Society of St. Francis Xavier, Pilar's

Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

# CURRICULUM STRUCTURE

# THIRD YEAR UG: B.E.

## MECHANICAL ENGINEERING

**REVISION: FRCRCE-1-25**

**Effective from Academic Year 2025-26**

| | | |
|---|---|---|
| Dr. DEEPAK BHOIR | Dr. BHUSHAN PATIL | DR. SURENDRA RATHOD |
| Dean Academics | HOD (Mechanical) | Principal |

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## Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.

Government of Maharashtra has also directed Autonomous Colleges to revise their curriculum in line with National Education Policy (NEP) 2020 through Government Resolution dated 4th July 2023. We commit to ourselves to the effective implementation of UGC Regulations and NEP 2020 in its spirit.

Based on recent recommendations of the GR, we are pleased to offer our holistic curriculum for 2024-28, a "**H-Tree Model"** of Engineering Education. A unique **"H-Tree Model"** of Engineering Education Curriculum is carefully designed to systematically develop IQ (Intelligence Quotient), PQ (Physical Quotient), EQ (Emotional Quotient) and SQ (Spiritual Quotient) of a learner. This curriculum aims at the development of an **all-rounded** personality with **holistic** approach to education in which learner receives **25% teacher-led learning, 25% peer learning, 25% self-learning and 25% experiential learning**. The curriculum model is outcome based that focuses on learning by doing. Curriculum is designed to provide multiple learning opportunities for students to acquire and demonstrate competencies for rewarding careers. It ensures multiple choices to leaner acquiring skills through systematic planning. It has 7 verticals aligned to GR recommendations with strong science, and mathematics foundation and program core, sequel of electives, Multidisciplinary Minor courses, humanities & management courses and sufficient experiential learning through projects and semester-long industry / research internship along with employable skill-based courses. Learner gets an opportunity to acquire skills through NSDC aligned courses during summer vacations. Learner also gets additional option to choose the kind of degree i.e. Honors or Double Minor or Honors with Research.

Various steps are taken to transform teaching learning process to make learning a joyful experience for students. We believe that this curriculum will raise the bar of academic standards with the active involvement and cooperation from students, academic and administrative units.

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# Curriculum Structure for UG Programs at Fr CRCE w.e.f. A.Y. 2025-26

| Nomenclature of the courses in the curriculum | |
|---|---|
| **Abbreviation** | **Title** |
| BSESC | Basic Science & Engineering Science Courses |
| PCPEC | Program Core and Program Elective Courses |
| MDC | Multidisciplinary Courses |
| SC | Skill Courses |
| HSSM | Humanities, Social Sciences and Management |
| EL | Experiential Learning |
| LLC | Liberal Learning Courses |
| BSC | Basic Science Courses |
| ESC | Engineering Science Courses |
| PCC | Program Core Courses |
| PEC | Program Elective Courses |
| MDM | Multidisciplinary Minor |
| OE | Open Elective |
| VSEC | Vocational and Skill Enhancement Course |
| VSC | Vocational Skill Courses |
| SEC | Skill Enhancement Courses |
| AEC | Ability Enhancement Course |
| EEMC | Entrepreneurship, Economics and Management Course |
| IKS | Indian Knowledge System |
| VEC | Value Education |
| RM | Research Methodologies |
| CEFP | Community Engagement or Field Project |
| ELC | Experiential Learning Courses |
| PRJ | Project |
| INT | Internship |
| CC | Cocurricular Courses |
| HMM | Honors and Multidisciplinary Minor |
| DM | Double Minor |
| BC | Bridge Course |

## Credit Specification:

- Theory: 1 credit=13 to 15 hrs of teaching
- Lab: 1 Credit=26 to 30 hrs of lab work
- Studio Activities: 1 Credit= 26 to 30 hrs of creative activities
- Workshop Based Activities: 1 Credit=26 to 30 hrs of hands-on activities related to vocation/professional practice/skill based
- Seminar/Group Discussion: 1 Credit=13 to 15 hrs of participation
- Internship: 1 Credit=Per 2 weeks OR 36 to 40 hrs of engagement
- Field Based Learning/Practices: 1 Credit=26 to 30 hrs of learning activities
- Community Engagement Projects: 1 Credit=26 to 30 hrs of contact time along with 13 to 15 hrs of activities preparation, report writing, independent reading etc.

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## Credit requirements for different options of the Degrees:

| Degree/SEM | I | II | III | IV | V | VI | VII | VIII | Total |
|---|---|---|---|---|---|---|---|---|---|
| B.E | 18 | 20 | 22+4# | 23+5# | 20 | 20 | 20 | 20 | 163+9#=172 |
| B.E with Honors/Minors | 18 | 20 | 22+4# | 23+5# | 20+4* | 20+4* | 20+6* | 20+4* | 163+9#+18*=190 |

*# Bridge courses*

**Optional Credits*

1. Learners who earn a minimum of total **172 credits** will be awarded "**Bachelor of Engineering**" degree.

2. Learners will have the following options to earn **B. E. in ……(regular) Engineering with Honours/Minor in …….. (specialization)**

| Sr. No. | Honors/Minor degree programs | Programs who can offer this Honours Degree Program | Programs who can offer this as Minor Degree program |
|---|---|---|---|
| 1 | Internet of Things | 1. Computer Engineering<br>2. Artificial Intelligence & Data Science<br>3. Electronics and Computer Science<br>4. Mechanical Engineering | -- |
| 2 | Artificial Intelligence and Machine Learning | 1. Computer Engineering<br>2. Electronics and Computer Science | Mechanical Engineering |
| 3 | Data Science | 1. Computer Engineering<br>2. Electronics and Computer Science<br>3. Mechanical Engineering | |
| 4 | Blockchain | 1. Computer Engineering<br>2. Artificial Intelligence & Data Science<br>3. Electronics and Computer Science | Mechanical Engineering |
| 5 | Cyber Security | 1. Computer Engineering<br>2. Artificial Intelligence & Data Science<br>3. Electronics and Computer Science | Mechanical Engineering |
| 6 | Robotics | Mechanical Engineering | 1. Computer Engineering<br>2. Artificial Intelligence & Data Science<br>3. Electronics and Computer Science |
| 7 | 3D Printing | Mechanical Engineering | 1. Computer Engineering<br>2. Artificial Intelligence & Data Science<br>3. Electronics and Computer Science |

3. **Honours and Minor Degree Eligibility Criteria for Students:**

i. Following is the eligibility criteria for students opting the Honours/ Minor Degree program:

a. Students with no backlog in semester I, II, and III

b. The CGPI (based on semester I, II, and III) of the students must be 6.75 and above

c. For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above

ii) Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.

iii) However, it is optional for learners to take Honours/Minor degree program.

iv) The Honours/ Minor degree program can be opted only during regular engineering studies

v) The student shall complete the Honours/ Minor degree program in stipulated four semesters only.

4. Courses offered during internship semester shall be in online mode

5. Learner can earn additional credits by enrolling to skill courses offered in summer. College shall explore feasibility to offer NSDC aligned skill based courses to the learners

6. Technical support team for registration of Academic Bank of Credits (ABC), registration of elective/optional courses, registration of online courses, registration for degree options etc. under supervision of Dean Academics.

**Salient Features of Curriculum:**

- ✓ Framed as per Government Resolution dated 4th July 2023 in line with National Education Policy (NEP) 2020.
- ✓ Minimum 172 choice-based credit structure with options of Degrees earning additional credits
- ✓ Unique 'H-Tree' Model of Curriculum: Hybrid model for holistic development with happy learning environment having bridge connecting verticals providing unique path for each learner for 3-dimensional growth, Life Long Learning, bridge courses, inclusive model indicating equal distribution of central resources
- ✓ More emphasis on laboratory based and experiential learning
- ✓ More weightage to continuous assessment to reduce examination stress
- ✓ Mandatory Semester-long internship, courses with emotional & spiritual learning and skill-based learning aligned with NSDC framework
- ✓ Well balanced curriculum to attain Program Outcomes and skills of 21st century learner
- ✓ Curriculum is designed to create excitement among learners for education through stories, activities, collaboration, hackathon, contest, case studies, creative art etc.
- ✓ Curriculum is designed to make graduates responsible citizens of country with future ready skills to handle challenges of 21st Century

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## SEMESTERWISE CURRICULUM STRUCTURE

## UG Mechanical Engineering Program:

| SEM-V | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Code | Course Vertical | Sub-Vertical | Course Name | | Contact Hours | Examination Marks (1 Credit=50 Marks) | | | | | Credits | |
| | | | | | | ISE 1 | MSE | ISE 2 | ESE | Total | Points | Total |
| 25PCC13ME11 | PCPEC | PCC | Applied Thermodynamics | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | PR | 2 | 20 | - | 30 | - | 50 | 1 | |
| 25PCC13ME12 | PCPEC | PCC | Theory of Machines | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | PR | 2 | 20 | - | 30 | - | 50 | 1 | |
| 25PCC13ME13 | PCPEC | PCC | Metrology and Quality Engineering | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 2 |
| 25PCC13ME14 | PCPEC | PCC | CAD/CAM and FEA | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PCC13ME15 | PCPEC | PCC | FEA and CFD Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Course | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25MDM0X | MDC | MDM | 1. Health, Wellness and Psychology<br>2. Emotional and Spiritual Intelligence | TH | 2 | 50 | - | 50 | - | 100 | 2 | 2 |
| 25OE03X | MDC | OE | Open Elective-4 | TH | 1 | 10 | 15 | 10 | 15 | 50 | 1 | 2 |
| | | | | PR | 2 | 20 | - | 30 | - | 50 | 1 | |
| 25HXXXC501 | HMM/DM | HMM/DM | Honors/Minor Degree Course | TH | 4 | 20 | 30 | 20 | 30 | 100 | 4 | 4* |
| | | | | **Total** | **TH:TU:PR 13:2:10=25** | | | | | **1000** | **-** | **20** |

* Introduced as Optional Honors/Minor Degree Courses

| SEM-VI | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Code | Course Vertical | Sub-Vertical | Course Name | | Contact Hours | Examination Marks (1 Credit=50 Marks) | | | | | Credits | |
| | | | | | | ISE 1 | MSE | ISE 2 | ESE | Total | Points | Total |
| 25PCC13ME16 | PCPEC | PCC | Fluid Mechanics & Hydraulic Machines | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PCC13ME17 | PCPEC | PCC | Machine Design | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PCC13ME18 | PCPEC | PCC | Fluid Mechanics & Hydraulic Machines Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25PCC13ME19 | PCPEC | PCC | Hydraulics and Pneumatics Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Course | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Course | TH | 2 | 20 | 30 | 20 | 30 | 100 | 2 | 3 |
| | | | | TU | 1 | 20 | - | 30 | - | 50 | 1 | |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25PEC13MEXX | PCPEC | PEC | Program Elective Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25MDM05 | MDC | MDM | Public Relations and Corporate Communication | TH | 2 | 50 | - | 50 | - | 100 | 2 | 2 |
| 25VSE13ME04 | SC | VSEC | Measurements and Systems Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25VSE13ME05 | SC | VSEC | CNC Lab | PR | 2 | 20 | - | 30 | - | 50 | 1 | 1 |
| 25HXXXC601 | HMM/DM | HMM/DM | Honors/Minor Degree Course | TH | 4 | 20 | 30 | 20 | 30 | 100 | 4 | 4* |
| | | | | **Total** | **TH:TU:PR 10:4:12=26** | | | | | **1000** | **-** | **20** |

* Introduced as Optional Honors/Minor Degree Courses

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## Structure of Credits to be completed in Final Year (SEM-VII and/or SEM-VIII):

| SEM-VII and/or SEM-VIII | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Code | Course Vertical | Sub-Vertical | Course Name | | Contact Hours | Examination Marks (1 Credit=50 Marks) | | | | | Credits | |
| | | | | | | ISE 1 | MSE | ISE 2 | ESE | Total | Points | Total |
| | PCPEC | PEC | Program Elective | | Online | As Per SWAYAM | | | | | 12 | 12 |
| MDM06 | MDC | MDM | MDM | | Online | As Per SWAYAM | | | | | 4 | 4 |
| RMC14ME01 | EL | RM | Essentials of Research Methodology | | Online | As Per SWAYAM | | | | | 2 | 2 |
| RMC14ME02 | EL | RM | Intellectual Property Rights | | Online | As Per SWAYAM | | | | | 2 | 2 |
| PRJ14ME01 | EL | PR | Capstone Project | PR | 12 | 100 | - | 100 | - | 200 | 6 | 6 |
| | PCPEC | PEC | Course Seminar | | Online | As per Rubrics for Seminar | | | | | 2 | 2 |
| INT14ME01 | EL | INT | Semester long Internship | PR | 36-40 hrs | As Per Internship Manual | | | | | 12 | 12 |
| HXXXCXXX | HMM/DM | HMM/DM | Honors/Minor Degree Course | TH | Online | As Per SWAYAM | | | | | 8 | 8* |
| HXXXCXXX | HMM/DM | HMM/DM | Honors/Minor Degree Lab (Project) | PR | | | | | | | **2** | **2*** |
| | | | **Total** | | | | | | | | **40** | **40+*10** |

@MDM should be **Non-technical** courses e.g. Principles of Management
Project or Internship is mutually exclusive in SEM-VII or SEM-VIII
Remaining credits can be acquired in SEM-V to SEM-VIII
# Online course 1 Credit=4 Week course from SWAYAM can be taken in SEM V to SEM VIII
# Online min 8 week course from SWAYAM can be taken in SEM V to SEM VIII to complete 2 credit course (Combination of two 4-week credit courses shall be allowed with prior approval)
* Online min 12 week course from SWAYAM can be taken in SEM V to SEM VIII to complete 3 credit course

## List of Program Elective Courses:

### Track-1: Manufacturing and Management

**SEM-V:** ***Any one Theory:***

25PEC13ME11: Supply chain management
25PEC13ME12: Costing and Cost Control
25PEC13ME13: Mould and Metal Forming Technology
25PEC13ME14: Additive Manufacturing

**Lab:**

25PEC13ME15: Additive Manufacturing

**SEM-VI:** ***Any two Theory:***

25PEC13ME16: Tool Engineering
25PEC13ME17: Advanced Materials
25PEC13ME18: Optimization Techniques
25PEC13ME19: Project Management
25PEC13ME110: Industrial Engineering and Operations Research

**Lab:**

25PEC13ME111: Manufacturing Systems
25PEC13ME112: Industrial Engineering and Operations Research

### Track-2: Design and Automation

**SEM-V:** ***Any one Theory:***

25PEC13ME21: Automation and Control
25PEC13ME22: Finite Element Analysis
25PEC13ME23: Dynamics of Machinery

**Lab:**

25PEC13ME24: Condition Monitoring

**SEM-VI:** ***Any two Theory*:**

25PEC13ME25: Industrial Robotics
25PEC13ME26: Modelling and Simulation
25PEC13ME27: Design of Mechanical Systems
25PEC13ME28: Product Design and Development

**Lab:**
25PEC13ME29: Robotics and Control Engineering
25PEC13ME210: Product Design

**Open Electives offered to Mechanical Engineering students:**
SEM-V Any one: 25**OE031:** Embedded Systems OR 25**OE032:** IoT OR 25**OE033:** E-Vehicle

**Honors Degree Offered to Mechanical Engineering Students from SEM-V to SEM-VIII:**

**A. Name**: **Robotics**
1. SEM-V: 25HRBC501: Industrial Robotics
2. SEM VI: 25HRBC601: Mechatronics & IoT
3. SEM VII: HRBC701: Artificial Intelligence & Data Analysis
4. SEM VII: HRBSBL701: Robotics and Automation Lab
5. SEM VIII: HRBC801: Autonomous Vehicle Systems

**B. Name: 3D Printing**
1. SEM-V: 25H3DPC501: Introduction to CAD
2. SEM VI: 25H3DPC601: 3D Printing: Introduction & Processes
3. SEM VII: H3DPC701: Applications of 3D Printing
4. SEM VII: H3DPSBL701: Skill Based Lab– Digital Fabrication
5. SEM VIII: H3DPC801: 3D Printing in Medical Technology

**C. Name: Data Science**
1. SEM-V: 25HDSC501: Mathematics for Data Science
2. SEM VI: 25HDSC601: Statistical Learning for Data Science
3. SEM VII: HDSC701: Data Science for Health and Social Care
4. SEM VII: HDSSBL701: Data Science for Health and Social Care Lab
5. SEM VIII: HDSC801: Text, Web and Social Media Analytics

**D. Name**: **Internet of Things**
1. SEM-V: 25HIoTC501: IoT Sensor Technologies
2. SEM VI: 25HIoTC601: IoT System Design
3. SEM VII: HIoTC701: Dynamic Paradigm in IoT
4. SEM VII: HIoTSBL701: Interfacing & Programming with IoT Lab (SBL)
5. SEM VIII: HIoTC801: Industrial IoT

**Minors Degree Offered to Mechanical Engineering Students from SEM-V to SEM-VIII:**

**A. Name Artificial Intelligence and Machine Learning**
1. SEM-V: 25HAIMLC501: Mathematics for AI & ML
2. SEM VI: 25HAIMLC601: Game Theory using AI & ML
3. SEM VII: HAIMLC701: AI & ML in Healthcare
4. SEM VII: HAIMLSBL701: AI & ML in Healthcare: Lab
5. SEM VIII: HAIMLC801: Text, Web and Social Media Analytics

**B. Name: Blockchain**
1. SEM-V: 25HBCC501: Bit coin and Crypto currency
2. SEM VI: 25HBCC601: Blockchain Platform
3. SEM VII: HBCC701: Blockchain Development
4. SEM VII: HBCSBL701: Private Blockchain Setup Lab (SBL)
5. SEM VIII: HBCC801: DeFi (Decentralized Finance)

**C. Name: Cyber Security**
1. SEM-V: 25HCSC501: Ethical Hacking
2. SEM VI: 25HCSC601: Digital Forensic
3. SEM VII: HCSC701: Security Information Management

4. SEM VII: HCSSBL601: Vulnerability Assessment Penetration Testing (VAPT) Lab
5. SEM VIII: HCSC801: Application Security

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| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME11 | Applied Thermodynamics | L | T | P | L | T | P | Total |
| | | 2 | -- | 2 | 2 | -- | 1 | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | - Fundamentals of Thermodynamics | |
|---|---|---|
| Course Outcomes | CO1 | Explain the fundamental modes of heat transfer (conduction, convection, and radiation) and their governing laws. |
| | CO2 | Analyze steady-state and unsteady-state heat conduction in different geometries including fins. |
| | CO3 | Understand the principles of free convection heat transfer, including velocity and thermal boundary layers, and perform thermal analysis. |
| | CO4 | Describe steam generators, boiler types, and performance. |
| | CO5 | Explain steam turbines, their classification, and efficiency analysis. |
| | CO6 | Understand gas turbines, jet propulsion, and efficiency improvements |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Modes of Heat Transfer:** Mechanism of conduction, Convection and radiation heat transfer and Governing laws. Generalized heat conduction equation in rectangular, cylindrical and spherical coordinates (only equations for cylindrical and spherical coordinates, no derivation). | 1-9 | 2 |
| | 1.2 | Steady state heat conduction through plane wall, composite wall, cylinder, composite cylinder, sphere and composite sphere. Thermal contact resistance. Critical radius of insulation in cylinder and sphere | 1-9 | 2 |
| 2 | 2.1 | **Heat transfer from Extended Surfaces:** Types of extended surfaces and its significance. Governing differential equation for fin (Finite, Infinite, and Insulated tips) and its solution. Fin efficiency and effectiveness. | 1-9 | 2 |
| 2 | 2.2 | Unsteady state heat transfer: Lumped heat capacity Analysis. Applications of unsteady state heat transfer, Thermal time constant. | 1-9 | 2 |

| | | | | |
|---|---|---|---|---|
| 3 | 3.1 | **Free Convection Heat Transfer:** External Flow (Flow Over a Flat Plate), Internal Flow (Flow in Tubes and Pipes), Velocity Boundary Layer and Thermal Boundary Layer, Thermal Analysis for Constant Heat Flux and Constant Surface Temperature | 1-9 | 2 |
| | 3.2 | **Forced Convection Heat Transfer:** External Flow (Flow Over a Flat Plate), Internal Flow (Flow in Tubes and Pipes), Velocity Boundary Layer and Thermal Boundary Layer, Thermal Analysis for Constant Heat Flux and Constant Surface Temperature | 1-9 | 2 |
| 4 | 4.1 | **Heat Exchangers:** Types of heat exchangers, Overall heat transfer coefficient, LMTD, Effectiveness, Effectiveness – Number of Transfer Unit (ε- NTU) method, Correction factor for multi pass (up to 2 passes on shell and tube side) and cross flow heat exchanger | 10-12 | 3 |
| 5 | 5.1 | **Steam Turbine**<br>Basic of steam turbine, Classification, compounding of turbine, Impulse turbine –velocity diagram, Condition for max efficiency Reaction turbine, Numerical on Simple Impulse turbine (De-Laval turbine) of single stage only. Degree of reaction, Parson's turbine, Condition for maximum efficiency, Numerical on Parson's turbine only. | 10-12 | 3 |
| 6 | 6.1 | **Gas Turbines**<br>Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration, Effect of operating variable on thermal efficiency and work ratio | 10-12 | 4 |
| | 6.2 | **Jet Propulsion Engines**<br>Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency. | 10-12 | 2 |
| | | **Total** | | 26 |

**Course Assessment:**

**PART A**

**THEORY**

**ISE-1:** Quiz (10 marks) and Assignments (10 marks) Continuous pre-defined rubrics-based evaluation
**ISE-2:** Quiz (10 marks) and Assignments (10 marks) Continuous pre-defined rubrics-based evaluation
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**PART B**

**LABORATORY**

| Sr. No | List of Experiment | Hrs. |
|---|---|---|
| 1 | Study of Boilers, Boiler Mountings and Accessories | 2 |
| 2 | Investigating the performance (COP, tonnage, Refrigeration efficiency) of an open-air conditioning unit. | 2 |
| 3 | Assessment of the performance (COP, tonnage, Refrigeration efficiency) of an ice-plant test rig. | 2 |
| 4 | Evaluation of the performance of a cooling tower. | 2 |
| 5 | Study of performance and emissions characteristics of a Single Cylinder/Multi Cylinder, Two/Four stroke petrol Engine at constant Speed/Load. | 2 |
| 6 | Determination of frictional power and mechanical efficiency of the Multi-cylinder Petrol Engine by Morse test. | 2 |
| 7 | Study of performance and emissions characteristics of a Single Cylinder/ Multi Cylinder, Two/Four stroke petrol Engine at constant Speed along with heat balance sheet. | 2 |
| 8 | Study of performance and emissions characteristics of a Single Cylinder, Four-stroke Diesel Engine at constant speed (With Electrical/ Rope Brake Dynamometer) (Load Test) along with Heat Balance Sheet. | 2 |
| 9 | Industrial Visit to a Power Plant | 2 |
| | **Total** | 18 |

**Course Assessment:**

**Laboratory Work**

**ISE-1:**
Experiments 1-4
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2:**
Remaining experiments.
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
1. Fundamentals of Heat and Mass Transfer by F.P. Incropera and D P deWitt, Wiley India 3rd Edition.
2. Introduction to thermodynamics and Heat transfer by YunusACengel 2ndEdition, McGraw Hill.
3. Fundamentals of Heat and Mass Transfer, M. Thirumaleshwar, Pearson Education India, 2009.
4. Introduction to Heat Transfer, Som S. K ,PHI Publication.

5. Heat Transfer by P S Ghoshdastidar, 2nd Edition, Oxford University Press.
6. Heat and Mass Transfer, by R Rudramoorthy and L Malaysamy, 2nd Edition, PEARSON.
7. Heat Transfer by J P Holman, Mcgraw Hill.
8. Heat Transfer by S P Sukhatme, University Press.
9. Heat and Mass Transfer by PK Nag, TMH.
10. Power Plant Engineering – P. K. Nag, McGraw Hill
11. Gas Turbines – V. Ganesan, McGraw Hill
12. Applied Thermodynamics for Engineering Technologists – T. D. Eastop & A. McConkey, Pearson

**Links for online NPTEL/SWAYAM courses:**

https://nptel.ac.in/courses/112/101/112101097/ - Heat and Mass Transfer, IIT Bombay

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME12 | Theory of Machines | L | T | P | L | T | P | Total |
| | | 2 | -- | 2 | 2 | -- | 1 | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Engineering Mechanics, Mechanics of Solids | |
|---|---|---|
| Course Outcomes | CO1 | Demonstrate basic concepts of kinematics and identify various components of common mechanisms. |
| | CO2 | Analyse the velocity and acceleration of various links in motion. |
| | CO3 | Illustrate different types of cams, followers with different motions and develop profiles of cams for engineering applications. |
| | CO4 | Illustrate various types of gears/ their terminology, areas of application analyse various parameters pertaining to spur gears and gear trains. |
| | CO5 | Demonstrate basic concepts pertaining to balancing/vibrations in evaluation of simple machine components. |
| | CO6 | Analyse clutches, brakes and dynamometers for evaluation of braking force and belt drive for power transmission. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Basic Concepts:** Structure, Machine, Mechanism, Kinematic link & its types, Kinematic pairs, Types of constrained motions, Types of Kinematic pairs, Kinematic chains, Types of joints. | 1-2 | 1 |
| | 1.2 | **Degree of freedom** (mobility): Kutzbach mobility criterion, Grűbler's criterion & its limitations | 1-2 | 1 |
| | 1.3 | **Inversions:** Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions | 1-2 | 1 |
| 2 | 2.1 | **Velocity Analysis of Mechanisms** (mechanisms up to 6 links) Velocity analysis by instantaneous centre of rotation method (Graphical approach), Velocity analysis by relative velocity method (Graphical approach) | 1-2 | 2 |
| | 2.2 | **Acceleration Analysis of Mechanisms** (mechanisms up to 6 links) Acceleration analysis by relative method including pairs involving Coriolis acceleration (Graphical approach) | 1-2 | 2 |
| 3 | 3.1 | **Cam and Follower Mechanism** | 1-2 | 1 |

| | | | | |
|---|---|---|---|---|
| | | Cam and its Classification based on shape, follower movement, and manner of constraint of follower; Followers and its Classification based on shape, movement, and location of line of movement; Cam and follower terminology | | |
| | **3.2** | **Motions of the follower:** SHM, Constant acceleration and deceleration (parabolic), Constant velocity, Cycloidal; | 1-2 | 1 |
| | **3.3** | **Layout of cam profile** for specified displacement characteristics for cams with translating and oscillating followers | 1-2 | 2 |
| **4** | **4.1** | **Gears:** Introduction, Types of gears and applications, Gear terminology, Condition for constant velocity ratio−conjugate profiles, profiles used in gears. Interference of involute teeth, methods of preventing interferences through undercutting, length of path of contact and contact ratio, no of teeth to avoid interference | 1-2 | 3 |
| | **4.2** | **Gear Trains:** Simple, compound, planetary and epicyclic gear trains (with numerical) | 1-2 | 2 |
| **5** | **5.1** | **Balancing:** Introduction. Rotary masses: several masses in same plane, several masses in different planes. (No numerical problems)<br>Balancing of locomotives− Variation of Tractive Effort, Swaying Couple and Hammer blow, The concept of primary and secondary balancing (No numerical problems) | 1-2 | 3 |
| | **5.2** | **Vibrations:** Introduction−free vibrations; longitudinal, transverse and torsional vibrations, critical or whirling speed of shaft. Torsional vibrations of two rotor system - torsionally equivalent shaft. | 1-2 | 2 |
| **6** | **6.1** | **Clutches, Brakes and Dynamometers:** Study and analysis of single plate clutch, multiple plate clutches and cone clutches. Types of brakes. viz. block and shoe brakes, band brake, band and block brakes Types of dynamometers, classification, Prony brake, Rope brake belt transmission dynamometers | 1-2 | 3 |
| | **6.2** | **Belts:** Introduction, Types and all other fundamentals of belting, Dynamic analysis –belt tensions, condition of maximum power transmission | 1-2 | 2 |
| | | | **Total** | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:**

Activity: Quiz on first three modules (20 marks)

Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:**

Activity: Quiz on last three modules (20 marks)

Continuous pre-defined rubrics-based evaluation for 20 marks.

**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus

**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Practical:**

| Sr. No. | PART A (Experiments) (Minimum 5) | Hours |
|---|---|---|
| 1 | Experiments on Gyroscope | 10 |
| 2 | Experiments on Governors- Porter Governor, Hartnell Governor | |
| 3 | Determine natural frequency of Simple Pendulum | |
| 4 | Determine natural frequency of Compound Pendulum | |
| 5 | Determine natural frequency and nodal points for single rotor and two-rotor vibratory system | |
| 6 | Determine whirling speed of shaft | |
| 7 | Experimental balancing of single and multi-rotor system | |
| | **PART B (Graphical Solutions)** | |
| 1 | Analysis of Velocity and Acceleration of Mechanisms | 3 |
| 2 | Development of CAM Profile for specific follower motion | 3 |
| | **PART C (Simulation)** | |
| 1 | Motion Analysis of Mechanisms using Solidworks | 2 |
| 2 | Vibration analysis of mechanical system using MATLAB/SCILAB/GNU Octave | 2 |
| | **Total** | **20** |

**Course Assessment:**

**Laboratory work:**

**ISE-1 (20 marks)**
Submission of the observations made during the lab performance for three Experiments (Part A) covered during this assessment duration Experiments covered during this assessment duration (10 marks)
Submission of graphical solutions for Part B – Assignment 1 and 2 (10 marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2 (30 marks)**
Submission of the observations made during the lab performance for the remaining 2 experiments (Part A) covered during this assessment duration. (10 marks).
Submission of Part C: Motion Analysis (10 Marks) and Vibration Analysis (10 Marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**

**Text Books:**

1. S.S. Ratan, "Theory of Machines", Tata McGraw Hill
2. Ghosh and A.K. Mallik, "Theory of Mechanisms and Machines", East-West Press

**Reference Books:**

1. J.J. Uicker, G.R. Pennock, and J.E. Shigley, "Theory of Machines and Mechanism", Oxford Higher Education
2. P.L. Ballaney, "Theory of Machines", Khanna Publishers
3. M.A. Mostafa, "Mechanics of Machinery", CRC Press
4. R.L. Norton, "Kinematics and Dynamics of Machinery", McGraw Hill
5. A.G. Erdman, G.N. Sander, and S. Kota, "Mechanism Design: Analysis and Synthesis Vol I", Pearson

**Links for online NPTEL/SWAYAM courses:**

1. https://nptel.ac.in/courses/112/105/112105268/

2. http://www.nptelvideos.in/2012/12/kinematics-of-machines.html

**AICTE Prescribed Textbook:**

Theory of Machines and Mechanisms, Prof. G C Mohan Kumar

(https://ekumbh.aicte-india.org/allbook.php#)

Society of St. Francis Xavier, Pilar's

Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME13 | Metrology and Quality Engineering | L | T | P | L | T | P | Total |
| | | 2 | -- | -- | 2 | -- | - | 2 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Understand the overall concept of metrology including standards of measurements, limits, fits, tolerances and gauge design. |
| | CO2 | Demonstrate knowledge of comparators, principle of interference and surface texture measurement. |
| | CO3 | Understand the methods to measure screw thread and gear parameters. |
| | CO4 | Understand and implement the concept of quality |
| | CO5 | Identify and use proper quality tools in various manufacturing or service problems. |
| | CO6 | Comprehend and apply quality standards in different situations. |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | Introduction to Metrology: Definition and Scope. Accuracy & Precision. Standards and characteristics of measurements.<br>Limits, fits and Tolerances: Basic definitions, Taylor's principle, Hole-basis and shaft-basis systems, Design of Go & No-Go gauges for hole and shaft using tolerance disposition diagram. | 1, 2 | 05 |
| 2 | Comparators: Understanding of features and operation of mechanical, optical, and pneumatic comparators, advantages, limitations, and field of applications.<br>Principles of interference, concept of flatness, flatness testing, optical flats.<br>Surface texture measurement: Importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters - Ra, Ry, Rz, RMS value etc., Different types of surface roughness measuring instruments and symbols. | 1, 2 | 05 |
| 3 | Screw Thread measurement: Two wire and three wire methods, floating carriage micrometer.<br>Gear measurement: Gear tooth comparator, measurement using rollers and Parkinson's Tester. | 1, 2 | 02 |
| 4 | Quality: Definition, Evolution of quality, Dimensions of quality planning, Principles of TQM, setup policy and objectives of quality control, quality of design and quality of conformance, compromise between quality & cost, Costs of quality | 3 | 05 |

| | | | |
|---|---|---|---|
| **5** | Process Data Collection & presentation – Bar Chart, Histogram and Run Charts.<br>Process Variability – variables & process variation (Measures of accuracy & centering, precision or spread, normal distribution and sampling averages).<br>Process Control by Variable – using X bar and R Chart and control charts for standard deviation.<br>Process Control by Attribute - for number of defectives or non-conforming units - np-charts, p-charts, c-charts and u-charts.<br>Process capability, OC curve, acceptance sampling AQL, LTPD, AOQL, producers and consumers risk, sampling plans. | 4 | 06 |
| **6** | Quality standards: ISO 9001:2000 Quality Management System Standard, ISO 14001:2004 Environmental Management System Standard | 5 | 03 |
| | **Total** | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Quiz or One assignment each on module 1, 2 and 3 (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:** Quiz or One assignment each on module 4, 5 and 6 or Presentations by students in groups of 3 on recent topics related to metrology and quality engineering (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**MSE:** 90 minutes of written examination based on 50% syllabus **(**30 Marks)

**ESE:** 90 minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Reference Books:**

1. Engineering. Metrology, I.C. Gupta, Dhanpat Rai Publications.
2. Engineering. Metrology, 22nd edition, R. K. Jain, Khanna Publisher, (2022).
3. Statistical quality Control, 2nd edition, Mahajan M., Dhanpat Rai & Sons, Delhi (2015).
4. Quality Control, 3rd edition, D. H. Besterfield, Pearson Education (2012).
5. Understanding and Implementing ISO 9000 and ISO Standards, 2nd edition, David L. Goetsch, Stanley Davis, Prentice Hall.

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Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME14 | CAD/CAM and FEA | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| | | |
|---|---|---|
| **Pre-requisite Course Codes** | Basics Mathematics. | |
| **Course Outcomes** | CO1 | Use of computer graphics in design. |
| | CO2 | Understand Fundamental Concepts geometric transformation. |
| | CO3 | Apply parametric equations for curve and surface generation. |
| | CO4 | Understand the fundamental principles, components, and working of CNC machines. |
| | CO5 | Implement appropriate CNC codes for specific tasks and analyse real-life engineering problems using FEA. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Introduction to CAD:**<br>Need and Utility of CAD systems in industry,<br>Fundamentals of computer graphics & hardware, Types of Geometric Modelling,<br>**Raster Graphics:** line and circle algorithm. | 1-8 | 6 |
| 2 | 2.1 | **Geometric Transformation:** Homogenous Transformation (2D Translation, scaling, Reflection, Rotation) | 1-8 | |
| | 2.2 | Window Viewport and Clipping. | 1-8 | 6 |
| 3 | 3.1 | **Curves And Surfaces:**<br>Cubic spines Bezier curves & B- spines (No Numerical). | 1-8 | |
| | 3.2 | Product data exchanges formats (STEP, IGES). | 1-8 | 4 |
| 4 | 4.1 | **CNC Machines:**<br>Fundamental elements of CNC, Benefits of CNC, Computer control concepts, Data processing units.<br>**Basics of control systems:**<br>Motion controller, Interpolation-Linear & Circular, Positioning & contouring control loops, Incremental & Absolute system, DNC & CNC systems and Adaptive control system.<br><br>**CNC Hardware Basics:**<br>CNC drives, Spindle design, Actuation and Feedback devices. | 1-8 | 4 |

| | | | | |
|---|---|---|---|---|
| | | | | |
| **5** | **5.1** | **CNC Programming(Turning & Machining):** G & M code, Tool length, nose radius & Diameter compensation, Canned cycles, Looping Jumping Subroutines Macros, Parametric programming, Turning & Machining centre programming. | 1-8 | 6 |
| | **5.2** | **FEA Software**: General Procedure & Application. | | |
| | | | **Total** | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | Line DDA algorithm numerical. | **01** |
| **2** | Bresenham's Line Algorithm. | **01** |
| **3** | Circle Algorithm. | **01** |
| **4** | 2 D transformation using translation and Rotation matrix. | **01** |
| **5** | Compound 2 D transformation. | **01** |
| **6** | Bezier Curve. | **01** |
| **7** | Turning Centre (Sinumerik)Programming. | **01** |
| **8** | Machining Centre (Fanuc) Programming. | **01** |
| | **Total Hours** | **08** |

**Course Assessment:**

**Theory:**

**ISE-1:**

Activity: Quizzes/Assignment on first two modules (20 Marks)

**ISE-2:**

Activity: Quizzes/Assignment on last three modules (20 Marks)

**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus

**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**

**ISE-1**:

First Four tutorials (20 marks)

Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:**

Next four tutorials (30 marks)

Continuous pre-defined rubrics-based evaluation for 30 marks

**Recommended Books:**

1. *CAD/CAM* by Groover and Zimmers

2. *CAD Principles and Applications* by Barr, Krimger and Lazaer

3. William M Neumann and Robert F.Sproul "*Principles of Computer Graphics*", Mc Graw Hill Book Co. Singapore, 1989.

4. Donald Hearn and M. Pauline Baker "*Computer Graphics*", Prentice Hall, Inc., 1992.

*5.* Foley, Wan Dam, Feiner and Hughes – *Computer graphics principles & practices, Pearson Education – 2003.*
6. CAD / CAM by P.N. Rao (Tata-Mcgraw- Hill) 2
7.*Computer Graphics* by Hearn and Baker (PHI)
8. *Mastering CAD – CAM* by Ibarahim Zeid (Tata-Mcgraw-Hill) 4

**Links for online NPTEL/SWAYAM courses:**

1. https://nptel.ac.in/courses/112/102/112102101/
2. https://nptel.ac.in/courses/106/102/106102065/
3. https://nptel.ac.in/courses/112/102/112102103/
4. https://nptel.ac.in/courses/112/105/112105211/

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME15 | FEA and CFD Lab | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | CAD Modelling. | |
|---|---|---|
| Course Outcomes | CO1 | Apply static structural analysis techniques to evaluate and interpret the behaviour of structures under various conditions. |
| | CO2 | Apply structural dynamic analysis techniques to evaluate and interpret the response of structures under dynamic loading conditions. |
| | CO3 | Apply thermal analysis techniques to evaluate and interpret heat transfer and temperature distribution in engineering systems. |
| | CO4 | Apply steady flow analysis techniques to evaluate and interpret fluid behaviour in engineering systems under steady conditions. |
| | CO5 | Apply turbulence modelling techniques to analyse and predict fluid flow behaviour in engineering systems. |

| Sr. No | Topics | Hr |
|---|---|---|
| 1 | Problem for Static structural analysis. | 6 |
| 2 | Problem for Dynamic Structural analysis. | 5 |
| 3 | Problem for Thermal Analysis. | 5 |
| 4 | Problem for Steady flow analysis. | 6 |
| 5 | Problem for Turbulence Modelling. | 4 |
| **Total** | | **26** |

**Course Assessment:**

**Laboratory:**

**ISE-1: (20 Marks)**

Experiments 1 to 2

Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2: (30 Marks)**

Experiments 3 to 5

i. Continuous pre-defined rubrics-based evaluation for 20 marks.
ii. Lab interaction (10 marks).

**Recommended Books:**

1. Programming the Finite Element Method, I M Smith, D V Griffiths and Margetts WILEY Publications.
2. The Finite Element Method: Theory, Implementation, and Applications, Larson, Mats G., Bengzon, Fredrik, Springer
3. Introduction to Finite Element Analysis and Design by N. H. Kim, B. V. Sankar, and A. V. Kumar by Wiley publication
4. Finite Element analysis using ANSYS by PaletiSrinivas, Krishna Chaitanya, Rajesh Kumar Detti, PHI Publication.
5. Finite Element Analysis Theory and Application With ANSYS by Saeed Moaveni, Pearson Publication.
6. Introduction to Finite Element Analysis Using MATLAB and Abaqus By Amar Khennane, CRC Press publication

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME11 | Supply Chain Management | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | - | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Demonstrate today's business environment and importance of Logistics and Supply Chain Management. |
| | CO2 | Identify the drivers of supply chain performance and uncertainty in supply chain management. |
| | CO3 | Understand the techniques of inventory management and rank the items using inventory management technique |
| | CO4 | Understand strategies and techniques to minimize overall logistics cost |
| | CO5 | Understand the role of digitization in supply chain management leading to sustainability |
| | CO6 | Understand various supply chain sustainable and productivity terminology |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | Objectives of a Supply Chain Management, Stages of Supply chain, Value Chain Process, Cycle view of Supply Chain Process, Push Pull in SC, Design Phases stage, logistics & SCM | 1-4 | 04 |
| 2 | Supply Chain Drivers /decisions and obstacles, Supply chain strategies & strategic fit. | 1-4 | 04 |
| 3 | Definition of Inventory, Inventory types, EOQ Model and Buffer Stock, Replenishment systems (Q and P system), Inventory Control- ABC Analysis, Numerical problems on ABC analysis, VED Analysis, | 1-4 | 04 |
| 4 | Bullwhip effect and measures, Balance delay, SCOR Model, Factors influencing distribution network design, Design options for distribution network | 1-4 | 05 |
| 5 | IT Framework and sustainable Supply Chain management, Transport Management System (TMS), Warehouse Management System (WMS). ERP (SAP) and integration of technology. | 1-4 | 05 |
| 6 | Value Stream Mapping (VSM), Order fill rate, Product fill rate, Order visibility, Lead time, Takt time, Logistics Vs Reverse Logistics, Third Party – Fourth Party Logistics and integration, Green SC | 1-4 | 04 |
| | **Total** | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Quiz (20 Marks)
**ISE-2:** Quiz (20 Marks)
**MSE:** 90 Minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 Minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial**

**ISE-1**

One assignment each on module 1, 2 and 3. Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2**

One assignment each on module 4, 5 and 6 followed by Presentation by groups based on recent updates on SC.

**Reference Books:**

1. Sunil Chopra, P. Meindl, "Supply Chain Management", 6th Edition 2016, Pearson Education Asia.
2. D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, and Ravi Shankar, "Designing and Managing the Supply Chain concepts, Strategies and Case studies", 3rd Edition, Tata McGraw Hill, New Delhi, 2008
3. Rahul V Altekar, "Supply Chain Management: Concepts and cases", Edition 2009, PHI, ISBN: 9788120328594. Quality Control, 3rd edition, D. H. Besterfield, Pearson Education (2012).
4. R.P. Mohanty, S.G. Deshmukh, "Essentials of Supply Chain management", 1st Edition 2004, Jaico Publishing House.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME12 | Costing and Cost Control | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | | Total |
| | | Theory | 20 | 30 | 20 | 30 | | 100 |
| | | Tutorial | 20 | -- | 30 | -- | | 50 |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Explain types of costs, cost control fundamentals, and the role of cost engineers. |
| | CO2 | Implement job, batch, process, and activity-based costing in manufacturing |
| | CO3 | Perform break-even analysis, standard costing, and cost estimation techniques. |
| | CO4 | Apply budgeting, marginal costing, value engineering, and lean techniques. |
| | CO5 | Use make-or-buy analysis, inventory costing, and cost-volume-profit analysis. |
| | CO6 | Analyze case studies and apply tools like Tally and Excel for cost management. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Overview of Costing**: Definition, objectives, and importance in manufacturing, Types of Costs: Fixed, variable, direct, indirect, and sunk costs. Cost Control Fundamentals: Principles and significance in engineering projects, Role of Cost Engineers: Key competencies and responsibilities. | 1-8 | 4 |
| 2 | 2.1 | **Cost Control vs. Cost Reduction**: Meaning, differences, and importance, Role of Costing in Industrial Engineering: Applications in production planning and control. | 1-8 | 3 |
| | 2.2 | **Costing Methods in Manufacturing:** Job Costing, Batch Costing, Process Costing, Activity-Based Costing (ABC). | 1-8 | 2 |
| 3 | 3.1 | **Cost Estimation Techniques in Production Engineering:** Elements of Cost: Material cost, labor cost, and overheads, Factors affecting cost estimation, Break-even Analysis: Determining the minimum production quantity for profitability, Standard Costing: Concept, advantages, and variance analysis. | 1-8 | 4 |

| | | | | |
|---|---|---|---|---|
| **4** | **4.1** | **Cost Control Techniques in Industry:** Budgeting and Cost Control: Definition, types of budgets, budgetary control, Marginal Costing: Concept and decision-making applications. | 1-8 | 3 |
| | **4.2** | **Value Engineering:** Reducing cost without affecting quality and performance. **Waste Reduction and Cost Savings:** Lean manufacturing techniques. | 1-8 | 2 |
| **5** | **5.1** | **Cost Analysis for Decision Making:** Make-or-Buy Decisions: Cost-based decision-making for outsourcing. Inventory Costing: EOQ, ABC analysis, and JIT in cost reduction. Depreciation and Its Impact on Costing: Different depreciation methods. Cost-Volume-Profit (CVP) Analysis: Understanding cost behavior and profitability. | 1-8 | 4 |
| **6** | **6.1** | **Industrial Case Studies and Costing Software:** Case Studies on Cost Control in Manufacturing: Real-world industry examples. Introduction to Costing Software: Tally, and Excel for cost management. Future Trends in Costing and Cost Control: Digital transformation in industrial costing. | 1-8 | 4 |
| **Total** | | | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Activity: Assignments , Quiz (20 marks)

**ISE-2:** Activity: Assignments, Quiz (20 marks)

**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus

**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**

**ISE-1:**

Examples/Assignments on Module 1, Module 2 and Module 3

Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:**

Examples/Assignments on Module 4, Module 5 and Module 6

Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**

**Text Books:**

1. M.L. Mehta & S.P. Gupta – Cost Accounting: Principles and Practice (Sultan Chand & Sons)
2. Charles T. Horngren, Srikant M. Datar, Madhav Rajan – Cost Accounting: A Managerial Emphasis (Pearson)
3. R. Kesavan, C. Elanchezhian, B. Vijaya Ramnath – Engineering Economics and Costing (Laxmi Publications)
4. V.K. Saxena & C.D. Vashist – Advanced Cost and Management Accounting (Sultan Chand & Sons)

**Reference Books**:

5. Colin Drury – Management and Cost Accounting (Cengage Learning)
6. Jawaharlal & Seema Srivastava – Cost Accounting (McGraw Hill)
7. Bhabatosh Banerjee – Cost Accounting: Theory and Practice (Prentice Hall India)
8. M.N. Arora – A Textbook of Cost and Management Accounting (Vikas Publishing)

**AICTE Prescribed Textbook:**

Book Name- Estimation, Costing & Valuation

Author Name-Dr. Sandeep Panchal
(https://ekumbh.aicte-india.org/allbook.php#)

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Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME13 | Mould and Metal Forming Technology | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | - | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | Learner will be able to | |
| | CO1 | Understand the different types of casting Process. |
| | CO2 | Understand the concept of different metal forming process. |
| | CO3 | Approach metal forming processes both analytically and numerically |
| | CO4 | Design metal forming processes |
| | CO5 | Develop approaches and solutions to analyze metal forming processes and the associated problems and flaws. |

| Module No. | Topics | Ref. | Hrs. |
|---|---|---|---|
| 1 | **Sand Casting of Metals**<br>Mould materials: Moulding sand; Constituents of moulding sand and its property requirements<br>Design and manufacture of Patterns and Cores: Pattern allowances, Types of patterns, Core print, Core<br>Use of Gating system, Pouring basin, Sprue, Runners and Ingates.<br>Use of chills, padding and risering.<br>Melting practices: Cupola, Arc and Induction furnaces.<br>Defects in cast components | 8 | 5 |
| 2 | **Introduction to Metal Forming:**<br>Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, effects of temperature, strain rate, microstructure and friction in metal forming-yield criteria and their significance, Classification of Metal Forming Processes, Advantages and Limitations, Stress strain relations in elastic and plastic deformation, concept of flow stresses, Hot and Cold Working Processes. | 1-7 | 4 |
| 3 | **Rolling:**<br>Introduction and Classification, Types of Rolling Mills, Forces and Geometrical Relationships in Rolling, Calculation of Rolling Load, Defects in Rolled Products. | 2-7 | 4 |

| | | | |
|---|---|---|---|
| **4** | **Forging:**<br>Introduction and Classification, operation and principle of Forging Processes and Equipment, Methods of forging, Open and Close Die Forging Processes, Defects in forged products. | 2-7 | 4 |
| **5** | **Extrusion:**<br>Introduction and Classification, Extrusion Equipment, Extrusion of components including Seamless Pipes and Tubes. Extrusion of pipes by cold working<br>**Drawing:**<br>Introduction and Classification, Wire Drawing, Rod Drawing, Tube Drawing, Deep Drawing, | 2-7 | 5 |
| **6** | **Sheet Metal Forming:**<br>Principle, working and application of the following processes: spinning, stretch forming, plate, V and edge bending, Ironing, Roll Bending, Metal Spinning, explosive forming, Hydro forming, electro hydraulic forming, and magnetic pulse forming. | 2-7 | 4 |
| | **Total** | | 26 |

**Theory:**

**ISE-1:** Quiz (20 Marks) based on 50% syllabus
**ISE-2:** Quiz (20 Marks) based on remaining syllabus
**MSE:** 90 Minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 Minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial**
**ISE:**
**ISE-1** (20 marks)
One assignment each on module 1, 2 and 3. Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2 (30 marks)**
One assignment each on module 4, 5 and 6 followed by Presentation by groups based on recent updates on Metal forming.

**Recommended Books:**

1. Lin D Balint M Pietrzyk, Microstructure Evolution in Metal Forming Processes 1st Edition
2. Amitabha Ghosh and Asok Kumar Mallick, Manufacturing Science, Affiliated East-West Press
3. Christian Brecher and Ozdemir , Advances in Production Technology, Springer Publications
4. P.C.Sharma , A Text Book on Production Engineering, S.Chand Publications
5. P. N. Rao, "Manufacturing Technology", Tata McGraw Hill
6. Aviter, "Fundamental of Metal Working", McGraw Hill Publisher
7. Dieter, "Mechanical Metallurgy"
8. Principles of Metal casting by Mahi Sahoo.

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/112/107/112107250/ - Principles of Metal Forming Technology, IIT Roorkee
https://nptel.ac.in/courses/112/106/112106153/ - Forming, IIT Madras

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME14 | Additive Manufacturing | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| | | |
|---|---|---|
| **Pre-requisite Course Codes** | Basic manufacturing. | |
| **Course Outcomes** | CO1 | Illustrate understanding of various cost-effective alternatives for manufacturing products and select the feasible additive manufacturing for specific technical application |
| | CO2 | Understand and apply the principles of liquid-based rapid prototyping and tooling processes to build and generate data for additive manufacturing of various objects. |
| | CO3 | Understand and apply the principles of solid-based rapid prototyping systems for efficient additive manufacturing and product development. |
| | CO4 | Understand and apply the principles of powder-based additive manufacturing systems for efficient prototyping and production of complex geometries. |
| | CO5 | Understand and apply reverse engineering techniques in additive manufacturing to reconstruct, modify, and optimize existing designs for manufacturing and prototyping. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | Introduction to additive manufacturing, its historical development, advantages. Classification of additive manufacturing process, Advantages & Disadvantages, Applications to various fields, Rapid Tooling, Design Consideration. | 1-8 | 6 |
| 2 | 2.1 | **Liquid-Based Systems:** Stereolithography (SLA): Photopolymerization process, Working Principle, Material used, Advantages and limitation, Application | 1-8 | 6 |
| | 2.2 | Solid ground curing: Working Principle, Material used, Advantages and limitation, Application. | | |
| | 3.1 | **Solid Based Rapid Prototyping Systems:** | | |

| | | | | |
|---|---|---|---|---|
| **3** | | LOM (Laminated Object Manufacturing) System: Working Principle, Material used ,Advantages and limitation, Application. | 1-8 | 4 |
| | **3.2** | FDM (Fused Deposition Modelling) System: Working Principle, Material used, Advantages and limitation, Application. | | |
| **4** | **4.1** | **Powder Based Systems:** SLS (Selective Laser Sintering): Working Principle, Material used , Advantages and limitation, Application. | 1-8 | 6 |
| | **4.2** | (3DP) Three-Dimensional Printing: Working Principle, Material used , Advantages and limitation, Application. | | |
| | **4.3** | (EBM) Electron Beam Melting: Working Principle, Material used , Advantages and limitation, Application. | | |
| **5** | **5.1** | **Reverse Engineering** Introduction to Digitizing Methods, Contact type and Non-contact type, Brief introduction to the types of medical imaging. **Virtual reality:** Definition, features of VR, Technologies used in VR, Introduction to Augmented reality **.** | 1-8 | 4 |
| | | | **Total** | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | Preprocessing of 3d Print Component. | **01** |
| **2** | 3D Printing of Component. | **01** |
| **3** | Case study on SLA. | **01** |
| **4** | Case study on LOM. | **01** |
| **5** | Case study on FDM. | **01** |
| **6** | Case study on SLS. | **01** |
| **7** | Case study on 3DP. | **01** |
| **8** | Case study on EBM. | **01** |
| **Total Hours** | | **08** |

**Course Assessment:**

**Theory:**
**ISE-1:**
Activity: Quizzes/Assignment on first two modules (20 Marks)
**ISE-2:**
Activity: Quizzes/Assignment on last three modules (20 Marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**

**ISE-1**

First Four tutorials (20 marks)

Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2**

Next four tutorials (30 marks)

Continuous pre-defined rubrics-based evaluation for 30 marks

**Recommended Books:**

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications",
2. World Publishing Co. Pte. Ltd.
3. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid
4. Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.
5. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer
6. RafiqNoorani, Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7
7. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
8. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.

**Links for online NPTEL/SWAYAM courses:**

1. https://onlinecourses.nptel.ac.in/noc24_me138/preview
2. https://onlinecourses.nptel.ac.in/noc22_me74/preview
3. https://onlinecourses.nptel.ac.in/noc22_me130/preview
4. https://onlinecourses.nptel.ac.in/noc25_mm02/preview

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME15 | Additive Manufacturing Lab | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | CAD Modelling. | |
|---|---|---|
| Course Outcomes | CO1 | Illustrate basic understanding of types of CAD model creation. |
| | CO2 | Apply segmentation techniques in Slicer's Segment Editor module to prepare 3D models for printing. |
| | CO3 | Develop 3D model using available 2D image. |
| | CO4 | Apply various design considerations to enhance the quality and functionality of 3D component printing. |
| | CO5 | Apply additive manufacturing processes to develop a physical 3D mechanical structure. |

| Sr. No | Topics | Hr |
|---|---|---|
| 1 | Modelling of a component using 3D modelling software | 4 |
| 2 | Segmentation in Slicer's Segment Editor module for the purpose of 3D printing. | 6 |
| 3 | Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any engineering or medical part.) | 6 |
| 4 | Application of various design considerations in 3D component printing. | 4 |
| 5 | Development of physical 3D mechanical structure using any one of the Additive manufacturing processes | 6 |
| **Total** | | **26** |

**Course Assessment:**

**Laboratory:**
**ISE-1: (20 Marks)**
Experiments 1 to 2
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2: (30 Marks)**
Experiments 3 to 5

i. Continuous pre-defined rubrics-based evaluation for 20 marks.
ii. Lab interaction (10 marks).

**Recommended Books:**

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by K.I. Narayana, P. Kannaiah, K.Venkata Reddy
4. Medical Modelling - The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd
5. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credit Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| 25PEC13ME21 | Automation and Control | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | | Total |
| | | Theory | 20 | 30 | 20 | 30 | | 100 |
| | | Tutorial | 20 | -- | 30 | -- | | 50 |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Code | CO1 | Illustrate the basic concept of Industrial automation in different manufacturing set-ups. |
| | CO2 | Design and Develop Pneumatic Circuits |
| | CO3 | Design and Develop Hydraulic Circuits |

| Modules No. | Topics | Ref. | Hrs. |
|---|---|---|---|
| 1 | Automation Definition; Automation in production systems; Automation principles and strategies; Basic elements of an automated system; Advanced automation functions; Levels of automation; Types of automation; Benefits and Impact of Automation in Manufacturing and Process Industries. Architecture of Industrial Automation Systems. | 1 | 4 |
| 2 | Pneumatic control systems Overview of different types of valves and Actuators in Pneumatics, their applications and their ISO symbols. Design of Pneumatic circuits using Cascade method and Shift register method (up to 3 cylinders). applications of Timers and Counters and concept of Flag and latching. | 2, 3 | 5 |
| 3 | Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves with and without grouping. Design of Pneumatic circuits using PLC Control (ladder programming only and up to 3 cylinders) with | 4 | 5 |
| 4 | Hydraulic Control System : Overview of different types of valves, Actuators and Accumulators used in Oil hydraulic circuits, their applications and their ISO symbols. Basic hydraulic circuits involving linear and rotary actuators (No sequential circuits). Fundamental concepts of digital and servo hydraulic controls. Comparison between proportional, digital and servo hydraulic control systems. | 5 | 4 |
| 5 | Fundamentals of Control System Control system concepts, classification of control systems, Mathematical representation of system equations, response characteristics of components and systems through classical solution. | 6 | 4 |
| 6 | Frequency response analysis, polar plots, Testing of System's stability using Routh's criteria, Bode plots, Nyquist plot and Root locus method of analysis. | 6 | 4 |
| | **TOTAL** | | 26 |

**Course Assessment :**

**Theory :**

**ISE-1:** Quiz (20 Marks)

**ISE-2:** Quiz (20 Marks)

**MSE:** 90 minutes of written examination based on 50% syllabus **(**30 Marks)

**ESE:** 90 minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial :**

**ISE-1:** Assignment of first 3 modules (20 Marks)

**ISE-2:** Assignment on last 3 modules (20 Marks)
Simulation of System Response on Matlab (10 marks )

**Recommended Books:**

1. Groover, M.P. "Automation, Production Systems, and Computer-Integrated Manufacturing", 4th Edition, Pearson, 2015.
2. Festo Didactic, "Fundamentals of Pneumatics", Festo Training Manual.
3. Andrew Parr, "Pneumatics and Hydraulics: A Technician's and Engineer's Guide", 3rd Edition, Butterworth-Heinemann, 2011.
4. Festo Didactic, "Electro-Pneumatics Basic Level", Festo Training Manual.
5. Eaton (Vickers), "Industrial Hydraulics Manual", Latest Edition, Eaton Hydraulics.
6. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson, 2010.

Society of St. Francis Xavier, Pilar's

# Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| 25PEC13ME22 | Finite Element Analysis | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Basic CAD, Design, Mathematics. | |
|---|---|---|
| Course Outcomes | CO1 | Solve differential equations using weighted residual methods. |
| | CO2 | Develop the finite element equations to model engineering problems governed by second order differential equations. |
| | CO3 | Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional elements. |
| | CO4 | Apply the basic finite element formulation techniques to solve engineering problems by using two dimensional elements. |
| | CO5 | Apply the basic finite element formulation techniques to find natural frequency of single degree of vibration system. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | Introduction to FEA: Introduction to FEM, | 1-8 | 4 |
| | 1.2 | Mathematical Modelling of field problems in engineering, Governing Differential equations, primary/secondary variables, boundary conditions types-essential/natural etc. | | |
| | 1.3 | Discrete and Continuous Models. | | |
| | 1.4 | Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom. | | |
| 2 | 2.1 | Approximate solution of differential equations, residual (Galerkin , Subdomain method, Rayleigh-Ritz method). | 1-8 | 6 |
| | 2.2 | Minimization of a functional, Principle of minimum total potential, Formulation of 'stiffness matrix', assembly concepts to develop system equation. | | |
| 3 | 3.1 | One Dimensional Problems:<br>One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors | 1-8 | 8 |
| | 3.2 | Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer (stepped and taper bars, spring-Cart Systems) | | |
| | 3.3 | Analysis of Plane trusses, Analysis of Beams. | | |
| 4 | 4.1 | **Two Dimensional Finite Element Formulations:**<br>Introduction, three node triangular element, four node rectangular element. | | |

| | | | | |
|---|---|---|---|---|
| | **4.2** | Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. | 1-8 | 4 |
| **5** | **5.1** | **Finite Element Formulation of Dynamics and Numerical Techniques:** Free vibration problems of rod and beam, Lumped and consistent mass matrices. | 1-8 | 4 |
| | **5.2** | Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams. | | |
| | | | **Total** | **26** |

**Tutorial:**

| **Sr. No.** | **Tutorial Details** | **Hours** |
|---|---|---|
| **1** | Numerical on Galerkin method. | **01** |
| **2** | Numerical on Subdomain method. | **01** |
| **3** | Numerical on Rayleigh-Ritz method. | **01** |
| **4** | Numerical on Stepped Bar/ spring-Cart Systems | **01** |
| **5** | Analysis of Plane trusses | **01** |
| **6** | Analysis of Beams. | **01** |
| **7** | Numerical on Natural frequency of axial vibration of bar. | **01** |
| **8** | Numerical on Natural frequency of transverse vibration of bar. | **01** |
| **Total Hours** | | **08** |

**Course Assessment:**

**Theory:**

**ISE-1:**

Activity: Quizzes/Assignment on first two modules (20 Marks)

**ISE-2:**

Activity: Quizzes/Assignment on last three modules (20 Marks)

**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus

**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**
**ISE-1**

First 3 tutorials (20 marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2**

Next 5 tutorials (30 marks)
Continuous pre-defined rubrics-based evaluation for 30 marks

**Recommended Books:**

1. Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
2. Finite Element Method by J N Reddy, TMH
3. 'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu, Pearson Education
4. Finite Element Methods by R Dhanraj and K Prabhakaran Nair, Oxford University Press
5. A first course in Finite Element Method by Logan D L, Thomson Asia PvtLtd
6. 'Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S, Plesha ME, John- Wiley Sons
7. The Finite Element Method in Engineering by S. S. Rao, Butter Worth Heinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

**Links for online NPTEL/SWAYAM courses:**

https://nptel.ac.in/courses/112/104/112104193/
https://nptel.ac.in/courses/105/106/105106051/
https://nptel.ac.in/courses/112/104/112104115/
https://nptel.ac.in/courses/112/103/112103295/
https://nptel.ac.in/courses/112/106/112106135/
https://nptel.ac.in/courses/112/106/112106130/
https://nptel.ac.in/courses/105/105/105105041/

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| 25PEC13ME23 | Dynamics of Machinery | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Theory of Machines | |
|---|---|---|
| Course Outcomes | CO1 | Demonstrate working Principles of different types of governors and Gyroscopic effects on the mechanical systems |
| | CO2 | Illustrate basic of static and dynamic forces |
| | CO3 | Determine natural frequency of element/system |
| | CO4 | Determine vibration response of mechanical elements / systems |
| | CO5 | Design vibration isolation system for a specific application |
| | CO6 | Demonstrate basic concepts of balancing of forces and couples |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Governors:** Introduction to Centrifugal and Inertia governors, Study and Force analysis of Porter and Hartnell governors including Performance characteristics, Governor effort and power | 3-4 | 4 |
| | 1.2 | **Gyroscope:** Introduction, Gyroscopic couple and its effect on spinning bodies, naval ships during steering, pitching, rolling and their stabilization. | 3-4 | 1 |
| 2 | 2.1 | Static and Dynamic force analysis of Slider crank mechanism (neglecting mass of connecting rod and crank), Turning moment on crank shaft | 3-4 | 2 |
| | 2.2 | Dynamically equivalent systems to convert rigid body into two mass with and without correction couple (Case study- Connecting rod ) | 3-4 | 2 |
| 3 | 3.1 | **Basic Concepts of Vibration:** Vibration and oscillation, causes and effects of vibrations, Importance of study of vibrations, Vibration parameters - springs, mass, damper, Motion- periodic, non-periodic, degree of freedom, static equilibrium position, vibration classification, steps involved in vibration analysis | 8-9 | 1 |
| | 3.2 | **Free Undamped Single Degree of Freedom Vibration System:** Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's method | 8-9 | 3 |

| | | | | |
|---|---|---|---|---|
| **4** | **4.1** | **Free Damped Single Degree of Freedom Vibration System:** Introduction to different methods of damping, Study and analysis of 1) Viscous damped system (under damped, critically damped, over damped; Logarithmic decrement ) 2)Coulomb's damping (Combined Viscous and Coulomb damping excluded) | 8-9 | 3 |
| | **4.2** | **Equivalent Single Degree of Freedom Vibration System:** Conversion of multi-springs, multi masses, multi-dampers into a single spring and damper with linear or rotational co-ordinate system | 8-9 | 3 |
| **5** | **5.1** | **Forced Single Degree of Freedom Vibratory System:** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) | 8-9 | 3 |
| **6** | **6.1** | **Rotor Dynamics:** Critical speed of single rotor, undamped and damped | 3-4 | 1 |
| | **6.2** | **Balancing:** Static and Dynamic balancing of multi rotor system (up to four rotors), balancing of reciprocating masses in In-line engines (up to four cylinders), Introduction to V-engines (excluding other radial engines) | 3-4 | 3 |
| **Total** | | | | **26** |

**Course Assessment:**

**Theory:**
**ISE-1:**
Activity: Quiz on first three modules (20 Marks)
**ISE-2:**
Activity: Quiz on last three modules (20 Marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**
**ISE-1:**
Assignment on Governors and Gyroscope (10 marks)
Assignment on Static and Dynamic Force Analysis (10 marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2:**
Assignment on Free Undamped and Damped Vibrations (10 marks)
Assignment on Forced Vibrations (10 marks)
Assignment on Balancing (10 marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
1. Theory of Machines Thomas Bevan CSB Publishers & Distributors
2. Theory of Machines by Jagdishlal Metropolitan Book New Delhi, Company, Daryaganj, Delhi
3. Theory of Machines by S.S.Ratan Tata McGraw Hill , New Delhi

4. Theory of Machines by P.L.Bellaney Khanna publication, NewDelhi
5. Theory of Machines and Mechanisms by John J Uicker, Gordon R Pennock and Joseph E Shigley, Oxford University Press
7. Theory of Vibration with Applications, by W. Thomson, 2nd edition, Pearson Education
8. Mechanical Vibrations by S.S.Rao, fourth edition, Pearson Education
9. Mechanical Vibraitons by G.K.Grover
10. Fundamentals of Mechanical Vibration by S.Graham Kelly, Tata McGraw Hll
11. Principles of Vibration by Benson H Tongue, 2nd Edition, Oxford University Press
12. Vibration Analysis by P. Srineevasan, TMH
13. Mechanical Vibrations- Schaum's outline series, William W.Seto, McGraw Hill
14. Theory and Practice of Mechanical Vibrations by J S Rao and K Gupta, New Age International
15. Elements of Vibration Analysis by Leonard Meirovitch, McGrav- Hill, New York

**Links for online NPTEL/SWAYAM courses:**

https://nptel.ac.in/courses/112/101/112101096/ - Dynamics of Machines, IIT Bombay
https://nptel.ac.in/courses/112/107/112107212/ - Introduction to Mechanical Vibration, IIT Roorkee

Society of St. Francis Xavier, Pilar's

Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME24 | Condition Monitoring | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | After completing the given assignments and experiments, students will be able to: | |
| | CO1 | Understand the fundamentals of condition monitoring |
| | CO2 | Explain condition monitoring techniques and equipment |
| | CO3 | Diagnose machinery faults using vibration analysis |
| | CO4 | Apply ISO standards for condition monitoring |
| | CO5 | Conduct experimental studies on machinery faults |
| | CO6 | Interpret and document condition monitoring results |

| Module No. | Experiments / Assignments List |
|---|---|
| 1 | Assignment on :<br>**Introduction to Condition Monitoring**<br>Overview of condition monitoring and its techniques, Introduction to condition monitoring equipment and software in Lab, Basics of data acquisition and signal processing, Vibration sensors (Accelerometers, Velometers, Displacement sensors), Time-domain and frequency-domain analysis (FFT, RMS, Peak values), Identification of common faults (imbalance, misalignment, bearing defects), Examples of Condition Monitoring in Industries, Case studies based on Maintenance Strategies (Breakdown, Preventive, Predictive and Proactive) |
| 2 | Assignment on : Study of ISO Standards for Condition Monitoring (ISO 17359, ISO 10816, ISO 18436) |
| 3 | **Experiment (any 4)** on<br>a. Condition Monitoring and Machinery Fault Diagnosis – Good Shaft and Bearing Signature<br>b. Condition Monitoring and Machinery Fault Diagnosis – Unbalancing with varying speed<br>c. Condition Monitoring and Machinery Fault Diagnosis – Misalignment<br>d. Condition Monitoring and Machinery Fault Diagnosis – Bent shaft<br>e. Condition Monitoring and Machinery Fault Diagnosis – Mechanical Looseness<br>f. Condition Monitoring and Machinery Fault Diagnosis – Bearing Defects / Fault<br>g. Condition Monitoring and Machinery Fault Diagnosis – Bent Shaft |

| | |
|---|---|
| | h. Condition Monitoring and Machinery Fault Diagnosis – Regular-triangle Method for Dynamic Balance<br>i. Condition Monitoring and Machinery Fault Diagnosis – Lissajous Figure<br>j. Condition Monitoring and Machinery Fault Diagnosis – Oil Whirl and Oil Whip of Sliding Bearing |

**Laboratory Course Assessment:**

**ISE-1:** Assignment on Module 1 (10 Marks)
Assignment on Module 2 (10 Marks)
**ISE-2:** Quiz based on Module 1 and 2 (10 Marks)
Atleast **4 experiments** to be conducted from Module 3 (20 Marks)

Note: ISE will be based on Continuous predefined rubrics based evaluation

## References :

**Books:**

1. A.R. Mohanty – *Machine Condition Monitoring: Principles and Practices, CRC Press*
2. R. B. Randall – *Vibration-Based Condition Monitoring: Industrial, Aerospace, and Automotive Applications*
3. Allan Davies – *Handbook of Condition Monitoring: Techniques and Methodology*
4. B.K.N. Rao – *Handbook of Condition Monitoring*
5. Clyde M. Creese – *Introduction to Machinery Analysis and Monitoring*
6. Tony L. Schmitz & K. Scott Smith – *Machinery Vibration Analysis*
7. R.A.Collacott – *Mechanical Fault Diagnosis and Conditon Monitoring, Chapman and Hall*

**ISO Standards for Condition Monitoring:**

1. **ISO 17359** – Guidelines for Condition Monitoring and Diagnostics of Machines
2. **ISO 10816** – Evaluation of Machine Vibration by Measurements on Non-Rotating Parts
3. **ISO 18436** – Requirements for Training and Certification of Condition Monitoring Personnel
4. **ISO 13373** – Guidelines for Vibration Condition Monitoring of Machines

**Research Papers & Journals:**

1. "Condition Monitoring and Fault Diagnosis: A Review" – *Elsevier, Mechanical Systems and Signal Processing*
2. "Vibration Analysis for Machine Fault Detection" – *IEEE Transactions on Industrial Electronics*
3. "Predictive Maintenance Using Machine Learning and IoT Sensors" – *Journal of Intelligent Manufacturing*
4. "Recent Advances in Rotating Machinery Condition Monitoring" – *International Journal of Prognostics and Health Management*

**Laboratory Manuals & Guides:**

1. SKF Vibration Analysis Handbook – Industry-standard guide for vibration monitoring.
2. Fluke Infrared Thermography Guide – Practical guide on thermal imaging for condition monitoring.
3. Emerson Condition Monitoring Manual – Industrial approach to vibration-based condition monitoring.

**Online Resources & Software:**

1. National Instruments – LabVIEW for Vibration Analysis (www.ni.com)
2. SKF Condition Monitoring & Predictive Maintenance (www.skf.com)
3. Emerson Machinery Health Management (www.emerson.com)
4. ReliabilityWeb – Condition Monitoring Articles & Webinars (www.reliabilityweb.com)
5. CBM Connect – Free Courses & Webinars on Condition Monitoring (www.cbmconnect.com)
6. NPTEL : Machinery Fault Diagnosis and Signal Processing - Prof. Amiya Ranjan Mohanty, IIT Kharagpur (12 Weeks)
7. Condition Monitoring and Maintenance Management (BME-025) - Dr. N. Venkateshwarlu, Indira Gandhi National Open University ( 8 Weeks)

Society of St. Francis Xavier, Pilar's

# Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25MDM03 | Health, Wellness and Psychology | L | T | P | L | T | P | Total |
| | | 2 | 0 | 0 | 2 | 0 | 0 | 2 |
| | | | Examination Scheme | | | | | |
| | | | ISE-I | MSE | ISE-II | | ESE | Total |
| | | Theory | 50 | --- | 50 | | --- | 100 |
| | | Lab | --- | --- | --- | | --- | --- |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | CO1 | Introduce the concept of health, wellness and psychology, and understand its effectiveness in handling stress. |
| | CO2 | Develop human strength and life-enhancement skills through recovery and goal setting. |
| | CO3 | Apply the holistic well-being quotient for personal and professional benefits. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Introduction to Psychology, Health and Wellness** | | |
| | 1.1 | Understanding holistic health- Meaning, components of holistic health-components of wellbeing, Psychology of overall health-enhancing behaviors component, Types of health-compromising behaviors, Illness Management and wellness enhancement. | R1 | 4 |
| | 1.2 | Nature and source of stress, personal and professional triggers of stress, Effects of stress, coping with stress (minimalistic yet effective exercise habits) | R2 | 4 |
| 2 | | **Promoting Personal and Professional Wellness: Human Strengths & Life-Enhancement** | | |
| | 2.1 | Strength: Definition, meaning; Realizing strength; Maximizing Unrealized strength<br>Weakness: Definition, meaning; Identifying and overcoming weakness; Developing hope and optimistic approach. | R2 & R3 | 4 |
| | 2.2 | Recovery and Goal Setting: analyzing trends in personality, Approaching Individual differences; Meaning of Goal setting, Types and effectiveness of Goal Setting.<br>Motivation: Meaning, Theory of Needs, 4A's of coping with stress during or after goal setting. | R2 | 4 |
| | 2.3 | Eudaimonic Wellness: Meaning and characteristics; concept of defensive coping. | R1, & R4 | 2 |
| 3 | | **Positive Approach and The Psychology of Living in The Present** | | |

| | | | | |
|---|---|---|---|---|
| | **3.1** | The Psychology of Living in the Present: meaning, self-registering to the flow of positive thoughts and actions; addressing positive and negative emotions; Eliminating daily hassles, creating happiness.<br><br>Responding to overthinking: Sociocultural factors and self- realization. | R1,R2, &R4 | 4 |
| | **3.2** | Resilience: Meaning and Nature; How to build resilience; Self-communication | R3 & R4 | 4 |
| | | and self-care, reframe thoughts; channelize gratitude; practice resilience building: physical and mental exercises. | | |
| | | **Total** | | 26 |

**Course Assessment:**

**ISE-1:**

**Certification: 50 marks**

NPTEL/ Swayam/any other authentic portal certification https://archive.nptel.ac.in/courses/109/103/109103182/ https://onlinecourses.nptel.ac.in/noc23_hs06/preview

**ISE-2:**

Health and Wellness: Introduce Group Happiness Project. Group work: Meet, exchange, contact, collect info, talk about why you chose this topic, brainstorm ideas, and present people's opinions in your designed PPT. **30 marks**

Psychology of wellness or happiness: Case Study and Brief Report on : Chris Gardener in the Pursuit of Happyness (Group-specific interpretation) **20 Marks**

**Recommended Books:**

1. Emmons, R.A., & McCullough, M.E. (2003). Counting blessings versus burdens: An experimental investigation of gratitude and subjective well-being in daily life. Journal of Personality & Social Psychology, 88, 377-389
2. Carpenter, S. (2012). Awakening to sleep. Monitor on Psychology, 44 (1), 40.
3. Emmons, R. A., & Mishra, A. (2012). Why gratitude enhances well-being: What we know, What We Need to Know.
4. Carr, A. (2004). Positive Psychology: The science of happiness and human strength UK Routledge.

Society of St. Francis Xavier, Pilar's

# Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050 (Autonomous College affiliated to University of Mumbai)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25MDM04 | Emotional and Spiritual Intelligence | L | T | P | L | T | P | Total |
| | | 2 | 0 | 0 | 2 | 0 | 0 | 2 |
| | | | Examination Scheme | | | | | |
| | | | ISE-I | MSE | ISE-II | ESE | | Total |
| | | Theory | 50 | --- | 50 | --- | | 100 |
| | | Lab | --- | --- | --- | --- | | --- |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | CO1 | Introduce the concept of emotional intelligence, its models, components and measures of emotional intelligence |
| | CO2 | Understand the significance of emotional intelligence in self-growth and building effective relationships, Understand the professional impact of emotional intelligence |
| | CO3 | Develop a wide range of work and life skills. |
| | CO4 | Display spiritual intelligence in different roles. |
| | CO5 | Apply the spiritual quotient for corporate benefits. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Fundamentals of Emotional Intelligence** | | |
| | 1.1 | Emotion- Meaning, characteristics of emotion, components of emotion- cognitive component, physiological component, Behavioural component. Types of emotions, exposing the myths about emotion, physiological or bodily changes accompanying emotions, how emotions affect our thinking and actions | R1 | 3 |
| | 1.2 | Nature and Significance of EI, Models of emotional intelligence: Ability, Trait and Mixed, Building blocks of emotional intelligence: self-awareness, self- management, social awareness, and relationship management | R2 | 3 |
| 2 | | **Personal and Social Competence** | | |
| | 2.1 | Self-Awareness: Observing and recognizing one's own feelings, Knowing one's strengths and areas of development<br>Self-Management: Managing emotions, anxiety, fear, and anger | R2 | 3 |
| | 2.2 | Social Awareness: Others' Perspectives, Empathy and Compassion<br>Relationship Management: Effective communication, Collaboration, Teamwork, and Conflict management (professional impact) | R2 | 3 |
| | 2.3 | Strategies to develop and enhance emotional intelligence and using them effectively in professional life | R1 | 2 |
| 3 | | **Background and Approach: Spiritual Intelligence and Karma Yoga** | | |

| | | | | |
|---|---|---|---|---|
| | **3.1** | Spiritual Intelligence- Definition, need, state of presence, psychological element, Intuitive intelligence.<br>Foundation of Spiritual Intelligence<br>Types of spiritual actions<br>Models- SQ and SI-Growth model<br>Yoga of Action and Spirituality: Professionalism | R6,R8 | 3 |
| | **3.2** | Types of spiritual actions | R5, R7 | 3 |
| | | Models- SQ and SI-Growth model<br>Readiness for spiritual intelligence: self-leadership, synthesize high performance, spiritual awareness, neuropsychology, and state of conscious identity. | | |
| **4** | | **Opposite Polarity in SI and Overall Impact on Personality** | | 4 |
| | **4.1** | Twin poles of attention- subject and the object pole<br>Benefits of Spiritual Intelligence- personal, social and corporate<br>Dimensions of Spiritual Intelligence- SI and Self Esteem, SI and Restoration of confidence<br>SI and clarity of thoughts and speech, Personality moulding and SI. | R8 | |
| **5** | **5.1** | **Spiritual Ecology and Environmental Grassroots Activism** | | |
| | | Spiritual Stewardship and Ecology: Case studies based on making a difference in ecology through environmental grassroots activism | R4 | 2 |
| **Total** | | | | **26** |

**Course Assessment:**

**ISE-1:**

**Certification: 50 marks**

NPTEL/ Swayam/ Farmer space Certification

https://onlinecourses.swayam2.ac.in/aic22_ge23/preview

https://www.framerspace.com/course/-Mx9gV_of5-self-directed-emotional-learning-for-empathy-and-kindness-short-course?cid=64815e6241de0ce10ee9c717

**ISE-2:**

**1.**Emotional Intelligence: Identifying emotions and applying it to personal and professional situations 20 marks

**2.** Spiritual Intelligence: Performing solutions based on given problems **30 Marks**

**Recommended Books:**

1. Bar-On, R., & Parker, J.D.A.(Eds.) (2000). The handbook of emotional intelligence, San Francisco, California: Jossey Bros.
2. Goleman, D. (2005). Emotional Intelligence. New York: Bantam Book.
3. Sternberg, R. J. (Ed.). (2000). Handbook of intelligence. Cambridge University Press.
4. Thich Nhat Hanh, V. S. (2016). *Spiritual Ecology: The Cry of the Earth.* Golden Sufi Center.
5. Vivekananda, S. (2015). *The Complete Book of Yoga.* Solar Books.

*6.* Yogananda, P. (1946). *Autobiography of a Yogi.* Thomas Press Ltd.

7. Krishnaswami, O. (2006). *Karma Yoga: Yoga of Action.* Dev Publishers.
8. Buzan, T. (2001). *Power of Spiritual Intelligence: 10 Ways to Tap into Your Spiritual Genius.* Thorsons.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25OE031 | Embedded Systems | L | T | P | L | T | P | Total |
| | | 1 | -- | 2 | 1 | -- | 1 | 2 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 10 | 15 | 10 | 15 | 50 | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Digital Electronics<br>Microcontrollers | |
|---|---|---|
| | **At the End of the course students will be able to:** | |
| **Course Outcomes (CO)** | CO1 | Identify and describe various characteristic features and applications of Embedded systems |
| | CO2 | Analyse and select hardware for Embedded system implementation |
| | CO3 | Compare GPOS and RTOS and investigate the concepts of RTOS |
| | CO4 | Evaluate and use various tools for testing and debugging embedded systems. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| **1** | | **Introduction to Embedded Systems** | | **02** |
| | **1.1** | Definition, Characteristics, Classification, Applications | 1,2 | |
| | **1.2** | Design metrics of Embedded system and Challenges in optimization of metrics | 1,2 | |
| **2** | | **Embedded system hardware** | | **04** |
| | **2.1** | Hardware components of Embedded systems | 1,2 | |
| | **2.2** | Sensors an Actuators: Criteria for selection (with examples) | 1,2 | |
| | **2.3** | Communication Interfaces: I2C, CAN | 1,2 | |
| | **2.4** | Low-power Embedded system design | 1,2 | |
| **3** | | **Embedded system software** | | |
| | **3.1** | Real-time Operating system (RTOS): Need of RTOS in Embedded systems, Comparison with GPOS,<br>Task, Task states, Multi-tasking, Task scheduling methods-Pre-emptive, Shortest Job First, Round-Robin, Priority, Rate Monotonic Scheduling, Earliest Deadline First. | 2,3 | **05** |
| | **3.2** | Inter-process communication: Usage of Semaphores<br>Task synchronization: Issues, Deadlock condition and solutions<br>Shared data problem, Priority inversion. | 2,3 | |
| **4** | | **Testing /Debugging and System Integration** | | **02** |
| | **4.1** | Hardware testing tools, White-Box and Black-Box testing. | 2 | |
| | **4.2** | Embedded Product Design Life-Cycle (EDLC)- Waterfall Model,<br>Hardware-Software Co-design | 2 | |

| | |
|---|---|
| **Total** | **13** |

| Sr.no | Suggested List of experiments | Ref. |
|---|---|---|
| **1** | Interfacing of LEDs /switches with any embedded core. | 4 |
| **2** | Interfacing of LCD/ Seven segment display with any embedded core. | 4 |
| **3** | Interfacing of Temperature sensor with any embedded core. | 4 |
| **4** | Implement the I2C communication to connect to DS1307 RTC | 2 |
| **5** | Implement a power saving mode with any embedded core | 2 |
| **6** | Porting of FreeRTOS to Arduino/STM32. | 5 |
| **7** | Write a Program to Create Multiple Tasks and understand the Multitasking capabilities of RTOS (FreeRTOS). | 5 |
| **8** | Write a Program to illustrate the use of Binary and Counting Semaphore for Task Synchronisation using FreeRTOS. | 5 |

**Course Assessment:**

**Theory:**
**ISE-1:** Think-Pair- Share activity (any case study) -10 marks
**ISE-2:** Assignment/Oral -10 marks
**MSE:** 15 Marks 60 minutes written examination based on 50% syllabus
**ESE:** 15 Marks 60 minutes written examination based on remaining syllabus after MSE

**Laboratory:**
**ISE-1** will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2** will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
Mini-project on design of an embedded system for any application for 10 marks

**Recommended Books:**

1.Dr. K.V. K. K. Prasad, "Embedded Real Time System: Concepts, Design and Programming", Dreamtech, New Delhi, Edition 2014.

2. Rajkamal, "Embedded Systems: Architecture, Programming and Design", McGraw Hill Education (India) Private Limited, New Delhi, 2015, Edition 3rd.

3. Sriram Iyer, Pankaj Gupta, "Embedded Real Time Systems Programming", Tata McGraw Hill Publishing Company ltd., 2003.

4. M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded Systems
Using Assembly and C", Pearson Education, Second Edition, 2007.

5. www.freertos.org

**Further Reading:**

1. David Simon, "An Embedded Software Primer", Pearson, 2009.

2. Jonathan W. Valvano, "Embedded Microcomputer Systems – Real Time Interfacing", Publisher - Cengage Learning, 2012 Edition 3rd.

3.FrankVahid, Tony Givargis, "Embedded System Design – A Unified Hardware/Software Introduction", John Wiley & Sons Inc., 2002.

4. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, New Delhi, 2009

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| | | 1 | -- | 2 | 1 | -- | 1 | 2 |
| 25OE032 | IoT | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 10 | 15 | 10 | 15 | 50 | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | CO1 | Explain the fundamentals of IoT and Industry 4.0, including their architectures, protocols, and applications. (Cognitive Level: Understand) |
| | CO2 | Apply networking and communication protocols like MQTT, CoAP, and LoRa to design efficient IoT systems. (Cognitive Level: Apply) |
| | CO3 | Analyze the requirements for IoT system design and development, integrating hardware platforms and software tools for real-world applications. (Cognitive Level: Analyze) |
| | CO4 | Use appropriate tools to process and visualize real-time data. (Cognitive Level: Apply) |
| | CO5 | Examine emerging trends such as AI in IoT, edge computing, and 5G to identify their potential impact on IoT and Industry 4.0 ecosystems. (Cognitive Level: Analyze) |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Module 1: Introduction to IoT and Industry 4.0** | 1 | 3 |
| | 1.1 | Concepts of IoT: Architecture, protocols, and standards.. | | |

| | | | | |
|---|---|---|---|---|
| | **1.2** | Industry 4.0 Fundamentals: Smart factories, cyber-physical systems (CPS), and digital twins. | | |
| | **1.3** | IoT Applications: Smart cities, healthcare, agriculture, and autonomous systems. | | |
| | **1.4** | Technological Pillars of Industry 4.0: IoT, AI, big data, and robotics integration | | |
| **2** | | **Module 2: IoT Protocols and Networking** | 1 | 3 |
| | **2.1** | Networking Basics for IoT: IP-based and non-IP-based protocols. | | |
| | **2.2** | IoT Communication Protocols: MQTT, CoAP, HTTP, LoRa, Zigbee, BLE, and 6LoWPAN. | | |
| | **2.3** | Edge and Fog Computing: Concepts and role in IoT data processing | | |
| | **2.4** | Security in IoT Networks: Challenges and solutions. | | |
| | | Module 3: IoT System Design and Development | | |
| **3** | | **IoT System Design and Development** | 2 | 3 |
| | **3.1** | IoT Hardware Platforms: Arduino, ESP32, and Raspberry Pi. | | |
| | **3.2** | IoT Software Tools: IDEs, Node-RED, and cloud platforms (AWS IoT, Google Cloud IoT). | | |
| | **3.3** | Sensor and Actuator Integration: Types, working, and interfacing techniques. | | |
| | **3.4** | Design Methodologies: Energy efficiency, scalability, and fault tolerance. | | |
| | | **Module 4: IoT Data Management and Analytics** | 3 | 3 |
| **4** | **4.1** | Data Analytics: Role of big data and machine learning in IoT. Visualization Tools: Grafana, Tableau, and Power BI. | | |
| | **4.2** | IoT Data Lifecycle: Acquisition, transmission, storage, and visualization | | |
| | **4.3** | IoT Databases: Time-series databases and NoSQL | | |
| | | **Module5:Industry 4.0 Use Cases and IoT Applications, Future Trends and Emerging Technologies** | 4 | 3 |
| **5** | **5.1** | Smart Manufacturing: Automation, predictive maintenance, and robotics. | | |

| | | | | |
|---|---|---|---|---|
| | **5.2** | IoT in Logistics and Supply Chain: RFID, smart tracking, and inventory management. | | |
| | **5.3** | IoT in Renewable Energy: Smart grids, monitoring, and optimization | | |
| | **5.4** | AI in IoT: Role of machine learning and deep learning.<br>5G and IoT: Opportunities and challenges.<br>Edge AI: Combining IoT devices with AI at the edge.<br>Sustainability in IoT: Energy-efficient frameworks and green IoT. | | |
| **Total** | | | | **15** |

| **Module No.** | **Sr.no** | **Suggested List of experiments** | **Ref.** | **Hrs.** |
|---|---|---|---|---|
| **1** | **1** | Experiment: Setup and Configuration of an IoT Development Board<br>Objective: Install and configure ESP32 or Raspberry Pi for IoT projects.<br>Tools: Arduino IDE, Python. | | 2 |
| **2** | **2** | Experiment: Implement MQTT for Sensor Data Communication<br>Objective: Transmit real-time sensor data to a cloud platform using MQTT.<br>Tools: MQTT.fx, HiveMQ. | | 2 |
| | **3** | Experiment: Compare IoT Protocols (CoAP vs. MQTT)<br>Objective: Analyze energy consumption and latency differences between protocols.<br>Tools: Python, Wireshark. | | |
| | **4** | Experiment: LoRa Communication Setup<br>Objective: Establish communication between two LoRa nodes and measure range.<br>Tools: LoRa modules, Arduino IDE. | | 2 |
| **3** | **5** | Experiment: Interfacing Sensors and Actuators<br>Objective: Interface temperature, humidity, and motion sensors with ESP32 to trigger an actuator.<br>Tools: Arduino IDE, Blynk App. | | 2 |
| | **6** | Experiment: Build a Smart Home Automation System<br>Objective: Control appliances using voice commands via Google Assistant. | | 4 |

| | | | | |
|---|---|---|---|---|
| | | Tools: ESP32, Node-RED, Google API. | | |
| | **7** | Experiment: IoT-Based Energy Monitoring<br>Objective: Monitor and analyze household energy consumption in real-time.<br>Tools: ESP32, Current Sensor, ThingSpeak. | | 4 |
| **4** | **8** | Experiment: IoT Data Visualization Using Grafana<br>Objective: Collect sensor data and visualize it in Grafana dashboards.<br>Tools: InfluxDB, Grafana. | | 2 |
| | **9** | Experiment: Real-Time IoT Data Analytics<br>Objective: Perform basic analytics on IoT data (e.g., finding temperature trends).<br>Tools: Python, Pandas, Matplotlib. | | 2 |
| | | | | 6 |
| **5** | **10** | INDUSTRIAL VISIT | | |
| **Total** | | | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:**

Activity: Quiz and assignments 10 Marks

Case Study Presentation

**ISE-2:** Two hours 10 Marks

Activity: Article Discussion, Quiz and Assignments

Outcome: Reflective Journal

**MSE:** 15 Marks 60 minutes written examination based on 50% syllabus

**ESE:** 15 Marks 60 minutes written examination based on remaining syllabus after MSE

**Lab:**

**ISE:**

**1. ISE-1** will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

**2. ISE-2**

a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 30 marks.

b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

**Recommended Books:**

[1] Arshdeep Bahga, Vijay Madisetti "Internet of Things: A Hands-On Approach" Publisher: Orient Blackswan Private Limited - New Delhi

[2] Peter Waher, "Mastering Internet of Things: Design and Create Your Own IoT Applications", Packt Publishing (March 28, 2018); eBook (Free Edition)

[3] Perry Lea," "IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Azure IoT and AWS IoT Core", Publisher(s): Packt Publishing ISBN: 9781839214806

[4] Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Publisher New York, NY : Apress

[5] David Hanes, Gonzalo Salgueiro, Rob Barton," IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" Released June 2017Publisher(s): Cisco Press ISBN: 978013430709

**Online Resources:**

https://onlinelibrary.wiley.com/doi/book/10.1002/9781119740780?msockid=0d711fd0b87062382ca90a8bb9c26374(Print ISBN:9781119740759 |Online ISBN:9781119740780 |DOI:10.1002/9781119740780)

**Further Reading:**

[1] Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things"

[2] Klaus Schwab, "The Fourth Industrial Revolution"

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25OE033 | E-Vehicle | L | T | P | L | T | P | Total |
| | | 1 | -- | 2 | 1 | -- | 1 | 2 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 10 | 15 | 10 | 15 | 50 | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | | |
|---|---|---|
| Course Outcomes | CO1 | Describe significance of Electric vehicle for sustainability. |
| | CO2 | Design and modelling of EV power train. |
| | CO3 | Describe Electric motor speed control and regenerative braking. |
| | CO4 | Describe battery monitoring and thermal protection. |
| | CO5 | Describe vehicle control units and communication protocols. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Introduction to Electric Vehicles** | 1,2 | 3 |
| | 1.1 | Introduction to Electric vehicles, Advantages and significance of EVs, motors and power electronics | | |
| | 1.2 | Different powertrain configuration of EVs and Hybrid vehicles. | | |
| | | **Components of EV Powertrain** | 1,2 | |
| 2 | | | | 6 |
| | 2.1 | Vehicle modelling, Vehicle dynamics , drive cycle ,Basics of Power train simulation. | | |

| | | | | |
|---|---|---|---|---|
| | **2.2** | Sizing and specifications of different sub-systems, Role of Power Electronics and Motors in EVs. | | |
| | | | | |
| **3** | | **EV Motor Drive and Control:** | 1,4,5 | 6 |
| | **3.1** | Introduction to different types of motors used in EVs and their comparison, Selection of Electric motor . | | |
| | **3.2** | Overview of speed control of BLDC and PMSM, Regenerative braking concept, energy saving | | |
| **4** | | **Battery Packs and Battery management System** | 1,4,5 | 6 |
| | **4.1** | Different battery technologies, Advantages of Lithium ion battery , Battery pack , Battery specifications and selection criteria. | | |
| | **4.2** | Battery monitoring and Protection , Thermal management, circuits and techniques for Battery management system (BMS) | | |
| **5** | | **Vehicle Control and Communication** | | 3 |
| | **5.1** | Features and functionality of Vehicle Control Unit, Architecture and Protocols of VCUs, Communications requirements | | |
| **6** | | **EV Safety & Standards:** | | 2 |
| | **6.1** | Safety aspects and protection arrangements, International and national standards | | |
| **Total** | | | | **26** |

| Module No. | Sr. no | Suggested List of experiments | Ref. | Hrs. |
|---|---|---|---|---|
| | **1** | Study of different powertrain configuration. | 1,2 | 2 |
| | **2** | Vehicle modelling and Simulation . | 1,2 | 3 |
| | **3** | Drive cycle simulation and plot under various driving conditions. | 1,2 | 2 |

| | | | | |
|---|---|---|---|---|
| | **4** | Design of simple battery charger circuit. | 1,2 | 2 |
| | **5** | Design of Thermal protection circuit for EV. | 1,2 | 2 |
| | **6** | Study of Electric motor speed control. | 1,2 | 2 |
| | **7** | Mini project , case study :-Design and simulation study of any EV model available in the market. | 1,2 | 5 |
| **Total** | | | | **20** |

**Course Assessment:**

**Theory:**

**ISE-1:**

Activity: Quiz and assignments 20 Marks

Practical assignment

**ISE-2:** Two hours 30 Marks

Activity: Crossword, MCQs, Quiz and Assignments

Outcome:

**MSE:** 60 minutes 15 Marks written examination based on 50% syllabus

**ESE:60** minutes 15 Marks written examination based on the remaining syllabus after MSE

**Lab:**

**ISE:**

1. **ISE-1** will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2**
   a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
   b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

**Recommended Books:**

1. Ali Emadi, "Advanced Electric Drive Vehicles", CRC Press, 2015
2. Mehrdad Ehsani, Yimin Gao and Ali Emadi, "Modern electric, hybrid electric and fuel cell vehicles : fundamentals, theory and design", CRC Press ; 2010 (available in IITB library)

3. James Larminie, John Lowry "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003 (available in IITB library)
4. Rodrigo Garcia-Valle, Joao A. Pecas Lopes, "Electric Vehicle Integration into Modern Power Networks", Springer, 2013
5. Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", Taylor & Francis, 200

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME16 | Fluid Mechanics and Hydraulic Machines | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Thermodynamics | |
|---|---|---|
| Course Outcomes | CO1 | Explain fluid properties, viscosity, and hydrostatics, including forces on submerged surfaces. |
| | CO2 | Analyse fluid kinematics, flow classification, and flow characteristics using stream and potential functions. |
| | CO3 | Apply Bernoulli's equation and control volume analysis for fluid flow problems. |
| | CO4 | Explain boundary layer concepts and aerofoil theory. |
| | CO5 | Describe turbomachinery principles and analyse hydraulic turbines. |
| | CO6 | Evaluate centrifugal and positive displacement pumps, including efficiency and cavitation. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Basic Concepts:** Significance of fluid mechanics, physical properties of fluid, Newton's law of viscosity, Newtonian and non-Newtonian Fluid | 1-4 | 2 |
| | 1.2 | **Fluid Statics:** Pascal's law, hydrostatic law, hydrostatic force on submerged surfaces (vertical, inclined & curved). Archimedes principle, buoyancy. | 1-4 | 3 |
| 2 | 2.1 | **Fluid Kinematics:** Classification of fluid flow, streamline, path line, streak line, acceleration of fluid particle, differential equation of continuity, rotational flow and vortices, stream function, potential function | 1-4 | 4 |
| 3 | 3.1 | **Fluid Dynamics:** Concept of control volume and control surface, Importance of Reynolds Transport theorem (RTT) | 1-4 | 2 |

| | | | | |
|---|---|---|---|---|
| | | (No numerical). Euler's equation, Expression of Bernoulli's equation. | | |
| | **3.2** | **Laminar Viscous flow:** Reynolds number, Laminar flow between parallel plates (Plane Poiseuille&Couette flow), Laminar flow in circular pipe (Hagen-Poiseuille flow). | 1-4 | 2 |
| **4** | **4.1** | **Boundary Layer Theory:** Concept of formation of boundary layer, boundary layer parameters, boundary layer along a long thin plate and in pipe | 1-4 | 2 |
| | **4.2** | Aerofoil Theory | 1-4 | 3 |
| **5** | **5.1** | Basic Euler's theory of turbo machines and it application to pumps, turbines and compressors | 5-6 | 2 |
| | **5.2** | **Hydraulic Turbines:** Basic theory, classification of turbines, theory of impulse and reaction turbines, estimation of work done, efficiency, characteristics of turbines | 5-6 | 2 |
| **6** | **6.1** | **Centrifugal pumps:** Construction, estimation of work done, efficiency, characteristics, determination of operating point, cavitation and NPSH, specific speed of pumps | 5-6 | 2 |
| | **6.2** | **Positive Displacement pumps**: Types and applications, Head, discharge, work done and efficiency, indicator diagram (no numerical on reciprocating pump). | 5-6 | 2 |
| | | | **Total** | **26** |

**Course Assessment:**

**PART A (Theory)**

**ISE-1:**
Activity: Quiz/Assignment/Mini-Project (20 Marks)
**ISE-2:**
Activity: Quiz/Assignment/Mini-Project (20 Marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Part B (Tutorial)**

**ISE-1:**
Examples/Assignments on first 3 modules
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:**
Examples/Assignments on remaining modules
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**

[1] Fluid Mechanics and Hydraulic Machines – R. K. Bansal, Laxmi Publications
[2] Fluid Mechanics: Fundamentals and Applications – Yunus A. Çengel, John M. Cimbala, McGraw Hill
[3] Hydraulics and Fluid Mechanics – P. N. Modi & S. M. Seth, Standard Book House
[4] Introduction to Fluid Mechanics – Fox, McDonald, Pritchard, Wiley Publications
[5] Hydraulic Machines – Jagdish Lal, Metropolitan Book Co. Pvt. Ltd.
[6] Turbomachinery: Basic Theory and Applications – S. L. Dixon, Elsevier

**AICTE Prescribed Textbook:**
Fluid Mechanics & Hydraulics Machinery
Author Name-Prof. Suman Chakraborty
(https://ekumbh.aicte-india.org/allbook.php# )

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME17 | Machine Design | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| **Pre-requisite Course Codes** | Engineering Mechanics, Mechanics of Solids | |
|---|---|---|
| **Course Outcomes** | CO1 | Use design data book/standard codes to standardize the designed dimensions |
| | CO2 | Design operational joints, welded and bolted joints subjected to static loads. |
| | CO3 | Design shaft, keys and couplings under various conditions. |
| | CO4 | Design helical and leaf springs and pressure vessels. |
| | CO5 | Select bearings for a given applications from the manufacturers catalogue. |
| | CO6 | Select and/or design belts and flywheel for given applications |

| **Module No.** | **Unit No.** | **Topics** | **Ref.** | **Hrs.** |
|---|---|---|---|---|
| **1** | **1.1** | Mechanical Engineering Design, Steps involved in design, types of design, Material properties and their uses in design, Manufacturing consideration in design, Modes of failures | 1-6 | 1 |
| | **1.2** | Factor of safety, Design stresses, Theories of failures (Selection in the process of designing) | 1-6 | 1 |
| | **1.3** | **Design of Operational Joints:** Socket and Spigot Cotter joint, Knuckle joint | 1-6 | 4 |
| **2** | **2.1** | **Design of welded joints:** Types & classification of welded joints, applications. Familiarization of AWS code. Strength of welded joints- Transverse & parallel fillet welds. Welded joints subjected to torsion. Circular fillet welds and adjacent fillet welds. Design of welded joints subjected to eccentric loading. | 1-6 | 2 |
| | **2.2** | **Design of bolted joints:** stresses in bolts, joints for leak proof fluid tight applications (like cylinder to cylinder cover fastening in an IC engine), bolts of uniform strength, Design of bolted joints subjected to eccentric loading | 1-6 | 2 |
| **3** | **3.1** | **Design of Shaft:** power transmitting, power distribution shafts, Module (excluding crank shaft) under static and fatigue criteria. | 1-6 | 2 |
| | **3.2** | **Keys:** Types of Keys and their selection based on shafting condition. | 1-6 | 1 |
| | **3.3** | **Couplings:** Classification of coupling, Design of Flange | 1-6 | 3 |

| | | | | |
|---|---|---|---|---|
| | | couplings, Bush pin type flexible couplings | | |
| **4** | **4.1** | Design of Springs: Classification and applications, design of helical compression and tension springs (only circular cross-section) | 1-6 | 2 |
| | **4.2** | Design of Pressure Vessels: Design concepts of thick Stresses in thick cylinders. Determination of wall thickness, hoop and radial stresses, nature of hoop and radial stress distribution on cylinder walls. | 1-6 | 2 |
| **5** | **5.1** | Rolling Contact Bearings: Types of bearing and designation, selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self-aligning bearing and thrust bearing) | 1-6 | 2 |
| **6** | **6.1** | Design and selection of Flat Belts with pulley construction. | 1-6 | 2 |
| | **6.2** | Design of Flywheel – Introduction, Fluctuation of energy and speed, turning moment diagram, estimating inertia of flywheel for reciprocating prime movers and machines, Weight of the flywheel | 1-6 | 2 |
| **Total** | | | | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | Design of Cotter Joint | **01** |
| **2** | Design of Knuckle Joint | **01** |
| **3** | Design of Bolted and Welded Joints | **01** |
| **4** | Design of Couplings | **01** |
| **5** | Design of Shafts | **01** |
| **6** | Design of Springs and Pressure Vessels | **01** |
| **7** | Design of Bearings | **01** |
| **8** | Design of Belts and Flywheels | **01** |
| | **Total Hours** | **08** |

**Course Assessment:**

**Theory:**
**ISE-1:** Quizzes on first Three Modules (20 Marks)
**ISE-2:** Quizzes on next Three modules (20 marks)

**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**
**ISE-1:** Design exercises on first four tutorials: (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:** Design exercises on next four tutorials (20 Marks)
Software Analysis of a machine element (10 Marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
**Text Books:**

1. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3. Machine Design by Pandya & Shah, Charotar Publishing
4. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
5. Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas& Co
6. Recommended Data Book – PSG

**Reference Books:**

1. Machine Design by Reshetov, Mir Publication
2. Machine Design by Black Adams, McGraw Hill
3. Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
4. Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill
5. Design of Machine Elements by V.M.Faires
6. Design of Machine Elements by Spotts.

**Links for online NPTEL/SWAYAM courses:**
https://archive.nptel.ac.in/courses/112/105/112105125/

**AICTE Prescribed Textbook:**
Design of Machine Elements, Dr. A Kumaravel, M. Kathirselvam
(https://ekumbh.aicte-india.org/allbook.php#)

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME18 | Fluid Mechanics and Hydraulic Machines Laboratory | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Thermodynamics | |
|---|---|---|
| Course Outcomes | CO1 | Analyse the stability of floating bodies and determine their equilibrium conditions |
| | CO2 | Calibrate flow measuring devices such as Venturimeter, Orifice meter, Nozzle, and Pitot tube. |
| | CO3 | Verify Bernoulli's equation experimentally and understand its practical applications. |
| | CO4 | Evaluate the impact of a jet on different surfaces and analyze force exerted by moving fluid. |
| | CO5 | Perform trials on Pelton wheel/Francis turbine to assess their performance characteristics. |
| | CO6 | Perform trials on Centrifugal Pump to assess its performance characteristics. |

| Sr. No | Experiments to be completed in laboratory | Hrs |
|---|---|---|
| | **PART A: Fluid Mechanics** | |
| 1 | Experiment to study stability of floating bodies | 2 |
| 2 | Calibration of Venturimeter/ Orifice meter/Nozzle/ Pitot tube | 2 |
| 3 | Verification of Bernoulli's Equation | 2 |
| 4 | Online Virtual/Simulation based Experiment on Fluid Mechanics | 2 |
| | **PART B: Hydraulic Machines** | |

| | | |
|---|---|---|
| 1 | Impact of jet | 2 |
| 2 | Trial on Pelton Wheel- Impulse Turbine | 2 |
| 3 | Trial on Francis Turbine – Reaction Turbine | 2 |
| 4 | Trial on Centrifugal Pump | 2 |
| 5 | Online Virtual/Simulation based Experiment on Fluid Machinery | 2 |
| | **TOTAL** | **18** |

**Course Assessment:**

**Laboratory:**
**ISE-1:**
Experiments from Part- A
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2:**
Experiments from Part- B
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**

[1] Fluid Mechanics and Hydraulic Machines – R. K. Bansal, Laxmi Publications
[2] Fluid Mechanics: Fundamentals and Applications – Yunus A. Çengel, John M. Cimbala, McGraw Hill
[3] Hydraulics and Fluid Mechanics – P. N. Modi & S. M. Seth, Standard Book House
[4] Introduction to Fluid Mechanics – Fox, McDonald, Pritchard, Wiley Publications
[5] Hydraulic Machines – Jagdish Lal, Metropolitan Book Co. Pvt. Ltd.
[6] Turbomachinery: Basic Theory and Applications – S. L. Dixon, Elsevier

**AICTE Prescribed Textbook:**

Fluid Mechanics & Hydraulics Machinery
Author Name-Prof. Suman Chakraborty
(https://ekumbh.aicte-india.org/allbook.php# )

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME19 | Hydraulics and Pneumatics Lab | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | **Lab** | **20** | **--** | **30** | **--** | **50** | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Design and Develop Pneumatic Circuits |
| | CO2 | Design and Develop Hydraulic Circuits |
| | CO3 | Design and Develop Electro-pneumatic Circuits |
| | CO4 | Design and Develop PLC Circuits |

| Sr. No. | Experiments Details | Hours |
|---|---|---|
| 1 | Basic Single Cylinder Pneumatic circuits | 4 |
| 2 | Basic Single Cylinder Hydraulic Circuits | 4 |
| 3 | Flow Control and Combination Valves Pneumatic Circuits | 6 |
| 4 | Multiple Cylinder circuit Simulation | 4 |
| 5 | Basic Electro-pneumatic Circuits | 4 |
| 6 | Basic PLC Circuits | 4 |
| | **Total** | **26** |

**Course Assessment:**

**Laboratory work:**

1. **ISE-1 (20 marks)**

Submission of the Circuit Diagrams made during the lab performance for the first 3 experiments covered during this assessment duration. Assessment will be based on pre-defined rubrics.

2. **ISE-2 (30 marks)**
   i. Submission of the Circuit Diagrams made during the lab performance for the last 3 experiments covered during this assessment duration. Assessment will be based on pre-defined rubrics (20 marks).
   ii. Lab interaction: (10 marks)

**Reference Books:**

1. **Festo Didactic – "Fundamentals of Pneumatics"**, Festo, Official Training ManualFesto Manual for Electro- Pneumatics
2. **Festo Didactic – "Electro-Pneumatics Basic Level"**, Festo, Official Training Manual
3. **Bolton, W. – "Pneumatic and Hydraulic Systems"**, Butterworth-Heinemann
4. John W. Webb & Ronald A. Reis – "**Programmable Logic Controllers: Principles and Applications**"

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME16 | Tool Engineering | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | - | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | PCC11ME03, PCC12ME05, PCC12ME07 | |
|---|---|---|
| Course Outcomes | After completion of this course, students will be able to: | |
| | CO1 | Understand the basics and importance of tool engineering in manufacturing industries. |
| | CO2 | Identify different types of tools and heat treatment for tool materials |
| | CO3 | Analyze the geometry, materials, and coatings of single-point and multi-point cutting tools. |
| | CO4 | Design **jigs and fixtures** for holding, locating, and guiding workpieces in machining |
| | CO5 | Classify different types of **press tools** such as shearing, bending, and forming dies and develop strip layouts |

| | | |
|---|---|---|
| | CO6 | Understand recent trends in tool engineering for **eco-friendly and sustainable solutions** |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | **Introduction to Tool Engineering**<br>• Definition, scope, and importance<br>• Types of tools and classifications<br>• Basic tool materials and their properties<br>• Tool Force Measurements using Tool Dynamometers | | 04 |
| 2 | **Cutting Tool Design**<br>• Single-point cutting tools: tool geometry, tool angles, materials<br>• Multi-point cutting tools: drills, milling cutters, broaches<br>• Tool life, wear, failure analysis and tool reconditioning<br>• Tool life estimation (Taylor's tool life equation)<br>• Cost analysis in cutting tool design<br>• Case studies on tool performance improvement | | 05 |
| 3 | **Jigs and Fixtures**<br>• Definition, purpose, and importance<br>• Principles of location and clamping<br>• Types of jigs (plate, channel, box, indexing jigs)<br>• Types of fixtures (milling, grinding, turning, welding) | | 04 |
| 4 | **Press Tools and Die Design**<br>• Types of press tools (shearing, bending, drawing, forming)<br>• Die components and materials<br>• Progressive, compound, and combination dies<br>• Strip layout and die design calculations | | 05 |
| 5 | **Heat Treatment and Coating Technology of Cutting Tools**<br>• Heat treatment processes: hardening, tempering, annealing<br>• Coating techniques (PVD, CVD, nitriding etc.) | | 04 |
| 6 | **Recent Trends in Tool Engineering**<br>• CAD/CAM in tool design<br>• Additive manufacturing for tool making<br>• Sustainable tool engineering practices | | 04 |
| | **Total** | | **26** |

## Course Assessment:

**Theory:**

**ISE-1:** Poster Presentation & PPT on any of the Module 1-6 (group of max.4 students) (20 marks)
**ISE-2:** Quiz – MCQ (20 Marks)
**MSE:** 90 Minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 Minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial**

**ISE-1 :** Assignment on Module 1, 2, and 3
**ISE-2 :** Assignment on Module 4, 5,an d 6

**References:**

1. "Fundamentals of Tool Design" – *ASTME (American Society of Tool and Manufacturing Engineers)*
2. "Tool Engineering" – *G.R. Nagpal*
3. "A Textbook of Production Engineering" – *P.C. Sharma*
4. "Manufacturing Science" – *Amitabha Ghosh & A.K. Mallik*
5. "Metal Cutting Principles" – *M.C. Shaw*
6. "Cutting Tool Design" – *Arthur L. McClure*
7. "Jigs and Fixture Design" – *Edward G. Hoffman*
8. "Fundamentals of Tool Engineering Design" – *Donald F. Eary & Edward A. Reed*
9. "Die Design Fundamentals" – *Vukota Boljanovic*
10. "Injection Mould Design" – *R.G.W. Pye*
11. "Tool Engineering Handbook" – *S. Kuppuswamy*
12. CIRP Journal of Manufacturing Science and Technology
13. International Journal of Advanced Manufacturing Technology (IJAMT)
14. Materials and Manufacturing Processes (Taylor & Francis)
15. ASME Journal of Manufacturing Science and Engineering
16. NPTEL (IIT Lectures) – Free lectures on tool design and manufacturing.
17. MIT OpenCourseWare – Covers mechanical and tool engineering concepts.
18. Tool and Die Design Courses on Udemy & Coursera
19. IIT Bombay NPTEL – Youtube Videos
20. Cutting Tool Engineering – Youtube Videos
21. The Engineering Mindset – Youtube Videos

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | - | 3 |
| 25PEC13ME17 | Advanced Materials | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Understand the concept of artificial skins and muscles along with other advanced materials. |
| | CO2 | Understand the function of Piezoelectric materials, Magneto strictive materials, Shape memory alloys, Electroactive polymers |
| | CO3 | Comprehend important concepts of Ferrofluids and Magneto rheological Fluids |
| | CO4 | Identify and understand different energy storage materials |
| | CO5 | Understand classification, terminology, and manufacturing methods of composite materials |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | Introduction to Advanced Materials. Artificial skins, artificial muscles, biomimetic materials, materials with tuneable responses, non-linear properties, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, hysteresis, integrated sensing and actuation | 1 | 06 |
| 2 | Overview of the following materials: Piezoelectric Materials, Magneto strictive Materials, Shape Memory Alloys, Electroactive Polymers | 2 | 05 |
| 3 | Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications. Ferrofluids and Magneto rheological Fluids and applications. Soft Matter and its applications. Carbon Nanotubes and Carbon nanostructures and its applications. Thermoelectric Materials and Peltier devices. | 3 | 05 |

| | | | |
|---|---|---|---|
| **4** | Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations. | 4 | 05 |
| **5** | Composites: Classifications based on fibres and matrix, Advantages, Applications, Terminology, types, and manufacturing methods. | 5 | 05 |
| | **Total** | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Quiz (20 Marks)
**ISE-2:** Quiz (20 Marks)
**MSE:** 90 minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial**

**ISE-1**

One assignment each on module 1, 2, and 3. Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2**

One assignment each on module 4, and 5 or presentations by students in groups of 3 on recent topics related to metrology and quality engineering (20 marks).
Interaction/viva other than presentation (10 marks)

**Reference Books:**

1. M.V. Gandhi and B.S. Thompson, "Smart Materials and Structures", Chapman & Hall, London; New York.
2. Mel Scwartz, "Encyclopaedia of Smart Materials Vol. I and II", John Wiley & Sons

3. Senol Utku, "Theory of Adaptive Structures: Incorporating Intelligence into Engineered Products", CRC Press.
4. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press, Cambridge; New York.
5. M. Balasubramanian, "Composites materials processing" ,1st edition, CRC press.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PCC13ME18 | Optimization Techniques | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Statistical Techniques and Partial Differential Equations | |
|---|---|---|
| Course Outcomes | CO1 | Identify the types of optimization problems and apply optimality criteria. |
| | CO2 | Formulate the problem as Linear Programming problem and analyse the sensitivity of a decision variable. |
| | CO3 | Apply integer programming and discrete event simulation techniques for problem solving in various domains. |
| | CO4 | Apply multi-objective decision-making methods for problem in manufacturing environment and other domain. |
| | CO5 | Apply multi criterion decision making methods for problem in manufacturing environment and other domain. |
| | CO6 | Apply Design of Experiments method for Optimization. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization | 1-4 | 1 |
| | 1.2 | Linear Programming Problem: Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis. | 1-4 | 6 |
| 2 | 2.1 | Integer Programming Model: Gomory's cutting plane method, Branch & Bound Technique | 1-4 | 4 |
| | 2.2 | Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique | 1-4 | 2 |

| | | | | |
|---|---|---|---|---|
| **3** | **3.1** | Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. | 1-4 | 4 |
| | **3.2** | Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, simulated annealing and Techniques based on Neural network & Fuzziness (Only concepts) | 3-6 | 2 |
| **4** | **4.1** | Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method | 1-4 | 3 |
| **5** | **5.1** | Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2k design, The general 2k-p fractional factorial design | 5 | 4 |
| **Total** | | | | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | Linear Programming and sensitivity analysis | **02** |
| **2** | Integer Programming | **02** |
| **3** | Monte Carlo Simulation | **01** |
| **4** | MODM methods for problem solving | **01** |
| **5** | MCDM methods for problem solving | **01** |
| **6** | DOE and ANOVA | **01** |
| | **Total Hours** | **08** |

**Course Assessment:**

**Theory:**
**ISE-1:** Quizzes on first Two Modules (20 Marks)
**ISE-2:** Quizzes on next Three modules (20 marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus

**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**
**ISE-1:** Assignment on first two tutorials (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:** Assignments on next four tutorials (20 Marks)
Group assignment on application of software for any optimization technique (10 Marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
**Text Books:**

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Malik, A. K., Yadav, S. K., & Yadav, S. R. "Optimization Techniques" IK International Publishing House vt. Limited.
3. Taha, H. A., "Operations research: an introduction" Pearson Education India.
4. Gupta, P. K., & Hira, D. S. "Operations research" S Chand & Company.
5. Douglas C. Montgomery, "Design and analysis of experiments" (John Wiley & Sons Inc.)

**Reference Books:**

1. Pablo Pedregal, "Introduction to Optimization", Springer
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. R V Rao, "Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making" (Springer Publication).
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.
6. Ritter, H., Martinetz, T., &Schulten, K., Addison, "Neural Computation and Self-Organizing Maps"-Wesley Publishing Company
7. Saravanan R,"Manufacturing Optimization through Intelligent Techniques", Taylor & Francis (CRC Press)-2006.

**Links for online NPTEL/SWAYAM courses:**

https://nptel.ac.in/courses/112/101/112101298/ - Optimization from Fundamentals, IIT Bombay

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME19 | Project Management | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Apply selection criteria and select an appropriate project from different options. |
| | CO2 | Write work break down structure for a project and develop a schedule based on it. |
| | CO3 | Identify opportunities and threats to the project and decide an approach to deal with them strategically |
| | CO4 | Use Earned value technique and determine & predict status of the project. |
| | CO5 | Capture lessons learned during project phases and document them for future reference |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | **Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures | 1-5 | 04 |
| 2 | **Initiating Projects:** How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics. | 1-5 | 04 |
| 3 | **Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling | 1-5 | 05 |

| | | | |
|---|---|---|---|
| | techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS). | | |
| **4** | **Planning Projects:**<br>Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan<br>**Risk Management in projects:** Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, | | 04 |
| **5** | **Executing Projects:**<br>Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings<br>**Monitoring and Controlling Projects:**<br>Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit<br>**Project Contracting**<br>Project procurement management, contracting and outsourcing, | 1-5 | 05 |
| **6** | **Project Leadership and Ethics:**<br>Introduction to project leadership, ethics in projects,Multicultural and virtual projects<br>**Closing the Project:**<br>Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study. | 1-5 | 04 |
| | **Total** | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Quiz (20 Marks)
**ISE-2:** Quiz (20 Marks)
**MSE:** 90 Minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 Minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial:**

**ISE-1**

One assignment each on module 1, 2 and 3. Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2**

One assignment each on module 4, 5 and 6 followed by Presentation by groups based on recent updates on SC.

**Recommended Books:**

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Project Management, Gido Clements, Cengage Learning
4. Project Management, Gopalan, Wiley India
5. Project Management, Dennis Lock, 9th Edition, Gower Publishing England

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| 25PEC13ME110 | Industrial Engineering and Operations Research | 2 | 1 | -- | 2 | 1 | - | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Analyze implications of Industrial Engineering in industries |
| | CO2 | Demonstrate the Work space design and Performance merit rating |
| | CO3 | Understand the material flow and importance of layout optimization |
| | CO4 | Understand importance of Inventory and leveraging the benefit to company. |
| | CO5 | Understanding material requirement through dependent and independent demand and meeting the deadline |
| | CO6 | Understanding value creation and secondary value addition. |

| Module No. | Topics | Ref | Hrs. |
|---|---|---|---|
| 1 | Evolution & Industrial Engineering in the modern world,<br>**Production and Productivity:** factors influencing productivity, Productivity Improvement tools **&** Quality Improvement tools and techniques (5s, Poka- Yoke, Kaizen, Kanban **&** QFD, FMEA, SMED) | 1-4 | 04 |
| 2 | **Work System Design:** Factors affecting human performance, physical workload and energy expenditure. Workspace design for standing and seated workers, Arrangements of components within a physical space.<br>**Job Evaluation and Wage Plan***:* job evaluation procedure, merit rating (performance appraisal), method of merit rating, wage and wage incentive plans | 1-4 | 04 |

| | | | |
|---|---|---|---|
| **3** | **Facility Location:** The need for location decision, Procedure for making location decisions, Factors affecting location decisions, Methods of evaluating location decisions.<br>**Facility Layout / Plant Layout:** Types of Layout, Significance and Factors influencing layout choices, Principles of Plant layout, Concepts of Group Technology and Cellular Manufacturing, Computerized Layout Techniques. | 1-4 | 04 |
| **4** | **Inventory Management:** Classification and Functions of Inventory, The EOQ Model, P & Q System, ABC & VED analysis. | 1-4 | 05 |
| **5** | Material requirement Planning (MRP) and Material Resource Planning (MRP II), Dependent Demand and Independent Demand with an example. | 1-4 | 05 |
| **6** | Value Engineering and Value Analysis: Distinction between value engineering & value analysis and their Significance. Steps in value engineering & analysis, function analysis system techniques- FAST diagram with Case studies | 1-4 | 04 |
| | **Total** | | **26** |

**Course Assessment:**

**Theory:**

**ISE-1:** Assignment on Module 1, 2, and 3 OR Quiz (20 Marks)
**ISE-2:** Assignment on Module 4, 5,an d 6 OR Quiz (20 Marks)
**MSE:** 90 Minutes of written examination based on 50% syllabus **(**30 Marks)
**ESE:** 90 Minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial**

**ISE-1** (20 marks)
Using FMEA with an example your own Solve the problem using FMEA
Using work space and Job evaluation analysis perform merit rating and short list the candidate in group of 4-5 students
Explain the importance of Plant Layout Using Vowel Methodology Muther's Grid

**ISE-2** (30 marks)
*Writeup*
Primary and Secondary value of a product and FAST diagram for a product.
MRP and MPS : Role of Computer in Industry
Inventory Vs Liquid Cash – Review and Industry Practice

**Reference Books:**

1. Production and Operations analysis by Steven Nahmia , McGraw-Hill / Irwin publication
2. Facilities Planning 4th Edition by James A. Tompkins, John Wiley and Sons Inc.
3. Elements Of Production Planning And Control by Eilon, Samuel, New York: Macmillan
4. Production Planning and Control by Prof. Jhamb L.C. by Everest Publishing House
5. Production (Operations) Management by Prof. Jhamb L.C. by Everest Publishing House
6. Inventory Management Prof. Jhamb L.C. by Everest Publishing House
7. Operations Management- an Integrated Approach 5th Edition by R. Dan Reid, Wiley
8. Production and Operations Management by R. Panneer selvam, Prentice-Hall Of India
9. Operations Management for Competitive Advantage by Richard B. Chase, MGH
10. Orlicky's Material Requirements Planning, by Carol Ptak, McGraw Hill.
11. Enterprise resource planning: concepts and practice by Vinod kumar Garg PHI Learning
12. Lean Thinking: Banish Waste and Create Wealth in Your Corporation, by James P. Womack, Free Press
13. Toyota Production System: An Integrated Approach to Just-In-Time, by Yasuhiro Monden ,CRC PRESS

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME111 | Manufacturing Systems | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | **Examination Scheme** | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | | Learners will be able to |
| | CO1 | Explain role of computers and information technology in manufacturing systems. |
| | CO2 | Develop an FMS (Flexible Manufacturing System) layout for given simple part family, using group technology concepts to and make proper grouping as per their attributes. |
| | CO3 | Recognize use of robotics, programmable logic controllers, microcontrollers and recent advances in the field of manufacturing |

| Sr. No. | Unit No. | Practical Exercises (outcomes in Psychomotor Domain) | Approx Hours. required |
|---|---|---|---|
| 1 | -- | **Presentation on "How it's made":** Faculty will assign any one part from Annexure-I. (Each student will have different part in a batch). Student will download movies/content and will present with the concept "How it's made". Note: Each student will make his/her folder having the name as <batch number_Enrollment number> and will save his/her downloaded content. | 04 |

| | | | |
|---|---|---|---|
| 2 | II | **GT codes:**<br>Faculty will ask each student to bring at least one component having mechanical features and having more than 5-6 machining operations. Each student will also prepare the drawing and process plan (As per attached Annexure-II).Then the data will be interchanged by batch students. Collection of parts and making drawing and process plans will be as home assignment. Faculty will assign this task in very first period of practice. Students would:<br>a. Prepare drawing of part brought by the student.<br>b. Prepare process plan as per Annexure-II for the part brought by student.<br>c. Interchange part drawings and process plans. (No photo copies are allowed. Each student in a batch will have total drawings and process plans equal to number of students in a batch who have brought parts. This may be also given as home assignment).<br>d. Prepare feature matrix.<br>e. Select GT coding system and assign GT code to each part. | 04 |
| 3 | III | **FMS layout:** Students would:<br>a. Develop part family (May be 3-6 parts) from all parts.(Taken in Ex. No. 2 above.) This is to be carried out logically from feature matrix.<br>b. Assume quantities of each part of part family developed in a. above.<br>c. Assume additional data for following:<br>i. Number of shifts and working hours in each shift.<br>ii. Average number of working days in a month.<br>iii. Utilisation factor of FMS unit.<br>d. Prepare process time matrix. (Suggested format is attached as per Annexure-III).<br>e. Determine type and number of work stations.<br>f. Perform necessary calculations and prepare conceptual FMS layout. | 06 |

| | | | |
|---|---|---|---|
| 4 | IV | **Demonstration:** Students would:<br>a. Demonstrate working of following:<br>i. Robot-anyone.<br>ii. Sensors-each one from force & torque type, velocity and acceleration type, proximity type, position type and vision type.<br>iii. PLC-anyone.<br>iv. MC-anyone.<br>v. Control system-anyone.<br>b. Sketch following.<br>i. Configuration sketch of robot demonstrated.<br>ii. Working sketch of sensors demonstrated.<br>iii. Block diagrams of PLC and MC demonstrated.<br>iv. Circuit diagram of control system demonstrated. | 06 |
| 5 | All | **Mini project (In the group of 4-6 students):** Students would:<br>a. Prepare at least one from the following (as approved by the faculty):<br>i. Prepare simple circuit using application of sensor.<br>ii. Prepare simple robot using available kit.<br>iii. Prepare ladder diagram for any one real life PLC application.<br>iv. Build and operate the functionality of basic or advance logic gates.<br>b. Prepare report which includes sketches, specifications, observation tables, parameters, truth tables, applications, etc. (as applicable).<br>c. Present the project. | 06 |
| | | **Total** | 26 |

**Laboratory Course Assessment:**

**ISE-1:** First Two experiments (20 Marks)

**ISE-2:** Remaining three experiments (30 M)

**Reference Books:**

| Sr. No. | Title of Book | Author | Publication |
|---|---|---|---|
| i. | CAD/CAM/CIM. | P. Radhakrishnan & S. Subranarayan. | New Age Intentional |
| ii. | Computer Design & Integrated Manufacturing. | Bedworth, Wolfe and Anderson | McGraw Hill International Publication. |
| iii. | Mechatronics. | - | HMT |
| iv. | Introduction to Robotics. | Arthur J. Critchlow | McMillan publication |
| v. | Robotics for engineers. | Yorom Koran | McGraw Hill Publication |
| vi. | Computer aided manufacturing. | Rao, Tiwari & Kundra. | Tata McGraw Hill Publication |
| vii. | Computer Aided Design & Manufacturing. | Dr Sadhu Singh. | KP |
| iii. | Computer Integrated Manufacturing. | S.K.Vajpayee. | PHI |
| ix. | Automation, Production and Computer integrated Manufacturing. | Mikell P. Groover. | PHI |
| x. | Mechatronics. | Bradleg and Offers. | Chapman and Hall |
| xi. | Practical Robotics. | Willium C. Burns Jr. & Janet Evans Worthington | PHI |
| xii. | Basic electronics. | Mehta ,V.K. | S.Chand Publication, New Delhi. |

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | Total |
| 25PEC13ME112 | Industrial Engineering and Operations Research | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Demonstrate to Calculate standard time for all the operations. |
| | CO2 | Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch |
| | CO3 | Prepare chart of Sequence of operation for manufacturing of simple job |
| | CO4 | Prepare supply chain management chart for online purchase of goods/products |

| Module No. | No. | Experiments List | Expts. No. |
|---|---|---|---|
| Group A | 1 | Experiment for Merit rating and Job Evaluation using pack of cards | 2 expts. Out of 4 |
| | 2 | Study Experiment using pin board | |
| | 3 | Study Experiment using two Handed process Chart | |
| | 4 | Study experiment on Multiple Activity Chart (Or) Man Machine Chart | |
| Group B | 1 | Analyze the motions involved in machining operation of the given job | 1 expts. Out of 3 |
| | 2 | Apply work measurement technique to analyze the time components involved in machining operation of given job using stop watch | |
| | 3 | Calculate standard time for all the operations involved in step turning process, or any other process. | |
| Group C | 1 | Prepare supply chain chart in day-to-day situation like supply of cold drink/tooth paste/any grocery item. | 2 expts. Out of 3 |
| | 2 | Prepare Supply Chain Management Chart For Online Purchase Of Goods/Products. | |
| | 3 | Prepare detailed process plan for manufacturing of simple job. | |
| | | **Total** | **5 expts.** |

**Laboratory Course Assessment:**
**Group A: at least two experiments**
**Group B: at least one experiments**
**Group C: at least two experiments**

**ISE-1:** Two experiments from Group A (20 Marks)
**ISE-2:** One experiment from Group B and 2 experiment from Group C (30 Marks)

**Reference Books:**

1. Production and Operations analysis by Steven Nahmia , McGraw-Hill / Irwin publication
2. Facilities Planning 4th Edition by James A. Tompkins, John Wiley and Sons Inc.
3. Elements Of Production Planning And Control by Eilon, Samuel, New York: Macmillan
4. Production Planning and Control by Prof. Jhamb L.C. by Everest Publishing House
5. Production (Operations) Management by Prof. Jhamb L.C. by Everest Publishing House
6. Inventory Management Prof. Jhamb L.C. by Everest Publishing House
7. Operations Management- an Integrated Approach 5th Edition by R. Dan Reid, Wiley
8. Production and Operations Management by R. Panneer selvam, Prentice-Hall Of India
9. Operations Management for Competitive Advantage by Richard B. Chase, MGH
10. Orlicky's Material Requirements Planning, by Carol Ptak, McGraw Hill.
11. Enterprise resource planning: concepts and practice by Vinod kumar Garg PHI Learning

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credit Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | L | T | P | TOTAL |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| 25PEC13ME25 | Industrial Robotics | | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | | Total |
| | | Theory | 20 | 30 | 20 | 30 | | 100 |
| | | Tutorial | 20 | -- | 30 | -- | | 50 |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Code | CO1 | Understand basic anatomy of a robot system |
| | CO2 | Understand working of various sensors and Robot Peripherals |
| | CO3 | Understanding Robot Direct and Inverse Kinematics |
| | CO4 | Demonstrate an understanding of robot intelligence and task planning |

| Modules No. | Topics | Ref. | Hrs. |
|---|---|---|---|
| 1 | **Introduction to Automation:** robotics, Robotic system & Anatomy, Classification and Future Prospects. **Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. | 1 | 2 |
| 2 | **Robot & its Peripherals**<br>**End Effecters:** Type mechanical and other grippers, Tool as end effecter.<br>**Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment | 1,2 | 4 |
| 3 | **Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretation and Applications. | 2 | 5 |

| | | | |
|---|---|---|---|
| 4 | **Robot Kinematics:** Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics. Introduction to wheeled and legged robots including humanoids | 1 | 5 |
| 5 | **Robot Intelligence & Task Planning:** Introduction, State space search, Problem reduction, use of predictive logic, Means. Ends, Analysis, Problem solving, Robot learning and Robot task planning. | 1 | 5 |
| 6 | **Robot application in manufacturing:** Material transfer, machine loading & unloading, processing operation, Assembly & inspectors, robotic Cell design & control, Social issues & Economics of Robotics. | 1 | 5 |
| | | TOTAL | 26 |

**Course Assessment:**

**Theory :**

**ISE-1:** Quiz (20 Marks)

**ISE-2:** Quiz (20 Marks)

**MSE:** 90 minutes of written examination based on 50% syllabus **(**30 Marks)

**ESE:** 90 minutes of written examination based on the rest of the syllabus covered after MSE (30 marks)

**Tutorial :**

ISE-1: Assignment of first 3 modules (20 Marks)

ISE-2: Assignment on last 3 modules (20 Marks)
Simulation of Robot Kinematics on Matlab (10 marks )

**Recommended Books :**

1. Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey, Mc Graw Hill.
2. Robotics: Control, Sensing, Vision & Intelligence, Fu, Gonzalex, Lee, Mc Graw Hill.
3. Robotic technology & Flexible Automation, S R Deb. TMH.
4. Robotics for Engineers, Yoram Koren , Mc Graw hill.
5. Fundamentals of Robotics, Larry Health.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME26 | Modelling and Simulation | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Basics Mathematics. | |
|---|---|---|
| Course Outcomes | CO1 | Explain the fundamental concepts of simulation, queuing systems, and inventory systems. |
| | CO2 | Explain the process of generating random numbers using different techniques. |
| | CO3 | Apply heuristic methods to develop simulation models and demonstrate the generation of random variates using different techniques. |
| | CO4 | Explain the analysis of simulation data, including input modelling, verification, and validation of the model. |
| | CO5 | Apply output analysis techniques to evaluate different types of simulations, analyze stochastic output data, and assess performance measures in terminating and steady-state simulations. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Introduction to Simulation:** Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study. | 1-6 | 6 |
| | 1.2 | **Simulation Examples**: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples. | 1-6 | |

| | | | | |
|---|---|---|---|---|
| **2** | **2.1** | **General Principles:** Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. | 1-6 | 4 |
| | **2.2** | **Random Numbers:** Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test. | 1-6 | |
| **3** | **3.1** | **Random Variate Generation:** Inverse Transform Technique- Exponential, Uniform, Weibull, Triangular distributions, Direct transformation for Normal and log normal Distributions, convolution methods- Erlang distribution, Acceptance Rejection Technique. | 1-6 | 5 |
| | **3.2** | **Optimisation Via Simulation:** Meaning, difficulty, Robust Heuristics, Random Search. | 1-6 | |
| **4** | **4.1** | **Analysis of Simulation Data:**<br>**Input Modelling:** Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. | 1-6 | 6 |
| | **4.2** | **Verification and Validation of Model –** Model Building, Verification, Calibration and Validation of Models. | 1-6 | |
| **5** | **5.1** | **Output Analysis –** Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations. | 1-6 | 5 |
| | | | **Total** | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | Queuing systems. | **01** |
| **2** | Frequency test. | **01** |
| **3** | Runs test. | **01** |
| **4** | Autocorrelation test. | **01** |
| **5** | Random Variate Generation. | **01** |
| **6** | Goodness of fit tests. | **01** |
| **7** | Multivariate and time series analysis. | **01** |

| | | |
|---|---|---|
| **8** | Output Analysis. | **01** |
| **Total Hours** | | **08** |

**Course Assessment:**

**Theory:**

**ISE-1:**
Activity: Quizzes/Assignment on first two modules (20 Marks)
**ISE-2:**
Activity: Quizzes/Assignment on last three modules (20 Marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**

**ISE-1**

First Four tutorials (20 marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2**
Next four tutorials (30 marks)
Continuous pre-defined rubrics-based evaluation for 30 marks

**Recommended Books:**

1.Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
2.Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.
3.Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
4.Narsingh Deo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN : 0-87692-028-8.
5. Frank L. Severance, "System Modeling and Simulation"
6. Trivedi K. S., "Probability and Statistics with Reliability, Queueing, and Computer Science Applications", PHI, 1982.

**Links for online NPTEL/SWAYAM courses:**

1. https://onlinecourses.nptel.ac.in/noc24_ch76/preview
2. https://onlinecourses.nptel.ac.in/noc22_ph42/preview
3. https://onlinecourses.nptel.ac.in/noc19_ph11/preview

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME27 | Design of Mechanical Systems | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Engineering Mechanics, Strength of Materials, Machine Design | |
|---|---|---|
| Course Outcomes | CO1 | Apply the concept of system design. |
| | CO2 | Select appropriate gears for power transmission on the basis of given load and speed |
| | CO3 | Design material handling systems such as hoisting mechanism of EOT crane, |
| | CO4 | Design belt conveyor systems |
| | CO5 | Design engine components such as cylinder, piston, connecting rod and crankshaft |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | Methodology & Morphology of design, Optimum design, system concepts in design. | 1-7 | 2 |
| 2 | 2.1 | **Design of Transmission Gear Box:** Single stage and Two stage Gear box with fixed ratio consisting of Design of spur and helical Gears, Design concept for bevel and worm and worm wheel gear pairs. | 1-7,9 | 6 |
| 3 | 3.1 | **Design of Hoisting Mechanism:** Design of Snatch Block Assembly including Rope Selection, Sheave, Hook, Bearing for hook, cross piece, Axle for sheave and shackle plate, Design of rope drum, selection motor with transmission system. | 1-7, 10 | 6 |
| 4 | 4.1 | **Design of Belt Conveyors:** Power requirement, selection of belt, de-sign of tension take up unit, idler pulley | 1-7, 10 | 4 |
| 5 | 5.1 | **Engine Design (Petrol and Diesel):** Design of cylinder, Piston with pin and rings, connecting rod & crank shaft with bearings | 1-7, 9 | 6 |

| Total | 26 |
|---|---|

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| 1 | Design of Transmission Gear Box | 02 |
| 2 | Design of EOT Crane | 02 |
| 3 | Design of Belt Conveyor | 02 |
| 4 | Design of IC Engine | 02 |
| Total Hours | | 08 |

**Course Assessment:**

**Theory:**

**ISE-1:** Quiz (20 marks)
**ISE-2:** Quiz (20 marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**

**ISE-1:** Design exercises on first two tutorials: (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:** Design exercises on next two tutorials (20 Marks)
Software Modelling of any one mechanical system (10 Marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
**Text Books:**

1. "Machine Design Exercises", S.N.Trikha - New Delhi Khanna Publisher 1978.
2. "Mechanical Engineering Design", Shigley J E and Mischke C R,11th Edition 2019, McGraw Hill, ISBN: 9788184956207.
3. "Design of Machine Elements", Bhandari VB,5th Edition 2020, TMH,ISBN: 9789390177479
4. "Machine Design", Black PH and O Eugene Adams, 3rd Edition, McGraw Hill ISBN 10:

0070055246
5. "Design Data", P.S.G. College of Technology, Coimbatore. ISBN: 978-8192735504
6. "Engineering Design", Dieter G E, McGraw Hill Inc, ISBN: 9781260113297
7. "Mechanical System Design", SP Patil, 2nd Edition., JAICO Publishing House ISBN: 978-8179923153
8. "Gear Design Handbook", Gitin Maitra, 2nd Edition, ISBN: 978-0074602379
9. "Design Data Book- Design of engine parts", Khandare S.S & Kale A.V, 2nd Edition, ISBN: 978-9352654260
10. "Material Handling Equipment", Rudenko,2nd Edition, M.I.R. publishers, Moscow

**Reference Books:**

11. "Mechanical design analysis", MF Spotts, 3rd Edition, Prentice Hall Inc.
12. "Machine Design-An Integrated Approach", Robert L. Norton,6th Edition, Pearson Education, ISBN: 9780135184233
13. "Material Handling Equipments", N. Rudenko, Peace Publication
14. "Material Handling Equipments", Alexandrov,5th Edition, Mir Publication ISBN: 9780714717456
15. Machine Desgin", Reshetov, Mir Publication 1978.
16. "Machine Design", R.C.Patel, Pandya, Sikh, Vol -I & II,12th Edition, C. Jamnadas& Co.
17. "Design of Machine Elements", 4th Edition, V. M. Faires, ISBN: 978-0023359507

**Links for online NPTEL/SWAYAM courses:**

1. https://onlinecourses.nptel.ac.in/noc22_me62 - Gear And Gear Unit Design: Theory and Practice, IIT Kharagpur
2. https://nptel.ac.in/courses/112/106/112106137/ - Machine Design-II, IIT Madras

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME28 | Product Design and Development | L | T | P | L | T | P | Total |
| | | 2 | 1 | -- | 2 | 1 | -- | 3 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | 20 | 30 | 20 | 30 | 100 | |
| | | Tutorial | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | Machine Design | |
|---|---|---|
| Course Outcomes | CO1 | Describe the process of product design & development. |
| | CO2 | Employ engineering, scientific, and mathematical principles to develop and execute a design project from a concept to a finished product. |
| | CO3 | Apply the principles of DFMA and other DFX principles in product design. |
| | CO4 | Analyze products based on ergonomics and aesthetic aspects. |
| | CO5 | Apply value engineering and software solutions in product design. |
| | CO6 | Illustrate various modern approaches like concurrent engineering, product life cycle management, robust design, rapid prototyping / rapid tooling. |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | 1.1 | **Introduction:** Definition of product design, Various phases in product development and Design, The Design Process, Considerations in product design | 1-3 | 2 |
| | 1.2 | **Planning for products**: Establishing markets - market segments - relevance of market research. | 1-3 | 1 |
| | 1.4 | **Materials:** Overview of materials including new generation materials, Tailor made material concepts, Material selection process. | 1-3 | 1 |
| 2 | 2.1 | **Identifying customer needs:** Voice of Customer (VoC), Customer populations, Hierarchy of human needs, Need | 1-3 | 2 |

| | | | | |
|---|---|---|---|---|
| | | gathering methods, Establishing engineering characteristics, Competitive benchmarking, Quality Function Deployment (QFD), House of Quality (HoQ), Product design specification, Development of product design with specifications using QFD, Relevant case studies. | | |
| **3** | **3.1** | **The design processes:** Descriptive and prescriptive design models, Concept development & evaluation, Pugh's total design activity model<br>**Conceptual Design:** Market research, Generation, Selection and Embodiment of concept, Product Architecture, Customer centric product designing | 1-3 | 2 |
| | **3.2** | **Creativity:** Role of creativity in problem solving, Vertical and lateral thinking, Brain storming, Synectics, Group working dynamics, Adaptation to changing scenarios in economics, social, cultural and technological fronts, Anticipation of new needs and aspirations. | | 1 |
| **4** | **4.1** | **Product Ergonomics:** Anthropometry, Environmental conditions, thermal, noise, vibration, displays, illusions, Psycho and psychological aspects in design, Man-machine information exchange. | 1-3 | 2 |
| | **4.2** | **Product Aesthetics:** Visual awareness, Form elements in context of product design, Concepts of size, shape and texture, Introduction to colour and colour as an element in design, Colour classifications and dimensions of colour, Colour combinations and colour dynamics, Interaction / communication of colours, Psychological aspects of colours, generation of products forms with analogies from nature. | 1-3 | 1 |
| | **4.3** | **Product Graphics:** Graphics composition and layout, Use of grids in graphics composition, Study of product graphics and textures. | 1-3 | 1 |
| **5** | **5.1** | **Design for Manufacturing:** Guidelines and Methodology, Producibility requirements, Accuracy and Precision requirements, Strength considerations in Design: Criteria and objectives, Designing for uniform strength, Designing for stiffness and rigidity, Practical ideas for material saving in design - ribs, corrugations, rim shapes, bosses, laminates, etc. | 1-3 | 2 |

| | | | | |
|---|---|---|---|---|
| | **5.2** | Design for forged and Cast components, Design for Sheet Metal processed components, powder metallurgical components, Expanded metals and wire forms | 1-3 | 2 |
| | **5.3** | **Design for Assembly (DFA):** DFA Index, Analysis of assembly requirements, Standardization, Ease of Assembly and disassembly, Design for bolted, welded and riveted components, Design for hinge and snap fit assemblies, maintenance, consideration of handling and safety, Modular concepts. | 1-3 | 2 |
| | **5.4** | **Other DFX Principles:** Designs for Maintainability, Safety, Reliability, Sustainable Design | 1-3 | 1 |
| **6** | **6.1** | **Value Engineering:** Product value and its importance, Value analysis job plan, Steps to problem solving and value analysis, Value analysis tests, Value Engineering idea generation check list, Material and process selection in value engineering, Cost reduction, case studies and exercises. | 1-3 | 1 |
| | **6.2** | **Software solutions:** Software for drafting, modeling, assembly, detailing, CAM interfacing, Rapid tooling/rapid prototyping, etc. | 1-3 | 1 |
| | **6.3** | **Modern Applications:** Concurrent Engineering, Robust Design, Additive Manufacturing/Rapid Prototyping, Product Life Cycle Management techniques and application areas. | 1-3 | 4 |
| **Total** | | | | **26** |

**Tutorial:**

| Sr. No. | Tutorial Details | Hours |
|---|---|---|
| **1** | House of quality | 01 |
| **2** | Concept Generation and Selection | 02 |
| **3** | Industrial Design | 02 |
| **4** | Value Engineering / Robust Design / Modern Approaches | 02 |
| **5** | DFX Principles | 01 |
| **Total Hours** | | **08** |

**Course Assessment:**

**Theory:**
**ISE-1:** Quizzes on first three modules (20 Marks)

**ISE-2:** Quizzes on next Three modules (20 marks)
**MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
**ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE

**Tutorial:**
**ISE-1:** Assignment on first two tutorials (20 Marks)
Continuous pre-defined rubrics-based evaluation for 20 marks.

**ISE-2:** Assignment on remaining three tutorials (30 marks)
Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
**Text Books:**

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, "Product Design," Indian Reprint 2004, Pearson Education, ISBN 9788177588217.
3. Product Design and Manufacturing - R.C. Gupta, A.K. Chitale PHI, 2011

**Reference Books:**

1. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction," 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C.Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process," 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

**Links for online NPTEL/SWAYAM courses:**

1. Product Design and Manufacturing by Prof. J. Ramkumar, Prof. Amandeep Singh | IIT Kanpur https://onlinecourses.nptel.ac.in/noc21_me66/preview
2. Product Design and Development by Prof. Inderdeep Singh, IIT Roorkee https://onlinecourses.nptel.ac.in/noc21_me83/preview

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME29 | Robotics and Control Engineering | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Design and Develop Kinematic of an Industrial Robotic arm |
| | CO2 | Develop machine vision based image processing techniques |
| | CO3 | Develop Solution for Trajectory planning in robots |
| | CO4 | Be able to check system stability by Root Locus or Bode Plot |

| Experiment No. | Experiments | Ref | Hrs. |
|---|---|---|---|
| 1 | Edge detection | 1 | 04 |
| 2 | segmentation using image processing | 1 | 05 |
| 3 | Programming the robots to solve direct and inverse kinematics problems | 1 | 05 |
| 4 | Trajectory planning for Robots | 1 | 04 |
| 5 | Checking Stability of a system using Root Locus | 3,4,5 | 04 |
| 6 | Checking stability of a system using Bode Plot | 3,4,6 | 04 |
| | **Total** | | **26** |

**Course Assessment:**

**Laboratory work:**

1. **ISE-1 (20 marks)**
Submission of the Circuit Diagrams made during the lab performance for the first 4 practicals covered during this assessment duration. Assessment will be based on pre-defined rubrics.

2. **ISE-2 (30 marks)**
Submission of the Programs made during the lab performance for the last 5 practicals covered during this assessment duration. Assessment will be based on pre-defined rubrics (20 marks).
Lab interaction: (10 marks)

**Reference Books:**

1. *"Introduction to Robotics: Mechanics and Control"* – John J. Craig
2. *"IoT: Building Arduino-Based Projects"* – Peter Waher
3. **Katsuhiko Ogata**, *"Modern Control Engineering"*, 5th Edition, Pearson, 2010.
4. **Rao V. Dukkipati**, *"Analysis and Design of Control Systems using MATLAB"*, New Age International, 2006.
5. **MATLAB Documentation**, *"Root Locus Analysis using rlocus()"*,
6. **MATLAB Documentation**, *"Bode Plot Analysis using bode()"*

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25PEC13ME210 | Product Design | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Lab | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | | Product Design and Development |
|---|---|---|
| Course Outcomes | CO1 | Identify the need for developing products |
| | CO2 | Select suitable PD&D processes |
| | CO3 | Apply the creativity & industrial design methods to design & develop the chosen product |
| | CO4 | Work collaboratively in a team to complete a PD&D project. |
| | CO5 | Effectively communicate the results of projects and other assignments in written and oral format. |

| Module No. | Topics |
|---|---|
| | *(All the following design exercises are to be treated as course project on product redevelopment to be completed by a group of 4 to 5 students. The results are to be documented and presented.)* |
| 1 | Identification of Customer Needs |
| 2 | Conversion of Voice of Customer into Voice of Company |
| 3 | Concept Generation and Selection |
| 4 | Industrial Design Aspects |
| 5 | DFMA and other DFX Considerations |
| 6 | Development of the Model of redesigned Product and Analysis (if any) |

**Course Assessment:**

**Lab:**

**ISE:**

**1. ISE-1**

Submission of report and presentation on first 2 modules of the course project
Continuous pre-defined rubrics-based evaluation for 20 marks.

**2. ISE-2**

Submission of report and presentation on last 4 modules of the course project

Continuous pre-defined rubrics-based evaluation for 30 marks.

**Recommended Books:**
**Text Books:**

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, "Product Design," Indian Reprint 2004, Pearson Education, ISBN 9788177588217.
3. Product Design and Manufacturing - R.C. Gupta, A.K. Chitale PHI, 2011

**Reference Books:**

1. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction," 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C.Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process," 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | L | T | P | Total |
| 25MDM05 | Public Relations and Corporate Communication (Semester-VI) | | 2 | -- | -- | 2 | -- | -- | 2 |
| | | Examination Scheme | | | | | | | |
| | | | ISE1 | | ISE2 | ESE | | | Total |
| | | Theory | 50 | | 50 | -- | | | 100 |

| Pre-requisite Course Codes | SLRW Skills | |
|---|---|---|
| Course Outcomes | CO1 | Develop professional communication skills through training and practice |
| | CO2 | Draft professional documents with precision |
| | CO3 | Develop effective communication strategies for diverse, cultural and global business environment |

| Module No. | Unit No. | Topics | Ref. | Hrs. |
|---|---|---|---|---|
| 1 | | **Professional Communication Skills** | R-1,3 | 5 |
| | 1.1 | Resume Writing & Cover Letter for Employment | | |
| | 1.2 | Group Discussion | | |
| | 1.3 | Formal dressing | | |
| | 1.4 | Communication – language and articulation | | |
| | 1.5 | Interview Techniques | | |
| | 1.6 | Formal email writing | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| **2** | | **Synergy Communication** | R-4 | 4 |
| | **2.1** | Presentation Skills – creating and delivering presentations | | |
| | **2.2** | Report Writing- Importance, Objective, type – versioning and storage | | |
| | **2.3** | Meetings and Documentation: Notice, Agenda, Minutes | | |
| | **2.4** | Phone and video communication | | |
| | | | | |
| **3** | | **Cross-Cultural Communication** | R-2,4 | 3 |
| | **3.1** | Cultural awareness | | |
| | **3.2** | Language barriers | | |
| | **3.3** | Global communication strategies | | |
| | **3.4** | Corporate etiquettes | | |
| | | | | |
| **4** | | **Corporate Identity and Branding** | R-5 | 3 |
| | **4.1** | Corporate image and reputation | | |
| | **4.2** | Branding strategies | | |
| | **4.3** | Visual identity | | |
| | **4.4** | Messaging and tone | | |
| | **4/5** | Cultural context of branding | | |
| **Total** | | | | **15** |

**Assessment:**

| Sr. No. | List of Written and Oral Assignments | ISE | Marks |
|---|---|---|---|
| 1 | Resume/ Cover Letter | ISE1 | 10 |
| 2 | GD Practices | | 10 |
| 3 | Mock Interview HR Question | | 10 |
| 4 | Team Building Activity | | 10 |
| 5 | Notice & Agenda and Minutes of the Meeting | | 10 |
| 6 | Formal presentation | ISE2 | 10 |
| 7 | GD Practices | | 20 |
| 8 | Mock Interview HR Question | | 20 |
| | Total (Average) | | 100 |

**Recommended Textbooks:**

1) Dr. K.Alex, Soft Skills- Know Yourself & know the World, S.Chand
2) John Hayes, Interpersonal Skills at Work, McGraw Hill Education
3) Ankur Malhotra,Campus Placement: A Comprehensive Guide, McGraw Hill Education
4) Meenakshi Raman,Sangeeta Sharma, Communication Skills, Oxford, India
5) Courtland L. Bovee, Business Communication Today, Pearson

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25VSE13ME04 | Measurements and Systems Lab | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | **Practical** | **20** | **--** | **30** | **--** | **50** | |

| Pre-requisite Course Codes | None | |
|---|---|---|
| Course Outcomes | CO1 | Able to use linear and angular measuring instruments. |
| | CO2 | Understand and use the slip gauges. |
| | CO3 | Able to use the optical profilometer. |
| | CO4 | Perform flatness testing using principle of interference. |
| | CO5 | Able to use the mechanical comparator to accept or reject a sample. |

| Sr. No. | Experiments Details | Hours |
|---|---|---|
| 1 | Measurement of linear dimensions using vernier caliper. | 3 |
| 2 | Measurement of linear dimensions using micrometer. | 3 |
| 3 | Setting of dimensions using slip gauges by wringing process. | 2 |
| 4 | Measurement of small dimensions by Optical Profile Projector. | 4 |
| 5 | Identification of surface flatness defects using principle of interferometry by optical flats and monochromatic light. | 4 |
| 6 | Measurement of components deviations with respect to standard using mechanical comparator. | 4 |
| | **Total** | **20** |

**Course Assessment:**

**Laboratory work:**

**ISE-1 (20 marks)**
Submission of the observations made during the lab performance for the first 3 experiments covered during this assessment duration. Assessment will be based on pre-defined rubrics.

**ISE-2 (30 marks)**
Submission of the observations made during the lab performance for the last 3 experiments covered during this assessment duration. Assessment will be based on pre-defined rubrics (20 marks).

Lab interaction: (10 marks)

**Reference Books:**

1. Engineering. Metrology, I.C. Gupta, Dhanpat Rai Publications.
2. Engineering. Metrology, 22nd edition, R. K. Jain, Khanna Publisher, (2022).
3. Statistical quality Control, 2nd edition, Mahajan M., Dhanpat Rai & Sons, Delhi (2015).
4. Quality Control, 3rd edition, D. H. Besterfield, Pearson Education (2012).
5. Understanding and Implementing ISO 9000 and ISO Standards, 2nd edition, David L. Goetsch, Stanley Davis, Prentice Hall.

| Course Code | Course Name | Teaching Scheme (Hrs/week) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| 25VSE13ME05 | CNC Lab | L | T | P | L | T | P | Total |
| | | -- | -- | 2 | -- | -- | 1 | 1 |
| | | Examination Scheme | | | | | | |
| | | | ISE1 | MSE | ISE2 | ESE | Total | |
| | | Theory | -- | -- | -- | -- | -- | |
| | | Practical | 20 | -- | 30 | -- | 50 | |

| Pre-requisite Course Codes | CAD Modelling. | |
|---|---|---|
| Course Outcomes | CO1 | Develop and execute part programming for CNC Turning Trainer to fabricate components |
| | CO2 | Develop and execute part programming for CNC Milling Trainer to fabricate components |
| | CO3 | Demonstrate CAM Tool path and prepare NC- G code. |
| | CO4 | Analyze and document the design features, preprocessing in CAM software, and capabilities of a commercial CNC machining center. |

| Sr. No | Topics | Hr |
|---|---|---|
| 1 | Part programming and part fabrication on CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.)<br>(One job in a group of 4-5 students) | 6 |
| 2 | Part programming and part fabrication on CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.)<br>(One job in a group of 4-5 students) | 6 |
| 3 | Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems. | 6 |
| 4 | Post processing of Code generated via CAM system . | 5 |
| 5 | Case Study: Report on a visit conducted to any Commercial CNC Machining Centre explaining the Design features, pre processing in CAM software and its capabilities. | 4 |
| Total | | 26 |

**Course Assessment:**

**Laboratory:**
**ISE-1: (20 Marks)**
Experiments 1 to 2
Continuous pre-defined rubrics-based evaluation for 20 marks.
**ISE-2: (30 Marks)**
Experiments 3 to 5

i. Continuous pre-defined rubrics-based evaluation for 20 marks.
ii. Lab interaction (10 marks).

**Recommended Books:**

1. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
2. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
3. CNC Programming for Machining, Kaushik Kumar, ChikeshRanjan, J. Paulo Davim, Springer Publication.