters, Grid-Connected Inverters vs. Stand-Alone Inverters, Inverter Communication and remote monitoring, Inverter Products For Use In India.

**Text Books:**

1. Miller, T. J. E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989.
2. Kenjo, T., and Sugawara, A., Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 1984.


**Reference Books:**

3. Krishnan, R., Electric Motor Drives: Modeling, Analysis, and Control. Prentice Hall, (2001).
4. Krishnan, R., “Permanent Magnet and BLDC Motor Drives”, CRC Press, 2009.
5. Chang-liang, X., "Permanent Magnet Brushless DC Motor Drives and Controls", Jun 2012.


## EE 4068 STATE ESTIMATION AND SECURITY Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. develop mathematical models for analysis of linear and non–linear State Estimation.
CO2. identify the strategic locations to analyze the state of the system.
CO3. demonstrate observability and bad data detection techniques from a measurement.
CO4. apply PMU in state estimation.
CO5. solve contingency analysis of any practical Power System.
CO6. identify the most appropriate algorithm for security of a system.

### Prerequisite: Power System Operation and Control (EE 3002)

**Module-1**
**State estimation** : Introduction to real time control of power system, Energy control center, security analysis and monitoring, Introduction to State Estimation (SE) in power systems: Maximum likelihood Weighted Least Square (WLS) Estimation SE. SE of AC networks. Types of measurements – linear WLS–SE theory – DC load flow based WLS–SE – linearized model of WLS–SE of non–linear AC power systems – sequential and non–sequential methods to process measurements.
**Activity:** Show the results of SE on an AC network, DC network by MATLAB/ MiPower/ Powerworld.

**Module-2**
**Network Observability and bad data detection**: Network Observability and Pseudo–measurements, Observability analysis for branch variable formulation, observability by Graphical technique and Triangularisation approach, network topology processing, topological observability and its algorithm. Bad data detection in WLS method, chi square test, identification of bad data: method of normalized residual and test, application of PMU in state estimation, linear measurement model with PMU’s, phasor measurements in dynamic state estimation, PMU placement to detect topology errors and bad data detection.

**Activity:** Measurement model using branch variables, Network configuration, detection and identification of topology errors, Hypothesis testing identification, case study for improved bad data processing with strategic placement of PMUs.

**Module-3**

**Power System Security:** Introduction, Factors affecting power system security, Contingency analysis, Detection of network problems, Linear sensitivity analysis, AC power flow methods contingency selection, concentric relaxation, Bounding area method.

**Activity:** Calculation of Network sensitivity factor, Generator sensitivity factor using MATLAB.

**Text Books :**

1. Allen J. Wood and Bruce Woolenberg: Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. Power system state estimation by Mukhtar Ahmad, Artech House, 2013.

**Reference Books :**

1. John J. Grainger and William D Stevenson Jr.: Power System Analysis, McGraw Hill ISE, 1994.
2. IEEE Proc. July 1974, Special Issue on Computer Control of Power Systems.

## EE 4069 VEHICLE CHARGING TECHNOLOGY Cr-3

**Course Outcomes:** At the end of the course, students will be able to:

CO1. understand the basics of Electric Vehicles and its charging
CO2. realize the various components required in EV charging
CO3. demonstrate the types of charging and their modes.
CO4. analyze the proper selection and sizing of charging components and connectors.
CO5. realize the necessary charging standard and process of commissioning.
CO6. design the charging station for EVs and HEVs.

**Prerequisites: Basic Electrical Engineering (EE 1003), Chemistry (CH 1007)**

**UNIT 1:**

Introduction: History of EV, Components of Electric Vehicle, EV classification and their electrification levels, Types of EV Chargers-Charging Equipment's, Basic charging Block Diagram of Charger, Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging, Inboard and off board charger specification, Types of Mode of charger Mode -2 , Mode-3 and Mode-4, Wireless Charging: static charging and dynamic charging.

**UNIT 2:**

Selection and sizing of fast and slow charger (AC & DC)-AC Pile Charger, DC Pile Charger, EVSE Power Module selection and technical specification, Selection of EVSE Communication Protocol (PLC / Ethernet / Modbus/ CAN Module ), Communication gateway, Specification of open charge point protocol (OCCP 1.6/2.0), Bharat DC001 & AC001 Charger specification, Communication Interface between charger and CMS ( central management system).

**UNIT 3:**

Selection and sizing of Common types of connectors and applications;Selection of AC charger type-1 , type -2 and type -3, Communication between AC charger and EV, Selection of DC charger connector GB/T, CHAdeMO , CCS-1 and CSS-2, Communication methodology of DC fast chargers, IS/ IEC/ARAI/ standard of Charging topology ,Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2 ), Selection sizing of Charger connector cable.

**UNIT 4:**

Public Charging infrastructure- Preparation of EV Charger Single Line Diagram, Assessment of site Location for Public charging station, Selection and Sizing of: Distribution transformer, HT Equipment ( VCB , CT , PT , Metering ), HT Cables and LT cables, Selection and sizing of Distribution Board / feeders, Sizing calculation of LT and HT cable, Selection and of Compact Substation (CSS for EV CS).

**Text Books:**

1. Chris Mi, M. AbulMasrur, David WenzhongGao, Hybrid Electric Vehicles Principles And Applications With Practical Perspectives, Wiley Publication, 2011.
2. C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, OXFORD University Press, 2001

**Reference Books**

3. M. Ehsani, Y. Gao, S. Gay and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, CRC Press, 2005.

## EE 4070 SMART GRID TECHNOLOGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the different elements of smart grid.
CO2. demonstrate on Smart Grid Architecture.
CO3. describe in Synchro Phasor Measurement Unit.
CO4. understand the wide area monitoring system of smart grid.
CO5. solve the load flow analysis in micro grid.
CO6. control of the voltage and reactive power in smart grid.

**Prerequisites : Power System Operation and Control (EE 3002), Renewable Energy Sources (EE 3017)**

**Module 1:**
**Introduction to Smart Grid:**
Definition of smart grid, Components and architecture of smart grid design, Review of the proposed architectures for smart grid, The fundamental components of smart grid designs, Transmission automation, Distribution automation, Renewable integration.
**Activity:** Comparison of Conventional grid and Smart grid, Smart grid architecture design and function of its components.

**Module 2:**
**Tools and Techniques for Smart Grid:**
Synchro Phasor Measurement Units (PMUs), Computational intelligence techniques, Distribution Generation Technologies

**Communication Technologies and Smart Grid:**
Computational techniques, Static and dynamic optimization techniques, Introduction to communication technology, Evolutionary algorithms, Artificial intelligence techniques.
**Activity:** Computational techniques, Computational intelligence techniques, Wide Area Monitoring System (WAMS), Phasor Measurement Units (PMU)

**Module 3:**
**Control of Smart Power Grid System:**
Load Frequency Control (LFC) in micro grid system, Voltage control in micro gridsystem, Reactive power control in smart grid, Case studies and test beds for the smart grids.
**Activity:** Smart grid and Microgrid comparison,

**Text Books :**

1. James Momoh, "SMART GRID, Fundamentals of Design and Analysis" IEEE press, 2013.

2. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer Edition, 2010

**Reference Books :**

1. Gil Masters, "Renewable and Efficient Electric Power System", Wiley–IEEE Press, 2004.
2. T. Ackermann, "Wind Power in Power Systems", Hoboken, NJ, USA, John Wiley, 2005.
3. Clark W Gellings P.E. "The Smart Grid enabling energy efficiency and demand response", CRC Press, 2013.
4. Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 2013.

## EE 4071 IoT in Electric Vehicles Cr-3

**Course Outcomes (CO):** At the end of the course, the students will be able to

CO1. identify the components of IoT.
CO2. analyze various protocols of internet.
CO3. study for various IoT networking techniques and cloud.
CO4. know the Security and Privacy in IoT.
CO5. realize for interconnected vehicle technology.
CO6. implement of IoT in Electric Vehicles.

**Prerequisites: Special Machines, Drives and Smart Inverter (EE 4067)and Computer Programming (CS 1093).**

**UNIT 1:**

Introduction: Definition, Components in the internet of things, Sensing and Actuation Anywhere, Anytime, Genesis of the Internet of Things, Power Sources, Internet Principles, sensor types and properties, different transducers and actuators,Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports.

**UNIT 2:**

IoTProtocols: MQTT,XMPP,CoAP,IEEE802.15.4,ZigBee,LORA,RFID,Client Server Model, HTTP, Thingspeak, AWS, CloudMQTT.

**UNIT 3:**

IoT Security: network and transport layer challenges, IoT Gateways, IoT Routing attacks, Fog computing, IoT Fog.

**UNIT 4:**

Connected vehicle with IoT: Levels of operations, vehicle to everything, V2X paradox, VANETs, Information centric networks, CCN for VANET, three layered architecture, intelligent connected vehicles.

**UNIT 5:**

Use cases: Charging management system(CMS), smart charging, Block-chain IoT for interconnected vehicle, transportation management system, logistic management system.

**Text Books:**

1) Precision: Principles, Practices and Solutions for the Internet of Things,Timothy Chou, TMH.
2) Designing the Internet of Things”, Adrian McEwen, Hakim Cassimally, Wiley publication, 1st Edition, November 2013.
3) The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, Ramamurthy, A. and Jain, P, 2017.

**Reference Books:**

**4)** The Internet of Things: A Survey, Journal on Networks, Luigi Atzori, Antonio Lera, Giacomo Morabito, Elsevier Publications, October, 2010.

5) The Internet of Things in the Cloud:A Middleware Perspective, Honbo Zhou, CRC Press-2012.
6) Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Springer, 2011.

## EE 4072 GRID INTEGRATION AND CONTROL Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the power quality issues in distributed power generation systems.
CO2. understand the basic idea of Instantaneous Power Theory.
CO3. analyze different Grid Synchronization structures and control techniques.
CO4. understand the design criteria for different passive and active filters used for grid connected converters.
CO5. compare different faults in grid.
CO6. know the synchronization of power converters under grid fault conditions.

### Pre-requisites: Power Electronics (EE 2026),Linear Control System (EE2028)

**Module 1: Overview of Power Quality and International Regulations**
Active and reactive power in electric system, voltage sag, voltage swell, unbalanced voltage, notch, harmonic distortion, frequency deviations, Abnormal Grid Conditions.
International Regulations, concept voltage ride through.
**Activity:** International standards for power quality.

**Module 2: The Instantaneous Power Theory**
The Clarke Transformation, concept of the p-q theory, p-q theory in three phase three wire systems.
**Activity:** Implementation of p-q theory in three phase four wire systems.

**Module 3: Grid Synchronization of three phase systems**
Grid Synchronization Techniques: Zero crossing detection Technique, Phase-Locked Loop.
Control structures for distributed generation system: Synchronously rotating reference frame control structure, Stationary reference frame control structure, Natural reference frame control structure.
**Activity:** Grid Synchronization based on Delayed Signal Cancellation (DSC) technique.

**Module 4: Grid Filter Design**
Passive tuned filters, Passive high-pass filters, shunt and series active power filters, STATCOM for reactive power compensation.
**Activity:** Comparison of passive and active filters.

**Module 5: Grid Synchronization of Power Converters under Grid Faults**
Symmetrical and unsymmetrical grid faults, Synchronous Reference Frame based PLL (SRF-PLL), SOGI-PNSC based grid synchronization technique under grid fault.
**Activity:** Performance comparison of different existing grid synchronization techniques under unbalanced and distorted grid fault condition.

**Text Books :**

1. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, Wiley Int. Jan 2011.
2. Hirofumi Akagi, Edson HirokazWatanable , Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning , Wiley- IEEE Press , Feb 2007.

**Reference Books :**

1. Robert W Erickson and Dragan Maksimovic , Fundamentals of Power Electronics, 2nd Ed, Springer (India) Pvt. Ltd. 2005.
2. Wind Power Plants and Project Development by Joshua Earnest, Tore Wizelius, Second Edition, PHI Publication, 2015.
3. F. Gardner, Phaselock Techniques, New York, NY, USA: Wiley, 2005.
4. M. H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions. IEEE Press, 2002.

## EE 4073 IoT in INDUSTRY Cr- 3

**Course Outcomes (CO):** At the end of the course, the students will be able to :

CO1. identify the components of IoT and Industrial IoT.
CO2. analyze various protocols of IoT.
CO3. apply internet of things in Industry.
CO4. understand the Security and Privacy in IoT.
CO5. understand the Create building blocks of IoT.
CO6. apply various use cases of IoT.

**Prerequisites: Electrical Circuits Analysis (EE 2015), Analog Electronic Circuit (EE 2013)and Computer Programming (CS 1093)**

**UNIT1:**
**Introduction:** Definition, Components in internet of things, Sensing and Actuation Anywhere, Anytime, Genesis of the Internet of Things, Power Sources, Internet Principles, Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports.

**UNIT2:**
**Smart Industry:**Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories,Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artical Intelligence, Big Data and Advanced Analysis.

**UNIT3:**
**Architecture:** Industrial Processes,Industrial Sensing & Actuation, Industrial Internet Systems.Business Model and Referece Architerture,IoT Reference Architecture, Industrial IoT- Layers,Sensing, IoT Processing,IoT Communication.

**UNIT4:**
**Security:** Security and Fog Computing,Fog Computing in IoT.

**UNIT5:**
**Application Domains:** Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries.

**Text Books:**
1. “Designing the Internet of Things”, Adrian McEwen, Hakim Cassimally, Wiley publication, 1st Edition, November 2013.
2. The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, Ramamurthy, A. and Jain, P, 2017.

**Reference Books:**
1. “The Internet of Things: A Survey”, Journal on Networks, Luigi Atzori, Antonio Lera, Giacomo Morabito, Elsevier Publications, October, 2010.
2. "The Internet of Things in the Cloud:A Middleware Perspective”, Honbo Zhou, CRC Press-2012.
3. “Architecting the Internet of Things”, Dieter Uckelmann, Mark Harrison, Springer, 2011.

## EE 4074 SMALL HYDRO POWER AND TIDAL ENERGY Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. know the basic characteristics of Hydro, Tidal and Geothermal Energy systems.
CO2. understand the components of Hydropower plant.

CO3. apply the knowledge in selecting the turbine according to site conditions.
CO4. demonstrate the basic components of Tidal and geothermal Energy systems.
CO5. reflect the scope of Hydro, Tidal and geothermal energy systems.
CO6. prepare a report of possible locations of SHP and Tidal energy around the globe.

### Prerequisite: Generation, Transmission and Distribution of Electrical Power (EE 2024)

**Module1: Basic working principle**
Classification of Hydroelectric power plants: Large, small, mini, micro - Energy equation, Numerical problems. Tidal power, mean extractable power, Numerical problems, Introduction to geothermal energy, Selection of Sites.
**Activity:**Measurement of head and flow, Hydrological cycle and Hydrographs.

**Module2 : Classification and components of hydro power plant**
Turbine Size, Types of Hydraulic turbines, Pelton Wheel, Francis Turbine, Propeller and Kaplan Turbines, Bulb Turbine, Specific Speed, Selection of turbines, Spillways, Surge Tanks, Water Hammer, Draft Tube, Schemes of Hydro Plants, Run-of-River Plants, Valley Dam Plants, High Head Diversion Plants, Pumped Storage Plants.
**Activity:**Small hydro power (SHP) development in India, Small hydro power plant design including financial aspects.

**Module 3: Tidal energy**
Introduction to tidal energy, Tidal characteristics, Tidal range, Components of tidal Power plant, Types of tidal power plants- single basin single effect plant, Single basin double effect plant, Double basin double effect plants, and tidal energy estimation.
**Activity:**Advantages and limitations of tidal power.

**Module 4: Geothermal energy**
Nature of geothermal Fields, Hydrothermal (Convective) resources, and Geothermal power generation- Liquid dominated and Vapour dominated geothermal electric power plants.
**Activity:**Limitations and future scope of geothermal power plants.

**Text Books:**

1. Nag P.K., “Power Plant Engineering” Tata McGraw Hill, 2nd Edition, $4^{th}$ Fourth Reprint,2003.
2. Ocean Energy: Tidal and Tidal power- R.H. Charlier, Springer, 2009.


**Reference Books:**

1. Small hydroelectric engineering practice- Bryan Leyland, CRC Press,2014.
2. Harvey, A., Brown, A. and Hettiarachi, P., “Micro Hydro Design Manual”, Intermediate Technologym,1993.
3. GD Rai, “Non-Conventional Energy” Khanna publication, 2011.


## EE 4075 IoT SENSORS AND PROTOCOLS Cr-3

**Course Outcomes (CO):** At the end of the course, the students will be able to
CO1. Identify the components of IoT sensors.
CO2. Analyze various types of actuators for IoT applications.
CO3. Understanding Various Protocols applied in internet of things.
CO4. Understanding the Security and Privacy in IoT.
CO5. Demonstrate an embedded development platform.
CO6. Understanding Devices and Cloud collaboration Framework.

**Prerequisites: Sensors for Engineering Applications (EE 4061) and Computer Programming (CS 1093)**

**UNIT 1**
Introduction to Sensor: sensor types and properties, different transducers and actuators, IoT sensors :Temperature sensors, Proximity sensor, Pressure sensor, Water quality sensor, Gas sensor, Smoke sensor, IR sensors, Level sensors, Image sensors, Motion detection sensors, Accelerometer sensors, Gyroscope sensors, Humidity sensors, Optical sensors.

**UNIT 2**
Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports.

**UNIT 3**
IoT Protocols: MQTT,XMPP,CoAP,IEEE802.15.4,ZigBee,LORA,RFID.

**UNIT 4**
Advanced Embedded Development Platforms: System on Chip (SoC), ARM®, Raspberry Pi, Evolution of Pi and technical specification comparative study, GPIO Interfacing Cloud, Analytics & UI, Client Server Model, HTTP, Thingspeak, AWS, CloudMQTT.

**UNIT 5**
IoT Security: network and transport layer challenges, IoT Gateways, IoT Routing attacks.

**Text Books:**

1. Internet of Things Principles and Paradigms, Rajkumar Buyya & Amir Vahid Dastjerdi,Elsevier.
2. Designing the Internet of Things, Adrian McEwen, Hakim Cassimally, Wiley publication, 1st Edition, November 2013.
3.The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, Ramamurthy, A. and Jain, P, 2017.

**Reference Books:**

1. The Internet of Things: A Survey, Journal on Networks, Luigi Atzori, Antonio Lera, Giacomo Morabito, Elsevier Publications, October, 2010.
2. The Internet of Things in the Cloud:A Middleware Perspective, Honbo Zhou, CRC Press-2012.
3. Architecting the Internet of Things", Dieter Uckelmann, Mark Harrison, Springer, 2011.

# ELECTRONICS
# &
# TELECOMMUNICATION
# ENGINEERING

# B. TECH IN ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## Program Educational Objectives (PEOs):

The B. Tech program in Electronics and Telecommunication Engineering aims to prepare the graduates with the following objectives:

1. The graduates shall be able to provide to solutions to Electronics and Telecommunication engineering problems and allied areas involving electronic system design, communication network operation and management issues.
2. The graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical and multidisciplinary contexts.
3. The graduates shall demonstrate professional and ethical responsibilities and thrive to reinforce their knowledge being a part of higher educational programs.

## Program Outcomes (POs) :

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs)

The program specific outcomes are:

m) Ability to design and implement electronic circuits, signal processing and communication systems in industry.
n) Ability to carry out research in fields of embedded systems, wireless and high speed communication, and advanced signal processing.
o) Ability to utilize the knowledge in solving practical problems in real li

## EC 1004 ANALOG ELECTRONIC CIRCUITS Cr-3

**Course outcomes :** At the end of the course, the students will be able to:

CO1. identify different diode circuits and analyze them.
CO2. understand the working of BJTs and FETs in different modes and configurations; identify and analyze their biasing circuits; understanding CMOS and CMOS inverter.
CO3. understand the working of BJT amplifiers and their analysis using small signal model.
CO4. understand the requirement and applications of negative and positive feedback in electronic circuits; identify different types of feedback.
CO5. understand the concept of power amplifiers and identify different classes of power amplifiers
CO6. understand the working and applications of different ICs including Operational Amplifiers, Timers and VCO.

### Prerequisite : NIL

**Diodes**

P-N junction diode and its characteristics, diode models, clippers and clampers, rectifiers (with filters), Zener diode, voltage regulator using Zener diode.

**Bipolar Junction Transistors**

Description of bipolar junction transistors, , current flow in BJT, modes of operation, CE, CB and CC configuration and their characteristics, BJT biasing and biasing circuits.

**Field Effect Transistors**

Operation of JFETs and their characteristics, operation of MOSFETs and their characteristics, CS, CG and CD configuration of MOSFETs, qualitative description of CMOS and CMOS inverter

**Amplifiers**

Amplification process in BJT. Single stage CE RC coupled amplifier using BJT and its analysis using small signal '$r_e$' model, frequency response (qualitative description) of amplifiers.

**Feedback Concepts**

Types of feedback. Properties and advantages of negative feedback, qualitative description of feedback topologies, positive feedback, Barkhausen criterion and oscillators, qualitative description of RC and LC oscillators.

**Power Amplifiers**

Classes of Power amplifiers.

Qualitative description of class A, B, C and push-pull power amplifiers.

**Operational Amplifiers**

Description of operational amplifier, ideal characteristics, concepts of differential mode gain, common mode gain, CMRR and virtual ground.

Applications of Op Amp: inverting amplifier, non inverting amplifier, and unity gain buffer, summing amplifier, difference amplifier, differentiator and integrator circuits, instrumentation amplifier, comparator and Schmitt Trigger.

**Timers, VCO and PLL**

Qualitative description of 555 timer and its modes, VCO and PLL

**Text Book :**
1. Electronic Principles -A. Malvino and D. J. Bates-7th Edition-McGraw Hill Education (India) Pvt. Ltd.

**Reference Books :**
1. Electronic Devices and circuits-R. L. Boylestad and L. Mashelsky-10th Edition (Pearson).
2. Integrated Electronics-J. Millman, Hlakias and Parikh-2nd Edition (TMH)
3. Linear Integrated circuits-D. R. Chowdhury and S. B. Jain-4th Edition-New Age International Publishers.

## EC 2004 PRINCIPLE OF DIGITAL COMMUNICATION Cr-4

**Course Outcomes:** At the end of the course, students will be able to :

CO1. understand and analyze signals in time and frequency domain.
CO2. understand different types of analog modulation systems and explain their properties and applications.
CO3. classify and implement different types of pulse modulations, multiplexing techniques and their applications.
CO4. identify different types of digital modulation techniques and analyze their properties.
CO5. understand data communication techniques and data transmission methods.
CO6. interpret fundamental problems of information theory and implement different coding techniques for data transmission.

**Prerequisites : Mathematics-I (MA 1003), Mathematics-II (MA 1004) and Digital Electronics (EC 2011)**

**Signal:**

Signals in time domain, Fourier transform, Periodic and non periodic signal Analysis, spectral density.

**Analog Modulation:**

Types of analog modulation, Need for modulation, principles of AM, Types of AM (DSB, SSB, VSB), power relationship, principle of FM & PM, Types of FM, spectrum of FM, Bandwidth of FM (Carson's rule).

**Pulse Modulation:**
Sampling Theorem, PAM, PWM, PPM, TDM, FDM.

**PCM & Delta Modulation:**
Quantization process, PCM, Noise consideration in PCM system, Delta and Adaptive Delta modulation.

**Digital Modulation Techniques & Data Transmission:**
ASK, FSK, PSK, DPSK, QPSK, probability of error, BER calculation, matched filter, relationship between Bit error rate and symbol error rate, comparison of modulation system, Data Communication systems, parity, Asynchronous and Synchronous transmission, low speed, medium speed and high speed modems.

**Basic Information theory:**
Information and Entropy, Binary symmetric channel and Binary error channel, Shannon's channel capacity theorem, capacity of Gaussian channel, Basics of source and channel coding (Huffman, Cyclic codes).

**Text Book :**
1. Communication Systems – Simon Haykin, 4th Edition, John Wiley

**Reference Books :**
1. Principle of Communication System – H. Taub & D. Schlling, TMH, 3rd Edition.
2. Data & Computer Communication – W. Stallings, Pearson, 9th Edition.

## EC2005 SEMICONDUCTOR DEVICES Cr-3

**Course Outcomes:** At the end of the course, the students will be able to :

CO1. differentiate between different conduction techniques in semi-conductor materials.
CO2. analyze characteristics of p-n junction diodes and solve relevant problems.
CO3. comprehend the working principle of breakdown diodes, graded junction diodes and metal semiconductor junction diodes.
CO4. analyze characteristics of Bipolar Transistors and solve relevant problems.
CO5. analyze characteristics of MOS Transistors and solve relevant problems.
CO6. differentiate between different optoelectronic devices.

**Prerequisite: Analog Electronic Circuits (EC1004)**

**Energy bands & Current Carriers in Semiconductors:** Bonding Forces in Solids, Energy Bands theory in crystals (Qualitative Analysis), Metals, Semiconductors, & Insulators, Fermi-Level, Intrinsic and Extrinsic Semiconductors, Concept of Holes, Carrier Concentration. and Mobility, diffusion and drift of carriers, continuity equation, Injected minority carrier charge, Recombination and generation of charge carriers.

**P- N Junction:** Physical Description of p-n junction, Basic device technologies for fabrication of a p-n junction current flow at a junction, homojunction and heterojunctions, equilibrium band diagram, charge, field and potential profiles in p-n junctions, depletion region, biased P-N junctions, diode equation and diode characteristics, equivalent circuit, temperature dependence, Capacitance of p-n junction diode (transition & storage), junction Breakdown (Avalanche & Zener), Step and linearly graded junction, diode switching characteristics, Metal – Semiconductor junction (Schottky barrier, Ohio contact and rectifying contact).

**BJT:** Junction transistors, Charge transport in BJT, base narrowing (Early effect), Avalanche breakdown & Punch Through, transistor switching, Coupled-Diode model, Ebers-Moll equations.

**MOSFET:** MOS structure, Basic operation of Enhancement & Depletion mode MOSFET, MOS capacitance (Operation with band diagram, threshold voltage & Characteristics), CCD and applications.

**Opto–Electronics:** Optical absorption in semiconductors, photovoltaic effects, solar cells (p-n junction), Photoconductors, Photodiode, PIN photodiode, Avalanche photodiode, Phototransistor, LED, Semiconductor Laser (p-n junction)

**Text Book :**

1. Solid State Electronic Devices by Streetman & Banerjee, $6^{TH}$ Edition/2013, PHI.

**Reference Books :**

1. Semiconductor Devices: Basic Principles by Jasprit Singh, John Wiley & Sons, 2000.
2. Integrated Electronics: Analog and Digital Circuits and Systems by Jacob Millman, Christos Halkias, ChetanParikh , Second Edition, TMH 2010.
3. Semiconductor Physics and Devices: Donald Neaman and Drubesh Biswas, TMH,$4^{TH}$ Edition, 2012
4. Semiconductor Physics: Device & Technology: S. M. Sze& M-K Lee, John Wiley & Sons, 2012

## EC 2011 DIGITAL ELECTRONIC CIRCUITS Cr-3

**Course Outcomes:** At the end of the course, students will be able to :

CO1. simplify and realize Boolean expression.
CO2. design various combinational circuits using logic gates.
CO3. design various asynchronous & synchronous sequential circuits using Flip-Flops.

CO4. design & implement Mealy and Moore model FSMs for different synchronous sequential circuits

CO5. differentiate between different logic families such as TTL & CMOS chips.

CO6. differentiate between different kinds of Analog-to-Digital converters and Digital-to-Analog converters

**Prerequisite: Nil**

**Introduction to Boolean Algebra**
Signed binary number, Binary arithmetic, Codes—BCD, Gray, Excess-3, Error detection & Correcting code-Hamming code, Universal gates, Boolean Algebra, Basic theorems & properties of Boolean Algebra, De-Morgan's theorem, Minterms & Maxterms, K-map representation, simplification and realization with logic gates.

**Combinational Circuits**
Adders (Half and Full adders, parallel binary adders, look ahead carry adder generator),Subtractors (Half and Full Subtractors, 4-bit Adder/Subtractor), Magnitude comparator, decoders (3 to 8, BCD to Decimal decoder, BCD to SSD) and Encoders, Priority Encoder, Multiplexer and Multiplexer-tree, De-multiplexer.

**Sequential Logic**
Latch, Concepts of level and edge triggering , flip flops, different types of flip flops, Shift Registers (SISO, SIPO, PIPO, PISO, Bidirectional), Counter (synchronous and asynchronous),Ring and Johnson Counters.

**Finite State Machine (FSM)**
Model of Finite State Machine---State diagram, Mealy and Moore models, Logicdiagrams, State table, State reduction, State assignment, Excitation table. Realization of memory elements (S-R, J-K, T, Master -Slave), State diagram, state table, Excitation table, Synthesis of Synchronous sequential circuits (Sequence detector)

**Logic Families:** Transistor as a switch, Characteristics (Propagation delay, Speed-power product, Noise margin,Fan-in, Fan-out), Standard logic families (TTL, ECL, CMOS), Digital ICs TTL (74 Series) and CMOS (4000 Series), fault diagnosis of digital circuits.

**Concepts of D/A and A/D converters:** Digital to Analog converter (Binary weighted resistor network & R-2R ladder network), Analog toDigital converter (Flash type, Counter type & Successive approximation type).

**Text Books:**

1. Fundamentals of Digital Logic – Anand Kumar - PHI, 2nd Edition, 2011
2. Digital Logic and Computer Design – M. Morris Mano – PHI,2011

**Reference Books :**

1. Digital Principles and Applications – Malvino & Leach –TMH, 7th edition, 2011
2. Digital Fundamentals – T. L. Floyd & Jain – Pearson Education, 10th edition, 2011

## EC 2012 ANALOG COMMUNICATION TECHNIQUES Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. revise basic concepts of signal and systems; analyze Hilbert Transform, Pre- Envelope, complex Envelope representation of band pass signal and its canonical form; understand different blocks of communication system, electromagnetic spectrum and need for modulation.

CO2. conduct time domain and frequency domain analysis of Amplitude Modulation(AM ) , Double Side Band Suppressed Carrier (DSB-SC) , Single Side Band Suppressed Carrier (SSB-SC), Vestigial Side Band (VSB) , Frequency Modulation (FM) and Phase Modulation (PM) .

CO3. distinguish between different analog modulation schemes with their advantages, disadvantages and applications; understand different blocks of Super heterodyne receiver.

CO4. analyze the process of sampling , sampling theorem and different sampling techniques ;understand Pulse modulation schemes; differentiate between Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM) methods.

CO5. analyze the noise performance of different analog modulation schemes by evaluating Signal power to Noise power Ratio(SNR).

CO6. design analog communication systems considering different parameters like modulation index, power, frequency and required SNR.

### Prerequisites :Signals and Networks (EC2021)/ Principle of signals and systems (EC2023)

**Introduction**
Introduction to communication system, dB, dBm, Concept of bandwidth, spectral efficiency, Hilbert Transform, Pre-envelope, base-band and band-pass signals

**Amplitude Modulation and Demodulation**
AM DSB , DSB-SC, SSB, modified SSB,Calculation of transmitted power, Efficiency, SSB-SC, VSB, method of recovery of the base signal, Square law demodulator, Envelop detector,Superheterodyne AM receiver, FDM

**Angle Modulation and Demodulation**
Phase and frequency modulation, Relationship between PM & FM, Threshold in FM**,** Phase and frequency deviation, Spectrum of an FM signal, Some features of Bessel's coefficient, Effect of modulation index on Bandwidth, Phasor diagram for FM signals, FM generation, parameter variation method, Armstrong system for NBFM, Frequency multiplier. An example of an Armstrong FM system, FM Demodulators, FM detection using PLL, Pre-emphasis and De-emphasis ,FM Radio receiver.

**Pulse Modulation and Demodulation**
Sampling theorem (low pass and Band pass signals), Natural sampling, Flat – top sampling, signal recovery through holding, Pulse Amplitude modulation, Channel bandwidth for PAM signal, TDM, PWM, PPM.

**Noise in Communication Systems**
Sources of noise, Types of Noise, Frequency domain representation of noise, Effect of filters on the PSD of noise, SNR of DSB/FC, DSB/SC, SSB/SC system, Comparison of AM, SSB, DSB, VSB modulation schemes. Calculation of output SNR of FM system, Comparison between FM and PM,

**Text Books :**

1. Communication Systems – Simon Haykin, John Wiley,4th edition,2011.
2. Modern Digital and Analog Communications Systems **-** B**.**P**.** Lathi & Z.Ding**-** Hardcover, Oxford Univ Pr,4th edition,2011.

**Reference Book :**

1. Principles of Communication System – H. Taub & D.L.Schilling – TMH,3rd edition,2011

## EC 2014 ELECTROMAGNETIC THEORY Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. apply the appropriate coordinate system for a particular vector based problem, and the laws of vector calculus.

CO2. analyze and solve numerical problems involving static charges.

CO3. analyze and solve numerical problems involving constant currents.

CO4. analyze and apply Maxwell's equations for electromagnetism.

CO5. analyze and apply wave behavior during its propagation through multiple media in presence of different boundary conditions.

CO6. design transmission line sections (Length propagation constant and characteristic impedance) along with feeding mechanism for realizing impedance matched conditions.

## Prerequisite: Mathematics-II (MA1004)

**Static Electric and Static Magnetic Fields**

Orthogonal Co-ordinate systems, statements of Coulomb's and Gauss's laws, boundary conditions for electrostatic fields, electrostatic energy density, Poisson's and Laplace's equations, Statement of Ampere's circuital law, Lorentz's force equation, vector magnetic potential, Biot-Savart law and applications, Boundary conditions for magentostatic fields.

**Time Varying Fields and Maxwell's Equations**

Faraday's law, Maxwell's Equations in point form and integral form, displacement current, electromagnetic boundary conditions, interface between a dielectric and a perfect conductor, wave equations and their solutions, source-free wave equations, Helmholtz's wave equation in free space, principle of duality.

**Plane Electromagnetic Waves**

Plane waves in lossless media, polarization of plane waves, plane waves in lossy media, low-loss dielectrics, skin depth, group and phase velocities, flow of electromagnetic power and Poynting vector, normal and oblique incidences of electromagnetic waves (parallel & perpendicular polarized) at plane perfect conducting and dielectric boundaries, Brewster's angle.

**Theory and Applications of Transmission Lines**

General transmission-line equations, wave characteristics on an infinite transmission line, transmission line parameters, attenuation constant from power relations, wave characteristics of finite transmission lines, transmission lines as circuit elements, transmission lines with resistive termination and arbitrary termination, transmission line circuits, transients on transmission lines, voltage reflection and current reflection diagrams*, S*mith chart, quarter wave transformer, single stub and double stub matching.

**Text Books :**

1. Elements of Electromagnetics (Fourth Edition) by Matthew N.O Sadiku, Oxford University Press, 2009.
2. Field and Wave Electromagnetics (Second Edition) By David K. Cheng, Pearson Education, 1989

**Reference Books :**

1. Engineering Electromagnetics (Seventh Edition) by William H. Hayt, Jr and John A. Buck, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
2. Electromagnetic Waves and Radiating Systems by Edward C. Jordan and Keith G. Balmain, Prentice Hall of India, New Delhi, 2nd Edition.

## EC 2016 COMMUNICATION ENGINEERING Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

CO1. recall the basics of signals and systems like Fourier series, Fourier transform and their properties, random variable, random process, power spectral density of a signal etc.

CO2. identify the need of communication; comprehending the block diagram of different communication systems and their functions.

CO3. sketch the waveform of different modulation technique. Implementing Fourier transform to interpret the information present in the radio spectrum.

CO4. distinguish and compare between different modulation techniques.

CO5. identify and select the range of elements needed for designing a communication system.

CO6. design a communication system by selecting an appropriate modulation technique used for a particular application.

**Prerequisites : Principle of Signals and Systems (EC2023)/Signals and Networks (EC2021)**

**Introduction:**
Brief Idea of Probability, Random Variable, Random Process, Cumulative Distributive Function, Probability Distributive Function, Mean, Variance, Gaussian and Rayleigh PDF, White Noise, Colored Noise, Signal to Noise Ratio.

**Signals**
Signals in time domain, Fourier transform and Series, properties of FT and FS, Unit impulse and unit step function

**Amplitude Modulation**
Principle of AM, side bands, Power Relationship, Assignable Frequency spectrum, Sideband Transmission, DSB, SSB, VSB, Balanced Modulator.

**AM Radio Receiver**
Super heterodyne Principle, Block Diagram, Typical features, Front end output S/N, Sensitivity, Selectivity, Fidelity.

**Angle Modulation**
Principle of FM, Frequency Deviation, Spectrum of FM wave, Power in Modulated wave, Narrow band FM, Pre-emphasis, De-emphasis, Block Diagram of FM Transmitter, Reactance modulator, Typical Characteristic features.

**FM Radio Receiver**
Block Diagram of FM Receiver, Noise in RF Amplifier, FM Detector: Slope Detector, Discriminator, Phase-locked loop, Selectivity, sensitivity of FM Receiver.

**Pulse Modulation and Demodulation**
Sampling Process, Pulse Amplitude Modulation, Time Division Multiplexing, Frequency Division Multiplexing, The Quantization Process, Pulse Code Modulation, Noise consideration in PCM systems.

**Digital Modulation**
Data Form, Principles involved in ASK, PSK (BPSK, QPSK, $\pi/4$ QPSK), FSK.

**Modern Communication Systems**
Introduction to Modems, Block diagram Description of satellite communication, Fiber optic communication and Mobile communication.

**Text Books :**
1. Introduction to Analog & Digital Communication System – Simon Haykins, Wiley Student edition 2011 – John Wiley.
2. Modern Digital and Analog Communications Systems -**B.P. Lathi** - Hardcover, Oxford Univ Press, $4^{th}$ Edition.

**Reference Book :**
1. Principles of Communication System – H. Taub& D.L.Schilling – TMH, 3rd Edition

## EC 2019 ELECTRONIC DEVICES AND CIRCUITS Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | analyze the electronic circuits using diodes and transistors. |
| CO2. | analyze biasing circuits using BJTs and FETs and determine their stability. |
| CO3. | analyze amplifier circuits using BJTs and FETs with the help of their small signal model. |
| CO4. | analyze and determine the bandwidth of different video amplifiers using frequency response method and step response method. |

CO5. differentiate between different negative feedback circuits and sinusoidal oscillators.

CO6. analyze different power amplifier circuits using BJTs.

## Prerequisite : Nil

**Semiconductor**
Review of energy band concept of materials (difference between metal, insulator and semiconductor), concept of electrons and holes in semiconductors, intrinsic and extrinsic semiconductors, Fermi level, carrier concentration and mobility, Drift and Diffusion current, Equation of continuity, injection of minority charge carriers, generation and recombination of charge carriers.

**P-N junction**
Operation of p-n junction diode and its characteristics (Qualitative), Equivalent circuit of p-n junction, transition and diffusion capacitance of p-n junction, Junction breakdown, Zener diode and voltage regulator, Diode switching characteristics, qualitative description of rectifiers, clippers, clampers and passive filters (C, LC and $\pi$ filters).

**Transistors**
Transistor operation and current components in BJT, CE,CB and CC configuration of BJT and their characteristics, base width modulation and Early effect, punch through, Operation and characteristics of JFET and MOSFET, application of transistors in amplification of signals.

**Transistor biasing circuits**
Requirement of biasing, Different types of biasing circuits for BJT and FET (fixed bias and self bias)Stability factors (S, S' and S"), Bias compensation.

**Small signal analysis of transistor amplifiers**
h-parameter (hybrid model) for transistors, Low frequency small signal analysis of CE and CC configurations (without feedback), Simplified CE and CC model, CE amplifier analysis with emitter resistance, Small signal model for FETs (JFET and MOSFET), Low frequency small signal analysis of CS and CD configurations.

**Frequency response of transistor amplifiers**
Classification of amplifiers, Distortion in amplifiers (qualitative), Frequency response of amplifiers (qualitative), Step response of an amplifier, Bandpass of cascaded stages, Frequency response of R-C coupled amplifier (qualitative)

**Feedback and oscillator circuits**
Feedback concept, feedback amplifier topologies, General characteristics of negative feedback amplifier, Input and output resistance with negative feedback, Method of analysis of feedback amplifier with practical examples, Positive feedback and Barkhausen criterion for oscillation, Sinusoidal oscillators-LC and crystal oscillators.

**Power amplifiers**
Definition of class A, B and C power amplifiers, Distortion analysis, Series fed and transformer coupled power amplifier, Push-Pull amplifiers, conversion efficiency.

**Text Books** :
1. Electronic Devices & Circuits- D. A. Bell- Oxford ($5^{th}$ Ed)
2.Integrated Electronics – J. Millman,Halkias& Parikh – MGH ($2^{nd}$ Ed)

**Reference Book :**
1. Electronics Devices and Circuits – Robert L. Boylestad and Lewis Nashelsky – Pearson ($10^{th}$ Ed)

## EC 2020 MICROPROCESSORS, MICROCONTROLLERS & INTERFACING Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | understand the concept of Bus structure, a basic 8 bit Microprocessor system, its architecture, concept of stack, Addressing modes etc. |
| CO2. | understand the architecture of a 16 bit Microprocessor like 8086 including the concept of instruction queue, segmented memory structure and address generation. |
| CO3. | understand the Addressing modes, Assembly language instructions of 8086 and implement them to solve 8086 related design problems. |
| CO4. | design Memory Interfacing using memory chips with proper decoder circuits with a 16 bit processor. |
| CO5. | analyze the interrupt structure of 8086 Microprocessor. |
| CO6. | understand the peripherals such as PPI, Programmable interrupt control, USART and their interfacing with a 16 bit processor. |
| CO7. | analyze memory organization of a 8 bit Microcontroller (like 8051), its addressing modes, instructions, timers & counters and its serial operation. |

### Prerequisite: Digital Electronics (EC 2011)

**Introduction** : Review of Semiconductor Memory Chips, Tristate Concept & Bus Structure, A Basic Microprocessor based system

**Outline of a 8 bit Processor** : Brief discussion of a 8085 Microprocessor based system, Architecture, Concept of stack, Overview of Instructions & Addressing Modes etc.

**8086 (16 bit Microprocessor)** : Introduction, Architecture, Pins & Signals, Minimum & Maximum Mode Configuration, Timing Diagrams; Addressing Modes, 8086 Assembly Language Instructions and Sample Problems, interrupts, Memory Interfacing and Multiprocessor Configuration.

**Interfacing chips** : 8255 (PPI), 8259 (PIC), 8251 (USART), Interfacing with A/D Converter

**8051 Family of Microcontrollers** : Introduction, Overview of MCS-51 Family of Microcontrollers
Memory Organization - Program Memory, Data Memory, Register Banks & SFRs, Bit Addressable RAM, Pins & Signals, Addressing Modes, 8051 Instruction Set & Sample problems, interrupts, timers & Counters, Serial Communication.

**Text Book :**


1. Microprocessors and Interfacing, Programming & Hardware - Douglas V. Hall, McGraw Hill Education Pvt Ltd., 3rd Edition


**Reference Books :**


1. Microprocessors & Microcomputer based System Design - Md. Rafiquzzaman, 2nd Edition
2. Advanced Microprocessor and Peripherals - Architecture, Programming and Interfacing by A. K Ray and K. M. Bhurchandi - McGraw Hill Eduction Pvt Ltd - 3rd Edition.
3. Microcontroller Theory & Applications - Deshmukh - McGraw Hill Eduction Pvt Ltd.
4. 8051 Microcontroller - Hardware, Software & Applications - V Udayshankara & M Mallikarjunswamy - TMH - 1st Edition.

## EC 2021 SIGNALS AND NETWORKS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | analyze and plot continuous and discrete signals, determine respective characteristics and understanding relation between signals and vectors. |
| CO2. | classify various types of systems and analyze system characteristics in time domain. |
| CO3. | analyze characteristics of signals and systems in frequency domain using Fourier analysis and its properties. |
| CO4. | determine the Laplace Transform of various signals and analyze analog systems characteristics using Laplace transform and its properties. |
| CO5. | understand and apply the different theorems for a given network |
| CO6. | estimate Z, Y, & ABCD parameters for 2 port networks. |

### Prerequisite: Mathematics-II (MA1004)

**Introduction to signals**: Definitions, classification and its examples, Representation of continuous and discrete time signals, Basic operation on signals, Decomposition of signals in terms of elementary signals. Analog to digital conversion, Sampling Theorem. Test of periodicity for signals and for sum of two periodic signals, Representation of analog and discrete time signals in terms of impulses.

**Introduction to systems:** Definition, Classification and its examples, Linear convolution, Causality and stability of LTI systems, IIR and FIR systems. Correlation.

**Continuous time Fourier analysis:** Significance of Fourier series in LTI system, continuous time Fourier series formula. Dirichlet conditions & properties, Approximation of Fourier series to Fourier transform for aperiodic signals, Properties, examples ,amplitude and power spectra, Analysis of LTI systems using Fourier Transform.

**Laplace transform** : Definition, S-plane mapping, ROC properties, and examples, Relationship between Fourier and Laplace Transform, Pole-zero Plot, Solution of differential equation and stability analysis of LTI systems , Transfer function, Transient in AC/ DC circuits, RL, RC, RLC with constant and sinusoidal excitation with Laplace Transform, Resonance, Q- factor, Bandwidth.

**Networks**: Network Topology, Tree, Nodes, Branches, Mesh Analysis, Loop Analysis, Admittance Matrix, Maximum Power transfer theorem, Reciprocity theorem, Star -delta transformation, Dot convention for coupled circuits, Coefficient of Coupling, Two port network parameters and functions : Z, Y and ABCD parameters with cascaded structures, driving point and transfer impedances and admittances,lattice network, T and pi networks .

**Text Books :**

1. Signals & Systems – Alan V Oppeinhem, Alan S Willsky– 2nd/ 2011–PHI
2. Circuit Theory, Analysis and Synthesis, A. Chakrabarti, DhanpatRai Publishing Company (P) Limited, 5th Edition,2008.

**Reference Books :**

1. Signals & Systems – P. Ramesh Babu –Scitec,4th Edition
2. Network Analysis 3rd Edition, by M. E. Van Valkenburg, Pearson Education, 2006

## EC 2022 ELECTROMAGNETIC WAVES & ANTENNAS Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

CO1. comprehend different coordinate systems necessary to solve electromagnetic problems.

CO2. recall, comprehend and apply basic laws and equations for electrostatics, magnetostatics and electromagnetics.

CO3. comprehend the characteristics of wave propagation in different media, power flow and polarization of waves.

CO4. design transmission line, transmission line components and stubs.

CO5. comprehend the role of electromagnetism to antenna radiation and perform design of dipole and monopole antennas.

CO6. design linear antenna arrays, understand design aspects of different types of antennas, like, horn antenna, parabolic disc antenna, loop antenna, helical antenna, log-periodic antenna and microstrip antenna.

**Prerequisite : Physics (PH1007)**

**Coordinate Systems:** Introduction to rectangular, cylindrical and spherical coordinate systems and coordinate transformation equations.

**Static Electric Field:** Coulomb's and Gauss's laws (statements only), electric Potential, equipotential surfaces, electric displacement. Continuity equation & relaxation time, Electrostatic boundary conditions (qualitative), electrostatic energy density for discrete charge distribution and continuous line charge distribution (infinite & finite), Poisson's & Laplace's Equations(statements only).

**Static Magnetic Field:** Ampere's circuital law (statement only), Biot-Savart's law (statement only), magnetic vector potential, Lorentz's force equation. Magnetostatic boundary conditions (qualitative), Magnetostatic energy density.

**Time Varying Electromagnetic Fields and Maxwell's Equations:** Faraday's Law, displacement current density, Maxwell's equations in integral and differential forms, Electromagnetic boundary conditions (qualitative).

**Plane Electromagnetic Waves:** Waves in general, source-free wave equations, Helmholtz's wave equation in free space. Wave propagation in lossless media and in lossy media, concept of propagation constant, intrinsic impedance, loss tangent, phase velocity and group velocity. Wave propagation in good conductors, concept of skin depth and surface resistance of conductors, polarization of electromagnetic waves (qualitative). Flow of electromagnetic power and Poynting vector. Normal incidences of electromagnetic waves (parallel and perpendicular polarized) at plane perfect conductors and dielectric boundaries, standing wave ratio.

**Transmission Lines:** Wave propagation in transmission line, Lumped element circuit model of transmission lines, transmission line parameters and transmission line equations. Input impedance, reflection coefficient, VSWR, transmission lines as circuit elements, quarter wave transformer. Transients on transmission lines (qualitative), Smith chart (qualitative), single stub matching.

**Electromagnetic Radiation and Thin Linear Antennas:** Vector magnetic potential, retarded potential, concept of antenna radiation, radiation from an oscillating electric dipole. Radiation resistance of quarter-wave monopole and half-wave dipole.

**Antenna Parameters:** Radiation patterns, E-plane & H-plane, directivity, gain, efficiency, effective length, effective aperture, wave polarization & cross-polarization, LHCP, RHCP. FRISS transmission formula, antenna noise temperature. Reciprocity theorem & its applications in antennas.

**Antenna Array:** Uniform n-element linear array, broadside & end-fire arrays, grating lobes, principle of pattern multiplication.

**Antennas:** Horn antenna,Parabolic disc antenna & its losses (qualitative), Loop antenna (qualitative), Helical antenna, Turnstile antenna, Log-periodic antenna, Microstrip antenna (basic structure, advantages & disadvantages, radiation mechanism & applications).

**Text Books :**
1. Elements of Electromagnetics (Fourth Edition) by M. N.O. Sadiku, Oxford University Press, 2009.

**Reference Books :**
1. Antennas for All Applications - J. D. Kraus & R. J. Marhefka, Tata McGraw Hill.
2. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Balmain, Prentice Hall of India, New Delhi.

## EC 2023 PRINCIPLE OF SIGNALS AND SYSTEMS Cr-2

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze and plot continuous and discrete signals, determine respective characteristics and understanding relation between signals and vectors.
CO2. classify various types of systems and analyze system characteristics in time domain.
CO3. analyze characteristics of signals and systems in frequency domain using Fourier analysis and its properties.
CO4. understand the sampling process and sampling theorem using Fourier transform.
CO5. determine the Laplace Transform of various signals and analyze analog systems characteristics using Laplace transform and its properties
CO6. perform analysis of various LTI systems from its transfer function and will be able to infer the pole and zero location of the system.

### Prerequisite :Mathematics-II (MA 1004)

**Introduction to signals**: Definitions, classification and its examples, Representation of continuous and discrete time signals, Basic operation on signals, Decomposition of signals in terms of elementary signals. Analog to digital conversion, Sampling Theorem. Test of periodicity for signals and for sum of two periodic signals, Representation of analog and discrete time signals in terms of impulses.

**Introduction to systems:** Definition, Classification and its examples, Linear convolution, Causality and stability of LTI systems, IIR and FIR systems. Correlation.
**Continuous time Fourier analysis:** Significance of Fourier series in LTI system, continuous time Fourier series formula. Dirichlet conditions & properties, Approximation of Fourier series to Fourier transform for aperiodic signals, Properties, examples ,amplitude and power spectra, Analysis of LTI systems using Fourier Transform.

**Laplace Transform:** Introduction, Properties with examples, Relationship between Fourier and Laplace transform, Pole-Zero plot, Solution of differential equation and stability analysis of LTI systems, Transfer function.

**Text Book :**
1.Signals & Systems – Alan V Oppeinhem, Alan S Willsky– 2nd/ 2011–PHI

**Reference Book :**
1.Signals & Systems – P. Ramesh Babu –Scitec,4th Edition.

## EC 2024 ADVANCED ELECTRONIC CIRCUITS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | analyze the response of different linear wave shaping circuits and attenuators. |
| CO2. | determine the DC and AC parameters of OPAMP; identify type of feedback and analyze its stability. |
| CO3. | analyze and comprehend the difference between circuits using OPAMPs (Closed loop: negative and positive feedback or open loop). |
| CO4. | design and analyze adder, substractor, differentiator, integrator, oscillator, comparator, waveform generators and active filters using OPAMPs 741 IC. |
| CO5. | design and analyze multi-vibrator with its different applications using IC 555 timer and PLL. |
| CO6. | design and analyze different dc power supply using fixed and variable IC regulators; evaluate the performance of negative resistance devices. |

**Prerequisite: Electronic Devices and Circuits (EC2019)**

**Linear Wave Shaping Circuits**
High pass and Low pass circuit, Response of RC circuit to various inputs such as sinusoidal, step, pulse, square wave, exponential and ramp, High pass RC circuit as differentiator, Low pass RC circuit as an integrator, Attenuator and its application.

**Op-amps and its parameters**
Differential amplifier, Differential amplifier circuit configuration, Constant current bias, current mirror, level translator, Block diagram representation, Analysis of equivalent circuit, Types of IC op-amp, Power supply for IC Op-amp, Input offset voltage, Input Bias current, Input offset current, total output offset voltage, Thermal drift, PSRR, Common mode configuration and CMRR, Noise in Op-amp, Slew rate

**Op-amp with Negative Feedback**
Op-amp circuits using negative feedback (voltage series feedback & voltage shunt feedback), Differential amplifier

**Frequency Response of an Op-amp**
Frequency response, Compensating Networks, Frequency response of compensated and non-compensated Op-amp, High frequency Op-amp equivalent circuit, open loop voltage gain as a function of frequency, Closed loop frequency response, Circuit stability

**Op-amp Applications**
Instrumentation amplifier, Voltage to current converter and vice versa, Integrator , Differentiator, First and second order active filter, Phase shift oscillator, Wien bridge oscillator, Voltage to frequency converter, comparator : zero crossing detector & Schmitt Trigger, Sample and Hold circuit, Square & Triangular wave generators using OP-AMPS, Clipper, Clamper & Voltage Limiters using OP-AMPS, The 555 timer as Monostable and astable mode, PLL and its application, IC voltage regulators

**Negative Resistance devices**
Tunnel diode & UJT, their V-I characteristics and performance analysis

**Text Books :**
1. Op-amp & LIC – R. K. Gayakwad – PHI
2. Pulse, Digital and Switching waveforms –J. Millman& H. Taub – TMH

**Reference Books :**
1. LIC – D. Ray Choudhury&Shail Jain (New Age)
2. Pulse Digital Circuit – Anand Kumar - PHI

## EC 2025 PRINCIPLES OF ELECTRONICS ENGINEERING Cr-3

**Course Outcomes:** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | understanding the properties of semiconductors and current conduction mechanism; |
| CO2. | comprehend the working of P-N junction diodes; Identify different diode circuits and analyze them; |
| CO3. | understand the working of BJTs and different modes and configurations; identify and analyze their biasing circuits; understanding the working of CE amplifier and its properties. |
| CO4. | analyze the working of operational amplifier, timing circuits , regulated power supply IC and their applications. |
| CO5. | comprehend the concept of feedback in electronic circuits, types of feedback, their applications |
| CO6. | comprehend the working of different logic gates , combinational and sequential circuits; develop a brief idea about microprocessors and microcontrollers. |

**Prerequisite: Nil**

**Semiconductors:** Energy band concept of materials, difference between metal, insulator and semiconductor,Intrinsic and extrinsic semiconductors (n-type & p-type), current conduction in semiconductor.

**Junction Diodes:** Operation of p-n junction diode, diode characteristics, half-wave, full-wave and bridge rectifiers,rectifiers with capacitor filter, clipper and clamper circuits, breakdown mechanisms, Zener diode and voltage regulator, regulated power supply IC based on 78XX and 79XX.

**Bipolar Junction Transistor (BJT):** Transistor operation and current components in p-n-p and n-p-n transistors,CE, CB, CC configurations and characteristics, biasing, load line analysis, amplification by transistors, qualitative description of CE amplifier and its frequency response.

**Feedback Concept:** General feedback structure, properties and advantages of negative feedback, positive feedback and Barkhausencriteria for oscillation, qualitative description of R-C Oscillators.

**Operational Amplifiers (OPAMP) and 555 timer:** Ideal OPAMP, CMRR, virtual ground, Inverting and non-inverting OPAMPs,summing amplifiers, Differential amplifier, integrator & differentiator, Comparator and Schmitt trigger, IC 555 timer and its application in monostable and astable mode (qualitative description).

**Digital Electronics:** Number systems, conversions and codes, Logic gates & Truth tables (OR, AND, NAND, EX-OR), Universal gates, logic expressions using minterms and maxterms, Simplification of Boolean expressions using K-map, qualitative description of adders, substractors, decoders, encoders, multiplexers and demultiplexers, flip-flops (RS flip-flop, D flip-flop, JK flip-flop and MS flip-flop). Shift register, Synchronous and asynchronous (ripple) counter,; overview of microprocessors, microcontrollers and arduino boards.

**Text Books :**


1. Electronics –Fundamentals & Applications –D. Chattopadhyay and P. C. Rakshit – 11 th Edition (New Age International)
2. Electronic Devices and Circuits **–** D. A. Bell - 5th Edition (Oxford)


**Reference Books :**


1. Electronic Devices & Circuits – R. L. Boylestad & L. Mashelsky – 10 th Edition (Pearson)
2. Electronic Principles – A. Malvino & D. J. Bates – 7 th Edition (TMH)
3. Digital Principles and Applications– A. Malvino and Leach – 7 th Edition (TMH)
4. Integrated Electronics – J. Millman, Halkias & Parikh – 2 nd Edition (TMH)

## EC 2027 ANALOG ELECTRONICS Cr-4

**Course Outcomes**: At the end of the course, the students will be able to:

CO 1. understand the electronic circuits using Diodes and transistors.
CO 2. analyze biasing circuits using BJTs and FETs and determine their stability.
CO 3. analyze amplifier circuits using BJTs and FETs with the help of their small signal model.
CO 4. analyze electronic circuits using BJTs or FETs for different negative feedback topologies depending on applications and analyze sinusoidal oscillators.
CO 5. analyze different power amplifier circuits using BJTs, Differential amplifier and Current mirror circuits.
CO 6. analyze Operational amplifiers and its applications including 555 timers.

### Prerequisite: NIL

**Semiconductor**
Review of energy band concept of materials (difference between metal, insulator and semiconductor), concept of electrons and holes in semiconductors, intrinsic and extrinsic semiconductors, Fermi level, carrier concentration and mobility, Drift and Diffusion current, generation and recombination of charge carriers.

**P-N junction**
Operation of p-n junction diode and its characteristics (Qualitative), Equivalent circuit of p-n junction, transition and diffusion capacitance of p-n junction, Junction breakdown, Zener diode and voltage regulator, Diode switching characteristics, qualitative description of rectifiers, clippers, clampers and passive filters (C, LC and π filters).

**Transistors**
Transistor operation and current components in BJT, CE,CB and CC configuration of BJT and their characteristics, Operation and characteristics of JFET and MOSFET, application of transistors in amplification of signals.

**Transistor biasing circuits**
Requirement of biasing, Different types of biasing circuits for BJT and FET (fixed bias and self-bias) Stability factors (S, S' and S"), Bias compensation.

**Small signal analysis of transistor amplifiers**
h-parameter (hybrid model) for transistors, Low frequency small signal analysis of CE and CC configurations (without feedback), Simplified CE and CC model, Small signal model for FETs (JFET and MOSFET), Low frequency small signal analysis of CS and CD configurations.

**Feedback and oscillator circuits**
Feedback concept, feedback amplifier topologies, General characteristics of negative feedback amplifier, Input and output resistance with negative feedback, Method of analysis of feedback amplifier with practical examples, Positive feedback and Barkhausen criterion for oscillation, Sinusoidal oscillators-LC, RC and crystal oscillators

**Power amplifiers**
Definition of class A, B and C power amplifiers, Distortion analysis, Series fed and transformer coupled power amplifier, Push-Pull amplifiers, conversion efficiency.

**Differential amplifiers**
Differential amplifiers, differential and common mode gain, Constant current bias, Current mirror circuits,Level Translator.

**Operational amplifiers**
Op Amp and its block diagram, Characteristics of ideal and non-ideal op amp, Equivalent circuit for op amp, AC and DC parameters, Inverting and non-inverting op amp with and without feedback, Basic and practical differentiator circuit, Basic and practical integrator circuit, Instrumentation amplifier and its applications, V-I converter and vice versa with its applications, Op amp as comparator and Schmitt trigger, Triangular and rectangular wave generator using op amp, 555 timer and its application.

**Text Books :**

1. Integrated Electronics- Analog and Digital Circuits and Systems – J. Millman&Halkias, C.D. Parikh- 2nd/ 2013 (10th Reprint)–Mc-Graw Hill India.
2. Op-Amps and LIC- Ramakant A. Gayakward -4$^{th}$ Edition- Pearson.

**Reference Books :**

1. Microelectronics circuits- A. S. Sedra and K. C. Smith- 5$^{th}$ Edition, 2011 - Oxford University Press.
2. Linear Integrated Circuits- D. Roy Choudhury and Shail B. Jain- 4$^{th}$ Edition- New Age International Publishers.

## EC 3005 DIGITAL COMMUNICATION TECHNIQUES Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

- CO1. apply the concepts of random process and various probability density functions (PDF), cumulative distribution functions (CDF) in solving problems associated with noise in communication channel.
- CO2. understand various blocks in the digital communication system and advantages and disadvantages of digital communication.
- CO3. comprehend and analyze the principle of sampling, quantization and encoding in various waveform coding techniques like Pulse Code Modulation , Differential PCM , Delta Modulation (DM) and Adaptive DM and apply the principle for problem solving. Understand digital multiplexing schemes.
- CO4. evaluate noise performance of various waveform coding techniques and compare them.
- CO5. conduct analysis of the modulated signals like phase and frequency shift keying techniques (ASK, FSK, PSK, MSK GMSK ,QAM ) , M-ary modulation schemes using orthogonal and orthonormal basis functions and signal space representation . Analyze coherent and non coherent receivers, optimum receivers, and matched filter.
- CO6. evaluate and analyze the Bit Error Rate (BER) performance of different digital modulation schemes.

### Prerequisite: Analog Communication Techniques (EC2012)

**Introduction**: Brief Idea of Probability, Random Variable, Random Process, Cumulative Distributive Function, Probability Density Function, Mean, Variance, Power spectral density, Gaussian, Rayleigh, Exponential and Poisson PDF.

**PCM, Delta Modulation and Demodulation**: Pulse Code Modulation, Electrical representation of Binary Digit, PCM system, companding, Multiplexing of PCM signals, Differential PCM, Delta Modulation, Adaptive Delta Modulation, Linear predictive coder, Comparison of PCM and DM, Delta Sigma modulation.

**Noise in PCM and Delta – Modulation**: Quantization noise, output signal power, output SNR in PCM, quantization noise in DM, output SNR in DM and DPCM.

**Multiplexing:** Introduction, frequency division multiplexing (FDM), time division multiplexing (TDM), Introduction to Code division multiplexing**.**

**Digital Modulation and Demodulation Techniques:** Band-pass transmission system, Gram-Schmidt orthogonalization, BPSK, DPSK (Differential Encoded PSK), QPSK, π/4 QPSK, OQPSK, M-ary PSK., BFSK, M-ary FSK, Minimum shift keying (MSK), GMSK, Comparison of BPSK, QPSK, π/4 QPSK, OQPSK, BFSK, GMSK,QAM. Comparison of modulation schemes in terms of probability of error and spectral efficiency .

**Data Transmissions:** Base-band Signal Receiver, Probability of Error, The Optimum Filter, White noise, the Matched filter, Probability of Error of Matched Filter, Coherent Reception: PSK, FSK, Non-coherent Detection of FSK, Differential PSK and QPSK, Error probability of BPSK, BFSK & QPSK, MSK & GMSK, QAM. Bit encoding, Symbol-by-symbol encoding, Relationship between bit error rate and symbol error rate.

**Text Book :**

1. Principles of Communication Systems – H. Taub& D.L. Schilling, G.Saha – 4$^{th}$ edition,2013- McGrawHill

**Reference Books :**

1. Communication System – Simon Haykin, John Willey - 4$^{th}$edition,2011
2. Modern Analog & Digital Communication System – B.P.Lathi Oxford University Press- 4$^{th}$ edition,2011

## EC 3007 DIGITAL SIGNAL PROCESSING Cr-4

**Course Outcomes :** At the end of the course, students will be able to :

CO1. understand appropriate transformation technique for signal analysis

CO2. analyze the signal and its properties in its frequency domain.

CO3. apply the knowledge of analog filters to digital filters, design and realization of digital filter.

CO4. analyze and implement multi-rate systems and filter banks.

CO5. apply the adaptive filters for system identification, channel equalization and noise cancellation.

CO6. interpret the spectral characteristics of different signals and also able to perform signal parameter estimation.

### Prerequisites: Principle of Signals And Systems (EC2023) / Signals and Networks (EC2021)

**Fundamental of Signals and System & Z-Transform:-** Brief idea about the DSP, Review of Signals and systems, Z-transform, ROCand it's properties , Inverse Z-transform, system analysis and one – sided z-transform.

**Fourier Transforms**: Discrete Time Fourier Transform, Conditions and properties of DTFT, Discrete Fourier Transform, Properties of DFT, Inverse Discrete Fourier Transform, Circular Convolution, Properties of Circular Convolution, Sectional convolution, Fast Fourier Transform, Radix 2 Decimation in Time (DIT), Radix-2-Decimation in Frequency (DIF).

**Digital filters:** Introduction to Digital Filter , Conversion to digital IIR Filter using impulse invariance technique, Bilinear Transformation, and approximation of derivatives, Realization of Digital Filters, Direct form – I and Direct form – II realization, Design of FIR Filter: Rectangular, Bartlett, Blackman Hamming, Hanning and Kaiser window, Frequency Transformations in the Analog domain, Frequency Transformations in the Digital domain.

**Multi-rate DSP**: Introduction to multi-rate DSP, Decimation and interpolation, Polyphase decomposition, Uniform DFT filter banks, Quadrature mirror filters and perfect reconstruction, Introduction to finite register length effects on digital filter performance.

**Adaptive filters:** Introduction to Adaptive Filters, Application of Adaptive Filters: System Identification or System Modelling, Adaptive Channel Equalization, Adaptive Line Enhancer, Adaptive Noise Cancelation, Introduction to spectral density and spectral estimation.

**Text Books :**

1. Digital Signal Processing – J. G. Proakis& D. G. Manolakes, 4th edition – PHI
2. Digital Signal Processing – T. K. Rawat , Oxford University Press; 1st edition (2015)

**Reference Books :**

1. Digital Signal Processing – Oppenheim & Schafer, PHI, 1st Edition.
2. Digital Signal Processing – P. Ramesh Babu, Scitech Publication,4th Edition.

**EC 3011** **VLSI DESIGN** **Cr-3**

**Course Outcomes:** At the end of the course, students will be able to :

CO1. adopt mathematical methods for circuit analysis using MOS Digital Circuits
CO2. identify the various IC fabrication methods.
CO3. learn basic circuit concept and scaling effects.
CO4. design the different logic structures using different design styles and CMOS
CO5. conceive the idea of layout and stick diagram approach for logic circuits
CO6. demonstrate an understanding of working principle of operation of different types of semiconductor memories

**Prerequisite: Digital Electronics (EC2011)**

VLSI Methodologies: Introduction to VLSI design, Moore's Law, VLSI Design flow, Design hierarchy, VLSI Design style: Full custom and semi-custom design, Field programmable devices.

Unit process in VLSI and IC fabrication: Unit process in VLSI: Wafer preparation, Oxidation, Diffusion, Ion implantation, Deposition, Metallization, Etching and Lithography, nMOS fabrication process, CMOS fabrication techniques in brief.

MOSFET: Two terminal MOS structure, Accumulation, depletion and inversion. Threshold voltage, substrate bias effect, drain current expression (gradual channel approximation method), Channel length modulation, MOSFET scaling: constant field and constant voltage scaling, Short-channel Effects (qualitative only).

CMOS Inverter and its analysis: General CMOS logic structure, VTC of inverter, noise margin, Resistive Load Inverter analysis, Pseudo NMOS and enhancement load Inverter (Qualitative only), CMOS inverter and its DC analysis.

Transient characteristics:Switching characteristic (rise time, fall time, propagation delay), Propagation delay of CMOS Inverter (average current and integral method), Dynamic Power Dissipation in CMOS Inverter, Elmore delay model for delay estimation of interconnects. Supper Buffer Design.

CMOS logic design:Introduction, NAND, NOR and other complex CMOS logic circuits. Stick diagram and layout. Layout design for complex logic circuit, Euler path Method, layout design rules. Sizing of CMOS logic circuits, Behaviour of Bistable Element, Static Random Access Memory (SRAM).

Dynamic Logic Circuit:Dynamic CMOS logic circuits, charge leakage and charge sharing problem, dynamic gate cascading problem, Domino and NORA logic; Pass transistor based logic design, complementary pass transistor logic (CPL), CMOS transmission gate logic.

**Text Book :**

1. CMOSDigital Integrated Circuits Analysis & Design by Sung-Mo Kang, Yusuf Leblebici, Chul Woo Kim, 4th Edition, McGraw Hill, 2014

**Reference Books :**

1. Introduction to VLSI Circuits and Systems by John P. Uyemura, Wiley Student Edition, Wiley, 2006
2. CMOS VLSI Design: A Circuits and Systems Perspective by Neil Weste, David Harris, 4th edition Pearson, 2010

## EC 3013 PRINCIPLE OF DIGITAL SIGNAL PROCESSING Cr-3

**Course Outcomes:** At the end of the course, the students will be able to :

- CO1. classification of analog and discrete time signals; perform different operations on discrete time signals.
- CO2. analysis of discrete time systems in time domain.
- CO3. analyze characteristics of signals and systems in frequency domain using Fourier analysis and its properties.
- CO4. comprehend the properties of z-transform; perform z-transform and its inverse; analysis of discrete time systems using z-transform.
- CO5. design IIR filter with given specifications using impulse invariance and bilinear transformation techniques.
- CO6. design of FIR filter with given specifications using different windowing techniques.

### Prerequisite: Mathematics-II (MA1004)

**Introduction**

Brief idea about analog and digital signals, Definition of signal and systems, Signal Processing (ASP and DSP), Advantages and Disadvantages of DSP, Application of DSP.

**Discrete time Signals & Systems**

Discrete Time Signals and its classification , Discrete Time Systems and its classification, Operation on Discrete Time Signals , LTI systems Linear convolution sum and de-convolution, Properties of convolution, Applications of convolution, Interconnection of LTI systems , Correlation of two sequences & its Properties

**Fourier Transform, DTFT, DFT, IDFT and FFT**

Introduction to Fourier Transform, Discrete Time Fourier Transform, DTFT of discrete time signal and its properties, Discrete Fourier Transform and its Properties, Inverse Discrete Fourier Transform , Circular convolution and its properties , Long duration sequences by digital filter method (Over-lap save and Over-lap add method) , Fast Fourier Transform and its properties.

**Z-Transform**

Introduction to Z-Transform , Definition of Z-Transform , ROC of the Z-Transform , Properties of ROC, Properties of Z-Transform , Inverse Z-Transform , Long division method, Convolution Method, Partial Fraction Expansion Method, Residue method, Solution of difference equations using one sided Z-Transform, Stability analysis of Discrete Time Systems.

**Digital filters (IIR & FIR FILTERS)**

Introduction to Digital Filter, Design of IIR filter using Approximation of Derivatives method, Design of IIR filter using impulse invariance technique, Design of IIR filter using Bilinear transformation , Design of FIR Filter using Rectangular, Hamming Window. Blackmann window, Kaiser window, and Bartlett window.

**Text Books :**

1. Digital Signal Processing by T. K. Rawat, Oxford Publication 1 st Edition
2. Principle of Signal Processing and Linear System: B.P.Lathi, First Edition ,Oxford University Press

**Reference Books :**

1. Digital Signal Processing – J.G.Proakis and D.G.Manolakis , 4th Edition-PHI
2. Signals & Systems: Alan V. Oppenheim & Schafer-2nd Edition 2011 Pearson
3. Digital Signal Processing: P. Ramesh Babu: Scitech,2nd Edition

## EC 3015 MICROWAVE ENGINEERING Cr 3

**Course Outcomes:** At the end of the course, students will be able to :

- CO1. comprehend wave propagation characteristics through different types of waveguides, modes of propagation, waveguide excitation, physics of cavity resonators and their characteristics
- CO2. comprehend working of klystron amplifier and oscillators and design the same.
- CO3. develop an understanding of magnetrons, travelling wave tubes, backward wave oscillator and their applications.
- CO4. comprehend the working of microwave active devices like GUNN diode, PIN diode and IMPATT diode; design GUNN diodes working in different modes.
- CO5. comprehend and analyze microwave passive components using scattering matrix parameters.
- CO6. understand techniques related to microwave power ,frequency impedance and gain measurement;, radiation pattern measurement of antenna and perform the same in labs and projects.

**Prerequisite :Electromagnetic Waves and Antennas (EC2022)**

**Waveguide and Cavity Resonator:** Transverse electric and transverse magnetic wave propagation in rectangular waveguide, circular waveguide (qualitative), wave impedances, rectangular cavity resonator, quality factor and resonance frequency of the rectangular cavity resonator (qualitative).

**Microwave Vacuum Type Amplifiers and Sources:** Limitations of conventional vacuum tubes, Velocity modulation process in a 2-Cavity Klystron Amplifier, Bunching process, derivations of beam coupling coefficient & bunching parameter of 2-cavity klystron amplifier. Working principle of Reflex Klystron, velocity modulation, derivation of bunching parameter, Applegate diagram of Reflex Klystron oscillator, Electronic admittance spiral of Reflex Klystron (qualitative). Slow-wave structures, Travelling Wave Tube (qualitative), Backward Wave Oscillator (qualitative). Magnetron oscillator.

**Microwave Solid State Devices & Sources:** TED, RWH theory, Gunn effect, two-valley model theory, modes of operation of Gunn diode (qualitative), READ diode, PIN diode, IMPATT diode, tunnel diode.

**Microwave Components:** Scattering matrix representation, variable attenuators, linear and rotary phase shifters, E-plane, H-Plane and Magic Tees, Rat race power divider, two-hole directional couplers, slotted section, matched terminations, coupling probes, crystal detector, Faraday rotation in ferrites, Isolator, 3-port Circulator.

**Microwave Measurements:** Power measurement, Bolometer, frequency and impedance measurements. Gain and radiation pattern measurement of antennas.

**Text book :**


1. Microwave Devices & Circuits. S. Y. Liao, PEA Publication, 2009


**Reference books :**


1. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Balmain, Prentice Hall of India, New Delhi.
2. Microwaves: Introduction to Circuits, Devices & Antennas. M. L. Sisodia and V. L. Gupta, New Age Publication, 2012.


## EC 3016 RF COMMUNICATION Cr - 4

**Course Outcomes:** At the end of the course, students will be able to :

- CO 1. comprehend the Maxwell's equations and their applications.
- CO 2. describe and explain the working of transmission lines, wave guides and passive microwave components.
- CO 3. describe and explain the working of RF amplifiers and oscillators.
- CO 4. classify, describe and compare different antennas and antenna arrays.
- CO 5. explain the different mechanisms of wave propagation through the atmosphere.
- CO 6. describe different multiplexing techniques and RF communication links..

## Prerequisite: Physics (PH1007)

**Maxwell's equations, electromagnetic plane waves and microwave systems**

Maxwell's equations in integral form, differential form, and their physical interpretation. Electromagnetic plane waves, polarization and electromagnetic power, IEEE microwave frequency bands, Microwave communication system (block diagram and description).

**Transmission lines and waveguides**

Fundamentals of transmission lines, types of transmission lines, traveling and standing waves on transmission lines, transmission line parameters, reflection coefficient and VSWR, impedance matching of transmission lines.

Introduction to rectangular waveguides, propagating modes in rectangular waveguides (qualitative only) , dominant and degenerate modes , waveguide parameters, methods of excitation, losses in waveguides.

Qualitative descriptions and applications of waveguide tees, resonators, directional coupler, isolator, circulator , duplexer and mixer using magic tee.

**RF amplifiers and oscillators**

Qualitative description and applications of klystron amplifiers and oscillators, magnetrons and traveling wave tubes, GUNN and PIN diodes.

**Antennas**

Hertzian dipole antenna, wire radiation in to space, resonant and non –resonant antennas, antenna terms and definitions (input impedance, antenna losses, radiation efficiency, radiation pattern, half power beam widths, first null beam widths, directivity, gain, effective aperture area and polarization), FRISS transmission formula, qualitative descriptions and applications of half wave dipole and quarter wave monopole antennas, antenna arrays, effect of ground, turnstile antenna, loop antenna, helical antenna , Yagi-Uda antenna array, Log-periodic dipole antenna array, aperture antennas, horn and dish antennas, microstrip antenna, adaptive and smart antennas.

**Propagation of waves**

Effect of environment on wave propagation, Modes of wave propagation, ground waves, sky waves, space waves, Tropospheric scatter phenomenon.

**RF communications links**

Overview of multiplexing techniques (FDM and TDM), microwave communication link, general satellite communication and block diagram, uplink and downlink frequencies, satellite sub systems, link budget calculation.

**Text Book :**

1. 'Electronic Communication Systems' by G. Kennedy, B. Davis and S. R. M. Prasanna, TataMcGraw Hill Education Pvt Ltd, 5$^{th}$ Edition.

**Reference Books :**

1. 'Electronic communication: Modulation and Transmission' by R. J. Scheoenbeck, PHI, 2$^{nd}$ Edition
2. 'Electromagnetic waves and radiating systems' by E.C. Jordan and K. G. Balmain, Pearson, 2$^{nd}$ Edition.

## EC 3021 NEURAL NETWORKS AND MACHINE LEARNING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. understand the fundamentals of neural networks and a develop an overview of broad learning strategies.
CO2. understand fundamental neural models (Mc-Culloch, Hebb neural nets, Adaptive Linear neurons and Multiple Adaptive Linear neurons), their learning strategies and apply them for simple modeling problems.
CO3. understand the architecture and need for multi-layer feed forward neural networks, Recurrent neural networks, radial basis function networks and apply them for simple modeling problems.
CO4. comprehend the concepts, architecture, training and testing algorithms corresponding to auto-associative, hetero-associative and bidirectional associative memory networks.
CO5. comprehend and apply discrete and continuous Hopfield network to practical problems.
CO6. develop a comprehensive idea on unsupervised learning networks and advanced neural networks.

**Prerequisites: Mathematics-I and Mathematics-II (MA1003 and MA1004)**

**Introduction to Artificial neural networks**:
Analogy between biological neural networks and artificial neural networks.
Overview of types of learning in neural network (supervised, unsupervised, reinforcement).
Basic terminologies (neuron ,weights, bias, activation , threshold).

**Fundamental neural networks with applications**:
McCulloch Neural model and its applications.
Hebb learning rule, Hebb neural networks and its applications.
Perceptrons, Perceptron learning rule (single output class and multiple output class), testing of perceptron networks and its applications.
Adaptive linear neuron (ADALINE), training and testing algorithms.
Multiple adaptive linear neurons (MADALINE), training and testing algorithms.
Muti-layer feedforward neural networks: theory, back-propagation training algorithm and learning factors, testing and its applications.
Recurrent neural networks, extended back propagation algorithms for recurrent neural networks.
Radial basis function networks: theory, training algorithms, testing and its applications.

**Associative memory networks:**
Auto associative memory networks: theory , architecture, training and testing algorithm.
Hetero associative memory network: theory , architecture, training and testing algorithm.
Bidirectional associative memory: theory, determination of weights and testing.
Discrete Hopfield network: architecture, training and testing, energy function and storage capacity of discrete Hopfield nets, applications of discrete Hopfield nets.
Continuous Hopfield network: Hardware model, analysis of energy functions and applications.

**Unsupervised Learning networks and advanced networks:**
Competitive neural networks.
Kohonen Self organizing maps: theory, architecture, training, testing and applications.
Learning vector quantization: theory, architecture, training, testing and applications.
Principal component analysis.
Qualitative description of Boltzmann machine and Gaussian machine.

**Text Book :**

1. "Principles of Soft Computing" by S. N. Sivanandam and S. N. Deepa –Wiley

**Reference Books :**

1. " Neuro-fuzzy and Soft Computing" by J.-S.R. Jang, C.-T. Sun, E. Mizutani-PHI Publications
2. "Neural networks and learning machines" by Simon Haykin-Parson, Prentice Hall

## EC 3023 OPTIMIZATION TECHNIQUES IN ENGINEERING Cr–3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. understand the need for optimization, formulate fitness/cost functions for simple problems and identify constraints involved (if any).
CO2. understand the concepts behind Single variable optimization algorithms and apply them to simple problems.
CO3. understand the concepts behind gradient based optimization algorithms and apply them for problem solving.
CO4. comprehend the importance of multivariable optimization, different multi-variable optimization techniques and concept of Pareto-front.
CO5. understanding different techniques for constrained optimization algorithms and their applications.
CO6. understand the algorithms for different nature inspired optimization algorithms, their advantages and limitations; be able to write simple codes for implementing the same and demonstrate convergence with optimal results.

**Prerequisite : Mathematics-I and Mathematics-II (MA 1003 and MA 1004)**

**Introduction:** Optimal problem formulation, Design variables constraints, Objective function, Variable bounds, Engineering optimization problems, Optimization algorithms.

**Single-variable Optimization Algorithm:** Optimality Criteria, Bracketing methods: Exhaustive search methods, Region-Elimination methods; Interval halving method, Fibonacci search method, Point estimation method; Successive quadratic estimation method.

**Gradient-based Methods:** Newton-Raphson method, Bisection method, Secant method, Computer programmes.

**Multivariable Optimization Algorithm:** Optimality criteria, unidirectional search, Direct search methods: Evolutionary optimization method, Simplex search method, Hooke-Jeeves pattern search method, Cauchy's (Steepest descent) method, Newton's method, multi-objective optimization, Pareto optimization.

**Constrained Optimization Algorithm:** Characteristics of a constrained problem. Direct methods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, Convex method.

**Advanced Optimization Algorithms:** Genetic Algorithm (GA), working principles, GA operators, selection methods, advanced GAs, computer programs, simulated annealing. Particle swarm optimization (PSO), differential evolution (DE) algorithm, bacterial foraging algorithm, ant colony optimization algorithm.

**Text Books :**

1. Optimization for Engineering Design-Algorithms & Examples – K. Deb, PHI, 2nd Ed., 2012.
2. Multi-objective Optimization Using Evolutionary Algorithms-K. Deb, John Wiley & Sons, 1st Ed., 2001.

**Reference Books :**

1. Optimization: Theory and Applications - S.S. Rao, Wiley Eastern Ltd, 2nd Ed., 1979.

## EC 3028 DATA COMMUNICATION AND NETWORKING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO 1. analyze the function of OSI model and Layered Architecture;compare and contrast different analog and digital data transmission techniques in LAYER-I.
CO 2. analyze algorithms and calculate parameters associated with Flow Control, Error control and Media Access Control (MAC) protocols used in LAYER-II.

| | |
|---|---|
| CO 3. | evaluate and calculate parameters related to Routing Algorithms and protocols and design network with different IPv4 and IPv6 addressing scheme used in LAYER-III. |
| CO 4. | investigate various network layer protocols for Address Resolution, Address Translation, Domain Name System, Internet Control Message Protocols |
| CO 5. | investigate different Transport layer protocols and calculate parameters used in LAYER-IV. |
| CO 6. | differentiate between different Quality of Service (QoS) approach and calculate parameters associated with it. |

**Prerequisites : Analog Communication Techniques (EC2012), Digital Communication Technique(EC3005)/Communication Engineering (EC2016)/ Introduction to communication Engineering (EC3044)**

**Introduction:** Overview of analog and digital data transmission, Historical background of data network, Protocol and their function, OSI model and layering.

**Physical Layer Issues:** Transmission impairments, transmission media: twisted pair, coaxial cable, optical fiber and wireless transmission. Line coding formats, typical feature and performance. Types of data and corresponding signal with examples: digital data-analog signal, analog data-digital signal, digital signal-digital data and analog data-analog signal, Asynchronous and synchronous transmission, transmission topology, MODEM, Time division and statistical multiplexing.

**Link Layer Protocols:** Circuit switching and packet switching. Framing, Error detection and correction, Retransmission Mechanisms (ARQ), Go Back N, Selective Repeat, Sliding window Protocol.

**Multiple Access Protocols:** Aloha System, Carrier Sensing (CSMA, CSMA/CD, CSMA/CA), Examples of Local area networks: Ethernet (IEEE 802.3), Wi-Fi (IEEE 802.11), IEEE 802.11ac .

**Internetworking:** Bridging, Global Internet, IP protocol and addressing (IP V4), Subnetting and supernetting, Classless Inter-domain Routing (CIDR), IP address lookup, Domain Name Systems (DNS), Network Address Translator (NATs), Unicasting, broadcasting and multicasting, Routing in Internet: Link-state, RIP, OSPF, ICMP

**End-to-End Protocols:** TCP and UDP, Congestion Control, Additive Increase/Multiplicative Decrease, Slow Start, Fast Retransmit/ Fast Recovery.

**Quality of Services(QoS):** Introduction to Quality of Services(QoS), Integrated and Differentiated Services.

**Text Books :**

1. Data Communications and Networking, B A Forouzan, McGraw-Hill, 4thEdition, 2011.
2. Computer Networking – A top-down approach featuring the Internet, James F. Kurose and Keith W. Ross, 2nd Edition, Pearson Education, Asia, 2004.

**Reference Books :**

1. Internetworking with TCP-IP: Principles, Protocols and Architecture, D. E. Comer, Vol I, 2nd Edition, Prentice Hall, 1991.
2. Data and Computer Communications, William Stalling, 10thEdition, Prentice Hall, 2013.
3. Communication Networking – An analytical Approach, Anurag Kumar, D Manjunath and Joy Kuri,Morgan Kaufmann, 2004.

## EC 3029 OPTICAL COMMUNICATION AND NETWORKING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze the principle of light propagation through optical fiber with concept of modes.
CO2. analyze various types of losses and dispersion in optical fiber.
CO3. analyze the structure, principle of operation and characteristic of optical sources and detectors.
CO4. analyze the optical communication system and preparation of link budget.
CO5. comprehend measurement techniques for optical communication system.
CO6. analyze the concept of optical networking and the concept of WDM..

**Prerequisites:Analog Communication Techniques (EC2012), Digital Communication Techniques (EC3005)/ Communication Engineering (EC2016)/ Introduction to Communication Engineering (EC3044)**

**Introduction**
Introduction, Characteristics of light, Basic principle of light propagation in optical fiber, Modal propagation of light in optical fiber, Different types of mode in optical fibers, Cut-off condition for guided modes, Boundary conditions, single mode / multi mode fiber, Concept of V number and its importance.

**Transmission Characteristics of Fibers:**
Analysis of Signal Distortion in Optical Fiber: Attenuation, material absorption and scattering loss, bending loss, intra-modal and inter-modal dispersion in step and graded fibers, overall dispersion in single and multi-mode fibers.

**Sources and detectors:**
Optical sources**:** Characteristics of good optical source, Principle of operation of LED, Principle of operation of laser diode, Intensity modulation using both LED and Laser diode.
Optical detectors:Principle of operation of PIN diode, Principle of operation of APD, Comparison of PIN / APD, Noises at optical receiver, Thermal noise, Short noise, SNR and Noise equivalent power.

**Optical Communication System and Measurements:**
Optical Fiber Connection: Optical fiber cables, stability of characteristics, fiber alignment; Fiber splices, connectors, couplers. System description and design considerations of an optical fiber communication system, Optical Link design, power budgeting, rise time budgeting.

**Optical measurements**:
Fiber Attenuation measurements, Dispersion measurements, Fiber Refractive index profile measurements, Fiber cutoff Wave length Measurements, Fiber Numerical Aperture Measurements.

**Optical networks:**
WDM concepts and principles, basic networks, SONET/SDH, broadcast-and-select WDM networks, wavelength-routed networks, nonlinear effects on network performance, performance of WDM & EDFA systems; Solutions; Optical CDMA, Ultra High Capacity Networks.

**Text Books :**
1. Fiber Optic Communications, Joseph C. Palais, Pearson Education,$5^{th}$ Edition 2013
2. Optical Fiber Communication, Gerd Keiser, McGraw Hill, Third Edition, 2000.

**Reference Books :**
1. Optical Fiber Communication, John M. Senior, Pearson Education, Second Edition, 2007.
2. Optical Communication System, J. Gower, Prentice Hall of India, 2001.
3. Optical Networks, Rajiv Rama swami, Elsevier ,Second Edition, , 2004.
4. Optical Communication Network, Viswanath Mukherjee, McGraw Hill Publication,2000

## EC 3031 ARM AND ADVANCED PROCESSORS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. learn the concepts implemented in higher level Processors like Multitasking, Virtual Memory, Memory Management etc.
CO2. learn the mode of Operation of 80286 like Real Address Mode and Protected Virtual Address Mode, Concept of program invisible registers, Segment Descriptors etc.
CO3. learn Mode of Operation of 80386, Segment Descriptors, Privilege level and Protection, Virtual '86 Mode and Paging
CO4. analyze the enhanced features incorporated in 80486 including the math processor and cache
CO5. analyze the RISC features implemented in the design of Pentium Processors, Parallel processing through U & V Pipelines / Superscalar Execution and Branch Prediction Techniques
CO6. analyze the concept of a 32 bit ARM Processor, its RISC features, Registers, Pipelining and Interrupts.
CO7. analyze the 32 bit ARM instruction set vis-a-vis 16 bit Thumb instructions and its applications

**Prerequisite : Microprocessors, Microcontrollers & Interfacing (EC 2020)**

**Introduction** : Overview of Intel higher level Processors, Concept of Multitasking, Virtual memory & Memory management

**Intel 80286 Microprocessor** : Brief outline of 80286 Architecture, Pins & Signals, Mode of operation : Real mode, Protected virtual Address mode, Program Invisible Registers, Segment descriptor, Limitation of 80286

**Intel 80386 & 80486** : Brief outline of 80386 Architecture, Pins & Signals, Mode of operation : Real mode, Protected virtual Address mode, Program Invisible Register, 80386 Segment descriptor, Privilege level & protection, Task switching, Virtual 86 mode, Paging, TLB, Enhanced features of 80486

**Pentium Processor** : Introduction, Features of RISC processors & Implementation of RISC features in Pentium, Pipelining, Superscalar execution & Branch prediction

**ARM Microcontroller**: Introduction to RISC design philosophy and ARM design, Arm family history.

Arm Processor fundamentals: Registers, CPSR, Memory map, Pipelines, Exceptions, Interrupt Vector Table

Introduction to ARM Instruction set and Thumb instructions

**Text Book :**

1) The 8088 and 8086 Microprocessors : Programming, Interfacing, Software, Hardware and Applications by Triebel and Singh - Pearson Edn - 4th Edition

**Reference Books :**

1) Microprocessors & Interfacing, Programming & Hardware by D. V. Hall - TMH - 3rd Edition, 2012
2) The Intel Microprocessors 8086/8088, 80186/80188, 80386, 80486, Pentium and Pentium Pro-Processor by B. B. Brey - PHI - 8th Edition
3) Microprocessors & Microcomputer based System Design by Md. Rafiquzzaman - UBS - 2nd Edition
4) An Introduction to the Intel Family of Microprocessors by James L. Antonakos - Pearson Education- 3rd Edition
5) ARM Assembly Language Programming & Architecture - M A Mazidi & others - www.MicroDigitalEd.Com
6) ARM System Developers Guide Design & Optimizing System Software – Andrew N. Sloss & others - Elsevier

## EC 3033 EMBEDDED SYSTEM DESIGN AND APPLICATIONS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. understand the architecture, programming, and interface requirements of ARM.

CO2. learn to use assemblers, compilers, simulators and emulators to help with design and verification for ARM processors.

CO3. interface a microprocessor to displays, memories, different I/O ports

CO4. apply ALP to solve real-time problems like timers, counters, A2D, Motors, etc. using ARM.

CO5. understand RTOS and its functionality for real time application.

CO6. develop closed and open embedded/Linux based systems for ARM processors

### Prerequisite: Microprocessor, Microcontrollers and Interfacing (EC2020)

**Overview of Embedded System:** Embedded System, Embedded Processor in System, Components of Embedded System, Brief introduction to Embedded software in system, Design Process in Embedded System.

**Embedded Hardware: Processor & Memory:** Brief overview of 8051 Architecture and real world interfacing, Processor and Memory organization, Parallelism in instruction level, Processor and memory selection.

**I/O Types:** Serial and Parallel communication Ports, Timer and Counting devices, Watchdog timers, real time clock, Serial bus Communication Protocols- I2C, CAN, and Parallel Communication Protocol-ISA.

Interrupt Service Mechanism: Concept of ISR, different interrupt sources, Interrupt handling Mechanism, Multiple Interrupts, Interrupt Latency and deadline.

**Embedded Software Development**

**Software Development:** Programming concept in ALP (assembly language programming) and High level language-C, Processor directives, functions and macros and other programming elements, Embedded C++ concept only.

**Embedded System Design using ARM:**
**PIC:** Introduction to PIC Architecture, Memory Mapped programming using Embedded C, Interfacing Programming- ADC, UART, PWM, I2C, SPI

**ARM Architectures**: Register Organisation, ARM Memory Map, CPSR, ARM Data Format and Directives, The Program Counter and Program ROM Space in the ARM, Addressing Modes, RISC Architecture in ARM, The ARM Instruction Set, ARM Organization and Implementation- 3-stage pipeline ARM, 5-stage pipeline in ARM.

**ARM Instruction Set and ARM Assembly Language Programming**: Data processing instructions, Data transfer instructions, Control flow instructions, Introduction to assembly language programs, Examples of ARM Assembly Language Programming, Interfacing with peripherals- ADC, Data EEPROM, Asynchronous serial port, SPI mode, I2C mode, Interfacing with LCD, ADC, sensors, stepper motor, key board, DAC.

**RTOS(Real time operating System):** OS overview, Process, Interrupt and memory management, RTOS overview, Basic Design rule using RTOS, Task scheduling using Priority based scheduling, cyclic scheduling and round robin scheduling.

**Case study of different types of Embedded System**: Design of Automated Chocolate Vending Machine, Digital Camera.

**Text Books :**


1. Embedded Systems: Architecture, Programming & Design, Raj Kamal, TMH, 2011
2. ARM Assembly Language:Fundamentals and Techniques by William Hohl
3. Christopher Hinds, CRC Press, $2^{nd}$ Edition, 2015.

**Reference Books :**

1. 1.Embedded System Design : A unified Hardware/Software Introduction by rank Vahid, Wiley Student Edition, Wiley, 2002
2. Arm Assembly Language Programming & Architecture: Volume 1 by Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, Microdigitaled.com, 2nd Edition, 2016

## EC 3035 HIGH SPEED DIGITAL SYSTEM DESIGN Cr- 3

**Course Outcomes :** At the end of the course, students will be able to :

CO 1. gain knowledge of different abstract level of digital system design using Verilog.
CO 2. model digital system using Verilog Modeling using dataflow or structural or behavioural style.
CO 3. apply, formulate, and solve problems in digital system design.
CO 4. analysis and synthesis of design with the use of the necessary technology.
CO 5. interpret the specifications of programmable devices and develop an appropriate application in hand.
CO 6. implement different digital systems in PLDs and FPGA to solve complex problems pertaining to society as a whole.

**Prerequisite : Digital Electronics (EC 2011)**

Overview of digital systems, digital design methodology using HDL–RTL design using Verilog, Design flow for FPGA and ASIC using HDL.

**Modeling concept:** module, instances, design verification using test bench, Lexical conventions, data types, arrays and memory, system tasks and compiler directives, modules and ports, port connection rules.

**Gate level modeling-** Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State Gates, Array of Instances of Primitives, Additional Examples, Design of Flipflops with Gate Primitives, Delays, Strengths and Contention Resolution, Net Types, Design of Basic Circuits.
Data flow modeling: Introduction, Continuous Assignment Structures, Delays and Continuous Assignments, Assignment to Vectors, Verilog Operators.

**SWITCH LEVEL MODELING:** Introduction, Basic Transistor Switches, CMOS Switch, Bi-directional Gates, Time Delays with Switch Primitives, Instantiations with Strengths and Delays, Strength Contention with Tri-reg Nets.

**BEHAVIORAL MODELING:** Introduction, Operations and Assignments, Functional Bifurcation, Initial Construct, Always Construct, Examples, Assignments with Delays, Wait construct, Multiple Always Blocks, Designs at Behavioral Level, Blocking and Non-blocking Assignments, The case statement, Simulation Flow. I*f* and i*f*-else constructs, assign-de-assign construct, repeat construct, for loop, the disable construct, while loop, forever loop, parallel blocks, force-release construct, Event. Finite State Machines- Overlap and Non-overlap modeling

**Hierarchical structural modeling:** module- parameter, module parameter values, hierarchical path names, generate statements- generate loop, generate-conditional and generate-case statements, combinational circuit design- encoders and decoders, multiplexers and de-multiplexers, comparators, a case study on seven segment display design

**Task and Function:** Differences between tasks and functions, declaration, invocation, automatic tasks and functions.

**Logic synthesis and verification:** Logic Synthesis, Impact of Logic Synthesis, Verilog HDL Synthesis, Synthesis Design Flow, Modeling tips for synthesis,Implications of Logic Synthesis Report, Delay and constraint AnalysisDesign Partitioning, Traditional Verification Technique, Assertion checking, Formal Verification

**Case study:** Sequence detector, UART, Chocolate Vending Machine, Multiplier Algorithm- Booth Multiplier(radix-2, radix-4)

**Text Book :**

1. Verilog HDL: A Guide to Digital Design and Synthesis; Samir Palnitkar; 2nd edition, Pearson Education, 2011.

**Reference Books :**

1. A System Verilog Primer by J. Bhaskar, BS Publication 2013
2. Advanced Digital Design with the Verilog HDL; Michael D. Ciletti; 2009,1st edition, PHI,2010
3. Design Through Verilog HDL by by T. R. Padmanabhan (Author), B. Bala Tripura Sundari, Wiley Student Edition, Wiley, 2012.

## EC 3036 CELLULAR COMMUNICATION Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze basic Cellular Architecture and practical mobile communication strategies.
CO2. solve basic propagation models and understand signal degradation in wireless channels.
CO3. apply channel equalization and diversity techniques in wireless systems.
CO4. distinguish between the different types of multiple access schemes and GSM technology
CO5. analyze multicarrier communication using OFDM technique
CO6. analyze MIMO and space time communication systems.

**Prerequisites : Analog Communication Techniques (EC2012), Digital Communication Techniques (EC3005)/ Communication Engineering(EC2016)**

**Cellular Communication Principle:** Cellular Concept System Architecture, Spectrum Allocation, Frequency Reuse, Channel Assignment Strategies, Co-channel Interference & System Capacity, Hand off, Hand off structure, Practical Hand off consideration, Prioritizing Hand off, Power Control, Near – Far Problem, System capacity, Improvement Techniques: Cell splitting, Sectoring, Micro cell Zone concept.

**RF Propagation & Multi-path Model:** Free space propagation model, propagation mechanism, Large Scale fading, Diffraction & Scattering by high – raise structures, shadowing and path loss, Small Scale Fading, Doppler and time-delay spread, coherence Bandwidth and coherence-Time, Types of Small – Scale Fading.

**Equalization and Diversity Techniques:** Fundamentals of Equalization, Adaptive equalizer, Concept of diversity, Types of diversity (space, time, frequency, polarization, Rake receiver .

**Multiple Access Techniques:** Multiplexing and multiple access, TDD and FDD techniques, Description of FDMA, TDMA, Spread spectrum technique and CDMA systems, Description and special features of GSM and IS – 95, WCDMA

**Multicarrier Communication:** Data transmission using multiple carriers, concept of OFDM for multicarrier communication.

**Multiple Antennas and space time communications:** Concept of Multi Input Multi Output Antenna system, Narrow band MIMO model, MIMO channel capacity, MIMO Diversity gain, Space time Modulation.

**Text Books :**

1. Wireless Communication Principle & Practice – T.S.Rappaport – 2nd edition 2012 - Pearson Education.
2. Wireless Communication – Andrea Goldsmith – Cambridge Press, 1st Edition, 2005.

**Reference Books :**

1. Wireless communications – A.F..Molisch-Wiley Publication,2nd Edition 2010
2. Wireless and Cellular Communication – C. Y. Lee – McGraw Hill, 3rd Edition, 2006.
3. Mobile Communication – Schillar – Pearson Education, 2nd Edition,2010.
4. Communication System – Simon Haykin – John Willey , 4th Edition
5. Fundamentals of Wireless Communication – Tse&Viswanath –Cambrige,2010.

## EC 3042 MEDIA & APPLICATIONS (Industry sponsored Elective) Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

- CO 1. analyze and evaluate different design and architectural aspect of IPTV and Media.
- CO 2. analyze and design applications related to Video on Demand (VOD) Middleware DRM, Content Delivery and Video Optimization.
- CO 3. investigate and construct various requirements of User Interface (UI) for different TV, Media and cloud applications.
- CO 4. analyze and investigate Value Added Services (VAS) & Machine to Machine (M2M) applications of Ericssonâ€™s Service Delivery platform (SDP) over 4G/ LTE.
- CO 5. analyze and develop applications based on various requirements of Service Applications designed over Ericsson Service Delivery Platform (SDP).
- CO 6. analyze and investigate various Intelligent Network (IN) and Next-Generation Intelligent Network architectures (NGIN) and its applications.

**Prerequisites : OOPS, Data Structure and JAVA Programming, Digital Communication Techniques, Analog Communication Techniques (CS-XXXX / EC2012, EC3005)**

**Topic 1:General**

OOPS & Programming concepts, Operating System Concepts & basic knowledge of Linux, Scripting knowledge - Unix Shells Scripting, Java Scripting, Perl Scripting, Data structure /Algorithm, DBMS, Networking Concepts

**Topic 2: Technology Specific**

Basic knowledge of JAVA, Servlets, JSP and XML processing with JAVA, Spring /Hibernate, JBoss(App Server), Messaging (JMS), Restful web service, AV formats ( HD ..), Video codecs
( MPEG…), IP Multicast

**Topic 3: Domain Specific**

Telecommunication Overview, Telecom Ecosystem (North / South Bound, GSM Concepts), VAS and Media as a function overview (EGI team would support), Basic concepts of Protocols (HTTP, TCP, UDP, STPP, SMPP, RTSP, IGMP)

**MAIN SYLLABUS**

**MODULE - 1: TVM**

**Topic 1:TVM Overview**

Introduction to TV and Media & Industry overview, Cable, DTH, IP network, IPTV concepts, Video Standards, Video Codecs, OTT, Catch up TV

**Topic 2: Multiscreen TV, Middleware, DRM, VOD**
Multiscreen TV - Live TV, Multiscreen TV Platforms, Multiscreen converged TV services & Middleware platform Middleware - Multiscreen converged TV services & Middleware platform, DRM, Encryption, Access control and Authentication, DRM implementations and various players, Digital rights management and digital Copy Protection, VOD
Video on Demand (VOD)
Subscription VOD (SVOD)

**Topic 3: Content Delivery & Video optimization , CDNs**
Content delivery & Video optimization - Diagnostics and monitoring systems, User authentication systems, Content delivery & optimization
CDN/ MDN
Encoders , streamers , Receivers
LTE Broadcast Overview

**Topic 4: End User devices & UI, Content management, DVR, Broadcast services**
End user devices & UI - Electronic Program Guide, Digital TV Consumption Devices, STB Architectures, Mobile clients, Tablets, Personal Computers, Digital home networking
Content management - Video on Demand (VOD) asset preparation, Content management systems (CMS), Analytics and Reporting systems, Content lifecycle
DVR - PVR/DVR, nPVR, Cloud
Broadcast services

**MODULE - 2: VAS**

**Topic 1: VAS & M2M Overview**
Overview of Service Delivery Platform, Overview of Service Enablement framework, Overview to Service Exposure & M2M, Overview of Device Connectivity Platforms & Remote Device Management, VAS & M2M Global Market trend, Evolution of VAS domain wrt Cloud /Virtualization , 4G & LTE, Overview of Service Delivery Platform (video)

**Topic 2: Service Enablement**
SDP Architecture Overview, Network Enablers Protocol (Native) SMPP, MM7 Architecture
Network Enablers Protocol (Web 2.0) Parlay X, Business Integration Protocol (Network Management) SNMP,
Content delivery concepts: OMA / Non OMA & HTTP - Premium messages, Infotainment Services, Caller/Hello Tunes, Wallpaper, Ringtones, Polytunes, Gifting services, Referrals services etc, Concept Handling using DRM, Application to peer messaging(A2P) & Peer to Application messaging (P2A)
Role of Operators, Service Provider and Subscribers, Subscriber provisioning, enable and access services, Use case Simulation, M2M Enablement Framework

**Topic 3: Service Applications - (IP/Messaging)**
SS7 and SIGTRAN: SS7 Overview, SIGTRAN Overview, MTP Links and Link-set, Low Speed and High Speed Links, MTP Route and Route-Sets, MTP Routing, MTP Connectivity Setup, SCCP, SCCP Connection Less Services, SCCP GT Translation, SCCP GT Based Routing, SIGTRAN SCTP and M3UA, SCTP Connectivity Setup, M3UA Connectivity Setup, TCAP, TCAP Dialog and Component Primitives, TCAP Session Examples, Messaging specific Protocols etc
Legacy Messaging – SMS, MMS, VMS: GSM overview, GSM Architecture Overview, GSM Nodes (Radio, MSC, HLR, VLR), SMS Flow, MMS Flow, VMS Flow
IP Messaging - RCS, EM (Rich communication Suit & Enriched Messaging): IP Messaging overview (SIP Messaging, RCS, etc), IP Messaging Gateway overview

**Topic 4: Service Applications - (IN Applications)**
**IN and NGIN Architecture:** Overview of Intelligent Networks (IN), IN and NGIN Architecture, IN BCSM, INAP Releases and Features, INAP Operations, CAP Releases and Features, CAP Operations, CAP and TCAP packets. CAP Application Example

**NGIN Applications:** Basic Telephone Call, Basic GSM Call, NGIN Application Overview, Toll-free, Universal Access Number, Premium Rate, Collect Call, VPN, Tele-Voting Services and Features. Custom NGIN Applications

**NGIN Platforms:** SS7 Cards, SS7 Hardware, SS7 FE and BE Architecture, NGIN Platform based on Java, Oracle OCCAS, JAIN SLEE, Open Cloud Rhino, Other NGIN Service Development Platforms, Traditional IN App Development, NGIN Application Development.

## EC 3044 INTRODUCTION TO COMMUNICATION ENGINEERING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. represent signals in time domain and analyze them in frequency domain.
CO2. comprehend different types of analog modulation schemes, their limitations, advantages and applications; analyze modulated signals in frequency domain
CO3. understand sampling theorem, importance of Nyquist rate, different types of sampling, quantization and need for pulse code modulation.
CO4. comprehend different types of digital modulation schemes and multiplexing techniques.
CO5. develop an understanding of different types of noise, their sources, representation of noise in frequency domain, effect of noise on communication systems and importance of Signal to Noise ratio.
CO6. develop an understanding of modern communication systems..

**Prerequisite : Nil**

**Signals:** Representation of signals in time domain and frequency domain (using Fourier series and Fourier transform). Properties of Fourier series and Fourier transform. Energy spectral density and power spectral density.

**Analog modulation:** Need for modulation, types of analog modulation, qualitative concepts of different types of amplitude modulation (AM,DSB-SC, SSB-SC, VSB), AM Modulators and Demodulators, super-heterodyne receiver, qualitative concepts of angle modulation (Narrowband FM, wideband FM, PM), Frequency Modulator and Demodulator.

**Sampling:** Sampling theorem and Nyquist rate, Sampling Types, quantization, Pulse code modulation.

**Digital modulation:** concepts of digital modulation (ASK, FSK, PSK, QPSK) probability of error.

**Multiplexing Techniques:** Frequency division multiplexing and Time division multiplexing. Multiplexing Vs Multiple Access

**Noise:** Random processes, concept of noise, different types of noises and their sources, Representation of white noise in frequency domain, concept of signal to noise ratio.

**Modern Communication Systems:** Inrtoduction to Satellite Communication, Wireless and Mobile Communication

**Text Books:**

1. Principles of Communication System- H. Taub and D.L. Schilling-TMH, 3rd Edition

**Reference Books:**

1. Introduction to Analog and Digital Communication System-Simon Haykins, Wiley Student Edition 2011-John Wiley
2. Electronics Communication System by Kennedy and Davis,Tata McGraw-Hill Publishing Company Limited,4th Edition

**EC 3046** **FIBER TECHNOLOGY** **Cr-3**

**(Industry Sponsored Elective)**

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze optical signal propagation through fiber and characteristics of fiber
CO2. explain and various light sources and detectors and important components of fiber link like Splitters, Isolators, Filters,OADMS,ROADM etc.
CO3. analyze and explain and testing fiber joints through connectors and splices.
CO4. design of optical link and preparation of link budget and analyzing optical fiber installation procedures
CO5. explain and analyze various optical networks.
CO6. explain and analyze concept of different Wavelength Division Multiplexing Techniques like OADM, DWDM, CWDM and link design .

**Prerequisites: Analog Communication Techniques (EC2012), Digital Communication Techniques (EC3005)**

**Optical Fiber Cables & System**
Introduction to Fiber optic communication; Principal of Fiber propagation; Structure of Fiber; Characteristics of Fiber

**Active and Passive Components**
Light Sources and Detectors ;Attenuator ;Couplers ;Splitters Gratings; Isolators; Circulators; Filters; Amplifier; OADMs ROADM; Photonics Cross connect; Transponder

**Optical Splice Connectors and Passive Nodes**
Fiber Splicing; Connectors; Fiber Testing

**Optical Fiber Link Design**
Link Budget Considerations; Power Budget; Power Budget Requirement; Examples, Case Studies

**Optical Fiber Installation**

Cable installation in underground Ducts; Guiding System and cable bending; Installation of aerial cables

**PDH SDH and OTN Overview**
PDH Overview; SDH Overview; OTN Overview

**Optical Networks**
Access Network; Metro Network; Core Network

**FTTX Overview**
FTTH; FTTP; FTTC; FTTB, Design Tools (AutoCAD, ArcGIS)

**GPON Fundamentals**
GPON - Principle; OLT / ONU; GPON Frame structure; Tripple Play Services; Case Studies and Examples

**WDM Overview**
DWDM Component - - MUX/ DEMUX, AMPLIFIER, OADM; DWDM Non Linear Effects; DWDM vs CWDM; DWDM Link Design

**Maintenance and Safety Aspect**
General support system architecture; Testing and Maintenance principle; Optical fiber and cable restoration; optical Monitoring parameters

## EC3050 INTERNET OF THINGS AND ITS APPLICATIONSCr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. differentiate, compare and contrast various MPU and MCU based embedded development platform for development of IoT prototypes and select suitable network interfaces for cloud connection.
CO2. identify application specific need of suitable sensors and actuators by analyzing the working of various sensors. Further they can calculate the parameters related to sensors based on design requirements.
CO3. design application specific IoT prototypes based on Arduino platform by means of hardware interfaces like Digital IO, Analog In, PWM, UART, SPI and I2C and develop software using Arduino IDE.
CO4. design application specific IoT prototypes based on Raspberry Pi Family development boards and develop software using python in Linux environment.
CO5. select suitable TCP/IP protocols and networking standards for development of IoT projects. In addition to that they can apply the concept of addressing: MAC, IP, Socket address to program and design suitable IoT & cloud networks.
CO6. design IoT application based on Client Server Model, HTTP, ThingSpeak, AWS, CloudMQTT and evaluate the design specifications and requirements from various case studies in the context of IoT product development life-cycle.

**Prerequisites : Microprocessors, Microcontrollers & Interfacing (EC 2020)/Principles of Microprocessors and Microcontrollers (EC 3066)**

**Introduction & Overview of IoT:** Internet of Things Overview, System Architecture, Smart Objects, Digital Computers, Microprocessor & Microcontrollers, Concept of Embedded System, Sensor & data acquisition, Actuator Control, Data Networks Concept: Internet and OSI layer.

**Sensors, Actuators & Signal Conditioning:** Instrumentation, Transducers and Sensors: Temperature, Humidity, Pressure, Gas(MQ Series). Sound Sensors: Ultra Sonic, Microphone. Optical Sensors: IR, LDR. Magnetic (Hall) Sensor, Accelerometer.Actuators: Introduction to Motors & drives.

**Embedded Platforms & Prototyping:** ATmega328P, Arduino UNO. Arduino Family. Interfacing of Sensors & Actuators: Arduino Programming basics using Arduino IDE for digital I/O, Analog In, PWM and Serial Communication.

**Advanced Embedded Development Platforms:** System on Chip (SoC), ARM®, Raspberry Pi, Evolution of Pi and technical specification comparative study, GPIO Interfacing, python programming for Digital I/O, I2C, SPI, UART, other platforms TI BeagleBone.

**Data Communication & Networking:** TCP/IP protocol stack, MAC Protocols, Underlying Technologies: IEEE 802.3, IEEE 802.11, ESP8266, Ethernet, MAC Addressing, IPv4, IPv6, IP Addressing, ARP, DHCP, DNS, NAT, ICMP Transport LayerProtocols: TCP, UDP. Application Layer Protocol: MQTT, CoAP.

**Cloud, Analytics & UI:** Client Server Model, HTTP, ThingSpeak, AWS, CloudMQTT
**IoT Applications:**Smart homes, smart grids, smart cities, connected vehicles, industrial IoT.

**Text Books :**

1. ”Internet of Things” by Jeeva Jose, 1$^{st}$ Edition-2018, Khanna Publications
2. “Internet of Things: A Hands-On Approach” by Arshdeep Bahga, Vijay Madisetti

**Reference Books :**

1. “Designing the Internet of Things” by Adrian McEwen, Hakim Cassimally, 1$^{st}$ Edition, Wiley Publishers
2. “Getting Started with the Internet of Things” by Cuno Pfister 1$^{st}$ Edition, O’Reilly Media.
3. IoT: Building Arduino-Based Projects” by Peter Waher, Pradeeka Seneviratne, Brian Russell, Drew Van Duren, 2016 Edition, Packt Publishing Ltd.
4. “Raspberry Pi IoT Projects: Prototyping Experiments for Makers” by John C. Shovic, 2016 Edition, Apress

## EC 3056 SPEECH & AUDIO SIGNAL PROCESSING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. determine the digital model of speech production
CO2 . analyze the spectral characteristics of the speech signal.
CO3. distinguish between different speech coding techniques
CO4. implement various types of algorithms for speech analysis and synthesis
CO5. design different models for speech recognition.
CO6. perform speaker verification, identification and enhance the quality of speech signal.

**Prerequisites: Digital Signal Processing (EC3007)/ Principle of Digital Signal Processing (EC3013)**

**Introduction:** Preliminaries of associated digital signal processing methodologies, such as convolution, Z-transform, Fourier transform, power spectrum etc. Digital models for the speech signal - mechanism of speech production - acoustic theory - lossless tube models – digital models - linear prediction of speech – auto correlation - formulation of LPC equation - solution of LPC equations - Levinson Durbin algorithm - Levinson recursion - Schur algorithm - lattice formulations and solutions – PARCOR coefficients - Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Frequency Analysis and Critical Bands - Masking properties of human ear.

**Speech coding** -subband coding of speech - transform coding - channel vocoder - formant vocoder - cepstral vocoder -vector quantizer coder- Linear predictive Coder. Speech synthesis - pitch extraction algorithms - Gold Rabiner pitch trackers - autocorrelation pitch trackers - voice/unvoiced detection - homomorphic speech processing – homomorphic systems for convolution - complex cepstrum - pitch extraction using homomorphic speech processing.

**Speech Transformations** - Time Scale Modification - Voice Morphing. Automatic speech recognition systems – isolated word recognition - connected word recognition -large vocabulary word recognition systems - pattern classification – Dynamic Time Warping – Hidden Markov Modeling - speaker recognition systems - speaker verification systems – speaker identification. Speech Enhancement Techniques — Approaches and Challenges in the design of Digital Hearing Aids.

**Text Book :**

1. Lawrence R. Rabiner and Ronald W. Schafer, Theory and Applications of Digital Speech Processing Pearson, 2010

**Reference Books :**

1. Thomas F. Quatieri , Discrete-time Speech Signal Processing: Principles and Practice, Prentice Hall, Signal Processing Series, 2002 .
2. Philipos C. Loizou, Speech Enhancement – Theory and Practice, CRC Press, 2013.

## EC 3058 NANOELECTRONICS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO 1. understand the basic and advanced concepts of nano electronics.
CO 2. understand and evaluate the use of fundamental science of quantum mechanics in nano electronics.
CO 3. get an idea on nano electronics materials and will be able to distinguish from other materials.
CO 4. analyze the different fabrication and characterization techniques of nanostructure materials.
CO 5. learn the concepts of few nano electronics devices.
CO 6. analyze and evaluate the idea of single electron transistors and its further applications.

**Prerequisites: Electronics Devices and Circuits (EC 2019) /
Analog Electronic Circuits (EC 1004)**

**Particles and Waves:** Introduction to Particles and waves, Wave Particle duality, Schrodinger Wave equation, Wave Mechanics of particle with suitable examples, Atoms and atomic orbitals

**Nano electronics Materials:** Introduction, Semiconductors, Crystal lattices: bonding in crystals, Electron energy bands, Semiconductor heterostructures, Carbon nanomaterials: nanotubes and fullerenes

**Tunnel junction and applications of tunneling:** Tunneling Through a Potential Barrier, Metal—Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions, Coulomb Blockade, Tunnel Junctions, Tunnel Junction Excited by a Current Source. Spintronics and Foundations of nano-photonics. Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in nano MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode.

**Growth, fabrication, and measurement techniques for nanostructures :** Introduction, Bulk crystal and heterostructure growth, Nanolithography, etching, and other means for fabrication ofnanostructures and nanodevices, Techniques for characterization of nanostructures, Spontaneous formation and ordering of nanostructures, Clusters and nanocrystals, Methods of nanotube growth, Chemical and biological methods for nanoscale fabrication, Fabrication of nanoelectromechanical systems

**Nano structure devices:**

**MEMS AND NEMS**: Introduction to MEMS and NEMS, working principles, as micro sensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor), micro actuation (thermal actuation, piezoelectric actuation, accelerometers), MEMS/NEMS design, processing, Oxidation, Sputter deposition, Evaporation, Chemical vapour deposition etc.

**Single Electron Transistor**: Introduction – Scaling of physical systems – Geometric scaling & Electrical system scaling. The Single-Electron Transistor , Single Electron Transistor Logic, Other SET and FET structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs.

**Text Books :**

1. Stephen D. Sentaria, Microsystem Design, Kluwer Academic Press
2. Marc Madou, Fundamentals of microfabrication & Nanofabrication.
3. T. Fukada & W.Mens, Micro Mechanical system Principle & Technology, Elsevier, 1998.

**Reference Book :**

1. Nano Terchnology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer.

## EC 3060 MOBILE COMMUNICATION ENGINEERING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. comprehend the concept of Cellular System
CO2 . model RF propagation and multi path propagation
CO3. differentiate between various digital modulation techniques such as QPSK, OQPSK, pi/4 QPSK ,MSK,GMSK and QAM
CO4. analyze and differentiate between various Equalization and diversity techniques
CO5. characterize various spread spectrum modulation
CO6. differentiate between various multiple access techniques like TDMA,FDMA and CDMA.

**Prerequisites: Communication Engineering (EC2016)/ Introduction to Communication Engineering (EC 3044)**

**Mobile Communication Principle:** Cellular Concept System Architecture, Spectrum Allocation, Frequency Reuse, Channel Assignment Strategies, Co-channel Interference & System Capacity, Hand off, Hand off structure, Practical Hand off consideration, Prioritizing Hand off, Power Control, Near – Far Problem, System capacity, Improvement Techniques: Cell splitting, Sectoring, Micro cell Zone concept.

**RF Propagation & Multi-path Model:** Free space propagation model, propagation mechanism, Large Scale fading, Diffraction & Scattering by high – raise structures, shadowing and path loss, Small Scale Fading, Doppler and time-delay spread, coherence Bandwidth and coherence-Time, Types of Small – Scale Fading.

**Modulation Techniques:** Overview of QPSK, Offset QPSK, $\pi/4$ QPSK, MSK, GMSK, QAM.

**Equalization and Diversity Techniques:** Fundamentals of Equalization, Adaptive equalizer, Concept of diversity, Types of diversity (space, time, frequency, polarization, Rake receiver .

**Spread Spectrum modulation:** Spread Spectrum Modulation and principle, PN sequence and its properties, Direct sequence SS and frequency – hopped SS (DS – SS and FH – SS), TH – SS.

**Multiple Access Techniques:** Multiplexing and multiple access, TDD and FDD techniques, Description of FDMA, TDMA, CDMA systems, Description and special features of GSM and IS – 95, Wireless data communication and services, Mobile communication standards, Transmitting and Receiving Antenna Systems.

**Text Book :**

1. Wireless Communication – T.S.Rappaport – Pearson Education, 2nd Edition, 2012.

**Reference Books :**

1. Wireless Communication – Andrea Goldsmith – Cambridge Press, 1st Edition,2005.
2. Wireless and Cellular Communication – C. Y. Lee – McGraw Hill, 3rd Edition,2006.
3. Mobile Communication – Schillar – Pearson Education, 2nd Edition, 2010.
4. Wireless Communication – Tse &Viswanath – Cambrige Press, 2010.

## EC 3062 SMART ANTENNAS Cr–3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze linear and circular antenna arrays.
CO2. classify adaptive processing for smart antenna using different methods.
CO3. solve design problems on smart antenna in presence of mutual coupling between the antennas.
CO4. compensate mutual coupling in presence of jammers.
CO5. solve design problems on smart antenna by estimating direction of arrival (DOA) of signal.
CO6. investigate different types of DOA estimation methods..

### Prerequisite: Electromagnetic Waves and Antennas (EC 2022)

**Introduction:** Analysis of linear and circular antenna arrays, and phased array antenna. Array synthesis methods. Adaptive antennas and smart antennas, adaptive processing using minimum variance distortionless technique.

**Direct Data Domain Least Square Approaches to Adaptive Processing:** Direct data domain least square procedures, eigenvalue method, forward method, backward method, forward-backward method, main beam construction for prevention of signal cancellation.

**Mutual Coupling in Adaptive Smart Antennas:** Mutual coupling among an array of dipoles (qualitative), compensation using open-circuit voltages and minimum norm formulation, effect of mutual coupling for constant jammers and constant signals, compensation for mutual coupling for constant jammers and constant signals.

**Direction of Arrival (DOA) Estimation and Adaptive Signal Processing for Smart Antennas:** Problem formulation, transformation matrix to compensate undesired electromagnetic effects, DOA estimation for a semicircular array, adaptive processing using a single snapshot from a non-uniformly spaced array in presence of mutual coupling and near-field scatterers, DOA estimation using a phased array on a conformal hemispherical surface, DOA estimation using cyclostationarity, Optimization of base station location for indoor wireless communication.

**Text Books :**

1. Smart Antennas – T. K. Sarkar, M. C. Wicks, M. Salazar-Palma and R. J. Bonneau, Wiley-Interscience, 1st Ed., 2003.

**Reference Books :**

1. Smart Antenna Engineering - Ahmed El-Zooghby, Artech House, 1st Ed., 2005.
2. Smart Antennas for Wireless Communication: With MATLAB- F. Gross, McGraw Hill, 1st Ed., 2005.

## EC 3064 INFORMATION THEORY & CODING Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

- CO1. understand the mathematical definitions of information, using conditional and unconditional probability theorem.
- CO2. understand the different sources of information and coding techniques.
- CO3. understand channel coding schemes and Shannon's information theory.
- CO4. distinguish between various error decoding schemes.
- CO5. design and simplify different codes such as cyclic codes, CRC codes (cyclic Redundancy Codes) and BCH codes.
- CO6. Understand Convolution codes..

**Prerequisite : Digital Communication Techniques (EC3005)**

**Source Coding:** Introduction to information theory, definitions of self-information and mutual information, conditional self-information, average mutual information and entropy, binary entropy function, FLC & VLC, prefix code and Kraft inequality, source coding theorem, code efficiency, redundancy, Shannon-Fano algorithm, discrete memory less source and Markov source, Huffman coding.

**Channel Capacity & Coding:** DMC, BSC, BEC & other special channels, channel capacity, channel coding, code rate, channel coding theorem, Information capacity theorem, Shannon limit.

**Speech Coding:** Characteristics of speech signals, frequency domain speech coding, sub-band coding, adaptive transform coding, Vocoders (channels vocoders, formant vocoders, cepstrumvocoders).

**Error Control Coding :** Code, codeword, weight of a codeword, generator polynomial, vector, matrices, Galois field, liner code, linear block code, matrix description of linear block code, parity check matrix, systematic code, decoding of a linear block code, standard array, syndrome decoding, error probability after coding, Hadamard code & Hamming code, optimal linear code, maximum distance separable code.

**Cyclic codes:** Method for generating cyclic codes, burst error correction, Fire code, Golay code, CRC codes, circuit implementation of cyclic codes.

**BCH Codes:** Primitive element, minimal polynomial, method of generating BCH code, examples of BCH codes, decoding of BCH code, Reed-Solomon code.

**Convolutional Codes:** Tree & Trellis codes, Convolutional codes, Viterbi decoding,

**Text Books :**

1. Information Theory, Coding and Cryptography – Ranjan Bose, Tata McGraw Hill – 2nd edition 2011
2. Principles of Digital Communication – J. Das, P. K. Chatterjee& S. K. Mullick, New Age Internationals, 2008

**Reference Books :**

1. Elements of Information Theory- T. M. Cover & J. A. Thomas, Wiley-Interscience – 2nd edition, 2010
2. Digital Communications – J. G. Proakis, McGraw Hill Education – 4th edition.

## EC 3066 PRINCIPLE OF MICROPROCESSORS AND MICROCONTROLLERS Cr-3

**Course outcomes :** At the end of the course, the students will be able to :

CO1. understand the concept of Bus and a basic 8 bit Microprocessor system.
CO2. understand the architecture of a 16 bit Microprocessor like 8086 including the concept of instruction queue, segmented memory structure and address generation technique.
CO3. understand the Addressing modes, Assembly language instructions of 8086 and implement them to solve 8086 related design problems.
CO4. analyze the interrupt structure of 8086 Microprocessor.
CO5. design Memory Interfacing circuits with a 16 bit processor.
CO6. understand the peripherals such as PPI, PIC, USART and their interfacing with a 16 bit processor .
CO7. analyze memory organization of a 8 bit Microcontroller (like 8051), its addressing modes & instructions.

**Pre-requisite : Digital Electronics (EC 2011)**

**8 bit Processor Overview**: Concept of Bus structure, Brief outline of a 8085 Microprocessor based system, Architecture, Overview of Instructions & Addressing Modes etc.

**8086 (16bit Microprocessor)**: Introduction, Architecture, Pins & Signals, Minimum & Maximum Mode Configuration, Timing Diagrams, 8086 Addressing Modes and Instructions, Memory Interfacing, Interrupts

**Interfacing chips** : 8255 (PPI), 8259 (PIC), 8251 (USART)

**8051 Family of Microcontrollers**: Introduction, Overview of MCS-51 Family of Microcontrollers

Memory Organization: Program Memory, Data Memory, Register Banks & SFRs, Bit Addressable RAM, Pins & Signals, Addressing Modes, 8051 Instruction Set & Sample problems, Interrupts

**Text Book :**

1. Microprocessors and Interfacing, Programming & Hardware - Douglas V. Hall, McGraw Hill Education Pvt Ltd., 3rd Edition

**Reference Books :**

1. Microprocessors & Microcomputer based System Design - Md. Rafiquzzaman, 2nd Edition
2. Advanced Microprocessor and Peripherals - Architecture, Programming and Interfacing by A. K. Ray and K. M. Bhurchandi - McGraw Hill Education Pvt Ltd - 3rd Edition
3. 8051 Microcontroller - Hardware, Software & Applications - V Udayshankara & M Mallikarjunswamy - TMH - 1st Edition

## EC 3068 REAL TIME SYSTEMS AND APPLICATION Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1. differentiate between a real-time system and other systems.
CO2. identify the different parts of hardware needed for Real Time system
CO3. analyse and design to interface a microprocessor to displays, memories, different I/O ports
CO4. analyse and use RTOS for Real Time System design
CO5. design and Evaluate the function of a real-time System
CO6. apply the knowledge to different Real Time System for solving Engineering and Social Problems

**Prerequisite: Digital Electronics (EC 2011)**

**Introduction to Real-time concepts:**
Real-Time Definitions, Events and Determinism, CPU Utilization, Real-Time System Design Issues, Example Real-Time Systems, Brief History.

**Hardware Considerations:**
Basic Architecture, Hardware Interfacing, Central Processing Unit, Memory, Input/Output, Enhancing Performance- Cache, Pipelining, Coprocessors, Other Special Devices, Non-von-Neumann Architectures

**Real-Time Operating Systems:**
Real-Time Kernels, Theoretical Foundations of Real-Time Operating Systems-Tasks, Task Scheduling- Clock Driven Scheduling, Event Driven Scheduling, Earliest Deadline First Scheduling and Scheduling in Multiprocessor Systems, Inter-task Communication and Synchronization- Mailbox, Semaphores, Deadlocks, Priority Inversion, Resource Sharing, Memory Management- Stack Management, Swapping, Overlays, A Real Time Operating System Case Study- POSIX.

**Software Requirements Engineering:**
Requirements-Engineering process, Types of Requirements, Requirements Specification for Real-Time Systems, Formal Methods in Software Specification: Finite State Machines, State-charts, Petri Nets, Software Design Process- Properties of Software, Basic Principle of Software, Procedural and Object Oriented Design.

**Applications Examples :**
Real-Time Data Processing of the Sensory Data of a Multi-Fingered Dextrous Robot Hand, Fly-By-Wire Systems for Military High Performance Aircraft.

**Text Book :**

1. Real-Time Systems Design And Analysis by Phillip A. Laplante John Wiley & Sons, Inc. Publication, 3rd Edn, 2011

**Reference Books :**

1. Embedded and Real-Time Operating Systems by K.C. Wang, Springer, 2017
2. Real-Time Systems: Theory and Practice by Rajiv Mall, Pearson Publisher, 1st Edition, 2017.

## EC 3070 MANET & WSN Cr-3

CO1. Comprehend the working and features of MANET.
CO2. Comprehend the goals, challenges, protocols and issues involved in designing MANET and quality of service required.
CO3. Comprehend the fundamentals of WSN.
CO4. Comprehend the working of physical layer for WSN.
CO5. Comprehend the different protocols, transport layer features and routing in WSN.
CO6. Realize the challenges in WSN and cross layer solutions.

**Prerequisite: Communication Engineering(EC 2016)**

**INTRODUCTION TO MANET**

Origin Of Ad-hoc: Packet Radio Networks – Technical Challenges – Architecture of PRNETs – Components of Packet Radios – Introduction to Ad-hoc networks – Definition, characteristics features – Issues in Mobile Ad Hoc networks- Types of Ad hoc Mobile Communications – Types of Mobile Host Movements – Ad hoc wireless Internet. Characteristics of Wireless channel Mobility models – Indoor and Outdoor.

**MAC, ROUTING & QoS IN MANET**

MAC protocols: design issues, goals and classification. Contention based protocols – With reservation, scheduling algorithms, protocols using direction antennas – Distributed packet reservation – Multiple access protocol, collision avoidance time allocation protocol. IEEE standards: 802.11 a, 802.11 b, 802.11g.

Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven routing protocols, Dynamic source routing protocol, AODV routing protocol, Zone routing protocol, Architecture Model and classification for Multicast Routing Protocols, Tree & Mesh Based Multicast Routing Protocols, Comparisons of Multicast Routing Protocols

Issues and Challenges in Providing QoS in Ad Hoc Wireless Networks – Classifications of QoS Solutions – MAC Layer Solutions – Network Layer Solutions

**INTRODUCTION TO WIRELESS SENSOR NETWORKS**

Basic Concepts, Platforms, Standardization, architecture and protocols, Applications in military, environment, healthcare, industry and energy, factors influencing WSN Design

**PHYSICAL, MAC & ROUTING FOR WSN**

PHY layer standard (IEEE 802.15.4), MAC challenges, MAC protocols for Sensor Network – Contention based (S-MAC, B-MAC, CC-MAC), reservation based-(TRAMA) & Hybrid MAC (Zebra MAC). Routing challenges, Data Centric and Flat- architecture protocol(SPIN), Hierarchical protocol (LEACH), Geographical routing protocol (MECN), QoS based Protocol(SAR).Challenges of Transport layer ,Transport Layer protocols (PSFQ & CODA).

**CHALLENGES IN WSN &CROSS LAYER SOLUTIONS**

Challenges in localization, Ranging Techniques, Range based Localization protocols, Range-Free Localization, Challenges for Time synchronization, Timing Sync protocol for sensor network (TPSN) Interlayer Effects, Cross layer Interactions (MAC-Network, MAC-Application, Network and PHY, Transport –PHY)

**Text Books :**

1. C.Sivaram Murthy and B.S Manoj, “Ad Hoc Wireless Networks”, Pearson Education, Second Edition India, 2001.
2. Wireless Sensor Networks – Ian F. Akyildiz and Mehmet Can Vuran -John Wiley and Sons Ltd, Publication,2010.

**Reference Books :**

1. K Toh, “Adhoc mobile wireless networks, Protocols and Systems”, 2nd Edition, Pearson Education, 2009.
2. Stefano Basagni, “ Mobile Ad hoc Networking”, Wiley Inter science, IEEE Press, 2004.
3. George Aggelou “Mobile Ad Hoc Networks”, McGrawHill, 2004.
4. Wireless Sensor Network - a networking perspective, Jun Zhny and Abbos Jama Lipcar,Wiley 2009. 5. Wireless Sensor Network, Springer, C. Raghavendram, K Sivalingam and T. Znati, ISBN:1-4020-7883-8, August 2005.

## EC 4047 BIOMEDICAL SIGNAL PROCESSING Cr-3

**Course Outcomes:** At the end of the course , students will be able to

CO1. Distinguish between different types of Bio medical signals and its origin.
CO2. perform time and frequency domain filtering on them using different filters to remove artifacts.
CO3. Analyze and Detect different events in ECG and EEG signals
CO4. Perform waveform analysis on different bio medical signals to extract different signal parameters
CO5. Design different types of estimators to perform signal parameter estimation.
CO6. Model different types of bio medical system.

**Prerequisites :Digital Signal Processing (EC3007),Math-III(Electronics) (MA2009)/Math-III (Electrical) (MA2007)**

**Introduction** : Biomedical signal origin & dynamics (ECG), Biomedical signal origin & dynamics (EEG, EMG etc.).

**Filtering for Removal of artifacts:** Statistical Preliminaries, Time domain filtering (Synchronized Averaging, Moving Average), Time domain filtering (Moving Average Filter to Integration, Derivative-based operator), Frequency Domain Filtering (Notch Filter), Optimal Filtering: The Weiner Filter.

**Filtering for Removal of artifacts contd.:** Optimal Filtering: The Weiner Filter, Adaptive Filtering Selecting Appropriate Filter .

**Event Detection:** Example events (viz. P, QRS and T wave in ECG), Derivative based Approaches for QRS Detection Pan Tompkins Algorithm for QRS Detection, Dicrotic Notch Detection Correlation Analysis of EEG Signal

**Waveform Analysis:** Illustrations of problem with case studies, Morphological Analysis of ECG, Correlation coefficient, The Minimum phase correspondent.

**Waveform Analysis contd.:** Signal length, Envelop Extraction, Amplitude demodulation, The Envelogram, Analysis of activity, Root Mean Square value, Zero-crossing rate, Turns Count, Form factor.

**Frequency-domain Analysis:** Periodogram, Averaged Periodogram, Blackman-Tukey Spectral Estimator, Daniell's Spectral Estimator, Measures derived from PSD.

**Modelling of Biomedical Systems:** Motor unit firing pattern, Cardiac rhythm, Formants and pitch of speech, Point process, Parametric system modelling, Autoregressive model, Autocorrelation method, Application to random signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and Cepstral coefficients.

**Text Books :**

1. R M Rangayyan "Biomedical Signal Analysis: A case Based Approach", IEEE Press, John Wiley & Sons. Inc, 2015
2. D. C Reddy "Biomedical Signal Processing: Principles and Techniques", Tata McGraw-Hill Publishing Co. Ltd, 2005

**Reference Book :**

1. Willis J. Tompkins " Biomedical Digital Signal Processing", EEE, PHI, 2004

## EC 4050 COMPUTER VISION AND PATTERN RECOGNITION Cr- 3

**Course Outcomes:** At the end of the course , students will be able to

- CO1. Differentiate between various techniques used for pattern recognition
- CO2. Perform feature extraction using different extraction techniques.
- CO3. Differentiate between various types of image model and their geometry
- CO4. Perform image transformation based on different types of transformation techniques.
- CO5. Design filters to perform image analysis using spatial and frequency domain methods.
- CO6. Design systems to detect and track various objects.

**Prerequisites :Digital Signal Processing (EC3007), Math-III (Electronics) (MA2009)/ Math-III (Electrical) (MA2007)**

**Overview of** Computer Vision (CV) and Pattern Recognition(PR) and examples.

**Basic Theories and Techniques in Pattern Recognition** : Bayesian decision theory, Parametric techniques, Non-parametric techniques, Formal linguistics theory, Linear discriminant function, Syntactic / structural PR techniques

**Feature Extraction** Feature extraction techniques in statistical PR, Feature extraction techniques in syntactic / structural PR. Edges Canny, Sobel, Line detectors (Hough Transform),Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, Feature analysis, feature vectors, distance/similarity measures.

**Digital Image Fundamentals**: Elements of visual perception, A simple image model, sampling and quantization, relationship between pixels, image geometry: translation, rotation.

**Image Transform** Review of mathematical preliminaries : matrix theory results: Toeplitz and circulant matrices, orthogonal and unitary matrices, block matrices and Kronecker products, separable operators, introduction to image transforms, Two dimensional orthogonal and unitary transforms, properties of unitary transforms, 2-D DFT, Walsh Transforms, Hadamard transform, Discrete Cosine Transform (DCT), Karhunan-Lauve (K-L) Transform, SVD Transform.

**Image Analysis** Introduction spatial domain methods, frequency domain method, enhancement by point processing : Histogram equalization, spatial filtering : Mean & Median filter, Sharpening filter, High boost filters, derivative filters, enhancement in frequency domain, Homomorphic filtering.

**Object Representation and Tracking** . Object detection: Face detection, Pedestrian detection ,Face recognition: Eigenfaces, Active appearance and 3D shape models. Object representation, Motion detection and tracking, Background Subtraction and Modelling, Optical Flow. Point tracking ,Kernel tracking ,Applications of Pattern Recognition

**Text Books :**

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011. [OPEN SOURCE BOOOK, Readily available in author's websit]
2. C.H. Chen, Handbook of Pattern Recognition & Computer Vision, 5th Edition, World Scientific, 2016.

**Reference Books :**

1. L.G. Shapiro and G. C. Stockman, Computer Vision, Prentice Hall, 2001.
2. Computer and Machine Vision Theory, Algorithms, Practicalities ,E.R Davis, Academic Press,4th Edition

## EC 4052 MACHINE LEARNING FOR DIGITAL SIGNAL PROCESSING Cr-3

**Course Outcomes:** At the end of the course , students will be able to

- CO1. Differentiate between from various types of real world signals and their representations.
- CO2. Perform feature extraction using different extraction techniques.
- CO3. Perform classification and detection of various signals based on different classification algorithms.
- CO4. Perform clustering of data to find out similarity between different signal parameters
- CO5. Apply time series and discriminative modeling techniques
- CO6. Apply different types of deep learning techniques to perform signal parameter prediction and analysis.

**Prerequisites :Digital Signal Processing (EC3007),Math-III(Electronics) (MA2009) / Math-III (Electrical) (MA2007)**

**Introduction** to real world signals - text, speech, image, video. Representation and interpretation of signals: Human perception of signals, sampling, quantization, the frequency domain, image and sound representations

**Feature extraction** and front-end signal processing - information rich representations, robustness to noise and artifacts. Useful fixed transforms (DCT, etc), adaptive transforms (KLT/PCA/EM-PCA/online-PCA), feature extraction from familiar signals (audio, video), eigenfaces. Independent Component Analysis (ICA), Non-Negative Matrix Factorization (NMF), Kernel PCA, Manifold embedding methods, random projections

**Detection and classification:** Matched filters, template matching, object detection, similarity measures, face detection, speech detection. Linear classifiers, linear discriminant analysis. Non-linear classifiers, neural nets, kernels, generative models, non-parametric methods. Real-world applications of classification models.

**Clustering** : K-means, Gaussian Mixture Models, Expectation-Maximization algorithm

**Time series** and dynamical models: Classification and similarity, time warping models, Markov models

**Discriminative modelling**: support vector machines, neural networks and back propagation.

**Introduction to deep learning**: convolutional and recurrent networks, pre-training and practical considerations in deep learning, understanding deep networks.Deep generative models - Autoencoders, Boltzmann machines, Adverserial Networks, Variational Learning.

**Text Books :**


1. "Pattern Recognition and Machine Learning", C.M. Bishop, 2nd Edition, Springer, 2011.
2. "Neural Networks", C.M. Bishop, Oxford Press, 1995.


**Reference Books:**


1. "Deep Learning : Methods and Applications", Li Deng, Microsoft Technical Report.
2. "Automatic Speech Recognition - Deep learning approach" - D. Yu, L. Deng, Springer, 2014.
3. "Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli, Springer, 2007.


## EC 4053 MILLIMETER WAVE AND TERAHERTZ TECHNOLOGY Cr-3

**Course Outcomes:** At the end of the course, students will be able to:

- CO1. Analyze and evaluate the characteristics, application and challenges related to millimetre wave communication.
- CO2. Analyze the millimetre wave propagation in channel based on different conditions and design specifications.

CO3. Analyze the antenna characteristics and requirements for millimetre wave communication.
CO4. Analyze the MIMO antenna requirements
CO5. Analyze the diversity techniques over MIMO channels.
CO6. Design and analyze the beam forming techniques

**Prerequisite: Cellular Communication (EC3036)**

**INTRODUCTION**
Millimeter Wave Characteristics, A preview of Millimeter Wave Implementation Challenges, Gigabit Wireless Communications, and applications of mm wave communication, Development of Millimeter Wave Standards, Review of modulations for millimeter wave communications.

**RADIO WAVE PROPAGATION AND MILLIMETER WAVE TRANSCEIVERS.**
Large scale propagation channel effect, small scale channel effect, Outdoor and Indoor channel model.
Millimeter Wave Link Budget, Transceiver Architecture, Transceiver Without Mixer, Receiver Without Local Oscillator, Millimeter Wave Calibration.

**MILLIMETER WAVE ANTENNAS and MIMO**
Path Loss and Antenna Directivity, Antenna Beamwidth, Maximum Possible Gain-to-Q, Polarization, Beam Steering Antenna, Millimeter Wave Design Consideration, Production and Manufacture.Spatial Diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise Coupling in a MIMO System.

**ADVANCED DIVERSITY OVER MIMO CHANNELS:**
Potential Benefits for Millimeter Wave Systems, Spatial and Temporal Diversity, Spatial and Frequency Diversity, Dynamic Spatial, Frequency, and Modulation Allocation.

**ADVANCED BEAM STEERING AND BEAM FORMING**
The Need for Beam-Steering/Beam-Forming, Adaptive Frame Structure, Advanced Beam Steering Technology, Advanced Antenna ID Technology, Advanced Beam Forming Technology.

**TERAHERTZ(THz) TECHNOLOGY**
Generation and detection of terahertz waves, transmission and propagation of terahertz waves, modeling of terahertz communication channels, modulator for terahertz waves, modulations format for terahertz signals, examples of terahertz communication systems

**Text Books :**
Millimeter Wave Communication Systems - Kao-Cheng Huang, Zhaocheng Wang, Wiley.

**Reference Books:**
Millimeter Wave Wireless Communication Systems- T.S. Rappaport, R.W. Heath Jr, R. C. Deniel, J. N. Murdock, Prentice Hall

## EC4056 MOBILE AD-HOC NETWORKS Cr-3

**Course Outcomes:** At the end of the course, students will be able to:

CO1. analyze and evaluate characteristics, Architecture, features, factors and challenges related to Mobile Ad-hoc Networks (MANET).
CO2. compare different Medium Access Control (MAC) protocols in the context of MANET and choose apt MAC protocol based on application requirements and network design specifications.
CO3. compare different Routing protocols in the context of MANET and choose apt Routing protocol based on network scenario.
CO4. assess issues and challenges for providing Quality of Service (QoS) in Ad-hoc wireless Networks and plan required QoS solutions in MAC and Network layers.
CO5. evaluate various Energy Management schemes in Ad Hoc Wireless Networks and would be able to judge the best scheme based on network specifications.
CO6. perceive various Ad-hoc Nomadic Mobile Applications to acquire skills required for designing and creating scenario specific Ad-hoc Mobile Applications.

**Prerequisite: Data Communication and Networking ( EC3028)**

**UNIT 1: INTRODUCTION**

Origin Of Adhoc:Packet Radio Networks - Technical Challenges - Architecture of PRNETs - Components of Packet Radios - Introduction to Adhoc networks - Definition, characteristics features - Issues in Mobile Ad Hoc networks- Types of Ad hoc Mobile Communications - Types of Mobile Host Movements - Ad hoc wireless Internet. Characteristics of Wireless channel Mobility models - Indoor and Outdoor.

**UNIT 2: MEDIUM ACCESS PROTOCOLS**

MAC protocols: design issues, goals and classification. Contention based protocols - With reservation, scheduling algorithms, protocols using direction antennas - Distributed packet reservation - Multiple access protocol, collision avoidance time allocation protocol. IEEE standards: 802.11 a, 802.11 b, 802.11g.

**UNIT 3: ROUTING PROTOCOLS AND MULTICAST ROUTING IN ADHOC NETWORKS**

Introduction - Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks - Classifications of Routing Protocols Table Driven routing protocols: Destination Sequenced Distance Vector Routing Protocol - Cluster head Gateway switched routing protocol. On Demand routing protocol: Dynamic source routing protocol, AODV routing protocol, temporarily ordered routing algorithm. Hybrid routing protocols: Zone routing protocol, Zone based Hierarchical link state routing protocol. Architecture Model for Multicast Routing Protocols - Classifications of Multicast Routing Protocols - Tree Based Multicast Routing Protocols - Mesh-Based Multicast Routing Protocols - Energy-Efficient Multicasting - Comparisons of Multicast Routing Protocols.

**UNIT 4: QOS AND ENERGY MANAGEMENT**

Issues and Challenges in Providing QoS in Ad Hoc Wireless Networks - Classifications of QoS Solutions - MAC Layer Solutions - Network Layer Solutions. Need for Energy Management in Ad Hoc Wireless Networks - Classification of Energy Management Schemes - Battery Management Schemes - Transmission Power Management Schemes - System Power Management Schemes.

**UNIT 5: ADHOC NOMADIC MOBILE APPLICATIONS**

In the Office, While Traveling, Arriving Home, In the Car, Shopping Malls, The Modern battlefield, Car-to-Car Mobile Communications, Mobile Collaborative Applications - Location/context based mobile services - Introduction to wireless mesh networks and vehicular adhoc networks.

**Text Books :**

1. C.Sivaram Murthy and B.S Manoj, “Ad Hoc Wireless Networks”, Pearson Education, Second Edition India, 2001.

**Reference Books:**

1. K Toh, “Adhoc mobile wireless networks, Protocols and Systems”, 2nd Edition, Pearson Education, 2009.
2. Stefano Basagni, “ Mobile Ad hoc Networking”, Wiley Inter science, IEEE Press, 2004.
3. George Aggelou “Mobile Ad Hoc Networks”, McGrawHill, 2004.
4. Thomas Krag and Sebastin Buettrich, “Wireless Mesh Networking”, 2nd Edition, OǒReilly Publishers, 2007.

## EC 4058 COGNITIVE RADIO AND COOPERATIVE COMMUNICATIONS Cr-3

**Course Outcomes:** At the end of the course, students will be able to:

CO1. analyze Cooperative Communication Concepts and Cooperation protocols.
CO2. differentiate between Distributed space–time coding (DSTC) - Distributed space–frequency coding (DSFC) and analyze Differential modulation for DF and AF cooperative communication.
CO3. analyze the features of cooperative Networking like energy efficiency, distributed routing, source channel coding etc.
CO4. analyze the concept of Software Defined Radio and Cognitive Radio.
CO5. model various cognitive Radio tasks.
CO6. comprehend the recent trends and challenges in Cognitive Radio.

### Prerequisite: Nil

**INTRODUCTION:**
Cooperative Communication, Cooperation protocols - Hierarchical cooperation, Cooperative communications with single relay, Multi-node cooperative communications.

**DISTRIBUTED SPACE–TIME CODING (DSTC) - DISTRIBUTED SPACE–FREQUENCY CODING (DSFC):**
Distributed space–time coding (DSTC) - Distributed space–frequency coding (DSFC); Relay selection- Differential modulations for DF cooperative communications - Differential modulation for AF cooperative communications.

**COOPERATIVE NETWORKING:**
Energy efficiency in cooperative sensor networks, Cognitive multiple access via cooperation, Content-aware cooperative multiple access, Distributed cooperative routing, Source–channel coding with cooperation.

**INTRODUCTION TO SOFTWARE DEFINED RADIO AND COGNITIVE RADIO:**
Characteristics and Benefits of Software Radio; Dynamic Spectrum Access; Digital dividend; Types of Cognitive Radio; Spectrum policies and Regulations; Information theoretic perspective on Cognitive Radio networks.

**COGNITIVE RADIO TASKS:**
Spectrum sensing and its methods; Cooperative Spectrum sensing; Spectrum sharing; spectrum mobility; spectrum management; spectrum trading.

**RECENT TRENDS AND CHALLENGES IN COGNITIVE RADIO:**
OFDM based Cognitive Radio; Security issues in cognitive radio; Game theory in Cognitive radio; applications of cognitive radio; IEEE 802.22 WRAN standard.

**Text Book :**

1. Rayliu K J, Sadek A K, Weifeng Su and Andres Kwasinski, “Cooperative Communications and Networking”, Cambridge University Press, 2009.


**Reference Books :**

1. 1.Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, PEA Publication, 2002.
2. Bruce A Fette, “Cognitive Radio Technology”, Elsevier Publication, Burlington, 2009.
3. Joseph Mitola III, “Cognitive Radio Architecture: The Engineering Foundations of Radio XML”, Wiley Interscience Publication, NEW JERSEY, 2006.
4. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, 2009.

## EC 6108 DIGITAL IMAGE PROCESSING Cr-3

**Course Outcomes**: At the end of the course, students will be able to :

CO1. analyze different image processing techniques to retrieve, create, and manipulate a digital image.
CO2. analyze and differentiate among various spatial and frequency domain enhancement techniques
CO3. analyze the concept of color image processing.
CO4. implement different image restoration techniques.
CO5. formulate and evaluate different image compression techniques and differentiate between different image compression and segmentation techniques.
CO6. distinguish between different image transformation techniques.

**Prerequisites : Digital Signal Processing (EC3007)/ Principle of Digital Signal Processing (EC 3013)**

**Introduction:** Historical Background of image processing, fundamental steps in image processing elements of digital image processing systems. Digital image representation, Different image processing tasks: Image enhancement, Image restoration, Image compression and image analysis.

**Digital Image Fundamentals**: Elements of visual perception, A simple image model, sampling and quantization, relationship between pixels, image geometry: translation, rotation.

**Image Transforms:** Review of mathematical preliminaries : matrix theory results: Toeplitz and circulant matrices, orthogonal and unitary matrices, block matrices and Kronecker products, separable operators, introduction to image transforms, Two dimensional orthogonal and unitary transforms, properties of unitary transforms, 2-D DFT, Walsh Transforms, Hadamard transform, Discrete Cosine Transform (DCT), Karhunan-Lauve (K-L) Transform, SVD Transform.

**Image Enhancement** : Introduction spatial domain methods, frequency domain method, enhancement by point processing : Histogram equalization, spatial filtering : Mean & Median filter, Sharpening filter, High boost filters, derivative filters, enhancement in frequency domain, Homomorphic filtering.

**Color Image Processing**: RGB, CMY and YIQ color models conversion from RGB to HIS and HIS to RGB.

**Image Restoration** : Introduction, degradation model, algebraic approach to restoration, inverse filtering, Weiner filter, constrained least squares restoration, restoration in spatial domain.

**Image Compression** : Introduction and motivation, fundamental concepts : Data redundancy (coding redundancy, interpixel redundancy and psycho visual redundancy), fidelity criteria, image compression models, elements of information theory, image compression techniques: pixel coding (Run-length – coding), Transform coding , Image compression standards.

**Morphological Image Processing**: Dilation and erosion, Opening and closing, some basic morphological algorithms.
**Image Segmentation:** Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation.

**Text Book :**

1. Digital Image Processing - R.C.Gonzalez and R. E. Woods – Prentice Hall,3rd Edition,2008.

**Reference Book :**

1. Fundamentals of Digital Image Processing- A. K. Jain – Prentice Hall 2. Digital Image Processing- S.Jayaram, S.Esakkirajan, T.Veerakumar – TMH,2009.

## EC 6112 COMMUNICATION & NETWORK SECURITY Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. analyze different security threats and attacks with reference to ISO/OSI model security and review the mathematical foundations for cryptography.
CO2. differentiate between various cryptography, watermarking, steganography methods.
CO3. analyze and apply different symmetric and asymmetric cryptographic algorithms.
CO4. investigate various key distribution and digital signature.
CO5. analyze the working of various communication security protocols with respect to OSI layer.
CO6. analyze different network security systems implementation in wireless networks.

**Prerequisites : Analog Communication Techniques (EC 2012), Digital communication Techniques (EC 3005) / Communication Engineering (EC 2016)**

**Introduction:** Cryptography, Watermarking, Steganography, Escrow & Crypt Analysis, ISO/OSI reference model & security, Security threatening attacks & actions, Reviews of mathematical foundations (Logarithms, Prime Number, GCD, Groups, Rings, Fields, Fermat's Theorem, Euler's Theorem, Exclusive-Or, Random Numbers).

**Ciphers &Algorithm:** Symmetric Ciphers, Asymmetric Ciphers systems, Elliptic Curve Crypto systems, RSA Algorithm.

**Cryptographic Key distribution system:** Key Distribution, Merkle's Puzzle Method, Shamir's Key Distribution Method, Digital Signature.

**Communication Security layer classification:** A synergistic security frame work, Firewalls & Gateways, Security Cross- portfolios, attacks and security in the internet, TACACS.

**Network security:** Wireless system: WLAN security, IEEE 802.11i robust security network and vulnerabilities, GSM Security, B3G/4G Security Concerns, Wimax Security, and Communication Satellite network security, Wireless Adhoc Network Security.

**Text Books :**

1. Cryptography & Network Security by B A Forouzan and D Mukhopadhyay, Mc-Graw Hill, India.
2. Security of Information and Communication Network by S V. Kartalopoulos, Wiley-IEEE Press., 2009.

**Reference Books :**

1. Handbook of Information and Communication Security by Stavroulakis, Peter; Springer, 2010
2. Secure Broadcast communication in Wired and Wireless Communication. By Adrian Perrig& Doug Tygar, Kluwer Publication.
3. Modern Cryptography: Theory and Practice by W Mao, Pearson Education, India.

## EC 6122 SATELLITE COMMUNICATION SYSTEMS Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | comprehend basic parameters for satellite communication. |
| CO2. | explain satellite launching methods and orbital control mechanisms. |
| CO3. | comprehend different types of losses in satellite link and satellite link design. |
| CO4. | differentiate between different types of noises and interferences associated with satellite link. |
| CO5. | evaluate the stability of a satellite in orbit and different satellite sub-systems. |
| CO6. | investigate different types of multiple access techniques for digital satellite communication. |

**Prerequisite : Electromagnetic Waves and Antennas (EC 2022)**

**Introduction :**
Frequency spectrum for satellite communication, Types of orbits, Kepler's Laws of planetary motion, Orbital perturbations, Geostationary orbit, Satellite launching, General satellite communication, Block diagram uplink, Downlink frequencies, Types of modulation techniques used orbits, and altitude control Satellite launch vehicles - Arian, SLV space shuttle.

**Losses/Attenuation :**
Signal loss on transmission through earth's atmosphere, Atmospheric losses, Ionospheric effects, Rain attenuation, Satellite link budget: Transmission losses, Interference, System noise temperature, Link power budget.

**Satellite sub-system :**
Antenna sub-systems, Altitude and orbit control sub-system, Power sub-system, Communication sub-system, TTC&M sub-systems

**Satellite Application :**
Satellite application in TV, Internet, Mobile telephony, Receive only home TV, Master Antenna, TV, Low earth orbit satellite systems and uses. Multiple access techniques - FDMA, TDMA, SS-TDMA, Interference in FDMA systems.

**Text Books :**
1. Satellite Communication, T.Pratt & C.W.Bostia, Wiley, 2003
2. Satellite Communication, D.Roddy, McGraw Hill, 2006

**Reference Book :**
1. Digital Satellite Communications, T.T.Ha, McGraw Hill, 1990

## EC 6128 WIRELESS SENSOR NETWORK Cr-3

**Course Outcomes :** At the end of the course, students will be able to :

| | |
|---|---|
| CO1. | analyze the architecture of Wireless Sensor Network and network design factors . |
| CO 2. | comprehend the physical and MAC layer issues in WSN. |
| CO3. | analyze routing mechanisms in WSN. |
| CO4. | analyze Interlayer and cross layer effects and solutions for WSN. |
| CO5. | analyze localization, ranging techniques and ranging based protocols for WSN. |
| CO 6. | Comprehend the concepts of Time Synchronization and challenges involved threin. |

**Prerequisite : Data Communication and Networking (EC 3028)**

**Introduction:** Basic Concepts, Platforms, Standardization, architecture and protocols, Applications in military, environment, healthcare, industry and energy, factors influencing WSN Design.

**Physical & MAC Layer:** PHY layer standard (IEEE 802.15.4), MAC challenges, MAC protocols for Sensor Network - Contention based (S-MAC, B-MAC, CC-MAC), reservation based-(TRAMA) & Hybrid MAC (Zebra MAC).

**Network & Transport layer:** Routing challenges, Data Centric and Flat- architecture protocol(SPIN), Hierarchical protocol (LEACH),Geographical routing protocol (MECN), QoS based Protocol(SAR).Challenges of Transport layer ,Transport Layer protocols (PSFQ & CODA).

**Cross Layer Solutions:** Interlayer Effects, Cross layer Interactions (MAC-Network, MAC-Application, Network and PHY, Transport –PHY), cross layer module.
**Localization:** Challenges in localization, Ranging Techniques, Range based Localization protocols, Range-Free Localization Protocol.

**Time Synchronization:** Challenges for Time synchronization, Timing Sync protocol for sensor network (TPSN), Time Diffusion Synchronization protocol (TDP), Rate based diffusion protocol (RDP).

**Text Book :**
1. Wireless Sensor Networks – Ian F. Akyildiz and Mehmet Can Vuran -John Wiley and Sons Ltd, Publication,2010.

**Reference Books :**
1. Wireless Sensor Network - a networking perspective, Jun Zhny and Abbos Jama Lipcar,Wiley 2009.
2. Wireless Sensor Network, Springer, C. Raghavendram, K Sivalingam and T. Znati, ISBN:1-4020-7883-8, August 2005.

## EC 6203 MOS DEVICE MODELLING Cr-3

**Course Outcomes :** At the end of the course, students will be able to

CO1. Understand characteristics and operation of of P-N junction, metal semiconductor junctions and MOS transistor.
CO2. Apply acquired knowledge to solve problems related to drain current, threshold voltage of MOSFET
CO3. Analyze short channel MOSFET and different 2nd order non-ideal effects .
CO4. Identify of different parasitic element present in MOSFET , measurement technique and their effect on device operation.
CO5. Formulate of Small signal modelling of MOS transistor and C-V characteristics.
CO6. Discuss about different MOSFET model such as Level-1,2,3 BSIM and EKV etc.

### Prerequisite: VLSI Design (EC 3011)

**Review of semiconductor fundamentals:** P- N junction characteristics and energy band diagram, Built in potential barrier, forward and reverse biased P-N junction. Metal-semiconductor contacts and their properties, Schottky barrier lowering.

**Two terminal MOS structure:** MOS capacitor at zero bias condition. Energy-band diagram. Flat band voltage. Work function, Oxide charges. MOS structure at non-zero bias condition: Accumulation, depletion and inversion condition. Threshold voltage and its components. Substrate bias effect and temperature dependency of threshold voltage. Quantum effect on threshold voltage.

**MOSFET Parasitic Elements:** Source/ drain resistance. Source/drain junction and sidewall capacitance and their variation with bias voltages. Equivalent junction capacitance. Oxide related capacitances in MOSFET.
**MOSFET DC Model:** Drain current modelling of long channel MOS transistor- Gradual Channel Approximation. Channel length modulation. Parameter extraction from experimental I-V dataset. Sub-threshold region model and sub-threshold slope.

**MOSFET Scaling:** Generalized scaling theory for MOSFET, Constant field and constant voltage scaling and their effects on device characteristics and reliability.

**Second order non-ideal effects:** Scattering of carriers and mobility degradation due to gate voltage. Velocity saturation effect, velocity overshoot. Effective mobility and its measurement.

Drain-induced barrier lowering (DIBL) and threshold voltage reduction. Gate induced drain leakage (GIDL). Impact ionization and hot carrier degradation in MOS transistor, punch-through. Tunnelling in MOS transistor-band to band and oxide tunnelling. Narrow-width effect.

**Small signal modelling of MOSFET:** Small signal equivalent model at low and high frequency. Intrinsic charge and capacitance modelling. Small signal capacitance-voltage characteristics (low and high frequency C-V characteristics). Anomalous C-V characteristics-Polysilicon depletion effect. Unity gain cut-off frequency.

**MOSFET Models:** SPICE modelling of MOSFET, introduction to LEVEL 1, LEVEL 2, LEVEL 3, BSIM and EKV Models.

**Text books :**

1. MOSFET Modeling for VLSI Simulation-Theory and Practice, Narain Arora, World Scientific Publishing,2007, ISBN-13: 9789812568625
2. Fundamentals of Modern VLSI devices, Y.Taur and T.Ning, 2nd Edition, Cambridge University Press

**Reference books :**

1. Operation and Modeling of the MOS transistor, Y.Tsividis, 2nd Ed. MGH publishers.
2. CMOS digital integrated circuits, S.M.Kang and Y.Leblebici, 4thRevised Ed. TMH, 2018
3. Solid state Electronic Devices, Streetman and Banerjee, 6th Ed. PHI.

## EC 6207 ANALOG CMOS VLSI CIRCUITS Cr- 3

**Course Outcomes :** At the end of the course, students will be able to

CO1. apply principles of MOSFET to the small signal analysis of MOS circuits.
CO2. select the most appropriate design configuration for a specified single stage amplifier implementation.
CO3. evaluate performance issues and trade-offs based on a knowledge of different current mirror circuits.
CO4. choose the most appropriate operational amplifier configuration for a specified analog circuit implementation.
CO5. model noiseless analog circuits based on the knowledge of different types of noises and their compensation.
CO6. analyze different designs of comparators best suited for a specific analog circuit application.

### Prerequisite: VLSI Design (EC 3011)

**Introduction***:* Analog circuits in VLSI, Overview of circuit performance comparison in Bipolar, BiCMOS and CMOS technologies. Review of MOS transistor theory, large signal and small signal models of MOS transistors, Feedback topologies and Stability theory.

**Amplifiers**: Basic amplifier topologies and their characteristics, common-source stage amplifier, Cascode amplifiers, Basic differential pair, Differential amplifier with active load; Two-stage differential amplifier: Analysis for different performance parameters, miller effect, types of noise, noise in single-stage amplifiers and differential pairs, Pole-zero compensation and Design.

**Biasing circuits**: Basic and Cascode current mirrors, Current and Voltage references; bandgap reference, Folded Cascode amplifier.

**Operational amplifier**: design of CMOS op-amp, one-stage op-amp, two-stage op-amp, cascade op-amp, performance parameters and analysis, compensation of op-amps.

**Comparator**: Simple comparator, Switch-based comparator, Latch-based comparator.

**Oscillator**: Ring oscillator, LC oscillator, Voltage control oscillator.

**Text Book :**

1. Design of Analog CMOS Integrated Circuits; Behad Razavi; 1st edition, TMH, 2007.

**Reference Books :**

1. CMOS Analog Circuit Design; Allen and Holberg; International 2nd edition, Oxford,2007.
2. VLSI Design Techniques for Analog and Digital Circuits; Geiger, Allen and Strader; 1st edition,TMH,2010.
3. Analog Integrated Circuit Design; D.A. Johns and K. Martin; 2/e, Wiley India,2013.
4. Analysis and Design of Analog Integrated Circuits; Gray and Meyer; 4th edition, Wiley,2010.
5. CMOS Circuit Design, Layout and Simulation; Baker, Li and Boyce; Indian edition, 1st edition, PHI,2002.

## EC 6224 LOW POWER VLSI DESIGN Cr- 3

**Course Outcomes :** At the end of the course, students will be able to :

CO1. comprehend the working of MOSFETs, their modeling techniques and use as inverter.
CO2. comprehend the sources of power dissipation in MOS circuits, types of power dissipation and constraints involved.
CO3. comprehend the supply voltage scaling techniques.
CO4. comprehend the architecture level, logic level, algorithm level and layout level design procedure of low power VLSI circuits.
CO5. comprehend leakage power minimization techniques and apply them for design of low power circuits.
CO6. perform gate sizing, design low power memory units, ROM, SRAM and DRAM.

### Prerequisite: VLSI Design (EC 3011)

**Basics of MOS circuits**: MOS transistor structure and device modeling, MOS inverters, MOS combinational circuits - different logic families.

**Sources of power dissipation in CMOS circuits**: static power dissipation - diode leakage power, subthreshold leakage power, gate and other tunnel currents; dynamic power dissipation - short circuit power, switching power, glitching power; degrees of freedom, energy delay product, power delay product.

**Supply voltage scaling approaches:** technology Level - feature size scaling, threshold voltage scaling; logic level - gate sizing for voltage architecture level - parallelism and pipelining; algorithm level - transformations to exploit concurrency; dynamic voltage scaling. Switched capacitance minimization approaches: system level - power down, system partitioning;algorithm level - concurrency, locality, regularity, data representation; architecture level - concurrency, signal correlation; logic level - gate sizing, logic styles; layout level - layout optimization; technology level - advanced packaging, SOI.

**Leakage power minimization techniques**: threshold voltage scaling: MTCMOS, VTCMOS and Multiple-Vt CMOS circuits; gate sizing. Low power memory design: ROM, SRAM (4T, 6T), DRAM.

**Text Books :**

1. CMOS Digital Integrated Circuits, Sung-Mo Kang and Yusuf Leblebici, 3rd edition, TMH,2011
2. Digital Integrated Circuits: A Design Perspective, J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, 2nd Edition, PHI,2001

**Reference Books :**

1. CMOS VLSI Design: A circuits and Systems Perspective, West, Harris and Banerjee, 3rd edition, Pearson Education,.
2. Low Power VLSI CMOS Circuit Design, A. Bellamour, and M. I. Elmasri, Kluwer Academic Press.
3. Low Power Digital CMOS Design, Anantha P. Chandrakasan and Robert W. Brodersen, Kluwer Academic Publishers,2002.
4. Low-Power CMOS VLSI Design, Kaushik Roy and Sharat C. Prasad, Wiley-India,2011.
5. Essentials of VLSI Circuits and Systems, Eshraghian, Puckness and Eshraghian, 2nd edition, Pearson Education,

## EC 6248 VLSI SIGNAL PROCESSING Cr-3

**Course Outcomes :** At the end of the course, students will be able to

CO1. understand the representation of DSP Algorithm.
CO2. apply pipelining and parallel processing to FIR filters for Low Power application
CO3. know the technique of retiming, folding and unfolding of DSP architecture to reduce critical path delay.
CO4. understand systolic array design of DSP architecture
CO5. apply Fast convolution and transform technique for Filtering Application
CO6. understand different arithmetic architecture for addition, subtraction and multiplications technique applicable to DSP

### Prerequisite: Digital Signal Processing (EC 3007)

**Introduction:** representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph. loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs.

**Pipelining and Parallel Processing:** Introduction, Pipelining and parallel processing of FIR digital filters, Pipelining and Parallel Processing for Low Power.

**Retiming, Unfolding and Folding:** retiming techniques; algorithm for unfolding, Folding transformation.

**systolic architecture design:** systolic array design methodology, FIR Systolic Arrays, Selection of Scheduling Vectors, 2D Matrix Multiplication Systolic Array Design

**Fast Convolution:** Cook-Toom algorithm, modified Cook-Toom algorithm, Winograd algorithm, iterated convolution

**DSP transforms:** Discrete Cosine Transform (DCT) and Inverse DCT

**Arithmetic Architectures:** Parallel Multipliers- Parallel Multiplication with sign extension( Parallel Carry Ripple Array and Parallel Carry Save Multipliers), Bit Serial Multipliers, Redundant Number presentation, Radix-2 and radix-4 Addition and Subtraction, Radix-2 Redundant Multiplier Architecture

**Text Book :**


1. VLSI Digital Signal Processing Systems, Design and Implementation by Keshab K.Parhi, John Wiley, Indian Reprint, 2007.


**Reference Books :**


1. VLSI Design Methodologies for Digital Signal Processing Architectures by Magdy A. Bayoumi, Springer/bsp Books; Edition (2005)
2. VLSI and Modern Signal Processing by S.Y.Kuang, H.J. White house, T. Kailath, Prentice Hall, 1995.

# ELECTRONICS
# &
# ELECTRICAL ENGINEERING

# B. Tech in Electronics and Electrical Engineering

## Program Educational Objectives (PEOs):

The B. Tech Program in Electronics and Electrical Engineering aims to prepare the graduates with the following objectives:

1. Graduates will be able to lead a successful career in industry, pursue higher study or entrepreneurial endeavor through application of domain specific knowledge in the areas of embedded system design, signal processing, instrumentation and control, electrical machines, power engineering and allied fields of Electronics and Electrical Engineering.
2. Graduates will be able to perceive feasibility and impact of engineering solutions in social, legal, environmental, economic and multi-disciplinary context.
3. Graduates will be able to demonstrate professional and ethical responsibility and engage in life-long learning.

## Program Outcomes (POs)

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs)

The program specific outcomes are:

m) Ability to design and implement electronic circuits, electrical machine, drives and different power systems in industry.
n) Ability to carry out research in the fields of embedded systems, renewable energy, machine design and smart grids.
o) Ability to utilize the knowledge in solving practical problems for electronics and electrical systems.

## EL 2002 PRINCIPLE OF CONTROL SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

- CO1. Demonstrate an understanding of the fundamentals of control systems and use models of physical Systems in forms suitable for use in the analysis and design of control systems .
- CO2. Calculate the effect of feedback on gain, time constant, bandwidth, noise etc.
- CO3. Define type and order and then calculate rise time , peak time, steady state error for standard test inputs.
- CO4. Determine the stability from characteristic equation using Routh stability criterion.
- CO5. Apply root locus technique to analyze and design control systems for find region of stability.
- CO6. Draw the bode and nyquist plots and determine the system stability

**Prerequisites: Principle of Signals and Systems (EC 2023) / Signals & Networks (EC 2021)**

**Introduction:**
Elements of control systems, concept of open loop and closed loop system, Examples and applications of open loop and closed loop systems. Classifications, Servomechanism and Regulators.

**Introduction to Mathematical modeling of Physical System:**

Differential Equation of Physical System, Transfer function of electrical and mechanical systems ,A.C. servomotor and D.C. Servomotor , Block Diagram Algebra, Signal flow graph, Mason's gain formula, application of signal flow graph to control system.

**Feedback Theory:**
Feedback and Non-feedback systems, Reduction of parameter variation by use of feedback, Control of the Effects of Disturbance Signals by use of feedback, Regenerative Feedback.

**Time domain Analysis, Design Specification & Performance Indices:**
Standard Test Signal: Impulse, Step, Ramp, Parabolic signals ,.Impulse response, Step response, Ramp response and parabolic response of first order system and performance characteristics

**Time Response of second-order System:**
Characteristics Equation, Response to the Unit Step Input, Time Domain specifications, Steady state Error and error constants , Need of Controller, Importance of P,I,D,PI,PD, PID controller.

**Stability Criteria:**
The concept of stability, necessary conditions for Routh- Hurwitz Criteria and its limitations., Application of Routh stability criterion to linear feedback systems, Root Locus Concept, Construction of Root Loci, Construction Rules, Determination of gain from Root Locus.

**Frequency Domain Analysis:**
Introduction to Frequency Response, Frequency Domain Specifications, Bode diagram, Log magnitude versus Phase Plots, Polar plots, Nyquist stability criterion, Stability Analysis, Stability Analysis using MATLAB for performance studies.

**Cascade Compensation in Frequency Domain:**
Correlation of time and frequency domain specifications, Lead and Lag compensation design using Bode plot, Comparison of Lead & Lag Compensation, Feedback compensation in Frequency domain.

**Text Book :**
1. Control System Engg. I. J. Nagrath & M. Gopal, $5^{th}$ edition New Age International (P) Ltd

**Reference Books :**

1. Modern Control Engg, K. Ogata, PHI, $3^{rd}$ Edn, 1997
2. System Dynamics & Control: Eronini Umez-Eronini, 1999 Edn, PWS Publishing International Thompson Publishing Company
3. Control Systems Engineering, Norman Nise, Wiley, $3^{rd}$ Edn.

## EL 3022 ADVANCED CONTROL SYSTEM Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. design cascade and feedback compensation using Bodes Plot.
CO2. design PID Controllers.
CO3. analyze State-Space Analysis for Linear Continuous time.
CO4. solve of stage equations, State Transform matrix
CO5. test for Controllability & Observability.
CO6. analyze various mathematical analysis for Nonlinear System and Discrete-Time System.

### Prerequisite: Principle of Control System (EL 2002)

**Introduction to Design:**
Cascade and feedback compensation, Lead and Lag compensation design using Bodes plot.

**PID and Robust Control System Design:**
Zigler Nichols rules for Turning PID controllers, Modifications of PID control Scheme. Robust control System Design Examples.

**State-space Analysis :**
(Linear Continuous time) Concept of state variables and state model State representation using physical variables and using phase variables & canonical variable.

**Solution of stage equations, State Transform matrix:**
Properties, Computation by Laplace Transform and using Caley-Hamilton Theorem. Transfer function from state equations. Characteristics equation eigen values & eign vectors. Digitalization using similarly Transform, Vander monde Matrix and Modal matrix.

**Controllability & Observbility Test:**
Pole placement using stage feedback for Regulator Type Systems, Full order state observer design, Ackermann's formula, Effect of observer on classed loop system.

**Discrete-Time System:**
Sampled data digital control system, Uniform periodic sampling, Mathematical description of sampling process, Spectrum analysis, sampling theorem, aliasing, signal reconstruction, using zero order hold.
Z transform of signals and discrete sequences Z transform theorems Conversion of G (&) to G(Z), Difference equation, Inverse Z-transform methods. The Z transfer function (pulse transfer function)
Difference equation Solution, Z & S domain relationship, Impulse response and step transient response, Error constants, steady state error.

**Text Books :**
1. Control System Engg, J. Nagrath & M. Gopal 3rd Edition New Age International Publisher
2. Modern Control Engg., By K. Ogata 3rd Edition PHI

**Reference Book :**
1. Discrete Time Control System, K. Ogata 2nd Edition Pearson Education

## EL 3024 INDUSTRIAL AUTOMATION AND CONTROL Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. select suitable sensor to measure industrial parameters and the different types of actuators and its working. They will be able to design proper signal conditioning circuit to the transducer.
CO2. determine the effect of proportional gain, integral time, derivative gain constant on the system performance and will be able to tune the controller using tuning methods, implement PID using electronic , digital, pneumatic and hydraulic methods.
CO3. design the ladder logic to implement any process with given problem statement.
CO4. analyze DCS hardware and its merits/demerits in an industrial automation
C05. analyze SCADA hardware and software and its merits/demerits in industrial automation.
CO6. design the complex control scheme to a particular process.

### Prerequisites : Principle of Control System (EL 2002) / Linear Control System (EE 2028)

**Sensors, Actuators and Signal conditioning:**
Sensors: Displacement sensors, Force sensors, Ultrasonic sensors, Temperature sensors, Pressure sensors etc
Actuators: Dc motors, Servo motors, Stepper motors, Piezo electric actuators, Pneumatic actuators etc.
Signal Conditioning: Filtering, Amplifying, Isolation, ADC, DAC, Sensor protection circuits, Signal transmission and noise suppression, Estimation of errors and calibration.

**Controller tuning:**
PI controller, PD controller, PID controller and tuning methods: *Ziegler-Nichols tuning method, Cohen coon tuning method,* Implementation of PID controllers (digital and analog).

**Automation:**
PLC (Programmable logic controllers): Overview, operation and architecture, PLC programming, Application examples.
DCS (Distributed control systems): Overview, Advantages, Functional requirements of Distributed control systems, Communication for distributed control, Application examples.
SCADA (supervisory control and data acquisition): Introduction to SCADA, SCADA system components, architecture and communication, SCADA applications.
Advanced control techniques:
Feed forward control, Ratio control, Cascade control, Adaptive control, Duplex or split range control, Override control, internal mode control.

**Text books :**
1. Computer-Based Industrial Control, Krishna Kant,2$^{nd}$ edition Prentice Hall of India Ltd.
2. Chemical Process Control – Theory and Practice, Stephanopoulous, Prentice Hall of India Ltd, 1984.
3. Fundamentals of Industrial Instrumentation and Process Control, William C. Dunn, TataMcGrawHill, 2009.

**Reference books :**
1. Modern Automation Systems, Muhammad Abdelati, University Science Press, 2009.
2. Modern Control Engineering, 4th edition, Ogata, Prentice Hall of India

# ELECTRONICS & INSTRUMENTATION ENGINEERING

# B. TECH IN ELECTRONICS AND INSTRUMENTATION ENGINEERING

## Program Educational Objectives (PEOs):

The B. Tech Program in Electronics and Instrumentation Engineering aims to prepare the graduates with the following objectives:

1. Graduates will be able to lead a successful career in industry, pursue higher study or entrepreneurial endeavour through application of domain specific knowledge in areas of microelectronics, embedded system design, analytical instrumentation and process control, Industrial Automation, power plant engineering and allied fields of Electronics and Instrumentation Engineering.
2. Graduates will be able to perceive the feasibility and impact of engineering solutions in social, legal, environmental, economic and multi-disciplinary context.
3. Graduates will be able to demonstrate professional and ethical responsibility and engage in life-long learning.

## Program Outcomes (POs)

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs)

The program specific outcomes are:

m) Ability to design and implement signal processing, and process instrumentation and control in industry.
n) Ability to carry out research in fields of embedded systems, medical instrumentation, control systems and sensor designs.
o) Ability to utilize the knowledge in solving practical problems in real life.

## EI 2003 ELECTRICAL & ELECTRONIC MEASUREMENT TECHNIQUES Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. analyze and differentiate between different measurement methods and universal instruments.
CO2. differentiate between measurement techniques for measuring the value of different electrical components.
CO3. analyze internal construction of instruments used for measuring current, voltage, frequency and spectrum.
CO4. measure the power, energy and power factor using watt-meters and energy-meters.
CO5. utilize the CRO for various electronic measurements.
CO6. analyze the signals on spectrum analyzers

**Prerequisite: Basic Electrical Engineering (EE 1003)**

**Introduction:**
Measurement and its significance, Methods of measurement, Classification of instruments, Errors in measurement, Types, Accuracy and Precision, Significant figures, Units and standards of measurement.

**Measurement of Resistance, Inductance and Capacitance:**
Resistance: Measurement of low and medium resistance, DC bridges - Wheatstone bridge, Limitations of Wheatstone bridge, Kelvin double bridge, Inductance: Maxwell, Hay, Anderson and Owen bridge.
Capacitance: Schering &Weinbridge. Errors in bridge measurement and Wagner earthing device.

**Measurement of voltage and current**:
Galvanometer: Construction, principle of operation of D'Arsonval and Ballistic, sensitivity and Galvanometer constants.
Ammeter and Voltmeter: Construction, theory and principle of operation of PMMC, MI, Electro dynamometer, Inductive, Electrostatic type.
DC Potentiometer: Construction, theory and Principle of Basic slide wire DC potentiometer, Crompton and Vernier potentiometers.
Sensitivity, Loading effect on measurements, Range extension and calibration of Voltmeter and Ammeter.

**Measurement of Power, Energy and Power factor:**
Power: Construction, Theory and principle of operation of electro dynamometer, electrostatic Wattmeter, Measurement of 1Φ power by Wattmeter.
Energy: Construction, Theory and principle of operation of 1Φ Induction watt-hour meter, Errors and compensation.
Theory and operation of frequency, power-factor meters, calibration of Wattmeters and Energymeters.

**Electronic Instruments for measurement of basic parameters:**
Introduction, Electronic DC & AC Voltmeters, Chopper amplifier type, True RMS Voltmeter, Peak response Voltmeter, Q-meter, Digital Voltmeters (Block diagram only).

**Oscilloscope:**
CRO, Block diagram, sweep circuits, Delay line, multiple trace, and oscilloscope probes. Introduction to analog and digital storage oscilloscope, Measurement of frequency, phase angle and time delay using oscilloscope.

**Function Generators and Spectrum analyzers**:
Function generators, spectrum analyzers: Block diagram, working, types.

**Text Books :**

1. A Course in Electrical and Electronic Measurements and Instrumentation, A K Sawhney, DhanpatRai& Co, Reprint, 2013.
2. Modern Electronic Instrumentation and Measurement Techniques, Helfrick& Cooper, 2nd Edition. PHI

**Reference Books :**

1. Electrical Measurements and Measuring Instruments, Golding &Widdis , 5th edition, Reem Publication,
2. Electronic Instrumentation, H S Kalsi , 3rd Edition, TMH.
2. Electronic Instrumentation &Measurements, David A. Bell, 3rd Edition, Oxford University press.
3. Elements of electronic instrumentation and measurement, Joseph J. Carr, 3rd Edition.

## EI 2008 INTRODUCTION TO INSTRUMENTATION ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the standard errors in instrument and its classification.
CO2. understand the mechanical, electronic, optical and pneumatic comparators.
CO3. understand the mechanical measurements necessary for engineering applications and development.
CO4. measure the unknown resistance, inductance and capacitance.
CO5. measurethe current and voltage of different ranges using electrical instruments.
CO6. understand the principles of digital voltmeters, signal generators and CRT.

### Prerequisite: Introduction to Electronics Engineering(EC 2025)

**Measurement System and Metrology**
Measurement and its significance, Methods of measurement, Classification of instruments, Errors in measurement, Types, Accuracy and Precision, Significant figures.Units and standards of measurement. Limit gauges, slip gauge. Comparators: Mechanical, electronic, optical and pneumatic. Angular measurement: sine bar, autocollimator. Measurement of straightness: Flatness, squareness, roundness and Rotation.

**Mechanical measurements**
Measurement of surface finish: Terminology, roughness, waviness, analysis of surface finish, stylus probe instrument-Talysurf. Screw thread metrology: Errors in thread-Pitch error-drunkenness-measurement of various elements thread-two and three wire method-floating carriage micrometer. Measurement of gears: tooth thickness, constant chord and base tangent method, Parkinson gear tester.

**Electrical Measurements**
Resistance Measurement of low and medium resistance, DC bridges - Wheatstone bridges, Limitations of Wheatstone bridge, Kelvin double bridge, Measurement of high resistance-Megohm bridge. Inductance: Maxwell, Hay, Anderson and Owen bridge. Capacitance: Schering &Weinbridge.Errors in bridge measurement, Wagner earthing device.

**Electrical Instruments**
Ammeter and Voltmeter: Construction, theory and principle of operation of PMMC, MI, Electro dynamometer rectifier type, True RMS meters. Sensitivity, loading effect on measurements. Range Extension of meters: Ammeter shunts, multiplier and instrument transformers (CT and PT).

**Electronic Instruments**
Introduction, Digital Voltmeters: Ramp type, dual slope and successive approximation type. Signal generators. Cathode ray oscilloscope: Block diagram, CRT.

**Text books :**

1. Engineering Metrology, R.K.Jain, 2005, khanna Publishers.
2. A course in Electrical and Electronic Measurements and Instrumentation, A K.Sawhney, 2001, DhanpatRai& Sons.

**Reference books :**

1. Modern electronic instrumentation and measurement techniques, Helfrick& Cooper, 2nd edition, PHI.
2. Engineering metrology, I.C.Gupta, 7th edition ,DhanpatRai& Sons.

## EI 2010 PRINCIPLE OF MEASUREMENTS& INSTRUMENTATION Cr–3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. estimate the error and interpret the instrument datasheet.
CO2. derive the balance equations to analyze the unknown electrical quantities.
CO3. select the appropriate instrument for measuring A.C & D.C currents and voltages.
CO4. select the appropriate sensor to measure physical parameters.
CO5. understand the working principle and construction of CRO.
CO6. differentiate between digital measuring instruments, function generators, spectrum analyzers.

### Prerequisite: Basic Electrical Engineering (EE 1003)

**Measurement & Error:** Calibration of Instruments, Accuracy, Precision & Resolution, Types of Errors, Statisticalanalysis, Probability of error, Limiting error.

**A.C. & D.C. bridges:** General equation for bridge balance, DC bridges: Wheatstone bridge, Kelvin's double bridge;General form of AC bridge; Maxwell's inductance-capacitance bridge, Hay's bridge, Schering bridge, Wienbridge; Sources of error in bridge measurement, Wagner's earthing device.

**Electrical measuring instruments:** Classification of instruments, Overview of PMMC, Dynamometer type instruments, Principle of Ammeter, Voltmeter, Multimeter, True RMS voltmeter,Potentiometer, Strip chart recorders.

**Transducers:** Strain Gauges, LVDT, Thermistor & Thermocouples, Piezo – electric transducer and Bourdon tube.

**Electronic measuring instruments & CRO:** Q-meter, Digital Voltmeter, Digital frequency meter, CRO:construction, Time base circuit, measurements with CRO, CRO probes.

**Signal generator & waveform analyzing instruments:** Function generator: Square, triangular &sinusoidalwaveform generator & Spectrum analyzer.

**Analysis instruments:** Principle of operation of pH meter, Liquid chromatograph, Spectrophotometer

**Text Books :**

1. Electrical and Electronic Measurements & Instrumentation By A.K. Sawhney – Dhanpat Rai,2013.
2. Electronic Measurement & Instrumentation By H. Cooper – PHI, 2nd Edition.

**Reference Book :**

1. Electronics Instruments & Measurement by David A. Bell –Oxford, 3rd Edition.

## EI 2012 SENSORS AND SIGNAL CONDITIONING Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. differentiate between various transducers, sensors and their brief performance specifications
CO2. analyze the principle of working of various transducers used to measure temperature.
CO3. analyze the principle of working of various transducers used to measure pressure
CO4. analyze the principle of working of various transducers used to measure force, weight, stress and strain.
CO5. analyze various signal conditioning techniques.
CO6. analyze applications of various transducers in industry.

**Prerequisite: Electrical and Electronic Measurement Techniques (EI 2003)**

**Introduction:** Instrument and measurement system and its functional elements
Input – Output configuration

**Performance characteristics of Instrumentation system:**
Static and dynamic characteristics

**Primary sensing elements and Transducers:**
Primary sensing elements: Mechanical, Pressure and flow sensing elements.
Transducers: Introduction, classification, characteristics and selection
Resistive transducers – Potentiometers, strain gauge, RTD, Thermistor, Photo Conductive cell
Inductive transducers: Variable inductance, LVDT, Synchro, Resolver.
Capacitive, Hall-effect, Proximity sensors, opto-electronic, ultrasonic and fibre-optic transducers.
Voltage generating transducers – thermocouple, piezoelectric and pyroelectric transducer
Magnetic type transducers – magnetostrictive and magneto resistive types

**Signal conditioning:**
Introduction, signal conditioning circuits using DC bridges (Wheatstone bridge), AC bridges with push-pull transducer - Blumlein bridge, A/D and D/A conversion in measurement.

**Measurement of non-electrical quantities:**
Measurement of force, weight, stress and strain, velocity and acceleration and torque
Introduction to vibration measurements

**Text Books :**
1. Transducers and Instrumentation – D. V. S. Murthy, 2nd edition, 2013 - PHI Learning.
2. Principle of Measurement Systems – J. P. Bentley 4th edition, Pearson Education.

**Reference Books :**
1. Measurement System Application and Design – E. O. Doeblin,5th edition, TMH
2. Sensors & Transducers - D. Patranabis, 2nd edition, PHI
3. Introduction to Measurement and instrumentation – A.K. Ghosh, 2012, PHI.
4. The Measurement, Instrumentation and Sensors Hand book – John G Webster, CRC press.

## EI 3007 SENSORS AND ACTUATORS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand components of sensor and selection criteria.
CO2. select suitable sensor for measuring displacement and velocity.
CO3. select suitable sensor for force, weight and pressure measurement.
CO4. select suitable sensor to measure temperature in different applications.

CO5. select suitable sensor to measure level and flow.
CO6. understand the working of micro sensor and micro actuators and its applications.

### Prerequisite: Introduction to Instrumentation Engineering (EI 2008)

**Introduction**
Definition of sensor and transducer, classification, characteristics. Selection criteria of transducers. Smart sensor: Block diagram, features.

**Displacement and velocity Measurement**
Linear and rotary displacement sensors: Potentiometer, capacitive, inductive. Position measurement: Optical Encoder, proximity sensors. Velocity measurement: Tachometer types, Stroboscope, Encoder.

**Measurement of Force, Weight and Pressure**
Force and weight measurement: Strain gauge, types, load cell. Pressure measurement: Manometer types, Strain gauge, diaphragm gauge, capsule, bellows, bourdon tube, piezoelectric sensor.

**Temperature measurement**
Temperature scales. Mechanical thermometers: Filled in systems, Metallic expansion. Electrical thermometers: RTD, Thermocouple, Semiconductor temperature sensors, Radiation pyrometers.

**Level measurement**
Mechanical methods: float and displacer. Electrical methods: Resistance, inductive, capacitance type. Gamma radiation method. Ultrasonic level gauging.

**Flow measurement**
Basic principles of flow measurement. Differential pressure devices: orifice, venturi, flow nozzle, pitot tube, annubar. Area flow meter: Rotameter. Mass flow meter: Coriolis, thermal & impeller types. Electromagnetic type, ultrasonic type, vortex type, turbomagnetic type, target type, positive displacement type.

**Micro sensors and actuators**
Micro sensors : Principles and examples, force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors , chemical sensors, bio sensors, temperature micro sensors and flow micro sensors. Micro actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators: Electrostatic, magnetic, fluidic, inverse piezo effect.

**Text book :**

1. Industrial instrumentation and control, S.K.singh, 3rd Edition, TMH

**Reference books :**

1. Transducers and Instrumentation, Murthy.D.V.S, 2001, Prentice Hall of India.
2. Sensors and transducers, Patranabis.D, 2003, PHI.
3. Microsystem Technology and Microrobotics, SergejFatikow and Ulrich Rembold , 1stedition ,Springer-Verlag Berlin Heidelberg.
4. Shape memory actuators, Manfred Kohl, first edition, Springer.

## EI 3009 INSTRUMENTATION MEASUREMENT TECHNIQUES Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. analyze the construction and working principle of Industrial Instruments for Temperature and Level, Pressure, Flow and Viscosity.
CO2. analyze the construction and working principle of Industrial Instruments for Pressure, Flow and Viscosity.

CO3. identify sensor, transducer and their performance specifications for measurement of different process variables.
CO4. apply specific instrument for the measurement of different process variable.
CO5. analyze the industrial application and calibration of Industrial Instruments.
CO6. analyze the use of Industrial Instruments in hazardous locations.

**Prerequisite: Electrical & Electronic Measurement Techniques (EI 2003)**

**Temperature measurement:**
Temperature scales, ITS90 Bimetal elements, Semiconductor temperature sensors, Radiation pyrometers.

**Pressure & vacuum measurement:**
Manometer types, Elastic type, D/P Transmitters. Electronic type: capacitive, piezoresistive
Vacuum: McLeod gauge, thermal conductivity gauge, ionization gauge.

**Level measurement:**
Gauge glass, float, displacer, D/P type, capacitive type, conductive type, ultrasonic type, microwave type, radiation type, vibration type.

**Flow measurement:**
Basic principles of flow measurement, Differential pressure devices: orifice, venturi, flow nozzle, pitot tube, Area flow meter: Rotameter Mass flow meter: Coriolis, thermal & impeller types.
Electromagnetic type, ultrasonic type, vortex type.

**Viscosity, density and humidity measurements:**
Capillary Viscometer, Saybolt viscometer, float viscometer, plastometer, vibrating type, oscillating type, ultrasonic type. Measurement of density: liquid density measurement, gas densitometers, Humidity measurement.

**Instrumentation in hazardous locations:**
Area, material & temperature, classification, explosion proof enclosures, intrinsic safety, Combustible gas detectors.

**Instrument calibration concepts:**
Introduction, comparison methods, digital multimeters as standard instruments, calibration instruments, potentiometer calibration methods.

**Text books :**

1. Industrial instrumentation & control, S. K. Singh , 3rd Edition, TMH.
2. Industrial instrumentation, K.Krishnaswamy, S.Vijayachitra, 2nd Edition, New age international.
3. Electronic Instrumentation and Measurements, David A. Bell, Third Edition, Oxford University Press.

**Reference books :**

1. Instrument engineers handbook, Vol-1, B.G Liptak, CRC press
2. Measurement System Application and Design – E. O. Doeblin,5th edition, TMH

## EI 3010 PROCESS CONTROL Cr-4

**Course Outcome :**At the end of the course, the students will be able to :

CO1. design active and passive compensators
CO2. analyze different physical controlling processes mathematically and compensator design for the same
CO3. differentiate between different controllers and control schemes
CO4. analyze digitize the system output and apply controllers whenever needed

CO5. analyze various different hardware used in industry for programming and controlling purposes.
CO6. differentiate between control elements and their application in industry.

**Prerequisites: Sensors & Signal conditioning (EI 2012) &Principle of Control System (EL 2002)**

**Basic Control Schemes & Controller Tuning**: On-Off control, Proportional Control, PI,PD &PID control, Lag, Lead and Lag-Lead compensator design, Feedback compensation, Frequency response of controllers, Pneumatic, Hydraulic and Electronic controllers, Process reaction curve method, Continuous cycling method and damped oscillation method, Ziegler Nichols method and Cohen Coon method.

**Process Dynamics &Modeling**: Mathematical model of flow, level, pressure and thermal processes, CSTR, Interacting and non-interacting systems, Degrees of freedom, Continuous and batch processes, MIMO process, Transient response of control systems, servo and regulatory operations, Proportional control of single, two and three capacity processes.

**Complex Control Schemes**: Ratio control, Cascaded control, Split range control, Feed-forward control, Selector control, Selective and Adaptive control system, Multivariable control systems dead time compensation smith predictor, Sample data digital control system, Sampling theorem, Steady state error analysis of Sample data digital control system, Digital implementation of PID controller, Z-plane analysis of discrete time control system.

**Final Control Elements**: Actuators: Pneumatic and Electrical actuators and drive circuit. Control valves: Ball valve, Butterfly valve, Glove valve. Valve characteristics: Quick opening, Linear and Equal Percentage. Valve sizing and selection, Valve positioners, P-I &I-P converters. Connecting elements in flow, level, pressure and temperature control loops. Introduction to P & I diagram.

**Automation**: PLC(Programmable logic controller): Introduction, Architecture, relay ladder logic, Programming, software, configurations and applications. DCS(Distributed Control System): Architecture and elements, Configurations and applications. SCADA: Structure, Hardware and Software.

**Plant Process Control & Applications**: Boiler control-control schemes, Combustion control, Feed water control, Furnace pressure control and steam temperature control, Distillation column control schemes, Batch process control-control schemes, Cement plant, Thermal power plant and steel plant objectives, Automation strategy and their DCS structure.

**Text Books :**

1. Process Dynamics & Control – Dale E-Seborg, Duncan A. Mellichamp, Thomas F.Edger, Francis J. Boyle, John Wiley & sons, 3rd edition.
2. Digital Control Systems, Benjamin C. Kuo, OXFORD, 1st Edition
3. Process Control Principles & Applications, SurekhaBhanot, OXFORD, 1st Edition

**Reference Books :**

1. Instrument Engineers Handbook ,B.G.Liptak, Volum-II&III, Chilton Book Co., Philadelphia
2. Computer Aided Process Control, S.K.Singh, 2005, PHI
3. Principles of ProcssCntrol- D.Patrnabis, 3rd Edition, TMH

## EI 3021 MATERIAL SCIENCE Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. apply knowledge of mathematics, science and engineering to solve problems related to materialscience.
CO2. design and conduct experiments using statistical, computational or mathematical methods.
CO3. analyze and interpret data using statistical, computational or mathematical methods.
CO4. differentiate between different materials for a wide range of applications in engineering.

CO5. realize the professional and ethical responsibilities of a materials scientist and engineer.
CO6. develop skills and techniques of modern materials engineering practice.

### Prerequisite: Physics (PH 1007)

Classification of engineering Materials :

**Crystal Structures:**
Types of crystal, Unit Cells and Basis Vectors, Miller Indices, Crystal Structure of materials (SCC, BCC, FCC, HCP), Classification of crystals – ionic, covalent and molecular crystals.

**Crystal Defects:** Point defects, Line Defects, Planar or Surface defects.

**Dielectric Materials and Insulators:**
Polarization, Dielectric constant of mono-atomic and polyatomic gases; Dielectric constant of solids, spontaneous polarization, ferroelectric materials, Curie-Weiss Law, Dielectrics in ac fields, complex polarizability and complex dielectric constant, Dielectric Losses.

**Magnetic Properties of materials:**
Dia, Para, ferro, anti-ferro and ferrimagnetism, Magnetic hysteresis, Ferrites and their applications, Hard and soft magnetic materials.

**Piezoelectric Materials:**
Electrostriction, Displacement strain and stressin solids, Quartz- Its piezoelectric properties, applications, Pyroelectric.

**Superconductivity:**
Review of superconductivity, Application of superconductivity- SQUID, Cryotron.
**Advance Materials:**
Brief description of other materials such as Corrosion Resistant materials, Nano-phase materials, Shape Memory Alloys, SMART materials, Biomaterials.

**Text Books :**
1. Electrical Engineering Materials: A.J. Dekker, 1st Edition,PHI,2013
2. Material Science: V. Rajendra and A. Marikani,1st Edition, TMH

**Reference Books :**
1. Material Science and Engineering: W.D. Callister, 2nd Edition , WILEY
2. Material Science and Engineering: V. Raghavan,5th Edition, PHI
3. Material Science and Engineering : M.S. Vijaya and G. Rangarajan, 1st edition, TMH
4. Material Science for Engineers, James F. Shackelford and M.K. Muralidhara,6th edition, PEAR

## EI 3022 BIOMEDICAL INSTRUMENTATION Cr-3

**Course Outcome :** At the end of the course, the students will be able to :

CO1. identify various bio-medical signals and instruments, transducers , sensors.
CO2. understand the performance specifications of bio-medical instruments, transducers and sensors.
CO3. analyze the principle of various bio-medical instruments.
CO4. apply knowledge of transducers to measure temperature, level, pressure.
CO5. differentiate between various bio-medical instruments.
CO6. analyze applications of various bio-medical instruments in medical purposes.

### Prerequisite: Chemistry (CH 1007)

**Fundamentals of Biomedical Instrumentation:**
Sources of Biomedical Signals, Basic Medical Instrumentation System, Intelligent Medical Instrumentation Systems, PC Based Medical Instrumentation Systems, General Constraints & Regulations of Medical Devices.

**Biomedical Signals & Electrodes:**
Origin of Bioelectric Signals-Repolarization, Depolarization, Resting Potential Recording Electrodes – Ag-AgCl Electrodes, Electrodes for ECG, EEG, EMG, Microelectrodes, Skin Contact Impedance, Motion Artifacts, Transducers used in biomedical applications.

**Blood pressure measurements:**
Manual / automatic systems, invasive and non invasive types, Sphygmomanometer, Blood flow measurements using ultrasonic and electromagnetic flowMeters.

**Heart:**
Engineering analog of heart, model of heart, electrocardiograph-principle of instrument, detail instrumentation, noises and interference in the measurement, its solutions, other systems of diagnosing the heart.
Pacemaker – general description and instrumentation details, Defibrillator.

**X-ray imaging:**
Range for medical use, principle of X-ray generation, instrumentation of X- ray image.

**Computer aided tomography (CAT):**
Basic principle, image acquisition, mathematical modeling for reconstruction of image, block diagram representation of the instrument and detailing of some parts.

**Surgical Diathermy:**

Principle of surgical diathermy, surgical diathermy machine, surgical diathermy analyser.

**Patient Safety:**
Electric Shock Hazards, Leakage Currents, Safety Codes for Biomedical Equipment.

**Text Books :**
1. Hand Book of Biomedical Instrumentation- by R. S. Khandpur, $2^{nd}$ Edition, Tata McGraw Hill.
2. Biomedical Instrumentation and Measurements- by Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, $2^{nd}$ Edition, PHI learning Pvt. Ltd.

**Reference Book :**
1. Introduction to Biomedical Equipment Technology- by Joseph J. Carr, John M. Brown, $4^{th}$ Edition. Pearson Educatio

## EI 3023 NEURAL NETWORK AND FUZZY LOGIC CONTROL Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. analyze and classify neural networks.
CO2. developimplementation algorithms for neural networks
CO3. apply suitable algorithms on different cases.
CO4. design fuzzy logic membership functions.
CO5. analyze the applications of neural network in image processing.
CO6. analyze the applications of fuzzy logic in image processing..

**Prerequisites: Mathematics-I (MA 1003), Mathematics-II (MA 1004) and Principle of Control System (EL 2002)**

**Neural Networks and Pattern Association:**

Differences between biological and artificial neural networks – Typical architecture – Common activation functions – McCulloch – Pitts neuron – Simple neural nets for pattern classification – Linear separability – Hebb net – Perceptron – Adaline – Madaline – Architecture – Algorithm and simple applications – Training algorithms for pattern association – Hebb rule and delta rule – Hetero associative – Auto associative and iterative auto associative net – Bidirectional associative memory – Architecture – Algorithm – Simple applications.

**Neural Netwroks based on Competition:**
Kohonen self organising maps – Learning vector quantization – Counter propagation – Architecture – Algorithm and applications

**Adaptive Resonance and Backpropagation Neural Networks:**
ART1 and ART2 – Basic operation and algorithm – Standard back propagation architecture –
Derivation of learning rules – Boltzmann machine learning – Architecture – Algorithm and simple applications

**Fuzzy sets and Membership Functions:**
Properties and operations on classical and fuzzy sets – Crisp and fuzzy relations – Cardinality – properties and operations – Composition – Tolerance and equivalence relations – Simple problems –Features of membership function – Standard forms and boundaries – Fuzzification – Membership value assignments – Fuzzy to crisp conversions – Lambda cuts for fuzzy sets and relations –Defuzzification methods.

**Applications of Neural networks and Fuzzy logic:**
Applications of neural networks – Pattern recognition – Image compression – Communication – Control systems – Applications of fuzzy logic – Fuzzy pattern recognition – Fuzzy image compression – Fuzzy logic controllers

**Text Books :**


1. Fundamentals of Neural Networks, LaureneFausett, 2004, Pearson Education.
2. Fuzzy Logic with Engineering Applications, Timothy Ross, 1998, McGraw-Hill.


**Reference Books :**


1. Introduction to Neural Networks Using Matlab 6.0, Sivanandam, S.N., Sumathi, S. and Deepa, S.N, 2005, TMH.
2. Fundamentals of Artificial Neural Networks, Mohammad H. Hassoun, 1st edition,2010, PHI
3. Neural Networks and Fuzzy Systems, Bark Kosko, 1st edition, P


## EI 3024 VIRTUAL INSTRUMENTATION Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. analyze the virtual instrumentation and programming techniques.
CO2. develop programs on virtual instrumentation.
CO3. differentiate between different data acquisition techniques on virtual instrumentation.
CO4. apply suitable data acquisition techniques required for different applications.
CO5. implement different controllers and test using industry standard software.
CO6. differentiate between various industrial network components and protocols.

### Prerequisites: Sensors and Signal Conditioning(EI 2012) and Digital Electronics (EC2011)

**Introduction:**

Virtual Instrumentation – Definition, flexibility – Block diagram and Architecture of Virtual Instruments – Virtual Instruments versus Traditional Instruments Data flow techniques-graphical programming in dataflow– Review of Popular softwares in virtual Instrumentation.

**VI Programming Techniques**:
VI- sub VI- Loops-structures-charts- arrays- clusters –graphs- formulae nodes –math script- local and global variable- strings- file I/O-execution control- Instrument drivers.

**Data Acquisition in VI:**
Introduction to data acquisition-signal conditioning-classes of signal conditioning-field wiring and signal measurement-ground loops-A/D, D/A converters, plug-in DAQ boards- Analog input/output cards -Digital Input/Output cards-counter and timer I/O boards-Isolation-techniques- Opt isolation -Data acquisition modules with serial communication.

**Communication networked modules:**
Introduction to PC Buses – Local bus: ISA – PCI –RS232 – RS422 – RS485 – Interface Bus – USB, PCMCIA, VXI, SCXI, PXI. Instrumentation buses: Modbus – GPIB – Networked bus – ISO/OSI Reference model, Ethernet, and VISA.

**Real time control and Applications:**
Design of ON/OFF controller- PID controller –electronic prototyping and testing with ELVIS- real-time data acquisition-transducer analysis-signal processing with DSP module-real-time embedded control with CRIO.

**Text Books :**

1. Virtual Instrumentation Using LabView, Jerome, 1st Edition, PHI
2. LabView Graphical Programming, Gary W. Johnson, Richard Jennings, 4th Edition, TMH

**Reference Books :**

1. Practical Data Acquisition for Instrumentation and Control Systems, John Park and Steve Mackay, 2003, Newnes
2. labview based advanced instrumentation system, psumathi, 1st edition,2007, springer science Elsevier

## EI 3025 PRINCIPLE OF ANALYTICAL INSTRUMENTATION Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. differentiate between various techniques involved to determine the concentration of each component from a mixture.
CO2. measure the pH level of a liquid using pH meters.
CO3. work with different gas analyzers used in industry.
CO4. analyze the different spectrums using spectrometers
CO5. analyze the operating principle of instruments used for radiation detection.
CO6. analyze the operating principle of instruments used for pollution monitoring.

### Prerequisite: Chemistry (CH 1007)

**Fundamentals of Analytical Instruments:**
Introduction, Elements of an Analytical Instrument.

**Spectrophotometry:**
Ultraviolet and Visible Absorption Spectroscopy. Different types of Spectrophotometers. Sources of Errors and Calibration. Infrared Spectrophotometers, Basic Components and Types, Sample Handling Techniques. Flame Photometers, Principle, Constructional Details, Types and accessories. Atomic Absorption Spectrophotometers and their instrumentation.

**Chromatography:**
Gas Chromatograph, Basic Parts of a Gas Chromatograph, Methods of Measurement of Peak Areas. Liquid Chromatography, principle, construction.

**pH Meters And Ion Analyzers :**
Principle of pH Measurement, Electrodes for pH Measurement, pH Meters, Ion Analyzers.

**Analyzers:**
Blood gas analyzers, Measurement of Blood $pCO_2$ and $pO_2$. Industrial Gas Analyzers, Paramagnetic Gas Analyzer, The Electrochemical methods, Infrared Gas Analyzers, Analyzers based on Gas density, Method based on Ionization of gases.

**Spectrometers:**
X-RAY Spectrometer: X-Ray Diffractometers, Electron Probe Microanalyzer. Massspectrometer : Principle, construction NMR &ESR Spectrometer: Principle, construction

**Radiochemical Instruments:**
Radiation Detectors, Liquid Scintillation Counters, Gamma Spectroscopy.

**Pollution Monitoring Instruments:**
Air pollution due to carbon monoxide, sulphur dioxide, Nitrogen oxides, Hydrocarbons, Ozone, Water pollution monitoring instruments.

**Text book :**
1.Handbook of Analytical Instruments – by R.S. Khandpur, 2nd edition, TMH

**Reference book :**
1.Instrumental Methods of Analysis ,Hobart H. Willard, 2012, 7th edition, CBS publisher
2.Principles of Industrial Instrumentation, D. Patranabis, 3rd edition, TMH.

## EI 3026 FIBER OPTIC INSTRUMENTATION Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. differentiate between various optical sources and detectors used for communication.
CO2. understand the working principle of LASER diodes.
CO3. designthe optical detectors based on p-n photo diodes.
CO4. analyze the optical fiber structure and its characteristics.
CO5. analyzethe coupling schemes used for fiber optical transmission.
CO6. differentiate between various sensors and amplifiers used in optical transmission for performance calculation.

### Prerequisite: Physics (PH 1007)

**Optical Sources:**
Light Emitting Diodes (LEDs), LED Structures, Light Source Materials, Quantum Efficiency and LED Power, Modulation of an LED.

**LASER diodes:**
Principle of Operation, Modes and Threshold Conditions, Optical output power and drive current, Quantum efficiency, Resonant frequencies, Radiation Pattern, Single Mode Lasers, Modulation of Laser diode.

**Optical Detectors:**
P-n junction Photo diodes, Power relationship, Responsivity Versus wavelength, Equivalent Circuit of a p-n Photo diode, Bandwidth, p-i-n photo diode and APD, Principle of operation, Sources of noise, Noise Equivalent Circuits, Signal to noise ratio for p-i-n and APD.

**Optical Fiber:**
Fiber Materials, Ray Propagation in Step-Index Fibers, Total internal reflection, Ray Propagation in Graded Index Fibers, Mode Theory, Monomode Fibers, Attenuation in Optical Fibers – absorption, scattering and bending losses

**Power Launching and Coupling:**
Source-to- Fiber Power Launching, Power-coupling calculation, Equilibrium Numerical Aperture, Lensing Schemes for coupling Improvement.

**Fiber-Optic Sensors:**
Intensity Modulated Sensors, Phase Modulated Sensors, Fiber-optic Mach-ZehnderInterferometric sensor, Fiber-optic Gyroscope, Spectrally Modulated Sensors, Distributed Fiber Optic Sensors,Fiber optic Bragg grating senor.

**Optical Amplifiers:**
Semiconductor Optical amplifiers (SOA), Erbium Doped Fiber amplifiers,Fiber Raman ampliflier.

**Text Books :**
1. Optical Fiber Communication by Gerd Keiser, 4$^{th}$ Edition ,McGraw Hill International Edition
2. Fiber Optics and Opto electronics by R. P. Khare, 1$^{st}$ Edition, Oxford University Press

**Reference Books :**
1. Optical Fiber Communications Principles and Practice by John M. Senior, 3$^{rd}$ Edition Pearson Education
2. Optoelectronics and Fiber Optics Communication by C.K.Sarkar and D.C Sarkar, 2$^{nd}$ Edition. New Age International

## EI 3027 INDUSTRIAL INSTRUMENTATION Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. analyze the construction and working principle of Industrial Instruments for measurement of different process variable like Temperature, Level and Pressure.
CO2. identify sensor, transducer and their performance specifications for measurement of different process variable.
CO3. analyze spectrophotometry and chromatography techniques.
CO4. measure and control the water and steam flow and pressure in the water circuit
CO5. measure the flow, pressure, temperature and level in air fuel circuit.
CO6. measure and control the electrical, mechanical and process turbine parameters.

**Prerequisite: Basic Electrical Engineering (EE1003)**

**Temperature measurement :**
Bimetal elements. RTD, Thermocouple, Semiconductor temperature sensors, Radiation pyrometers, thermistor.

**Pressure & vacuum measurement:**
Manometer types, Elastic type, D/P Transmitters. Electronic type: capacitive
Vacuum: McLeod gauge, thermal conductivity gauge, ionization gauge**,** Bourdon tube.

**Level measurement:**
D/P type, capacitive type, ultrasonic type, microwave type, radiation type**.**

**Analytical measurements :**
Spectrophotometry: Ultraviolet and Visible Absorption Spectroscopy, Infrared Spectrophotometers.
Mass Spectrometer: Principle, Types, Components of a mass spectrometer.
Chromatography: Gas chromatograph, Basic parts of gas chromatograph, Methods of measurements of peak areas.
Pollution Monitoring Instruments: Air pollution due to carbon monoxide, sulphur dioxide, Nitrogen oxides, Hydrocarbons, Ozone, Water pollution monitoring Instruments.

**Power Plant Instrumentation :**
Over view Of Power Generation: Introduction, Basic overview of power generation in thermal power plants, P & I diagram, Cogeneration of Power, Importance of Instrumentation and control in power generation.
Instrumentation and Control In Water Circuit: Introduction, Measurements in Water Circuit Water flow, steam flow, water and steam pressure, water and steam temperature, boiler drum water level, Measurement of impurities in water and steam

Controls in water circuit: Boiler, drum level, superheated steam temperature, steam pressure.
Turbine – Monitoring and Control: Introduction, Turbine Measurements Electrical, Mechanical and Process parameters, Turbine control systems Safety and process, Lubrication system for Turbo Alternator and its control, Turbo Alternator cooling system.

**Text books :**
1. Industrial instrumentation & control, S. K. Singh , 3rd Edition, TMH.
2. Power plant Instrumentation-K .Krishnaswamy, M. Ponnibala, 2nd edition,PHI publication

**Reference books :**
1. Industrial instrumentation, K. Krishnaswamy, S. Vijayachitra, 2nd edition, New age international.
2. Instrument engineers handbook, Vol-1, B.G Liptak, CRC press
3. Handbook of Analytical Instruments- by R. S. Khandpur, 2nd edition, TMH

## EI 3028 INSTRUMENTATION FOR OIL & GAS INDUSTRIES Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. differentiate between various processes involved in petrochemical industry.
CO2. understand the different products obtained from oil and gas industries.
CO3. measure the different parameters of oil and gas industries.
CO4. differentiate between various sensors used in petrochemical industry and their working mechanism, limitations, range of operation.
CO5. design the controller for distillation column, catalytic crackers and pyrolysis unit.
CO6. design the controller for safety.

**Prerequisite: Instrumentation Devices and Systems (EI 3009)**

**Overview of petrochemical processes:**
Introduction, Petroleum Feedstocks: exploration, recovery, composition, Oil and Gas separation, Refining of crude oil, Processes, Products from crude oil: Methane, Acetylene, Ethylene, Propylene – derivatives etc., Unit operations: Distillation etc.

**Measurements:**
Pressure, Temperature, Flow, Level sensors; Analytical Instruments: Chromatography, Gas analyzer etc.; Special types of sensors: Soft-sensors in distillation columns, magnetostrictive and magnetic float for level measurement etc.

**Control of refinery processes:**
Process control in refinery and petrochemical industry: Control of distillation column, Control of catalytic crackers and pyrolysis unit, Automatic control of polyethylene production, Control of vinyl chloride and PVC production; Controls for Safety.

**Text books :**
1. Chemicals from Petroleum, L. Waddams,2nd edition, Chemical Publishing Company
2. Process Control Structures and Applications, Balchan.J.G., and Mumme K.I., Van 1988, Nostrand Reinhold Company, New York

**Reference books :**
1. The Refinery of the Future, James G. Speight, 2010. William Andrew Publishing
2. Instrumentation in Process Industries, B. G. Liptak 2005, CRC Press

## EI 3029 PROCESS DYNAMICS AND CONTROL Cr-3

**Course Outcome :**At the end of the course , the students will be able to :

CO1. develop the mathematical model of process.
CO2. analyze the dynamic behavior of different processes.
CO3. design the basic control schemes using hydraulic, electronic and pneumatic methods.
CO4. tune the PID controller to improve the performance.
CO5. design various complex control schemes for SISO systems.
CO6. design controller for multivaribleprocesses.

**Prerequisite: Principle of Control System (EL 2002)**

**PROCESS DYNAMICS AND MODELLING**
Need for process control. Mathematical model of flow, Level, Pressure and Thermal Processes, CSTR.Interacting and non-interacting systems, Degrees of freedom, Continuous and batch processes.

**DYNAMIC RESPONSE OF PROCESSES**
Transient response of control systems, servo and Regulatory operations, Proportional control of single capacity, two-capacity, three-capacity processes.Linearization of nonlinear systems.

**BASIC CONTROL SCHEMES**
On-off control, proportional control, PI,PD,PID Control, Frequency response of controllers, Comparison of control actions. Implementation of controllers: Pneumatic, Hydraulic, Electronic Methods.

**CONTROLLER TUNING**
Performance criteria.Tuning methods: Process Reaction Curve method, Continuous cycling method and Damped oscillation method, Zeigler-nichols method, Cohen - Coon method and 3-C, method of parameter adjustment.

**COMPLEX CONTROL SCHEMES**
Ratio control, Split range control, Cascade control, Feed forward control, selector control, Inverse derivative control, Antireset control. Multivariable control systems Dead time compensation-Smith predictor, selective and Adaptive control systems.

**CONTROLLER DESIGN FOR MULTIVARIBLE PROCESS**
Synthesis of alternative control configuration**.** Interaction and Decoupling of control loops: Relative gain array, Control loop selection.Design of noninteracting control loops. Design of control systems for complete plant : Case study.

**Text Books :**

1. Chemical Process control, An Introduction to Theory and Practice, George Stephanopoulos , PHI, 2008
2. Process Control: Principles and Applications, SurekhaBhanot, Oxford , 2008.


**Reference Books :**

1. Process Dynamics & control – Dale E-Seborg, Duncan A. Mellichamp, Thomas F. Edger, Francis J. boyle, 3rd Edition, John wiley& sons.
2. Modern Control Engineering , K. Ogata, 5th Edition, PHI.
3. B. G. Liptak, Instrument Engineers Handbook, Chilton Book Co., Philadelphia.
4. P. Harriott, Process control, McGraw Hill, New York.
5. Process Control , Dynamics Concepts and Applications – SK Singh, PHI ,2007.

## EI 3030 POWER PLANT INSTRUMENTATION Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. understand the various components of thermal power plants in brief and their operations.
CO2. measure the water and steam flow and pressure in the water circuit
CO3. design the control schemes for the water circuit.
CO4. measure the flow, pressure, temperature and level in air fuel circuit.
CO5. measure the electrical, mechanical and process turbine parameters .
CO6. design control schemes for turbines.

### Prerequisite: Instrumentation Devices and Systems (EI 3009)

**Overview of Power Generation:**
Introduction, Basic overview of power generation in thermal power plants, P& I diagram, Cogeneration of power, Importance of instrumentation and control in power generation.

**Instrumentation and Control in Water Circuit:**
Introduction, Measurements in water circuit: water flow, steam flow, water and steam pressure, water and steam temperature, boiler drum water level, Measurement of impurities in water and steam, Controls in water circuit: boiler drum level, superheated steam temperature, steam pressure.

**Instrumentation and Control in Air-Fuel Circuit:**
Introduction, Measurements in air-fuel circuit: flow, pressures, temperatures and level. Controls in air-fuel circuit: combustion and furnace draft. Analytical measurements in air-fuel circuit: oxygen and carbon dioxide in flue gas, combustibles analyser, and infrared flue gas analyser, smoke detector, dust monitor, fuel analysers and chromatography, Pollution monitoring instruments.

**Turbine–Monitoring and Control:**
Introduction, Turbine measurements: electrical, mechanical and process parameters. Turbine control systems: safety and process, Lubrication system for Turbo Alternator and its control, Turbo Alternator cooling system.

**Text Books :**

1. Power Plant Instrumentation – K.Krishnaswamy, M.Ponnibala, 2nd Edition, PHI publications.
2. Power Plant Engineering - P.K Nag, 3rd Edition, Tata McGraw-Hill.

**Reference Books :**

1. Standard Boiler Operations - S.M. Elonka and A.L Kohal, Tata McGraw-Hill.
2. Mechanical and Industrial Measurements - R.K Jain, 2008, Khanna Publishers.
3. Power Plant Engineering – EL. Wakil, Tata McGraw-Hill.

## EI 3031 NONLINEAR CONTROL THEORY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the behavior of nonlinear systems such as limit cycles, different nonlinearities.
CO2. analyze various applications of nonlinear control in practical applications.
CO3. perform various types of phase planeanalysis.
CO4. performthe describing function analysis.
CO5. analyze various types of stability on different types of system.
CO6. linearize nonlinear systems and check the stability.

### Prerequisite: Principle of Control System (EL 2002)

**Introduction to nonlinear phenomena:**
Nonlinear systems-introduction-behavior of nonlinear systems-jump resonance-limit cycles, Common physical nonlinearities-saturation-friction-backlash-dead zone-relay, Multivariable nonlinearities (definition).

**Phase plane analysis:**
The phase-plane method-basic concepts-singular points-nodal point-saddle point-focus point-vortex point, Construction of phase trajectories-analytical method-graphical methods-isocline method, delta method, Example problems.

**Describing function analysis:**
Describing function method-basic concepts, derivation of describing functions-dead zone and saturation, relay with dead-zone and hysterisis, backlash, Stability of nonlinear systems- analysis bydescribing function-using Nyquist stability criterion- limit cycles-Reliability of describing function analysis.

**Lyapunov Stability Theory:**
Stability of nonlinear systems-Lyapunov theory (review)- autonomous and non-autonomous systems ,equilibrium points, Stability in the sense of Lyapunov, asymptotic stability and exponential stability, Linearization and local stability, Lyapunov's direct method, positive definite functions and Lyapunov functions, Lyapunov theorem for local stability and global stability, Analysis based on Lyapunov's direct method-LTI systems-Krasovskii's method, Variable gradient method for constructing Lyapunov functions-simple examples, Popov's stability criterion. Stability of non-autonomous systems (basic concepts only)-Lyapunov's direct method –simple problems.

**Text Books :**
1. Systems and control, Stanislaw H. Zak, 1st Edition, oxford university press
2. Control System Engg. I. J. Nagrath& M. Gopal, 5$^{th}$edition ,New Age International (P) Ltd

**Reference Books :**
1. Nonlinear Systems Analysis, M. Vidyasagar, Englewood Cliffs. 2nd edition 1993, Prentice Hall
2. Nonlinear Systems, H. K. Khalil, Englewood Cliffs, N.J ,3rd edition, 2001 Prentice Hall
3. Nonlinear Control of Engineering Systems: W. E. Dixon, A. Behal, D.M. Dawson, and S. Nagarkatti A Lyapunov-Based Approach, Birkhäuser, Boston, 2003

## EI 3032 PRINCIPLE OF SENSORS AND DATA ACQUISITION Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. working principle of transducers and sensors
CO2. characterize and calibrate the transducers and sensors.
CO3. understand the design of motion transducers used for measuring rotational displacement and velocity.
CO4. work on industrial automation systems such as PLC and SCADA.
CO5. design amplifiers used for signal conditioning.
CO6. understand the applications of different data acquisition and conversion systems

**Prerequisites: Electrical & Electronic Measurement Techniques(EI 2003) /Principle of Measurements and Instrumentation (EI 2010)**

**Introduction to Sensors and Transducers:**
Classification of Transducers, Capacitive and Resistive Transducers, Magnetic Transducers, Hall-effect Transducers, Piezoelectric transducers, Proximity Sensors, Pneumatic Sensors, Light Sensors, Digital Optical Encoders. Sensor Characterization and Calibration:Introduction, Classification, Performance Characteristics, Calibrations, Errors and Reliability.

**Rotational Displacements:** Circular& Helical Potentiometers, Rotational Differential Transformer, Incremental Shaft encoders, Coded-disc shaft encoders, Resolver, Synchros, Induction Potentiometer, Rotary Inductosyn, Gyroscopes.
**Rotational Velocity:** Digital Tachometers, Stroboscopic Methods, Analog Tachometer, Mechanical Flyball, The rate gyrosocope, fibre-optic gyroscope, accelerometer, Inertial Measurement Unit, Inertial Navigation System.

**PLC and SCADA:**
Introduction, Logic Gates, PLC System, PLC Programming, Case Studies, DCS system architecture and elements, configuration and applications, The basic SCADA structure,hardware and software.

**Signal Conditioning:**
Introduction, Functions of Signal Conditioning Equipment, Amplification, Type of Amplifiers, Mechanical Amplifiers, Fluid Amplifiers, Optical Amplifiers, Electrical and Electronic Amplifiers, Attenuators, Filters.

**Data Acquisition System:**
Objectives and Configuration of Data Acquisition System, Different types of Data Acquisition Systems andtheir applications, Data Conversion.

**Instrument calibration concepts:**
Introduction, comparison methods, digital multimeters as standard instruments, calibration instruments, potentiometer calibration methods.

**Text Books :**
1. Electronic Measurements and Instrumentation by R.K Rajput (S.Chand 2nd revised edition 2011)
2. Measurement and Instrumentation Principles by Alan S Morris ( Elsevier 1st edition,2006)
3. Electronic Instrumentation and Measurements, David A. Bell, Third Edition, Oxford University Press.

**Reference Book :**
1. Instrumentation & Control Systems by W. Bolton (Newnes-*An imprint of Elsevier,* 1st edition, 2011)
2. Digital Control and State Variable Methods: Conventional and Intelligent Control Systems by M. Gopal (4th Edition, 2012)

## EI 3034 ROBOTIC CONTROL Cr-3

**Course Outcome :**At the end of the course, the students will be able to :

CO1. classify the commercial robots and robot controllers.
CO2. understand the state space analysis of linear and nonlinear systems.
CO3. obtain the robot equations and its state space analysis.
CO4. simulate the robotic systems and its controllers.
CO5. design the nonlinear robot controllers.
CO6. design the adaptive and robust robot controllers.

**Prerequisites : Principle of Control System (EL 2002) and Signals and Systems (EC 2023)**

**Commercial Robot Manipulators**
Introduction, Commercial Robot Configurations and Types, Commercial Robot Controllers, Sensors.

**Introduction to Control Theory**
Linear State-Variable Systems, Nonlinear State-Variable Systems, Nonlinear Systems and Equilibrium Points,Vector Spaces, Norms, and Inner Products,Stability Theory,Lyapunov Stability Theorems, Input/Output Stability, Linear Controller Design.

**Robot Dynamics:**
Lagrange-Euler Dynamics, Structure and Properties of the Robot Equation, State-Variable Representations and Feedback Linearization, Cartesian and Other Dynamics, Cartesian Arm Dynamics, Structure and Properties of the CartesianDynamics, Actuator Dynamics.

**Computed-Torque Control**:
Path Generation, Computer Simulation of Robotic Systems, Simulation of Robot Dynamics, Simulation of Digital Robot Controllers, Derivation of Inner Feedforward Loop, PD and PID Outer-Loop Design, Digital Robot Control, Guaranteed Performance on Sampling, Optimal Outer-Loop Design, Cartesian control.

**Robust Control of Robotic Manipulators**:
Feedback-Linearization Controllers, Nonlinear Controllers, Dynamics Redesign.

**Adaptive Control of Robotic Manipulators**:
Adaptive Control by a Computed-Torque Approach, Adaptive Control by an Inertia-Related Approach, Adaptive Controllers Based on Passivity, Persistency of Excitation, Composite Adaptive Controller, Robustness of Adaptive Controllers.

**Text Books :**

1. RobotManipulatorControlTheory and Practice, Frank L. Lewis, Darren M. Dawson and Chaouki T.Abdallah, MARCEL DEKKER.
2. Robotics and Control, R. K. Mittal and I. J. Nagrath, TMH

**Reference Books :**

1. Robotics Technology and Flexible automation, S. R. Deb and S. Deb, TMH (2nd edition)
2. Fundamentals of robotics Analysis & Control, Robert J. Schilling, PHI,
3. Robotics; control, sensing, vision and intelligence, K. S. Fu, R. s. Gonzalez and C. S. G. Lee, TMH

## EI 3036 OPTIMAL CONTROL THEORY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic characteristics of optimal control problems.
CO2. use the dynamic programming for obtaining optimal control law.
CO3. design the continuous and discrete linear regulators.
CO4. understand the concepts of functionals in calculus of variation
CO5. deal with minimum-time and control effort based problems.
CO6. design the iterative learning algorithms for optimal control.

**Prerequisites: Principle of Control System (EL 2002)and Signals and Systems (EC 2023)**

**Introduction:** Problem formulation, state variable representation of systems. Performance measure for optimal control systems, selecting a performance measure.
**Dynamic Programming:**
Optimal control law, the principal of optimality, application of their optimality principle to decision making, an optimal control system.Recurrence relation of dynamic programming, computational procedure for solving control problem, characteristics of dynamic programming solution.

**Linear Regulator Design:**
Discrete linear regulator problem.Hamilton –jocobi-bellman equation.Continuous linear regulator problems, necessary and sufficient conditions examples.

**Calculus of Variations:**
Fundamental concepts, functional of a single function, functional involving several independent functions, necessary conditions for optimal control, linear regulator problems.

**The Variational Approach to Optimal Control:**
Pontrygin's minimum principle and state inequality constrains, minimum time problems, minimum control effort problems.

**Iterative Numerical Techniques:**
Two point boundary value problems, method of steepest descent algorithm, variation of extremalas, variation of extremal algorithm, gradient projection algorithm.

**Text Books :**

1. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series – First edition,1970.
2. D.S. Naidu, Optimal control systems, CRC Press, First edition, 2002.

**Reference Books :**

1. Jasbir S. Arora, Introduction to optimum design, Elesevier, 2005.
2. A Ravindran, K.M. Ragsdell, and G.V. Reklaitis, Engineering optimization: Methods and applications,Wiley India Edition.
3. S.H. Zak, Systems and Controll, Indian Edition , Oxford University, 2003.
4. Optimal Theory and application –Dr. S.S. Rao-eastern Willy- First edition.

## EI 3038 DIGITAL CONTROL SYSTEM Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the historical perspectives of classical and computer based control.
CO2. analyse the signal and systems in discrete-time domain.
CO3. work on applications based on digital control devices.
CO4. perform the state space analysis on discrete-time systems
CO5. design the state feedback controller using pole placement.
CO6. design the state observers for digital control systems.

**Prerequisites : Principle of Control System (EL 2002) and Signals and Systems (EC 2023)**

**Introduction:** History and trends of computer based control, an overview of the classical approach to analog controller design

**Discrete-time Signals and Systems:**
Principles of signal conversion, basic discrete-time signals, time-domain and frequency domain models of discrete-time-systems, Stability Analysis on z-plane, Jury Stability Criterion, Routh stability criterion on the r-plane.

**Digital Control Devices:**
Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control System, Digital Position Control System, Stepping Motors and Their Control, Programmable Logic Controllers.

**State Variable Analysis of Digital Control Systems:**
State description of digital processors, sampled continuous-time plants and systems with dead-time.Solution of state difference equations, controllability and observability.Multi-variable systems.

**Pole Placement Design and State Observers:**
Necessary and sufficient conditions for Arbitrary pole-placement, State regulator design, Design of state observers, Compensator design by separation principle, Servo design, digital control systems with state feedback, deadbeat controller and observer design.

**Text Books :**

1. M. Gopal, "Digital control and state variable methods," McGraw Hill Education (India) Private Limited 3 edition, 2008.
2. K. Ogata, "Discrete time control systems," Prentice Hall, 2 edition, 1995.

**References Books :**

1. B. C. Kuo, “Digital control systems,” Oxford University Press, 2 edition, 1995.
2. G.H. Hostetter, “Digital control system design,” Oxford UnivPr (Sd), 1987.
3. W. Forsythe  and R.M. Goodall, “Digital control,” Mcgraw-Hill, 1991.

## EI 4041 DESIGN OF SENSORS AND TRANSDUCERS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select and design diaphragm for different practical applications.

CO2. design strain gauge based torque, force, load and pressure measurement systems.

CO3. designthe capacitance based displacement, pressure and level sensors.

CO4.design of capacitive and inductive proximity sensors.

CO5. acquire knowledge in design of accelerometer and gyroscope.

CO6. acquire knowledge in design of chemical sensors.

**Prerequisites: Sensors and Signal Conditioning (EI 2012) and Instrumentation Devices and Systems (EI 3009)**

Introduction to diaphragm; Diaphragm performance and materials, Design of flat diaphragms, flat diaphragms with rigid centre – Design of convex diaphragms, semiconductor diaphragms and rectangular diaphragms – Design of corrugated diaphragms.

Design of strain gauge based load cells, torque sensors, force sensors and pressure sensors.

Design of capacitance based displacement, pressure and level sensors; Design of self and mutual inductance transducers for measurement of displacement and other parameters; Design of capacitive and inductive proximity sensors.

Accelerometer and Gyroscopic design and its applications.Design of Hall Effect sensors, Electromagnetic sensors, Magneto-elastic sensors.

Introduction to chemical sensors, characteristics.Design of direct and complex chemical sensors.

**Text Books :**

1. Karl Hoffmann, An introduction to stress analysis and transducer design using strain gauges, HBM, 1989.
2. James W. Dally, William F. Riley, Kenneth G. McConnell, Instrumentation for Engineering Measurements, Wiley, 1993.
3. Di Giovanni, Flat and Corrugated Diaphragm Design Handbook, CRC Press, 1982.
2. Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer, 3rd Editions, 1993.

**Reference Books:**

1. Richard S. Figliola, Donald E. Beasley, Theory and Design for Mechanical Measurements, John Wiley & Sons, Inc, 6th Edition, 1991.
2. Fraden, Jacob, Handbook of Modern Sensors: Physics, Designs, and Applications, Springe, 3rd Editions, 2010.
3. Alexander D. Khazan, Transducers and Their Elements: Design and Application, PTR Prentice Hall, 1994
4. Peter H. Sydenham, Richard Thorn, Handbook of Measuring System Design, Wiley, 2005.

## EI 4042 INSTRUMENTATION SYSTEM DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. designthe orifice meter for flow measurement and design of RTD measuring circuit.
CO2. designthe pressure and level measurement devices.
CO3. understand the design of actuators and positioners.
CO4. differentiate between characteristics of control valves for typical applications.
CO5. interpret the performance and characteristics of different pumps and design of controllers.
CO6. design microcontroller based measurement and control system.

**Prerequisites: Sensors and Signal Conditioning (EI 2012) and Instrumentation Devices and Systems (EI 3009)**

**Flow and Temperature:**Orifice meter - design of orifice for given flow condition - design of rotameter -design of RTD measuring circuit - design of cold junction compensation circuit for thermocouple using RTD - Transmitters – zero and span adjustment in D/P transmitters and temperature transmitters.

**Pressure and Level:**Bourdon gauges - factors affecting sensitivity - design of Bourdon tube -design of Air purge system for level measurement.

**Valves:**Control valves - design of actuators and positioners - types of valve bodies -valve characteristics - materials for body and trim - sizing of control valves - selection of body materials and characteristics of control valves for typical applications.

**Pumps:**Types of pumps - pump performance - pipe work calculation - characteristics of different pumps - pump operation - maintenance - instruments used in pumping practice - pump noise and vibration - selection of pumps. Electronic P+I+D controllers - design - adjustment of setpoint, bias and controller settings.

**Microcontroller Based Design:**Design of logic circuits for alarm and annunciator circuits, interlocks - design of microcontroller based system for data acquisition - design of microprocessor based P+I+D controller.

**Text Books :**

1. Anderson N.A., Instrumentation for Process Measurment and Control, Routledge, 3rd Edition, 1997.
2. Considine D.M., Process Instruments and Controls Handbook, McGraw-Hill., 5th Edition 2009.

**Reference Books :**

1. Johnson C.D., Process Control Instrumentation Technology, Prentice Hall of India, 8th Edition, 2009.

## EI 4044 CONTROL SYSTEM DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. developcompensators for linear systems.
CO2. designthe control schemes using Root Locus and Bode Diagrams.
CO3. developstate space models for various physical systems.
CO4. design state feedback controllers and observers.
CO5. perform theLyapunovstability analysis of nonlinear systems.
CO6. design nonlinear controllers using Lyapunov theory.

**Prerequisite: Principle of Control System (EL 2002)**

**Design of Feedback Control Systems:** Introduction; Approaches to System Design; Cascade Compensation Networks; Phase-Lead Design Using the Bode Diagram; Phase-Lead Design Using the Root Locus; System Design Using Integration Networks; Phase-Lag Design Using the Root Locus; Phase-Lag Design Using the Bode Diagram; Design on the Bode Diagram Using Analytical Methods; Systems with a Pre-filter; Design for Deadbeat Response; Design Examples.

**Design of State Variable Feedback Systems** Introduction, State space representation of physical systems, State space models of some common systems like R-L-C networks, DC motor, inverted pendulum etc., Controllable Canonical Form, Observable Canonical Form, Diagonal Canonical Form, State transition matrix, Solution of state equations, Controllability and Observability

**State Feedback Controller and Observer Design:**Full-State Feedback Control Design; Observer Design; Integrated Full-State Feedback and Observer; Tracking Reference Inputs; Internal Model Design; Design Examples.

**Lyapunov's stability:**Lyapunov's stability and optimal control positive/negative definite, positive/negative semi-definite functions, Lyapunov stability criteria, introduction to optimal control, Riccatti Equation, Linear Quadratic Regulator, Design Examples.

**Text Books:**

1. Bernard Friedland, Control System Design: An Introduction to State-Space Methods (Dover Books on Electrical Engineering), Dover Publications Inc., 2005.
2. Gene F. Franklin, J. Da Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Pearson Prentice Hall, 7th Edition, 2014.
3. Richard C Dorf, Robert H Bishop, Modern Control Systems, Pearson Education India, 12th Edition, 2013.

**Reference Books:**

1. Katsuhiko Ogata, Modern Control Engineering, Pearson, 5th Edition, 2009.
2. MadanGopal, Modern Control System Theory, New Age International Private Limited, 2014.

# MECHANICAL ENGINEERING

## B. TECH IN MECHANICAL ENGINEERING

### Program Educational Objectives(PEOs):

The B. Tech program in Mechanical Engineering aims to prepare students so that they shall get widely employed in mechanical or allied disciplines and adhere to professional ethics in engineering practice. The program also aims to prepare the graduates with the following objectives:

1. Graduates shall be able to provide solutions to mechanical engineering problems involving design, manufacturing, heat power, and operational management issues.
2. Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.
3. Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

### Program Outcomes(POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

The program specific outcomes are:

m) Join a technical workforce as successful professionals in a wide range of mechanical engineering and related domains.
n) Pursue advanced degrees in engineering, business, or other professional fields.
o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

**ME 1003** **ENGINEERING MECHANICS** **Cr-3**

**Course Outcome:** At the end of the course, the students will be able to:

- CO1. identify and formulate elementary level engineering problems related to particle mechanics in conceptual form as well as in terms of mathematical and physical models and to solve problems dealing with forces in a plane or in space and equivalent force systems.
- CO2. solve real life problems by using mathematics, physical laws and theorems.
- CO3. utilize scalar and vector analytical techniques for analyzing forces in statically determinate structures and to analyze and design a bridge in a safe and economical way using the knowledge gained from trusses and frames.
- CO4. apply the basic principles of energy methods to the analyze is of particles subjected to forces.
- CO5. apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple, practical problems.
- CO6. evaluate the kinetics of rotation.

**Prerequisite: Nil**

**Concurrent Forces in a Plane:**

Introduction to Engineering Mechanics, Free-body diagrams, Composition and resolution of forces, Equilibrium of concurrent forces in a plane, Methods of projections, Methods of moments

**Friction:**

Static friction, Laws of dry friction, Applied of friction in inclined plane, Wedge friction, Belt friction

**Parallel Forces in a Plane:**

Parallel forces acting in the same and opposite directions, General case of parallel forces in a plane, Centre of parallel forces, Centroid and Centre of gravity, Theorem of Pappus, Centre of composite plane figures and Curves, Distributed forces in a plane.

**Moment of Inertia:**

M I of plane figures, Parallel Axis Theorem, Perpendicular axis theorem and MI of composite figures.

**Force analysis of Plane Trusses and Frames:**

Methods of joints, Method of Sections and Method of members.

**Principle of Virtual work:**

Equilibrium of Ideal Systems, Virtual work.

**Kinematics of Rectilinear Motion:**

Differential equations of rectilinear motion, Force proportional to displacement, Free vibration, D' Alembert's Principle, Momentum and Impulse, Work & Energy, Conservation of energy, Impact.

**Kinematics of Curvilinear Motion:**

Normal and Tangential acceleration, Motion of a Projectile, Work and Energy in curvilinear motion.

**Rotation of a rigid body:**

Kinematic s of rotation, Rotation under the action of a constant moment.

**Text Book :**

1. Engineering Mechanics – S Timoshenko, D. H Young & J.V. Rao-TMH

**Reference Books :**


1. Engineering Mechanics (Statics and Dynamics) - Bear and Johnson, TMH
2. Engineering Mechanics (Statics and Dynamics), IH Shames, Prentice Hall
3. Engineering Mechanics –S.S. Bhavikatti, New Age International
4. Engineering Mechanics (Statics and Dynamics), S. Rajasekaran and G. Sankarasubramanian, Vikas publishing House


## ME 2010 BASIC MANUFACTURING PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand and select the casting process for a particular industrial product
CO2. identify the suitable rolling process and sheet metal for different material and product.
CO3. understand the forging process for various components and its application
CO4. understand the fundamental processes of extrusion and drawing
CO5. apply powder metallurgy process to produce powder of various materials and to manufacture new composite material
CO6. identify the best welding technique for joining of various components and to produce defect free products

### Prerequisite: Nil

**Foundry Process:**

Pattern making, pattern materials, allowances, types of pattern, sand casting types, sand cast, moulding procedure, types of sand, gates and riser (basic design considerations) essential properties of moulding sand, core making, types of cores. Essential qualities, core mixtures and binder sand testing, Mould and core hardness test, fineness test, clay content test, permeability test, moisture content test, sand conditioning. Cleaning of casting and defects in casting, die casting. Precision investment casting, shell moulds, centrifugal casting processes, permanent moulds casting, dies casting.

**Metal Working Process:**

Hot and cold working of Metals: Basic Principles of hot and cold working of metals.

**Rolling:**

Types of Rolling, Rolling equipments hot and cold rolling, General deformation pattern, Pressure and forces in rolling. Distribution of roll pressure, angle of bite, effect of rolling on microstructure, Rolling defects, Numerical on rolling load and power required for reduction, Thread rolling.

**Forgings:**

Smith forging, Drop forging, press forging & Machine forging, Description of Presses and hammers, forging defects.

**Extrusion:**

Direct, Indirect and impact extrusion and their applications, Extrusion defects. Determination of extrusion force.

**Drawing:**

Wire and rod drawing, Tube drawing, Process variables in drawing process. Deep drawing. Determination of drawing force.

**Sheet metal working:**

Blanking. piercing, coining, embossing, bending, deep drawing and spinning.

**Powder Metallurgy:**

Preparation of powder, properties of powder, fabrication methods & procedure, applications, advantages.

**Fabrication Processes:**

Classification, types of welding joints, Gas welding: principles, types of flames, equipment, techniques of gas cutting. Electric Arc Welding: Principles of electric welding equipment and electrodes. Principles of Inert Gas Welding: TIG, MIG, sub-merged arc welding. Atomic hydrogen welding, plasma are welding. Resistance Welding: Principle of forge welding, spot welding, seam welding, projection welding, Upset-butt welding, flash welding. thermit welding, electro-slag welding, friction welding. Brazing and Soldering. Welding defects and inspection.

**Text Books :**

1. Manufacturing Technology (Part I), P.N. Rao (Tata Mc-Graw Hill, Publication. Co.Ltd.)
2. Manufacturing Processes, J. P. Kaushish, PHI (2nd Edition)

**Reference Books :**

1. Manufacturing Technology: Materials, Processes and Equipment: Helmi A. Youssef, Hassan A. El. Hofy and M.H. Ahmed, CRC Press, 2015
2. Principle of Manufacturing Materials and Processes: J.S. Cambell, TMH
3. Welding & Welding Technology - R. Little, TMH, 43rd reprint, 2014
4. Manufacturing Science: A. Ghosh & A.K. Mallick, EWP

## ME 2013 KINEMATICS AND DYNAMICS OF MACHINES Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analyze the velocities and accelerations of mechanisms and IC engine parts

CO2. illustrate Hook’s joint, Davis and Ackerman Steering gears. Compound pendulum, Bifilar and Trifler suspension.

CO3. assess the effect of friction on mechanisms and the kinematics of cam and followers.

CO4. understand the gyroscopic couple and its effect to two wheelers, four wheelers, ships, air-crafts etc.

CO5. understand the static and dynamic balancing of high speed rotary and reciprocating machine parts like gear, cam, belt and chain drives.

CO6. analysis both free and forced vibrations of machines and structures.

**Prerequisite: Engineering Mechanics (ME 1003)**

**Simple Mechanisms:**

Classification of links and pairs, kinematics chains, degrees of freedom, Grashof’s law, Grubler’s criterion for plane mechanism. Four bar mechanism and its inversions. Single slider crank chain and its inversions. Double slider crank chain and its inversions.

**Velocity Analysis:**

Velocity of a point in a link by relative velocity methods and instantaneous center method, Numbers and types of instantaneous centers in a mechanism. Location of instantaneous centers. Kennedy’s theorem, Velocities of four-bar and slider crank mechanisms.

**Acceleration Analysis:**

Acceleration of point on a link, Acceleration diagram of a link, Acceleration in the slider crank and four bar mechanism. Klein’s construction, Coriolis’ components of acceleration.

**Belt and Rope and Chain Drive:**
Velocity ratio, Effect of belt thickness and slip on velocity ratio, Length of belt, Ratio of driving tensions, Power transmitted by belt, Centrifugal tension. Maximum power transmitted by belts, Creep and initial tension, V-belt. Ratio of tensions in rope drive. Chain length, angular speed ratio and Classification of chains.

**Gear and Gear Trains:**
Simple, compound, Riveted and Epicyclic Gear Trains, Calculation of velocity ratio. Theory of shape and action of tooth properties and methods of generation of standard tooth profiles, Standard proportions, Interference and under cutting, methods of elimination of interference, minimum number of teeth to avoid interference.

**Cams:**
Types of cams and followers, Displacement velocity and acceleration-time curves for uniform velocity, uniform acceleration and deceleration, simple harmonic motion and cycloid motion, Graphical construction of cam profiles for different types of followers, Cams with specified contours.

**Force analysis:**
Analytical method of finding acceleration of a piston and connecting rod. Inertia force, Torque. Inertia forces in the Reciprocating Engines, Turning Moment diagrams, Flywheel.

**Gyroscope:**
Gyroscopic couple of plane disc. Analysis of the forces on bearings due to the forced processing of rotating disc mounted on shafts. Gyroscopic effects on a two wheel and four-wheel vehicle. Gyroscopic stabilization with reference to practical application.

**Governors:**
Centrifugal Governor: Watt and Porter Governors, Spring loaded Governor-Hartnell Governor, Sensitiveness, Stability, Isochronous, Hunting, Governor Effort and Power, curves of Controlling force.

**Balancing:**
Balancing of revolving masses in the same planes and different planes, Partial balance of Locomotives. Variation of tractive efforts, swaying couple. Primary and Secondary balance of multi cylinder engines.

**Vibration:**
Free vibration of single degree system without and with damping, Equilibrium Method, Energy method, stiffness of spring elements, viscous damping, Logarithmic decrement. Equation of motion, Dynamic amplifier, Vibration isolation and transmissibility, transverse vibration of shafts carrying a point load, uniformly distributed load and several loads. Dunkerly's method and energy method, whirling of shafts, Two rotor systems.

**Text Book :**

1. Theory of Machines, S. S Rattan, TMH, 4th Edition

**Reference Books :**

1. Theory of Machines, J. Shigley, TMH
2. Machines and Mechanisms: Applied Kinematics Analysis, David H Myszka, PHI
3. Kinematics of Machinery through Hyper Works, J.S.Rao, Springer, 1st Edition
4. Theory of Machines, Sadhu Singh, Pearson
5. Theory of Mechanism and Machines, Sharma & Purohit, PHI
6. Theory of Machines and Mechanisms, John Joseph Uicker, Gordon R. Pennock, Joselph E.Shigley, Oxford Univ Pr (Sd), 2010

## ME 2015 MANUFACTURING TECHNOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand and select the casting process for a particular industrial product.
CO2. identify the suitable forming process for different material and product.

CO3. identify the best welding technique for joining of various components and to produce defect-free products.
CO4. understand the different basic machining processes and machine tools.
CO5. apply the different non- traditional machining processes for up growing high strength materials with complicated and miniaturized product manufacturing.

## Prerequisite: Chemistry (CH 1007)

**Casting**
Introduction to casting - Patterns - Types - Pattern materials - Allowances. Moulding - types - Moulding sand - Gating and Risering - Core making. Special Casting Process – Shell- Investment - Die casting - Centrifugal Casting - Design of Casting, defects in casting.

**Mechanical working of metals**
Hot and Cold Working: Rolling, Forging, Wire Drawing, Extrusion - types – Forward backward and tube extrusion. Sheet Metal Operations: Blanking - blank size calculation, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch forming, Shearing, Bending - simple problems - Bending force calculation, Tube forming - Embossing and coining, Types of dies: Progressive, compound and combination dies, defects in forming.

**Machine tools**
Turning, Drilling, Milling Machine - Types, Types of cutters, operations, Indexing methods. Shaping, Planing and Slotting Machine – Operations and quick return mechanisms, Work and tool holding devices. Boring machine - Operations, Jig boring machine. Broaching machine - operations, Tool nomenclature-Simple Problems.

**Theory of metal cutting**
Orthogonal and oblique cutting - Classification of cutting tools: single, multipoint - Tool signature for single point cutting tool - Mechanics of orthogonal cutting - Force relations: Merchant circle – Determination of Shear angle - Chip formation-Cutting tool materials - Tool wear and tool life - Machinability - Cutting Fluids – Economics of machining. Non-conventional machining processes such as AJM, EDM, USM, ECM, PAM, LBM and EBM.

**Gear manufacturing and surface finishing process**
Gear manufacturing processes: Extrusion, Stamping, and Powder Metallurgy. Gear Machining: Forming. Gear generating process - Gear shaping, Gear hobbing. Surface Finishing Process: Grinding process, various types of grinding machine, Grinding Wheel - types - Selection of Cutting speed and work speed, dressing and truing. Fine Finishing - Lapping, Buffing, Honing, and Super finishing.

**Text Books :**


1. Sharma. P.C, “Production Technology: Manufacturing Processes”, 7th Edition, S. Chand Publisher, 2008.
2. Rao. P.N, “Manufacturing Technology, Vol I and II”, Tata McGraw Hill Publishing Co., 2nd edition, 2009.


**Reference Books :**


1. Hajra Choudhary.S.K and Hajra Choudhary.A.K, “Elements of Manufacturing Technology”, Vol II, Media Publishers, Bombay,
2. Jain.R.K, “Production Technology : Manufacturing Processes, Technology and Automation”, 17th Edition, Khanna Publishers, 2011.
3. Kalpakjian, “Manufacturing Engineering and Technology”, 4th edition, Addison Wesley Congmen Pvt. Ltd., Singapore, 2009.
4. Chapman.W.A.J, “Workshop Technology Vol. I and II”, Arnold Publisher, New Delhi, 2001.

## ME 2017 THERMODYNAMICS & FLUID MECHANICS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. develop an intuitive fundamental understanding of thermo-fluid systems
CO2. determine the thermodynamic and physical properties of numerous substances
CO3. apply the first and second laws of thermodynamics to several engineering devices
CO4. apply control volume analysis to numerous fluid mechanical systems
CO5. analyse simple, incompressible and inviscid fluid flows, such as pipe and pump flow systems
CO6. develop basic understanding of fluid machineries.

**Prerequisite : Mathematics-I (MA 1001)**

**The Thermal/Fluid Sciences: Introductory Concepts**

Thermodynamics, Fluid Mechanics, Importance and Applications of Thermodynamics and Fluid Mechanics in Electronic Product Design, Thermal/Fluid Sciences and the Environment.

**Thermodynamics**

**Preliminary Concept:**

Temperature and the Zeroth Law of Thermodynamics,The First Law of Thermodynamics, Second law of thermodynamics: Entropy, Work done, heat added and entropy changes in simple processes, Laws of perfect gas in Engineering Units. Relationship between CP, CV, R and J, Constant Pressure, Constant Volume, isothermal and adiabatic process.

**Steam Properties:**
Constant pressure formation of steam, Enthalpy and specific volume of dry, wet and super heated steam. Use of Mollier chart.

**Gas Power Systems:**
The Internal Combustion Engine, The Air Standard Otto Cycle, Design Example, The Air Standard Diesel Cycle, Air standard efficiency of Dual combustion cycle, The Gas Turbine, Simple open and closed cycles.

**Vapor Power and Refrigeration Cycles:**
The Ideal Rankine Cycle, The Effect of Irreversibilities, The Rankine Cycle with Superheat and Reheat, Design Example, The Ideal Rankine Cycle with Regeneration, The Ideal Refrigeration Cycle, The Ideal Vapor Compression Refrigeration Cycle, Departures from the Ideal Refrigeration Cycle, Solution of Engineering Problems using Psychrometric Chart.

**Fluid Mechanics**

**Fluid Properties**:

Physical properties of fluids, Types of fluid, Hydrostatic Law, Measurement of pressure by manometers. Total pressure and centre of pressure on horizontal, vertical and inclined surfaces submerged in liquid.

**Buoyancy and Floatation**:
Centre of buoyancy, Meta center & meta-centric height, Analytical method for metacentric height, Stability of floating and submerged bodies, Oscillation of a floating body.

**Dimensional Analysis and Model study**:
Dimensional homogeneity, dimensional analysis, Raleigh’s method and Buckingham theorem. Superfluous and Omitted Variables, Similarity laws and model studies, Distorted models.

**Flow in Pipes and Pipe Networks:**
Frictional Loss in Pipes, Dimensional Analysis of Pipe Flow, Fully Developed Flow, Friction Factors for Fully Developed Flow, Friction Factor and Head Loss Determination for Pipe Flow, Design Examples, Multiple-Path Pipe Systems.

**Fluid Machineries:**
The Principles of Centrifugal Pump, The Net Positive Suction Head,Combining Pump and System Performance**,** Scaling Laws for Pumps and Fans**,** Axial and Mixed Flow Pumps**,** Turbines.

**Text Book :**
1. Introduction to Thermal and Fluid Engineering, Allan D. Kraus, James R. Welty, Abdul Aziz, CRC Press, 2011.

**Reference Books :**
1. Introduction to Thermal and Fluids Engineering, D. A. Kaminski, M. K. Jensen, Wiley, 2011.
2. Engineering Thermodynamics, Parthasarthi Chattopadhyay, 1st Ed., Oxford Univ. Press
3. A Textbook of Thermal Engineering: (SI Units), R.S. Khurmi, J.K. Gupta, 15th Ed., S. Chand
4. A Textbook of Fluid Mechanics and Hydraulic Machines, R.K. Bansal, 9th Ed., Laxhmi Publ.
5. Fluid mechanics: Fundamentals and Applications, Y.A.Cengel, J.N.Cimbala, 3rd Ed., Tata McGraw Hill Education P. Ltd.

## ME 2020 SOLID MECHANICS AND MACHINE DESIGN Cr-4

**Course Outcome:** At the end of the course, the students will be able to :

CO1. analytically evaluate various types of stresses in different structural element
CO2. estimate two dimensional stresses and strains analytically
CO3. draw shear force and Bending Moment diagram beams
CO4. calculate the stresses in thin shells and circular shafts subjected to combined bending and twisting
CO5. ability design the component subjected to static and variable loads.
CO6. determine the life of component subjected to complex loading
CO7. design, model and solve using modern engineering tools

**Pre-requisite: Engineering Mechanics (ME 1003)**

**Simple stress and strain**
Concept of stress: Definition, Reason of stress phenomenon, normal stress and shear stress; Concept of strain: Types, Stress strain diagram and its features. Stress strain diagram for ductile and brittle materials, Stress, Stress due to self weight of members, Stress in nuts and bolts, Thermal stress.

**Compound stress and strain**
Two-dimensional stresses, principal stress, principal planes, Mohr's circle for the stresses, strain analysis, principal strains.

**Shear force and bending moment**
Types of support and beams, Shear force (SF), Bending Moment (BM), Relation between load, SF and BM. Shear force diagram and Bending Moment diagram of beams subject to concentrated and distributed load.

**Theories of Failure**
Maximum principal stress theory, Maximum Shearing stress Theory, Maximum Strain Theory, Total strain energy Theory, Maximum Distortion Energy Theory, Octahedral Shearing Stress Theory, Graphical representation of theories of failure.

**Torsion**
Torsion in solid and hollow circular shafts, Torque and Horse Power transmitted by solid and hollow shafts, combined bending and Torsion, close coiled helical springs, strain energy in Torsion, Combined bending and torsion.

**Stresses in cylindrical and spherical shells**
Stresses in thin cylinders and thin spherical shell under internal pressure, Thick cylinders subjected to internal and external pressures.

**Columns**
Definition of a column, types of failure in a column, definition of the critical load of a column, Slenderness ratio of a column, Influence of end conditions and effective length,

**Design of fastening elements**
Design of riveted joints (Methods of riveting, Application to Boiler Drum), Design of welded joints (strength of butt, transverse and parallel fillet weld, circular fillet weld subjected to torsion and bending, axially loaded unsymmetrical,), Design of bolted joints (types of screw fastening/locking devices, bolts of uniform strength, Design of cotter joints, Design of knuckle joints.

**Design of transmission elements**
Design of shafts (types of shaft, shafts subjected to torsion, bending and combined loading, design consideration/application as per ASME code), Design of keys (types of keys, design of sunk key), Design of couplings (protected type rigid and bushed-pin- type flexible coupling).

**Design of springs**
Closed coil helical springs of circular section, spiral spring.

**Text Books :**

1. Strength of Materials, S.S. Rattan, TMH
2. Design of Machine Elements - VB Bhandari (TMH), 3rd Ed.
3. Design Data Hand Book, S. Md. Jallaludeen (Anuradha Pub.)

**Reference Books :**

1. Strength of Materials, Lehri&Lehri, Kataria,
2. Mechanics of Materials, R.C. Hibler
3. Mechanics of solids, S.H. Crandall &Dahl,TMH

## ME 2021 FLUID MECHANICS AND HYDRAULIC MACHINES Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. apply conservation laws to fluid flow problems in engineering applications.
CO2. design experimental procedure for physical model studies.
CO3. design the working proportions of hydraulic machines.
CO4. compute drag and lift coefficients using the theory of boundary layer flows.
CO5. analyze and design pipe flows.
CO6. analyze the performance of turbines and pumps.

**Prerequisite: Mathematics-I (MA1003) and Engineering Mechanics (ME 1003)**

**Introduction:**
Definition of a fluid, the concept of continuum, properties of a fluid, Newton's law of viscosity, types of fluids, pressure and stress in the fluid, absolute, gauge and vacuum pressure.

**Fluid under rest:**
Variation of pressure in a fluid, Pascal's law, Manometers, thrust on the submerged surfaces, Buoyancy and flotation, concept of metacentre and metacentic height

**Kinematics of fluid flow:**
Lagrangian and Eulerian approach, types of fluid flow, convective and local acceleration, Streamline, pathline, streakline, differential form of continuity equation, stream function, velocity potential function, vorticity, circulation

**Dynamics of flows:**
Bernoulli's equation along a streamline for ideal and real fluid, Venturimeter, Orificemeter, Pitot tube, free vortex and forced vortex flow

**Flow through pipes:**
Major loss in the pipe, Darcy-weisbach formula, minor losses in the pipe, EGL, HGL, fully developed laminar flow through pipe

**Dimensional analysis and Similitude:**
Buckingham's pi theorem, model study, model laws

**Flow past immersed bodies:**
Concept of boundary layer, boundary layer thickness, displacement, momentum and energy thickness, Von-karman integral equation, Boundary layer separation, drag and lift, Magnus effect

**Hydraulic turbines:**
Types of turbines, velocity triangle diagram for Pelton wheel, Francis and Kaplan turbine, efficiency, design parameters, draft tube, cavitation, specific speed, unit quantities, model study

**Hydraulic pumps:**
Types of pumps, centrifugal pump, velocity triangle diagram for centrifugal pump, Multi-staging of centrifugal pumps, NPSH, specific speed, cavitation, model study, reciprocating pump, slip, indicator diagram, air vessels

**Text Book :**

1. Fluid Mechanics and Hydraulic Machines by Sukumar Pati, McGraw Hill Education (India) Pvt. Ltd, New Delhi

**Reference Books :**

1. Introduction to Fluid Mechanics and Fluid Machines, S. K. Som, G. Biswas & S. Chakraborty, McGraw Hill Education (India) Pvt. Ltd, New Delhi
2. Hydraulics and Fluid Mechanics Including Hydraulics Machines, P.N. Modi, Standard Publishers Distributors
3. Fluid Mechanics, Y. Cengel and J. Cimbala, McGraw Hill Education (India) Pvt. Ltd, New Delhi
4. Fluid Mechanics and Hydraulic Machines, R. K. Rajput, S. Chand
5. Fluid Mechanics and Hydraulics, Jagdish Lal, Metropolitan Book Co. Pvt Ltd., NEW DEL

## ME 2022 INTERNAL COMBUSTION ENGINES AND GAS TURBINES Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

- CO1. identify various IC engines used in automobiles according to their basic mechanism and arrangement and also able to analyze engine performance with the help of different air standard cycles.
- CO2. demonstrate and design the mechanism of various fuel supply system of IC engines.
- CO3. analyze the combustion process inside the engine and suggest controlling measures.
- CO4. evaluate the performance of IC engines through the measurement of various performance parameter also can explain the mechanism and advantages of supercharging as well.

CO5. explain the need and mechanism of cooling, lubrication and ignition systems in IC engines.

CO6. identify methods of improving work output and efficiency of gas turbine through the analysis by using air standard cycle.

## Prerequisite: Engineering Thermodynamics (ME2031)

**Introductions:**

Classifications of IC Engines, Fundamental difference between SI & CI engines, Comparison of two stroke & four stroke engines, Valve and port timing diagram, Otto, Diesel & Dual cycle.

**Carburetion and Fuel injection:**

Function of carburettors, Description and principle of simple carburettor and its drawback, Petrol injections. Requirements of diesel injections system. Types of injection systems, Types of solid injection systems; Individual pump and injector system, Unit injection system, Common rail injection system and Rotary distributor injection system. Nozzles

**Combustion of Fuels:**

Properties and rating of IC engine fuels, Additive and non-petroleum fuels, Stages of SI engine combustion, Effect of engine variables on ignition lag and flame propagation, SI engine knock, Control of knock. Stages of diesel combustion, Variables affecting delay period, Diesel engine knock and methods of control.

**Supercharging:**

Thermodynamic cycle with supercharging and its effect, Methods of supercharging.

**Testing and Performance:**

Fuel, air and power measurement methods. Performance of SI and CI engines, Characteristic curves

**Engine Emission and Control:**

Engine Emissions and its harmful effects. Gasoline and Diesel emission. Methods of measuring pollutants controlling of engine emission.

**Cooling Lubrication and ignition systems:**

Air cooling and water cooling systems effects of cooling on power output and efficiency, Properties of lubricants additives lubricating systems. Types of lubrication mechanism, Battery, Magneto and Electronics ignition systems, Ignition timing, Firing order.

**Gas Turbines:**

Gas turbine power cycle: Introduction to open cycle and closed cycle gas turbine, Reheating, Regeneration and Inter cooling arrangements. Introduction to Turbojet, Turboprop, Turbofan and Ram jet engines.

**Text Books :**

1. IC Engines, V Ganeshan, TMH, 4th edition
2. Gas Turbines, V Ganeshan, TMH, 3rd edition

**Reference Books :**

1. IC Engines, Mathur and Sharma, Dhanpat Rai & Sons
2. IC Engines, S.P. Sen, Khanna Publishers
3. IC Engines, Gill and Smith, OXFORD & IBH
4. An introduction to energy Conversion (Vol. II), Kadambi & Prasad, Wiley Eastern.
5. Gas Turbine Theory, Cohen, Rogers and Saravanamutto, Pearson Education

## ME 2023 THERMOFLUIDCS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. develop an intuitive fundamental understanding of thermo-fluid systems
CO2. determine the thermodynamic and physical properties of numerous substances
CO3. apply the first and second laws of thermodynamics to several engineering devices
CO4. apply control volume analysis to numerous fluid mechanical systems
CO5. analyse simple, incompressible and inviscid fluid flows, such as pipe and pump flow systems
CO6. develop basic understanding of fluid machineries.

**Prerequisite: Mathematics-I (MA 1003)**

**The Thermal/Fluid Sciences: Introductory Concepts**

Thermodynamics, Fluid Mechanics, Importance and Applications of Thermodynamics and Fluid Mechanics in Electronic Product Design, Thermal/Fluid Sciences and the Environment.

**Thermodynamics**

**Preliminary Concept:**
Temperature and the Zeroth Law of Thermodynamics,The First Law of Thermodynamics, Second law of thermodynamics: Entropy, Work done, heat added and entropy changes in simple processes, Laws of perfect gas in Engineering Units. Relationship between CP, CV, R and J, Constant Pressure, Constant Volume, isothermal and adiabatic process.

**Steam Properties:**
Constant pressure formation of steam, Enthalpy and specific volume of dry, wet and super heated steam. Use of Mollier chart.

**Gas Power Systems:**
The Internal Combustion Engine, The Air Standard Otto Cycle, Design Example, The Air Standard Diesel Cycle, Air standard efficiency of Dual combustion cycle, The Gas Turbine, Simple open and closed cycles.

**Vapor Power and Refrigeration Cycles:**
The Ideal Rankine Cycle, The Effect of Irreversibilities, The Rankine Cycle with Superheat and Reheat, Design Example, The Ideal Rankine Cycle with Regeneration, The Ideal Refrigeration Cycle, The Ideal Vapor Compression Refrigeration Cycle, Departures from the Ideal Refrigeration Cycle, Solution of Engineering Problems using Psychrometric Chart.

**Fluid Mechanics**

**Fluid Properties**:

Physical properties of fluids, Types of fluid, Hydrostatic Law, Measurement of pressure by manometers. Total pressure and centre of pressure on horizontal, vertical and inclined surfaces submerged in liquid.

**Buoyancy and Floatation**:
Centre of buoyancy, Meta center & meta-centric height, Analytical method for metacentric height, Stability of floating and submerged bodies, Oscillation of a floating body.

**Dimensional Analysis and Model study**:
Dimensional homogeneity, dimensional analysis, Raleigh’s method and Buckingham theorem. Superfluous and Omitted Variables, Similarity laws and model studies, Distorted models.

**Flow in Pipes and Pipe Networks:**
Frictional Loss in Pipes, Dimensional Analysis of Pipe Flow, Fully Developed Flow, Friction Factors for Fully Developed Flow, Friction Factor and Head Loss Determination for Pipe Flow, Design Examples, Multiple-Path Pipe Systems.

**Fluid Machineries:**
The Principles of Centrifugal Pump, The Net Positive Suction Head,Combining Pump and System Performance**,** Scaling Laws for Pumps and Fans**,** Axial and Mixed Flow Pumps**,** Turbines.

**Text Book :**
1. Introduction to Thermal and Fluid Engineering, Allan D. Kraus, James R. Welty, Abdul Aziz, CRC Press, 2011.

**Reference Books :**
1. Introduction to Thermal and Fluids Engineering, D. A. Kaminski, M. K. Jensen, Wiley, 2011.
2. Engineering Thermodynamics, Parthasarthi Chattopadhyay, 1$^{st}$ Ed., Oxford Univ. Press
3. A Textbook of Thermal Engineering: (SI Units), R.S. Khurmi, J.K. Gupta, 15$^{th}$ Ed., S. Chand
4. A Textbook of Fluid Mechanics and Hydraulic Machines, R.K. Bansal, 9$^{th}$ Ed., Laxhmi Publ.
5. Fluid mechanics: Fundamentals and Applications, Y.A.Cengel, J.N.Cimbala, 3$^{rd}$ Ed., Tata McGraw Hill Education P. Ltd.

## ME 2024 INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCHCr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. learn the concept ofany real life industrial problem and solve it by Quality control tools and charts
CO2. convert the problem into a mathematical model.& Solve the mathematical model manually
CO3. understand variety of problems such as assignment, transportation, travelling salesman etc.
CO4. solve the problems mentioned using linear programming
CO5. use the techniques, skills, and modern engineering tools necessary for engineering practice like scheduling, JIT, inventory model and forcasting etc.
CO6. design develop, implement, and improve integrated systems that include people, materials, and equipment,machine ,energy and information.

### Prerequisite: NIL

**Types of Production Processes, Plant location and Layout.**
Introduction, Types of Production processes (Project/Job, Batch, Mass/Line, Continuous), Role of Production, Planning & Control (PPC), New Product Development, Product life cycle, Importance & Factors affecting the Plant Location, Plant Layout & its classification, Line balancing method

**Inventory Control, Quality control**
Inventory Control: Relevant Costs, P & Q Systems of Inventory, Basic EOQ Model, and Model with Quantity discount, Economic Batch Quantity. Safety Stock, Reorder Point, ABC Analysis, Material Requirement Planning, Quality control, Statistical process control using X Bar Chart, P Chart and C Chart, Acceptance Sampling, Forecasting, Scheduling. Sequencing, 2 and 3 Machine cases:

**Operations Research:**
Introduction to operations research, linear programming, Graphical method, Simplex method, Big-M Method, Transportation problems using Row minima, Column Minima, Least Cost, North west corner Rule, Vogel's Approximation and MODI Method, Assignment problems using Hungarian method, Network models: CPM and PERT,

**Text Books :**
1. Production and Operation Management, R. Paneerselvam, Third Edition,2013
2. Operations Research by P K Gupta, D.S. Hira, S Chand & Sons.

**References Books :**
1. A. Muhlemann, J. Oakland and K. Lockyer, Productions and Operations Management*, Macmillan, 1992.*
2. H. A. Taha, Operations Research – An Introduction*,* Prentice Hall of India, 1997.
*3.* J. K. Sharma, Operations Research*,* Macmillan, 1997.
*4.* A. P. Verma, Operations Research, *SK Kataria & Sons*

## ME 2026 ENGINEERING METROLOGY Cr-3

**Course Outcome:** On completion of the course, students will be able to:

CO1. demonstrate different measurement techniques.
CO2. reproduce the fundamental knowledge on metrology techniques.
CO3. apply statistical process control and acceptance sampling procedures in a manufacturing environment to improve quality of processes / products.
CO4. identify suitable metrological methods for measuring the components.
CO5. explain the acceptance test for machines.
CO6. outline the working of various optical measuring instruments.

### Prerequisite: Nil

**Metrology:**

Definition, Needs of inspection, principle and methods of measurements, Sources of error, precision and accuracy,

**Standards of measurement:**
Line, End and Wave length standards.

**Limits, Fits and Tolerances:**
Basic concepts of limit fits and tolerance, Interchangeability and selective assembly, ISO system of tolerance, Fundamental deviation, Hole & Shaft basis systems, Limit gauges, Taylor's principle of limit gauge design, Basic Gauge design rules for plug and ring gauges.

**Simple measurement tools**:
Rules, Callipers, Height gauges, Micrometers, Depth gauge, Dial indicator, Slip gauges, Sine bar, Auto-collimator: Principle, construction and application. Coordinate measuring machine (CMM) - an introduction.

**Screw Thread Measurement**:
Standard thread profiles, Errors in threads and pitch errors, Measurement of effective diameter by 2-wires and 3-wires methods. Best wire size.

**Surface Roughness:**
Elements of surface texture, Order of surface irregularity, Evaluation of surface finish, Measurement of surface roughness using Tomlinson surface meter and Taylor Hobson's Talysurf, Measurement of straightness, flatness, parallelism, squareness and roundness (circularity) testing.

**Comparators:**
Needs of comparator, Basic principle, use, classification and characteristics of comparators, Types of mechanical comparators, Pneumatic comparator and its sensitivity.

**Measurement of Force, Torque and Strain:**
Direct methods of force measurement, Elastic members: Load cells, Cantilever beams, Proving rings, Differential transformers, Torsion bar dynamometer, Servo controlled dynamometer, Absorption dynamometer,

Mechanical strain gages, Theory of strain gage, Gage factor, Methods of strain measurements, Strain gauge bridge arrangement.

**Measurement of Temperature and Pressure:**
Methods of measuring temperature, Thermocouples, Law of thermocouples, Thermistor, Pyrometry, IR Thermography, Methods of pressure measurement, Static pressure measurement, Elastic pressure transducers, Dead weight pressure gauges, Measurement of vacuum, Measurement of high pressure.

**Modern Measurement Techniques:**
Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), X-ray Diffraction Systems (XRD).

**Text Books :**

1. Engineering Metrology, R. K. Jain, Khanna Publication
2. Mechanical Measurements, T.G. Beckwith and M. Lewis Buck, Oxford & IBH Publishing

**Reference Books :**

1. Mechanical Measurements, R. S. Sirohi, H. C. Radha Krishna, New Age International, 1991
2. A course in Mechanical Measurements and Instrumentation, A.K. Sawhney, Puneet Sawhney, Dhanpat Rai & Co
3. Mechanical Measurements, R. S. Sirohi, H. C. Radha Krishna, New Age International, 1991

## ME 2027 MATERIALS SCIENCE AND ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. recognize appropriate material for a particular engineering application.
CO2. develop and change the chemical, physical and mechanical properties of steel and its alloys for different structural applications.
CO3. select different no ferrous materials for different industrial and day to day life application.
CO4. change the mechanical properties of steel with or without change in chemical compositions.
CO5. use the technique to prevent corrosion of different ferrous and non-ferrous alloys
CO6. use different material testing methods to identify different properties and behaviour of material at various conditions

### Prerequisite: Chemistry (CH 1007)

**Introduction of Engineering Materials**:
Materials Classification, Engineering requirements of materials, crystallography: crystalline and non-crystalline material, unit cells, crystal structures, crystal systems, Crystallographic plane and directions, single and poly-crystalline materials
**Structure of Materials:**
Defects in crystals – point defects, line defects (dislocations), surface defects and volume defects, Grains, Grain Boundaries, Grain size, Effect of grain size on properties of materials, Mechanical behaviour of materials (tensile, hardness, creep and fatigue), strengthening mechanism of metals, electrical properties, thermal properties, magnetic properties and optical properties.

**Phase Diagram and Phase transformation of metals and alloys:**
Basics of phase diagram, Gibb's phase rule, Lever rule, Isomorphous, Eutectic and Peritectic alloy system, Iron-carbon equilibrium diagram, Isothermal decomposition of austenite (TTT curve), transformation of austenite upon continuous cooling, Principles of heat treatment, basics of heat treatment furnaces, Annealing, Normalizing, Hardening, Tempering, Martempering, Age hardening, Surface hardening, Case hardening, Hardenability of steel and Jominey end quench test.

**Engineering Materials and their Applications:**
Pig iron, Cast iron, Tool steels, Stainless steel, Advanced high strength steel, Aluminum, Magnesium and Titanium alloys, Super alloys, Ceramics, Polymers and Composites.

**Material Testing:**
Destructive testing: Tensile testing, compression testing, fatigue testing, Impact testing, Nondestructive testing: Ultrasonic testing, Dye penetration testing, magnetic testing, acoustic testing, X-ray testing

**Materials Selection and Design Considerations:**
Introduction, Corrosion & its Prevention, Component design, case studies to select material for Torsionally-stressed cylindrical shaft, Automotive valve spring.

**Text Books :**

1. Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications
2. The Science and Engineering of Materials, Donald R Askeland, Cengage Publication, 7th Edition,

**Reference Books :**

1. Materials Science and Engineering, William F Smith, Mc Graw Hill, 5th Edition
2. Material Science and Engineering, V. Ragvan, Prentice Hall of India, 4th Edition

## ME 2029 MECHANICS OF SOLIDS Cr-4

**Course Outcome:** On completion of the course, students will be able to :

- CO1. interpret stress strain diagrams and compute significant material characteristics
- CO2. derive and apply stress equations under different load conditions to determine stress and strains
- CO3. analyze a system under complex load system
- CO4. derive and represent profiles for shear force, bending moment, slope and deflection of simple structural members under different load states.
- CO5. comprehend the concept of strain energy, derive and apply equations thereof in finding elastic profiles and stress under sudden or impact load
- CO6. apply the concepts to analyze columns, cylindrical shells, spherical shells, springs and composite beams

**Prerequisite: Engineering Mechanics (ME1003)**

**Stress, strain and elastic constants:**
Concept of stress: definition, types of stresses (normal stress and shear stress), Concept of strain: definition, types of strains (Longitudinal, lateral, superficial, volumetric, shear), Poisson's ratio, Stress strain diagram for ductile and brittle materials, salient features of the diagram, Elastic constants and relationship thereof, Test instruments for mechanical properties – stress, strain, hardness, toughness, impact strength
**Stress under axial load:**
Expression for stress and strain for members under axial load, Computation of stress and strain in uniform bars, stepped bars, tapered bars under axial load, Computation of stress and strain due to self-weight of members, Principle of superposition, Computation of stress and strain composite rods, Thermal stress

**Stress under bending and torsion**:
Derivation of theory of simple bending, Application of simple bending theory in beams of circular, rectangular, I-section (solid and hollow as applicable), Torsion in solid and hollow circular shafts, power-torsion relationship, Derivation and application of torsional stress expression in solid and hollow shafts, Stress distribution (normal and shear stress), concept of shear center

**Compound stress and strain:**
Two-dimensional stresses, Principal stress, principal planes: Analytical method and Mohr's circle method, Principal strains: Derivation and application**,** Members under combined bending moment and torsion

**Shear force and bending moment diagrams:**
Beams: Definition, boundary conditions at different types of supports, Shear force and bending moment: Concepts, derivation and relation between load, SF and BM, Computation and representation of shear force and bending moment in beams (simply supported, cantilever and overhang) subjected to couples, concentrated and uniformly distributed load

**Slope and deflection:**
Slope and deflection of simply supported beams, cantilever and overhang beams under point load, uniformly distributed load and couples (Macaulay's method to be followed; hints on other methods to be provided), Slope and deflection of statically indeterminate structures: Fixed beam by Macaulay's method, Continuous beam using Clapeyron's three moment equation

**Strain energy**:
Concept of strain energy, concept of toughness and resilience, Strain energy due to axial load, bending moment and twisting moment, Application of strain energy concept: Stress under sudden load and impact, Castigliano's theorem to find slope and deflection with applications involving simple structures under point load and uniformly distributed load, Concept and derivation of energy of dilation and energy of distortion

**Theories of failure**:
System under complex loading, Maximum principal stress theory, Maximum shearing stress theory, Total strain energy theory, Maximum distortion energy theory, Graphical representation of theories of failure

**Stresses in cylindrical and spherical shells**:
Stresses in thin cylinders and thin spherical shell under internal pressure, Thick cylinders subjected to internal and external pressures, compound cylinders, Membrane stress in shells, application to cylindrical, spherical and conical shells.

**Columns**:
Members under compression – concept of columns and struts, concept of buckling, Euler's theory of buckling, concept of slenderness ratio, application in columns with different end conditions, limitation of Euler's theory and usefulness of Rankine's theory, Design of eccentrically loaded columns

**Stress in some other significant elements:**
Composite beams, Close coiled helical springs, Carriage springs

**Text Boook :**
1. Strength of Materials, G. H. Ryder, MACMILLAN

**Reference Books :**
1. Mechanics of Materials, R. C. Hibler, PEARSON
2. Strength of Materials, S. S. Rattan, TMH
3. Strength of Materials, R.K. Rajput, S.Chand
4. Strength of Materials, R. S. Khurmi, S. Chand
5. A Text Book of Strength of Materials, R. K. Bansal, Laxmi Publications Pvt Ltd

## ME 2031 ENGINEERING THERMODYNAMICS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. comprehend terminology related to thermal engineering.
CO2. recognize the need of learning thermodynamics.
CO3. appreciate the 1$^{st}$ law in cyclic and acyclic processes.
CO4. interpret the 2$^{nd}$ law in applications related to heat engine, heat pump and refrigerators.
CO5. read and comprehend steam table and Mollier chart in solving complex thermal problems.
CO6. compute availability.

### Prerequisite: Mathematics-I (MA1003)

**Basic concepts and definitions**:
Scope of thermodynamics, Macroscopic and microscopic approaches, Thermodynamic~~s~~ systems, Thermodynamic~~s~~ Properties and processes, thermodynamic equilibrium, Zeroth law of thermodynamics, Measurement of temperature, energy interaction with closed system- Heat and work transfer,

**First law of thermodynamics**:
pdV work for different processes, first law for closed systems (for cyclic and non-cyclic processes), introduction of internal energy and enthalpy as thermodynamic properties, Application of first law to different processes of closed system. first law for open systems. control volumes, flow work and energy of a flowing fluid, steady flow energy equation.

**Second law of thermodynamics:**
Kelvin-Planck and Clausius statements of second law, Reversible and irreversible processes, Irreversibilities, causes of irreversibility, Carnot principles, Clausius inequality, definition of entropy and its evaluation for various processes of pure substances, principle of increase of entropy, Entropy generation.

**Pure substances**:
Definition of pure substance, p-v, p-T, T-s and h-s diagrams for pure substances, dryness fraction, specific volumes of saturated liquid, wet vapor and superheated vapor. Use of steam tables in finding internal energy and enthalpy of steam at different conditions. Measurement of steam quality.

**Exergy:**
Available energy or Exergy, Useful work, availability for closed systems.

**Introduction to thermal devices:**
Compressor: Single stage reciprocating compressor with and without clearance. Steam turbines: Classification of turbines, impulse and reaction turbines. Boiler: Classification of boilers, Boiler efficiency. Steam nozzles: Flow through steam nozzles. Steam condensers: Types of condensers, Surface condenser, Evaporative condenser

**Text Book :**

1. Thermodynamics, An Engineering Approach, Yunus A Cengel and Michael A. Boles, Mc Graw Hill Education, 7$^{th}$ Edition, 2011 (reprint 2013)


**Reference Books :**

1. Fundamentals of Classical Thermodynamics, Gordon J. Van Wylen , Richard E. Sonntag, Claus Borgnakke, John Wiley, Fifth Edition
2. Engineering thermodynamics, P. K. Nag, McGraw Hill Education, Fifth Edition
3. Engineering Thermodynamics, Gordon Rogers and Yon Mayhew, Pearson Education Ltd
4. Engineering Thermodynamics, Krieth, CRC Press
5. Engineering Thermodynamics, Jones and Dugan, PHI Learning Pvt. Ltd.
6. Engineering Thermodynamics, D. P. Mishra, CENGAGE

## ME 3014 REFRIGERATION AND AIR CONDITIONING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. recognize the natural refrigeration processes and limitations thereof.
CO2. compute COP, power required and mass of refrigerants in theoretical and actual refrigeration systems.
CO3. compute moist air properties using fundamental science based formulae and psychrometric chart.
CO4. comprehend the components and their interaction in air conditioning systems.
CO5. prescribe primary data for air-conditioning for predefined requirements.
CO6. comprehend environmental concerns related to modern refrigeration and air-conditioning practices.

**Prerequisites: Engineering Thermodynamics (ME2031) , Heat Transfer (ME3021)**

**Introduction to Refrigeration:**
Definition, Reversed Carnot Cycle, Units of refrigeration, Coefficient of performance.

**Refrigerants:**
Classification of refrigerants and its designations, Halocarbon compounds, Azeotrope, Hydrocarbons, Inorganic compounds, Properties of refrigerants, Comparison of common refrigerants, uses of important refrigerants.

**Air Refrigeration System:**
Reversed Brayton Cycle, Open Air refrigeration cycle, Closed or dense Air refrigeration cycle, Air refrigerator working on Bell-Coleman cycle, Methods of Air refrigeration systems, Simple Air cooling system, Boot-strap Air cooling system, Reduced Ambient Systems, Regenerative Air cooling system.

**Vapour Compression System:**
Vapour compression cycle, Types of Vapour Compression Cycle, Actual vapour compression cycle, T-s and P-h diagram simple saturation cycle, super-heated and sub-cooled cycle, Effect of suction pressure and discharge pressure on performance.

**Multistage Compression and Multi-Evaporator system:**
Different arrangements of compressors, inter cooler and flash chamber, multistage compression, multi-evaporation system, dual compression system.

**Vapour Absorption system:**
Simple Ammonia-Water and Lithium Bomide-Water absorption system, Comparison of vapour absorption system with vapour compression system.

**Psychometrics and Air Conditioning Processes:**
Properties of air-vapour mixtures, Psychometric chart, Law of air-water vapour mixture, Enthalpy of mixture, simple heating and cooling, Humidification, Dehumidification, mixing of air streams, Adiabatic mixing, By-pass Factor, Apparatus Dew Point Temperature

**Comfort Air conditioning:**
Oxygen supply, Heat removal, Moisture removal, Air-motion purity of air, Thermodynamics of human body, Comfort and comfort chart, Effective temperature, factors governing optimum effective temperature.

**Air conditioning system:**
Classification of Air Conditioning System, Cooling load calculation, RSHF, GSHF and ERSHF, Room and Coil Apparatus Dew Point Temperatures, Summer air conditioning, Winter air conditioning and Year round air conditioning, Air-Washer,

**Air Conditioning Equipment:**
Hermetic Sealed Compressor, Rotary compressor, Centrifugal Compressor, Cooling coil, Heating coil, Filter, Humidifier, Fan

**Text Books :**

1. A course in Refrigeration and Air Conditioning, S.C. Arora and S. Domkundwar, Dhanpat Rai & Co (P) Ltd, 2013.
2. Refrigeration and Air Conditioning, C. P. Arora, McGraw Hill Education, 3rd Edition, 2013.

**Reference Books :**

1. Refrigeration and Air Conditioning, R. C. Arora, PHI Learning Pvt. Ltd., 2013.
2. Refrigeration and Air Conditioning, Manohar Prasad, New Age International, 2003.
3. Refrigeration and Air Conditioning, R. S. Khurmi, and J. K. Gupta, S. Chand Ltd, 2013

## ME 3016 METAL CUTTING AND TOOL DESIGN Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify the necessity of manufacturing, purpose and principle of machining, demonstrate tool geometry and convert tool angles from one system to another.
CO2. categorize between orthogonal and oblique cutting and chip flow deviation. Illustrate the mechanism of chip formation in machining ductile and brittle materials and able to conduct complex mechanical engineering experiments to analyze and interpret the experimental data.
CO3. explain the benefits and the purposes of determining cutting forces and able to conduct complex mechanical engineering experiments to analyze and interpret the experimental data.
CO4. assess failure of cutting tools, mechanisms and pattern of tool wear, the essential properties of cutting tool materials, and assess tool life, Machinability & economics of machining.
CO5. conduct advanced conventional machining processes.
CO6. design of cutting tools, press tool and forging die.

**Prerequisite: Manufacturing Processes, Automation (ME3019)**

**Geometry of Cutting Tools**

Need of manufacturing, Purpose and principles of machining, Objectives of machining in manufacturing industries, Types of tools-Single point and Multipoint, Concept of rake and clearance angles, Tool geometry and nomenclature- Tool-in-Hand system, ASA, ORS and NRS system, Geometry of multiple-point cutting tools, Conversion of tool angles, Effect of Tool geometry and machining variables on machining.

**Mechanism of Chip Formation**

Orthogonal and oblique cutting, Causes of chip flow deviation, Effective rake angle, Chip-tool contact length, Mechanism of chip formation in machining ductile and brittle materials, Shear deformation and shear plane, Classification and characteristics of chips, Chip reduction coefficient and cutting ratio, Shear angle, Cutting strain, Velocity relationship and Kronenberg relationship, Effect of cutting variables on chip reduction co-efficient, Built-up-edge (BUE) formation.

**Mechanics of Metal Cutting**

Purposes of determination of cutting forces, Force system during turning and their significances, Merchant circle diagram- Construction, use, advantages and limitations; Development of mathematical expressions for cutting forces using MCD, stress in conventional shear plane, energy of cutting process, Ernst-Merchant angle relationship, Lee-Shaffer's relationship, Dynamometers for measuring turning and drilling forces.

**Failure, Wear, Tool life and Tool materials**

Causes and modes of failure of cutting tools, Mechanism and pattern of cutting tool wear, Form stability, Criteria of flank and crater wear, Tool life-definition in R&D and shop floor, Evaluation of tool life, Taylor's tool life equation, Role of machining parameters on tool life and surface finish, Economics of machining, Gilbert's model, Evaluation of machinability, Factors affecting machinability, Tool Materials and chronological development, Location and causes of heat generation in machining, Chip-tool interface temperature, Cutting fluids & its effect, Surface integrity in machining, Surface roughness evaluation and measurements. High speed machining, Hard machining, Machining with minimum quantity lubrication, Multitasking and one-pass machining, Ultrasonically and thermally assisted machining, Micro-machining.

**Cutting Tool Design**

Design of single point cutting tool; Form tools (Graphical method) and Broach tool.

**Press Tool Design**

Press working equipment and operations, Press selection, Shearing principle, Stock strip layout, Pressure calculation, Blanking and Piercing die design, Design procedure for progressive and compound dies, Wire drawing and deep drawing.

**Forging Die Design**

Open die forging, Drop forging, Press forging and upset forging, Load estimation in forging, Forging design, allowances, Die design for drop forging and upset forging, Design of flash and gutter, Forging defects and inspection, Materials and manufacture of forging dies.

**Text Books :**

1. Machining and Machine Tools: A. B. Chattopadhyay, Wiley-India Pub,
2. A Text. Book of Production Engineering: P.C. Sharma, S.Chand & Co.

**Reference Books :**

1. Metal Cutting Theory and Practice: A. Bhattacharyya, New Central Book Pub, 1984.
2. Fundamentals of Metal Cutting and Machine Tools: B.L. Juneja, G.S. Sekhon, & Nitin Seth, New Age International Pub, 2005.
3. Metal Cutting Principles: M. C. Shaw, Oxford Pub, 2002.
4. Fundamentals of Machining & Machine Tools: Boothroyd & Knight, CRC press, 1988.
5. Tool Design: Cyril Donaldson, V. C. Goold, Tata McGraw-Hill, 1976.

## ME 3018 DESIGN OF MACHINE ELEMENTS-II Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic design requirement and suitable material selection for machine components.
CO2. analyze and apply the domain knowledge in practical problems using engineering tools such as Solidworks and ANSYS.
CO3. implement and design the domain knowledge in practical systems.
CO4. design the component subjected to static and variable loads.
CO5. determine the life of component subjected to complex loading.
CO6. acquaint themselves with the design of IC engine components for the schematic evaluation of elements in an engine.
CO7. develop awareness of tribological issues in the design of machine components such as rolling element bearing, journal bearing etc.

**Prerequisites: Design of Machine Elements-I (ME 3023), Mechanics of Solids (ME2029), Materials Science and Engineering (ME 2027)**

**Design against fatigue load:**
Stress concentration and factors, methods for reduction of stress concentration, endurance strength and limit stress, notch sensitivity, LCF and HCF. Design for finite life of components and cumulative damage. Design for infinite life, Soderberg and Goodman lines, and modified Goodman's lines. Design of springs against fatigue load. Bolted joint under fluctuating load. Evaluation of fatigue life in machine components.

**Design of IC Engine Components:**
Cylinder liners & Piston, Connecting rod, Crankshaft, Valve mechanism, Demonstration of temperature and stress/strain distribution in IC Engine components.

**Design of Gear Drives:**
Design of spur gear, Design of Helical gear (equivalent spur gear and virtual number of teeth, force analysis and design of helical gear by AGMA method), Design of bevel gear.

**Sliding and Rolling contact bearings:**
Basic modes of lubrication, viscosity index, Petroff's & McKee's Equation, Selection of Lubricants, Theory of film (Stribeck's Equation), Static and dynamic load carrying capacity, equivalent bearing load, selection of bearing life from manufacturer's catalogue (SKF Bearing). Demonstration of a typical bearing failure.

**Strategies in design of machine elements**:
Design optimization for functional life and cost.

**Text Books :**


1. Design of Machine Elements: VB Bhandari (TMH)
2. A Textbook of Machine Design, S. Md. Jalaludeen


**Reference Books :**


1. Mechanical Engineering Design, Shigley J E, Mischiee C R (TMH)
2. Hand Book- Design Data Handbook, S. Md. Jalaludeen.
3. Machine Design, Dr. P.C. Sharma and Dr. D.K. Aggrawal.


## ME 3019 MANUFACTURING PROCESSES AND AUTOMATION Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understanding the various machine tools and its related accessories.
CO2. understanding the conventional machining processes.
CO3. applying the different non- traditional machining processes for up growing high strength materials with complicated and miniaturized product manufacturing.
CO4. designing of Jigs and fixtures for different machining operations.
CO5. defining sequence of operations leading to optimized time and cost.
CO6. understanding the industrial automation with computer controlled machines and industrial robots.

### Prerequisite: Basic Manufacturing Processes (ME2010)

**Conventional Machine Tools & Machining Processes:**
Types, Specification, Operations, Tools, Accessories and attachments, Estimation of cutting time of conventional machining processes. Turning; Taper turning and thread cutting, Shaping; Quick return Mechanisms. Milling; Up milling, down milling and indexing. Grinding; Surface grinding, Centreless grinding, grinding wheel specification, wheel truing and dressing. Finishing Processes: Reaming and boring, Lapping, Honing, Super finishing. Turret & Capstan lathe, multi spindle automatic lathe, Gear Machining & Transfer machines.

**Non-conventional machining:**
Classification and principles of non-conventional machining processes such as AJM, USM, EDM, ECM, PAM, LBM and EBM.

**Jigs and Fixtures**
Principles of design and construction. Principles of Location and Clamping. Design of simple Jigs for drilling operations, simple fixtures for milling and broaching operation.

**Process Planning:**
Contents of process plan, process operations, steps in process planning, planning and tooling for low cost processing.

**Manufacturing Process Automation:**
Introduction to industrial automation and control, NC & CNC, part programming, DNC, CNC and adaptive control, Industrial robot application, robot anatomy, coordinate system, work envelope, grippers, actuators, sensors, automated guided vehicles (AGV) system.

**Control System:**
Description of open and closed loop control system and their block diagrams, Use of block diagram and signal flow graph to find overall transfer function,

**Text Books :**

1. Manufacturing Processes, J. P. Kaushish, PHI Learning Pvt. Ltd.; 2$^{nd}$ Edition (2010)
2. Automation, Productions systems, and computer Integrated manufacturing, Mikell P. Groover, PHI Learning Pvt. Ltd-New Delhi (3rd edition)

**Reference Books :**

1. Advanced Machining Processes, V. K. Jain, Allied Publishers Pvt. Ltd.; 1st edition (2007)
2. A Text Book of production Engineering, P C Sharma, S. Chand Publications, 2010
3. Modern Machining Process, P.C. Pandey, H.S. Shan, TMH,3$^{rd}$ Edition
4. Introduction to Micromachining, V.K. Jain, Narosa Publishing house, 2010

## ME 3020 ADVANCED MANUFACTURING PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the different non- traditional machining processes for up growing high strength materials with complicated and miniaturized products.
CO2. understand the challenging issues in production of micro dimensioned products.
CO3. apply the advanced forming processes for production of precession parts.
CO4. apply the different micro fabrication processes to produce micro components.
CO5. understand the concepts of smart materials and their use to mankind.
CO6. apply the non-conventional processes in industry 4.0

### Prerequisite: Basic Manufacturing Processes (ME 2010)

**Non-conventional Machining**:
Classification of non-conventional machining processes, Basic Principles, features of equipment, process variables and application of AJM, USM, ECM, EDM, PAM, LBM, and EBM**.**

**Micro manufacturing**:

Scopes of micro manufacturing, size effect and tooling issues in micro manufacturing. Micro turning, micro grinding, Ultrasonic assisted micromachining, Abrasive jet micromachining.

**Metal Forming processes**:

Hydro forming, Explosive forming, Electromagnetic forming and hydroelectric forming. Micro forming– micro bending, micro extrusion, micro molding.

**Micro Fabrication processes:**

Electron Beam Welding, Laser Beam Welding, Fabrication of MEMS-Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Epitaxy, Sputtering, Lithography, Etching, Additive manufacturing, Green manufacturing, Concurrent engineering, Lean manufacturing, Various shape memory alloys. Manufacturing technology of SMAs. Electro rheological (ER) and magneto-rheological (MR) materials: Characteristics of ER and EM fluids. ER and EM materials.

**Text Books :**

1. Advanced Machining Processes, V. K. Jain, Allied Publishers Pvt. Ltd.; 1st edition (2007)
2. Introduction to Micromachining, V.K. Jain, Narosa Publishing house, 2010

**Reference Books :**

1. Manufacturing Technology, Part –II, P.N. Rao, TMH, 3rd Edition, 2014
2. High Velocity Forming of Metals, ASTM
3. An Introduction to Microelectromechanical Systems Engineering, Maluf, Nadim, Norwood, Massachusetts, U.S.A.: Artech House, 1999, ISBN 10: 0890065810 / ISBN 13: 9780890065815
4. Smart materials and Structures, Gandhi, M.V. and Thompson, B.S., , Chapman and Hall, 1992

## ME 3021 HEAT TRANSFER Cr-4

**Course Outcome:** At the end of the course, the student will be able to:

CO1. analyze the mechanism of conduction and its application to thermal and energy systems.
CO2. solve the complex problems of conduction heat transfer in fluids for implementation in various industrial and scientific systems.
CO3. calculate heat transfer of a convective problem by using various correlations for various conditions.
CO4. develop an efficient heat exchange process for design and fabrication of heat exchangers used in various industrial purposes.
CO5. formulate an analysis of radiation heat exchange process in various thermal and energy systems for the solution of heat transfer problems.
CO6. design of the thermal equipment considering three modes of heat transfer simultaneously.

### Prerequisites: Engineering Thermodynamics (ME2031), Fluid Mechanics and Hydraulic Machines (ME 2021)

**Introduction:**
Different Modes of heat transfer; conduction, convection and radiation: Fourier's Law
of heat conduction equation, Newton's law of cooling, Stefan-Boltzmann equation for black body radiation.

**Conduction:**
Mechanism of conduction, Derivation of the generalized heat conduction equation in Cartesian coordinates, polar cylindrical and polar spherical coordinates. Different types of boundary conditions encountered in heat

conduction problems. Solution of the one dimensional steady state heat conduction equation with constant thermal conductivity and with/without heat generation in Cartesian coordinates. Extension of the solution to composite walls by electrical analogy. Thermal contact resistance. Solution of the one dimensional steady state heat conduction equation with constant thermal conductivity and without internal heat generation in Cylindrical and Spherical coordinates. Extension of the solution to composite cylinders/sphere by electrical analogy. Critical thickness of insulation. Heat transfer from fins (only longitudinal fins with constant cross sectional area), Fin efficiency and effectiveness. Unsteady heat conduction, lumped parameter system.

**Convection:**
Mechanism of convection and basic concepts, Concept of thermal boundary layer, Conservation equations for mass, momentum and energy, Significance of dimensionless numbers in forced and free convection, Expression of local and average values of heat transfer coefficients, Nusselt number for flat plate. Experimental correlations for forced and free convection for various geometries (Both laminar and turbulent flow)

**Radiation:**
Blackbody radiation, Plank's law, Spectral and total emissive power, Wein's displacement law, Spectral and total intensity of radiation, Radiation properties: emissivity, absorptivity, reflectivity and transmissibility, Kirchoff's law. Radiation shape factor, Relation for shape factor and shape factor algebra. Heat exchange between black bodies through non absorbing medium. Grey bodies and real bodies. Heat exchanges between gray bodies. Radiosity and irradiation. Electrical analogy and radiation network for a 2-surface and 3-surface enclosures in non-absorbing medium, radiation shields.

**Boiling and Condensation:**
Introduction, Boiling regimes, boiling correlations. Types of condensation, use of correlations for condensation on vertical flat surfaces, horizontal tube, Introduction to heat pipe.

**Heat Exchangers:**
Types of heat exchangers and heat exchanger configurations. The overall heat transfer coefficient and fouling factor. LMTD and effectiveness-NTU analysis of heat exchangers.

**Text Books :**

1. Engineering Heat and Mass Transfer, M M Rathore, Laxmi Publications Pvt. Ltd, 3rd edition.
2. Heat and Mass Transfer, Y A Cengel and A J Ghajar, McGraw-Hill Publication, 4th edition.

**Reference Books :**

1. Principles of Heat Transfer, Frank Kreith, Raj M. Manglik, M.S. Bohn, Cengage Learning, 7th edition
2. Heat and Mass Transfer, R.K. Rajput, S. Chand & Company, 5th edition.
3. Fundamental of Heat and Mass Transfer, Frank P. Incropera, David P. Dewitt, Willey 1996, 4th edition.
4. Heat Transfer, J. P. Holman and S. Bhattacharya, McGraw Hill Education, 10th Edition.
5. Introduction to Heat Transfer, S. K. Som, PHI Learning Private Ltd, 2013.

## ME 3023 DESIGN OF MACHINE ELEMENTS - I Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify basic requirements for machine elements, machines and manufacturing considerations in design.
CO2. design and determine geometrical dimensions of a component subjected to complex stress system.
CO3. read and adapt themselves with different machine components.
CO4. use of technical skill and imagination to construct a proper design configuration.

CO5. develop a link between fundamental concepts with realistic component design.
CO6. acquaint themselves with the design of various temporary and permanent fasteners.
CO7. analyze and synthesize different power transmission elements and springs.

**Prerequisites: Engineering Mechanics (ME 1003), Materials Science & Engineering (ME 2027) and Mechanics of Solids (ME 2029)**

**Introduction:**
Basic requirement for machine elements and machines, Design procedure, Design Synthesis, Use of standards in design, Selection of engineering materials, Selection of factor of safety, Manufacturing considerations in design, Various stresses in machine elements.

**Design of fastening elements:**
Design of riveted joints (Methods of riveting, Application to Boiler Drum), Design of welded joints (strength of butt, transverse and parallel fillet weld, circular fillet weld subjected to torsion and bending, axially loaded unsymmetrical, eccentrically loaded welded joint), Design of bolted joints (types of screw fastening/locking devices, bolts of uniform strength, eccentrically loaded (in-plane, out-plane) bolted joints. Design of cotter joints, Design of knuckle joints.

**Design of transmission elements:**
Design of shafts (types of shaft, shafts subjected to torsion, bending and combined loading, design consideration/application as per ASME code), Design of keys (types of keys, design of sunk key), Design of couplings (types of couplings, protected type rigid and bushed-pin- type flexible coupling), Design of belt (selection of flat/ V-belt from manufacture's catalogue), Design of chain drive (selection of roller chain from manufacture's catalogue)

**Design of springs**:
Closed coil helical springs of circular section, spiral spring, Leaf springs.

**Design of levers & brackets:**
Hand lever, foot lever, bell crank lever, rocker arm, wall brackets.

**Text Books :**
1. Design of Machine Elements - V. B. Bhandari (TMH), 3rd Ed.
2. Design Data Hand Book, S. Md. Jallaludeen (Anuradha Pub.)

**Reference Books :**
1. Machine Design - Sharma/Agarwal (Katson publishing House)
2. Machines Design Data Book - P.S.G. College of Technology, Coimbatore.
3. Mechanical Engineering Design - Shigley J E, Mischiee C. R.; TMH
4. Mechanical Design - of Machines, Maleev/Hartman (CBS)
5. Machine Design - Gupta J. K. and Khurmi R. S. (S. Chand Pub.)

## ME 3022 PRINCIPLES OF TURBOMACHINES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. estimate different design parameters of Turbomachines
CO2. understand the aerodynamics of turbomachine blades and their design
CO3. evaluate compressor and fan performances
CO4. demonstrate various features of a Turbine
CO5. examine difficulties associated with pump and their remedies
CO6. interpretation of performance curves of different mechanical devices.

**Prerequisite: Fluid Mechanics and Hydraulic Machines (ME 2021)**

**Introduction:**
Definition of Turbo-machines, classification, Basic laws and Governing Equations, work and efficiency of Turbine and compressor stage.

**Blade Theory:**
Aero-foil Section, Drag and Lift Coefficients, Blade Terminology, Cascade Nomenclature, Cascaded Testing and curves.

**Centrifugal Compressors and Fans:**
Basic constructional features, velocity diagrams, slip factor, energy transfer, power input factor, stage pressure rise and loading coefficient, pressure coefficient, degree of reaction, Centrifugal compressor characteristic, surging, rotating Stall and Choking.

**Axial Flow Compressors and Fans:**
Basic constructional features, Advantages of axial flow compressors, working principle, velocity triangle, stage work, work done factor, stage loading,

**Radial Flow Turbine:**
Basic constructional features, stage velocity triangle, Enthalpy-Entropy Diagram, Stage losses, performance characteristics.

**Axial Flow Turbine:**
Basic constructional features, velocity triangle, single impulse stage, multi-stage velocity compounded, multi-stage pressure compounded, reaction stage, blade to gas speed ratio, losses and efficiency, work done factor, low hub -tip ratio stages, performance characteristic.

**Axial Pump:**
Description, velocity triangles, work done on the fluid, energy transfer, axial pump characteristics, cavitation.

**Text Book :**
1. Turbo Machines, A Valan Arusu, Vikash Publishing House Private Limited

**Reference Books :**
1. Turbines, Compressors and Fans, S.M. Yahya, Tata McGraw- Hill Education.
2. Principles of Turbo Machinery, Turton R.K., Springer Publication.
3. Fundamentals of Turbo Machinery, William W., John Wiley and Sons.
4. Gas Turbine Theory, Cohen and Roger, Pearson Education
5. Fluid Mechanics, Thermodynamics of Turbomachinery by S.L. Dixon

## ME 3024 MECHANICAL VIBRATION AND NOISE ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the importance of vibration study in engineering.
CO2. write governing differential equation of a vibration system and its solution.
CO3 develop models of dynamic system with varying degrees of freedom (SDOF, MDOF).
CO4. determine the natural frequency of certain physical systems and understand the advantage of providing damping in mechanical systems.
CO5. understand the concept of noise, its measurement and its adverse effects on human.
CO6. select and implement the best noise control technique.

**Prerequisite: Kinematics and Dynamics of Machine (ME 2013)**

**Two Degree of Freedom Systems:**
Generalized Derivation of Equation of motion, Static and dynamic coupling, Langrange's equations. Undamped dynamic vibration observers.

**Multi-Degree of freedom system:**
Derivation of Equations, Influence coefficients, Eigen values and Eigen vectors, Calculation of Natural Frequencies by Rayleigh, Stodala, Matrix iteration and Holzer-Methods.

**Torsional Vibration:**
Multi-rotor systems, geared system and branched system

**Vibration of continuous system:**
Vibration of strings, free longitudinal vibration of prismatic bars, Lateral vibrations of uniform beams.

**Introduction to acoustics:**
Propagation of acoustic disturbances, the decibel scale for the measurement of sound pressure, Acoustic energy density and intensity, the wave equations, acoustic impedance.

**Human Response to sound:**
Noise effects, auditory response, Ratings and Regulations**.**

**Noise control:**
Principles of passive noise control, Acoustic enclosures, Acoustic barriers, Sound-absorbing materials, Vibration isolations materials and Damping materials.

**Text Book :**
1 Mechanical Vibrations and Noise Engineering, Ashok G. Ambekar, PHI.

**Reference Books :**
1. Theory of Vibration and Application, William T. Thomson, CBS.
2. Mechanical Vibrations, V.P.Singh, Dhanpat Rai & Co.(P) LTD.
3. Textbook of Mechanical Vibrations, Rao.V. Dukkipati, PHI.
4. Noise and vibration control, L. Beranek, McGraw-Hill.

## ME 3025 OPTIMIZATION TECHNIQUES Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. understand importance of optimization of industrial process management.
CO2. apply basic concepts of mathematics to formulate an optimization problem and solve it by simulation.
CO3. analyse and appreciate variety of performance measures for various problems like game theory
CO4. define and Use Optimization Terminology and some multi-criteria decision making (Ahp and ANP).
CO5. apply unconstrained & constrained search methods for optimization theory for continuous problems, including the necessary and sufficient optimality condition.
CO6. apply constrained optimization theory for continuous problems, including the Karush-Kuhn-Tucker conditions and algorithms such as: quadratic & separable programming

**Prerequasite: Mathematic-II (MA 1004)**

**Non-Linear Programming:**
Unconstrained univariate optimization problems: Bisection method & Unconstrained multivariate optimization: Gradient search method; Constrained optimization: Lagrangian multiplier function Kuhn Tucker conditions, Quadratic and Separable Programming methods

**Dynamic Programming:**
Principle of Optimality, Concepts of state and stage, Solution of Discrete Problems through Backward Dynamic Programming, Multi-stage Dynamic programming problems,Game theory.

**QueuingTheory**:
Markov Process -Description of state, Transition probability matrix, Birth and Death process, Markovian and Semi-Markovian Single-channel and Multiple-channel queues, Queuing Networks Discrete-event Simulation: Time-flow mechanisms, Random number and Random variate generation, Simulation of queuing, inventory and industrial problems.MCDM methods.AHP,ANP.

**Text Books :**
1. Operation Research: An Introduction, Taha H. A., PHI
2. Operation Research, Phillips, Rabindran and Solberg, John Wiley & Sons
3. Introduction to Operation Research, Hiller F. S., McGraw Hill Education

**Reference Books :**
1. Operation Research, S.D Sharma, Laxmi Publications
2. Operation Research, AP Verma, S.K. Kataria & Sons

## ME 3026 MECHATRONICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select and apply the knowledge, techniques, skills and modern tools in mechatronics engineering technology.
CO2. apply concepts of circuit analysis, analog and digital electronics, automation and controls, motors, electric drives, power systems, instrumentation, and computers to aid in the design, characterization, analysis, and troubleshooting of mechatronics systems.
CO3. apply the different drive systems for actuation of various parts and components of a system.
CO4. understand the different controllers used in industries, machines and industrial robots.
CO5. understand the concept of CNC machining
CO6. develop the G code for part programming

**Prerequisites: Principles of Electronics Engineering (EC2025) and Fluid Mechanics & Hydraulic Machines (ME2021)**

**Introduction:**
Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics. Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

**Drives:**
Stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems.

**Hydraulic systems**:
Flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits.

**Pneumatics**:
Production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.

**Controllers:**
Description of PD, PI and PID controllers. CNC machines and part programming. Industrial Robotics.

**Text Books :**

1. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Boltan, W., Longman, Singapore, 1999.
2. Mechatronics, HMT Ltd. TMH.

**Reference Books :**

1. Robotics Technology and Flexible Automation, S. R Deb and S. Deb., TMH, New Delhi, 1994.
2. Computer Automation in Manufacturing - An Introduction, T. O. Boucher, Chapman and Hall, 1996.
3. Mechatronics: Principles, Concepts and Applications, N. P. Mahalik, TMH

## ME 3027 PLANT LAYOUT AND MATERIAL HANDLING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. plan, analyze and design to improve manufacturing and services facilities.
CO2. explore equipment requirements for a specific process.
CO3. summarize the benefit of an efficient material handling system.
CO4. understand what effect process layout has on the material handling system.
CO5. apply the techniques to evaluate and design material handling and storage systems.
CO6. explore integrate concepts and techniques learned through this course in order to design and efficient plant layout in a team environment.

**Prerequisite: Nil**

**Introduction:**
Classification of Layout, Advantages and Limitations of different layouts, Layout design procedures, Overview of the plant layout. Process layout & Product layout: Selection, specification, Implementation and follow up, comparison of product and process layout.

**Plant layout:**
Heuristics for Plant layout — ALDEP, CORELAP, CRAFT, Group Layout, Fixed position layout- Quadratic assignment model. Branch and bound method

**Material Handling:**
Introduction, Material Handling systems, Material Handling principles, Classification of Material Handling Equipment, Relationship of material handling to plant layout.

**Material handlingsystems:**
Basic Material Handling systems: Selection, Material Handling method- path, Equipment, function oriented systems.

**Improved Material Handling:**
Methods to minimize cost of material handling- Maintenance of Material Handling Equipments, Safety in handling Ergonomics of Material Handling equipment. Design, Miscellaneous equipments.

**Text Books :**
1. Operations Management. P.B. Mahapatra, PHI.
2. Aspects of Material handling. K.C. Arora, Lakshmi Publications.

**Reference Books :**
1. Production and Operations Management. R. Panneerselvam, PHI.
2. Introduction to Material handling. Siddhartha Ray, New Age.
3. Plant Layout and Material Handling. R.B Chowdary, G.R.N. Tagore, Khanna Publishers.
4. Plant Maintenance and Reliability Engineering. N.V.S Raju, Cengage Learning.
5. Facility Layout and Location: An Analytical Approach. R. L. Francis and J. A. White. Prentice-Hall Inc., 1974.

## ME 3028 SUPPLY CHAIN MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand fundamental supply chain management concepts.
CO2. evaluate and manage an effective supply chain.
CO3. understand the foundational role of logistics as it relates to transportation and warehousing.
CO4. analyze and improve supply chain processes.
CO5. apply core methodologies (probability, statistics, optimization) used in supply chain modeling and analysis
CO6. understand and use fundamental models to make trade-offs between forecasting, inventory, and transportation

### Prerequisite: Nil

**Introduction:**
Understanding the supply chain, decision phases in supply chain, process view of supply chain, supply chain flows. Drivers & Obstacles of Supply Chain Performance, Supply chain performance: Strategic fit and scope; Supply chain drivers, Obstacles to Achieving Strategic fit.

**Distribution network:**
Designing the distribution network, role of distribution, factors influencing distribution, design option for distribution. Network design in the SC, factors influencing network design, models for facility location. Transportation in the supply chain, factors affecting transportation decisions, modes of transportation and their performance.

**Pricing and revenue management:**
Pricing and revenue management in the SC, Sourcing decision in SC, supplier selection, supplier assessment. Coordination in the SC, Lack of coordination and the bullwhip effect, Supply chain information system, E-business and supply chain.

**Text Books :**
1. Supply Chain Management: Strategy, Planning, and Operation, Chopra Sunil and Meindl Peter, PHI.
2. Designing and Managing the Supply Chain, David Semchi-Levi, Philip Kaminsy, McGraw Hill Education

**Reference Books :**


1. Supply Chain Management: Text and Cases, Janat Saha, Pearson Education
2. Logistics and Supply Chain Management, Martin Christoper, Pearson Education.


## ME 3029 ROBOTICS AND FLEXIBLE MANUFACTURING SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the use of robots and design the robotic path generation

CO2. understand the kinematics and dynamics of robotic manipulator

CO3. use the different drive systems for different robot application and analyze the sensing and vision of a robot

CO4. understand the robotic programming languages and their application

CO5. understand the need of flexible manufacturing and application of robot in it

CO6. select appropriate tooling for manufacturing the part in integrated environment.

### Prerequisite: Nil

**Introduction:**
Robotics: historical background & definition, robotic system: robotic manipulator and coordinate system, description of position and orientation, transformation of coordinate frames, Euler's angle.

**Kinematics of manipulators:**
Joint variable and link connection, Direct manipulator kinematics, D-H algorithm, inverse kinematics, velocity and static forces, Jacobian, dynamics of manipulator.

**Robot drives, actuators and control:**
Drive systems in manipulator, Hydraulic systems: fluid properties and pump classification, Pneumatic systems: introduction and elements of pneumatic system, Electrical drives: d.c., a.c. and servo motors, piezoelectric actuators, drive mechanism.

**Robot end-effectors:**
Introduction, classification of end-effectors, types of grippers-mechanical grippers (two and three fingers grippers), magnetic grippers, pneumatic and hydraulic grippers, vacuum and adhesive grippers, drive systems for grippers, analysis of gripper force, active and passive grippers.

**Sensor and robot vision:**
Need of a sensor, sensory devices, types of sensors - displacement and position sensors (optical encoders, potentiometers, LVDT, piezoelectric, hall sensors) - Range and proximity sensors, force and torque sensors, Robot vision systems - vision cameras, lightening devices, vision sensors, signal conversion, image storage, segmentation, edge detection.

**Robot languages and programming:**
Robot programming language features, classification, computer control and robot software (monitor mode, run mode and editor mode), VAL system and language.

**Group technology and FMS:**
Introduction to group technology, part families, part classification and coding, benefits and application of group technology, introduction to flexible manufacturing system, FMS work station, planning and analysis, application of FMS.

**Computer Integrated Manufacturing:**
Definition of CIM and automation, computer aided process planning, computer integrated production planning, material requirement planning, material handling system, manufacturing resource planning, computer hierarchy.

**Text Books :**
1. Robotics technology and Flexible automation, S.R. Deb and S. Deb, TMH (2nd edition)
2. Automation, production systems, and computer integrated manufacturing, Mikell P. Groover, PHI (3rd edition)

**Reference Books :**
1. Introduction to Robotics Mechanics and Control, J.J. Craig, Pearson Education, 2008.
2. Robotics and Control, R.K. Mittal & I.J. Nagrath, TMH.
3. Robotics; control, sensing, vision, and intelligence, K.S. Fu, R.S. Gonzalez and C.S.G. Lee, TMH
4. Fundamentals of robotics Analysis & Control, Robert J. Schilling, PHI

## ME 3030 PRODUCT LIFECYCLE MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify and analyse the product design and development processes in manufacturing industry and to define the components and their functions of product design and development processes and their relationships from concept to customer over whole product lifecycle.
CO2. analyse, evaluate and apply the methodologies for product design, development and management and to undertake a methodical approach to the management of product development to satisfy customer needs.
CO3. generate an innovative idea for product design in a systematic approach and apply the check the quality of the new design by using product design tools.
CO4. understand the stages of product lifecycle management and the components of Product life cycle environment to integrate the various stages of PLM into engineering product ranges and portfolios that will eventuate into commercial success.
CO5. integrate lifecycle management strategies and knowledge to develop new and/or formulate appropriate engineering design solutions in engineering environment
CO6. develop the methodology to evaluate the life cycle.

**Prerequisite: Nil**

**Fundamentals of Product Development**:

Trend analysis, competitive landscape, PESTLE Analysis, Overview of Products and services, Types of Product development, Overview of Product development methodologies, Product development Planning and Management,

**Generic Product Development Process:**

Identifying customer needs –voice of customer –customer populations- hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality- product design specification-case studies,concept development stages, systemlevel design, Detail design, Testing and refinement Production ramp up

**Product design tools and technology:**

Theory of inventive problem solving, General Theory of Innovation and **TRIZ**, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas, Quality aspects in product design, Failure mode effect analysis.

**Product Life Cycle Management:**

System architecture, Information models and product structure, functioning of the system. Significance of PLM, Customer Involvement.

**Product life cycle environment:**

Product Data and Product Workflow, The Link between Product data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy.

**Components of Product Life Cycle Management:**

Different phases of product lifecycle and corresponding technologies, Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration), Core functions (e.g., data vaults, document and content management, workflow and program management), Functional applications (e.g., configuration management) Product organizational structure, Human resources in product lifecycle, Methods, techniques, Practices, Methodologies, Processes, System, components in lifecycle, slicing and dicing the systems , Interfaces, Information, Standards, Examples of PLM in use.

**Text Books :**


1. Product design and development, Ulrich Karl T and Eppinger Steven D., McGraw Hill Pub. Company, 1995.
2. Product Design, Kevin Otto, Kristin Wood, Indian Reprint 2004, Pearson Education, ISBN 9788177588217
3. Product Life Cycle Management, Antti Saaksvuori, AnselmiImmonen, Springer,1st Edition (Nov.5,2003).


**Reference Books :**


1. Product Design and Manufacture, Chitale A. K. and Gupta R. C, Prentice-Hall of India, New Delhi
2. Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving, Semyon D. Savransky, CRC Press.
3. Systematic innovation: an introduction to TRIZ; (theory of inventive Problem Solving), John Terninko, Alla Zusman, CRC Press.
4. Emotional Design, Donald A. Norman, Perseus Books Group New York, 2004
5. Product Lifecycle Management - Driving the Next Generation of Lean Thinking, Grieves Michael, McGraw-Hill, 2006.


## ME 3031 FINITE ELEMENT METHOD FOR ENGINEERS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. obtain an understanding of the fundamental theory of the FEA method.
CO2. generate the governing FE equations for systems governed by partial differential equations.
CO3. formulate with Rayleigh-Ritz and Galerkin Method.
CO4. understand the use of the basic finite elements for structural applications using truss, beam
CO5. understand the application and use of the FE method for heat transfer problems
CO6. understand the application and use of the FE method for other engineering problems.

**Prerequisite: Mathematics - I (MA 1003)**

**Introduction to FEM:**

Introduction, Basic concepts of FEM, Comparison of Finite Element and Exact solutions, Applications of FEM.

**Direct Formulation:**

Axial rod problem, Beam problem, Heat conduction problem, Electrical circuit problem.

**Basic Procedure:**

General procedure of FEM, Elements and shape functions, Co-ordinate transformations: Global coordinates and natural coordinates,

**Types of Elements:**

One dimensional linear element, One dimensional quadratic element, Two dimensional linear triangular element (CST: Constant Strain Triangle), Isoparametric elements, Three dimensional elements.

**Finite Element Formulation:**

Derivation of Finite Element equations using Rayleigh-Ritz and Galerkin Method. Rayleigh-Ritz method for one dimensional structural (bar) problem, Stiffness matrix and load vector for one dimensional structural problems, Galerkin method for one dimensional heat conduction problem. Conductivity matrix and heat rate vector for one dimensional heat conduction problems.

**Assembly of Element Matrices and Treatment of Boundary Conditions:**

Assemblage of element equations, Treatment of boundary conditions.

**Application to Engineering Problems:**

Application to structural bar problems, truss problems, heat conduction problems with various boundary conditions, electrical and magnetic field problems.

**Text Book :**

1. Introduction to Finite Elements in Engineering, T. R. Chandrupatla, A. D. Belegundu, Pearson, 4$^{th}$ Edition, 2015.

**Reference Books :**

1. Fundamentals of the Finite Element Method for Heat and Fluid Flow, Roland W. Lewis, Perumal Nithiarasu and K.N. Seetharamu, Wiley; 1$^{st}$ edition, 2004.
2. Fundamentals of Finite Element Analysis, D.V. Hutton, McGraw Hill.

## ME 3032 INTRODUCTION TO FLUID MECHANICS AND HEAT TRANSFER Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the concept of heat and fluid flow phenomena.
CO2. express the mathematical formulation of a physical problem.
CO3. think for a solution to cooling or heating in industrial equipment.
CO4. analyze and develop the different techniques for thermal energy storage.
CO5. understand the different solution methods of radiative heat transfer problems
CO6. aware of basic principle of mass transfer process and its applications

**Prerequisite: Mathematics-I (MA 1003)**

**Introduction:**
Properties of fluids, Types of fluids, Types of fluid flow, modes of heat transfer, Laws of heat transfer.

**Kinematics of fluid flow:**

Streamlines, path line & streak lines, stream tube, Types of fluid flow, Continuity equation of motion in three-dimensions, Local and convective acceleration, Velocity potential function and stream function, Vorticity and circulation, Vortex flow, Equation of forced vortex flow and free vortex.

**Dynamics of fluid flow:**

Euler's equation of motion, Bernoulli's equation from Euler's equation, Practical applications of Bernoulli's equation—Venturimeter, Orficemeter, Pitot tube.

**Conduction Heat Transfer:**

Derivation of the general 3-dimensional heat conduction equation with variable thermal conductivity and internal heat generation in Cartesian coordinates. Transformation of the conduction equation into polar cylindrical and polar spherical coordinates, different types of boundary conditions encountered in heat conduction. Solution of the one dimensional steady state heat conduction equation with constant thermal conductivity and without heat generation in Cartesian, Cylindrical and Spherical coordinates. Extension of the solution to composite walls/cylinders/spheres by electrical analogy. Effect of variable thermal conductivity., Introduction to numerical solution of the heat conduction equation.

**Convection Heat Transfer:**

Conservation equations for mass, momentum and energy for two dimensional steady state flow in Cartesian, cylindrical and spherical coordinates. Non dimensionalization of the conservation equations.

**Boundary Layer:**

Hydrodynamic and thermal boundary layer concepts, Boundary layer growth over a flat plate, Boundary layer thickness, displacement thickness, Momentum thickness, and energy thickness, Laminar and Turbulent boundary layer, Boundary layer equations, momentum integral and energy integral equations for boundary layer flow over a flat plate. Solution of the integral equations to derive expressions for drag and heat transfer coefficients. Average values of drag and heat transfer coefficients. Experimental correlations for forced and free convection for various geometries.

**Radiation Heat Transfer:**

Radiation properties, emissive power and emissivity, Kirchoff's identity. Planck's relation for monochromatic emissive power of a black body, Stefan-Boltzman law and Wein's displacement law , Radiation shape factor, Relation for shape factor and shape factor algebra.

**Text Books :**
1. Fluid Mechnics, Modi & Seth
2. Heat & Mass Transfer, R. K. Rajput, S. Chand & Company

**Reference Books :**
1. Heat Transfer, J. P. Holman, Tata McGraw-Hill
2. Engineering Heat & Mass Transfer, Mahesh M. Rathore, University Science Press
3. Heat and Mass Transfer: Fundamentals and Applications, Yunus A. Cengel , Afshin J. Ghajar
4. Fluid Mechanics Fundamentals and Applications, John M. Cimbala , Yunus A. Cengel
5. Introduction to Fluid Mechanics and Fluid Machines, S K Som , Gautam Biswas , S Chakraborty

**ME 3033** **RENEWABLE ENERGY SOURCES** **Cr-3**

**Course Outcome :** At the end of the course, the students will be able to:

CO1. understand the potential, availability and the properties of the alternative and renewable energy sources and their needs in present energy scenario
CO2. explain the basic principles of wind energy technology and their merits and demerits.
CO3. evaluate the basic principles of solar energy technology (both thermal and PV) and its merits and demerits.
CO4. analyze the basic principles of biomass and biofuel technology and its merits and demerits.
CO5. elaborate the basic principles of geothermal energy technology and their merits and demerits.
CO6. discuss the basic principles of tidal energy technology, ocean and wave energy technology and their merits and demerits.

**Prerequisite: Nil**

**Introduction of Renewable Energy:** Need for renewable energy sources. Availability, properties and different engineering applications of renewable fuels like solar, wind, tidal, biomass, ocean, geothermal, etc. The merits and demerits of various renewable energy sources.

**Solar Power Generation:** Solar Radiation Measurement, Estimation of Solar Radiation, Solar Thermal Process, Heat Transfer Devices**,** Solar Energy Storage: Stratified Storage, Well Mixed Storage, Comparison, Hot water System, Practical Consideration, Solar Ponds, Non-convective Solar Ponds, Extraction of Thermal Energy and application of Solar Ponds.

**Bio Power Generation:** Bio-energy past and present, Biomass as a solar energy store, biomass as a fuel, primary biomass energy sources, plant materials, secondary biomass sources: wastes, residues and co-products, physical processing of biomass, thermo chemical processing, biochemical processing, vegetable oils and biodiesel, environmental benefits and impacts, economics, future prospects for bio-energy.

**Wind Power Generation:** Energy and power in the wind, characteristics of wind, Wind turbines (types, horizontal and vertical axis wind turbines), linear momentum and basic theory. Aerodynamics of wind turbines, power generation by a turbine, electricity generation, environmental impact, economics of energy generation, commercial development and wind energy potential, offshore wind energy.

**Tidal and Wave Power Generation:** Nature of tidal sources, physics of tidal energy, power generation from barrages, Economics of tidal barrages, tidal lagoons, tidal streams/currents. Physical principles of wave energy, wave energy sources, wave energy technology, Integration (wave energy for isolated communities and large electricity grids).

**Geothermal Power Generation:** Origin and types of geothermal energy and utilization., the mining of geothermal heat, source of heat, physics of geothermal resources, technologies for exploiting high enthalpy stream fields, technologies for direct use of geothermal energy, harnessing geothermal resources, environmental implications, economics and world potential.

**Text Books :**

1. Renewable Energy-Power for a Sustainable future, Godfrey Boyle, Oxford University Press, 3rd Edition, 2012.
2. S. P. Sukhatme, Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 1990.

**Reference Books :**


1. V.S. Mangal, Solar Engineering', Tata McGraw Hill, 1992.
2. N. K. Bansal, Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 1989.
3. G. L. Johnson, 'Wind Energy Systems', Prentice Hall Inc, New Jersey.
4. N K Bansal, Non-Conventional Energy Resources, Vikas Publishing House Pvt. Ltd., 2014.
5. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, Fourth Edition.


## ME 3034 APPLIED THERMODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. apply the knowledge of science and engineering fundamentals to model the energy conversion phenomenon.
CO2. identify and formulate power production based on the fundamental laws of thermal engineering.
CO3. investigate appropriate performance measurement related to heat engines.
CO4. investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankind.
CO5. appreciate concepts learnt in laws of thermodynamics and learn how to sustain in energy crisis
CO6. communicate effectively the concepts of combustion in engines and model the propulsion system of aircrafts

### Prerequisites: Mathematics-I (MA 1003) and Engineering Thermodynamics (ME 2031)

**Basic Concepts:**
Thermodynamic systems, properties with measurements – Zeroth law of thermodynamics, states, and processes-definition and classification, Thermodynamic work and heat – Classification and sign convention. Point and path functions.

**First Law of Thermodynamics:**
Statement for control mass undergoing cycle, corollaries – For a process, Perpetual motion machine of First kind (PMMFK/PMM-I)). Internal energy and Enthalpy – specific heats, application of First law to standard reversible processes – Isochoric, Isobaric, Isothermal, reversible adiabatic and Polytropic. Control volume analysis, First Law applied to steady flow processes; Throttling process, comparison between steady flow and displacement works.

**Second Law of Thermodynamics:**
Limitations of First law of thermodynamics; Cyclic devices, Directional constraints. Thermal Energy reservoirs. Heat engines, refrigerators/heat pump, Mathematical interpretations with efficiency, COP, Ton of Refrigeration, Equivalence of statements with illustrations, Carnot Theorems, Absolute temperature scale. Entropy: Clausius Inequality, Temperature entropy plane – all standard reversible processes; Entropy change - irreversible process, flow processes, concept of lost work, entropy generation – applications.

**Modelling of Basic Energy Conversion Cycles:**
Air standard assumptions, Overview of reciprocating engines, Air standard cycles for reciprocating engines – Otto, Diesel & dual, Criteria for comparison & comparative analysis, Derivation for efficiency, Mean effective pressure (MEP) & Carnot efficiency, calculation of Heat transfer at mean temperature. Brayton Cycle; Enhancement with regeneration, with reheating, with intercooling and combination, First Law and second law applied to these cycles.

**Fuels and Combustion:**
Theoretical & actual processes, enthalpy of formation, first law of reacting system – steady flow and closed systems, adiabatic flame temperature, Heat of reaction, Second law analysis, entropy change of reacting systems.

**Jet Propulsion:**
Theory, Classification of jet engines, Thermodynamic cycle - Ram-jet, turbo-jet, turbo prop, I and II law analysis on each cycle, thermal efficiency, Carnot efficiency and propulsive efficiency, Derivation & calculations.

**Rocket Propulsion:**
Brief evolution & theory of operation, Thermodynamics involved in propulsion, Basic rocket propulsion air cycle analysis.

**Text Book :**

1. Engineering Thermodynamics, P. Chattopadhyay, Oxford University Press, First edition, 2011.

**Reference Books :**

1. Thermodynamics – An Engineering Approach, Y. A. Cengel, M. A. Boles, Tata McGraw Hill Education Pvt. Ltd. New Delhi. 4th Ed, 2012.
2. Engineering Thermodynamics, P. K Nag, Tata McGraw Hill Education Pvt. Ltd., New Delhi. 4th Ed., 2008.
3. Fundamentals of Classical Thermodynamics, G. V. Wylen, R. Sonntag, C. Borgnakke, John Wiley & Sons, 4th Ed., 1996.
4. Engineering Thermodynamics-Work and Heat Transfer, G. Rogers, Y. Mayhew, Pearson Education Ltd., 7th Ed., 2012.
5. Engineering Thermodynamics, J. B. Jones, R. E. Dungan, Prentice Hall of India Pvt. Ltd., New Delhi, Eastern Economy Ed., 1996.
6. Fundamentals of Engineering Thermodynamics, E. Radhakrishna, Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Ed., 2011.

## ME 3035 BIOMECHANICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. apply principle of mechanics to model human body.
CO2. analyze motion of leg parts and hand parts to develop artificial limbs.
CO3. find out the stress produces in different body parts during physical activities in daily life.
CO4. design and develop set up for physiotherapy applications.
CO5. Know the concept of Biomechanics of Tendons and Ligaments
CO6. Determine the Uniaxial Motion with Constant Acceleration.

**Prerequisite: Nil**

**Introduction:**
Mechanics, Biomechanics, Basic Concepts, Newton's Laws, Dimensional Analysis, Systems of Units, Conversion of Units, Mathematics, Scalars and Vectors, Modelling and Approximation, Generalized Procedure, Scope of the Text, Notation.

**Statics Analyses of System in Equilibrium:**

Overview, Newton's Laws of Mechanics, Conditions for Equilibrium, Free-Body Diagrams, Procedure to analyse Systems in Equilibrium, Notes Concerning the Equilibrium Equations, Constraints and Reactions, Simply Supported Structures, Cable-Pulley systems and Traction Devices, Built-in-Structures, Systems involving Friction, Center of Gravity Determination.

**Applications of Statics to Biomechanics:**

Skeletal Joints, Skeletal Muscles, Basic Considerations, Basic Assumptions and Limitations, Mechanics of the Elbow, Mechanics of the shoulder, Mechanics of the spinal column, Mechanics of the Hip, Mechanics of the knee, Mechanics of the ankle.

**Stress and Strain:**

Basic Loading Configurations, Uniaxial Tension Test, Load-Elongation Diagrams, Simple Stress, Simple Strain, Stress-Strain Diagrams, Elastic Deformations, Hooke's Law, Plastic Deformation, Necking, Work and Strain Energy, Strain Hardening, Hysteresis Loop, Properties Based on Stress-Strain Diagrams, Idealized Models of Material Behavior, Mechanical Properties of Materials.

**Mechanical Properties of Biological Tissues:**

Viscoelasticity, Analogies Based on Springs and Dashpots, Empirical Models of Viscoelasticity, Time-Dependant Material Response, Comparison of Elasticity and Viscoelasticity, Common Characteristics of Biological Tissues, Biomechanics of Bone, Biomechanics of Tendons and Ligaments, Biomechanics of Skeletal Muscles, Biomechanics of Articular Cartilage.

**Introduction to Dynamics & Linear Kinematics:**

Dynamics, Kinematics and kinetics, Linear, angular, and General Motions, Distance and Displacement, Speed and Velocity, Acceleration, Inertia and Momentum, Degree of Freedom, Particle Concept, Reference Frames and Coordinates Systems, Prerequisites for Dynamic Analyses. Uniaxial Motion, Position, Displacements, Velocity and Acceleration, Dimensions and Units, Measured and Derived Quantities, Uniaxial Motion with Constant Acceleration.

**Text Book :**

1. Fundamentals of Biomechanics – Nihat Ozkaya and Margareta Nordin (Springer), 2$^{nd}$ Ed.

**Reference Books :**

1. Fundamentals of Biomechanics-Duane Knudson. (Springer)
2. Text book of Biomechanics and exercise therapy- Dr. C. Nagavani

## ME 3036 STRENGTH OF MATERIALS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analytically evaluate various types of stresses in different structural element
CO2. estimate two dimensional stresses and strains analytically
CO3. draw shear force and Bending Moment diagram in simply supported and cantilever beams subject to various loads.
CO4. evaluate the bending stress in simple, composite, and curved beam.
CO5. calculate the stresses in thin shells and circular shafts subjected to combined bending and twisting
CO6. find out the slope and deflection of simply supported beams and cantilevers.

**Prerequisite: Engineering Mechanics (ME1003)**

**Simple Stress and Strain**: Concept of stress: Definition, Reason of stress phenomenon, normal stress and shear stress, Concept of strain: Types, Stress strain diagram and its features. Stress strain diagram for ductile and brittle materials, Stress and strain in composite rods, Stress due to self-weight of members, Stress in nuts and bolts, Thermal stress.
**Compound Stress and Strain**: Two-dimensional stresses, principal stress, principal planes, Mohr's circle for the stresses, strain analysis, principal strains.

**Shear Force and Bending Moment:** Types of support and beams, Shear force (SF), Bending Moment (BM), Relation between load, SF and BM. Shear force diagram and Bending Moment diagram of beams subject to concentrated and distributed load. Beams with overhangs, Beams subjected to couples.

**Bending and Shear Stress**: Theory of simple bending of initially straight beams. Distribution of normal and shear stresses in different sections. Composite beams.

**Strain Energy**: Strain Energy, Resilience and Strain Energy due to Axial load, Bending Moment and Twisting Moment.

**Slope and Deflection:** Slope and deflection of beams by double integration method, Macaulay's method and moment area method, Principle of Virtual Work, Unit load and Unit couple method for determining slope and deflection of beams, Castigliano's theorem, Maxwell's theorem of Reciprocal Relations.

**Theories of Failure**: Maximum principal stress theory, Maximum Shearing stress Theory, Maximum Strain Theory, Total strain energy Theory, Maximum Distortion Energy Theory, Octahedral Shearing Stress Theory, Graphical representation of theories of failure.

**Torsion:** Torsion in solid and hollow circular shafts, Torque and Horse Power transmitted by solid and hollow shafts, combined bending and Torsion, close coiled helical springs, strain energy in Torsion, Combined bending and torsion.

**Stresses in Cylindrical and Spherical Shells**: Stresses in thin cylinders and thin spherical shell under internal pressure, Thick cylinders subjected to internal and external pressures, compound cylinders, Membrane stress in shells, Application to cylindrical, spherical and conical shells.

**Text Book :**

1. Strength of Materials, S.S. Rattan,McGraw Hill Education; Third edition, 2017.

**Reference Books :**

1. Strength of Materials, Lehri & Lehri, S.K. Kataria & Sons; 2012.
2. Mechanics of Materials, R.C. Hibler, Pearson; 9th edition 2013.
3. Strength of Materials: G.H. Ryder, Macmillan Education.
4. Strength of Materials: Sadhu Singh, SCHAND.
5. Strength of materials, Beer and Johnson, Tata McGraw-Hill.

## ME 3037 QUALITY ENGINEERING AND MANAGEMENT Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. Compare and appreciate the contributions of Quality Gurus
CO2. Understand quality engineering methods and tools

CO3. Apply SQC methods to improve quality of products and services
CO4. Gain the knowledge regarding sampling plans
CO5. Understand the concept of acceptance sampling and OC Curve
CO6. Have a working knowledge of the techniques of reliability engineering.

### Prerequisite: Nil

**Introduction to Quality:**

Defining Quality, Quality as a Management Framework, some important philosophies and their impact on quality (Deming, Juran, Crossby), Quality cost, Quality losses, link between Quality and productivity

**Tools for Quality Control:**
Basic tools of quality (the stem and leaf plot, histogram, box plot etc.), ISO 9000:2000, Six Sigma, Total quality management, introduction to total quality management, the evolution of total quality, Statistical methods for Quality control and improvement.

**Statistical Process control**:
Process capability analysis using histogram, Use and interpretation of Cp, Statistical Process Control, Specification & Limits, Charts for variables & attributes, Process Control (X, R, P, C chart), Summary of Control Chart Construction, Designing Control Charts.

**Sampling Plan:**
Design of single sampling plan. Double, multiple and sequential sampling plans, O.C. curve, Acceptance quality Level, Lot tolerance percentage defective.

**Reliability:**
Reliability analysis and predictions, Bath-Tub Curve, Exponential and Weibull distribution in modelling reliability, System reliability. ANOVA,

**Text Book :**
1. Fundamental of Quality Control and Improvement, Mitra A, PHI
2. Quality Planning and Analysis, Juran J M and Gryna F M, Tata McGraw Hill

**Reference Books :**
1. Total Quality Management, J.R. Evans – Cengage
2. Quality Management, Bedi, Oxford
3. Quality Management, Gitlow Oppenheim Levine, TMH

## ME 3038 KINEMATICS AND DYNAMICS OF MACHINERY Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. understand the principles of kinematic pairs, chains and their classification
CO2. know about the gear system in various mechanical installations
CO3. evaluate the degree of freedom, inversions, equivalent chains and planar mechanisms.
CO4. model planar four bar and slider crank mechanisms for specified kinematic conditions.
CO5. analyse the motion and the dynamical forces acting on mechanical systems composed of linkages, gears and cams.
CO6. model field of balancing and dynamics of flywheel and governors.

**Prerequisites: Mathematics –I (MA1003) and Engineering Mechanics (ME1003)**

**Introduction to Mechanisms:**

Definition, Kinematic pairs, Classification of kinematic chains, degrees of freedom, Grashof's law, Grubler's criterion for plane mechanism. Kinematic inversions, equivalent linkages.

**Kinematic Analysis of Planar Mechanisms**:

Mobility analysis and range of movement, Grashof criterion and inversions, displacement analysis, relative instantaneous centers, Aronhold-Kennedy theorem, velocity and acceleration analysis

**Kinematic Inversions**

Inversion of four bar chain, inversion of slider crank chain, inversion of double slider chain, quick return mechanism

**Design of Flywheel and Governors:**

Inertia forces and their balancing for rotating and reciprocating machines.

**Dynamics of Machines:**

Free and forced vibration analysis of single and two degrees of freedom systems. Balancing of inertia forces: Balancing of rotors, balancing of in-line internal combustion engines. Cams: Synthesis of translating flat-face, translating roller and oscillating roller follower cams. Gears: Fundamental law of gearing, characteristics of involutive action, analysis of gear trains.

**Text Books :**

1. Theory of Machines, Rattan S S, Tata McGraw-Hill
2. Mechanism and Machine Theory, Ambekar, A G, Prentice Hall, 2007.

**Reference Books :**

1. Kinematics and Dynamics of Machinery, Norton R L, McGraw Hill Education, 2017
2. Theory of machines and Mechanisms Si Edition, Gordon R. Pennock & Joseph E. Shigley John J. Uicker, Oxford University Press; 4th edition, 2014
3. Theory of Mechanisms and Machines, Amitabha Ghosh & Mallik A. K., East West Press

## ME 3039 MECHATRONIC SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select and apply the knowledge, techniques, skills and modern tools in mechatronics engineering technology.

CO2. apply concepts of circuit analysis, analog and digital electronics, automation and controls, motors, electric drives, power systems, instrumentation, and computers to aid in the design, characterization, analysis, and troubleshooting of mechatronics systems used in industries as well as home appliances.

CO3. apply the different drive systems for actuation of various parts and components of a system.

CO4. understand the different controllers used in industries, machines and industrial robots.

CO5. understand the concept of CNC machining

CO6. develop the G code for part programming

**Prerequisite: Nil**

**Introduction:**
Definition of mechatronics, need of mechatronics system, Examples of mechatronics systems in manufacturing, products, design. Review of fundamentals of electronics. Data conversion devices, sensors and transducers, (pressure, velocity, level, light, accelerometers, gyros, compass, encoders, strain gauges, LVDT, potentio meter), smart sensors, micro sensors, transducers, signal processing devices, relays, contactors and timers. Signal conditioning basics, filtering, protection, pulse width modulation, opamps and their applications, Microprocessors (8085 and Arduino) micro controllers for sensing, actuation and control, and PLCs. Digital data, analog data, AD-DA conversion, demonstration on data acquisition systems using NI LabVIEW)

**Logic circuits**:
Digital logic, logic gates, application of logic gates, sequential logic Basic modelling of systems, first order systems, second order systems, performance measure of second order systems

**Drives**:
Switching, solenoids, stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams. (Programming a servomotor using NI Labview)

**Pneumatics and Hydraulic actuation systems**:
Flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps, production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.

**Controllers:**
Close loop and open loop systems, description of PD, PI and PID controllers. CNC machines and part programming. Introduction to Robotics, forward and invers kinematics (Demonstration on programing robot and CNC part programming).

**Text Books :**


1. Mechatronics: electronic control systems in mechanical and electrical engineering, Boltan, W., Longman, Singapore, 1999.
2. Mechatronics, HMT ltd. Tata Mcgraw-Hill, New Delhi, 1988.
3. A Text book of Mechatronics, Rajput, S Chand, New Delhi, 2008


**Reference Books :**


1. Robotics technology and flexible automation, S. R Deb and S. Deb., , Tata McGraw-Hill, New Delhi, 1994.
2. Computer automation in manufacturing - an Introduction, T. O. Boucher, Chapman and Hall, 1996.
3. Micromechatronics, modelling, analysis, and design with MATLAB, V. Giurgiutiu, S. E. lyshevski, CRC Press,2015
4. Mechatronics: Principles, concepts and applications, N. P. Mahalik, TMH


## ME 3040 ENGINEERING MATERIALS Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. correlate structure-properties relationship of materials
CO2. identify structural materials for different engineering applications
CO3. can differentiate alloy and composites
CO4. understand need of different manufacturing process for different material

CO5. can interpret the properties of the material through different characterization
CO6. know about various non-destructive testing of material

## Prerequisite: Chemistry (CH1007)

**Introduction to Materials Science**

Materials classifications, structure-properties co-relationship, and behavior of materials, stress-strain diagrams, yielding, strain hardening, precipitation hardening, toughness, resilience and etc.

**Phase Diagrams**
Basics of phase diagram, Gibb's phase rule, lever rule, isomorphous, eutectic and peritectic alloy system. Heat treatment: principles of heat treatment, annealing, normalizing, hardening, tempering.

**Materials Processing**
Basic Methods: casting, forging, extrusion, rolling, sheet metal forming, welding, brazing and soldering
Advanced Methods: powder metallurgy, thin film fabrication, fabrication of composites, rapid Prototyping.

**Material Characterization**
Destructive Testing: Hardness, Tensile testing, compression testing, fatigue testing, torsion testing, impact testing, creep, fatigue testing, microstructure analysis

**Non-Destructive Testing**
Ultrasonic testing, dye penetration testing, magnetic particle inspection, acoustic testing, x-ray testing, radiographic

**Text Books :**
1. Fundamentals of Materials Science and Engineering, W. D. Callister, Wiley, 4th edition.
2. Manufacturing Processes by J. P. Kaushish, PHI Learning, 2nd edition.

**Reference Books :**
1. Engineering Materials, S. C. Rangwala, Charotar Publishing House, 2011.
2. Material Science, V. Rajendran and A Marikani, Tata McGraw-Hill, New Delhi,2009.
3. Material Science, M.S. Vijay and G. Rangarajan, Tata McGraw-Hill, New Delhi, 2011.
4. Material Science for Engineers, J.F. Shackelford and M.K. Muralidhara, 6th edition, PEARSON
5. Engineering Materials Technology, W. Bolton, 3rd Edition, Butterworth & Heinemann, 2001

## ME 3041 MECHANICAL SYSTEM DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. aanalytically evaluate various types of stresses in different structural elements
CO2. use of technical skill and imagination to construct a proper design configuration.
CO3. develop a link between fundamental concepts with realistic component design.
CO4. acquaint themselves with the design of various temporary and permanent fasteners.
CO5. uunderstand the importance of vibration study in engineering.
CO6. write governing differential equation of a vibration system and its solution.
CO7. realize the importance of proper choice of tribological elements and design tribological system for optimal performance.

**Prerequisite: Nil**

**Simple stress and strain**:
Concept of stress: definition, reason of stress phenomenon, normal stress and shear stress; concept of strain: types, stress strain diagram and its features. stress strain diagram for ductile and brittle materials, stress and strain in composite rods, stress and strain in bolt and nut assembly,

**Compound stress and strain**:

Two-dimensional stresses, principal stress, principal planes, Mohr's circle for the stresses, strain analysis, principal strains.

**Shear force and bending moment:**

Types of support and beams, shear force (SF), bending moment (BM), relation between load, SF and BM. shear force diagram and bending moment diagram of beams subject to concentrated and uniformly distributed load.

**Design of fastening elements:**

Design of riveted and welded joints, Design of bolted joints, Design of cotter joints, Design of knuckle joints.

**Degree of Freedom Systems:**

Generalized Derivation of Equation of motion, Static and dynamic coupling, Langrange's equations. Undamped dynamic vibration observers.

**Torsional Vibration and Vibration of continuous systemn**

Multi-rotor systems, geared system and branched system, Vibration of strings, free longitudinal vibration of prismatic bars, Lateral vibrations of uniform beams.

**Hydrostatic and Hydrodynamic theory of lubrication:**
Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, Various theories of lubrication, petroffs equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl anti -friction bearing.

**Text Books :**


1. Strength of Materials, S.S. Rattan, TMH
2. Design of Machine Elements: VB Bhandari (TMH)
3. Mechanical Vibrations and Noise Engineering, Ashok G. Ambekar, PHI.
4. Fundamentals of Tribology, Basu, Sen Gupta and Ahuja, PHI


**Reference Books :**


1. Machine Design by Dr. P.C. Sharma and Dr. D.K. Aggrawal.
2. Strength of Materials, Lehri & Lehri, Kataria,
3. Theory of Vibration and Application, William T. Thomson, CBS
4. Tribology in Industry:Sushil Kumar Srivatsava, S. Chand &Co.
5. Hand Book- Design Data Handbook by S. Md. Jalaludeen.
6. Machine Design Data book by V.B.Bhandari


## ME 3042 COMPUTER CONTROLLED MANUFACTURING SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the latest developments and the main elements in computer integrated manufacturing systems.

CO2. create awareness about the implementation techniques for GT and CAPP.

CO3. classify and distinguish NC, CNC and DNC systems.

CO4. develop manual and APT part programs for 2D complex profiles, automated tool paths and G-codes for machining components and test the programs through simulation.

CO5. apply modern computational, analytical, simulation tools and techniques to face the challenges in manufacturing.

## Prerequisite: NIL

**Fundamental of Manufacturing and automation**:

Types of production, Objectives of a manufacturing system, production concepts and mathematical models, automation strategies.

**Process planning:**
Group Technology and Computer Aided Process Planning, Introduction-part families-parts classification and cooling - group technology machine cells benefits of group - technology. Process planning function CAPP - Computer generated time standards.

**Numerical Control Production System:**

Numerical control, coordinate system and machine motion, Types of NC system, machine tool applications, problems of conventional NC, CNC, DNC.

**Part Programming:**

Basics of NC programming, mathematics of tool paths, machining forces, Tool offsets, programming steps, NC programming Languages, G-Code and M-Code, APT Programming, CAD/CAM NC programming. Rapid prototyping

**Computer Networks for manufacturing:**

Hierarchy of computers in manufacturing, local area networking, manufacturing automation protocol.

**The Future Automated Factory**:

Trends in manufacturing, The future automated factory.

**Text Books :**

1. Automation, Production Systems, and Computer-Integrated Manufacturing, Mikell P. Groover, Pearson Education, ISBN 81-7808-511-9. 3rd Edition, 2007
2. CAD/CAM, Ibrahim Zeid, TMH

**Reference Books :**

1. Computer Integrated Manufacturing, Paul Ranky Prentice Hall of India
2. Computer Integrated Manufacturing System, Yorem Koren, McGraw-Hill, 1983

## ME 3043 POWER PLANT ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the location and layout of power plants

CO2. understand basic principles of physics and mathematical expression used in power generation by steam turbine

CO3. understand the principles for improving the efficiency and speed of steam turbines with minimum consumption of water, coal and other resources

CO4. know to manage coal based power plants in the country

CO5. discuss energy scenario of the country and globe

CO6. apply the overall understanding to meet the demand for power in an effective way

**Prerequisites: Engineering Thermodynamics (ME2031) and Fluid Mechanics & Hydraulic Machines (ME 2021)**

**Sources of energy and Utilization:**
Classification of used energy, Sources: Fuel, water, wind and nuclear reactors, principal types of power plants and choice of power plants, power plant layouts, Global and Indian energy scenario, Different terminologies.

**Analysis of steam cycles:**
Introduction, Classification of power plant cycles, Carnot cycle, Rankine cycle, Modified Rankine cycle, Reheat cycle, Regenerative cycle, Binary vapour cycle, Its engineering applications.

**Generation of steam:**
Fire and Water Tube Boiler, Low Pressure and High Pressure Boiler, Once through Boiler, Examples, Important features, mountings and accessories, Equivalent evaporation, Boiler performance and efficiency, combustion equipment, Air supply systems for combustion, fuel and ash handling systems, dust collectors,

**Flow of steam through nozzles:**
Continuity, energy and momentum equations, nozzle shape for different applications, Outer velocity, throat and exit areas for flow without and with friction, choked flow and critical pressure ratio, effect of variations in nozzle back pressures, super saturated flow in nozzles.

**Steam Turbine:**
Types of steam turbines, axial variation of pressure and velocity through various types of turbines. Power, efficiency and other related calculations for simple impulse, pressure compounded impulse and velocity compounded impulse turbines using velocity triangles. Reaction turbines and degree of reaction. Parsons' turbines, Power, efficiency and other related calculations for reaction turbine. Internal losses in steam turbines and reheat factor. Governing of steam turbines.

**Steam condensers and cooling tower:**
Surface condensers, condenser vacuum and vacuum efficiency, maintaining vacuum by air pumps, sources of air leakage into the condenser, Dalton's law of partial pressures applied to steam and air mixtures, Air pump capacity for wet and dry air pumps, Cooling water requirements, Cooling towers.

**Introduction to Nuclear power plants:**
Nuclear fuels, Chain reaction, Neutron balance, coolants, Reflectors, Moderators, control rods, types of reactors, Boiling water reactors, pressurized water reactors.

**Text Book :**

1. Power Plant Engineering, P. K. Nag Tata McGraw-Hill Education, 2002

**Reference Books :**

1. Power Plant Engineering, R. K. Rajput Laxmi Publications (P) Ltd., Fourth Edition.
2. Power Plant Engineering, M. K. Gupta, PHI Learning, 2012.
3. Power Plant Engineering, P.C. Sharma, S. K. Kataria & Sons, 2009.

## ME 3044 ROBOTICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1 know the relationship between mechanical structures of industrial robots and their operational workspace characteristics.

CO2 apply spatial transformation to adopt forward kinematic equations of robot manipulators and solve inverse kinematics of simple robot manipulators.

CO3 control Robot by different types of programming method.
CO4 select the best robotic applications and be able to justify the overall advantages to Industry.
CO5 explore the field of machine vision as a fundamental sensor technology in robotics.
CO6 obtain the Jacobian matrix and use it to identify singularities and also to generate joint trajectory for motion planning.

### Prerequisite: NIL

**Introduction**:

Definition of a Robot, Basic Concepts, Robot configurations, Types of Robot drives, Basic robot motions, Point to point control and Continuous path control.

**Components and Operation**:

Basic control system concepts, Control system analysis, Robot actuation and feedback, Manipulators, direct and inverse kinematics, Coordinate transformation, Brief Robot dynamics, Types of Robot and Effectors, Robot/ End and Effectors interface.

**Sensing and Machine Vision**:

Range sensing, Proximity sensing, Touch sensing, Force and Torque sensing. Introduction to Machine vision, Sensing and Digitizing. Image processing and analysis.

**Robot Programming Methods**:

Languages, Capabilities and limitation, Artificial intelligence, Knowledge representation, Search techniques in A I and Robotics.

**Industrial Applications**:

Application of robots in machining, Welding, Assembly, Material handling, Loading and Unloading, CIM, Hostile and Remote environments.

**Text Book :**

1. Robotic Engineering: An Integrated Approach- Richard D. Klafter, Thomas A. Chmielewski and Michael Negin , Prentice Hall of India

**Reference Books :**

1. Industrial Robotics Technology – Programming and Applications- Mikell P. Groover, Mitchell Weiss, McGraw Hill International Edition.
2. Foundation of Robotics: Analysis and Control -Yoshikawa, Prentice Hall of India.
3. Robotics; control, sensing, vision and intelligence, K. S. Fu, R. s. Gonzalez and C. S. G. Lee, TMH

## ME 3045 METAL FORMING PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. explain the plastic deformation of metals on industrial scale and analyze the behaviour of materials during forming processes.
CO2. explain different types of metal forming process utilized in manufacturing industries.

CO3. understand the concept of technological procedures in industrial manufacturing processes related to pressure shaping of metals and estimate the forming loads and power requirement for different forming processes.

CO4. explain the essence of each technological operation employed in industrial pressure shaping of metals.

CO5. understand the industrial limitations and safety measures for the kind of manufacturing.

CO6. integrate knowledge gained in this course to select and design a complete metal forming system.

**Prerequisite: Basic Manufacturing Processes (ME2010)**

**Introduction:**
Fundamentals of plasticity, stress and strain, stress-strain relationship, yield criteria and flow rules, instability.

**Fundamentals of Metal Forming:**
Metallurgical aspects of metal forming, slip, twinning, classification of forming processes, mechanisms of metal forming- lab method, limit analysis, upper bound and lower bound theorem, slip line solution, temperature of metal working, hot working, cold working; workability, Recovery, recrystallization and grain growth, friction and lubricants in metal forming, industrial limitations and safety measures.

**Rolling:**
Rolling processes, forces and geometrical relationship in rolling, simplified analysis of cold and hot rolling, rolling load, rolling process variables, defects in rolling, torque and power calculations, friction hill.

**Forging:**
Classification of forging process, forging of plates and circular discs, forging load calculation, open-die and closed-die forging, stress and strain distribution in forging process, friction and lubrication in forging process, residual stress in forging.

**Extrusion and drawing:**
Classification of extrusion process, Analysis of Extrusion process, Extrusion load estimation, extrusion process parameters, extrusion of tubes and production of seamless pipes, lubrication in hot and cold extrusion process. Wire tube and strip drawing process.

**Sheet Metal forming:**
Forming methods, bending, stretch forming, spinning, hydraulic forming, forming limit criteria, defect in formed parts.

**Text Books :**


1. Fundamentals of Metal Forming Processes, B. L. Juneja, New Age International Publishers, 2010.
2. Mechanical Metallurgy by G. E. Dieter, McGraw-Hill.


**References Books :**


1. Principles of Metal Working Processes, G.W. Rowe, CBS Publishers, 2005.
2. Metal Forming Hand book, ASM


## ME 3046 INTRODUCTION TO COMPOSITE MATERIALS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the science and technology behind the composite materials.

CO2. know the secondary processing and joining of composite material.

CO3. understand the properties of the composites material in the context of strength, fracture and safety in view of its structural application.
CO4. determine various elastic constants.
CO5. apply the classical lamination theory for understanding the stress-strain variation in laminate.
CO6. familiarize with composite test procedures.

## Prerequisite- Nil

**Introduction:**

Definition of composite material, Classification based on matrix and topology, Constituents of composites, Interfaces and Interphases, Distribution of constituents, Nano composites.

**Performance of Structural Composites:**
Combination effects (Summation, Complementation andInteraction), Basic analytical concepts(Qualitative black box approach andQuantitative analytical approach),Performance analysis by various models(Law of Mixtures, Shear lag model,Laminated plate model, Eshelby's modelsand Other models, -thermoelasticity,plasticity and creep), Strengtheningmechanisms, Stress distribution in fibreand the matrix (shear stress and axialtensile stress in the fibre along its length),critical length of fibre for full strengthening,Analysis of uniaxial tensile stress-strain curve of unidirectional continuous and short fibre composites, Estimation of the required minimum amount of fibre and critical amount of fibre to gain a composite strength, Analysis of strength of a composite during loading at an angle to the fibres, Nano-structured composites

**Performance of Composite in Non-structural Applications:**
Composites inElectrical, Superconducting and MagneticApplications, Nano-composite devices

**Fabrication Composites:**
Fabrication of Metal Matrix Composites: Commonly used Matrices, Basic Requirements in Selection of constituents, solidification processing of composites - XD process, Spray processes - Osprey Process, Rapid solidification processing, Dispersion Processes - Stir-casting & Compocasting, Screw extrusion, Liquidmetal impregnation technique - Squeeze casting, Pressure infiltration, Lanxide process), Pinciple of molten alloy infiltration, rheological behaviour of meltparticle slurry, Synthesis of In situ Composites, Fabrication of

**Polymer Matrix Composites:**
Commonly used Matrices Basic Requirements in selection of Constituents, Moulding method, Low pressure closed moulding, pultrusion.
Filament winding, Fabrication of ceramic matrix composites - Various techniques of vapour deposition, Liquid phase method and Hot pressing etc., Fabrication of nano-composites

**Characterisation Composites:**
Control of particle/fibre and porosity content, particle/fibre distribution, Interfacial Reaction of matrix-reinforcing component, Coating of reinforcing component, Strength analysis

**Secondary Processing and Joining of Composite:**
Forging and extrusion ofcomposites – critical issues, dynamic recovery and dynamic recrystallization, mechanical properties, Induction Heating, Fusion Bonding, Ultrasonic welding, Gas tungsten arc welding, Gas metal arc welding, Resistance spot & seam welding, Resistance brazing, Resistance spot joining, Resistant spot brazing, Resistance welding of thermoplastic graphite composite, Weld bonding, Brazing of MMC.

**Industrial Application of Composite Materials:**
Civil constructions ofstructures/pannels, Aerospace industries,Automobile and other surface transportindustries, Packaging industries, Household and sports components etc.

**Fracture & Safety of Composite:**
Fracture behaviour of composites, Mechanics and Weakest link statistics,Griffith theory of brittle fracture andmodification for structural materials, Basic fracture mechanics of composite (Fracture toughness, COD and J-integral approaches, Fatigue crack growth rate), Fracture Mechanics of brittle matrix fibre composite, Fracture mechanics of metal matrix fibre composite, Experimental evaluation (composite), Elementary reliability analysis.

**Text Books :**

1. Composite materials, K.K. Chawala, 2nd ed., Springer-Verlag, New York 1987.
2. Mechanics and Analysis of Composite Materials, V.V. Vasiliev and E.V. Morozov, Elsevier Science Ltd, Oxford, 2001.

**Reference Books :**

1. Nanocomposite Science and Technology, P. M. Ajayan, L. S. Schadler, P. V. Braun, (2003), Wiley-VCH Weinheim.
2. Ceramic matrix composites, K.K. Chawala, Chapman & Hall, London, 1993.
3. Advances in composite materials, G. Piatti, Applied Science Publishers Ltd., London

## ME 3047 PRODUCTION AND OPERATIONS MANAGEMENT Cr-3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. describe (identify/write) the various components that make up the manufacturing planning and control system and the interaction among them.
CO2. develop the models that are applicable for supply chain inventory management, including those for quantity discounts, safety stocks, and order quantity and reorder point interactions.
CO3. develop the algorithms that are appropriate for solving single-machine, two-machine, parallel-machines and flow shop scheduling problems.
CO4. show how (i) the material requirement plans, manufacturing resource plans, and capacity requirement plans can be developed, and (ii) lot sizing decisions can be made for a manufacturing system.
CO5. determine the best plant location using different tools and design the plant layout using different techniques
CO6. find out the process capability using statistical control techniques, study the attributes chart and importance of acceptance sampling

**Prerequisite: Nil**

**Overview of Operations Management:**
Introduction, Responsibilities of Production Manager, Strategic Decisions in Operations, Manufacturing Vs. Service Operation, Types of Production processes (Project/Job, Batch, Mass/Line, Continuous), Concept of FMS (Flexible Manufacturing System), Role of Production, Planning & Control (PPC), New Product Development & Process Design, Importance of operations in services, service classifications, service package, Distinctive characteristics of service operations.

**Work Study and Aggregate Planning:**
Introduction of Work Study, Method study Procedure, Principles of Motion Economy, Stop Watch Time Study Procedure, Importance of Rating & Allowances in Time Study, Aggregate Planning: Relevant cost; Evaluation of strategic alternatives (Level, Chase and Mixed),

**Project Management and Supply chain Management:**
Project Management: Basic concept, Network principles-CPM, PERT, Crashing**.** Understanding the supply chain, decision phases in supply chain, process view of supply chain, supply chain flows

**Facility Location and Layout, Scheduling:**
Importance & Factors affecting the Plant Location, Single and Multi-facility location Techniques (Centroid and Minimax method), Plant Layout & its classification, Relationship Diagram & Block Diagramming, Assembly Line of Balancing, Sequencing,2 and 3 Machine cases: Johnson's Rule, Job shop Scheduling: Priority dispatching Rules,

**Inventory Control and Quality Control:**
Inventory Control: Relevant Costs, P & Q Systems of Inventory, Basic EOQ Model, and Model with Quantity discount, Economic Batch Quantity. Safety Stock, Reorder Point, ABC Analysis, Material Requirement Planning. Concept of Quality Management, Statistical Quality Control, X Bar, R and P Charts. Acceptance sampling

**Text Book :**
1. Production and Operations Management, R. Paneerselvam, Third Edition,2013

**Reference Books :**
1. Production and Operations Management, K. Aswathappa, K. Shridhara Bhat
1. Production and Operations management, S. N. Charry, TMH

## ME 3048 FUNDAMENTALS OF COMPUTATIONAL FLUID DYNAMICS Cr-3

**Course Outcome** : At the end of the course, the students will be able to:

CO1. make the mathematical interpretation of the physical problems.
CO2. understand the basic algorithm and think to develop suitable algorithms.
CO3. choose suitable discretization techniques for a particular problem.
CO4. analyze the different numerical solution methods and choose the suitable method.
CO5. understand the advantages of numerical solution before attempting experimental solutions
CO6. Understand the tri-diagonal matrix

### Prerequisite: Physics (PH 1007) and Mathematic-I(MA 1003)

**Introduction:**
Definition of CFD, solution procedure of a CFD problem, Classification of partial differential equations: Elliptic equations, Parabolic equations, Hyperbolic equations, Accuracy, Consistency, Stability and Convergence.

**Mathematical Formulation:**
Governing Equations: Mass Conservation Equation, Energy Equation, Momentum Equation, The general scalar transport equation, Boundary conditions, Initial condition.
**Discretization Methods:**

**Finite Difference Formulation:**
Steady one dimensional conduction problem, Unsteady one dimensional conduction problem (simple explicit method, simple implicit method, Crank-Nicolson method), Two dimensional heat conduction problem, Convection diffusion problem.

**Finite Volume Formulation:**
Steady one dimensional conduction problem, Unsteady one dimensional conduction problem, Two dimensional conduction problem, Steady one dimensional convection diffusion problem (upwind scheme), Two dimensional convection diffusion problem.

**Flow Field Calculation:**
Discretization of the momentum equation, Staggered grid, SIMPLE algorithm, SIMPLER algorithm.

**Solution Methods:**
Direct vs Iterative methods, Gauss-Seidel Method, SOR method, Tri-Diagonal Matrix (TDMA) algorithm.

**Text Book :**

1. Numerical Heat Transfer and Fluid Flow, S V Patankar, Hemisphere Publishing.

**Reference Books :**

1. Computational Fluid Dynamics, John D Anderson, Jr, McGraw Hill Book Company.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H. Versteeg , W. Malalasekera, Prentice Hall.
3. Computer Simulation of flow and heat transfer, P.S., Ghoshdasdidar, Tata McGraw-Hill Publishing Company Ltd.
4. Finite Difference Method, M. N. Ozisik, CRC.
5. Computational Fluid Flow and Heat Transfer, Muralidhar and T. Sundararajan, Narosa

## ME 3049 INDUSTRIAL SAFETY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know industry safety norms.
CO2. provide safety, health & environmental awareness
CO3. enhance knowledge, skills and develop good working environment to teach skills to avoid accidents and loss.
CO4. estimate the cost to safety measures
CO5. evaluate critical areas of processes
CO6. outline DOW index

**Prerequisite: NIL**

**Introduction to Industrial Safety:**
History and development of safety movement, Need for safety, Safety legislation: Acts and rules, Safety standards and codes, Safety policy: safety organization and responsibilities and authorities of different levels.

**Types of industries:**
Light, heavy, high tech – manufacturing (iron and steel), process (oil refinery), service (hospital); Overview of a typical modern industry: activity flow, machineries, operations, parameters which could lead to accidents; ranges of temperatures and pressures, working media like fluids and gases, safety concerns (over pressure, gas leaks, etc.)

**Areas of industrial safety:**
Process safety, personnel safety, instrument safety, facility safety, environmental safety.

**Accidents:**

Accident sequence theory, Causes of accidents, Accident prevention and control techniques, Plant safety inspections, Job safety Analysis and investigation of accidents, First aid.

**Financial costs:**

Direct and indirect social costs of accidents. Compilation procedure for financial costs. Cost data, quality and its limitations-Budgeting.

**Hazard Identification:**

Identification of hazard, Categorization methods for elimination of hazard, Mechanical hazards; machine guarding, safety with hand tools/ portable power tools, Pressure vessel hazards and their control, Safety in material handling: hazards and safe Practices, safety with storage of materials, Electrical hazards: classification, safe work practices, Chemical hazards: laboratory safety, bulk handling of chemicals, Fire and explosion hazards, Fire detection, Prevention ,control, and extinguishments, Industrial layout, Industrial waste management.

**Hazard analysis:**

Checklist procedure, Preliminary hazard analysis, What if analysis, Failure mode effect analysis,
Hazard and operability (HAZOP) studies, Hazard analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index, Risk estimation and management, Major hazard control, On-site and Off-site emergency preparedness.

**Text Book :**

1. Industrial Safety, Health and Environment Management Systems, R.K. Jain and Sunil S. Rao, Khanna publishers, 2006.

**Reference Books :**

1. Check list for work place inspection for improving safety, " health and working condition ", Intl. Labour Organisation Geneva, 1987.
2. Safety and failure of components, "Proceedings of Mechanical Engineering ", London, Vol. 184, Part 38, 1974.
3. Industrial Safety Management,L M Deshmukh, TMH, 1st Edition, 2005.

## ME 3050 AUTOMOBILE TECHNOLOGY Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. differentiate between engines and use them for different applications
CO2. select gearbox and power train for a vehicle
CO3. chose suitable steering, suspension and braking for a new vehicle
CO4. implement passenger and pedestrian safety measures in vehicle
CO5. evaluate a safety feature of an automobile
CO6. evaluate an automobile run on electric, fuel cell or solar energy

**Prerequisite: Nil**

**Introduction:**

Evolution of automobiles, classification of vehicles, structure of automobile, frame and body

**Engine and Combustion System:**

Classification of I.C Engines, two stroke petrol engines construction, working, four stroke petrol and diesel engines-construction, working, valve timing diagram; firing order, fuel supply system for SI engines; carburetors, fuel supply system for CI engines: fuel filter, fuel pump and injector, air fuel ratio for petrol and diesel. Modern fuel Injection systems – SPFI, MPFI, DI, CRDI, Digital twin spark technology, comparison of knock in SI and CI engines, supercharging and turbo-charging methods, Performance tests in IC engines.

**Transmission System:**
Requirement of transmission system. Different types of clutch, principle, Construction, torque capacity and design aspects. Different types of gear boxes – Sliding, Constant and Synchromesh gearbox. Propeller shaft, universal joint, Construction of rear axles. Types of load acting on axles. Full floating, three-quarter floating and semi-floating rear axles; Differential: construction of differential. Differential locks.

**Steering, Suspension and Braking Systems:**
Front wheel geometry: camber, castor, king pin inclination, toe-in and toe-out. Condition for true rolling motion. Steering geometry: Ackerman and Davis steering system; constructional details of steering linkages and layouts. Different types of steering gear levers-construction and operation, power and power assisted steering.

**Suspension System:**
Need of suspension system, types of suspension; construction details of suspension springs; leaf springs; Coil springs and torsion bar; Shock absorbers: telescopic type shock absorber. Independent suspension system. Introduction to pneumatic suspension system.

**Brakes:**
Classification of brakes- drum and disc brakes. Different types of breaking system as mechanical, hydraulic, cylinder and pneumatic breaking system. Master cylinder, tandem master cylinder and wheel power and power assisted brakes. Anti-locking braking systems.

**Automotive Safety:**
Seat belt types and its mounting; Air bags positioning and deployment; Children and pedestrian safety devices; Driver warning system

**Advanced Automobile:**
Combined power source vehicles, Hybrid Vehicle, Electric vehicles and solar powered vehicle, Hydrogen Oxygen fuel cell vehicle.

**Text Book :**

1. Automobile Engineering, Jain and Asthana, Tata McGraw Hill, 1st Edition, 2002

**Reference Books :**


1. A Textbook for Automobile Engineering, S.K. Gupta, S Chand Publications
2. Automotive Mechanics, William H. Crouse and Donald L Anglin, McGraw Hill 2016
3. Automobile Engineering - K.M. Gupta. Vol I & II, Umesh Publications


## ME 3051 FINITE ELEMENT ANALYSIS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. obtain an understanding of the fundamental theory of the Finite Element Analysis (FEA).
CO2. generate the governing finite element equations for systems governed by partial differential equations.
CO3. formulate and solve various complicated beam problems using Galerkin’s Technique.
CO4. understand the use of the basic finite elements to solve the bar and truss problems.
CO5. understand the application and use of the one-dimensional and two-dimensional problems.
CO6. solve complicated engineering problems using FEM software.

**Prerequisites: Mathematics - I (MA 1003), Mechanics of Solids (ME 2029)**

**Introduction to Finite Element Method:**
Introduction, Basic concepts of FEM, Brief story of FEM, need for studying FEM, Comparison of Finite Element and Exact solutions, Applications of FEM.

**Direct Formulation:**
Stiffness matrices, Spring and Bar Elements, Linear spring as a finite element, Axial rod problem.

**Finite Element Formulation:**
General procedure of FEM, Finite element formulation starting from governing differential equations, Weighted residual method (Galerkin's Technique) and its statement, Weak form of Weighted residual method, Comparison of differential equation, Weighted residual and weak forms.

**One-dimensional finite element analysis:**
Elements and shape functions, Co-ordinate transformations: Global coordinates and natural coordinates, One-dimensional bar/truss finite element, One-dimensional bar under self-weight, One-dimensional heat transfer element.

**Two-dimensional finite element analysis:**
Polynomial shape functions, Pascal triangle for two-dimensional polynomial shape functions, Two-dimensional shape function for three-noded triangular element CST (Constant Strain Triangle), Four-noded rectangular element, Determining shape functions using Lagrange polynomials, Strain displacement matrices.

**FEA Software and its Applications:**
Basic of FEM software, Standard procedure of FEM software and its role in engineering field, Application of FEM software.

**Text Book :**

1. Textbook of Finite Element Analysis, P. Seshu, PHI.

**Reference Books :**

1. Finite Element Analysis, S. S. Bhavikatti, New Age International Publishers.
2. Fundamentals of Finite Element Analysis, D.V. Hutton, McGraw Hill.

## ME 3052 NANOTECHNOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. choose the terminologies of nanotechnology and structure-property relationship of materials.
CO2. outline the synthesis of nanomaterials, structure and their methods of characterization.
CO3. identify and compare state-of-the-art nanofabrication methods.
CO4. design processing conditions to engineer functional nanomaterials.
CO5. evaluate current constraints, such as regulatory, ethical, political, social and economical
CO6. utilize nanotechnology for various engineering disciplines.

**Prerequisites: Chemistry (CH 1007), Physics (PH 1007), Materials Science and Engineering (ME 2027)**

**Introduction:**

Introduction to nanoscience, a brief history of the super small, definition of nanotechnology, zero dimensional: nano particle, 1-D: nano wires, nano rods, 2-D: thin films, special nanomaterials: buckyballs (Fullerenes), nanotubes, nanowire, nanoshells, magnetic nanoparticle, Quantum Dot (Nanocrystals), self-assembled monolayers.

**Synthesis of Nanomaterials**:

Bulk synthesis:top down and bottom up approaches and inert gas condensation technique, Chemical approaches: Sol gel processing-Solvothermal, hydrothermal, precipitation, spray pyrolysis, Electro spraying and spin coating routes,micro emulsion polymerization- templated synthesis, pulsed electrochemical deposition, Physical approaches: vapor deposition and different types of epitaxial growth techniques (CVD, MOCVD, MBE, ALD)-pulsed laser deposition, magnetron sputtering - lithography: Photo/UV/EB/FIB techniques, dip pen nanolithography, Etching process: dry and wet etching, micro contact printing.

**Physicochemical Characterization of Nanomaterials:**

Molecular spectroscopy and differences: atomic spectroscopy, infrared (IR) spectroscopy, microwave spectroscopy, Thermal analysis methods:thermogravimetry, differential scanning calorimetry, Qualitative and quantitative analysis: electron energy loss spectroscopy; high resolution imaging techniques- HREM, atom probe field ion microscopy-X-ray photoelectron spectroscopy -EDAX and WDA analysis, Nanoindentation: nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions.

**Imaging Techniques for Nanotechnology**:

Optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), scanning tunneling microscopy (STM) and X-ray diffraction (XRD): basic principles - modes of operation – specimen preparation.

**Applications of Nanotechnology:**

Sporting goods equipment, apparel industry, cosmetics, appliances, automobile/vehicle industry, paint and other water resistance coatings, removing windshield fog, medical bandages, organic light-emitting displays, medical applications, food and agriculture, nanotechnology for data storage, risk assessment, management and ethical aspects.

**Text Book :**

1. Textbook of Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill, 2012.

**Reference Books :**

1. Nanotechnology: Fundamentals and Applications, R, Booker and Boysen Earl (Eds), I K International Publishing House Pvt. Ltd, 2008.
2. Nanoscience and Nanotechnology: Fundamentals of Frontiers, Shubra Singh and M.S. Ramachandra Rao, Wiley, 2013.
3. Fundamentals of Nanoscience, S. L. Kakani and Subhra Kakani, New Age International, 2017.
4. Introduction to Nanoscience, S. M. Lindsay, Oxford University Press, 2009.
5. Nanostructure and nanomaterial, G. Cao, World scientific, 2011.

## ME 3053 PROJECT MANAGEMENT Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. develop plans with relevant people to achieve the project's goals
CO2. break work down into tasks and determine handover procedures
CO3. identify links and dependencies, and schedule to achieve deliverables

CO4. estimate and cost the human and physical resources required, and make plans to obtain the necessary resources

CO5. allocate roles with clear lines of responsibility and accountability.

CO6. understand the roles of project manager and project organizations

## Prerequisite: Nil

**Project Management Concepts and Needs Identification**

Attributes of a Project, Project Life Cycle, The Project management Process, Global Project Management, Benefits of Project Management, Needs Identification, Project Selection (AHP technique), preparing a Request for Proposal, Soliciting Proposals,Project organization, the project as part of the functional organization, pure project organization, the matrix organization, mixed organizational systems.

**Project Planning and Scheduling**

Design of project management system; project work system; work breakdown structure, project execution plan, work packaging plan, project procedure manual; project scheduling; bar charts, line of balance (LOB) and Network Techniques (PERT / CPM), Crashing.

**Project Monitoring and Control and Project Performance**

Planning, Monitoring and Control; Role of Production, Planning & Control (PPC), New Product Development & Process Design, Aggregate Planning: Relevant cost; Evaluation of strategic alternatives (Level, Chase and mixed, types of capacity, Economics and Diseconomies of scale, Developing capacity alternatives Project Audit; Project Audit Life Cycle.

**The Project Manager**

Responsibilities of the Project Manager, Skills of the Project Manager, Developing the Skills needed to be a Project Manager, Delegation Managing Change, Developing a Winning Proposal, Proposal Preparation, Proposal Contents, Pricing Considerations, Proposal Submissions and Follow-Up, Customer Evaluation of Proposals.

**Text Book :**

1. Project Management, James P. Clements & Jack Gido, Cengage Learning, $5^{th}$ edition, 2012

**Reference Book:**

1. Project Management: *A Managerial Approach*, Jack R. *Meredith*, Samuel J. *Mantel*, Jr., 8th Edition, *Wiley Publications,* August 2011

## ME 3054 GAS DYNAMICS AND JET PROPULSION Cr-3

**Course Outcome:** After successful completion of the course, the students should be able to :

CO1. know the differences between compressible and incompressible flows.

CO2. explain basic concepts of gas dynamics and describe the basic fundamental equations of one dimensional flow of compressible fluid and isentropic flow of an ideal gas.

CO3. formulate and solve problems in one -dimensional steady compressible flow including isentropic nozzle flow, constant area flow with friction (Fanno flow) and constant area flow with heat transfer (Rayleigh flow).

CO4. discuss the effect of heat transfer on flow parameters.

CO5. understand the knowledge about the rocket propulsion and various propellants.

CO6. analyze the energy flow through jet engines and perform the performance calculations.

**Prerequisites: Engineering Thermodynamics (ME 2031), Fluid Mechanics and Hydraulic Machines (ME 2021)**

**Introduction to gas dynamics:**

Control volume and system approaches acoustic waves and sonic velocity; mach number – classification of fluid flow based on mach number; mach cone-compressibility factor; general features of one dimensional flow of a compressible fluid – continuity and momentum equations for a control volume.

**Isentropic flow of an ideal gas:**

Basic equation – stagnation enthalpy, temperature, pressure and density-stagnation, acoustic speed – critical speed of sound- dimensionless velocity-governing equations for isentropic flow of a perfect gas; critical flow area – stream thrust and impulse function. Steady one dimensional isentropic flow with area change-effect of area change on flow parameters- chocking- convergent nozzle; performance of a nozzle under decreasing back pressure; de Laval nozzle; optimum area ratio effect of back pressure; nozzle discharge coefficients – nozzle efficiencies.

**Simple frictional flow**:

Adiabatic flow with friction in a constant area duct- governing equations – fanno line limiting conditions – effect of wall friction on flow properties in an Isothermal flow with friction in a constant area duct- governing equations – limiting conditions. Steady one dimensional flow with heat transfer in constant area ducts- governing equations Rayleigh line entropy change caused by heat transfer – conditions of maximum enthalpy and entropy.

**Effect of heat transfer on flow parameters:**

Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas- properties of flow across a normal shock – governing equations – Rankine Hugoniat equations – Prandtl's velocity relationship – converging diverging nozzle flow with shock thickness – shock strength.

**Propulsion: Air craft propulsion:**

Types of jet engines – energy flow through jet engines, thrust, thrust power and propulsive efficiency turbojet components-diffuser, compressor, combustion chamber, turbines, exhaust systems.

**Performance of turbo propeller engines:**

Ramjet and pulsejet, scramjet engines. Rocket propulsion – rocket engines, Basic theory of equations – thrust equation – effective jet velocity – specific impulse – rocket engine performance – solid and liquid propellant rockets – comparison of various propulsion systems.

**Text Books :**

1. Fundamental of compressible flow with Aircraft and Rocket Propulson, S. M. Yahya,, New Age International (p) Ltd., New Delhi, 2005.
2. Gas Dynamics, E. Radhakrishnan, Prentice Hall of India, New Delhi, 2001.

**Reference Books :**

1. Fundamental of gas dynamics, 2nd edition– Zucker- Wiley publishers.
2. Elements of gas dynamics – Liepman & Roshko.
3. Compressible fluid flow, Patrich.H. Oosthvizen, William E.Carscallen, McGraw-Hill, 1997.
4. Gas Turbines, V. Ganesan, Tata McGraw-Hill, New Delhi, 1999.
5. Gas Dynamics and Jet Propulsions, P. R.S.L.Somasundaram, New Age International Publishers, 1996.
6. Gas Turbine Theory, H. Cohen, G.E.C. Rogers and Saravanamutto, Longman Group Ltd., 1980.

## ME 3055 ADDITIVE MANUFACTURING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the concept of additive manufacturing, its benefits and applications
CO2. know the various liquid, powder and solid material based technologies in Rapid Prototyping and Rapid Tooling.
CO3. design solid models and converting it to STL file format required for part generation.
CO4. focus on the various errors in the RP parts
CO5. develop rapid tooling techniques.
CO6. apply reverse engineering for generating RP parts.

**Prerequisite: NIL**

**Introduction**:
Need & Development of RP systems, RP process chain, Impact of Rapid prototyping and Tooling on Product Development, Benefits, Applications, Digital prototyping, Virtual prototyping.

**Liquid and Solid Based Rapid Prototyping Systems:**
Stereo lithography Apparatus, Fused deposition Modelling, Laminated object manufacturing, 3D printing: Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

**Powder Based Rapid Prototyping Systems:**
Selective Laser Sintering, Direct Metal Laser Sintering, 3D Printing, Laser Engineered Net Shaping, Selective Laser Melting, Electron Beam Melting: Processes, materials, products, advantages, applications and limitations.

**Medical and Bio- Additive Manufacturing:**
Customized implants and prosthesis: Design and production, Bio additive manufacturing: Computer Aided Tissue Engineering (CATE) followed by case studies.

**Data Processing for Rapid Prototyping:**
Process planning for rapid prototyping, CAD model preparation, Data Requirements & geometric modelling techniques: Wire frame, surface and solid modelling data formats - Data interfacing, Tessellation of surfaces, STL file generation Defects in STL files and repairing algorithms, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.

**Issues of Prototype**:
Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost etc.

**Rapid Tooling:**
Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect, Fabrication processes, Applications, Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, vacuum casting.

**Reverse Engineering:**
Introduction to reverse engineering, Integration of reverse engineering and rapid prototyping.

**Text Book :**

1. Rapid Prototyping: Principle and Applications, Rafiq I Noorani, Wiley & Sons, 2006

**References Books :**


1. Rapid prototyping: Principles and applications, Chua C.K., Leong K.F., and Lim C.S., Yes Dee Publishing Pvt. Ltd, Third edition, 2010.
2. Rapid Prototyping And Engineering Applications, Frank W. Liou, CRC Press, Special Indian Edition, 2007.
3. Journey from Rapid Prototyping to Rapid Manufacturing, Somnath Chattopadhyaya, LAP Lambert Academic Publishing, 2011.
4. Rapid Prototyping Technology: Selection and Application, Kenneth G. Cooper, Cooper Cooper, Marcel Dekker Inc, 1st Edition, 2001.
5. Rapid-prototyping-of-biomaterials-Principles-and-applications,Narayan, Roger, ed. Woodhead Publishing, 2014.
6. Medical modelling: the application of advanced design and rapid prototyping techniques in medicine, Bibb, Richard, Dominic Eggbeer, and Abby Paterson. Woodhead Publishing, 2014.


## ME 3056 TRIBOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

- CO1. realize the importance of proper choice of tribological elements.
- CO2. design a tribological system for optimal performance.
- CO3. enhance students' awareness of tribological issues in the design of machine components, such as rolling element bearings, journal bearings, thrust bearings, seals, and braking systems.
- CO4. demonstrate basic understanding of friction, lubrication, wear processes and Sommerfeld number.
- CO5. select tribological elements based on design considerations
- CO6. apply the knowledge of wear and lubricants for different applications

**Prerequisite: Kinematicsand Dynamics of Machines (ME 2013)**

**Introduction:**
Viscosity, flow of fluids, viscosity and its variation -absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers used.

**Hydrostatic lubrication:**
Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing.

**Hydrodynamic theory of lubrication:**
Various theories of lubrication, petroffs equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl anti -friction bearing.

**Friction and power losses in journal bearings:**
Calibration of friction loss friction in concentric bearings, bearing moduIus, Sommerfield number, heat balance, practical consideration of journal bearing design considerations.

**Air lubricated bearing:**
Advantages and disadvantages application to Hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydrostatic thrust bearings. Hydrostatic bearing Analysis including compressibility effect.Study of current concepts of boundary friction and dry friction.

**Types of bearing oil pads:**
Hydrostatic bearing wick oiled bearings, oil rings, pressure feed bearing, partial bearings -externally pressurized bearings.

**Bearing materials:**
General requirements of bearing materials, types of bearing materials.

**Text Book :**
1. Fundamentals of Tribology, Basu, Sen Gupta and Ahuja, PHI

**Reference Books :**
1. Tribology in Industry:Sushil Kumar Srivatsava, S. Chand & Co.
2. Tribilogy, Friction and Wear of Engineering Materials, I.M. Hutchings, Elsevier Limited.
3. Introduction to Tribology of Bearing, B.C. Majumdar, S.Chand.
4. Theory and Practice of lubrication of Engineers, D.D. Fuller, John Wiley Sons 1998.

## ME 3057 MACHINE MAINTENANCE AND CONDITION MONITORING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the philosophy behind different maintenance techniques and select the best maintenance practices.
CO2. use successfully different condition monitoring techniques to predict health of a machine.
CO3. analyze and find out the root cause of defect in machine and system.
CO4. apply different NDT methods to find out fault in machine and structure.
CO5. know wear and debris analysis
CO6. know advanced maintenance practices

### Prerequisite: Kinematics and Dynamics of Machines (ME 2013)

**Maintenance strategies:**
Breakdown, Preventive, Predictive and Proactive maintenance. Plant machinery classification, Condition based maintenance.

**Transducers for condition monitoring:**
Principles and application of accelerometers, velocity pickups, eddy current probes, stroboscopes, proximity probes, spike energy detector, laser vibrometer, condenser microphones, thermocouples, optical pyrometer, ultrasonic thickness detector, acoustic emission transducer.

**Fundamentals of Signal processing:**
Fast Fourier Transform (FFT) analysis, Sampling rate, Nyquist sampling theorem, aliasing, filters, A/D converter, Windowing.

**Vibration Monitoring:**
Measuring vibration: Signal forms, phase, overall and spectral vibration, Measurement point location, Transducer mountings.

**Rotating machinery fault analysis:**
Imbalance, Misalignments, Looseness, Oil whirl, Bent shafts, Coupling problem, Bearing defects, Gear defects.

**Vibration level classification:**
ISO standards, Peak and RMS levels, Time domain averaging, Trending fault data. Case studies based on vibration data and signature of machines.

**Wear and Debris Analysis:**
Principle of Tribology, Industrial and Automotive Lubricants, Lubricants Properties, Lubricants Contamination and Prevention, Lubricants Mechanism and Failures, Sampling of Lubricants, Wear particle size, Ferrography, Particle Counting, Magnetic Plugs, Spectrometric metals analysis and Types of Wear Particles. Case studies based on oil analysis data of machines.

**Temperature Monitoring:**
Infra-red Thermograghy, Principles, Instruments, Thermal imaging, Locating hot spots for maintenance intervention, Ascertaining condition of refractory lining, Identifying faults in cooling system and in electrical Equipments, Plant Heat audit. Case studies based on thermal images.

**Non Destructive Testing:**
Faults that can be detected by NDT, Ultrasonic, Radiography Methods, Eddy Current Method, Acoustic Emission Method, Dye penetrant Method. Case studies based on available NDT data.

**Advance Maintenance Practices**:
Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), Computerized Maintenance Management Systems (CMMS), Five Zero Maintenance Concept. Maintenance Planning and Scheduling, Budgeting, Costing.

**Text Book :**

1. Maintenance Engineering and Management, Sushil Kumar Srivastava, S.CHAND,

**Reference Books :**

1. Maintenance Engineering and Management, K.Venkataraman, PHI, 1st Edition
2. Plant Maintenance and Reliability Engineering, N.V.S. Raju, CENGAGE, 1st Edition

## ME3059 COMUTATIONAL FLUID DYANAMICS Cr-3

**Course Outcome**: After the completion of the course, the students will be able to

CO1. understand the advantages and disadvantages of numerical solution compared to the analytical and experimental results.
CO2. make interpretation of different forms of conservation equations and choose the suitable form depending on the problems.
CO3. understand the basic algorithm for solving problems of fluid flow and heat transfer and to develop suitable algorithms.
CO4. choose suitable discretization technique for a particular problem.
CO5. analyze the different numerical solution methods and to choose the suitable method.
CO6. apply the knowledge of CFD for simulation of the industrial problems in commercial softwares and make correct interpretation of the numerical results.

**Prerequisites: Fluid Mechanics and Hydraulic Machines (ME 2021), Heat Transfer (ME 3021)**
**Introduction:**
Methods of prediction- Analytical, numerical and experimental, classification of partial differential equations (PDE), elliptic, parabolic and hyperbolic PDE, overview of finite difference, finite volume and finite element method.

**Mathematical formulation of physical phenomena:**
Governing equations: mass conservation equation, momentum conservation equation and energy conservation equation, the general scalar transport equation, different types of boundary conditions and initial conditions

**Different methods for solving linear algebraic equations:**
Direct and indirect methods, Gauss elimination method, Gauss-Seidel iteration method, Jacobi iteration method, SOR, tri-diagonal matrix (TDMA) or Thoma's algorithm.

**Introduction to finite difference approximation, accuracy and errors:**
Taylor series expansion, two-point forward difference and backward difference formula, central difference formula for uniform grid, forward and backward difference formula involving higher number of grids, different types of error (truncation error, round off error), consistency, stability and convergence.

**Discretization methods:**
Finite difference formulation, Steady one-dimensional conduction problem, unsteady one-dimensional conduction problem (explicit method, implicit method, Crank-Nicolson scheme), two-dimensional heat conduction problem, convection-diffusion problem (upwind scheme, exponential scheme, hybrid scheme, power-law scheme).

**Finite volume formulation:**
Steady one dimensional conduction problem, interface conductivity, source term linearization, Implementation of different types of boundary conditions, unsteady one dimensional conduction problem, two dimensional conduction problem, steady one dimensional convection-diffusion problem (upwind scheme, exponential scheme, hybrid scheme, power-law scheme), two dimensional convection-diffusion problem.

**Flow field calculation:**
Solution of Navier-Stokes equations for incompressible flows, stream function vorticity method and artificial compressibility method, staggered grid, SIMPLE, SIMPLEC and SIMPLER algorithm.

**Special topics:**
Numerical solution of phase change problems.

**Text Book :**
1. Computational Fluid Dynamics, John D Anderson, McGraw Hill.
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H, Versteeg, Malalasekhara, Prentice Hall.

**Reference Books :**
1. Computer Simulation of Flow and Heat Transfer, P. S. Ghoshdastidar, Tata McGraw Hill Publishing Company.
2. Computational Fluid Flow and Heat Transfer, Murlidhar and Sundarrajan, Narosa Publishers.
3. Numerical Heat Transfer and Fluid Flow, S. V. Patankar, Hemisphere Publishing.

## ME 3061 ADVANCED MECHANICS OF SOLIDS Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. evaluate general 3-dimensional stress analytically in structural elements.
CO2. find the 3-dimensional strain components in structural elements.
CO3. derive the constitutive relation of a material in its generalized form (3-dimensional).
CO4. understand different theories of failure in order to design a machine element or a structural member.
CO5. evaluate the stresses developed in the bending of straight and curved beams having general cross section and finding the deflection of such beams.
CO6. evaluate the stresses in general prismatic bars under torsion.

**Prerequisite: Mechanics of Solids (ME 2029)**

**Analysis of stress:**
3-D state of stress at a point (in rectangular coordinate), Sign convention for stress, Mohr's circles for 3-D state of stress, Differential equation of equilibrium, Stress invariants, Equilibrium equations for plane stress condition.

**Analysis of strain:**
Rectangular 3-D strain components, Cubical dilatation, Plane state of strain, Compatibility conditions, Strain deviator and invariants.

**General Stress-strain relation:**
Generalised Hooke's law, Stress-strain relation for isotropic materials, relation between different elastic constants.

**Theories of failures:**
Different failure theories and their significance, Mohr's theory of failure, Stress space and strain space.

**Unsymmetrical bending:**
Straight beams and asymmetrical bending, Shear centre for different sections, Bending of curved beams (Winker-Bach formula).

**Torsion of non-circular sections:**
Torsion of general prismatic Bars, torsion of circular, elliptical triangular and rectangular bars; Membrane analogy, Centre of twist and Flexural centre.

**Text Book :**
1. Advanced Mechanics of Solids, L. S. Srinath, McGraw Hill Education, 2010.

**Reference Books :**
1. Advanced Mechanics of Materials, A.P. Boresi, R.J. Schimdt; Wiley.
2. Strength of Materials, Sadhu Singh, Khanna Publishers.
3. Strength of Materials, Beer and Johnson, McGraw-Hill Education, 2014.

## ME 3062 THERMODYNAMICS AND HYDRAULIC DEVICES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. develop an intuitive fundamental understanding of thermal-hydraulic systems
CO2. determine the thermodynamic and physical properties of numerous substances
CO3. apply the first and second laws of thermodynamics to several engineering devices
CO4. develop the fundamental understanding of boilers.
CO5. develop fundamental understanding of fluid machineries.
CO6. apply fluid dynamics principles to numerous fluid mechanical systems

**Prerequisite: Physics (PH 1007)**

**Principle of Thermodynamics:**
First law of thermodynamics, internal energy, enthalpy, different thermodynamic processes, Second law of thermodynamics, entropy, Carnot cycle, properties of steam, use of steam table and Mollier chart, Rankine cycle, reheat and regeneration.

**Principle of Fluid Dynamics:**
Introduction, Euler's equation, Bernoulli's equation. Practical applications of Bernoulli's equation- Venturi-meter, Orifice-meter, Pilot tube.

**Steam turbine:**
Types, working principle of impulse and reaction turbines, work done and efficiencies.

**Hydraulic turbines:**
Types, working principle of Pelton, Francis, Kaplan and Propeller turbines, different heads and efficiencies, work done & efficiency of turbines. Specific speed equation and specific discharge equation.

**Boiler:**
Fire Tube and Water Tube Type boiler

**Centrifugal pump:**
Classification, construction, work done, efficiencies, cavitation.

**Reciprocating pump:**
Classification, construction, working, work done, slip and coefficient discharge.

**Text Books :**
1. Thermal Engineering, A. S. Sarao, Satya Prakashan, New Delhi, Eighth Edition.
2. Fluid Mechanics and Hydraulics Machines: R.K. Rajput, S. Chand

**Reference Books :**
1. Engineering thermodynamics, P K Nag, McGraw Hill Education, Fifth Edition
2. Hydraulics and Fluid Mechanics, P.N. Modi and S.M. Seth
3. Introduction to Thermal and Fluid Engineering, Allan D Kraus, James R Welty, Abdul Aziz, CRC Press

## ME 3063 AUTOMOBILE ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the evolution of automobiles and its construction.
CO2. select and identify most appropriate chassis and engine for given mobility application.
CO2. understand and model charging, starting and ignition systems for new vehicle.
CO3. understand and select a suitable fuel supply system for automobiles.
CO4. design and analyze the gear ratios in gear box, suspension, springs and brakes.
CO6. model and Calculate cornering force and cornering power required to steer a vehicle.

### Prerequisite: Kinematicsand Dynamics of Machines (ME 2013)

**Introduction:**
Classification of automobiles as per motor vehicle act, Main units of automobile chassis and body, different types of chassis, Types of engines used in automobiles, description of the main parts of the engine: Piston, Piston ring, Connecting rod, crank shaft, valve and manifold.

**Fuel Supply System:**
Types of fuel used in automobile, Atomization and Vaporization, Fuel Air ratio, Carburettor, Flow through an orifice, Electronic fuel injection system, Diesel injection pump, Common rail diesel injection system

**Transmission System:**
Clutch: single plate, multi plate, cone clutch, their functions; Gear box: Sliding mesh, constant mesh and synchromesh gearbox, Gear ratio, Design of 3 speed and 4 speed gear box, over drive, torque converter, Automatic transmission; Hooks Joint, propeller shaft, Hotchkiss and torque tube drives; Differential and rear axle: differential, rear axles, types of rear axles, semi floating, three quarter floating and full floating types.

**Braking System and wheels:**
Differences in drum and disc brake, Hydraulic braking system, braking of vehicles when applied to rear, front and all four wheels, theory of internal shoe brake, design of brake lining and brake drum different arrangement of brake shoes, servo and power brakes. Wheels, Tyres: desirable tyre properties, Types of tyres.

**Front wheel Geometry and Steering System:**
Steering gears; Camber, castor, Kingpin inclination, toe-in, center point steering condition for true rolling, Ackermann and Davis steering mechanism. Cornering force calculation, power steering system.

**Suspension System:**
Functions of suspension system, classification, leaf spring suspension system, coil spring suspension system, torsion bar, telescopic type shock absorber.

**Electrical systems of an automobile:**
Starting system, starter drive, Electricity generation system, Fuel ignition system: Battery ignition system.

**Text Book :**
1. A Textbook of Automobile Engineering – R K Rajput, Laxmi Publications, New Delhi 2015

**Reference Books :**
1. Automobile Engineering, Jain and Asthana, Tata McGraw Hill, 1st Edition, 2002
2. Automobile Mechanics - J. Heitner, East West Press, 2006
3. Automobile Engineering - K.M. Gupta. Vol I & II Umesh Publications, 2012

## ME 3065 COMBUSTION ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. explain basics of combustion and thermo chemistry relations.
CO2. explain the fundamentals of chemical kinetics
CO3. identify the mechanism and explain technicality of laminar premixed flame
CO4. identify the needs and explain the technical detail of laminar diffusion flame.
CO5. explain the physical process through mathematical relation of droplet evaporation.
CO6. explain the meaning and hazards of pollution and also identify the causes and can suggest to minimize it.

**Prerequisite: Engineering Thermodynamics (ME 2031)**

**Introduction:**
Definition, need, application, classification etc. of combustion systems, Energy sources.

**Combustion and Thermo chemistry:** Review of property relations, Equation of state, calorific equations of state, ideal gas mixtures, Thermodynamics (1st & 2nd law for pure, non-reacting (mixture) and reacting systems); Stoichiometry, absolute enthalpy and enthalpy of formation, enthalpy of combustion and heating values, adiabatic flame temperatures.

**Chemical Kinetics:**
Global versus elementary reactions, elementary reaction rates, unimolecular, bimolecular and termolecular reactions, Collision theory; reaction rate and its functional dependence; Arrhenius equation; order of reaction, steric factor, collision frequency, activation energy etc.

**Laminar premixed flame**:
Definition, principal characteristics; Simplified Analysis: assumptions, conservation (mass, species & energy) equations with boundary conditions and their solutions to find out temperature & mass-fraction distribution; Factors affecting flame velocity and thickness, Correlations of flame velocity & thickness; quenching; flammability & ignition, flame stabilization.

**Laminar diffusion flame:**
Laminar Jet, Jet flame physical description, simplified theoretical descriptions, Burke-Schumann solution: assumptions, simplification and solution of mass, species, momentum & energy equation with the boundary conditions; determination of temperature & mass fraction distribution as well as flame height, soot formation and destruction.

**Droplet evaporation & combustion**:
Applications, Simple model of droplet evaporation, assumptions, solution of mass, species & energy equation with the boundary conditions; determination of temperature & mass-fraction distribution, mass evaporation rate, flame stand-off ratio, flame temperature, expression for transfer numbers, evaporation/burning rate constant, droplet life-time etc.

**Pollutant emissions**:
Effects of pollutants, quantification of emissions, emission indices, various specific emission measures, emissions from premixed combustion, emissions from non-premixed combustion.

**Text Book :**
1. Introduction to Combustion: Concepts and Applications, Stephen R Turns, McGraw Hill, 2000

**Reference Books :**

1. Combustion: Fundamentals and Application, Amitava Datta, Alpha Science International Ltd, 2017
2. Combustion Engineering, K. Kuo, New Age Pvt. Ltd.

## ME 3067 CRYOGENICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. recognize historical developments in cryogenic systems
CO2. explain material behaviour at low temperature.
CO3. demonstrate the applications of cryogenics
CO4. choose the measurement systems at low temperature
CO5. compare gas liquefaction and purification systems/methods
CO6. analyze system parameters and performance

**Prerequisite: Engineering Thermodynamics (ME 2031), Heat Transfer (ME 3021)**

**Introduction to Cryogenics Systems:**
Chronology of cryogenic technology, present areas of cryogenic engineering, low temperature properties of engineering material: mechanical, thermal and magnetic properties.

**Gas Liquefaction Systems:**
System performance parameters, ideal systems, Joule-Thomson Effect, Linde-Hanpson System, Pre- cooled Linde-Hampson System, LInde Dual Pressure System, Claude and Kaptiza System, liquefaction systems for Neon, Hydrogen and Helium, critical components for liquefaction systems

**Gas Separation and Purification Systems:**
Physical adsorption, Refrigeration purification: Gibbs phase rule, Dalton and Raults law, Rectification Column, Design of rectification column (Mccabe-Thiele Method)

**Cryogenic Refrigeration:**
Ideal refrigeration systems, Refrigerator above 2 K: J-T refrigerator, Expansion engine refrigerator, Philips refrigerator, G-M Refrigerator Refrigerator below 2 K: Magnetic cooling, Magnetic refrigerator system

**Measurement Systems for Low Temperatures:**
Introduction, Metallic resistance thermometer, Semiconductor resistance thermometer, Thermocouples, Constant volume gas thermometer, vapor pressure thermometers, Liquid level measurement: Hydrostatic gauges, Electric resistance gauges, Thermodynamic liquid level gauges.

**Application of Cryogenics:**
Cryogenic fluid storage systems, Insulation, Important of vacuum technology in cryogenics, super conductive devices and its application, Space technology, Cryogenics in Biology and Medicine.

**Text Books :**

1. Cryogenics Systems: R. Barron, Oxford Press.
2. Cryogenics: Applications and Progress, A. Bose and P. Sengupta, TMH.

**Reference Books :**

1. Cryogenics Engineering, T M Flynn and Marcel Dekkar
2. Cryo-Cooler Fundamentals, G. Walker, Plenum Press New York.

## ME 3069 TOTAL QUALITY MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. understand the paradigm shift i.e. Quality journey to TQM philosophy
CO2. know and Techniques for improving Quality in Organization and supplier end for overall improvement.
CO3. improve the Processes with SPC, Process capability analysis for competitive edge
CO4. familiarization with Leadership concepts, Employee motivation, TOP management mission and vision to drive employee for effective performance for achievement of Key Targets
CO5. aware of Top most Quality awards for International recognition and Customer satisfaction
CO6. develop learning and research skills to be a part of World Class Quality and Excellence thereof

**Prerequisite: Nil**

**Introduction:**
Defining Quality, 4 stages of Quality, Quality as a management Frame work, Quality Cost., Quality Losses and its competitive advantage, Relation between Quality and Productivity. Basic Tools of Quality, ISO 9000/TS 16949, American Malcolm Baldridge award, Deming philosophy, JRD Quality Values, Concepts of Six Sigma, Total Quality Management and its evolution. TQM and TPM. Leadership -concepts, Role of Senior Management. Components of TQM, Mission and Vision.

**Statistical Methods for Quality Control:**
Statistical Methods for Quality Control and improvement, Statistical Process Control, Specification & Limits, Charts for variables and Attributes, Process control (X, R and P chart), Designing Control charts. Calculation of Process capability (Cp/Cpk studies).and its interpretation and analysis. New 7 management Tools. FMEA and Control Plan. Zero Defect.

**Planning:**
Long Term Understanding with Supplier (LOTUS), Supplier as Partner, Supplier selection and Rating, supplier Mentoring and continuous Improvement, Sampling Plan, Design of Sampling Plan, AOQ and AOQL

**Quality Auditing:**
5s &Kaizen, Benchmarking, QFD process and House of Quality, Implementation of Quality system, Documentation, Quality Auditing, Customer perception of Quality, Customer Loyalty, Service Quality and Retention of Customer. Employee motivation and Reward, Employee Involvement and Performance measures.

**Text Books :**
1. Quality Management: concepts and Tasks, V. Narayana and N.S Sreenivasan, New Age International, 1996
2. Total Quality Management for Engineers, M Zeiri, Wood Head Publishers

**Reference Books :**
1. Total Quality Management, Dale H Besterfield, Pearson Education, 2003
2. The Management and Control of Quality, James R Evans and William M Lidsay
3. Total Quality Management, L Suganthi, PHI, 2004

## ME 3071 RENEWABLE ENERGY TECHNOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to

- CO1. understand the potential, availability and the properties of the alternative and renewable energy sources and their needs in present energy scenario
- CO2. explain the basic principles of wind energy technology and their merits and demerits.
- CO3. evaluate the basic principles of solar energy technology (both thermal and PV) and its merits and demerits.
- CO4. analyze the basic principles of biomass and biofuel technology and its merits and demerits.
- CO5. elaborate the basic principles of geothermal energy technology and their merits and demerits.
- CO6. discuss the basic principles of tidal energy technology, ocean and wave energy technology and their merits and demerits.

### Prerequisite: Nil

**Introduction of Renewable Energy:**
Need for renewable energy sources. Availability, properties and different engineering applications of renewable fuels like solar, wind, tidal, biomass, ocean, geothermal, etc. The merits and demerits of various renewable energy sources.

**Solar Power Generation:**
Solar Radiation Measurement, Estimation of Solar Radiation, Solar Thermal Process, Heat Transfer Devices, Solar Energy Storage: Stratified Storage, Well Mixed Storage, Comparison, Hot water System, Practical Consideration, Solar Ponds, Non-convective Solar Ponds, Extraction of Thermal Energy and application of Solar Ponds.

**Bio Power Generation:**
Bio-energy past and present, Biomass as a solar energy store, biomass as a fuel, primary biomass energy sources, plant materials, secondary biomass sources: wastes, residues and co-products, physical processing of biomass, thermo chemical processing, biochemical processing, vegetable oils and biodiesel, environmental benefits and impacts, economics, future prospects for bio-energy.

**Wind Power Generation:**
Energy and power in the wind, characteristics of wind, Wind turbines (types, horizontal and vertical axis wind turbines), linear momentum and basic theory. Aerodynamics of wind turbines, power generation by a turbine, electricity generation, environmental impact, economics of energy generation, commercial development and wind energy potential, offshore wind energy.

**Tidal and Wave Power Generation:**
Nature of tidal sources, physics of tidal energy, power generation from barrages, Economics of tidal barrages, tidal lagoons, tidal streams/currents. Physical principles of wave energy, wave energy sources, wave energy technology, Integration (wave energy for isolated communities and large electricity grids).

**Geothermal Power Generation:**
Origin and types of geothermal energy and utilization., the mining of geothermal heat, source of heat, physics of geothermal resources, technologies for exploiting high enthalpy stream fields, technologies for direct use of geothermal energy, harnessing geothermal resources, environmental implications, economics and world potential.

**Text Books :**

1. Renewable Energy-Power for a Sustainable future, Godfrey Boyle, Oxford University Press, $3^{rd}$ Edition, 2012.
2. S. P. Sukhatme, Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 1990.

**Reference Books :**

1. V.S. Mangal, Solar Engineering', Tata McGraw Hill, 1992.
2. N. K. Bansal, Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 1989.
3. G. L. Johnson, 'Wind Energy Systems', Prentice Hall Inc, New Jersey.
4. N K Bansal, Non-Conventional Energy Resources, Vikas Publishing House Pvt. Ltd., 2014.
5. G. D. Rai, Non-Conventional Energy Sources, Khanna Publishers, Fourth Edition.

## ME 3073 MECHANICS OF COMPOSITE MATERIALS Cr-3

**Course Outcome:** On completion of the course, students will be able to

CO1. understand the characteristics and application of a composite material and different manufacturing methods of laminated fiber-reinforced composite materials.
CO2. understand the strength of a unidirectional lamina, strength and failure criteria of an orthotropic lamina.
CO3. understand the macromechanical behavior of a lamina, stress-strain relation for anisotropic material.
CO4. determine various elastic constants.
CO5. apply the classical lamination theory for understanding the stress-strain variation in laminate.
CO6. familiarize with composite test procedures.

**Prerequisite: Mechanics of Solids (ME 2029)**

**Introduction:**
An overview of composites, Classification & characteristics of composite materials, Application and advantages of composites, Advanced fibers, Fiber properties, Matrix materials, Fillers, Fabrication of polymer metal, ceramic matrix composites

**Elastic behavior of unidirectional lamina:**
Longitudinal behavior of unidirectional composites, Transverse stiffness and strength, Failure modes, Expansion coefficients, Transport properties

**Macro-mechanical behavior of a lamina:**
Stress-strain relation for anisotropic materials, Stiffness, compliances and engineering constants for orthotropic materials, Stress-strain relation for plane stress in an orthotropic material

**Micro-mechanical behavior of a lamina:**
Determination of elastic constants ($E_1$, $E_2$, $\mu_{12}$, $G_{12}$)

**Analysis of laminated composites:**
Classical lamination theory lamina stress-strain behaviour, Stress and strain variation in laminate, Resultant laminate forces and moments

**Test Methods:**
Measurement of physical properties, Measurement of mechanical properties, Flexural properties, Fracture toughness, Impact properties

**Text Book :**

1. Mechanics of Composite Materials, R. M. Jones, Taylor and Francis

**Reference Books :**

1. Composite Materials, K. K. Chawla, SPRINGER-VERLAG.
2. Engineering Mechanics of Composite Materials, I. M. Daniel and Ori Ishai, Oxford University Press.

## ME 4010 METAL FORMING AND CASTING PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. explain the plastic deformation of metals on industrial scale and analyze the behaviour of materials during forming processes.
CO2. explain different types of metal forming process utilized in manufacturing industries.
CO3. understand the concept of technological procedures in industrial manufacturing processes related to pressure shaping of metals and estimate the forming loads and power requirement for different forming processes.
CO4. explain the essence of each technological operation employed in industrial pressure shaping of metals.
CO5. understand the industrial limitations and application of casting.
CO6. integrate knowledge gained in design of gating system in casting.

### Prerequisite: Manufacturing Processes and Automation (ME 3019)

**Forming:** Classification of metal forming processes; basic metal working concepts and plasticity. Elements of theory of plasticity: Stress-Strain / strain rate, strain rate, analysis of strain, Yield stress, yield conditions (Mises/Tresca), anisotropy in yielding, flow behavior of the material and determination of flow stress, instability, workability, residual stresses.

**Analysis of metal flow in metal forming processes:**slip line field theory, Upper bound solution, application to extrusion and indentation problems, Slab methods; Mechanics of rolling, forging, drawing, extrusion. Friction and surface integrity: formability, friction and lubrication in metal working; theories of friction and lubrication, measurement of friction in metal forming, powder forming.

**Casting:** Survey and scope, Solidification and pure metals and alloys, Solidification of actual casting, Risering, Riser design, Risering curves, NRL methods, Feeding distance, Risering of complex casting, Gating, System and their characteristics.

**Gating design:** Types of gates and design considerations, pattern design considerations and testing, various moulding processes, gases in metals, fluidity of metals, casting defects and casting quality measurement and improvement techniques.requisite

**Text Book :**

1. Technology of Metal Forming Processes, S. Kumar, PHI Ltd, 2008
2. Metal Forming: Fundamentals and Applications, T. Altan, S.Oh & H.L. Gegel, American Society for Metals, 1983

**Reference Books :**

1. Metal forming and the Finite-Element Method, S. Kobayashi, S. Oh, T. Altan, Oxford University Press, USA, 09-Mar-1989
2. Casting Technology and Cast Alloys, A.K. Chakrabarti, PHI Ltd., 2005
3. Manufacturing Technology, Vol. – I, P.N. Rao, Tata McGraw Hill, 2007 reprint
4. Plasticity for Mechanical Engineers, W. Johnson & P.B. Mellor, London, Princeton, N.J., Van Nostrand [1962]
5. Principle of Metal Working, G.W. Rowe, ISBN: 8123904282

## ME 4011 THEORY OF MACHINING Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. identify the necessity of manufacturing, purpose and principle of machining, demonstrate tool geometry and convert tool angles from one system to another.
CO2. categorize between orthogonal and oblique cutting and chip flow deviation. Illustrate the mechanism of chip formation in machining ductile and brittle materials and able to conduct complex mechanical engineering experiments to analyze and interpret the experimental data.
CO3. explain the benefits and the purposes of determining cutting forces and able to conduct complex mechanical engineering experiments to analyze and interpret the experimental data.
CO4. assess failure of cutting tools, mechanisms and pattern of tool wear, the essential properties of cutting tool materials, and assess tool life, Machinability & economics of machining.
CO5. conduct advanced conventional machining processes.
CO6. design cutting tools for conventional machining.

**Prerequisite:Metal Cutting and Tool Design (ME 3016)**

**Steriometry of cutting tools:** Basic shape of cutting tools: The wedge, concept of rake & clearance angle & its advantages & disadvantages, systems of description of tool geometry & nomenclature, Tool-in-hand system. Machine Reference system (ASA) & its planes & axes. Tool Reference system (ORS & NRS) & its planes & axes. Interrelation between different systems of rake angle, Conversion of tool angles from one system to another-Master line method.

**Tool Materials:** Requirements of cutting tool materials, Tool material properties, Major classes of tool materials, carbon tool steels, medium alloy steels, high speed steels, cast alloy steels, cemented carbide tools, cermet tools, ceramic tools, CBN tool, and polycrystalline diamond tools. Development of tool materials: coated carbides. CVD & PVD, Indexable inserts, groove geometry, edge preparations, wiper geometry, insert clamping methods, High speed machining, hard machining and comparison with grinding operations, technological processes including hard machining, equipment & tooling for hard machining, characterization of hard machining processes.

**Mechanism of chip formation:** Mechanism of chip formation in machining. Levy lodes theorem, Classification of chips & factors involved in chip formation. Brief description on orthogonal & oblique cutting. Causes & amount of chip flow deviation. Free & Restricted cutting. Geometry & characteristics of chip forms (chip reduction coefficient or cutting ratio, shear angle), Dynamic shear strain in chip formation. Velocity relationship, kronenberg relationship, BUE formation. Effect of cutting variables on chip reduction coefficient. Criticism of single shear plane theory. Chip formation in drilling & milling.

**Mechanics of Metal cutting:** Benefit of knowing & purpose of determining cutting forces. Cutting force components & their significances. Stablers rule, Merchant’s circle diagram (MCD): Assumptions & its use. Frictional & shear plane force systems. Advantageous use of MCD & some limitations of use of MCD. Development of cutting forces under orthogonal & oblique cutting, Stress in conventional shear plane & Energy of cutting process. Ernst-Merchant angle relationship & Lee-shaffers relationship. Obliquity effects in restricted cutting, Effect of wear land on force system, computation of cutting forces & empirical relations, Merchants second solution & machining constant, Bridgeman effect, Design requirements of dynamometer, Dynamometer for turning process, drilling. Design of single point & high production cutting tools, Tool tips, optimization of tool shape & chip breakers.

**Thermal aspects & cutting fluids:** Heat generation in metal cutting, shear plane temperature, average chip tool interface temperature, theory of cutting fluid action at the chip tool interface & techniques of application, hot machining, Dry machining & minimum quantity lubrication (MQL).

**Tool wear, tool life & machinability:** Mechanism of plastic failure, form stability, progressive tool wear & causes, flank & crater wear, Taylors tool life equation, Tool life (Definition in R&D, industries or shop floor), factors affecting tool life, derivation of Taylors tool life equation, woxens tool life equation, experimental techniques for evaluating Taylor exponent, wear measurement methods. Machinability criteria, tests & indices, factors affecting machinability. Role of variation of machining parameters or factors on machinability of work materials.

**Economics of metal cutting:** Different costs involved in machining, Economic tool life: Gilberts model, Optimum cutting speed & tool life for minimum cost & maximum production.

**Text Books :**

1. Metal cutting (Theory & practice), A. Bhattacharya, Central Pub.,1984
2. Fundamental of machining & machine tools, Boothroyd & Knight, Taylor & Francis Pub., 2006

**Reference Books :**

1. Metal cutting (Theory & practice), David A. Stephenson & J.S.Agapiou, Taylor & Francis Pub.2006
2. Metal cutting principles, M.C. Shaw, Oxford Pub., 2005
3. Metal cutting, Trent & Wright, Elsevier Pub.,4$^{th}$ edition, 2000
4. Metal cutting & tool design, V. Arsinov, MIR Pub., 3$^{rd}$ edition, 1996.

## ME 4012 NON- CONVENTIONAL MACHINING AND FABRICATION PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. conceptualize the principle, applications, advantages and limitations of non-conventional Manufacturing processes.
CO2. prepare process plan in context of adaptability of the non-conventional manufacturing processes.
CO3. develop mathematical model and compute material removal rate on different non-conventional manufacturing processes.
CO4. comprehend and apply the science of welding to improve welding process performance.
CO5. evaluate strategies towards mitigating the challenges in non-traditional forming processes.
CO6. select materials and fabrication processes in context of weldability.

### Prerequisite: Manufacturing Processes and Automation (ME 3019)

Need of non-conventional manufacturing processes, Considerations in process selection. Overview of non-traditional machining processes.

Principle, applications, advantages and limitations of non-conventional machining processes (Ultrasonic Machining, Abrasive jet machining, abrasive-water jet machining, ECM, EDM, Wire-EDM, EBM, LBM)

Mechanics of material removal in above processes, Development of mathematical model for computing MRR, Process parameters and their effect on MRR, accuracy and surface integrity

Principle and applications of explosive forming, electro-hydraulic and electro-magnetic forming, fundamentals of contour roll forming and stress forming techniques.

Principle and applications of TIG, MIG, MMAW, $CO_2$ welding, SAW, Resistance, friction, diffusion, Ultrasonic, electron beam and laser welding process and Ultrasonic welding processes

**Text Books :**

1. Modern machining process, P.C. Pandey, H.S. Shan, TMH, 33rd reprint, 2008
2. Non-conventional machining, P.C. Mishra, Narosa publishing house, 3rd reprint, 2005

**Reference Books :**

1. Manufacturing science, A. Ghose & A.K. Mallik, East-west press, 2001
2. Welding & Welding technology, R. Little, TMH, 2004
3. Welding Engineering & Welding Technology, R. S. Parmar, Khanna Publisher, 1997

## ME 4013 THEORY OF ADVANCED FLUID MECHANICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. knowledge of different fluid forces causing the fluid flow and understand the stress tensor
CO2. understand the continuity and momentum equation in fluid motion
CO3. apply the conservation equations in different fluid flow problems
CO4. understand the concepts of boundary layer and its estimation in different flows
CO5. ability to analyze the type of flow, flow over different geometries with stability
CO6. develop the skill to apply analytical and numerical methods used to solve fluid dynamics problems.

### Prerequisite: Fluid Mechanics & Hydraulic Machines (ME 2021)

**Basic Concepts:** Fluid as continuum, Langragian and Eulerian description, stress tensor
Governing Equations of Fluid Motion: Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier Stokes equations, Euler's equation, Bernoulli's Equation.

**Exact solutions of Navier-Stokes Equations:** Couette flows, Poiseuille flows, Unsteady flows, Creeping flows. Potential Flow: Conformal transformation technique; Flow round a sharp edge; Joukowski transformation; Flow around an ellipse; Kutta condition and flow over thin air foil

**Laminar Boundary Layers:** Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation
Elements of Stability: Theory Concept of small-disturbance stability, Orr-Sommerfeld equation, Inviscid stability theory, Boundary layer stability, Thermal instability, Transition to turbulence.

**Turbulent Flow:** Introduction, Fluctuations and time averaging, General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis
Compressible Flows: Speed of sound and Mach number,Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Compressible viscous flows.

**Introduction to Computational Fluid Dynamics (CFD):** Boundary conditions, Basic discretization – Finite difference method, Finite volume method and Finite element method.

**Text Books :**

1. Fluid Mechanics, R.N. Fox and A.T McDonald, John Wiley & Sons, 4th Ed., 1994.
2. Frank M. White, Fluid Mechanics, Tata McGraw-Hill,Singapore,Sixth Edition, 2008.
3. Frank M. White,Viscous Fluid Flow, Third Edition, McGraw-Hill Series of Mechanical Engineering, 2006.

**Reference Books :**


1. Fundamentals of Fluid Mechanics, Schlitching, Springer Links, 2000
2. Advanced Engineering Fluid Mechanics, K Muralidhar and G. Biswas, Second Edition, Narosa, 2005.
3. Boundary Layer Theory, H. Schlichting, Springer Verlag, 2000.
4. The dynamics and thermodynamics of compressible fluid flow, Vol. I & II, A.H. Shapin, The Ronald Press Co., 1955.
5. Foundations of Fluid Mechanics, S.W. Yuan, Prentice Hall of India, 1976.
6. Advanced Engineering Fluid Mechanics, Muralidhar & Biswas, Alpha Science International Ltd, 2005.
7. John D.Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Series of Mechanical Engineering, 1995


## ME 4014 THEORY OF ADVANCED THERMODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. to understand the laws of thermodynamics
CO2. evaluate the useful and non-recovered work of a system during different processes
CO3. determine the different thermodynamic properties of systems
CO4. analyze the basic postulates in irreversible thermodynamics
CO5. aware of molecular-level understanding of key thermodynamic quantities such as heat, work, free energy and entropy
CO6. understand the thermodynamics of combustion

### Prerequisite: Engineering Thermodynamics (ME 2031)

Review of Basic concepts: Laws of thermodynamics, Concept of entropy generation
Thermodynamic Relations: Exergy concept; Physical and Chemical Exergy; Helm Holtz function, Gibb's function, Reciprocity relation, Availability analysis for processes and cycles, Thermodynamic relations, Maxwell's relations, T-ds equations, specific heat relations, energy equation, Joule Thomson effect, Clausius-Claperyon Equation, Criteria for Equilibrium, Gibb's phase rule, The third law of thermodynamics.

Thermodynamics of Mixtures: Thermodynamic properties of homogeneous mixture and multiphase, multi-component systems; Chemical availability, combustion
Irreversible Thermodynamics: Stability; Phase transition; Critical phenomena; Classical irreversible thermodynamics.

**Text Books :**


1. Fundamentals of Classical Thermodynamics, G.J. Van Wylen & R.E. Sonntag, Willy Eastern Ltd. 1989 (Chapters: I, II & III)
2. Principles of Thermodynamics, J. Hsieg, McGraw Hill, 1978.


**Reference Books :**


1. Thermodynamic for Engineers, A.S. Michael, Prentice Hall, 1972.
2. Engineering Thermodynamics, 2nd Ed., P.K. Nag, McGraw Hill, 1995.
3. Thermodynamics, 4th Ed., J.P. Holman., McGraw Hill, 1988.
4. Statistical Thermodynamics, Lee and Sears, Addition Wesley, 1976.
5. Thermodynamics for Chemists, V. Nastrand & S. Glasstne, 1974.
6. Engg Thermodynamics for Engineers, M.D. Burghardt, Harper & Row, NY, 1987.
7. Advanced Thermodynamics for Engineers, K. Wark, McGraw Hill, NY, 1987.
8. Introduction to Chemical Engineering Thermodynamics, K. Smith & H.C. Van Ness, McGraw Hill, 1987.

## ME 4015 THEORY OF ADVANCED HEAT AND MASS TRANSFER Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. understand the application of heat conduction in different heat transfer problems with numerical analysis
CO2. awareness of the boundary layer theory; Be able to solve the external and internal laminar boundary flow and heat transfer.
CO3. understanding of Natural convection and its applications
CO4. understand the basics of radiative heat transfer
CO5. understand the different solution methods of radiative heat transfer problems
CO6. aware of basic principle of mass transfer process and its applications

**Prerequisite: Heat Transfer (ME 3021)**

**Conduction:** Review of heat transfer modes; Heat conduction in anisotropic media, Inverse heat conduction problems, Heat conduction in porous media, Phase change problems, Moving heat source problems, Non-Fourier conduction problems, Numerical analysis of heat conduction problems

**Convection:** Derivation of boundary layer equations by order of magnitude analysis; Solution of boundary layer equations by similarity variable and integral methods; Natural convection in boundary layers; Integral method, Rayleigh-Benard convection, Turbulent heat transfer, and Turbulent Prandtl number.

**Radiation:** Equation of radiative transfer in participating media; Exact solution for one dimensional grey media; Approximate solution methods; Pn and Sn approximate methods; Zonal method; Monte Carlo method for thermal radiation; Experimental techniques on radiation heat transfer.

**Mass Transfer:** Basic definitions; Fick's law of diffusion; Species conservation equation; Solution of one dimensional mass transfer problem, Associated illustrations.

**Text Books :**

1. Fundamentals of Heat and Mass Transfer, F.P. Incropera and D. P. Dewit, John Wiley & Sons, 1998.
2. Principles of Heat Transfer, F Kreith, R. M. Manglik, M. S. Bohn; Cengage Learning; 7th edition, 2010.

**Reference Books :**

1. Heat and Mass Transfer, Y.A.Cengel, Tata McGraw Hill, 2003.
2. Heat Conduction, M. N. Ozisik, John Wiley and Sons, 1993.
2. Convective Heat Transfer, L.C. Burmister, John Willey and Sons, 1983.
3. Essential of Radiation Heat Transfer, C. Balaji, Wiley, 2014.
4. Analysis of Heat and Mass Transfer, E. R. D. Eckert and R.M. Drake, McGraw Hill, 1980.
5. Convective Heat and Mass Transfer, W.M. Kays and W. Crawford, McGraw Hill Inc., 1993

## ME 4016 MECHANICS OF SOLIDS AND STRUCTURES Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. understand the behaviour of material under stress and evaluate principal stresses, their directions and stress invariants.
CO2. draw the Mohr's circle for three dimensional state of stress.
CO3. determine the strain invariants, principal strains and their associated directions.

CO4. understand the generalized Hooke’s law.
CO5. analyze theories of failure and their application in designing the machine components.
CO6. expertise to solve engineering problems like shear stresses in curved beams, axisymmetric bodies.

### Prerequisite: Mechanics of Solids (ME 2029)

**Analysis of Stresses and Strains in rectangular and polar coordinates:** Cauchy’s formula, Principal stresses and principal strains, 3D Mohr’s Circle, Octahedral Stresses, Hydrostatic and deviatoric stress.

**Stress-strain relations for linearly elastic solids:** Differential equations of equilibrium, Plane stress and plane strain, compatibility conditions. Introduction to curvilinear coordinates. Generalized Hooke’s law and theories of failure.

**Bending of straight/curved beams and shear centre:** Effect of shear stresses, Curved beams, Unsymmetrical bending, Shear center and shear flow, thick curved bars.

**Axisymmetric Problems:** Thick and thin walled cylinders, Rotating disks and cylinders. Euler’s buckling load, Beam Column equations. Strain measurement techniques using strain gages, characteristics, instrumentations, principles of photo-elasticity.

**Text Books :**

1. A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.
2. L. S. Srinath, Advanced Mechanics of Solids, 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003.

**Reference Books :**

1. R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill Publishing Co, 1999.
2. A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.
3. S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.
4. P. Raymond, Solid Mechanics for Engineering, 1st Edition, John Willey & Sons, 2001.

## ME 4017 NOISE AND VIBRATION CONTROL ENGINEERING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. model a two degrees of freedom dynamic systems
CO2. find out natural frequencies and mode shapes
CO3. design a dynamic vibration absorber
CO4. measure noise source and calculate the combined effects
CO5. select the best noise control method
CO6. find out physiological effects of noise and vibration level in humans.

### Prerequisite: Kinematics and Dynamics of Machines (ME 2013)

**Multi degrees of freedom systems:** Generalised co-ordinates, constraints, virtual work; Hamilton's principle, Lagrange's equations; Discrete and continuous system; Vibration absorbers; Response of discrete systems - SDOF & MDOF: Free-vibration, periodic excitation and Fourier series, impulse and step response, convolution integral.

**Continuous systems:** Modal analysis: undamped and damped non-gyroscopic, undamped gyroscopic and general dynamical systems. Effect of damping; Vibration of strings, beams, bars, membranes and plates, free and forced vibrations; Raleigh-Ritz and Galerkin's methods. Measurement techniques.

**Basics of noise engineering:** Principles of sound generation and propagation, sound attenuation, sound absorption, sources of industrial noise, effects of noise, noise measurement units and instruments, identification of source of noise.

**Noise Control:** Noise evaluation procedures, acoustical enclosures, design of reactive and absorptive mufflers, active noise control, designing for quieter machines and processes, case studies.

**Text Book :**
1. Vibration and Acoustics by C. Sujatha, TMH

**Reference Books :**
1. F S Tse, I E Morse and R T Hinkle, Mechanical Vibrations, CBS Publ., 1983.
2. J S Rao and K Gupta, Theory and Practice of Mechanical Vibrations, New Age Publication, 1995
3. Harold Lord, Gatley and Eversen, Noise Control for Engineers, McGraw-Hill
4. R. H. Lyon, Machinery Noise and Diagnostics, Butterworths, 1987. 5. J. W. Dally and W.

## ME 4018 THEORY OF ADVANCED MACHINESAND MECHANISMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to

- CO1. know the concept fundamental to the synthesis and analysis of mechanisms.
- CO2. explore synthesis techniques to create potential linkage design solutions for some typical kinematic applications.
- CO3. synthesize linkages for specified output positions analytically.
- CO4. solve the synthesis of spatial mechanism by using different technique.
- CO5. know the control systems and components of Robot.
- CO6. solve mathematical models of active mechanism by using computer aided methods.

**Prerequisite: Kinematics and Dynamics of Machines (ME 2013)**

**Review of Kinematic synthesis:** Graphical and analytical methods, two and three precision point synthesis. Function, Path and motion generation by 4-bar linkage: four and five precision point synthesis.

**Synthesis of planer mechanisms:** Geared linkages, path and motion generation by Watt and Stephenson's six-bar chain, precision point synthesis Vis some vis optimization methods. Newton-Raphson solution Method for four bar linkage.

**Synthesis of spatial mechanisms:** displacement analysis, matrix method of analysis, Synthesis of 4 – revolute spherical mechanisms, synthesis of 2- revolute 2 spheric- pair mechanisms.
**Application to robotics:** Manipulator Dynamics and Controls, Computer-Aided Methods for setting and solving Mathematical models of active mechanisms.

**Text Book :**
1. Norton, R.L., 1999, "Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and machines", 2nd Ed., WCB McGraw-Hill.

**References Books :**
1. Hartenberg, R.S., Denavit, J., 1964, "Kinaematic Synthesis of Linkages", McGraw-Hill, New York.
2. Sandor, G.N., Erdman, A.G., 1984"Advanced Mechanism Design Analysis and Synthesis", Vol. - 1, Prentice-Hall, New Jersey.

## ME 4061 OPERATIONS RESEARCH Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. convert the problem into a mathematical model& solve the mathematical model manually
CO2. understand the problems mentioned using linear programming.
CO3. understand the mathematical tools that are needed to solve optimization problems.
CO4. understand concept of assignment problem.
CO5. apply the transportation problem in context of real life.
CO6. propose the best strategy using decision making methods under uncertainty and game theory

### Prerequisite: Nil

**Linear Programming:** Mathematical formulation of the problem, graphical solution method, general linear programming problem.

**Simplex & Duplex Method:** Introduction, fundamental properties of solution, Simplex method, Artificial Variable Method (Big-M method) computational procedure, concept of duality in simplex method, dual simplex algorithm.

**Transportation Problem:** Initial basic feasible solution, transportation table moving towards optimality, degeneracy in transportation problem.

**Assignment & Routing Problem:** Assignment problem, assignment algorithm, routing problems.
**Job sequencing:** Johnson's rule (n-job two machine, n-job three machine and n-job m machine)
**Game Theory:** Introduction, classification, Saddle Point, Dominance.

**Text Book :**

1. Operations Research by P K Gupta, D.S. Hira, S Chand & Sons.

**Reference Book :**

1. Operations Research by Kanti Swaroop, P K Gupta, Manmohan, S Chand & Sons.

## ME 4070 MANUFACTURING PROCESSES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand and select the casting process for a particular industrial product
CO2. identify the suitable rolling process and sheet metal for different material and product.
CO3. understand the forging extrusion process for various components and its application
CO4. understand the various welding processes and its applicatiopn
CO5. understanding the various conventional machine tools and its related accessories.
CO6. applying the different non- traditional machining processes for up growing high strength materials

### Prerequisite: Nil

**Foundry Process:**

Pattern making, pattern materials, allowances, types of pattern, sand casting types, sand cast, moulding procedure, types of sand, gates and riser (basic design considerations) essential properties of moulding sand, core making, types of cores. Essential qualities, core mixtures and binder sand testing, Precision investment casting, shell moulds, centrifugal casting processes, dies casting.

**Metal Working Process:**

Hot and cold working of Metals: Basic Principles of hot and cold working of metals. Types of Rolling, Rolling equipment hot and cold rolling, Smith forging, Drop forging, press forging & Machine forging, Direct, Indirect and impact extrusion and their applications, Wire and rod drawing, Tube drawing, Process variables in drawing process. Deep drawing. Blanking and piercing,

**Fabrication Processes:**

Classification, types of welding joints, Gas welding: principles, types of flames, equipment, techniques of gas cutting. Electric Arc Welding: Principles of electric welding equipment and electrodes. Principles of Inert Gas Welding: TIG, MIG, sub-merged arc welding. Brazing and Soldering. Welding defects and inspection.

**Conventional Machine Tools**

Conventional machining processes. Turning; Taper turning: Shaping; Quick return Mechanisms. Milling; Up milling, down milling Grinding; Surface grinding, Centreless grinding, grinding wheel specification, wheel truing and dressing. Finishing Processes: Reaming and boring, Lapping, Honing, Super finishing.

**Non-conventional machining:**

Classification and principles of non-conventional machining processes such as AJM, EDM, ECM, LBM and EBM.

**Text Books :**

1. Manufacturing Technology (Part I), P.N. Rao (Tata Mc-Graw Hill, Publication. Co.Ltd.)
2. Manufacturing Processes, J. P. Kaushish, PHI (2nd Edition)

**Reference Books :**

1. Manufacturing Technology: Materials, Processes and Equipment: Helmi A. Youssef, Hassan A. El. Hofy and M.H. Ahmed, CRC Press, 2015
2. Principle of Manufacturing Materials and Processes: J.S. Cambell, TMH
3. Welding & Welding Technology - R. Little, TMH, 43rd reprint, 2014
4. Manufacturing Science: A. Ghosh & A.K. Mallick, EWP

## ME 4072 INDUSTRIAL AUTOMATION AND ROBOTICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the importance of automation in the of field machine tool based manufacturing
CO2. understand knowledge of various elements of manufacturing automation – CAD/CAM, sensors, pneumatics, hydraulics and CNC
CO3. get a comprehensive picture of computer based automation of manufacturing operations
CO4. understand the basics of product design and the role of manufacturing automation
CO5. understand the classification of Robots
CO6. identify the trajectory planning and control of Robots.

**Prerequisite: Nil**

**Course Contents:**

Introduction: Why automation, Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools. Flexible automation: Computer control of Machine Tools and Machining Centers, NC and NC part programming, CNC-Adaptive Control, Automated Material handling. Assembly, Flexible fixturing. Computer Aided Design: Fundamentals of CAD - Hardware in CAD-Computer Graphics Software and Data Base, Geometric modeling for downstream applications and analysis methods; Computer Aided Manufacturing: CNC technology, PLC, Micro-controllers, CNC Adaptive Control
Low cost automation: Mechanical & Electro mechanical Systems, Pneumatics and

Hydraulics, Illustrative Examples and case studies
Introduction to Modeling and Simulation: Product design, process route modeling, Optimization techniques, Case studies & industrial applications.

Robot Introduction – Definition – Classification and Specification. Work envelops and other basic parameters of Robots. Mechanics: Kinematic Parameters and Modeling- Direct and Inverse Kinematics - Differential motion and jacobians – Introduction to Dynamics Path planning – Trajectory Planning and Control – Slew, Joint interpolated and straight line motion.

**Text Books :**

1. Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall
2. Robotics Technology & Flexible Automation, S.R. Deb & S. Deb, Tata McGraw Hill, 2010

**Reference Books :**

1. Yoram Koren, Computer control of manufacturing system, 1st edition
2. Ibrahim Zeid, CAD/CAM: Theory & Practice, 2nd edition.

## ME 4074 QUALITY ENGINEERING Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. compare and appreciate the contributions of Quality Gurus.
CO2. know the concept about ISO, Six Sigma and TQM
CO3. understand quality engineering methods and tools.
CO4. apply statistical methods to improve quality of products and services
CO5. know about acceptance sampling, OC Curve
CO6. have a working knowledge of the techniques of reliability engineering

**Prerequisite: Nil**

**Introduction to Quality:** Defining Quality, Quality as a Management Framework, some important philosophies and their impact on quality (Deming, Juran, Crossby), Quality cost, Quality losses, link between Quality and productivity

**Tools for Quality Control:** Basic tools of quality (the stem and leaf plot, histogram, box plot etc.), ISO 9000:2000, Six Sigma, Total quality management, introduction to total quality management, the evolution of total quality, Statistical methods for Quality control and improvement.

**Statistical Process control**: Process capability analysis using histogram, Use and interpretation of Cp, Statistical Process Control, Specification & Limits, Charts for variables & attributes, Process Control (X, R, P, C chart), Summary of Control Chart Construction, Designing Control Charts.

**Sampling Plan:** Design of single sampling plan. Double, multiple and sequential sampling plans, O.C. curve, Acceptance quality Level, Lot tolerance percentage defective.

**Reliability:** Reliability analysis and predictions, Bath-Tub Curve, Exponential and Weibull distribution in modelling reliability, System reliability. ANOVA.

**Text Book :**

1. Fundamental of Quality Control and Improvement, Mitra A, PHI

**Reference Books :**

1. Total Quality Management, J.R. Evans – Cengage
2. Quality Management, Bedi, Oxford
3. Quality Management, Gitlow Oppenheim Levine, TMH

## ME 4076 PRODUCTION PLANNING AND CONTROL Cr-3

**Course outcome:** At the end of the course, student will be able to:

CO1. describe (identify/write) the various components that make up the manufacturing planning and control system and the interaction among them.
CO2. select the best method and different timing using time study procedure.
CO3. know about the factors affecting plant location and the techniques used for plant layout
CO4. develop the algorithms that are appropriate for solving single-machine, two-machine, parallel-machines and flow shop scheduling problems.
CO5. show how (i) the material requirement plans, manufacturing resource plans, and capacity requirement plans can be developed, and (ii) lot sizing decisions can be made for a manufacturing system
CO6. develop the models that are applicable for inventory management, including those for quantity discounts, safety stocks, and order quantity and reorder point interactions.

**Prerequisite: Nil**

**Overview of Operations Management**

Introduction, Responsibilities of Production Manager, Strategic Decisions in Operations, Manufacturing Vs. Service Operation, Types of Production processes (Project/Job, Batch, Mass/Line, Continuous), Concept of FMS (Flexible Manufacturing System), Role of Production, Planning & Control (PPC), New Product Development & Process Design,

**Work Study, Aggregate Planning**

Introduction of Work Study, Method study Procedure, Principles of Motion Economy, Stop Watch Time Study Procedure, Importance of Rating & Allowances in Time Study, Aggregate Planning: Relevant cost; Evaluation of strategic alternatives (Level, Chase and Mixed),

**Facility Location and Layout, Scheduling**

Importance & Factors affecting the Plant Location, Single and Multi-facility location Techniques (Centroid and Minimax method), Plant Layout & its classification, Relationship Diagram & Block Diagramming, Assembly Line of Balancing.

**Inventory Control**

Inventory Control: Relevant Costs, P & Q Systems of Inventory, Basic EOQ Model, and Model with Quantity discount, Economic Batch Quantity. Safety Stock, Reorder Point, ABC Analysis, Material Requirement Planning,

**Text Book :**

1. Production and Operation Management, R. Paneerselvam, Third Edition,2013

**Reference Books :**

1. Production and Operation Management, K. Aswathappa K. Shridhara Bhat

2.S.N. Charry, Production and operations management, TMH

**ME 4078** **WORK SYSTEM DESIGN** **Cr-3**

**Course outcome:** At the end of the course, student will be able to:

CO1. calculate the basic work content of a specific job for employees of an organization.
CO2. analyze and calculate the level of risk in a job causing stress
CO3. rate a worker engaged on a live job and calculate basic, allowed and standard time
CO4. analyze the existing methods of working for a particular job and develop an improved method through questioning technique.
CO5. inculcate analyzing skills among the students with respect to work place design, working postures and lifting tasks
CO6. devise appropriate wage and incentive plan for the employees of an organization

**Prerequisite: Nil**

**Productivity and Human factor in work-study**

Definition, reasons for low productivity, methods to improve productivity, work-study and productivity Relationship of work-study man with management, supervisor & workers, qualities of a work-study man.

**Method-study**

Definition, objectives, step-by-step procedure, , charts and diagrams for recording data. Like outline process charts, flow process charts, multiple activity charts, two handed process chart, string diagram, travel chart, cycle graph, Chrono-cycle graph, therbligs, micro motion study and film analysis, Simo chart, principles of motion economy. Development and installation of new method

**Work-Measurement**

Definition, various techniques of work-measurement work-sampling, stopwatch time study & its procedure, Job selection, Equipment and forms used for time study, rating, methods of rating, allowances and their types, standard time, numerical problems, predetermined - time standards and standard data techniques.

**Incentive**

Meaning, objectives of an incentive plan, various types of incentive plans Assessment of occupational exposure to noise, heat stress and dust. Effect of vibration/ noise, temperature, illumination and dust on human health and performance.

**Text Book :**

1. Marvin E, Mundel & David L, "Motion & Time Study: Improving Productivity", Pearson Education,2000.

**References Books :**

1. Work Measurement and Methods Improvement, Lawrence S. Aft, John Wiley and Sons, New York, 2000
2. Benjamin E Niebel and Freivalds Andris, "Methods Standards & Work Design", Mc Graw Hill, 1997.
3. International Labour organization, "Work-study", Oxford and IBH publishing company Pvt. Ltd., N.Delhi, 2001.

# MECHANICAL ENGINEERING (AUTOMOBILE)

## B. Tech in Mechanical Engineering (Automobile):

### Program Educational Objectives(PEOs):

The B. Tech program in Mechanical Engineering (Automobile) aims to prepare students so that they shall get widely employed in automobile or allied disciplines and adhere to professional ethics in engineering practice. The program also aims to prepare the graduates with the following objectives:

1. Graduates shall be able to provide solutions to automobile engineering problems involving design, manufacturing, heat power, and operational management issues.
2. Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.
3. Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

### Program Outcomes(POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

#### Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Join a technical workforce as successful professionals in a wide range of automobile engineering and related domains.
n) Pursue advanced degrees in engineering, business, or other professional fields.
o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

## AE2002 AUTOMOTIVES, SUSPENSION AND TRANSMISSION SYSTEM Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic structure of different automobile
CO2. select most suitable Drive train, Steering System, Brakes and Suspension System for new automobile
CO3. design and analysis of gear ratios in transmission system.
CO4. model and analysis of springs and brakes used in different automobiles
CO5. identify and solve problems related to Steering System.
CO6. identify and solve problems related to Brakes, and Suspension.

**Prerequisite: Nil**

**Introduction:**

History of automobile, Classification of automobile: Motor Vehicle Act, Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Testing of vehicles frames. Unitized frame body construction, Loads acting on vehicle frame.

**Transmission:**

Layout of power transmission system, requirement of transmission system Clutch: Need of clutch. Types of clutches, principle, construction, torque capacity, clutch operating system. Performance curve.

**Gear Box:**

Requirement of gearbox, different types of gear box: sliding, constant mesh and synchromesh gear box; Construction details of gear boxes; Gear ratios of vehicle Gear box operation principle.

**Hydro-dynamic drive:**

Fluid coupling, Principle and operation Torque capacity Performance characteristic. Torque converter Construction, principle of operation, Torque capacity multi stage torque converter Performance behavior.

**Automatic transmission:**

Construction and operating principle, 4 forward and reverse & 3 forward and reverse. Over drive unit and its operation.

**Electrical drive:**

Construction and operation Electric drive Ward Leonard control system, construction and operation, advantages and disadvantages.

**Front axle and Steering System:**

Types of front axle. Constructions details. Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry. Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power and Power assisted Steering.

**Drive Line:**

Effect of driving thrust and torque reactions; Hotchkiss drive, torque tube drive and radius rods; Propeller shaft. Universal joints; Constants velocity universal joints; Front wheel drive. Final Drive Differential: Different types of final drive. Worm and worm wheel, Straight bevel gear, Spiral bevel gear and hypoid gear final drives. Differential principles; Construction details of differential unit. Differential locks; Differential housing.

**Rear Axles:**

Construction of rear axles. Types of loads acting on rear axles. Full floating. Three quarter floating and semi floating rear axles; Rear axle housing; Construction of different types of axle housings.

**Suspension System:**

Need of suspension system, types of suspension, suspension springs, constructional details and characteristics of leaf, coil and torsion bar springs. Independent suspension; Rubber suspension, Pneumatic suspension, Shock absorbers.

**Braking System:**

Classification of brakes, drum brake & disc brakes. Constructional details; Theory of braking. Mechanical hydraulic and Pneumatic brakes. Servo brake. Power and power assisted brakes different types of retarders like eddy current and hydraulic retarder. Anti-lock braking systems.

**Text Book :**

1. Automobile Engineering Vol-I, Kripal Singh, Standard Publisher Distributor, 2017.

**Reference Books :**

1. A Text book of Automobile Engineering, Volume-II. P.S. Gill, S.K. Kataria & Sons, First Edition, 2012
2. Basic automobile Engineering, Nakra C. P., Dhanpat Rai Publication Co. Ltd 7$^{th}$ edition, 2005
3. Automobile Engineering, A. De, Galgotia Publication Pvt. Ltd. 2004.

## AE 2004 AUTOMOTIVE MECHATRONICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the functions of a basic microcomputer
CO2. select appropriate microcomputer to be used in an automobile
CO3. use different sensors and actuators for various automotive systems.
CO4. model the electronic engine management systems.
CO5. adopt the electronic vehicle management and special instrumentation systems.
CO6. perform ECU diagnostics

### Prerequisite: Principle of Electronics Engineering (EC 2025)

**Introduction to microcomputer:**

Microcomputer: Buses, memory, timing, CPU registers; Microprocessor architecture: Initialization, operation codes, program counter, branch and jump instructions, subroutine. Analog to digital converters and Digital to analog converters, sampling, polling and interrupts, digital filters, lookup table.

**Sensors and actuators:**

Speed sensors, Pressure sensors: Manifold Absolute Pressure sensor, knock sensor, Temperature sensors: Coolant and Exhaust gas temperature, Exhaust Oxygen level sensor, Position sensors: Throttle position sensor, accelerator pedal position sensor and crankshaft position sensor, Air mass flow sensor. Solenoids, stepper motors and relays.

**Electronic engine management system:**

Electronic engine control: Input, output and control strategies, electronic fuel control system, fuel control modes: open loop and closed loop control at various modes, EGR control, Electronic ignition systems; Spark advance correction schemes, fuel injection timing control.

**Electronic vehicle management system**:

Cruise control system, Anti-lock braking system, electronic suspension system, electronic steering control, traction control system, Transmission control, Safety: Air bags, collision avoiding system, low tire pressure warning system.

**Other instrumentation systems:**

Input and output signal conversion, multiplexing, fuel quantity measurement, coolant temperature and oil pressure measurement, display devices- LED, LCD, VFD and CRT, Onboard diagnostics (OBD), OBD-II, off board diagnostics, telematics, GPS navigation, the GPS system structure.

**Text Book :**


1. Understanding Automotive Electronics, William B. Riddens, Butterworth Heinemann, Woburn, 5th edition 1998.


**Reference Books :**


1. Embedded System – Architecture, Programming, Design, Rajkamal, Tata McGraw Hill, 2003.
2. Instrumentation Devices and Systems, Raman, C.S., Sharma, G.R., Mani, V.S.V., Tata McGraw Hill, New Delhi, 1983.
3. Understanding Automotive Electronics, Bechhold, SAE- 1998.
4. Embedded System Design – A Unified hardware & Software Introduction, Frank Vahid, John Wiley, 2002.


## AE 3002 VEHICLE MAINTENANCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. keep record of vehicle operation and maintenance, service schedules.
CO2. know the best vehicle maintenance procedures.
CO3. acquire skills in handling situations where the vehicle is likely to fail.
CO4. repairing and overhauling procedure.
CO5. enabling students to operate and manage maintenance workshops.
CO6. inspect and diagnose the problems occurring in the various components of the vehicle.

**Prerequisite: Nil**

**Maintenance records and Schedules:**

Importance of maintenance; Scheduled and unscheduled maintenance; Preparation of check lists. Chassis lubrication; Cost effectiveness. Pre-trip; Inspection forms; Log books; Trip sheets; Other maintenance record forms.

**Maintenance, Repair and Overhauling of engine:**

Dismantling of engine components; Cleaning methods; Visual inspection and dimensional check of various engine components. Minor and Major tune up Reconditioning; repairing methods of engine components; Assembly procedure; Special tools used for maintenance, repair and overhauling.

**Maintenance, Repair and Overhauling of Chassis, Drive Line components:**

Clutch - Mechanical, Automatic types Gear box - Mechanical Automatic types. Final reduction. Propeller shaft. Front and rear suspension systems. Rigid and independent types; Brakes systems: Hydraulic, Servo, Air brakes; Air bleeding. Steering system; Tyres: Wheel balance and wheel alignment.

**Maintenance, Repair and Servicing of Electrical System:**

Battery - Testing methods. Starter motor; Charging system - DC Generator, AC Alternator, Regulator, Ignition systems - Coil ignition, Transistor assisted ignition, Capacitor discharge ignition. Electric Horn, Wiper, Flasher, Electric fuel pump, Gauges. Lighting system; Head lights focusing; Wiring system.

**Maintenance, Repair and Servicing of Cooling System:**

Cooling system - types, water pump, radiator, thermostat valve. Anti-corrosion and anti-freezing solutions.

**Lubrication system, Fuel system and Body:**

Lubricating system - Oil analysis, oil topping up, oil change, oil filters, oil relief valve. Fuel system: Petrol, diesel fuel feed system components; Body repair tools, minor body panel beating, tinkering, and soldering, polishing, painting; Door locks mechanism. Window glass actuating mechanism.

**Text Book :**


1. Fleet Management, John Doke, McGraw Hill Co, 1984.


**Reference Books :**


1. Motor vehicle engine servicing, Judge A.N., 3rd Edition, Pitman Paperback, London, 1969.
2. Maintenance of High speed diesel engines, Judge. A.W., Chapman Hall Ltd., London, 1956.
3. Diesel Engine operation and Maintenance, Maleev V.L., Maintenance, McGrawHill Book Co., New York, 1954.


## AE3003 ELECTRICAL AND HYBRID VEHICLE TECHNOLOGY Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand electric vehicle technology and hybrid vehicles
CO2. understand the basics of hybrid and electric drive trains
CO3. perform design calculations of hybrid system under study
CO4. understand the various vehicle power sources in hybrid vehicle technology
CO5. evaluate drive train system and energy storage system of electric and hybrid vehicle
CO6. create a low cost and energy efficient concept car following international regulations

### Prerequisite: Nil

**Electric Vehicle Propulsion and Energy Sources:**

Introduction Electric Vehicles, Vehicle Mechanics - Kinetics And Dynamics, Roadway fundamentals, Propulsion System Design - Force Velocity Characteristics, Calculation of Tractive Power And Tractive Energy, Electric Vehicle Power Source – Battery Charge Capacity, State of Charge and Discharge, Specific Energy, Specific Power, Ragone Plot, Battery Pack Design, Battery Modelling - Run Time Battery Model, First Principle Model, Battery Management System- SOC Measurement, Battery Cell Balancing. Traction batteries-Nickel metal hydride Battery, Li-Ion, Li-Polymer Battery.

**Electric Vehicle Power plant and Drives:**

Introduction Electric Vehicle Power Plants, Induction Machines, Permanent Magnet Machines, Switch Reluctance Machines, Power Electronic Converters-DC/DC Converters - Buck Boost Converter, Isolated DC/DC Converter, Two Quadrant Chopper And Switching Modes, AC Drives- PWM, Current Control Method, Switch Reluctance Machine Drives - Voltage Control, Current Control

**Electric and Hybrid DriveTrains:**

Introduction Hybrid Electric Vehicles, History and SocialImportance, Impact of Modern Drive Trains In Energy Supplies, Hybrid Traction And Electric Traction, Hybrid And Electric Drive Train Topologies, Power Flow Control And Energy Efficiency Analysis, Configuration And Control of DC Motor Drives And Induction Motor Drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drives, Drive System Efficiency

**Hybrid Vehicles Combinations:**

Parallel Hybrid, Series Hybrid -Charge Sustaining, ChargeDepleting, Hybrid Vehicle Case Study –Toyota Prius, Honda Insight,Chevrolet Volt, 42V-72V System for Traction Applications, Lightly Hybridized Vehicles and Low Voltage System, Electric Vehicle Case Study - GM EV1, Nissan Leaf,Mitsubishi Miev, Tesla Model-S, Hybrid Electric Heavy Duty Vehicles.

**Electric and Hybrid Vehicle Design:**

Introduction to Hybrid Vehicle Design, Matching the Electric Machine and the Internal Combustion Engine, Sizing of Propulsion Motor, Power Electronics, DriveSystem. Selection of Energy Storage Technology,Communications, Supporting Subsystem, Energy Management Strategies in Hybrid and ElectricVehicles - Energy Management Strategies- Classification,Comparison, Implementation

**Fuel Cell vehicles:**

PEM fuel cell, Fuel cell stack, Toyota FCV, Fuel Cell Heavy DutyVehicles

**Text Book :**

1. Electric and Hybrid vehicles Design Fundamentals,Iqbal Husain, CRC Press, second edition 2013

**Reference Books :**

1. Electric vehicle technology Explained, James Larminie, John Lowry, second Edition,Wiley 2015
2. Hand book of Automotive Power Electronics and Motor Drives*,* Ali Emadi, CRC Press 2005
3. Introduction to Hybrid Vehicle System Modeling and Control, Wei Liu, Wiley 2015

## AE 3004 DESIGN OF AUTOMOTIVE COMPONENTS Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analyze and apply the design principle to study basic automotive components
CO2. design and determine geometrical dimensions of a component subjected to complex stress system.
CO3. implement and design the domain knowledge in practical systems.
CO4. design the component subjected to static and variable loads.
CO5. determine the life of component subjected to complex loading.
CO6. design and assemble complex machine parts

**Prerequisite: Design of machine elements – I (ME 3023)**

**Introduction:**

Stress concentration, Endurance limit, Fracture and Fatigue based design

**Design of Shaft:**

Materials used for shaft, manufacturing of shaft and types of shaft, Standard size of transmission shafts, stresses in shafts, Maximum permissible working stresses for transmission for transmission shafts, Design of shaft- shaft subjected to twisting moment only, shaft subjected to bending moment, shaft subjected to combined twisting moment and bending moment, Design of shaft subjected to fluctuating load, axial load in addition to combined torsion and bending loads, Design of shaft on the basis of rigidity

**Design of Cylinder and Piston:**

Introduction to I.C engines and components, Materials selection based on engine components and its function; Design of cylinder block and cylinder. Description on function of piston in an I.C engines-Design of piston, Description on piston rings-compression ring-oil rings, piston failure

**Design of Connecting Rod:**

Introduction - material selection for connecting rod, Design of connecting rod small end, Design of connecting rod big end and shank design, Design of connecting rod-cap bolt design, Design of connecting rod-cap bolt design

**Design of Crankshaft:**

Introduction about crank shaft and its function in an I.C Engine;Materials selection for crankshaft, Balancing of I.C. engines, MI of Crankshaft, significance of firing order; Design of crankshaft under bending and twisting; balancing weight calculations. Development of short and long crank arms; Front and rear end details. Matrix from element stiffness

**Design of Cylinder Head and Valve ActuatingMechanisms**

Introduction about cylinder block and head in an I.C Engine, Design of cylinder block head, bolt loads and gasket, Design of valve spring and valves, Design of push rod

**Text Book :**

1. Design of Machine Elements, V.B. Bhandari,Tata McGraw Hill, 3rd Edition.
2. Design Data Hand Book, S. Md. Jallaludeen, Anuradha Pub.

**Reference Books :**

1. Machine Design, P.C. Sharma, K. Agarwal, S K Kataria and Sons, 2010.
2. Machines Design Data Book, P.S.G. College of Technology, Coimbatore.
3. Mechanical Engineering Design, Shigley J E, Mischiee C. R.; Tata McGraw Hill
4. Maleev and Hartman's Machine Design, CBS; 5th edition, 2011.

## AE 3011 FUELS AND EMISSIONS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the need of different types of Alternative fuels in Automobiles.

CO2. predict Performance of Alternative Fuels used in Automobiles.

CO3. model the mechanism of pollutant formation in engines.

CO4. predict the efficacy of policy to curb pollution in India.

CO5. understand different standards of automobile emission measurement.

CO6. select a suitable exhaust treatment and control technique to curb harmful emission.

**Prerequisite: Nil**

**Introduction:**

Conventional fuel, calorific value, Bomb calorimeter and Gas calorimeter, octane and cetane number, viscosity, flash point, fire point, cloud point, pour point, petrol and diesel additives.

General Scenario on automotive Pollution, Pollutants: sources; formation; effects; transient operational effects on pollution.

**Engine Combustion and Pollutant Formation:**

Unburnt hydrocarbon, Carbon monoxide, Oxides of nitrogen, Sulfur dioxide, Particulate Matters, Aldehyde emissions, Effect of operating variables on emission formation.

**Emission Control Efforts:**

Policy on pollution control; Supply of fuel; establishment of national test centers; Improvement of road networks.

**Alternate Fuels:**

Estimation of petroleum reserve; need for alternate fuels; Merits & Demerits and uses of CNG, LPG, Biogas, Alcohols, Hydrogen, Bio-fuels, Transesterification of biodiesel, Electric Car, Solar Car.

**Emission Standards:**

Evaluation of Emission Standards – Mandatory Tests for Emission measurement; Type Approval & Production Conformity Tests; Driving Cycles, Bharat Stages & Euro emission standards.

**Test Procedure & Instrumentation for Emission Measurement:**

Test procedures- Measurements of invisible emissions -ORSAT apparatus, NDIR analyzer, Flame ionization detectors, Chemiluminescent analyzer, Gas analyzer, Measurements of visible emissions – Comparison methods & Obscure methods - Smoke meters, Emission standards.

**Control Techniques for SI and CI Engine:**

Design changes, optimization of operating factors, Control of Crankcase emission, Evaporative emission, Exhaust emission - exhaust gas recirculation, air injector PCV system, thermal reactors, catalytic converters.

**Text book :**


1. Automotive Engineering Fuels and Emissions (Classroom & Shop Manual), Ollembeak, CENGAGE Learning


**Reference Books :**


1. Engine Emissions, B.P. Pundir, Narosa Publishing House, 2007.
2. Internal Combustion Engines, V. Ganesan, Tata McGraw Hill, 2004.
3. Automobile Engineering, K.K. Ramalingam, Scitech Publications Pvt. Ltd., 2005

**AE3021 TRACTOR AND FARM EQUIPMENTS Cr-3**

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify different component and part of tractor and power tiller.
CO2. select Farm Equipment for land preparation.
CO3. do trouble shooting of tractor power tiller.
CO4. evaluate proper engine and power train for tractor
CO5. select proper attachment for lifting farm produce with minimum intervention
CO6. use PTO for different applications to suite Indian agriculture

**Prerequisite: Nil**

**General Design of Tractors:**
Classification of Tractors; Main components of Tractor; Safety Rules; Difference with regular automobile; Bharat emission standard for Diesel Tractors

**Control of the Tractor and Fundamentals of Engine Operation:**
Tractor controls and the starting of the tractor engines; Basic notions and definition-Engine cycles; Operation of multi-cylinder engines; General engine design; Basic engine performance characteristics.

**Engine Frame Work and Valve Mechanism of Tractor:**
Cylinder and pistons-Connecting rods and crankshafts Engine balancing – Construction and operation of the valve mechanism-Valve mechanism components – Valve mechanism troubles.

**Cooling system, Lubrication System and Fuel System of a Tractor:**
Cooling system; Classification; Liquid cooling system; Components, Lubricating system servicing and troubles; Air cleaner and turbocharger; Fuel tanks and filters; Fuel pumps.

**Farm Equipments:**
Working attachment of tractors; Farm equipment; Classification; Auxiliary equipment; Trailers and body tipping mechanism; Power Take off, Basics of hydraulics and pneumatics, valves and actuators, electro pneumatics.

**Text Book :**
1. Farm Tractor-Maintenance and Repair, S.C. Jain and C.R. Rai, McGraw-Hill Education.

**Reference Books :**
1. Tractor and Automobiles, Rodichev and G. Rodicheva, Mir Publishers, 1987.
2. Design of Automotive engines for tractor, Kolchin. A., and V. Demidov, Mir Publishers, 1972.

## AE 3022 TWO AND THREE WHEELERS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select best components of two and three wheeled vehicles given application.

CO2. design and develop a two wheeler or a three wheeler

CO3. do trouble shooting of two-wheeler and three-wheeler.

CO4. evaluate different models of two-wheeler and three-wheeler existing in India

CO5. analyze the drive train of electric scooter and e-rickshaws

CO6. evaluate the different models of pick up and vans

**Prerequisite: Nil**

**Power Unit:**

Two stroke and four stroke SI engine, merits and demerits. Symmetrical and unsymmetrical port timing diagrams. Types of scavenging processes merits and demerits, scavenging efficiency. Scavenging pumps. Rotary valve engine. Fuel system. Lubrication system. Magneto coil and battery coil spark ignition system. electronic Ignition system. Starting system. Kick starter system.

**Chassis and Sub-Systems:**

Mainframe, its types. Chassis and shaft drive. Single, multiple plates and centrifugal clutches. Gear box and gear controls. Front and rear suspension- systems. Shock absorbers. Panel meters and controls on handle bar.

**Brake and Wheels:**

Drum brakes, Disc brakes, front and rear brake links layouts. Spoked wheel, Cast wheel. Disc wheel. Disc types. Tyres & tubes.

**Two wheeler dynamics:**

Stability of two wheelers on straight and curved path. Chassis dynamometer

**Two Wheelers:**

Case study of major Indian models of motorcycles; Bajaj, Vespa, Lambretta scooters. Enfield, TVS-Suzuki, Hero-Honda, Yamaha RX-100, Kawasaki Bajaj Motor cycle. Kinetic Spark, Hero Majestic, TVS mopeds. Servicing and maintenance.

**Three Wheelers:**

Case study of Indian Models. Front engine and rear engine. Auto rickshaws. Pickup van. Delivery Van and Trailer, stability of three wheelers.

Latest developments in two and three wheelers; CNG for three wheelers, Electric and hybrid three wheeler, e-rickshaw and pick up van

**Text Book :**

1. Two and Three Wheeler Technology, D.U. Panchal, PHI Learning 2015.

**Reference Books :**

1. Two Wheelers, K. K. Ramlingam, SCITECH
2. Automobile Engineering vol. I & II, Gupta, Satya Prakashan, 1st edition Reprint 2006.

## AE 3023 OFF-ROAD VEHICLES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select off road vehicles for different constructional and land preparation activities.
CO2. gain knowledge of various types of off road vehicles and their application
CO3. select prime components' operating principle
CO4. evaluate the efficacy of hydraulic systems used in off road vehicles
CO5. do trouble shooting of off road vehicles.
CO6. select proper maintenance schedule and mechanism of off road vehicles

**Prerequisite: Nil**

**Introduction:**

Classification of off road vehicles and their application Excavator: Different types of Shovel and Drag-line, their construction, operating principles, operating cycles. Production capacity and cost of production.

**Transport Equipment:**

Various types of Dumpers, Main system, components and Carrying capacity of Dumper. Chassis of dumper, mobility calculation

**Road making and maintenance Machines:**

Different types of Dozer, Grader, and their construction. Operating principles, Production capacity and application mechanism.

**Other equipment:**

Scraper and front end loader, their construction and operation.

**Maintenance**:

Maintenance aspect of Off Road vehicles. Maintenance of hydraulic and pneumatic equipment, Bharat emission standards for diesel construction machinery

**Text Book :**

1. Latest Development of Heavy Earth Moving Machinery, De, A., Annapurna Publishers, Dhanbad 1995

**Reference Books :**

1. Road Making Machinery, Abrosimov K., Bromberg and KatayevF., Mir Publishers, Moscow1971.
2. Moving the Earth, Nichols, Herber L (Jr.), Galgotia Publishing House, New Delhi, 1962.
3. Digging of soils by earthmover with Powered Parts, Rudnev, V.K., Oxonian Press, 1985

## AE 3031 SIMULATION OF IC ENGINE Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand combustion phenomena and measurements of URP and HRP
CO2. simulate SI engine Air flow
CO3. acquire knowledge about pressure crank angle and engine performance
CO4. understand simulation of two stroke SI engine Performance
CO5. gain knowledge about Diesel engine performance and Simulation
CO6. validate the Computer Code by comparing with experimental data on IC engine

**Prerequisite: IC Engine and Gas Turbines (ME 2022)**

**Introduction to Combustion:**

Introduction; Heat of reaction; Measurement of URP, Measurement of HRP; Adiabatic flame temperature, Complete combustion in C/H/O/N Systems, Constant volume adiabatic combustion, constant pressure adiabatic combustion. Calculation of adiabatic flame temperature - Isentropic changes of state.

**SI Engine Simulation with Air as Working Medium:**

Deviation Between Actual and Ideal Cycle – Problems, SI Engine Simulation with Adiabatic Combustion, SI Engine Temperature drop due to Fuel Vaporization, Full Throttle Operation - Efficiency Calculation, SI Engine Part-Throttle Operation, and Supercharged Operation.

**Progressive Combustion:**

SI Engines Simulation with Progressive Combustion; Simulation of Gas Exchange Process; Heat Transfer Process, Friction Calculation; Compression of Simulated Values, Validation of The Computer Code, Engine Performance Simulation. Pressure Crank Angle Diagram and Other Engine Performance.

**Simulation of 2-Stroke SI Engine:**

Simulation of the Performance; Simulation of Unbalanced Forces on Two Stroke Engine;

**Diesel Engine Simulation:**

Multi Zone Model For Diesel Combustion; Different Heat Transfer Models For Diesel Engine Simulation; Diesel Engine Equilibrium Calculations, Simulation Of Engine Performance; Diesel Engine Simulation For Pollution Estimation.

**Text Book :**


1. Computer Simulation of spark ignition engine process, Ganesan. V., Universities Press (I) Ltd, Hyderbad, 1996.


**Reference Books :**


1. Modelling of Internal Combustion Engines Processes, Ramoss. A. L, McGraw Hill Publishing Co., 1992
2. Computer Simulation of Compression Ignition Engines, Ganesan. V Orient Longman, 2000.


## AE 3033 THERMAL SYSTEMS IN AUTOMOTIVE Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand various thermal systems and its functions

CO2. solve cooling load calculations and to select different types of fans.

CO3. understand various types of compressors

CO4. familiarize with the applications of different fluid systems

CO5. understand the concepts to design heat exchangers

CO6. simulate one thermal system in computer and validate the result

**Prerequisite: Heat Transfer (ME 3021)**

**Introduction to Thermal Systems:**

System, boundary and surroundings, heat transfer, fluid flow; Heat engines – Functions, components, working; Cooling, properties of coolant, coolant recirculation and lubrication systems.

**Automotive Air Conditioning:**

Psychrometric properties, Use of psychrometric chart; Refrigerants; Types of refrigerants, Properties and Selection of refrigerants; Factors affecting the air flow, types of fans; Axial and Centrifugal fans; Load calculations; Winter air conditioning

**Air Compressors:**

Types and classification of compressors, working principle; Reciprocating compressors – single and multi stage compressors; compression with and without clearance; Calculations - volumetric, isothermal and isentropic efficiency, Rotary compressors; Comparison between reciprocating and rotary compressors, Comparison between centrifugal and axial compressors

**Fluid Transport:**

Incompressibility and expansion of fluids, Transmission of forces through fluids, multiplication of forces Fluid power, Applications of fluid power – power brakes, power steering, shock absorber; Components of hydraulic and pneumatic systems – Reservoir, pumps, strainers, filters, valve types, actuators, motors, accumulators, oil coolers, cooling fan, tubing, piping, hose; Fluid transport and power systems, applications of pneumatic and hydraulic systems, advantage and disadvantages of systems

**Heat Exchangers:**

Functions of radiator, compressor, condenser, evaporator, expansion valve; Classification of heat exchangers; According to transfer process, number of fluids, surface compactness, construction features, flow arrangements, heat transfer mechanisms. Selection and design of heat exchangers based on – Types, heat transfer rate, cost, pumping power, size and weight, materials; Basic thermal design theory for reciprocators.

**Text Books :**

1. Thermal Engineering, R.K Rajput, Laxmi Publications, 8th Edition, New Delhi, 2010
2. Design and Optimization of Thermal Systems, Yogesh Jaluria, CRC Press; 2nd edition, 2007

**Reference Books :**

1. Fundamentals of Engineering Heat and Mass Transfer, New Age Science Ltd., New Delhi, 2009
2. Heat and Mass Transfer, Yunus A. Cengel, Afshin J. Ghajar, Tata McGraw Hill, New Delhi, 2013

## AE 3034 VEHICLE DYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. apply concept of mechanical vibrating system.

CO2. predict and model suspension and tyre related vibrations.

CO3. simulate and analyze vibrations from vehicles.

CO4. analyze the stability and handling characteristics of vehicle at different operating conditions.

CO5: analyze and select suitable tyres for a vehicle.

CO6. calculate the roll centre and pitch centre

**Prerequisite: Nil**

**Introduction:**

Fundamental of vibration, Mechanical vibrating systems. Modelling and Simulation - Model of an automobile, Single, two, multi degrees of freedom systems, Free, forced and damped vibrations. Magnification factor - Transmissibility

**Multi-degree of freedom systems**:

Vibration absorber, Closed coupled system, Eigen value problems, Far coupled Systems, Orthogonality of mode shapes, Modal analysis, and Forced vibration by matrix inversion. Approximate methods for fundamental frequency, Dunkerley's lower bound, Rayleigh's upper bound, Hozler method for close coupled systems and branched systems.

**Suspension and Tyers:**

Requirements. Sprung mass frequency. Wheel hop, wheel wobble, wheel shimmy. Choice of suspension spring rate. Calculation of effective spring rate. Vehicle suspension in fore and apt directions. Ride characteristics of tyre, Effect of driving and braking torque, Gough's tyre characteristics.

**Vehicle Handling:**

Oversteer, under steer, steady state cornering. Effect of braking, driving torques on steering. Effect of camber, transient effects in cornering.

**Stability of Vehicles:**

Directional stability of vehicles. Load distribution. Calculation of Tractive effort and reactions for different drives - Stability of a vehicle on a slope, on a curve and a banked road.

**Text Book :**

1. Vehicle handling Dynamics Theory and Application, Masato Abe, Elsevier.

**Reference Books :**

1. Vehicle Dynamics Theory and Application, Theory and Application, Reza N. Jazar, Springer.
2. Automotive Chassis, Heldt. P.M., Chilton Co., New York, 1992.
3. Vehicle Dynamics, Ellis. J.R., Business Books Ltd., London, 1991.
4. Steering, Suspension and Tyres, Giles. J.G. Steering, Iliffe Books Ltd, London, 1998.

## AE 3037 AUTOMOTIVE AERODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to

CO1. understand the fundamentals of various automotive body construction details
CO2. understand the specific body styling of bus and passenger car
CO3. calculate forces and moments acting on car and bus under ideal flow conditions.
CO4. model the wind tunnel testing and visualize flow field
CO5. design of a car body and determine aerodynamic interaction effects between different components attached on top of it
CO6. select the optimized cab of a commercial vehicle

**Prerequisite: Nil**

**Evolution of vehicle body:**

Importance of vehicle body, Car Body Terminologies & types of car bodies; Visibility - Forward visibility, Forward vision measurement and Regulations; Driver's Visibility, All round visibility of the vehicle – sensors and its functions, Methods of improving visibility; Safety aspects in design - Bumper end, front end, Rear end and; importance of larger distance. Air bag, Telescopic/Collapsible Steering column

**Bus Body:**

Bus body panels & terminologies; Classification of bus body based on distance travelled by the vehicle; Classification of bus body based on capacity of the vehicle; Classification of bus body based on shape and style of the vehicle; Classification of bus body based on types of metal section used; Bus body regulations & Sequence of bus building operation; Construction of conventional type of bus body, Construction of Integral type of bus body; Comparison of Conventional and Integral type of bus body.

**Passenger Car:**

Car Aerodynamics; Types of Aerodynamic drag; Various Forces and moments influencing drag, Effects of forces and moments; various body optimization techniques for minimum drag;

**Wind tunnel technology**:

Basic laws of fluid flow – Continuity, momentum and energy equations as applied to system and control volume –Concept of flow fields.
Principle and Construction details of wind tunnel; Types of wind tunnels; Flow visualization techniques; Testing with wind tunnel balance (scale models).

**Commercial vehicles:**

Light commercial vehicles and Heavy commercial vehicles; Dimensions of commercial vehicle driver's seat in relation to various controls; Construction of Tanker and Tipper body, Segmental design of driver's cabin; Effects of rounding sharp front body edges; Effects of various cabs on trailer body; Fore body pressure distribution; Effects of a cab to trailer body; Effects of a cab to trailer body roof height; Effects of a cab to trailer body gab seals; Commercial vehicle drag reduction devices; Cab roof deflectors.

**Text Books :**

1. Aerodynamics of road vehicles, Wolf-Heinrich Hucho, $4^{th}$ edition, 2000.
2. Modifying the Aerodynamics of Your Road Car: Step-by-step instructions to improve the aerodynamics of road cars, Julian Edgar, Richard H. Barnard, Veloce Publishing, 2019

**Reference Books :**

1. Vehicle Body layout and analysis, Mechanical Engineering Publication Ltd.,1984
2. Vehicle Aerodynamics: Wind Tunnels, CFD, Aeroacoustics, and Ground Transportation Systems Society of Automotive Engineers, U.S., 1996.
3. Low Speed Aerodynamics, PHI Learning Private Limited, 2017.

## AE 3039 BATTERY TECHNOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the need to evolve storage as a substitute to conventional IC engine.
CO2. understand the process involved in the inter conversion of electrical energy and chemical energy
CO3. evaluate the health of a battery
CO4. model process of battery state estimation
CO5. design a battery pack for an automobile
CO6. know the difference of fuel cell and battery

**Prerequisite: Nil**

**Modern batteries:**

Introduction to Energy Storage Systems and Devices; Rechargeable Batteries and their Fundamental Electrochemistry; working and industrial applications of Lead acid battery; Construction, working and industrial applications of Zincair battery Nickel metal hydride battery and Li-$MnO_2$ battery.

**Evolution of Battery:**

Li-ion Battery Technology and Challenges; Cathode Materials; Anode Materials; Electrolytes; Beyond Li-ion Battery Technologies; Manufacturing Technologies of Batteries; Sustainable Design of Batteries; Capacitors and Super-capacitors

**Battery Management System:**

Introduction and BMS functionality; High-voltage contactor control;Isolation sensing and thermal control; Protection and interface; State-of-charge estimation; Energy and power estimation.

**Cell Balancing:**

Causes of imbalance; Design choices when implementing balancing; Passive and Active circuit balancing; Active Capacitive circuit balancing; Active inducing circuit balancing

**Battery State Estimation:**

Estimate state of charge; Overview of vector random (stochastic) processes; Sequential-probabilistic-inference solution; The six-step process.

**Battery Health Estimation**

Lithium-ion ageing: Negative electrode; Positive electrode; Sensitivity of voltage to ESR and total capacity;

**Fuel Cells:**

Introduction, definition, Construction, working and industrial applications of $H_2$-$O_2$ fuel cell. Methanol-oxygen fuel cell; Differences between battery and fuel cell.

**Text Book :**

1. Battery Technology for Electric Vehicles: Public science and private innovation, Albert N. Link, Alan C. O'Connor, Troy J. Scott, Routledge; 1st edition, 2015

**Reference Book/e-Materials :**

1. Lithium-Ion Batteries: Science and TechnologiesMasaki Yoshio, Ralph J. Brodd, Akiya Kozawa, Springer, 2009
2. https://batteryuniversity.com/learn/

## AE 3042 AUTOMOTIVE SAFETY AND LIGHTING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know how to design an automobile for the safety and comfort
CO2. select best safety attachments and ergonomics
CO3. conduct test as per safety standard
CO4. understand basics of lighting, reflection and refraction
CO5. select most suitable automotive lighting systems
CO6. model and select an electronic system to improve a car to make it an intelligent vehicle

**Prerequisite: Nil**

**Automotive Safety**:

Active and passive safety, Driver assistance systems in automobiles, Definitions and terminology, Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Design of crash crumple zones, Modeling and simulation studies, Optimization of vehicle structures for crash worthiness, Types of impacts, and Impact with rebound, movable barrier tests, Analysis and simulation of vehicle in barrier impacts, Roll over crash tests, Behaviour of specific body structures in crash testing, Photographic analysis of impact tests, Regulatory requirements for crash testing.

**Ergonomics and Human response to Impact:**

Importance of Ergonomics in Automotive safety, Locations of controls, Anthropometry, Human impact tolerance, Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria and relation with crash; modeling and simulation studies in dummy.

**Vehicle safety systems:**

Survival space requirements, Restraints systems used automobiles, Types of safety belts, Head restraints, Air bags used in automobiles, Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles. Importance of Bumpers in automobiles, Damageability criteria in bumper designs. Introduction to the types of safety glass and their requirements and rearward field of vision in automobiles, Types of rear view mirrors and their assessment. Warning devices, indicators, hinges, latches, wipers, horns etc.

**Fundamentals of light, vision and colour:**

Electromagnetic radiation and light, Propagation of light, Spectral sensitivity of light, Measures of radiation and light, standard elements for optical control. Illuminant calculations, Derivation of luminous flux from luminous intensity, flux transfer and inter reflection, luminance calculations, discomfort glare, eyes as an optical system, visual processing, lighting for results, modes of appearance, Pointers for lighting devices. Nature of the colour, Tri-chromatic Colorimetry, Surface colour, colour spaces and colour solids, colour rendering.

**Light Measurements, Testing equipment, calibration and photometric practice:**

Basics of standards and detectors, spectral measurements and Colorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio-Photometer, Reflectometer, Colorimeter, Integrating sphere, types, application, coordinates system, Types of sensors and working principle, construction, characteristics etc. used in different equipment. National and international Regulations, test requirements and testing procedure.

**New Technology in Automotive lighting:**

Technology progress in automotive lighting, Gas Discharges lamps, LED, adoptive front lighting system, Daylight running lamps.

**Text Book :**

1. Low speed Automobile Accidents, Alan J. Watts, Dale R. Atkinson, Corey J. Hennessy, Lawyers & Judges Pub Co; 3rd edition, 1996

**Reference Books :**

1. An Introduction to Modern Vehicle Design, Jullian Happian-Smith SAE, 2002
2. Crashworthiness of Vehicles, Johnson, W. and Mamalis, A.G., MEP, London, 1995
3. Lamps and Lighting, Edward A., Hodder & Stoughton, London, 1993.

## AE3044 THEORY AND DESIGN OF JIGS AND FIXTURES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. select most suitable jigs and fixture for automotive application.

CO2. design and prepare Jigs and fixtures for given components.

CO3. select proper clamping and support system

CO4. evaluate different method of loading and unloading

CO5. select effective cutter guidance system

CO6. evaluate different jigs and fixtures

**Prerequisite: Nil**

**Introduction:**

Definitions of Jigs and Fixtures, Principles of Jigs and Fixtures design, preliminary analysis and planning of Jigs and fixture parts and their materials, Basic steps in the design of jigs and fixtures and Advantages of Jigs & Fixtures.

**Location and Clamping:**

Degrees of freedom-3-2-1 location principle, Radial location and diamond pin location, Principle of pin location, Location from pin surfaces, location from a profile, location from a cylinder, Circular location, Jamming and remedies. Location Adjustable locators, redundant locators, fool proofing; Adjustable supports and centralizes Strap clamps, cam clamps , screw clamping, latch clamps, wedge clamps, pivoted clamps, eccentric operator clamp, power clamps, quick acting clamps, equalizers.

**Loading and unloading problems:**

Loading, Entering, locating and clamping, symmetric consideration. Unloading, Bur clearance, ejectors, receivers, chip problems, relief and projection, shields and seals.

**Cutter Guidance:**

Various types of setting blocks, Press fit bushes, Renewable bushes, Slip bushes, Threaded bushes, Special bushes, Drills with attached bushing for small holes.

**Design of Jigs and Fixtures:**

Three construction principles; Built-up type; casting and weldment; Optimizing various types of jigs, practicing the various types of milling fixtures, broaching fixtures, function of broaching fixtures-internal and external broaching fixtures.

**Text Book :**

1. Jigs and fixtures, Joshi. P.H. Tata McGraw-Hill, 1988

**References Books :**

1. Jigs and Fixtures, Design Manual Industrial Henriksen, Erik. K., Press Inc., Madison Avenue, New York, 1983.
2. Tool design Donaldson G.H., Lecain, Gould. V.V., , TMH Edition, 1990
3. Fundamentals of Tool design ASTME, Prentice Hall, 1989.

## AE 3052 INTELLIGENT VEHICLE TECHNOOGY Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand the intelligent vision system used in automobiles
CO2. understand the architecture of intelligent transportation system
CO3. model the adaptive control technique for an autonomous vehicle
CO4. evaluate the scope of intelligent vehicle in Smart city development in India
CO5. predict the reliability of Sensor Based Manoeuvre
CO6. study about the successful autonomous vehicle projects

**Prerequisite: Nil**

**Intelligent Vision System:**

Vision Based Driver Assistance System –Vehicle optical Sensor, Laser Radar; Non-Contact ground velocity detecting Sensor, Road Surface Recognition Sensor; Vehicle Sensors for Electronic Toll Collection System; Components of a Vision Sensor System, Driver Assistance on Highways –Lane Recognition, Traffic Sign Recognition; Driver Assistance in Urban Traffic-Stereo Vision, Shape base analysis and Pedestrian Recognition;

**Vehicle Information System and Intelligent Transport:**

Intelligent Transportation System (ITS) – requirements for ITS Communications; Multimedia communication in a car; Current ITS Communication Systems and Services; Vehicle to Vehicle and Road to Vehicle Communication Systems; Inter and Intra Vehicle Communication; VANETS-Devices; Optical Technologies and Millimetre Wave technologies; Global Positioning system.

**Adaptive Control Techniques:**

Automatic Control Of Highway Traffic And Moving Vehicles; Adaptive Control –Gain Scheduling; Model Reference Adaptive Control; Self Tuning Adaptive Control System Model – System Identification Basics, Recursive Parameter Estimation, Estimator Initialization; Design Of Self-Tuning Controllers –Generalized Minimum Variance (GMV) Control, Pole Placement Control And Model Predictive Control.

**Decisional Architecture for Autonomous Vehicles:**

Control Architectures and Motion Autonomy –Deliberative Architectures, Reactive Architectures, Hybrid Architectures. Overview of Sharp Architecture, Models Of Vehicle; Concepts of Sensor Based Manoeuvre, Reactive Trajectory Following, Parallel Parking, Platooning; Main Approaches To Trajectory Planning, Non-Holonomic Path Planning.

**Autonomous Vehicle:**

DARPA Challenge Case Study; ARGO Prototype Vehicle; The Gold System-The inverse Perspective Mapping, Lane Detection, Obstacle Detection, Vehicle Detection, Pedestrian Detection. Software systems architecture, Computational Performances. ARGO Prototype vehicle Hardware; Functionalities, Data acquisition System, Processing System and Control System.

**Text Book :**

1. Intelligent Vehicle Technologies, Ljubo Vlacic, Michel Parent and Fumio Harashima, Butterworth-Heinemann publications, Oxford, 2001

**Reference Books :**

1. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies, Nicu Bizon, Lucian D. Ascalescu and Naser Mahdavit Abatabaei, Nova Publishers, 2014
2. Intelligent Vehicle Technology and Trends, Richard Bishop, Artech House Publishers, 2005

## AE 3054 DESIGN OF RACING CAR Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of racing vehicle characteristics.
CO2. predict the aerodynamic requirements in racing vehicles.
CO3. understand the concepts of chassis behaviour of racing vehicles.
CO4. evaluate the suspension characteristics of racing vehicles.
CO5. understand the problems faced in drives and braking systems in motorsports.
CO6. build a g-g curve for a sports car developed indigenously

**Prerequisite: Nil**

**Racing Car Development:**

Problems Imposed By Racing, Racing Objective, longitudinal acceleration and lateral acceleration of a car; Constraints And Specifications – Performance, Handling, Structure; Driver Accommodation And Safety, Tyres; Adjustable Features, Preliminary Design And Analysis; Driver-Vehicle Relationship. Desirable Vehicle Characteristics, Fundamentals of Testing; Track Test Program Planning and Test Methodology; General Notes on Development – Circular Skid Pad Testing.

**Racing Car Aerodynamics:**

Aerodynamic Force and Moment, Race Car Drag Components, Drag Improvement and Estimation; Ground Effects and Ground-Plane Simulation In Race Car Applications; Spoilers, Dams, Wings - Effectiveness Of Wings In Steady

State Cornering; High Lift Devices- Flaps and Slats. Flow Control Devices- Dams, Fences, Vanes, Skirts, Spoilers. Vortex Creating Devices- Ledges, Edges, Cusps, Lips; Pressure Change Creation Devices-Perforations, Vents,

Bleeds, Scoops, Seals; Air-Foil Devices- Slats, Flaps, End Plates, Cuffs, Fillets, Trips; Active Flow Control Devices- Internal Airflow, RAM Air Ducted Radiator, Air Entrance Scoop.

**Chassis Design:**

Conditions For Traversing A 90° Corner, Principle Chassis Tuning Items; Effects Of High Speed Braking, Cornering, Combined Braking Cornering; Steady State Cornering, Acceleration Out Of A Corner, Straight Line Acceleration. Throttle Behaviour, Steering Wheel Force And Kick Back; Moving CG Position, Roll Centre Position Changing Anti- Pitch Geometry; Chassis Steering Axis Geometry, Changing Camber; Chassis Ride Roll Characteristics, Chassis Track Width; Chassis Ride Spring Rate, Tires And Rims, Adjusting Roll Stiffness And Roll Stiffness Distribution.

**Suspension System:**

Front Suspension- General Design Issues, Camber Effects; SLA Suspension, McPherson Struts; Independent Rear Suspension- Trailing Arm Types, Instant Axis Concept; Independent Rear Suspension- Trailing Arm Types, Instant Axis Concept; Torque Tube And Torque Arm Suspension, Decoupled Rear Axle Suspension.

Suspension Springs- Torsion Springs, Coil Springs, Progressive Rate Coil Springs; Leaf Springs, Types, Installation Consideration, Inter Leaf Friction, Spring Fatigue; Damping In Racing- Ride/Handling Compromise, Steering Activity, Transient Manoeuvrings, Bump Damping and Rebound Damping.

**Car drives and Braking Systems:**

Front, Rear and Four-Wheel Drive in Racing; Differentials Used In Racing- Open Differentials, Locked (Spool), Limited Slip Differentials; Traction Control and Other Electronic Improvements in Racing.

Mechanical Components In Braking System; Limitations And Considerations Of Braking In Racing; Brake Boost, Effects Of "g" Force On Brake Fluids; Brake Hydraulics, Ventilation; Brake Distribution, ABS In Racing; Carbon-Carbon discs.

**Text Book :**

1. Advanced Race Car Chassis Technology HP1562: Winning Chassis Design and Setup for Circle Track and Road Race Cars, Bob Bolles, HP Books; Revised edition, 2010

**Reference Books :**

1. Race car vehicle dynamics, William F. Milliken and Douglas L. Milliken, 11th edition, SAE, 1995.
2. Formula 1Technology, Peter Wright, SAE International; 1st edition 2001.

## AE 3056 FUNDAMENTALS OF TYRE TECHNOLOGY Cr-3

**Course outcome:** At the end of the course, the students will be able to:

CO1. understand various methods of tyre manufacturing
CO2. calculate the forces and moments acting on tyres
CO3. understand wear possibilities, their causes and measurements
CO4. understand the safety of tyres and its failure analysis
CO5. gain knowledge about the tyre testing methods
CO6. select the best tyre with respect to load, service life

### Prerequisite: NIL

**Introduction:**

Tyre Basic Functions; Tyre Types: Diagonal, Belted Bias, Radial Bias; Tyre Nomenclature; Tyre Bias Types: Diagonal, Belted Bias, Radial Bias; Radial Tyre Design Process; Tyre Performance Criteria – Indoor Test And Outdoor Test; Tyre Manufacturing; Compound Preparation- Calendaring; Tyre Assembly: Curing, Inspection, Quality Control Tests

**Forces and Moments:**

Tyre dynamics; Rolling Resistance; The effective rolling radius; Cornering Properties- Slip Angle And Cornering Force; Performance Of Tyre On Wet Surface; Ride Properties of Tyres.

**Rubber Abrasion and Tyre Wear:**

Sliding Abrasion; Tyre Wear; Influence of Road Surface- Driving Influences; Speed and Load Distributions; Road Wear and Force Distribution; Tire Construction.

**Tyre Noise:**

Sound Generation Mechanisms; Sound Enhancement Mechanisms; Analyzing/reducing tyre noise.

**Tire Safety, Durability and Failure Analysis**

Service; Maintenance Safety; On Vehicle- In-Service Safety; Fundamentals Of Tyre Durability; Nature Of Tyre Durability; Deflection, Heat, Speed, Tyre Structural Failures; Common In-Service Tyre Failure Modes; Run Low/ Flux Break; Tyre Tread Bead Detachment- Rapid Air Loss; Over Deflection; Intra-Carcass Pressurization- Cuts And Punctures; Improper Repair; Tyre Defects.

**Non-Destructive Tests:**

Inspection Techniques; X-Ray Examination; Shearography; Ultrasound test; Eddy Current test.

**Text Books/ e-books :**

1. Systematic Review of Tyre Technology, Yasuhiro Ishikawa, National Museum of Nature and Science Vol.16, 2011
2. US Department of Transportation., The Pneumatic Tire, February 2006

**Reference Books :**

1. Tire and Vehicle Dynamics, Hans B. Pacejka, 3rd Edition, 2002
2. Vehicle Dynamics: Theory and Application, Reza N. Jazar, Springer 2008

## AE3058 ASSEMBLY LINE AUTOMATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. identify the applications of PLC applicable to automobile assembly line.
CO2. design PLC programs to solve industrial control problems.
CO3. identify processes to be best done by robotics application to reduce cost and increase productivity.
CO4. design and apply pneumatics and hydraulic circuit using computer for automated factory.
CO5. select the best pneumatic actuator for a given application
CO6. evaluate an hydraulic link based on load requirements

**Prerequisites: Nil**

**Fundamental of Manufacturing and automation:**
Types of production, functions in manufacturing, production concepts and mathematical models, automation strategies.

**PLC (Programmable Logic controller):**
Over view and architecture, PLC programming, Application examples.

**Pneumatics and Hydraulics:**
Pneumatic components: Properties of air compressors-filter, regulators, Unit- Air control Valves, Quick Exhaust valves, Pneumatic actuators- Fluid Power, Circuit design, speed control circuits. Hydraulic system- sources of hydraulic power, Fluid power actuators, Pumping theory, Direction control valves, pressure control valves, Types of hydraulic cylinders.

**Robotics and Robot applications:**
Robot introduction- definition; classification and specification. Mechanism: Kinematic parameters and modeling Direct and inverse kinematic differential motion and Jacobians. Introduction to Dynamics path planning, trajectory planning and control –skew, joint interpolation and straight line motion. Off line programming and simulation.

**Computer Networks for manufacturing:**
Hierarchy of computers in manufacturing, local area networking, manufacturing automation protocol.

**Future automated Factory:**
Trends in manufacturing, Industry 4.0, Effects and challenges of industry 4.0, big data and analytics; Future automated factory.

**Text Books :**

1. Industrial Automation and Robotics, A. K. Gupta and S. K. Arora, Laxmi Publications, New Delhi
2. Computer-Based Industrial Control, Krishna Kant, Prentice Hall of India Ltd, 1997.
3. Fundamentals of Industrial Instrumentation and Process Control", William C. Dunn, Tata McGraw Hill, 2009.

**Reference Books :**

1. Oil Hydraulics, Majumdar S.R., Tata McGraw Hill, 2000.
2. Fluid power with application, Anthony Esposito. Pearson education, 2000.
3. Chemical Process Control – Theory and Practice, Stephanopoulos, Prentice Hall of India Ltd, 1984.

## AE3060 VEHICLE LIFE CYCLE MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. distinguish between the terms PDM and PLM
CO2. understand and implement basic components and functionality of a PDM system.
CO3. use a PDM system to support and control a product realization process.
CO4. given project, choose, configure, and adjust a PDM system to effectively support, follow up and control the project.
CO5. select environment friendly scrap management policy
CO6. evaluate the best waste management technique in recycling old vehicle

### Prerequisite: Nil

**Introduction:**

Definition of total life cycle (TLC)-Concept of TLC-Life cycle impacts-Integrating life cycle technologies-Products and processes within TLC-TLC methodology-TLC assessment data to complex products-Results Improvement for product, Life Cycle Costing (LCC).

**Vehicle End Life:**

Design for end of old vehicle management –Problems of old vehicles in emerging markets-recovery and economic feasibility of materials such as Plastics, rubber aluminium, steel etc.

**Trade-off:**

Applying life cycle thinking to define trade-off along the supply, manufacture; use and end of life chain; Effect on the customer; Expectation of the customer-Evaluate product cost on fuel consumption, emissions, durability, environment and health.

**Sustainability:**

What is sustainability-Use of renewable resources-View to design horizon. Harmonization of Environmental Goals: TLC for emerging and developed markets; Rules and regulations to guide designers; International common practices for end of life products.

**Total quality environment (TQE)**:

Environmental management system (EMS), product evaluation standards, requirements of ISO 14001, environmental policy, elements of environmental planning: environmental aspects, legal and other requirements, objectives and targets, and environmental management programme.

**Text Book :**

1. Automotive Scrap Recycling: Processes, Prices and Prospects, James. W Sawyer, Routledge, 2015

**Reference Books :**

1. Sustainable Management of Automobile Waste, Forbid George Teke, VDM Verlag, 2010
2. Automobile Life Cycle Tools and Recycling Technologies, Society of Automotive Engineers, 1993

## AE4001 AUTOMOTIVE QUALITY MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basics of quality engineering and quality management
CO2. understand the evolution of quality assessment in Automobile Industry
CO3. identify the quality concepts in different time frame and different countries
CO4. evaluate different Quality Management techniques, system and standards
CO5. identify and solve problems related to Application of management tools and techniques for process improvement
CO6. understand Automotive TS16949 quality system practices

**Prerequisite: Nil**

**Introduction:**

Quality, classification of quality and services; Quality systems overview; Product Quality design; Quality engineering in design of production processes, characteristics; Reliability and Safety; Quality engineering in production; Quality engineering in service.

**Quality Management Systems:**

Dimensions of Quality; Costs of Quality; Quality System Standards; ISO 9000 clauses and its interpretations; ISO TS16949 clauses and interpretation.

**Modern Management Tools and Techniques:**

5s concepts; Kaizen techniques; Six sigma methodologies; Quality circles; Taguchi loss function; POKE-YOKE Techniques

**ISO TS16949 Requirements:**

Advanced Product Quality Planning (APQP); Design Failure Mode Effects Analysis; Process Failure Mode Effects Analysis; Production Part Approval Process (PPAP); IATF 16949:2016

**Quality Tools and Measurement Systems:**

Statistical process control; SPC detection and SPC prevention; Data collection methods; Statistical Tools: Analysis of variance (ANOVA), Chi-squared test, Correlation, Factor analysis, Mann–Whitney U, Mean square weighted deviation (MSWD), Pearson product-moment correlation coefficient, Regression analysis.

**Measurement systems:**

Repeatability, reproducibility, Variable Gauge R&R, Introduction to Hypothesis Testing

**Text Book :**

1. Automotive quality system Handbook, David Hoyle, Butterworth Heinemann Ltd., Second edition, Oxford, 2000

**Reference Books :**


1. Introduction to statistical control, Montgomery Douglus C., John Wiley and Sons, New Delhi, 2007
2. Managing for total quality-From Deming to Taguchi and SPC, Logo Thetis N., Prentice Hall of India (P)Ltd., New Delhi, 1997


## AE4002 AUXILIARY SYSTEMS IN AUTOMOTIVES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the role of artificial intelligence in modern automobiles
CO2. evaluate the auxiliary systems of chassis.
CO3. model the vehicle motion control and stabilization system
CO4. know the importance of Driver assistance, security and warning System
CO5. evaluate the Safety and comfort system used in automobiles
CO6. understand the recent changes in Motor vehicle act regarding safety

**Prerequisite: Internal Combustion Engines and Gas Turbines(ME2022)**

**Introduction:**

Introduction to artificial intelligence and machine learning, Vehicle Motion Control and Stabilization System, Adaptive Cruise Control System; Electronic Transmission Control System, Anti lock Braking System, Traction Control System; Electronic Stability Program, Electronic Brake Force Distribution System

**Chassis Auxiliary System**

Power Assisted Steering System, Regenerative Braking System; Servo Brake; Hand Brake, Engine Exhaust Brakes, Hydro Elastic Suspension System, Rubber Suspension, Pneumatic Suspension, Drive By Wire System: Throttle, brake, gear shift, steer, parking

**Information, Security and Warning System**

Global positioning system, Collision Warning System, Onboard Diagnosis System, Immobilizer, Anti-theft Alarm System; Voice Warning System, Keyless Entry System, Central Locking System; Tyre Pressure Monitoring System, Lane Departure Warning System, Blind Spot Detection, Navigation And Infotainment System

**Safety System**

Automatic Seat Belt Fastening System; Collapsible Steering Column, Child Lock System; Air Bags Deployment System; Bumper Design for Safety; Frontal Object Detection, Rear Vehicle Object Detection System; Hill Start Assist, Rollover Prevention, Emergency Brake Assist, Emergency Response

**Comfort Systems**

Heating, Ventilation and Air Conditioning Systems (HVAC), Electronic Outside Rear View Mirror (OVRM), Rain Sensing Wiper System; Environment Information System, Tilt Able Steering Wheel, Garage Door

Opening System, Tilt Able Steering Wheel, Garage Door Opening System, Automatic Climate Control, Adaptive Head Light, Night Vision Assist, Traffic Jam Assist

**Motor vehicle act amendment**

Motor vehicle (amendment) bill 2017; Recalling of Vehicles, Electronic monitoring and enforcement of road safety

**Text Book/Literatures :**

1. Modern Automotive Technology, James E Duffy, Goodheart-Wilcox Publisher; 9th Edition, 2015
2. Motor vehicle (amendment) bill 2017, Save life foundation, www.savelifefoundation.org

**Reference Books :**

1. A Text book of Automobile Engineering, Volume-II. P.S. Gill, S.K. Kataria & Sons, First Edition, 2012
2. Understanding Automotive Electronics, Bechhold, SAE, 1998.
3. The Motor Vehicle, T. K. Garrett, SAE USA, 13th edition 2009.

## AE4003 TURBOCHARGERS AND SUPERCHARGERS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basics of Supercharging and compressor mapping.
CO2. draw Flow maps of supercharging systems.
CO3. understand the Modern design features of exhaust turbocharger features.
CO4. analyze turbocharger thermodynamically
CO5. acquire knowledge about Engine thermal management
CO6. solve numerical problems on blade design

**Prerequisite: Fluid Mechanics & Hydraulic Machines(ME2021)**

**Introduction:**

Fundamentals of compressor matching, compressor power, air consumption, types and characteristics of compressors; Relationship between air consumption and power. Volumetric efficiency of supercharged four stroke engines. Computations of gas exchange process, Charge boosting, exhaust pre-release, turbo-cooling, miller, two stage, Comprex, Hyperbar, rotor designs; Types of impellers, bearing arrangements, types and lubrication on bearings; Examples of supercharged engines of road vehicles (cases).

**Flow Maps of Supercharging Systems:**

Two and four stroke engines, interaction between supercharger and engine; Two and four stroke engines, interaction between turbocharger and engine; Pulse supercharging and diagram for determination of operating condition of a single stage supercharger system; Examples of computed results

**Thermodynamics of Turbo-charging:**

Cylinder release temperature and mean exhaust temperature, theoretical aspects of complete extraction of work by expanding from release pressure to ambient pressure; Complete conversion into kinetic energy at ambient pressure; Complete conversion into kinetic energy at ambient pressure; Effect of cooling the charge air. Exhaust turbocharger as a means to increase efficiency.

**Exhaust Turbo-charging:**

Exhaust manifold arrangements for various firing sequences of engines. Constant pressure turbo-charging and pulse turbo-charging; Modified forms of pulse turbo-charging. Transient response; Torque characteristics of engines with exhaust turbochargers; Measures to improve acceleration and torque characteristics of exhaust turbocharged engines; Altitude de-rating. Effect of supercharging on exhaust emissions of ci and SI engines.

**Engine Thermal Management:**

Introduction to engine cooling systems, engine coolants, heat exchangers, in-vehicle installation, performance curves; Pressurized engine cooling systems: filling, de- aeration anddraw-down, accessories. On-highway cooling system test code, engine cooling systems field test (air-to-boil), heat exchanger thermal & pressure cycle durability. Cooling fans: fan laws, fan characteristics, and system resistance curve; Cooling flow measurement techniques. Cooling system inspection, trouble diagnosis & service. Radiator field failures. Introduction to EGR (exhaust gas recirculation) coolers & its significance in reduction of vehicle emissions.

**Text Book :**

1. Engine Systems by Supercharging of Internal Combustion Engines,Zinner K A., Auxillary Springer, 1978.

**Reference Books :**

1. Turbocharging the Internal Combustion Engines,Watson N., Janota M S., Springer 1982
2. Charging the Internal Combustion Engine,Hermann Hiereth, Peter Prenninger, Springer 2010

# MECHANICAL (MECHATRONICS) ENGINEERING

# B. TECH IN MECHATRONICS ENGINEERING

## Program Educational Objectives(PEOs):

The B. Tech program in Mechatronics Engineering aims to prepare students so that they shall get widely employed in mechatronics or allied disciplines and adhere to professional ethics in engineering practice. The program also aims to prepare the graduates with the following objectives:

1. Graduates shall be able to provide solutions to mechatronics engineering problems involving design, manufacturing, and operational management issues.
2. Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.
3. Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

## Program Outcomes(POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Join a technical workforce as successful professionals in a wide range of mechatronics engineering and related domains.

n) Pursue advanced degrees in engineering, business, or other professional fields.

o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

## MH 2002 PRINCIPLES OF MACHINE TOOLS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the different basic machining processes and machine tools.
CO2. able to distinguish the configurations and functions of machine tools
CO3. understand and develop some idea about the drives and kinematics in machine tools
CO4. understand the underlying concepts, methods and application of Machine Tool Design.
CO5. apply various design aspects of spindles and bearings
CO6. able to reduce vibration and chatter on various machine tools.

### Prerequisite: Nil

**Machine Tools:**

Turning, Drilling, Milling Machine - Types, Types of cutters, operations, Indexing methods. Shaping, Planning and Slotting Machine – Operations and quick return mechanisms, Work and tool holding devices. Boring machine - Operations, Jig boring machine. Broaching machine – operations

**Classification and principles of Machine Tools:**

General classification of machine tools, working and auxiliary motions in machine tools, Parameters defining working motion of a Machine Tool, Machine Tool Drives, Hydraulics transmission and its elements, Mechanical transmission and its elements, General requirement of machine tools, Layout of Machine Tool

**Machine tool drives:**

Design considerations for drives based on continuous and intermittent requirement of power, Types and selection of motor for the drive, Regulation and range of speed based on preferred number series, geometric progression. Design of speed gear box for spindle drive and feed gear box, stepped speed drives and step less speed drive

**Design of Machine Tool Structures:**

Functions of Machine Tool Structures and their requirements, Design criteria, materials, static and dynamic stiffness, Basic design procedure, design of beds and columns, Housings, bases and tables. Design of Guideways and Power Screws. Functions and types of Guideways

**Machine Tool spindles and its Bearings:**

Materials of spindles, Effect of machine tool compliance on machining accuracy, Design principles of spindles, Antifriction and sliding bearings.

**Controlling systems in Machine Tools:**

Classification, Control systems for changing speeds and feeds, Ergonomic considerations applied to design of control members, principles of automatic and adaptive control.

**Text Books :**

1. Machine Tools Design and Numerical Control, N. K. Mehta, TMH.
2. Design of Machine Tools, S. K. Basu, D. K. Pal, OIBH.

**Reference Books :**

1. Principles of Machine Tools, G. C. Sen, Bhattacharya, New Central Book Agency.
2. Metal Cutting Theory and Practice, A. Bhattacharya, New Central Book Agency (P) Ltd.
3. Machining and Machine Tools, A. B. Chattopadhyay, Wiley-India Publication.

## MH 3008 DESIGN OF MECHATRONIC SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the mechatronic systems design and their structure, ergonomic and safety.
CO2. design and use of system models in mechatronic system
CO3. analyze theoretical and practical aspects of computer interfacing and real time data acquisition and control.
CO4. apply the knowledge to design mechatronics products.
CO5. design and implement the micro mechatronic system
CO6. Understand the real time interfacing.

**Prerequisite: Digital Electronics (EC 2018), Principle of Control Systems (EE 3009), Sensors and Actuators (EI 3007), DC AC and Special Electrical Machines (EE 2011)**

**Introduction to Mechatronics System:**

Key Elements – Mechatronics Design Process –Design Parameters – Traditional and Mechatronics Designs Advanced Approaches in Mechatronics - Industrial Design and Ergonomics, Safety.

**System Modelling:**

Introduction-Model Categories-Fields of Application-Model Development-Model Verification-Model Validation-Model Simulation-Design of Mixed Systems-Electro Mechanics Design-Model Transformation-Domain-Independent Description Forms-Simulator Coupling.

**Real Time Interfacing:**

Introduction-Selection of Interfacing Standards Elements of Data Acquisition & Control Systems- Over View of I/O Process, General Purpose I/O Card and Its Installation, Data Conversion Process, Application Software- Lab View Environment and Its Applications, Vim-Sim Environment & Its Applications -Man Machine Interface.

**Case Studies on Mechatronic System:**

Introduction –Fuzzy Based Washing Machine – pH Control System – Autofocus Camera, Exposure Control– Motion Control Using D.C. Motor & Solenoids – Engine Management Systems. – Controlling Temperature of a Hot/Cold Reservoir Using PID- Control of Pick and Place Robot – Part Identification and Tracking Using RFID – Online Surface Measurement Using Image Processing.

**Micro Mechatronic System:**

Introduction- System Principle - Component Design – System Design – Scaling Laws – Micro Actuation – Micro Robot – Micro Pump – Applications of Micro Mechatronic Components.

**Text Books :**

1. Mechatronics System Design", Devdas Shetty, Richard A. Kolk 2nd Edition, Cengage Learning 2011.
2. Mechatronic Systems: Modeling and simulation" with HDL's, Georg Pelz, John Wiley and sons Ltd, 2003

**Reference Books :**

1. Mechatronics Hand book, Bishop, Robert H CRC Press, 2002.
2. Mechatronics: Electronics in Products and Processes, Bradley, D. Dawson, N.C. Burd and A.J. Loader CRC Press 1991, First Indian print 2010.
3. Mechatronics: A Foundation Course, De Silva Taylor & Francis, Indian Reprint, 2013

## MH 3010 INDUSTRIAL AUTOMATION AND ROBOTICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the industrial automation with computer controlled machines, measurement systems and industrial robots.
CO2. design and apply pneumatics and hydraulic circuit using computer for automated factory.
CO3. identify and Design PLC programs, implement PID using electronic, digital, pneumatic and hydraulic methods to solve industrial control problems.
CO4. select the best robotics applications and be able to justify the overall advantages to industry
CO5. uunderstand the principles of application of AGV, ASRS in automated industries.
CO6. apply modern computational, analytical, simulation tools and techniques in manufacturing

**Prerequisites:** Kinematic and Dynamics Machinery (ME2013) and Principle of Control Systems (EE-3009)

**Introduction:**

Introduction to Industrial Automation and Control, Automations; basic laws and principles, level of automation Introductions to sensors and measurement systems; pressure measurement, temperature measurement, velocity measurement, force and torque measurements, response of measuring systems.

**Laws and principles of hydraulics and pneumatics:**

Components of basic Pneumatic and Hydraulic systems; Characteristics and properties pumps and compressors used in industry; Pneumatic and Hydraulic accessories like filters, lubricators, air dryers, pipelines, connectors; Pneumatic and Hydraulic actuators and their classifications; Proportional and Servo Valves, Construction and working of various Pneumatics and Hydraulics valves; Pneumatic and hydraulic circuits.

**Industrial Control systems:**

Continuous and discrete control, Control requirements, Programmable Logic Controllers (PLCs), Sensors and Actuators. Introduction to Process Control, PID Control, Implementation of PID Controllers, Logic circuits: Pneumatic logic circuits, Electric and electronic controls used in automation.

**Industrial Robotics**

Industrial robot applications, Robotic Grippers, Sensors in robotics. Robot Programming, Robot application in machining, Welding and assembly, Hostile and remote environment.

**Automation in material handling and storage system:**

Automated guided vehicle systems (AGV), Monorails and other rail guided vehicles, Conveyor systems, Automated storage systems, Engineering analysis of storage system.

**Text Books :**


1. Industrial Automation and Robotics, A. K. Gupta and S. K. Arora, Lakshmi Publication, New Delhi, ISBN 8131805921, 2009
2. Mechatronics Principles, Concepts and Application, N. P. Mahalik, TMH, ISBN-0-07-048374-4, 2003


**Reference Books :**


1. Automation, Production Systems, and Computer-Integrated Manufacturing, Mikell P. Groover, Pearson Education, ISBN 81-7808-511-9. 3rd Edition, 2007
2. Overview of Industrial Process Automation (1st Edition), K. L. S. Sharma, Elsevier, ISBN-978-012-415779-8
3. Industrial Robotics-Technology, Programming and Applications, M. P. Groover, McGraw Hill, 2001.

## MH 3032 MODELING AND SIMULATION OF MECHATRONIC SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic concept and principles of modeling and simulation of systems
CO2. understand and apply various modeling techniques to physical systems
CO3. apply various simulation techniques to solve practical problems related to mechatronic systems
CO4. able to design, model and simulate the Mechatronic Systems using software's
CO5. able to analyze system behavior with respect to parameter modifications
CO6. able to integrate systems across different physical domains and understand the control aspects to achieve desired system behavior

**Pre-requisite: Nil**

**Introduction:**

Principles of modeling and simulation, modeling and simulation of mixed systems, transfer function, state space representation of SISO, MIMO, modeling of dynamic systems, construction, analysis, practical applications.

**Physical Modelling:**

Mechanical and electrical systems, physical laws, continuity equations, compatibility equations, system engineering concept, system modelling with structured analysis, modelling paradigms for mechatronic system, block diagrams, mathematical models, systems of differential-algebraic equations, response analysis of electrical systems, thermal systems, fluid systems, mechanical rotational system, electrical-mechanical coupling.

**Simulation Techniques:**
Solution of model equations and their interpretation, zeroth, first and second order system, solution of 2nd order electro-mechanical equation by finite element method, transfer function and frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis, design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, coupling of simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment.

**Modelling and Simulation of Practical Problems:**
Pure mechanical models, Models for electromagnetic actuators including the electrical drivers, Models for DC-engines with different closed loop controllers using operational amplifiers, Models for transistor amplifiers, Models for vehicle system.

**Text Books :**
1. L. Ljung, T. Glad, "Modeling of Dynamical Systems", Prentice Hall Inc. (1994).
2. D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, "System Dynamics: A Unified Approach", 2nd Edition, Wiley-Inderscience (1990).
3. G. Gordon, "System Simulation", 2nd Edition, PHI Learning (2009).

**Reference Book :**
1. V. Giurgiutiu and S. E. Lyshevski, "Micromechatronics, Modeling, Analysis, and Design with MATLAB", 2nd Edition, CRC Press (2009).

## MH 3034 PRODUCT DESIGN & DEVELOPMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. identify and analyse the product design and development processes in manufacturing industry.
CO2. analyse, evaluate and apply the methodologies for product design, development and management.
CO3. undertake a methodical approach to the management of product development to satisfy customer needs.
CO4. carry out cost and benefit analysis through various cost models.
CO5. understand and familiar with the design protection and intellectual property.
CO6. able to integrate the marketing, design, and manufacturing functions of the firm in creating a new product

**Prerequisite: Solid Mechanics and Machine Design(MH 2018)**

**Introduction:**

Need for IPPD, Strategic importance of Product development, integration of customer, designer, material supplier and process planner, Competitor and customer, Behavior analysis. Understanding customer, prompting customer understanding, involve customer in development and managing requirements, Organization process management and improvement, Plan and establish product specifications.

**Concept Generation and Selection:**

Task, Structured, approaches clarification, search, externally and internally, explore systematically, reflect on the solutions and processes, concept selection, methodology, benefits.

**Product Architecture:**

Implications, Product change, variety, component standardization, product performance, manufacturability, product development management, establishing the architecture, creation, clustering, geometric layout development, fundamental and incidental interactions, related system level design issues, secondary systems, architecture of the chunks, creating detailed interface specifications.

**Industrial Design:**

Integrate process design, managing costs, Robust design, Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing processes electronically, need for industrial design, impact, design process, investigation of for industrial design, impact, design process, investigation of customer needs, conceptualization, refinement, management of the industrial design process, technology driven products, user, driven products, assessing the quality of industrial design.

**Design for Manufacturing and Product Development:**

Definition, Estimation of Manufacturing cost, reducing the component costs and assembly costs, minimize system complexity, Prototype basics, principles of prototyping, planning for prototypes, Economic Analysis, Understanding and representing tasks, baseline project planning, accelerating the project, project execution.

**Text Book :**

1. Kari T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw-Hill International Ed. 1999.

**Reference Books :**

1. Kemnneth Crow, Concurrent Engg./Integrated Product Development, DRM Associates,26/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
2. Stephen Rosenthal, Effective Product Design and Development, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
3. Staurt Pugh, Tool Design –Integrated Methods for Successful Product Engineering, Addison Wesley Publishing, New York, NY.

## MH 3035 PROCESS PLANNING AND COST ESTIMATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the basic concepts of manual and computer aided process planning in industries.
CO2. ability to use the concepts of process planning and its activities
CO3. understand and estimate the different elements of cost of production including depreciation.
CO4. ability to estimate the cost involved for foundry, forging, welding and sheet metal shops.
CO5. ability to estimate the cost involved in machining operations.

**Prerequisite: Principles of Machine Tools (MH-2002)**

**Process Planning:**

Introduction: methods of Process Planning, drawing interpretation, Material evaluation, selection and analysis: Manual, experienced based planning, Computer aided process planning, Variant, Generative Processes analysis, Types of Production. Production equipment and tooling selection.

**Introduction to Costing Estimation:**

Aims of costing and Estimation, Functions and Procedure, Introduction to Costs, Computing Material cost, Direct Labor cost, Analysis of Overhead costs, Factory expenses, Administrative expenses, Selling and Distributing expenses, Cost Ladder, Cost of Product, Depreciation, Analysis of Depreciation.

**Production Cost Estimation:**

Estimation in Foundry shop, Pattern Cost Casting cost, Illustrative examples. Estimation in Forging Shop, Losses in forging, Forging cost, Illustrative examples. Estimation in welding shop, Gas cutting, Electric Welding, Illustrative examples. Estimation in sheet metal shop, Shearing and Forming, Illustrative examples.

**Calculation of Machining Times and Costs:**
Estimation of machining time for lathe operations, Estimation of machining time for drilling, boring, shaping, planning, milling and grinding operations, Illustrative examples.

**Text Books :**

1. M.S. Adithan and Pabla, "Estimating and Costing," Konark Publishers Pvt. Ltd, 1989.
2. A.K. Chitale and R.C. Gupta, "Product Design and manufacturing", Prentice Hall Pvt. Ltd., 1997.
3. Nanua Singh, "System Approach to Computer Integrated Design and Manufacturing", John Wiley & sons, Inc., 1996.
4. Joseph G. Monks., "Operations Management, Theory and Problems", McGraw Hill Book Company, 1982.


**Reference Books :**

1. G.B.S. Narang and V. Kumar, "Production and Planning", Khanna Publishers, 1995.
2. T.R. Banga and S.C. Sharma, "Estimating and Costing", Khanna publishers, 1986.


## MH 3037 MICRO AND NANO MANUFACTURING SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand manufacturing considerations at the micro and nano scale.
CO2. understand the definition of nanotechnology and increase in nanotechnology awareness.
CO3. understand design-and-analysis methods and tools used for micro and nano manufacturing
CO4. know the processing and applications of nanoparticles and nanomaterials.

CO5. design and select industrially-viable processes, equipment and manufacturing tools for specific industrial products

CO6. understand the application of computers in the area of nano design.

## Prerequisite: Principles of Machine Tools (MH 2002)

**Introduction:**

Working principles and process parameters, machine tools, applications of the micro manufacturing processes, challenges in meso, micro, and nano manufacturing, industrial applications and future scope of micro-manufacturing processes.

**Microfabrication:**

Mechanical Micromachining, Physical Fabrication Methods, Lithography, Processing Setup, Nano Lithgraphy & Manipulation, Precision Micro and Nano grinding, Use of Spectrometers & Microscopes
Laser Based Micro and Nanofabrication Pulsed Water Drop Micromachining, Nano Materials, Synthesis of Nano materials, Bio Materials, Nano Composites, Development of Nano Particles.

**Nano Technology:**

Nano technology Concepts and Applications Micro and Nanofabrication, Nano technology in India Scope for Microfabrication, Rise Nano technology Fields Commercialization Issues of Micro-Nano Technology.

**Innovative Applications on Present Devices:**

Nanochips, Nanotubes and Nanowires, Integration of chips and microprocessors, Technology Support, Meeting Social Needs

**Nano Design & CAD:**

Computer Aided Nano Design, VLSI product detailing Finite Element Analysis of Microstructures, 3-D Molecular Modelling

**Acceptability of Nano Workmanship:**

Nano to millimeter Integration Atomic Scale Precision & Control, Promising Nano-centered Future.

**Text Books :**

1. Tai Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata-McGraw Hill, New Delhi, 2002.
2. Sami Franssila," Introduction to Micro fabrication", John Wiley & sons Ltd, 2004. ISBN:470-85106-6
3. W.R. Fahrner "Nanotechnology and Nanoelectronics", Springer (India) Private Ltd., 2011.
4. Norio Taniguchi, "Nano Technology", Oxford University Press, New York, 2003

**Reference Books :**

1. Microfabrication & Nonmanufacturing by Mark J. Jackson 2. ASM handbook on machining
2. Mohamed Gad-el-Hak, MEMS Handbook, CRC press, 2006, ISBN: 8493-9138-5
3. Mark Madou, Fundamentals of Microfabrication, CRC Press, New York, 1997

## MH 3039 ARTIFICIAL INTELLIGENCE FOR MECHATRONICS SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the concepts of artificial intelligence approaches

CO2. demonstrate awareness of the major challenges facing AI and the complex of typical problems within the field.

CO3. exhibit strong familiarity with a number of important AI techniques, including in particular search

CO4. understand the concepts of Neural Networks and various types of learning algorithms

CO5. apply neural networks to pattern classification problems.
CO6. evaluate and compare solutions by various soft computing approaches for a given problem

## Prerequisite: Nil

**Introduction:**

Overview; Foundation; History; The State of Art.

**Intelligent Agents:**

Agents and environment; Rationality; The nature of environment; The structure of agents.

**Solving Problems by Searching:**

Problem-solving agents; Well defined problems & solutions; Formulating problems; Searching for solution; Informed/Uninformed search strategies: (BFS, DFS, DLS, IDDFS, Bidirectional Search)

**Knowledge Representation and Reasoning:**

Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

**Neural Networks:**

Supervised Learning Neural Networks, Perceptrons, Adaline, Back propagation Mutilayer Perceptrons, Radial Basis Function Networks, Unsupervised Learning Neural Networks, Competitive Learning Networks, Kohonen Self-Organizing Networks, Learning Vector Quantization, Hebbian Learning, Hop-field networks.

**Recent Advances:**

Neural network structures for pattern recognition - Neural network based pattern associators – Unsupervised learning in neural pattern recognition - Self organizing networks - Fuzzy logic - Fuzzy pattern classifiers - Pattern classification using Genetic Algorithms.

**Text Book :**

1. Artificial Intelligence: A Modern Approach – Stuart Russel, Peter Norvig, 3rd Edition, Pearson Education, 2009.

**Reference Books :**

1. Artificial Intelligence - Elaine Rich, Kevin Knight and Shivashankar B Nair, 3rd Edition, Tata McGraw Hill, 2008.
2. Artificial Intelligence: A new Synthesis – Nils J. Nilsson, 1st Edition, Elsevier, 1997.
3. Introduction to Artificial Intelligence and Expert Systems- Dan W. Patterson 2nd Edition, PHI, 2009.
4. Christopher-M-Bishop," Pattern-Recognition-and-Machine-Learning", Springer.

## MH 3040 MICRO ELECTRO MECHANICAL SYSTEMSCr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic concepts of micro electromechanical systems.
CO2. understand the tools and processes used in micromaching of microelectromechanical systems (MEMS)
CO3. understand the concepts of working of micro-sensors and actuators, to enable selection, design and configuration of Micro-sensors and actuators
CO3. critically analyze microsystems technology for technical feasibility as well as practicality.

CO4. understand the knowledge about nano materials and various nano measurements techniques.
CO5. choose appropriate material for any microsystem and packaging method for any microsystem
CO6. Understand reliability in MEMS.

**Prerequisites: Material Science and Engineering (ME 2007), Digital Electronics (EC 2011) and Sensors & Actuators (EI 3007)**

**Introduction to Microsystems:**

Overview of microelectronics manufacture and Microsystems technology. Definition- MEMS materials. Laws of scaling. The multi-disciplinary nature of MEMS. Survey of materials central to micro engineering. Applications of MEMS in various industries.

**Micro Sensors & Actuators:**

Working principle of Microsystems, micro actuation techniques, micro sensors types, Micro actuators types: micro pump, micro motors, micro valves, micro grippers, micro accelerometers.

**Fabrication Process:**

Substrates-single crystal silicon wafer Formation-Photolithography-Ion Implantation-Diffusion Oxidation, CVD-Physical Vapor Deposition-Deposition by epitaxy-etching process.

**Micro System Manufacturing:**

Bulk Micro manufacturing- surface micro machining, LIGA, SLIGA, Micro system packaging materials, die level, device level, system level, packaging techniques, die preparation, surface bonding, wire bonding, sealing.

**Microsystems Design and Packaging:**

Design considerations, Mechanical Design, Process design, Realization of MEMS components using intellisuite. Micro system packaging, Packing Technologies, Assembly of Microsystems, Reliability in MEMS. What's next- NEMS, micro factories and nanotechnology.

**Text Books :**

1. Mohamed Gad el Hak, "MEMS Handbook", CRC Press, 2002.
2. P. Rai Choudhury "MEMS and MOEMS Technology and Applications", PHI Learning Private Limited, 2009.
3. Sabrie Solomon, "Sensors Handbook," Mc Graw Hill, 1998.
4. Marc F Madou, "Fundamentals of Micro Fabrication", CRC Press, 2nd Edition, 2002.

**Reference Books :**

1. E.H. Francis, Tay and W.O. Choong, "Micro fluidics and Bio mems application", IEEE Press New York, 1997.
2. S. Trimmer William, Ed., "Micromechanics and MEMS", IEEE Press New York, 1997.

## MH 3042 MOBILE AND AUTONOMOUS ROBOTS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. define key issues and constraints of locomotion
CO2. interpret different sensor technologies for tracking
CO3. identify robotic platforms and their limitations
CO4. analyze the kinematics of robot
CO5. determination of different parameters of mobile robot by programming
CO6. design of automation solutions using mobile robots

**Prerequisites: Principle of Control Systems (EE 3009), Sensors & Actuators (EI 3007), Robotics, Advanced Concepts and Analysis (MH 4001)**

**Locomotion:**

Introduction: Key issues for locomotion, Legged Mobile Robots, Leg configurations and stability, Consideration of dynamics, Examples of legged robot locomotion, Wheeled Mobile Robots, Wheeled locomotion: The design space.

**Mobile Robot Kinematics:**

Introduction, Kinematic Models and Constraints, representing robot position, forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints, Mobile Robot Manoeuvrability, Degree of mobility, Degree of steer-ability, Robot manoeuvrability, Mobile Robot Workspace, Degrees of freedom, Holonomic robots, Path and trajectory considerations, Beyond Basic Kinematics, Motion Control (Kinematic Control), Open loop control (trajectory-following), Feedback control

**Perception:**

Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, representing uncertainty, Wheel/motor sensors, heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors, Fundamentals of Computer Vision, Digital camera, Image formation, Omnidirectional cameras, Structure from stereo, Structure from motion, Motion and optical flow, Colour tracking, Fundamentals of Image Processing, Image filtering, Edge detection, Computing image similarity, Image Feature Extraction: Interest Point Detectors, Place Recognition, Line fitting, Six line-extraction algorithms

**Mobile Robot Localization: Introduction:**

The Challenge of Localization: Noise and Aliasing, Sensor noise, Sensor aliasing, Effector noise an error model for odometric position estimation, To Localize or Not to Localize: Localization-Based Navigation Versus, Single-hypothesis belief, Multiple-hypothesis belief, The ingredients of probabilistic map-based localization, Classification of localization problems, Markov localization, Kalman filter localization. SLAM: The simultaneous localization and mapping problem, Mathematical definition of SLAM

**Planning and Navigation:**

Introduction, Competences for Navigation: Planning and Reacting, Path Planning, Graph search, Potential field path planning, Obstacle avoidance, Bug algorithm, Navigation Architectures, Control localization, Techniques for decomposition Case studies: tiered robot architectures.

**Text Book :**

1. Howard Choset, et. al. 2005. Principles of Robot Motion: Theory, Algorithms, and Implementations, The MIT Press, ISBN-10: 0262033275.

**Reference Book :**

1. Hexmoor, 2013. Essential Principles for Autonomous Robotics, Morgan and Claypool publishers.

## MH 3044 VIRTUAL REALITY AND HAPTICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic concept of virtual reality and haptics in engineering application
CO2. ability to design current generation systems for creating 3D VR environments
CO3. ability to do the geometric modelling and virtual reality programming.
CO4. understand the application of VR in various engineering applications

CO5. earn knowledge on haptic architecture
CO6. have the knowledge on various types of haptic devices

## Prerequisite: Nil

**Virtual Reality:**

The historical development of VR: Requirements for VR, benefits of Virtual reality. Hardware Technologies for 3d User Interfaces: Visual Displays Auditory Displays, Haptic Displays, Choosing Output Devices for 3D User Interfaces.

**3d User Interface Input Hardware:**

Input device characteristics, Desktop input devices, Tracking Devices, 3D Mice, Special Purpose Input Devices, Direct Human Input, Home - Brewed Input Devices, Choosing Input Devices for 3D Interfaces.

**Geometry of Virtual Worlds:**

Objects - Geometry, Position / Orientation, Hierarchy, Bounding Volume, Scripts and other attributes, Properties of Lights and Lenses, Scripts, Human visual perception of VR worlds, Interaction - Simple, Feedback, Graphical User Interface.

**3d Interaction and interface Techniques:**

3D Manipulation tasks, Manipulation Techniques and Input Devices, Interaction Techniques for 3D Manipulation, Design Guidelines - 3D Travel Tasks, Travel Techniques, Theoretical Foundations of Wayfinding, System Control, Classification, Graphical Menus, Voice Commands, Gestrual Commands, Tools, Multi modal System Control Techniques, 3D User Interfaces for the Real World, AR Interfaces as 3D Data Browsers, 3D Augmented Reality Interfaces, Augmented Surfaces and Tangible Interfaces, Agents in AR, Transitional AR-VR Interfaces .

**Virtual Reality Applications:**

Engineering, Architecture, Education, Medicine, Entertainment, Science, Training.

**Haptics:**

Definition - Importance of Touch, Tactile Proprioception, Tactual Stereo genesis, Kinesthetic Interfaces, Tactile Interfaces, Human Haptics, Overview of existing applications, Design of Haptic Devices: Virtual Reality Input and Virtual Reality Output parameters, Computing Architectures for VR -Haptic assembly architecture, Haptic Interface Design, Kinesthetic devices.

**Text Books :**

1. John vince, Essential Virtual Reality Fast (2012), Springer.
2. Matjaz Mihelj, Jonezpodobnik, Haptics for virtual reality and tele operation (2012), Springer

**Reference Books :**

1. Alan B Craig, William R Sherman and Jeffrey D Will, “Developing Virtual Reality Applications: Foundations of Effective Design”, Morgan Kaufmann, 2009.
2. Gerard Jounghyun Kim, “Designing Virtual Systems: The Structured Approach”, 2005.
3. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, “3D User Interfaces, Theory and Practice”, Addison Wesley, USA, 2005.
4. Oliver Bimber and Ramesh Raskar, “Spatial Augmented Reality: Meging Real and Virtual Worlds”, 2005.
5. Burdea, Grigore C and Philippe Coiffet, “Virtual Reality Technology”, Wiley Interscience, India, 2003.

6. Howard Rheingold, “Virtual Reality: The Revolutionary Technology and how it Promises to Transform Society”, Simon and Schuster, 1991.
7. William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design (The Morgan Kaufmann Series in Computer Graphics)”. Morgan Kaufmann Publishers, San Francisco, CA, 2002.

## MH 3036 INTELLIGENT MANUFACTURING SYSTEMS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand and demonstrate the concepts of machine learning techniques.
CO2. understand the concepts of AI and its various applications.
CO3. identify various components of knowledge based systems.
CO4. apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems
CO5. apply various Intelligent techniques for manufacturing process optimization.
CO6. apply various methods to solve group technology problems and demonstrate the structure for knowledge based system for group technology.

**Prerequisite: Neural network & fuzzy logic control (EI-3023)**

**Introduction to Machine Learning:**

Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, Evolutionary computation, fuzzy logic, Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, Kalman filter, Decision theory and Utility theory, statistical learning methods, support vector machines, neural networks, expert systems.

**Industrial planning and decision making using intelligent systems:**

Production planning using fuzzy cognitive maps, computer aided process planning, Methods for inventory space allocation and storage processes analysis, Optimization of production costs and methods finding of the best process plan, Methods for production equipment selection and layout, Heuristic scheduling of multiple resources, Fuzzy multiple attribute decision making methods.

**Intelligent techniques for manufacturing process optimization:**

Application of neural networks and fuzzy sets to machining and metal forming, Artificial neural network modeling of surface quality characteristics in machining processes, parametric optimization of machining processes using evolutionary optimization methods.

**Knowledge Based Group Technology:**

Group Technology: Models and Algorithms, Visual method, Coding method, Cluster analysis method, Knowledge based group technology, Group technology in automated manufacturing system, Structure of knowledge based system for group technology (KBSGT), database, knowledge base, Clustering algorithms. Knowledge Based System for Equipment Selection (KBSES), Manufacturing system design, equipment selection problem, modelling the manufacturing equipment selection problem, problem-solving approach in KBSES, structure of the KBSES

**Text Book**

1. Yagna Narayana, “Artificial Neural Networks”, PHI, 2009.
2. Andrew Kussiak, “Intelligent Manufacturing Systems”, Prentice Hall, 1990.
3. A.B. Badiru , “Expert Systems Applications in Engineering and Manufacturing”, Prentice-Hall, New Jersey, 1992.

**Reference Book**

1. R.V. Rao "Advanced Modeling and Optimization of Manufacturing Processes", Springer-verlag, London. ISBN 978-0-85729-014-4.
2. Hamid R. Parsaei and Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems", PHI, 2009`.
3. Maluf, Nadim, "An introduction to Micro electro mechanical Systems Engineering", AR Tech house, Boston 2000.
4. Julian W.Gardner, K. Vijay, Varadan, O. Osama, Awadel Karim, "Micro sensors MEMS and Smart Devices", John Wiby & sons Ltd.,2001.

## MH 3048 INTERNET OF THINGS AND SMART MANUFACTURING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the requirements of IOT and apply on the relevant domain
CO2. work and contribute on digital transformation
CO3. apply various IoT enabled techniques for manufacturing processes
CO4. understand the technology behind industry 4.0 manufacturing
CO5. apply the concept of adopting and implementing a smart factory solution
CO6. identify the opportunities for automating operations and use of data analytics

### Pre-requisite: Computer Networks (IT 3001)

**Introduction:**

Concept of Internet of Things (IoT), common definitions, IoT applications, and functional view.
Internet of Things and Internet Technology

**Design Principles for Connected Devices:**

Calm and Ambient Technology, Magic as Metaphor, Privacy, Web Thinking for Connected Devices, Affordances.

**Internet Principles:**

Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports, Application Layer Protocols

**IoT Enabled Manufacturing System:**

Architecture of IoT- Manufacturing System, Integration framework of Real-time manufacturing information, Work
logic of IoT- Manufacturing System, Cloud based Manufacturing Resource configuration, Concept of cloud manufacturing, Real-time production information perception and capturing, Cloud service selection, Cloud Machine model.

**Smart Factory and Smart Manufacturing:**

Concepts of Industry 4.0 standard, Real-time information based scheduling, capacity planning, material planning, Real-time production monitoring techniques with smart sensors, Configuration of smart shop floor, traceability and call back of defective products

**Text Book :**

1. Yingfeng Zhang, Fei Tao, Optimization of Manufacturing Systems using the Internet of Things, Academic Press- Technology & Engineering, 2016.

**Reference Books :**

1. Jiafu Wan, Iztok Humar, Daqiang Zhang, Industrial IoT Technologies and Applications, Springer, 17-Aug-2016.
2. K. Wang, Y. Wang, J.O. Strandhagen, T. Yu, Advanced Manufacturing and Automation V, WIT Press, 2016
3. Ovidiu Vermesan and Peter Friess, Internet of Things – From Research and Innovation to Market Deployment, River Publishers, 2014.

## MH 4001 ROBOTICS: ADVANCED CONCEPTS AND ANALYSIS Cr-3

**Course Outcome:**At the end of the course, the students will be able to:

CO1. select kinematic mechanisms for a particular task by robot
CO2. classify different sensors and actuators for body parts of robot
CO3. model the mechanism for position, velocity and acceleration at various points
CO4. analyze the kinematics of robot
CO5. assess different controlling parameters of robot by programming
CO6. design the best robotics applications for overall advantages to industry

### Prerequisites: Principle of Control Systems (EE 3009), Sensors & Actuators (EI 3007)

**Introduction:**
Definition of a Robot, Basic Concepts, Robot configurations, Types of Robot drives.

**Kinematics of robot:**
Direct and inverse kinematics problems and workspace, inverse kinematics solution for the general 6R manipulator, redundant and over-constrained manipulators. Velocity and static analysis of manipulators: Linear and angular velocity, Jacobian of manipulators, singularity, static analysis.

**Dynamics of manipulators:**
Formulation of equations of motion, recursive dynamics, and generation of symbolic equations of motion by a computer simulations of robots using software and commercially available packages.

**Planning and control:**
Trajectory planning, position control, force control, hybrid control

**Industrial Applications:**
Application of robots in machining, Welding, Assembly, Material handling, Loading and Unloading, CIM, Hostile
and Remote environments. Medical robots: image guided surgical robots, radiotherapy etc.

**Advanced topics in robotics:**
Modelling and control of flexible manipulators, wheeled mobile robots, bipeds, etc. Future of robotics.

**Text Book :**

1. Robotic Engineering: An Integrated Approach- Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Prentice Hall of India

**Reference Books :**


1. M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, "Industrial Robotics-Technology, Programming and Applications", McGraw-Hill Book and Company (1986).
2. S. K. Saha, "Introduction to Robotics", Tata McGraw-Hill Publishing Company Ltd. (2008).
3. S. B. Niku, "Introduction to Robotics–Analysis Systems, Applications", Pearson Education (2001).
4. A. Ghosal, Robotics: "Fundamental Concepts and Analysis", Oxford University Press (2008).
5. Pires, "Industrial Robot Programming–Building Application for the Factories of the Future", Springer (2007).
6. Peters, "Image Guided Interventions – Technology and Applications", Springer (2008).
7. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 2nd edition, Addison-Wesley (1989).


## MH 4003 INTRODUCTION TO BIOMECHATRONICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand both the biomechanical and neuro-scientific principles governing human movement
CO2. work and contribute on sensors and actuators used in biomedical system design
CO3. understand the principle, design and applications of various flow measurement assisted device for the human functional system
CO4. design and develop bio mechatronic devices and prostheses for amputees
CO5. design and develop wearable mechatronics devices

### Pre-requisites: Principle of Control Systems (EE 3009), Sensors & Actuators (EI 3007)

**Biomechanics:**

Musculoskeletal biomechanics, orthopaedics biomechanics, biomechanics of Tendons and Ligaments cardiovascular biomechanics, human ergonomic, rehabilitation, review of multi-body dynamics

**Biosensors and actuators:**

Fundamentals of biosensor, working principle and types of metabolism sensors, affinity sensors, applications, smart actuators for biological applications.

**Biomedical signal and image processing:**

Biomedical signals and images, neurological signal processing, cardiological signal processing, adaptive noise cancelling, bio-Image processing.

**Sensory Assist Devices:**

Hearing aids – Implants, Optical Prosthetics, Visual Neuro-prostheses – Sonar based systems, Respiratory aids, Tactile devices for visually challenged.

**Active and Passive Prosthetic Limbs:**

Introduction to prosthetics, Passive Prosthetics – walking dynamics, Knee and foot prosthesis. Active prosthesis - Control of Prosthetic Arms and Hands, Leg Mechanisms, Ankle–Foot Mechanisms, Prosthesis Suspension.

**Wearable mechatronics devices Hours:**

Wearable Artificial Kidney, Wireless capsule endoscope, Wearable Exoskeletal rehabilitation system, Wearable hand rehabilitation.

**Text Book :**

1. Graham M. Brooker, "Introduction to Bio-Mechatronics", Sci Tech Publishing, 2012.

**Reference Books :**

1. Reddy D C. "Modern Biomedical Signal Processing – Principles and Techniques", TMH, New Delhi, 2005
2. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "Bio-Medical Instrumentation and Measurements", II edition, Pearson Education, 2009.
3. Raymond Tong Kaiyu . "Bio-mechatronics in Medicine and Healthcare" Pan Stanford Publishing, CRC Press, 2011.

## MH 4005 COMPUTER VISION AND IMAGE PROCESSING Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analyze different image processing technique to retrieve image information.
CO2. differentiate between different image transformation techniques.
CO3. analyze different image enhancement techniques.
CO4. analyze the concept of color image processing.
CO5. analyze the concept of image restoration.
CO6. differentiate between different image compression and segmentation techniques

### Prerequisites: Digital Signal Processing (EC 3007) & Principle of Digital Signal Processing (EC 3013)

**Image Formation:**

Coordinate Transformations, Camera Matrix, Motion/Stereo Pin-hole model, Human eye / cognitive aspects of colour / 3D space; illumination, Sampling and Quantization, Coordinate transformations and camera parameters,3D transformations problem (theory); Introduction to OpenCV: Image Data Structure, Coding format.

**Image Processing:**

Noise Removal, Blurring, Edge Detection: Canny / Gaussian/ Gabor/Texture Edges/ Curvature / Corner Detection Motion Estimation: Horn-Schunk Optical Flow Formulation Euler-Lagrange formulation: Calculus of variations theory. Structure Recovery from Motion.

**Segmentation:**

Concept of Figure vs. Ground, Watershed, Change Detection, Background Subtraction, Texture Segmentation, Gaussian Mixture Models - Applications in Color/Motion based Image, Segmentation, Background Modeling and Shape Clustering, Machine Learning techniques in Vision, Bayesian Classification, Maximum Likelihood Methods, Neural Networks; Non-parametric models; Manifold estimation. Support Vector Machines; Temporal sequence learning

**Introduction to Object Tracking:**

Exhaustive vs. Stochastic Search, Shapes, Contours, and Appearance Models, Mean-shift tracking; Contour-based models

**Object Modeling and Recognition:**

Fundamental matrix / Epipolar geometry, Adaboost approaches: Face Detection / Recognition Large Datasets; Attention models. Applications: Surveillance, Object detection, etc.

**Text Books :**

1. David Forsyth and Jean Ponce, Computer Vision: A modern Approach, Prentice Hall India 2004:
2. B. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2008

**Reference Books :**

1. E.R. Davies, Machine Vision, Theory Algorithms Practicalities, Elsevier 2005
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis, and Machine Vision. Brooks/Cole / Thomson 1999
3. Basics of some image processing aspects. Texture Chapter 24 (Perception) of Russell and Norvig: AI: A modern Approach. Prentice Hall 2000.
4. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Compute Vision, Cambridge Univ Press 2000.
5. Richard O. Duda, Peter E. Hart, and David G. Stork, Pattern Classification, 2nd ed., Wiley Asia, 2002

## MH 4007 ADVANCE CONTROL AND OPTIMIZATION Cr-3

**Course Outcome**: At the end of the course, the students will be able to :

CO1. design cascade and feedback compensation using Bodes Plot.
CO2. design PID Controllers.
CO3. create theoretical and computer models of multivariable automotive systems.
CO4. apply different advanced control techniques to automotive control problems.
CO5. use MATLAB and Simulink (commercial software packages) to design control algorithms for automotive systems.
CO6. design state estimators for multivariable automotive control systems using established techniques.

### Prerequisite: Control Systems (EL 3001)

**Introduction to Design**

Cascade and feedback compensation, Lead and Lag compensation design using Bodes plot. Cascade Compensation in Frequency Domain: Correlation of time and frequency domain specifications, Lead and Lag compensation design using Bode plot, Comparison of Lead & Lag Compensation, Feedback compensation in Frequency domain.

**PID and Robust Control System Design**

Zigler Nichols rules for Turning PID controllers, Modifications of PID control Scheme. Robust control System Design Examples.

**Modelling multi-variable systems**

Describing multi-variable systems using state-space representations using norms to describe the sizes and behaviors of signals and systems. Modelling uncertainty, noise and non-linearity. The Nyquist stability criterion and robustness.

**Optimization in multi-variable control**

Representing feedback using state-space techniques, Pole-placement techniques, Optimal control using the Linear-Quadratic Regulator (LQR), Introduction to Model-Predictive Control (MPC).

**Estimator design**

Multi-variable estimator design using pole-placement techniques, Optimal estimator design for linear systems using the Kalman Filte, Introduction to optimal control using Linear-Quadratic-Gaussian (LQG) techniques, Introduction to non-linear Kalman filtering techniques.

**Neoclassical control**

SISO design using the Youla parameter technique, Direct shaping of S(s) and T(s) and the associated stability criteria, MIMO design using the Youla parameter technique.

**Robust control**

H loop-shaping, estimating robust performance using the v-gap metric, Shaping R(s) using two degree-of-freedom compensators.

**Text Books :**
1. Control System Engg, J. Nagrath & M. Gopal 3rd Edition New Age International Publisher
2. Modern Control Engg., By K. Ogata 3rd Edition PHI

**Reference Book :**
1. Discrete Time Control System, K. Ogata 2nd Edition Pearson Education

## MH 4009 SENSORS AND SIGNAL Cr-3

**Course Outcome**: At the end of the course, the students will be able to :

CO1. apply different methods for the measurement of length and angle
CO2. elucidate the construction and working of various industrial parameters / devices used to measure pressure, sound and flow
CO3. explicate the construction and working of various industrial parameters / devices used to measure temperature, level, vibration, viscosity and humidity
CO4. analyze, formulate and select suitable sensor for the given industrial applications
CO5. understand signal conditioning circuits

### Prerequisite: Introduction to Instrumentation Engineering (EI 2008)

**Introduction**

Definition, Application and types of measurements, Instrument classification, Functional elements of an instrument, Input-output configuration of measuring instruments, Methods of correction for interfering and modifying inputs, Standards, Calibration, Introduction to Static characteristics and Dynamic characteristics, Selection of instruments, Loading effects.

**Error Analysis**

Types of errors, Methods of error analysis, Uncertainty analysis, Statistical analysis, Gaussian error distribution, Chi-Square test, Correlation coefficient, Student's t-test, Method of least square, Curve fitting, Graphical analysis, General consideration in data analysis, Design of Experiment planning.

**Sensors/Transducers**

Definition, Types, Basic principle and applications of Resistive, Inductive, Capacitive, Piezoelectric and their dynamic performance. Fiber optic sensors, Bio-chemical sensors, Hall-Effect, Photoemissive, Photo Diode/ Photo Transistor, Photovoltaic, LVDT, Strain Gauge Digital transducers: Principle, Construction, Encoders, Absolute and incremental encoders, Silicon micro transducers.

**Signal Conditioning**

Operational Amplifiers: application in instrumentation, Charge amplifier, Carrier amplifier, Introduction to active filters, Classification, Butterworth, Chebyshev, Couir filters, First order, Second order and higher order filters, Voltage to frequency and frequency to voltage converters.

**Text Books :**

1. Doebelin, E.O. and Manic, D.N., Measurement Systems: Applications and Design, McGraw Hill (2004).
2. Sawhney, A.K. and Sawhney, P., A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai (2008).

**Reference Books :**

1. Murthy, D.V.S., Transducers and Instrumentation, Prentice Hall of India (2003).
2. Nakra, B.C. and Chaudhry, K.K., Instrumentation, Measurement and Analysis, Tata McGraw Hill (2003).

# MECHANICAL (AEROSPACE) ENGINEERING)

# B. TECH IN AEROSPACE ENGINEERING

## Program Educational Objectives(PEOs):

The B. Tech program in Aerospace Engineering aims to prepare students so that they shall get widely employed in aerospace or allied disciplines and adhere to professional ethics in engineering practice. The program also aims to prepare the graduates with the following objectives:

1. Graduates shall be able to provide solutions to aerospace engineering problems involving design, manufacturing, heat power, and operational management issues.
2. Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.
3. Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

## Program Outcomes(POs):

The program outcomes are:

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes (PSOs):

The program specific outcomes are:

m) Join a technical workforce as successful professionals in a wide range of aerospace engineering and related domains.

n) Pursue advanced degrees in aerospace engineering, business, or other professional fields.

o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

## AS 2002 AUTOMATIC CONTROL THEORY Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. describe the transfer functions for automatic control systems; open-loop and closed-loop systems.
CO2. describe the various time domain and frequency domain tools for design of linear control systems.
CO3. describe the various time domain and frequency domain tools for analysis of linear control systems.
CO4. describe the methods to analyze the stability of systems from transfer function forms.
CO5. describe the methods to analyze the stability of systems from transfer function forms.
CO6. describe the methods to analyze the sampled-data control systems.

### Prerequisite: Mathematics-II (MA 1004)

**Introduction to Automatic Control Systems:**

Historical review, Examples of control systems: simple pneumatic, hydraulic and thermal systems, series and parallel systems, analogies, mechanical and electrical components.

**Open and Closed Loop Systems:**

Closed loop control versus open loop control, Feedback control systems, Block diagram representation of control systems, reduction of block diagrams, Signal Flow Graph (SFG), Mason's Gain Formula, Output to input ratios.

**Transient and Steady-State Response Analysis:**

Laplace transformation, Response of systems to different inputs viz. Step, impulse, pulse, parabolic and sinusoidal inputs, Time response of first and second order systems, steady state errors and error constants of unity feedback circuit.

**Stability Analysis:**

Stability definitions, characteristic equation, location of roots in the s-plane for stability, Routh-Hurwitz criteria of stability, Root locus and Bode techniques, concept and construction, frequency response.

**Sampled Data Control Systems:**

Sampled data control systems - functional elements-sampling process - ztransforms- properties - inverse z-transforms- response between samples modified z-transforms - ZOH and First order Hold process- mapping between s and z planes - pulse transfer functions - step response.

**Text Books :**


1. Katsuhiko Ogata., “Modern Control Engineering”, 4th edition, Prentice Hall of India Private Ltd, NewDelhi, 2004.
2. Nagrath, I J and Gopal, .M., “Control Systems Engineering”, 4th edition, New Age International Pvt. Ltd., New Delhi, 2006.


**Reference Books :**


1. Benjamin, C Kuo., “Automatic Control System”, 7th edition, Prentice Hall of India Private Ltd, New Delhi, 1993.
2. Richard, C. Dorf and Robert H. Bishop., “Modern Control System Engineering”, Addison Wesley, 1999.

## AS 2003 INTRODUCTORY AERODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. explain fluid properties and determine hydrostatic pressure using manometric data
CO2. demonstrate stability of floating bodies and types of flow. visualize different motion.
CO3. apply Bernoulli's equation in moving fluids to find flow rate.
CO4. solve hydraulic pipe flow problems and hence calculate hydraulic and energy grade lines.
CO5. understand the practical applications of Bernoulli's equation.
CO6. apply Raleigh's method and Buckingham theorem for dimensional analysis and model study.

### Prerequisite: Physics (PH 1007) and Mathematics-I (MA 1003)

**Fundamental Concepts:**

Scope of fluid mechanics and its development as a science Physical property of Fluid: Density, specific gravity, specific weight, specific volume, surface tension and capillarity, viscosity, compressibility and bulk modulus, Fluid classification.

**Fluid Statics:**

Fundamental equation and its solution (constant density and constant temperature solutions), Units and scales of pressure measurement, Manometers, Hydrostatic thrusts on submerged surfaces (plane and curved), Buoyancy, Stability of unconstrained bodies in fluids, Fluids under relative equilibrium.

**Kinematics of Fluid Flow:**

Introduction, description of fluid flow, classification of fluid flow. Reynold's number, Acceleration of fluid particles, flow rate and continuity equation, differential equation of continuity, Mathematical definitions of irrotational and rotational motion. Circulation, potential function and stream function. Flow net.

**Fluid Dynamics:**

Introduction, Euler's equation along a streamline, energy equation, Bernoulli's equation and its application to siphon, venturimeter, orificemeter, pitot tube. Flow in pipes and ducts: Loss due to friction, Minor energy losses in pipes Hydraulic Gradient Line (HGL), Total Energy Line (TEL), Power transmission in the fluid flow in pipes, fluid flow in pipes in series and parallel. Flow through nozzles.

**Dimensional Analysis and Model study:**

Dimensional homogeneity, dimensional analysis, Raleigh's method and Buckingham theorem. Superfluous and Omitted Variables, Similarity laws and model studies, Distorted models.

**Text Book :**

1. A Text Book of Fluid Mechanics and Hydraulic Machines, R. K. Bansal . Laxmi Publications(p) Ltd. 2010, $9^{th}$ Edition

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**Reference Books :**

1. Introduction to Fluid Mechanics and Fluid Machines, S. K. Som, G. Biswas & S. Chakraborty, McGraw Hill Education (India) Pvt. Ltd, New Delhi, 3rd Edition, 2014.
2. A Text Book of Fluid Mechanics, R. K. Rajput, S. Chand Limited, 2008.
3. Hydraulics and Fluid Mechanics Including Hydraulics Machines, P.N. Modi, Standard Publishers Distributors, 19th Edition, 2013.
4. Fluid Mechanics, A. K. Mohanty, PHI Learning Pvt. Ltd., 2001.
5. Engineering Fluid Mechanics, K. L. Kumar, S. Chand Limited, 2008.
6. Fluid Mechanics, Y. Cengel and J. Cimbala, McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2rd Edition, 2010.

## AS 2005 AEROSPACE STRUCTURES - I Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analyze structural elements in aircraft.
CO2. solve three moment equation and moment distribution.
CO3. make simplified analysis of a/c structures & apply energy methods.
CO4. understand and solve the column problems.
CO5. apply failure theories for various loading conditions.
CO6. understand the working principles of thin and thick cylinders.

### Prerequisite: Engineering Mechanics (ME 1003)

**Introduction to Aircraft Structures:**

Definition of structure, Type of supports, Types of loads, Types of structural members (Beams, Column, Truss, Frame, Plate and Shells), Tension, Compression, Bending and Torsion Boundary conditions, Determinate and Indeterminate structures, Aircraft structural components and their functions, Loads on aircraft.

**Stress and Strain:**
Concept of stress and strain, Normal and shear stresses in beams, Hooke's Law, Poisson's Ratio, Elastic constants and their relationship, Principal stress and strain, Principal planes, Maximum shearing stress, Uni-axial and Bi-axial state of stress, Mohr's circle, Equilibrium and Compatibility equations for elastic solids.

**Shear Force and Bending Moment:**
Relation between shear force and bending moment, Shear force and bending moment diagrams for determinate beams and frames, Theory of simple bending, Distribution of normal and shear stresses in different sections.

**Slope and Deflection:**
Slope and deflection of beams using Double Integration Method, Macaulay's Method and Area-Moment Method, Maxwell's and Betti's reciprocal theorems.

**Strain Energy:**
Strain energy due to Axial load, Bending moment and Twisting moment, Principle of Virtual work, Unit Load method, Castigliano's Theorem for analysis of beams and frames.

**Torsion:**
Torsion in solid and hollow circular shafts, Combined bending and torsion.

**Theories of Failure:**
Maximum Principle Stress Theory, Maximum Principle Strain Theory, Maximum Shear Stress Theory, Total Strain Energy Theory, Maximum Distortion Energy Theory, Octahedral shear Stress theory, Graphical representation of theories of failure.

**Columns and Cylinders:**
Euler's Theory, Critical Load, Slenderness ratio, Effective length of columns Stresses in thin and thick cylinders.

**Text Book :**
1. Donaldson, B.K., "Analysis of Aircraft Structures - An Introduction", McGraw-Hill, 1993.

**Reference Book :**
1. Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co, 1990.

## AS 2007 AEROSPACE THERMODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. comprehend terminology related to thermal engineering and recognize the need of learning thermodynamics
CO2. appreciate the 1$^{st}$ law in cyclic and acyclic processes.
CO3. interpret the 2$^{nd}$ law in applications related to heat engine, heat pump and refrigerators.
CO4. read and comprehend steam table and Mollier chart in solving complex thermal problems.
CO5. understand the applicability of gas and steam power cycles in thermal engineering.
CO6. analyze the mechanism of conduction, convection and radiation and heat exchanger principle.

**Prerequisite: Physics (PH 1007)**

**Basic concepts and definitions:**
Scope of thermodynamics, Macroscopic and microscopic approaches, Definition of closed system and open system, Extensive and Intensive Properties, Point and Path function, Reversible and irreversible processes, Thermal, mechanical and chemical equilibrium, thermodynamic equilibrium, Zeroth law of thermodynamics, Forms of energy, energy transfer by heat, forms of work (electrical and mechanical), energy transfer by work.

**First law of thermodynamics:**
Moving boundary work (PdV work), PdV work for different processes, First law for closed systems (for cyclic and non-cyclic processes), introduction of internal energy as a thermodynamic property, flow work and energy of a flowing fluid, first law for control volumes (open systems) and introduction of enthalpy as a thermodynamic property.

**Second law and Entropy:**
Second law - thermal efficiency of heat engines – Kelvin-Planck statement and Clausius statement - perpetual motion machines - reversible and irreversible processes- Carnot cycle. Entropy: increase of entropy principle-isentropic process - T-ds relations and entropy change of ideal gases – isentropic efficiencies of steady flow devices - Exergy (only introductory information).

**Pure substances:**
Definition of pure substance, p-V and T-v diagrams for pure substances, specific volumes of saturated liquid, wet vapor and superheated vapour.

**Gas Power Cycles:**
The Carnot cycle and its value in engineering - Otto cycle- Diesel cycle- Dual Cycle, Brayton cycle, Gas Turbine cycle with intercooling, reheat and regeneration.

**Heat Transfer:**
Three modes of heat transfer-conduction, convection and radiation. Fourier conduction equation, Mechanism of convection and basic concepts: Dimensional analysis for forced and free convection, Nusselt number, Concept of thermal boundary layer, Prandtl number, Radiation properties, emissive power and emissivity, Kirchoff's identity. Planck's relation for monochromatic emissive power of a black body, Stefan-Boltzman law and Wein's displacement law, Radiation shape factor.

**Heat Exchanger:**
Types of heat exchangers and heat exchanger configurations. The overall heat transfer coefficient and fouling factor. LMTD and effectiveness-NTU analysis of heat exchangers.

**Text Book :**
1. Engineering Thermodynamics, Second Edition, P. Chattopadhyay, Oxford University Press.

**Reference Books :**
1. Fundamentals of Classical Thermodynamics, Gordon J. Van Wylen , Richard E. Sonntag, Claus Borgnakke, John Wiley, Fifth Edition.
2. Engineering thermodynamics, P. K. Nag, McGraw Hill Education, Fifth Edition.
3. Thermodynamics, An Engineering Approach, Yunus A Cengel and Michael A. Boles, Mc Graw Hill Education, 7$^{th}$ Edition, 2011 (reprint 2013).

## AS 2010 AEROSPACE MATERIALS TECHNOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. recognize appropriate material for particular aerospace application.
CO2. develop and change the chemical, physical and mechanical properties of ferrous and non-ferrous alloys for aero structural applications.
CO3. select different non-ferrous materials for different industrial and day to day life application.
CO4. change the mechanical properties of steel with or without change in chemical compositions.
CO5. use the technique to prevent corrosion of different ferrous and non-ferrous alloys.
CO6. understand the selection criteria of materials for designing various aircraft, missile and satellite components.

**Prerequisite: Chemistry (CH 1007)**

**Introduction:**

Types of Materials, Crystallography: crystalline and non-crystalline solids, space lattices, crystal systems and unit cells. Defects in Materials: point defects, line defects (dislocations), surface defects and volume defects.

**Structure of Materials:**

Grains, grain boundaries, grain size, effect of grain size on properties of materials. Behaviour of Materials: Stress-strain diagrams, yielding, strain hardening, precipitation hardening, toughness, Resilience, Bauschinger's effect, Creep, Fatigue.

**Phase Diagrams:**
Basics of phase diagram, Gibb's phase rule, Lever rule, Isomorphous, Eutectic and Peritectic alloy system. Heat Treatment: Principles of heat treatment, Annealing, Normalizing, Hardening, Tempering, Mar tempering, Age hardening, Surface hardening, Case hardening.

**Engineering Materials in Aerospace:**

Ferrous Alloys in Aircrafts: Iron- C phase diagram, Alloy Steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications, Maraging Steels, Super Alloys. Non-Ferrous (NF) Alloys in Aircrafts: Aluminium and its alloys, Magnesium and its alloys, Titanium and its alloys, Copper and its alloys, Corrosion resistance of NF alloys. Composites: Metal Matrix composites used in aircrafts.

**Module 5: Materials Testing:**

Destructive Testing - Tensile testing, compression testing, fatigue testing, torsion testing, impact testing. Non-Destructive Testing - Ultrasonic testing, Dye penetration testing, magnetic testing, acoustic testing, X-ray testing.

**Materials Selection and Design Considerations:**
Real life and hypothetical case studies to illustrate the procedure for selection of materials for designing various aircraft, missile and satellite components.

**Text Book :**

1. Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications

   **or**

   Callister's Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley India, Edition - 2010.

**Reference Books :**

1. Material Science and Engineering, V. Raghavan, Prentice Hall of India, $4^{th}$ Edition.
2. Engineering Metallurgy: Applied Physical Metallurgy, R. A. Higgins, 6th Edition.

## AS 2012 AEROSPACE STRUCTURES - II Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. analyze for maximum bending stress in unsymmetrical sections.
CO2. analyze for flexural shear stress.
CO3. analyze for Torsional shear stress.
CO4. analyze for Panel Buckling allowable load.
CO5. analyze for flange and web load
CO6. analyze for failure methods in joints and fittings.

### Prerequisite: Aerospace Structures-I (AS 2005)

**Indeterminate Structures:**
Introduction to static and kinematic indeterminacy, Analysis Methods for redundant Structures: Slope deflection method, Clapeyron's Three Moment Equation Method, Castigliano's theorem for analysis of indeterminate beams and frames, Matrix method of Analysis.

**Unsymmetrical Bending:**
Definition of symmetric and unsymmetric sections, Principal axis and Neutral axis methods, Bending stresses in beams of symmetric sections, Bending stresses in beams of unsymmetrical sections

**Shear Flow In Thin Walled Sections:**
Concept of shear flow, shear centre and elastic axis, Flexural shear flow in open symmetric and unsymmetric thin walled sections, Closed single cell and multicell thin walled sections, Combined flexural and torsional shear flow, Warping in open and closed thin walled sections.

**Bending of Thin Plates:**
Pure bending of thin plates, Strain energy of pure bending of plates, Plate subjected to bending and twisting, Stiffened panel.

**Joints and Fittings:**
Bolts and Rivets and Welded connection, Bolt shear, tension and bending strength, Bolts in combined shear and tension, Bushing Method of failures of bolt fitting: Failure by bolt shear, Failure by bold bending, Failure by bearing, Failure in tension, Failure by shear tear out.

**Text Book :**
1. Lakshmi Narasaiah, G., "Aircraft Structures", BS Publications, Hyderabad, 2010.

**Reference Books :**
1. Peery, D.J., and Azar, J.J., "Aircraft Structures", 2nd edition, McGraw-Hill, N.Y., 1993.
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Edward Arnold, 1995.
3. Rivello, R.M., "Theory and Analysis of Flight Structures", McGraw-Hill, 1993
4. Bruhn. E.H. "Analysis and Design of Flight Vehicles Structures", Tri - state off set company, USA, 1973.

## AS 2014 AIRCRAFT SYSTEMS AND INSTRUMENTATION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know about Location, visibility and probing of Instrument, Panels, Basic Instrument elements and Mechanism.
CO2. know about basic electrical system, communication and navigating system in aircraft.
CO3. state the ICAO instrumentation requirements and describe instrumentation elements, mechanisms, error sources and temperature compensation.
CO4. demonstrate an aircraft control system, engine control systems (such as fuel control, ignition control, engine indications etc.) fuel systems and its components for both civil and military aircrafts.

CO5. demonstrate the electrical systems (both A.C & D.C) utilizing as an auxiliary power sources in aircrafts.

CO6. understand the working principles of navigation system.

## Prerequisite: Aerospace Thermodynamics (AS 2007)

**Airplane Control Systems:**
Conventional Systems - fully powered flight controls - Power actuated systems – Modern control systems - Digital fly by wire systems - Auto pilot system active control Technology.

**Aircraft Systems:**
Hydraulic systems - Study of typical workable system - components - Pneumatic systems - Advantages - Working principles - Typical Air pressure system – Brake system - Typical Pneumatic power system - Components, Landing Gear systems - Classification.

**Air-Conditioning and Pressurizing System:**
Vapor Cycle systems, Bootstrap air cycle system - Evaporative vapour cycle systems - Evaporative air cycle systems - Oxygen systems - Fire protection systems, Deicing and anti icing systems- Humidity control. Air distribution systems. Cabin pressurization, tolerance, rain dispersal, antimisting and demisting.

**Engine Systems:**
Fuels – Characteristics – Fuel Systems – Lubricant and Lubricant systems – Ignition and starting system – Electronic Engine controls – Full Authority Digital Control (FADEC) – engine Indicating, warning and control systems, Fire protection systems, Deicing and anti icing systems.

**Aircraft Instruments:**
Flight Instruments and Navigation Instruments – Gyroscope - Accelerometers, Air speed Indicators – TAS, EAS- Mach Meters - Altimeters - Principles and operation - Study of various types of engine instruments - Tachometers - Temperature gauges - Pressure gauges - Operation and Principles.

**Flight Instruments:**
Location, visibility and grouping of Instruments, Panels, Basic Instrument elements and Mechanism, Instruments Panels – Displays – Layouts – Grouping details of: i. Pitot instrument and systems. ii. Primary flight instruments. iii. Heading indicating instruments. iv. Remote indicating systems. v. Synchronous data transmission systems. vi. Flight director and Flight data recording systems. vii. ECAM/EICA/EFIS – Their concepts, detailed description maintenance and practices. ECAM – Electronic Central Aircraft Monitor. EICAS – Engine Indicator Crew Alert Systems. EFIS – Electronic flight Instruments Systems.

**Communication and Navigations Systems:**
Basic Principles Equipment – Power Sources – Airborne Navigational Equipment – VHF – ILS – DME – ADF – Radar and Doppler Navigation – Inertial Navigation, VOR MLS (Microwave Landing Systems) Cockpit Voice Recorder (CVR), ELT (Emergency Locator Transmitter).

**Text Book :**

1. Treager, S., “Gas Turbine Technology”, McGraw-Hill, 1997.


**Reference Books :**

1. McKinley, J.L., and Bent, R.D., “Aircraft Maintenance & Repair”, McGraw-Hill, 1993.
2. “General Hand Books of Airframe and Powerplant Mechanics”, U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995.
3. Mekinley, J.L. and Bent, R.D., “Aircraft Power Plants”, McGraw-Hill, 1993.
4. Pallet, E.H.J., “Aircraft Instruments & Principles”, Pitman & Co., 1993.

## AS 2016 AERODYNAMICS - I Cr-4

**Course Outcome:** At the end of the course, the students will be able to :

CO1. apply fluid mechanics concepts.
CO2. understand the fundamentals of lift generation.
CO3. calculate forces and moments acting on airfoils and wings under ideal flow conditions.
CO4. determine the airfoil and wing characteristics.
CO5. understand the concept of downwash and its effect on lift and drag.
CO6. understand the real time viscous flow and boundary layer behavior.

**Prerequisite: Introductory Aerodynamics (AS 2003) and Mathematics (MA 1003 & MA 1004)**

**Introductory Topics for Aerodynamic:**

Vortex motions – vortex line, vortex tube- vortex sheet – circulation – Kelvin and Helmhotz theorem- Biot – Savarts' law – applications, Rankine's Vortex - Kutta – Joukowski theorem.

**Aerofoil Theory:**

Aero foil nomenclature – aerodynamic characteristics – centre of pressure and aerodynamic centre- wing of finite aspect ratio – CL-α - diagram for a wing of finite aspect ratio. Generation of lift - starting and bound vortices - Kutta's trailing edge condition – thin aerofoil theory- method of singularities – elements of panel method.

**Theory of Propellers:**

Axial momentum theory – influence of wake rotation – blade-element theory – combined blade element and momentum theories- tip correction –performance of propellers.

**Wing Theory:**

Flow past finite wings - vortex model of the wing - induced drag – Prandtl's lifting line theory - elliptic wing – influence of taper and twist applied to wings – effect of sweep back – delta wings- elements of lifting surface theory.

**Flow Past Non-Lifting Bodies and Interference Effects:**

Flow past non lifting bodies- method of singularities – wing – body interference- effect of propeller on wings and bodies and tail unit –flow over airplane as a whole.

**Viscous Flow:**

Newton's law of viscosity, Boundary Layer, Navier-Stokes equation, displacement, Momentum thickness, Flow over a flat plate, Blasius solution.

**Text Book :**

1. Fundamentals of Aerodynamics, John D. Anderson (Jr.) Fifth Edition, McGraw Hill Series.

**Reference Book :**

1. Aerodynamics for Engineering Students, sixth Edition, Houghton, E.L., P. W. Carpenter, Steven H. Collicott, Daniel T. Valentine Elseveir Publishers Ltd.
2. Aerodynamics, Clancy, L.J., Indian Edition 2006, Sterling Book House Mumbai.
3. Aerodynamics for Engineers, fourth Edition, Bertin J J., Pearson Education 2002.
4. Milne Thomson, L.H., "Theoretical aerodynamics", Macmillan, 1985.

## AS 2018 PROPULSION - I Cr-4

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the working principle, thermodynamic cycles and performance characteristics of gas turbine engines.
CO2. understand the internal flow and external characteristics near the inlets, starting problems and different modes of operation in supersonic inlets.
CO3. know the types and working principles of axial compressors, its velocity diagrams, blade design and performance characteristics of compressors.
CO4. know the types of combustion chambers, the flame stabilization and combustion techniques.
CO5. understand flow through nozzle, losses in nozzle, variable area nozzle and thrust vectoring.
CO6. understand the efficiency calculations for over-expanded and under-expanded nozzles.

**Prerequisite: Aerospace Thermodynamics (AS 2007)**

**Fundamentals of Gas Turbine Engines:**
Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust– Effect of pressure, velocity and temperature changes of air entering compressor –Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet –Performance characteristics.

**Subsonic And Supersonic Inlets For Jet Engines:**
Internal flow and Stall in subsonic inlets – Boundary layer separation – Major features of external flow near a subsonic inlet – Relation between minimum area ratio and external deceleration ratio – Diffuser performance – Supersonic inlets – Starting problem on supersonic inlets – Shock swallowing by area variation – External declaration – Models of inlet operation.

**Compressors:**
Principle of operation of centrifugal compressor – Work done and pressure rise – Velocity diagrams – Diffuser vane design considerations – Concept of prewhirl, rotation stall and surge – Elementary theory of axial flow compressor – Velocity triangles – degree of reaction – Three dimensional – Air angle distributions for free vortex and constant reaction designs – Compressor blade design – Centrifugal and Axial compressor performance characteristics.

**Combustion Chambers:**
Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders – Numerical problems.

**Turbines:**
Impulse and reaction blading of gas turbines – Velocity triangles and power output – Elementary theory – Vortex theory – Choice of blade profile, pitch and chord – Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – Methods of blade cooling – Matching of turbine and compressor.

**Nozzles:**
Theory of flow in isentropic nozzles – nozzles and choking – Nozzle throat conditions – Nozzle efficiency – Losses in nozzles – Over expanded and under – expanded nozzles – Ejector and variable area nozzles – Interaction of nozzle flow with adjacent surfaces – Thrust reversal.

**Text Book :**

1. Hill, P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Addison – Wesley Longman INC, 1999.


**Reference Books :**

1. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. “Gas Turbine Theory”, Longman, 1989.
2. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, New York, 1985.

3. “Rolls Royce Jet Engine” – Third Edition – 1983.
4. Mathur, M.L. and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 1999.

## AS 3005 AERODYNAMICS - II Cr-4

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the energy, momentum and continuity equations.
CO2. know the various parameters affecting the normal and oblique shock waves.
CO3. know the various theories regarding the steady compressible flow.
CO4. know the various parameters of airfoil in high speed flow.
CO5. know the various methods for creating supersonic flow in wind tunnels.
CO6. understand transonic flow over wing.

### Prerequisite: Aerodynamics-I (AS 2016)

**One Dimensional Compressible Flow:**

Energy, Momentum, continuity and state equations, velocity of sound, adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures.

**Normal, Oblique Shocks:**

Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polar, flow past wedges and concave corners, strong, weak and detached shocks.

**Expansion Waves, Rayleigh and Fanno Flow:**

Flow past convex corners, Expansion hodograph, Reflection and interaction of shocks and expansion, waves. Method of Characteristics Two dimensional supersonic nozzle contours. Rayleigh and Fanno Flow.

**Differential Equations of Motion for Steady Compressible Flow:**

Small perturbation potential theory, solutions for supersonic flows, Mach waves and Mach angles, Prandtl-Glauert affine transformation relations for subsonic flows, Linearized two dimensional supersonic flow theory, Lift, drag pitching moment and center of pressure of supersonic profiles.

**Transonic Flow Over Wing:**

Lower and upper critical Mach numbers, Lift and drag divergence, shock induced separation, Characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects.

**Wind Tunnels:**

Blow down, indraft and induction tunnel layouts and their design features, Transonic, supersonic and hypersonic tunnels and their peculiarities, Helium and gun tunnels, Shock tubes, Optical methods of flow visualization.

**Text Book :**

1. Rathakrishnan, E., "Gas Dynamics", Prentice Hall of India, 2003.

**Reference Books :**

1. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronold Press, 1982.
2. Zucrow, M.J. and Anderson, J.D., "Elements of gas dynamics", McGraw-Hill Book Co., New York, 1989.

3. Mc Cornick. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, New York, 1979.
4. Anderson Jr., D., - "Modern compressible flows", McGraw-Hill Book Co., New York 1999.

## AS 3007 PROPULSION - II Cr-4

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the types of rocket, missiles and its basic configuration.
CO2. know In detail about liquid propellant rockets and the various types of propellants used with their burning rates.
CO3. know the operating principle of ramjet, combustion and its performance.
CO4. know the solid rocket operating principles and components of solid rocket motor
CO5. know about electric, ion and nuclear rockets. The basics of solar sails and its operating principle
CO6. understand the performance characteristics of aerospace vehicles.

**Prerequisite: Propulsion-I (AS 2018)**

**Ramjet Propulsion:**

Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance– Simple ramjet design calculations – Introduction to scramjet.

**Fundamentals of Rocket Propulsion:**
History of rocket propulsion, Operating principle – Specific impulse of a rocket – internal ballistics types of rocket, Basic configurations and application -Types of missiles and their structure, Heat transfer and cooling system in rocket , classification of Chemical rocket propulsion system, Rocket performance considerations.

**Chemical Rockets:**

Solid propellant rockets – Selection criteria of solid propellants – Important hardware components of solid rockets – Propellant grain design considerations – Liquid propellant rockets – Selection of liquid propellants. Cooling in liquid rockets – Hybrid rockets.

**Advanced Propulsion Techniques:**

Electric rocket propulsion – Ion propulsion techniques – Nuclear rocket – Types – Solar sail- Preliminary Concepts in nozzle less propulsion.

**Scramjet Propulsion:**

Fundamentals of hypersonic air birthing vehicles, Preliminary concepts in engine airframe integration, Various types of supersonic combustors, Requirements for supersonic combustors, Performance estimation of supersonic combustors.

**Performance of Aerospace Vehicles:**

Static performance, vehicle acceleration, performance characteristics, nozzle.

**Text Books :**

1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Edn., 1993.
2. Hill, P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Addison – Wesley Longman INC, 1999.

**Reference Books :**


1. Cohen, H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., “Gas Turbine Theory”, Longman Co., ELBS Ed., 1989.
2. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.
3. "Rolls Royce Jet Engine" - Third Edition - 1983.
4. Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi,1999


## AS 3010 AIRCRAFT STABILITY AND CONTROL Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. knowledge about degrees of stability, stability criteria, effect of fuselage and CG location, stick forces, aerodynamic balancing. (stick fixed).
CO2. knowledge about degrees of stability, stability criteria, effect of fuselage and CG location, stick forces, aerodynamic balancing. (stick free condition).
CO3. understanding about lateral control, rolling and yawing moments, static directional stability, rudder and aileron control requirements and rudder lock.
CO4. understanding about dynamic longitudinal stability, stability derivatives, modes and stability criterion, lateral and directional dynamic stability.
CO5. understanding the rotor function in vertical flight, rotor mechanism.
CO6. understand the stability and control mechanisms in vertical and forward flights.

**Prerequisite: Aerodynamics-I (AS 2016) and Aerodynamics-II (AS 3005)**

**Static Longitudinal Stability and Control - Stick Fixed:**

Degree of freedom of rigid bodies in space - Static and dynamic stability - Purpose of controls in airplanes - Inherently stable and marginal stable airplanes - Static, Longitudinal stability - Stick fixed stability - Basic equilibrium equation - Stability criterion - Effects of fuselage and nacelle - Influence of CG location - Power effects - Stick fixed neutral point.

**Static Longitudinal Stability And Control - Stick Free:**

Stick free stability-Hinge moment coefficient - Stick free neutral points-Symmetric maneuvers - Stick force gradients - Stick _ force per 'g' - Aerodynamic balancing. Determination of neutral points and maneuver points from flight test.

**Lateral And Directional Stability:**

Dihedral effect - Lateral control - Coupling between rolling and yawing moments - Adverse yaw effects - Aileron reversal - Static directional stability - Weather cocking effect - Rudder requirements - One engine inoperative condition - Rudder lock.

**Dynamic Stability:**

Dynamic longitudinal stability: Equations of motion - Stability derivatives - Characteristic equation of stick fixed case - Modes and stability criterion - Effect of freeing-the stick - Brief description of lateral and directional. Dynamic stability - Spiral, divergence, Dutch roll, auto rotation and spin.

**Helicopter Flight Dynamics:**

Rotor function in vertical flight, Rotor Mechanism for forward flight, Trim, Stability and control.

**Text Books :**


1. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1998.
2. J.Seddon, "Basic Helicopter Aerodynamics", AIAA Series, 1990.

**Reference Books :**


1. Etkin, B., "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York, 1982.
2. Babister, A.W., "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford, 1980.
3. Dommasch, D.O., Shelby, S.S., and Connolly, T.F., "Aeroplane Aero dynamics", Third Edition, Issac Pitman, London, 1981.
4. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley & Son:, Inc, New York, 1988.


## AS 3012 SPACE MECHANICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand solar time solar system and associated basic terms.
CO2. understand satellite orbits relation between position and time.
CO3. understand satellite orbit transfer, special perturbations.
CO4. understand about the various phases in missile launching.
CO5. understand about the spacecraft trajectories between planets.
CO6. understand the effects of influence coefficients on missile trajectories.

### Prerequisite: Engineering Mechanics (ME 1003)

**Basic Concepts:**

The solar system, Reference frame and coordinate, the celestial sphere, the ecliptic , sidereal time, solar time, standard time, the earth atmosphere.

**N-Body Problem:**

The many body problem, circular restricted three body problem, liberation points, two body problem, satellite orbits, relation between position and time, orbital elements.

**Satellite Injection and Satellite Orbit Perturbations:**

Introduction to satellite injection , satellite orbit transfer, orbit deviation due to injection errors, special and general perturbations, methods of vibration of orbital elements.

**Ballistic Missile Trajectory:**

The boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of the impact point, influence coefficients.

**Interplanetary Trajectories:**

Two dimensional interplanetary trajectories, Fast interplanetary trajectories, three dimensional interplanetary trajectories, Launch of Interplanetary spacecraft, Trajectory about the target planet.

**Text Books :**


1. Curtis Howard D., "Orbital Mechanics for Engineering Students", Elsevier India.
2. Bate Roger R., Mueller Donald D., White Jerry E., "Fundamentals of Astrodynamics", Dover Publications Inc., New York.


**Reference Book :**


1. Sutton, G. P., "Rocket Propulsion Elements", John Wiley, 1993
2. Van de Kamp, P., "Elements of Astromechanics", Pitman, 1979
3. Parker, E. R., "Materials for Missile and Spacecraft", McGraw-Hill Book Co. Inc., 1982.
4. Cornelisse, J.W., " Rocket propulsion and space dynamics ", W.H. Freeman & co,1984.

## AS 3014 AVIONICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to :

CO1. understand the avionics system in weapons design and technologies.
CO2. understand the digital computers, microprocessors and memories.
CO3. understand the avionics system architecture like data bus MIL STD 1553, B ARINC 429.
CO4. understand the control and display technologies like CRT, LED, LCD, EL and plasma panel.
CO5. understand the communication system, flight control system and radar electronic warfare.
CO6. understand the phenomena of utility, reliability and maintainability of avionics systems.

### Prerequisite: Aircraft Systems & Instrumentation (AS 2014)

**Introduction to Avionics:**

Importance and role of Avionics, Basic principles of Avionics – Typical avionics sub system in civil/ military aircraft and space vehicles, Need for avionics in civil and military aircraft and space systems - Integrated avionics and weapon systems-design, technologies.

**Principles of Digital Systems:**

Digital Computers - Microprocessors - Memories

**Digital Avionics Architecture:**

Avionics system architecture-Data buses MIL-STD 1553 - B, ARINC 429, ARINC 629

**Flight Deck and Cockpits:**

Control and display technologies CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS

**Introduction to Avionics Systems:**

Communication Systems - Navigation systems - Flight control systems - Radar electronic warfare - Utility systems Reliability and maintainability - Certification.

**Text Books :**

1. Malcrno A.P. and Leach, D.P., "Digital Principles and Application", Tata McGraw-Hill, 1990.
2. Gaonkar, R.S., "Microprocessors Architecture - Programming and Application", Wiley and Sons Ltd., New Delhi, 1990.

**Reference Books :**

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1919.
2. Spitzer, C.R., "Digital Avionic Systems", Prentice Hall, Englewood Cliffs, N.J., USA., 1917.
3. Brain Kendal, "Manual of Avionics", The English Book House, 3rd Edition, New Delhi, 1993.

## AS 3015 AIRCRAFT PERFORMANCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the airplane as a dynamic system, equilibrium conditions.
CO2 . understand the different types of drag and drag polar.
CO3. understand the variation of thrust, power, SFC with velocity and altitude.
CO4. understand about performance in level flight, minimum drag and power required, climbing, gliding and turning flight, VN diagram and load factor.

CO5. understand the principles and mechanics behind the Helicopter flight.
CO6. understand the ground effect on the performance of helicopter aerodynamics.

## Prerequisite: Aerodynamics-I (AS 2016), Propulsion-I (AS 2018)

**Aircraft Properties:**

The airplane as a rigid body, the airplane as a dynamic system, Equilibrium conditions, Static stability conditions, Airplane dynamics, Airplane control. Aerodynamic properties of wing and its components.

**Drag Estimation:**

Drag aerodynamics - Dimensional Analysis, Potential flow, induced drag, Flow of viscous fluid, parasite drag, and flow of a compressible fluid. Aerodynamic data - section characteristics, plan form characteristics, high lift and control devices, Determination of three dimensional wing data. Estimation of airplane drag, low speed drag estimation, high speed drag estimation.

**Performance:**

Performance computation, generalized performance method, compressibility speed correction, Range and Endurance, Take - off and landing distances, acceleration in climb, turning performance, design performance.

**Cruising Flight Performance:**

International Standard Atmosphere - Forces and moments acting on a flight vehicle -Equation of motion of a rigid flight vehicle - Different types of drag –estimation of parasite drag co-efficient by proper area method- Drag polar of vehicles from low speed to high speeds - Variation of thrust, power with velocity and altitudes for air breathing engines. Performance of airplane in level flight - Power available and power required curves. Maximum speed in level flight - Conditions for minimum drag and power required.

**Manoeuvering Flight Performance:**

Range and endurance - Climbing and gliding flight (Maximum rate of climb and steepest angle of climb, minimum rate of sink and shallowest angle of glide) -Turning performance (Turning rate turn radius). Bank angle and load factor – limitations on turn - V-n diagram and load factor.

**Helicopter Rotor Aerodynamics And Performance:**

Introduction, effect of gyroscopic precession, Torque reaction and directional control, dissymmetry of lift, Blade tip stall , Translating tendency and its correction, Coriolis effect and compensation, vortex ring state, power settling, over pitching, Auto-rotation, Ground effect.

**Text Books :**

1. Perkins, C.D., and Hage, R.E., "Airplane Performance Stability and Control", John Wiley & soInc., New York, 1988.
2. Leishman, J.G., "Principle of Helicopter Aerodynamics", Cambridge Aerospace.

**Reference Books :**

1. Etkin, B., "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York, 1982.
2. Babister, A.W., "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford, 1980.
3. Dommasch, D.O., Shelby, S.S., and Connolly, T.F., "Aeroplane Aero dynamics", Third Edition, Issac Pitman, London, 1981.
4. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 1998

## AS 3031 COMPUTATIONAL AERODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. execute subsonic potential flow computations.
CO2. understand the basics of discretization process for numerical calculations.
CO3. implement 2D panel methods on lifting and non-lifting bodies.
CO4. design components which require compressible flow computations.
CO5. design Converging nozzles, C&D nozzles and diffusers using Euler equations.
CO6. write numerical solvers from scratch for 2D compressible flow computations.

**Prerequisite: Aerodynamics-I (AS 2016), Aerodynamics-II (AS 3005)**

**Basic Aspects of Computational Aerodynamics:**

Introduction to computational fluid dynamics, CFD as a research tool- as a design tool. Applications in various branches of engineering - Models of fluid flow- Finite Control Volume, Infinitesimal Fluid Element. Substantial derivative- physical meaning of Divergence of velocity.

**Governing Equations and Physical Boundary Conditions:**

Derivation of continuity, momentum and energy equations- physical boundary conditions significance of conservation and non-conservation forms and their implication on CFD applications- strong and weak conservation forms- shock capturing and shock fitting approaches.

**Mathematical Behavior of Partial Differential Equations and Their Impact on Computational Aerodynamics:**

Classification of quasilinear partial differential equations by Cramer's rule and eigen value method. General behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations- domain of dependence and range of influence for hyperbolic equations. Well-posed problems.

**Basic Aspects of Discretization:**

Introduction to finite differences- finite difference approximation for first order, second order and mixed derivatives. Pros and cons of higher order difference schemes. Difference equations- explicit and implicit approaches- truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions-Von Neumann stability analysis. Physical significance of CFL stability condition.

**Finite Volume Methods:**

Basis of finite volume method- conditions on the finite volume selections- cell-centered and cell-vertex approaches. Definition of finite volume discretization -general formulation of a numerical scheme- two dimensional finite volume methods with example.

**Grid Types and Characteristics:**

Need for grid generation. Structured grids-Cartesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, Cmesh, O-mesh, I-mesh, Multi-block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids. Unstructured grids- triangular/ tetrahedral cells, hybrid grids, quadrilateral/hexahedra cells.

**CFD Techniques:**

Lax-Wendroff technique, MacCormack's technique-Crank Nicholson technique-Relaxation technique - aspects of numerical dissipation and dispersion. Alternating-Direction-Implicit (ADI) Technique. Pressure correction technique- application to incompressible viscous flow- need for staggered grid. Philosophy of pressure correction method- pressure correction formula. Numerical procedures- SIMPLE, SIMPLER, SIMPLEC and PISO algorithms. Boundary conditions for pressure correction method.

**Text Books :**

1. Computational Fluid Dynamics- The Basics with Applications, Anderson, J.D., Jr.,McGraw-Hill Inc., 1995.
2. Computational Fluid Mechanics and Heat Transfer, Second Edition, Anderson, D.A., Tannehill, J.C., Pletcher, R.H., Taylor and Francis, 1997.

**Reference Books :**

1. Numerical Computation of Internal and External Flows-Fundamentals of Computational Fluid Dynamics, Second Edition, Hirsch, C., Elsevier, 2007.
2. An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Second Edition, Versteeg, H.K. and Malalasekera, W., Pearson Education Ltd, 2010.
3. Computational Fluid Dynamics-A Practical Approach, Tu, J., Yeoh, G.H., Liu, C., Butterworth-Heinemann, 2008.

## AS 3032 THEORY OF AEROELASTICITY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the phenomenon of aero elasticity.
CO2. solve problem related to single degrees of freedom
CO3. solve problems using the theorems of multiple degrees of freedom.
CO4. solve problems by analysing the systems which undergo static aero elasticity problems.
CO5. solve problems in aero elasticity using MATLAB.
CO6. use MATLAB for solving systems having multi-degrees of freedom.

### Prerequisite: Mathematics-II (MA 1004) and Aerodynamics-I (AS 2016)

**Introduction:**
Aero elasticity phenomena, flutter, divergence, control reversal, flexibility effects on stability and control.

**Single Degree of Freedom:**
Introduction to degrees of freedom, Response of single degree of freedom, system, Laplace transform, Harmonic excitation virtual work, Lagrange's equation.

**Multiple Degrees of Freedom:**
Classical theories of multi degree freedom system, Undamped mode and frequencies.

**Static Aero-elasticity:**
Static problem, divergence of wind tunnel models, wall - sting and strut - mounted models, control reversal, classical flutter analysis, one and two - degree of freedom flutter, flutter boundary characteristics.

**MATLAB:**
Introduction to MATLAB, application of MATLAB for solving aero elastic problem. Design of spline - MATLAB coding.

**Text Book :**

1. Y.C. Fung, " An Introduction to the Theory of Aero elasticity (2002) ", John Wiley & Sons.

**Reference Book :**

1. Bisplinghoff R.L., Ashley H and Hoffman R.L., “Aeroelasticity” – Addision Wesley Publication, New York, 1983.

## AS 3035 SATELLITES AND SPACE SYSTEM DESIGN Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know about the Payloads and missions, system view of spacecraft propulsion system, launch vehicles, and spacecraft mechanisms.
CO2. know about the about Preoperational spacecraft environment, operational spacecraft environments, Environmental effects on design, the sun, the earth, and spacecraft effects, spacecraft structure and thermal control.
CO3. know about the various Attitude control, Electrical power systems, Telecommunications, telemetry command, data handling and process.
CO4. know about the various Failures, Reliability, material and process, safety, configuration control, build and verification, system engineering, case studies.
CO5. know about the Satellite design philosophy, satellite system design, COTS components in the space environment, Micro satellites, mini satellites and nanosatellites in orbit operation.
CO6. know about the satellite application for meteorology, navigation, communication, geo observation, and space environmental studies.

**Prerequisite: Propulsion-II (AS 3007), Space Mechanics (AS 3012).**

**Space System Design:**

Payloads and missions, system view of spacecraft propulsion system, launch vehicles, spacecraft mechanisms.

**Spcaecraft Environment and Its Effects on Design:**

Preoperational spacecraft environment, operational spacecraft environments, Environmental effects on design, the sun, the earth, and spacecraft effects, spacecraft structure, thermal control.

**Spacecraft Systems:**

Attitude control, Electrical power systems, Telecommunications, telemetry command, data handling and process.

**Product Assurance:**

Failures, Reliability, material and process, safety, configuration control, build and verification, system engineering, case studies

**Satellite Engineering and Applications:**

Satellite design philoshopy, satellite system design, COTS components in the space environment. Micro satellites, mini satellites and nano satellites, in orbit operation, satellite application for meteorology, navigation, communication, geo observation, and space environment study.

**Text Book :**
1. P. Fortescue J. Stark, and G. Swinerd, "Spcaecraft systems engineering", John Wiley and sons, 2002

## AS 3037 AIRFRAME REPAIR AND MAINTENANCE Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. familiarize in welding technology and sheet metal repair works.
CO2. know the use of plastic and composite materials in Aircraft.
CO3. know the Hydraulic and Pneumatic systems in Aircraft.
CO4. know the Safety Practices.
CO5. understand the inspection and maintenance of auxiliary systems
CO6. understand the trouble shooting processes.

**Prerequisite: Manufacturing Technology (ME 2015), Aircraft Systems & Instrumentation (AS 2014)**

**Welding in Aircraft Structural Components:**

Equipments used in welding shop and their maintenance - Ensuring quality welds - Welding jigs and fixtures - Soldering and brazing. Sheet metal Repair and Maintenance: Inspection of damage Classification - Repair or replacement - Sheet metal inspection - N.D.T. testing, riveted repair design, Damage investigation – Reverse technology.

**Plastics and Composites in Aircraft:**

Plastics in Aircraft: Review of types of plastics used in airplanes -Maintenance and repair of plastic components - Repair of cracks, holes etc., various repair schemes - Scopes. Advanced composites in Aircraft: Inspection - Repair of composite components — Special precautions - Autoclaves.

**Aircraft Jacking, Assembly and Rigging:**

Airplane jacking and weighing and C.G. Location. Balancing of control surfaces – Inspection and maintenance. Helicopter flight controls. Tracking and balancing of main rotor.

**Review of Hydraulic and Pneumatic System:**

Trouble shooting and maintenance practices - Service and inspection -Inspection and maintenance of landing gear systems. - Inspection and maintenance of air - conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing -Inspection. Inspection and maintenance of auxiliary systems - Fire protection systems - Ice protection system - Rain removal system - Position and warning system - Auxiliary Power Units (APUs).

**Safety Practices:**

Hazardous materials storage and handling, aircraft furnishing practices -Equipments. Trouble shooting-theory and practices.

**Text Books :**

1. Kroes, Watkins, Delp., "Aircraft Maintenance and Repair", McGraw Hill, New York, 1992.
2. Brimm, D. J., Bogges R. E., "Aircraft Maintenance", Pitman Publishing corp., New York, 1940.

**Reference Book :**

1. Larry Reithmeir., "Aircraft Repair Manual", Palamar Books, Marquette, 1992.

## AS 3038 AVIATION FUELS & COMBUSTION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

- CO1. understand the concepts in combustion and make combustion calculations
- CO2. know the flame temperature of commercial fuels burning in the combustion chambers of various engines.
- CO3. know the rate of chemical reactions and emission characteristics of hydrocarbon fuels used in power plants and transportation sector.
- CO4. know the thermodynamic and transport properties of fuels at elevated pressures and temperatures prevalent in the combustion chambers of actual engines
- CO5. know the supersonic combustion.
- CO6. understand the reaction and mixing processes.

**Prerequisite: Aerospace thermodynamics (AS 2007) and Propulsion-I (AS 2018)**

**Unit I- Fundamental Concepts in Combustion:**

Thermo - chemical equations - Heat of reaction first order, second order and third order reactions — premixed flames - Diffusion flames

**Unit Ii- Chemical Kinetics and Flames:**

Measurement of burning velocity - Various methods - Effect of various parameters on burning velocity - Flame stability - Detonation - Deflagration -Rankine – Hugoniot curve - Radiation by flames.

**Unit Iii- Combustion in Gas Turbine Engines:**

Combustion in gas turbine combustion chambers - Re-circulation – Combustion efficiency - Factors affecting combustion efficiency - Fuels used for gas turbine combustion chambers - Combustion stability - Flame holder types – Numerical problems.

**Unit Iv- Combustion in Rockets:**

Solid propellant combustion - Double base and composite propellant combustion - Various combustion models - Combustion in liquid rocket engines - Single fuel droplet combustion model - Combustion in hybrid rockets.

**Unit V- Supersonic Combustion:**

Introduction - Supersonic combustion controlled by mixing, diffusion and heat convection - Analysis of reaction and mixing processes - Supersonic burning with detonation shocks.

**Text Books :**


1. Sharma, S.P., and Chandra Mohan, "Fuels and Combustion", Tata McGraw Hill Publishing Co., Ltd., New Delhi 1987.
2. Loh, W.H.T., Jet Rocket, "Nuclear, Ion and Electric Propulsion Theory and Design", Springer Verlag, New York 1982.


**Reference Books:**


1. Beer, J.M. and Chigier, N.A., Combustion Aerodynamics, Applied Science Publishers Ltd., London, 1981.
2. Chowdhury, R., Applied Engineering Thermodynamics, Khanna Publishers, New Delhi, 1986.
3. Sutton, G.P., and Biblarz, 0., Rocket Propulsion Elements, 7th Edition John Wiley and Sons, Inc., New York, 2001.
4. Mathur, M., and Sharma, R.P., Gas Turbines and Jet and Rocket Propulsion, Standard Publishers,New Delhi, 1988.
5. Turns, S.R., An Introduction to Combustion Concepts and Applications,2nd Edition. McGraw Hill International Editions, New Delhi, 2000.


## AS 3040 ROCKETS AND MISSILES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. compute and analyze the various forces and moments acting on a rocket.
CO2. formulate the equations of motions for flight and separation phases
CO3. understand the combustion and propulsion systems in rocket
CO4. select suitable materials for the rockets and missiles
CO5. understand the design, performance and testing aspects.
CO6. understand the performance evaluation and assessment techniques of rockets.

**Prerequisite: Space Mechanics (AS 3012) and Propulsion-II (AS 3007)**

**Rocket Dynamics:**

Classification of launch vehicles and missiles – Rocket systems - Airframe components - Forces and moments acting on a rocket – Propulsion, aerodynamics, gravity – inertial and non-inertial frames - coordinate transformation – Equations of motion for three dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems

**Solid Propulsion and Pyrotechnics:**

Solid propellant rockets - classification, components and their design considerations, propellant grain design - grain mechanical properties, ballistics and burn rate design issues - igniter design - types of nozzles and thrust vector control, pyrotechnic devices and systems-classification, mechanisms and application of pyrotechnic devices in rockets and missiles. Design problems in rocket systems

**Liquid Propulsion and Control Systems:**

Liquid propellant rockets – classification and components - thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications- their design considerations. Different bipropellant systems like cryogenics and their characteristics, pogo and slooh engine gimbal systems and thrusters for control. Spacecraft propulsion and control systems-Design problems.

**Multi-Staging of Rocket and Separation Dynamics:**

Navigation and guidance systems in rockets and missiles - aerodynamic control systems of missiles- multi-staging of rockets - vehicle optimization techniques -stage separation system – dynamics, separation techniques - rocket flight dispersion, numerical problems.

**Design, Materials and Testing of Rockets:**

Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials-super alloys and composite materials. Qualification of rocket and missile systems, types of testing and evaluation of design and function.

**Text Books :**

1. Ramamurthi.K.: Rocket Propulsion. Macmillan Publishers India first edition. 2010.
2. Sutton.G.P. and Biblarz.O.: Rocket Propulsion Elements.7th edition.Wiley India Pvt Ltd.2010.
3. Cornelisse, J.W, Schoyer H F R, and Wakker K F, "Rocket Propulsion and Space Dynamic", Pitman Publishing Co., 1979.

**Reference Books :**

1. Ronald Humble, Henry and Larson.Space Propulsion Analysis and Design. McGraw-Hill. 1995
2. George M. Siouris, Missile Guidance and Control Systems, Springer-Verlag New York, 2000.

## AS 3046 ROTOR DYNAMICS & TRIBOLOGY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. derive the equations of motion of a rigid rotor in the absolute and rotating coordinate systems.
CO2. explain the critical speed of revolution and the self-balancing effect.
CO3. explain the external damping, and internal damping and their effects.
CO4. differentiate between the types of lubricants and its respective application area.
CO5. understand behavior of bearing in different lubrication regimes and able to develop mathematical model.
CO6. select the type of bearing for any given required engineering use and determine the load carrying capacity and other related parameters.

**Pre-requisite: Aerospace Structures-I (AS 2005) and Aerospace Structures-II (AS 2012)**

**Introduction to Vibration and the Laval-Jeffcott Rotor Model:**

Co-ordinate systems, Steady state rotor motion, Elliptical motion, Single degree of freedom systems, Free and forced vibrations. The two degrees of freedom rotor system, Geared systems, Translational motion, Natural frequencies and Natural modes, Steady state response to unbalance, The effect of flexible support.

**Torsional Vibrations of Rotating Machinery:**

Modeling of rotating machinery shafting, Multi degree of freedom systems, Determination of natural frequencies and mode shapes, Branched systems, Numerical methods for fundamental frequency.

**Rigid Rotor Dynamics and Critical Speed:**

Rigid disk equation -Rigid rotor dynamics, Rigid rotor and flexible rotor, The gyroscopic effect on rotor dynamics, Whirling of an unbalanced simple elastic rotor, Unbalance response, Orbital Analysis and Cascade Plots, Simple shafts with several disks, Effect of axial stiffness, Determination of bending critical speeds, Campbell diagram.

**Overview and Fundamentals of Tribology:**

Tribology, Historical background, practical importance and subsequent use in the field. Lubricants: Types and specific field of applications. Requisite properties of lubricants. Viscosity, its measurement, effect of temperature and pressure on viscosity, standard grades of lubricants, selection of lubricants. Lubricant Rheology, Lubrication Types, Basic equation of lubrication.

**Hydrodynamic Bearings:**

Mechanism of pressure development, classification, Idealized Journal Bearing, oil film thickness, pressure distribution, load carrying capacity. Failure Case Studies.

**Antifriction Bearings:**

Ball and roller bearings,geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. Failure Case Studies

**Text Books :**


1. J. S. Rao, “Rotor Dynamics”, New Age International Publishers, New Delhi.
2. Fundamentals of Tribology –S.K. Basu, S.N. Sengupta, B.B. Ahuja –PHI Learning Pvt. Ltd., 2010.


**Reference Book :**


1. W J Chen and J E Gunter, “Introduction to Dynamics of Rotor –Bearing Systems”,Trafford Publishing Ltd.
2. Tribology in Industries –S.K. Shrivastava –S. Chand & Company Ltd., New Delhi, 2001.


## AS 3048 HELICOPTER AERODYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. know the major helicopter components, characteristics and configurations.
CO2. analyse the performance of a helicopter in forward flight, identifying conditions which limit the performance of the helicopter.
CO3. analyse the rotor and aircraft performance under conditions in which a helicopter is in hovering and axial flight.
CO4. use simplified aerodynamic theory as it applies to helicopter flight to perform preliminary aerodynamic design of a helicopter rotor
CO5. calculate the special power estimates.

**Prerequisite: Aerodynamics-I (AS 2016) and Aerodynamics-II (AS 3005)**

**Elements of Helicopter Aerodynamics:**

Configurations based on torque reaction-Jet rotors and compound helicopters-Methods of control -Collective and cyclic pitch changes - Lead - Lag and flapping hinges.

**Ideal Rotor Theory:**
Hovering performance - Momentum and simple blade element theories - Figure of merit - Profile and induced power estimation - Constant chord and ideal twist rotors.

**Power Estimates:**
Induced, profile and parasite power requirements in forward flight-Performance curves with effects of altitude-Preliminary ideas on helicopter stability.

**Lift, Propulsion and Control of Vistol Aircraft:**
Various configuration - Propeller, rotor, ducted fan and jet lift - Tilt wing and vectored thrust - Performance of VTOL and STOL aircraft in hover, transition and forward motion.

**Ground Effect Machines:**
Types - Hover height, lift augmentation and power calculations for plenum chamber and peripheral jet machine - Drag of hovercraft on land and water, Applications of hovercraft.

**Text Books :**
1. Gessow, A., and Myers, G, C., "Aerodynamics of Helicopter", Macmillan & Co., N.Y. 1987.
2. McCormick, B, W., "Aerodynamics of V/STOL Flight", Academic Press, 1987

**Reference Books :**
1. Johnson, W., "Helicopter Theory," Princeton University Press, 1980.
2. McCormick, B, W., "Aerodynamics, Aeronautics and Flight Mechanics"John Wiley, 1995.
3. Gupta, L., "Helicopter Engineering", Himalayan Books, 1996.

## AS 3050 AIRPORT AND AIRLINES MANAGEMENT Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the basic management aspect of airport and airlines system such as airports layout, air traffic control, landing procedure.
CO2. know the scheduling, flight planning and other economic and commercial activities.
CO3. know how government regulation and industry standards effect the cost of operating an airline.
CO4. know the relationship between various airlines, and operational issues affecting airlines and passengers.
CO5. understand the economic characteristics of airlines.
CO6. understand the design and development in fleet planning process.

**Prerequisite: Nil**

**Airports and Airport Systems:**

Introduction, Organization and administration, Historical and legislative perspective.

**Airport Operations Management:**

The airfield, Airspace and air traffic management, Airport operations management under FAR Part 139, Airport terminals and ground access, Airport security.

**Airport Administrative Management:**

Airport financial management, The economic, political, and social role of airports, Airport planning, Airport capacity and delay, The future of airport management.

**Introduction to Airline Planning:**

Structure of Airline Industry (Domestic & International)-Growth and Regulation-Deregulation-Major and National Carriers-Regional Carriers-Economic characteristics of the Airlines Airline Planning Process-Airline Terminology and Measures: airline demand, airline supply, average load factor, unit revenue, Airline Planning Decisions: Fleet Planning, Route Evaluation, Schedule Development, Pricing, Revenue Management.

**Fleet Planning and Route Evaluation:**

Factors in Fleet Planning-Hub-and-Spoke System-Technical Aspects-Fleet Rationalization-Fleet Commonality-Long Range Aircraft-Noise Restrictions-Factors in Design and Development-Fleet Planning Process; Route Evaluation in Hub Networks-Route profitability estimation issues-Demand Driven Dispatch.

**Text Books :**

1. Airport Planning and Management 6/E 0006 Edition by Young Seth, Mc GRAW Hills.
2. Airport Management by Ravindran P.C.K, Asian Law House.
3. Air Transportation: A Management Perspective (Fifth Edition) by Alexander T.Wells and John G.Wensveen, Brooks Cole,2003.
4. Airline Management by Charles Banfe, Prentice-Hall, 1991.

**Reference Books :**

1. Airport Systems: Planning, Design and Management by Rechard De Neufville Tata Mc Graw Hills.
2. Straight and Level:Practical Airline Economics by Stephen Holloway, Ashgate Publishing, 2003
3. Airline Marketing and Management by Stephen Shaw, Ashgate Publishing, 2004
4. An Introduction to Airline Economics (Sixth Edition), William O' Connor, Praeger Publishers,2000
5. Airline Management, by Peter P BelobabaMIT Open Courseware Lecture Notes, 2006.
6. Airline Operations and Scheduling by Massoud Bazargan, Ashgate Publishing, 2004.

## AS 3056 INTRODUCTION TO UAV TECHNOLOGY Cr-3

**Course Outcome:** Upon successful completion of the course, the student will be able to:

CO1. recognize and describe the role of unmanned aerial vehicles (UAVs) in past, present and future society
CO2. comprehend and explain various components of UAVs
CO3. comprehend and explain basics of flight and flight control systems
CO4. understand and describe basic regulations applicable to UAV flight

**Pre-requisite: Aerodynamics-I & II (AS 2016 & AS 3005) and Propulsion-I (AS 2018)**

**Overview and Background:**

Definitions, history of UAVs, classifications of UAVs, contemporary applications, societal impact and future outlook, operational considerations: liability/legal issues, insurance, ethical implications, human factors, LOS/BLOS.

**Unmanned Aerial System (UAS) Components:**

Configurations, characteristics, applications; propulsion types; on-board flight control; payloads: sensing/surveillance, weaponized, delivery; communications, launch/recovery systems, ground control stations.

**Concepts of Flight:**

Aerodynamics: lift, weight, thrust, drag; flight performance: climbing vs gliding flight, range/endurance; stability and control: flight axes, flight controls, autopilots.

**Regulatory and Regulations:**

Homeland regulatory: FCC/FAA; foreign regulatory; regulations: FCC compliance, UAS registration, federal aircraft regulations (FARs); safety considerations

**Text Book :**

**1.** Austin, "Unmanned Aircraft Systems: UAVs Design, Development and Deployment", Wiley, 2010.

**Reference Book :**

**1.** Beard and Mclain, "Small Unmanned Aircrfat: Theory and Practice", Princeton University Press, 2012.

## AS 4001 COMPOSITE MATERIALS AND STRUCTURES Cr -3

**Course Outcome**: At the end of the course, the students will be able to:

CO1. understand the fundamentals of structural mechanics
CO2. analyse composite layer and laminates in anisotropic and orthotropic manner
CO3. analyse the failure criteria of composite materials
CO4. understand composite beams and columns
CO5. understand allowable stresses for laminates consisting of unidirectional plies
CO6. understand the post-buckling behavior of symmetric plates under axial compression.

**Pre-requisite: Aerospace Materials Technology (AS 2010) and Aerospace Structures-I (AS 2005)**

**Fundamentals of mechanics of solids:**

Structural materials, composite materials, equilibrium equations, stress transformation, principal stresses, displacements and strains, transformation of small strains, compatibility equations, admissible static and kinematic fields, constitutive equations for an elastic solid, variational principles.

**Mechanics of a composite layer:**

Isotropic layer, unidirectional orthotropic layer, unidirectional anisotropic layer, orthogonally reinforced orthotropic layer, angle-ply orthotropic layer, layer made by angle-ply circumferential winding, fabric layers, lattice layer, spatially reinforced layers and bulk materials

**Mechanics of laminates:**

Stiffness coefficients of a non-homogeneous anisotropic layer, stiffness coefficients of a homogeneous layer, stiffness coefficients of a laminate, symmetric laminates, engineering stiffness coefficients of orthotropic laminates, quasi-homogeneous laminates, quasi-isotropic laminates in the plane stress state, anti-symmetric laminates, sandwich structures, coordinate of the reference plane, stresses in laminates

**Failure criteria and strength of laminates:**

Failure criteria for an elementary composite layer or ply, practical recommendations, allowable stresses for laminates consisting of unidirectional plies, progressive failure: modeling and analysis.

**Laminated composite beams and columns:**

Basic equations, stiffness coefficients, bending of laminated beams, nonlinear bending, buckling of composite columns, free vibrations of composite beams, refined theories of beams and plates.

**Laminated composite plates:**

Equations of the theory of anisotropic laminated plates, equations for the orthotropic plates with symmetric structure, analysis of the equations of plate theory for transversely isotropic plates, bending of orthotropic symmetric plates, buckling of orthotropic symmetric plates, post-buckling behavior of orthotropic symmetric plates under axial compression.

**Text Books :**

1. V.V. Vasiliev and E.V. Morzov, "Advanced Mechanics of Composite Materials", 3rd edition,Elsevier, 2007.
2. R. F. Gibson, "Principle of Composite Material Mechanics", 2nd edition, McGraw-Hill 1994

**Reference Books :**

1. R.M. Jones, "Mechanics of Composite Material", 2nd edition, Taylor and Francis (1999)
2. I.M. Daniel and O. Ishai, "Engineering Mechanics of Composite Materials", 2nd edition, Oxford University Press, 2005.
3. T.H. Hong and S.W. Tsai, "Introduction to Composite Materials", Techonomic Pub. Co. 1980.

## AS 4002 ADVANCED AEROSPACE STRUCTURES Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. function of the aircraft structural components
CO2. analyse the different types of load associated with aircraft
CO3. analyse the open and closed section beams of wings and fuselage
CO4. understand structural loading of aircraft components

### Pre-requisite: Aerospace Structures-I & II (AS 2005 and AS 2012)

**Bucking of Structural Members:**

Buckling of straight bars, columns, Buckling of thin plates in compression, shear and bending
Torsion-Flexural buckling of thin-walled bars, Column under local crippling, Needham and Gerard methods for determining crippling stresses, Pure and semi-tension field beams, Angles of diagonal tension in web, Inelastic buckling: Introduction, Tangent-modulus theory.

**Stress Analysis in Wing and Fuselage:**

Flange type wing beam, Wing sections, Factors affecting wing structural arrangements, Method of stress analysis for wing structures, Basic structure of fuselage, Method of stress analysis for wing structures.

**Fatigue Analysis:**

Introduction to fatigue of structures and materials, Different phases of fatigue life, Fatigue mechanism.

**Stress Concentration:**
Introduction to stress concentration, Stress concentration factor, Calculation on stress concentration, Effect of notch geometry on stress concentration factor.

**Composite Material for Aircraft Structures:**

Introduction, Efficiency of composite materials application, Basic principle of fiber composite materials, Design of aircraft structures using composite materials.

**Dynamic Analysis of Structures:**

Introduction to dynamics, Free and forced vibration.

**Text Book :**

1. T.H.G. Megson, "Aircraft Structures for Engineering Students", 4th ed., Butterworth-Hein- emann (2007).

**Reference Books :**

1. S.P Timoshenko and J.N. Goodier, "Theory of Elasticity, 3rd ed., McGraw-Hill, 1970.
2. E.F. Bruhn,"Analysis and Design of Flight Vehicle Structures", 2nd ed., Jacobs Publishing Inc., 1973.

## AS 4003 THEORY OF PLATES AND SHELLS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of plate theory
CO2. analyse and solve the problems related to plates and shells using governing equations
CO3. understand the phenomenon of pure bending in plates
CO4. application of approximate methods applied to problems

**Pre-requisite: Engineering Mechanics (ME1003) and Aerospace Structures-I & II (AS 2005 and AS 2012)**

**Classical Plate Theory:**

Classical plate theory – assumptions – differential equation – boundary conditions.

**Plates of Various Shades:**

Navier's method of solution for simply supported rectangular plates – Leavy's method of solution for rectangular plates under different boundary conditions, governing equation – solution for axi-symmetric loading, annular plates and plates of other shapes.

**Pure Bending of Plates:**
Slopes, curvatures of bent plates, relations between bending moments and curvature, strain energy in pure bending, symmetrical bending of circular plates.

**Eigen Value Analysis:**

Stability and free vibration analysis of rectangular plates.

**Approximate Methods:**

Rayleigh – Ritz, Galerkin methods– Finite Difference Method, Application to Rectangular Plates for static, free vibration and stability analysis.

**Shells:**
Basic concepts of shell type of structures – membrane and bending theories for circular cylindrical shells.

**Text Books :**

1. S.P. Timoshenko, S. Winowsky and Kreger, "Theory of Plates and Shells", McGraw-Hill Book Co., 1990.
2. T.K. Varadan and K. Bhaskar, "Theory of Plates and Shells", Narosa Publishing House, 1999.

**Reference Books :**

1. W. Flugge, "Stresses in Shells", Springer – Verlag, 1985.
2. S.P. Timoshenko and J.M. Gere, "Theory of Elastic Stability", McGraw-Hill Book Co. 1986

## AS 4004 BOUNDARY LAYER THEORY Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the boundary layer phenomenon
CO2. analyse laminar boundary layer application and consequences
CO3. solve boundary layer problems using exact solutions
CO4. understand transition and turbulent boundary layer and types of boundary layer control

**Pre-requisite: Introductory Aerodynamics (AS 2003)**

**Fundamentals of Boundary Layer Theory:**

Boundary layer concept, laminar and turbulent boundary layer on a flat plate at zero incidence, boundary layer on an airfoil, separation of boundary layer

**Boundary Layer Equations in Plane Flow:**

Setting up the boundary layer equations, wall friction, separation and displacement of plate boundary layer, dimensional representation of the boundary layer equations, friction dragand plate boundary layer.

**General Properties and Exact Solutions of the Boundary Layer Equations for Plane Flows:**

Compatibility condition at the wall, ordinary differential equation of boundary layers with and without outer flow, similar solutions of the boundary layer equations for wedge flow, mixing layer and moving plate.

**Transition:**

Introduction of transition of laminar boundary layers

**Turbulent boundary layer:**

Fundamental of turbulent flow, assumption for calculation of turbulent flow, turbulent flow through pipes, turbulent boundary layer with zero pressure gradient, flat plate, turbulent boundary layer with pressure gradient, turbulent boundary layer in compressible flow, free turbulent flow and jets

**Boundary Layer Controls:**

Different kinds of boundary layer controls, continuous suction and blowing, binary boundary layers.

**Text Books :**

**1.** H. Schlichting and K. Gersten, “Boundary Layer Theory”, 8th ed., McGraw-Hill, 2001.


**Reference Books :**

1. G.K. Batchelor, “Introduction to Fluid Dynamics”, 2nd ed., Cambridge Univ. Press, 2000.
2. F. M. White, “Viscous Fluid Flow”, 3rd ed., McGraw-Hill, 2006.
3. T. Cebeci and A.M.O Smith, “Analysis of Turbulent Boundary Layers”, Academic Press, 1974.
4. T.B. Gatski and J.P. Bonnet, “Compressibility, Turbulence and High Speed Flow”, 2nd ed., Academic Press, 2013.

## AS 4005 TURBULENCE IN FLUID FLOWS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of turbulence in fluid flows
CO2. understand the phenomena of turbulent heat transfer and turbulent shear flow
CO3. understand the dynamics of temperature fluctuations in turbulent flow
CO4. understand the flow characteristics at the wake of a self-propelled body
CO5. understand the effects of pressure gradient on the flow in surface layers
CO6. understand the dispersion of contaminants in turbulent flows

### Pre-requisite: Introductory Aerodynamics (AS 2003)

**Introduction:**

The nature of turbulence, origin of turbulence, methods of analysis, diffusivity of turbulence, length scales in turbulent flows

**Turbulent Transport of Momentum and Heat:**

The Reynolds equation, elements of the kinetic theory of gases, estimates of the Reynolds stress, turbulent heat transfer, and turbulent shear flow near a rigid wall

**Dynamics of Turbulence:**

Kinetic energy of the mean flow, pure shear flow, the effects of viscosity, kinetic energy of turbulence, vorticity dynamics, the dynamics of temperature fluctuations

**Boundary-free Shear Flows:**

Almost parallel, two-dimensional flows, turbulent wakes, the wake of a self-propelled body, turbulent jets and mixing layers

**Wall-bounded Shear Flows:**

Problem of multiple scales, turbulent flows in pipes and channels, planetary boundary layers, effects of a pressure gradient on the flow in surface layers.

**Turbulent Transport:**

Transport in stationary homogeneous turbulence, transport in shear flows, dispersion of contaminants, and turbulent transport in evolving flows.

**Text Book :**

1. H. Tennekes and J.L. Lumley, “A First Course in Turbulence”, The MIT Press, 1972.

**Reference Books :**

1. U. Frisch, “Turbulence”, Cambridge Univ. Press, 1996.
2. P.A. Davidson, “Turbulence: An Introduction to Scientist and Engineers”, Oxford Univ. Press (2004).
3. S.B. Pope, “Turbulent Flows”, Cambridge Univ. Press, 2000.
4. J. Mathieu and J. Scott, “An Introduction to Turbulent Flow, Cambridge Univ. Press, 2000

## AS 4006 VISCOUS FLUID FLOW Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of compressible flow and the governing equations
CO2. understand the solutions of Newtonian viscous-flow equations
CO3. understand the similarity solutions for various types of flows with laminar boundary layers
CO4. understand the effects of linear stability theory for laminar flows
CO5. understand the physical and mathematical description of turbulence
CO6. understand the similarity solutions for compressible boundary layer flows

**Pre-requisite: Introductory Aerodynamics (AS 2003)**

**Fundamental Equations of Compressible Flow:**

Introduction, classification of the fundamental equations, mass, momentum and energy equations, boundary conditions for viscous heat-conducting flows, mathematical characteristics of the basic equations.

**Solutions of the Newtonian Viscous-flow Equations:**

Introduction and classification of solutions, Couette flow due to moving surfaces, Poiseuille flow through ducts, unsteady duct flows, unsteady flows with moving boundaries, wind driven flows, similarity solutions.

**Laminar Boundary Layers:**

Introduction, laminar boundary-layer equations, similarity solutions for steady two-dimensional flows, free shear flows, thermal boundary layer calculations, three-dimensional boundary layers, and unsteady boundary layers.

**Stability of Laminar Flows:**

Introduction: the concept of small disturbance stability, linearized stability of parallel viscous flows, parametric effects in the linear stability theory, transition to turbulence

**Incompressible Turbulent Mean Flow:**

Physical and mathematical description of turbulence, the Reynolds equation of turbulent motion, two-dimensional turbulent boundary layer equations, velocity profiles: inner, outer and overlap layers

**Compressible Boundary Layer Flow:**

Introduction: compressible boundary layer equations, similar solutions for compressible laminar flow, solutions for laminar flat-plate and stagnation point flow.

**Text Book :**

1. F. M. White, “Viscous Fluid Flow”, McGraw-Hill, 1991.

**Reference Books :**

1. H. Schlichting and K. Gersten, “Boundary-Layer Theory”, Springer-Verlag, 2000.
2. F. S. Sherman, “Viscous Flow”, McGraw-Hill, 1990.

## AS 4007 HYPERSONIC AIR-BREATHING PROPULSION Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of hypersonic air-breathing propulsion techniques
CO2. understand the aerodynamics of combustor/inlet and combustor/nozzle interaction.
CO3. understand the performance of HAP inlets, isolators and nozzles
CO4. understand the performance of HAP combustors and fuels
CO5. understand the basics of dual mode combustion and dual mode transition
CO6. understand the characteristics of air-breathing hypersonic vehicles

### Pre-requisite: Propulsion-I & II (AS 2018 and AS 3007)

**Introduction to Hypersonic Air Breathing Propulsion:**

Definition of hypersonic flight and hypersonic flow, types of hypersonic vehicles, Ram/Scramjet operating principles, Engine-vehicle integration, and hypersonic propulsion challenges

**Aerodynamics of Aircraft Integrated Scramjet:**

Propulsion of airframe integration, aerothermodynamics, hypersonic flight environment, vehicle fore body, inlet capture, shock ingestion and spillage, vehicle angle of attack, engine starting, combustor/inlet interaction, combustor flow field, combustor nozzle interaction.

**HAP Inlets, Isolators and Nozzles:**

Inlet function and operating modes, inlet types, inlet aerodynamics, performance and operability, isolator, nozzle configurations and nozzle aerodynamics, performance parameters.

**HAP Combustors and Fuels:**

Combustion process desired properties, combustor entrance conditions, fuels for hypersonic propulsion, combustion process: reaction rates, stoichiometric fuel/air ratio and equivalence ratio.

**Dual Mode Combustion:**

Dual-mode combustion propulsion concept, 1-D ideal flow in burner, Isolator shock-trains, dual mode transition, dual-mode, free jet combustor.

**Combined Cycle Propulsion:**

Characteristic earth flight trajectories, air-breathing hypersonic vehicles, challenge of hypersonic air breathing propulsion (HAP), combined cycle definition, requirement for a hap combined cycle propulsion, combined cycle proposed concepts: turbine-based combined cycle (TBCC), rocket-based combined cycle (RBCC), space planes, air-breathing rocket (SABRE)

**Text Book :**

1. H. W. Heiser and D.T. Pratt, “AIAA Education Series”. 5$^{th}$ Edition.


**Reference Books :**

1. H. Cohen, G.F.C Rogers and H.I.H. Saravanamuttoo, “Gas Turbine Theory”, Longman, 1989
2. M.L. Mathur and R.P. Sharma, “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers and Distributors, Delhi, 1999.

## AS 4008 RADIATIVE HEAT TRANSFER Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of radiative heat transfer
CO2. understand the role of configuration factors for diffuse surfaces with uniform radiosity
CO3. understand the analysis of enclosures with black and/or diffuse-gray surfaces
CO4. estimate net-radiation in enclosures with specular and diffuse reflecting surfaces
CO5. understand the numerical solution methods for radiation heat transfer
CO6. understand absorption and emission phenomena in participating media

### Pre-requisite: Aerospace Thermodynamics (AS 2007)

**Introduction to Radiative Transfer:**

Importance of thermal radiation in engineering, thermal energy transfer, thermal radiative transfer, radiative energy exchange and radiative intensity, chracteristics of emission, radiative energy loss and gain along a line of sight, radiative transfer equation, radiative transfer in non participating enclosures, properties at interference, emissivity, absorptivity, reflectivity, transmissivity, relations among the properties, radiative properties of opaque materials, electromagnetic wave theory predictions, measured properties of real dielectric materials, metals, selective and directional opaque surfaces

**Configuration Factors for Diffuse Surfaces with Uniform Radiosity:**

Radiative transfer equation for surfaces separated by a transparent, geometric configuration factors between two surfaces, methods for determining configuration factors, constraints an configuration factor accuracy

**Radiation Exchange in Enclosures Composed of Black and/or Diffuse-Gray Surfaces:**

Approximations and restrictions for analysis of enclosures with black and/or diffuse-gray surfaces, radiative transfer for black surfaces, radiation between finite diffuse-gray areas, radiation analysis using infinitesimal areas

**Exchange of Thermal Radiation among Non-diffuse Non-gray Surface:**

Introduction, enclosure theory for diffuse non-gray surfaces, directional-gray surfaces, surfaces with directionally and spectrally dependent properties, radiation exchange in enclosures with some specularly reflecting surfaces, net-radiation method in enclosures having specular and diffuse reflecting surfaces, multiple radiation shields

**Radiation Combined with Conduction and Convection at Boundaries:**

Introduction, energy relations and boundary conditions, radiation transfer withconduction boundary conditions, radiation with convection and conduction, numerical solution methods, Monte Carlo method

**Absorption and Emission in Participating Media:**

Spectral lines and bands for absorption and emission of gases, absorption oremission by a single spectral line, band absorption, band models and correlations for gas absorption and emission, total gas-total emittance correlations, mean absorption coefficients, true absorption coefficient, radiative properties of translucent liquids and solids

**Text Book :**

1. R. Siegel and J. Howell, “Thermal Radiation Heat Transfer”, Taylor and Francis, 2002.

## AS 4009 HIGH TEMPERATURE GAS DYNAMICS Cr-3

**Course Outcome:** At the end of the course, the students will be able to:

CO1. understand the fundamentals of high temperature gas dynamics
CO2. evaluate the thermodynamic properties in terms of partition function
CO3. understand the basics of kinetic theory of gases
CO4. understand the governing equations for inviscid high-temperature equilibrium flow
CO5. understand the governing equations for inviscid high-temperature non-equilibrium flow
CO6. understand the applications of Navier–Stokes solutions to chemically reacting flows

### Pre-requisite: Aerospace Thermodynamics (AS 2007) and Aerodynamics II (AS 3005)

**Introduction to high temperature gas dynamics:**

Importance of high-temperature flows, nature of high-temperature flows, chemical effects in air: the velocity-altitude map, definition of real gases and perfect gases, various forms of the perfect-gas equation, composition of equilibrium chemically reacting mixtures: the equilibrium constant, heat of reaction

**Elements of Statistical Thermodynamics:**

Microscopic description of gases, Boltzmann distribution, evaluation of thermodynamic properties in terms of the partition function, evaluation of the partition function, practical evaluation of thermodynamic properties for a single chemical species, thermodynamic properties of an equilibrium chemically reacting gas, equilibrium properties of high-temperature air

**Elements of Kinetic Theory:**

Perfect gas equation, collision frequency and mean free path, velocity and speed distribution functions: mean velocities, introduction to chemical and vibrational non-equilibrium, vibrational non-equilibrium: the vibrational rate equation, chemical non-equilibrium

**Inviscid High-Temperature Equilibrium Flows:**

Governing equations for inviscid high-temperature equilibrium flow, equilibrium normal and oblique shock-wave flows, equilibrium quasi-one-dimensional nozzle flows, equilibrium speed of sound, equilibrium conical flow, blunt-body flows

**Inviscid High-Temperature Non-equilibrium Flows:**

Governing equations for inviscid, non-equilibrium flows, non-equilibrium normal and oblique shock-wave flows, non-equilibrium quasi-one-dimensional nozzle flows, blunt-body flows, binary scaling

**Viscous High-Temperature Flows:**

Transport properties in high-temperature gases, definition of transport phenomena, transport coefficients, mechanism of diffusion, energy transport by thermal conduction and diffusion: total thermal conductivity, transport properties for high-temperature air, governing equations for chemically reacting viscous flow, boundary-layer equations for a chemically reacting gas, full and parabolized Navier–Stokes solutions to chemically reacting flows.

**Text Book :**

1. J.D. Anderson, "Hypersonic and High-Temperature Gas Dynamics", 2nd ed., AIAA, 2006.

**Reference Books :**

1. W.G. Vincenti and C.H. Kruger, "Introduction to Physical Gas Dynamics", Krieger Pub, 1975.
2. J.F. Clarke and M. McChesney, "The Dynamics of Real Gases", Butterworths, 1964.
3. R. Brun, "Introduction to Reactive Gas Dynamics", Oxford Univ. Press, 2009