### III SEMESTER

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<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Hours /Week</th>
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<td>Engineering Mathematics – III</td>
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### IV SEMESTER

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## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

**CHOICE BASED CREDIT SYSTEM (CBCS)**

**SCHEME OF TEACHING AND EXAMINATION 2015-2016**

**B.E. Mechanical Engineering**

### V SEMESTER

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Subject Code</th>
<th>Title</th>
<th>Lecture</th>
<th>Tutorial</th>
<th>Practical</th>
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<th>Theory/Practical Marks</th>
<th>I.A. Marks</th>
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### Professional Elective-I

- 15ME551 Refrigeration and Air-conditioning
- 15ME552 Theory of Elasticity
- 15ME553 Human Resource Management
- 15ME554 Non Traditional Machining

### Open Elective-I

- 15ME561 Optimization Techniques
- 15ME562 Energy and Environment
- 15ME563 Automation and Robotics
- 15ME564 Project Management

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch
3. **Open Elective:** Electives from other technical and/or emerging subject areas.
### B.E. Mechanical Engineering

#### VI SEMESTER

<table>
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<th>Title</th>
<th>Lecture</th>
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<th>Theory/Practical Marks</th>
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**Professional Elective-II**

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<td>15ME652</td>
<td>Mechanics of Composite Materials</td>
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<td>15ME653</td>
<td>Metal Forming</td>
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<td>15ME654</td>
<td>Tool Design</td>
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**Open Elective-II**

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<td>Industrial Safety</td>
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<td>15ME663</td>
<td>Maintenance Engineering</td>
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<tr>
<td>15ME664</td>
<td>Total Quality Management</td>
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1. **Core subject**: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective**: Elective relevant to chosen specialization/branch
3. **Open Elective**: Electives from other technical and/or emerging subject areas.
### VII Semester

**B.E. Mechanical Engineering**

<table>
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### Professional Elective - III
- 15ME741 Design of Thermal Equipments
- 15ME742 Tribology
- 15ME743 Financial Management
- 15ME744 Design for Manufacturing
- 15ME745 Smart Materials & MEMS

### Professional Elective - IV
- 15ME751 Automotive Electronics
- 15ME752 Fracture Mechanics
- 15ME753 Human Resource Management
- 15ME754 Mechatronics
- 15ME755 Advanced Vibrations

1. **Core Subject**: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. **Professional Elective**: Elective relevant to chosen specialization/branch
### VIII SEMESTER

**B.E. Mechanical Engineering**

<table>
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**Professional Elective-V**

- 15ME831  Cryogenics
- 15ME832  Experimental Stress Analysis
- 15ME833  Theory of Plasticity
- 15ME834  Green Manufacturing
- 15ME835  Product life cycle management

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. **Professional Elective:** Elective relevant to chosen specialization/ branch

3. **Internship / Professional Practice:** To be carried out between 6th & 7th semester vacation or 7th & 8th semester vacation.
VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SYLLABUS FOR 2015 -2019

ENGINEERING MATHEMATICS-III
(Common to all Branches)

Course Title: Engineering Mathematics - III
Course Code: 15MAT31
Credits: 04
L-T-P : 4-0-0
Contact Hours/Week : 04
Total Hours: 50
Exam. Marks : 80
IA Marks : 20
Exam. Hours : 03

Course Objectives:
The objectives of this course is to introduce students to the mostly used analytical and numerical methods in the different engineering fields by making them to learn Fourier series, Fourier transforms and Z-transforms, statistical methods, numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variations.

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<thead>
<tr>
<th>MODULE</th>
<th>RBT Levels</th>
<th>No. of Hrs</th>
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<td>MODULE-I</td>
<td>L1, L2 &amp; L4</td>
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<tr>
<td>Fourier Series: Periodic functions, Dirichlet’s condition, Fourier Series of periodic functions with period $2\pi$ and with arbitrary period $2c$. Fourier series of even and odd functions. Half range Fourier Series, practical harmonic analysis-Illustrative examples from engineering field.</td>
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<tr>
<td>MODULE-II</td>
<td>L2, L3 &amp; L4</td>
<td>10</td>
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<tr>
<td>Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transform.</td>
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<tr>
<td>Z-transform: Difference equations, basic definition, $z$-transform-definition, Standard $z$-transforms, Damping rule, Shifting rule, Initial value and final value theorems (without proof) and problems, Inverse $z$-transform. Applications of $z$-transforms to solve difference equations.</td>
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<td>L3</td>
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<tr>
<td>Curve Fitting: Curve fitting by the method of least squares- fitting of the curves of the form, $y = ax + b, y = ax^2 + bx + c$ and $y = ae^{bx}$. Numerical Methods: Numerical solution of algebraic and transcendental equations by Regula- Falsi Method and Newton-Raphson method.</td>
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<tr>
<td>MODULE IV</td>
<td>L3</td>
<td>10</td>
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<tr>
<td>Finite differences: Forward and backward differences, Newton’s forward and backward interpolation formulae. Divided differences- Newton’s divided difference formula. Lagrange’s interpolation formula and inverse interpolation formula (all formulae without proof)-Problems.</td>
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<tr>
<td>Numerical integration: : Simpson’s $(1/3)^{th}$ and $(3/8)^{th}$ rules, Weddle’s rule (without proof ) –Problems.</td>
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<tr>
<td>MODULE-V</td>
<td>L3 &amp; L4</td>
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<tr>
<td>Vector integration:</td>
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<tr>
<td>Line integrals-definition and problems, surface and volume integrals-definition, Green’s theorem in a plane, Stokes and Gauss-divergence theorem(without proof) and problems.</td>
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<tr>
<td>Calculus of Variations: Variation of function and Functional, variational problems. Euler’s equation, Geodesics, hanging chain, problems.</td>
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</table>
**Course Outcomes:** On completion of this course, students are able to:

1. Know the use of periodic signals and Fourier series to analyze circuits and system communications.
2. Explain the general linear system theory for continuous-time signals and digital signal processing using the Fourier Transform and z-transform.
3. Employ appropriate numerical methods to solve algebraic and transcendental equations.
4. Apply Green's Theorem, Divergence Theorem and Stokes' theorem in various applications in the field of electro-magnetic and gravitational fields and fluid flow problems.
5. Determine the extremals of functionals and solve the simple problems of the calculus of variations.

**Question paper pattern:**
- The question paper will have **ten** full questions carrying equal marks.
- Each full question consisting of **16** marks.
- There will be **two** full questions (with a maximum of **four** sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer **five** full questions, selecting **one** full question from each module.

**Graduate Attributes (as per NBA)**
1. Engineering Knowledge
2. Problem Analysis
3. Life-Long Learning
4. Accomplishment of Complex Problems

**Text Books:**

**Reference books:**

**We links and Video Lectures:**
1. [http://nptel.ac.in/courses.php?disciplineID=111](http://nptel.ac.in/courses.php?disciplineID=111)
MATERIAL SCIENCE
[AS PER CHOICE ASEED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
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<td>15 ME 32</td>
<td>20</td>
<td>04</td>
<td>80</td>
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</tr>
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</table>

CREDITS – 04

COURSE OBJECTIVES:
This course provides
1. The foundation for understanding the structure and various modes of failure in materials common in mechanical engineering.
2. Topics are designed to explore the mechanical properties of metals and their alloys, polymers, ceramics, smart materials and composites.
3. The means of modifying such properties, as well as the processing and failure of materials.
4. Concepts of use of materials for various applications are highlighted.

COURSE OUTCOMES:
The student shall be able to
1. Describe the mechanical properties of metals, their alloys and various modes of failure.
2. Understand the microstructures of ferrous and non-ferrous materials to mechanical properties.
3. Explain the processes of heat treatment of various alloys.
4. Understand the properties and potentialities of various materials available and material selection procedures.
5. Know about composite materials and their processing as well as applications.

MODULE 1
Basics, Mechanical Behavior, Failure of Materials
Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures, Crystal imperfections – point, line, surface and volume imperfections, Atomic Diffusion: Phenomenon, Fick’s laws of diffusion; Factors affecting diffusion.

Mechanical Behavior:
Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains, Linear and non-linear elastic behavior and properties, Mechanical properties in plastic range. Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals

Fracture: Type I, Type II and Type III,
Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties, S-N diagram, Fatigue testing.
Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness, numerical on diffusion, strain and stress relaxation

10 Hours

MODULE 2
Alloys, Steels, Solidification

10 Hours
MODULE 3
Heat Treatment, Ferrous and Non-Ferrous Alloys

MODULE 4
Other Materials, Material Selection
Ceramics: Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics.
Plastics: Various types of polymers/plastics and their applications. Mechanical behaviors and processing of plastics, Failure of plastics.
Other materials: Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials, piezo-electrics, shape memory alloys Shape Memory Alloys – Nitinol, superelasticity, Biological applications of smart materials - materials used as implants in human Body, Selection of Materials, Performance of materials in service Residual life assessment – use of non-destructive testing, Economics, Environment and Sustainability 10 Hours

MODULE 5
Composite Materials
Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber-reinforced composites, Fundamentals of production of composites, Processes for production of composites, Characterization of composites, Constitutive relations of composites, Determination of composite properties from component properties, Hybrid composites, Applications of composite materials, Numericals on determining properties of composites 10 Hours

TEXT BOOKS:

REFERENCE BOOKS
1. V.Raghavan, Materials Science and Engineering, PHI, 2002
4. ASM Handbooks, American Society of Metals.

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
BASIC THERMODYNAMICS
[AS PER CHOICEASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – III

<table>
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<table>
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<th>Total Number of Lecture Hrs</th>
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<tbody>
<tr>
<td>50</td>
<td>03</td>
</tr>
</tbody>
</table>

CREDITS – 04

COURSE OBJECTIVES
1. Learn about thermodynamic systems and boundaries
2. Study the basic laws of thermodynamics including, conservation of mass, conservation of energy or first law, second law and Zeroth law.
3. Understand various forms of energy including heat transfer and work
4. Identify various types of properties (e.g., extensive and intensive properties)
5. Use tables, equations, and charts in evaluation of thermodynamic properties
6. Apply conservation of mass, first law, and second law in thermodynamic analysis of systems (e.g., turbines, pumps, compressors, heat exchangers, etc.)
7. Enhance their problem solving skills in thermal engineering

COURSE OUTCOMES
The student will be able to

<table>
<thead>
<tr>
<th>Course Outcomes</th>
<th>PO's</th>
<th>Course Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 1 Explain thermodynamic systems, properties, Zeroth law of thermodynamics, temperature scales and energy interactions.</td>
<td>PO1</td>
<td>U</td>
</tr>
<tr>
<td>CO 2 Determine heat, work, internal energy, enthalpy for flow &amp; non flow process using First and Second Law of Thermodynamics.</td>
<td>PO1, PO2</td>
<td>Ap</td>
</tr>
<tr>
<td>CO3 Interpret behavior of pure substances and its applications to practical problems.</td>
<td>PO1, PO2</td>
<td>U</td>
</tr>
<tr>
<td>CO4 Determine change in internal energy, change in enthalpy and change in entropy using TD relations for ideal gases.</td>
<td>PO1, PO2</td>
<td>Ap</td>
</tr>
<tr>
<td>CO 5 Calculate Thermodynamics properties of real gases at all ranges of pressure, temperatures using modified equation of state including Vander Waals equation, Redlich Wong equation and Beattie-Bridgeman equation.</td>
<td>PO1, PO2</td>
<td>Ap</td>
</tr>
</tbody>
</table>

Total Number Lecture hours 50

MODULE 1
Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume. Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer

Work and Heat: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through P-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems 10 Hours
MODULE 2
First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non-cyclic processes, energy, energy as a property, modes of energy, Extension of the First law to control volume; steady flow energy equation(SFEE), important applications.
Second Law of Thermodynamics: limitations of first law of thermodynamics Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir, Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Problems 10 Hours

MODULE 3
Reversibility: Definitions of a reversible process, reversible heat engine, importance and superiority of a reversible heat engine and irreversible processes; factors that make a process irreversible, reversible heat engines. Unresisted expansion, remarks on Carnot’s engine, internal and external reversibility, Definition of the thermodynamic temperature scale. Problems
Entropy: Clausius inequality, Statement-proof, Entropy-definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, , calculation of entropy using Tds relations, entropy as a coordinate. 10 Hours

MODULE 4
Availability, Irreversibility and General Thermodynamic relations. Introduction, Availability (Exergy), Unavailable energy (anergy), Relation between increase in unavailable energy and increase in entropy. Maximum work, maximum useful work for a system and control volume, irreversibility, second law efficiency (effectiveness). Gibbs and Helmholtz functions, Maxwell relations, Clapeyron equation, Joule Thomson coefficient, general relations for change in entropy, enthalpy, internal energy and specific heats.
Pure Substances: P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter. 10 Hours

MODULE 5
Ideal gases: Ideal gas mixtures, Daltons law of partial pressures, Amagat’s law of additive volumes, evaluation of properties of perfect and ideal gases,
Air- Water mixtures and related properties, Psychrometric properties, Construction and use of Psychrometric chart.
Real gases – Introduction, Air water mixture and related properties, Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Redlich and Kwong equation of state Beattie-Bridgeman equation, Law of corresponding states, compressibility factor; compressibility chart. Difference between Ideal and real gases. 10 Hours

TEXT BOOKS:

REFERENCE BOOKS:
2. Engineering Thermodynamics, J.B.Jones and G.A.Hawkins, John Wiley and Sons..
4. An Introduction to Thermodynamics, Y.V.C.Rao, Wiley Eastern, 1993,
5. B.K Venkanna, Swati B. Wadavadagi “Basic Thermodynamics, PHI, New Delhi, 2010

Scheme of Examination: Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
COURSE OBJECTIVES:
1. Classify the stresses into various categories and define elastic properties of materials and compute stress and strain intensities caused by applied loads in simple and compound sections and temperature changes.
2. Derive the equations for principal stress and maximum in-plane shear stress and calculate their magnitude and direction. Draw Mohr circle for plane stress system and interpret this circle.
3. Determine the shear force, bending moment and draw shear force and bending moment diagrams, describe behavior of beams under lateral loads.
4. Explain the structural behavior of members subjected to torque, Calculate twist and stress induced in shafts subjected to bending and torsion.
5. Understand the concept of stability and derive crippling loads for columns.
6. Understand the concept of strain energy and compute strain energy for applied loads.

COURSE OUTCOMES:
The student shall be able to

<table>
<thead>
<tr>
<th>Course Outcomes</th>
<th>POs</th>
<th>CL</th>
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<tbody>
<tr>
<td>CO1 Understand simple, compound, thermal stresses and strains their relations, Poisson's ratio, Hooke's law, mechanical properties including elastic constants and their relations</td>
<td>PO1</td>
<td>U</td>
</tr>
<tr>
<td>CO2 Determine stresses, strains and deformations in bars with varying circular and rectangular cross-sections subjected to normal and temperature loads</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO3 Determine plane stress, principal stress, maximum shear stress and their orientations using analytical method and Mohr’s circle</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO4 Determine the dimensions of structural members including beams, bars and rods using Energy methods and also stress distribution in thick and thin cylinders</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO5 Draw SFD and BMD for different beams including cantilever beams, simply supported beams and overhanging beams subjected to UDL, UVL, Point loads and couples</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO6 Determine dimensions, bending stress, shear stress and its distribution in beams of circular, rectangular, symmetrical I and T sections subjected to point loads and UDL</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO7 Determine slopes and deflections at various points on beams subjected to UDL, UVL, Point loads and couples</td>
<td>PO1, Ap</td>
<td></td>
</tr>
<tr>
<td>CO8 Determine the dimensions of shafts based on torsional strength, rigidity and flexibility and also elastic stability of columns using Rankin’s and Euler’s theory</td>
<td>PO1, Ap</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours of instruction 50

MODULE 1
**Stress and Strain:** Introduction, Hooke’s law, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson’s ratio, Generalized Hooke’s law, Bulk modulus, Relationship between elastic constants. 10 Hours

MODULE 2
**Analysis of Stress and Strain:** Plane stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear stress, Mohr circle for plane stress conditions.

MODULE 3
Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads and uniformly distributed constant / varying loads.
Stress in Beams: Pure bending, Curvature of a beam, Longitudinal strains in beams, Normal stresses in Beams with rectangular, circular, ‘I’ and ‘T’ cross sections, Flexure Formula, Bending Stresses, Deflection of beams (Curvature).

MODULE 4
Torsion: Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections
Columns: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, Secant formula for columns.

MODULE 5
Strain Energy: Castigliano’s theorem I and II, Load deformation diagram, Strain energy due to normal stresses, Shear stresses, Modulus of resilience, Strain energy due to bending and torsion.
Theories of Failure: Maximum Principal stress theory, Maximum shear stress theory.

TEXT BOOKS:

REFERENCE BOOKS:

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
METAL CASTING AND WELDING
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

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CREDITS – 04

COURSE OBJECTIVE
- To provide detailed information about the moulding processes.
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of various joining process used in manufacturing.
- To provide adequate knowledge of quality test methods conducted on welded and casted components.

COURSE OUTCOMES

<table>
<thead>
<tr>
<th>CO No.</th>
<th>Course Outcomes</th>
<th>Blooms level</th>
<th>PO</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Describe the casting process, preparation of Green, Core, dry sand molds and Sweep, Shell, Investment and plaster molds.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO2</td>
<td>Explain the Pattern, Core, Gating, Riser system and Jolt, Squeeze, Sand Slinger Molding Machines.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO3</td>
<td>Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO4</td>
<td>Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO5</td>
<td>Explain the Solidification process and Casting of Non-Ferrous Metals.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes used in manufacturing.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO7</td>
<td>Explain the Resistance spot, Seam, Butt, Projection, Friction, Explosive, Thermit, Laser and Electron Beam Special type of welding process used in manufacturing.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO8</td>
<td>Describe the Metallurgical aspects in Welding and inspection methods for the quality assurance of components made of casting and joining process.</td>
<td>U</td>
<td>PO1</td>
</tr>
</tbody>
</table>

Total Hours of instruction: 50

MODULE -1
INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY
Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.
Introduction to casting process & steps involved. Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.
Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types
Preparation of sand molds: Molding machines- Jolt type, squeegee type and Sand slinger. Study of important molding process: Green sand, core sand, dry sand, sweep mold, CO2 mold, shell mold, investment mold, plaster mold, cement bonded mold. Cores: Definition, need, types. Method of making cores, concept of gating (top, bottom, parting line, horn gate) and risering (open, blind) Functions and types

MODULE -2
MELTING & METAL MOLD CASTING METHODS
Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.
Casting using metal molds: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes

10 Hours
MODULE -3
SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE
Solidification: Definition, Nucleation, solidification variables, Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods.
Fettling and cleaning of castings: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process
Nonferrous foundry practice: Aluminum castings - Advantages, limitations, melting of aluminum using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.

MODULE -4
WELDING PROCESS

MODULE -5
SOLDERING, BRAZING AND METALLURGICAL ASPECTS IN WELDING
Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ. Effect of carbon content on structure and properties of steel, Shrinkage in welds & Residual stresses, Concept of electrodes, filler rod and fluxes. Welding defects- Detection, causes & remedy.

TEXT BOOKS:

REFERENCE BOOKS:

Question paper pattern:
- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be 2 full questions (with a maximum of 4 sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.
MACHINE TOOLS AND OPERATIONS
[AS PER CHOICEASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
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<td>80</td>
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CREDITS – 04

COURSE OBJECTIVES:
- To introduce students to different machine tools in order to produce components having different shapes and sizes.
- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To develop the knowledge on mechanics of machining process and effect of various parameters on economics of machining.

COURSE OUTCOMES:
- Explain the construction & specification of various machine tools.
- Describe various machining processes pertaining to relative motions between tool & work piece.
- Discuss different cutting tool materials, tool nomenclature & surface finish.
- Apply mechanics of machining process to evaluate machining time.
- Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.

MODULE 1
MACHINE TOOLS
Introduction, Classification, construction and specifications of lathe, drilling machine, milling machine, boring machine, broaching machine, shaping machine, planing machine, grinding machine [Simple sketches showing major parts of the machines] 10 hours

MODULE 2
MACHINING PROCESSES
Introduction, Types of motions in machining, turning and Boring, Shaping, Planing and Slotting, Thread cutting, Drilling and reaming, Milling, Broaching, Gear cutting and Grinding, Machining parameters and related quantities. [Sketches pertaining to relative motions between tool and work piece only] 10 Hours

MODULE 3
CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH
Introduction, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish. Machining equations for cutting operations: Turning, Shaping, Planing, slab milling, cylindrical grinding and internal grinding, Numerical Problems 10 Hours

MODULE 4
MECHANICS OF MACHINING PROCESSES
Introduction, Chip formation, Orthogonal cutting, Merchants model for orthogonal cutting, Oblique cutting, Mechanics of turning process, Mechanics of drilling process, Mechanics of milling process, Numerical problems 10 Hours

MODULE 5
TOOL WEAR, TOOL LIFE: Introduction, tool wear mechanism, tool wear equations, tool life equations, effect of process parameters on tool life, machinability, Numerical problems
ECONOMICS OF MACHINING PROCESSES: Introduction, choice of feed, choice of cutting speed, tool life for minimum cost and minimum production time, machining at maximum efficiency, Numerical problems 10 Hours
TEXT BOOKS:

REFERENCE BOOKS:

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
COMPUTER AIDED MACHINE DRAWING
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]

<table>
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<td>20</td>
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<td>80</td>
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CREDITS – 04

COURSE OBJECTIVES
- To acquire the knowledge of CAD software and its features.
- To inculcate understanding of the theory of projection and make drawings using orthographic projections and sectional views.
- To familiarize the students with Indian Standards on drawing practices.
- To impart knowledge of thread forms, fasteners, keys, joints and couplings.
- To make the students understand and interpret drawings of machine components so as to prepare assembly drawings either manually and using CAD packages.
- To acquire the knowledge of limits fits and tolerance pertaining to machine drawings.

COURSE OUTCOMES
Having successfully completed this course, the student will be able to draw and use modelling software’s to generate

<table>
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<tr>
<th>Course Outcome</th>
<th>Cognitive Level</th>
<th>POs</th>
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<tbody>
<tr>
<td>CO1 Sections of pyramids, prisms, cubes, cones and cylinders resting on their bases in 2D</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO2 Orthographic views of machine parts with and without sectioning in 2D.</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO3 Sectional views for threads with terminologies of ISO Metric, BSW, square and acme, sellers and American standard threads in 2D.</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO4 Hexagonal and square headed bolt and nut with washer, stud bolts with nut and lock nut, flanged nut, slotted nut, taper and split pin for locking counter sunk head screw, grub screw, Allen screw assemblies in 2D.</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO5 Parallel key, Taper key, and Woodruff Key as per the ISO standards in 2D</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO6 single and double riveted lap joints, butt joints with single/double cover straps, cotter and knuckle joint for two rods in 2D</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO7 Sketch split muff, protected type flanged, pin type flexible, Oldham’s and universal couplings in 2D</td>
<td>U</td>
<td>PO1, PO5,</td>
</tr>
<tr>
<td>CO8 assemblies from the part drawings with limits, fits and tolerance given for Plummer block, Ram bottom safety valve, I.C. Engine connecting rod, Screw Jack, Tailstock of lathe, Machine Vice and Lathe square tool post in 2D and 3D</td>
<td>U</td>
<td>PO1, PO5, PO12</td>
</tr>
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</table>

Total Hours of instruction 50
INTRODUCTION TO COMPUTER AIDED SKETCHING
Review of graphic interface of the software. Review of basic sketching commands and navigational commands.

02 Hours

PART A

UNIT I
Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on, axis inclinations, spheres and hollow solids), True shape of section.
Orthographic views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings), Hidden line conventions, Precedence of lines.

04 Hours

UNIT II
Thread forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal and External), square, Acme and Sellers thread, American Standard thread.
Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.

04 Hours

UNIT III
Keys and Joints: Parallel, Taper, Feather Key, Gib head key and Woodruff key
Riveted joints: Single and double riveted lap joints, Butt joints with single/double cover straps (Chain and zigzag using snap head riveters).
Joints: Cotter joint (socket and spigot), Knuckle joint (pin joint) for two rods.

08 Hours

UNIT IV
Couplings: Split muff coupling, Protected type flange coupling, Pin (bush) type flexible coupling, Oldham’s coupling and Universal coupling (Hook’s Joint).

06 Hours

PART B

UNIT III
Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Types of fits with symbols and applications, Geometrical tolerances on drawings, Standards followed in industry.

03 Hours

Assembly Drawings: (Part drawings shall be given)
1. Plummer block (Pedestal Bearing)
2. Rams Bottom Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Lathe square tool post

15 Hours

TEXT BOOKS:

REFERENCE BOOK:
Note:

Internal Assessment: 20 Marks
Sketches shall be in sketch books and drawing shall through use of software on A3/A4 sheets. Sketch book and all the drawing printouts shall be submitted.

Scheme of Evaluation for Internal Assessment (20 Marks)
(a) Class work (Sketching and Computer Aided Machine drawing printouts in A4/A3 size sheets): 10 Marks.
(b) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests): 10 marks.

Scheme of Examination:
Two questions to be set from each Part A, part B and Part C.
Student has to answer one question each from Part A, Part B for 15 marks each and one question from Part C for 50 marks.

<table>
<thead>
<tr>
<th>Part</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A 1 x 15</td>
<td>15</td>
</tr>
<tr>
<td>Part B 1 x 15</td>
<td>15</td>
</tr>
<tr>
<td>Part C 1 x 50</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>

INSTRUCTION FOR COMPUTER AIDED MACHINE DRAWING (15ME36A/46A) EXAMINATION
1. No restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.
2. It is desirable to do sketching of all the solutions before computerization.
3. Drawing instruments may be used for sketching.
4. For Part A and Part B 2D drafting environment should be used.
5. For Part C 3D part environment should be used for parts assembly drawing and extract 2D views.
MECHANICAL MEASUREMENTS AND METROLOGY
[AS PER CHOICE ASEd CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – III / IV

| Subject Code | 15 ME 36 B / 46B | IA Marks | 20 |
| Number of Lecture Hrs / Week | 04 | Exam Marks | 80 |
| Total Number of Lecture Hrs | 50 | Exam Hours | 03 |

CREDITS – 03

COURSE OBJECTIVES
Students are expected to –
- Understand metrology, its advancements & measuring instruments,
- Acquire knowledge on different standards of length, calibration of End Bars, linear and angular measurements, Screw thread and gear measurement & comparators.
- Equip with knowledge of limits, fits, tolerances and gauging.
- Acquire knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying and terminating devices.
- Understand the measurement of Force, Torque, Pressure, Temperature and Strain.

COURSE OUTCOMES
At the end of the course students will be able to –

<table>
<thead>
<tr>
<th>Description</th>
<th>CL</th>
<th>POs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 Understand the objectives of metrology, methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO2 Describe slip gauges, wringing of slip gauges and building of slip gauges, angle measurement using sine bar, sine center, angle gauges, optical instruments and straightness measurement using Autocollimator.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO3 Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO4 Understand the principle of Johnson Mikrometer, sigma comparator, dial indicator, LVDT, back pressure gauges, Solex comparators and Zeiss Ultra Optimeter</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO5 Describe measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2 – wire, 3 – wire methods, screw thread gauges and tool maker’s microscope.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6 Explain measurement of tooth thickness using constant chord method, addendum comparator methods and base tangent method, composite error using gear roll tester and measurement of pitch, concentricity, run out and involute profile.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO7 Understand laser interferometers and Coordinate measuring machines.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO8 Explain measurement systems, transducers, intermediate modifying devices and terminating devices.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO9 Describe functioning of force, torque, pressure, strain and temperature measuring devices.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
</tbody>
</table>

Total Hours of Instructions 50
MODULE -1
Introduction to Metrology: Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement.
Linear Measurement and angular measurements:
Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112).
Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.

10 Hours

MODULE -2
System of Limits, Fits, Tolerance and Gauging:
Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances.
Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.
Comparators:
Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical-principles, , LVDT, Pneumatic- back pressure gauges, solex comparators and optical comparators- Zeiss ultra-optimeter.

10 Hours

MODULE -3
Measurement of screw thread and gear:
Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope.
Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.
Advances in metrology:
Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructational features, applications.

10 Hours

MODULE -4
Measurement systems and basic concepts of measurement methods:
Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors. Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers.
Intermediate modifying and terminating devices: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs.

10 Hours

MODULE -5
Force, Torque and Pressure Measurement:
Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments. Pressure measurement, principle, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.
Measurement of strain and temperature:
Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.
Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
1. Engineering Metrology and Measurements, Bentley, Pearson Education.

**Scheme of Examination:**
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
MATERIALS TESTING LAB
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>15MEL37A/47A</th>
<th>IA Marks</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Lecture Hrs / Week</td>
<td>01</td>
<td>Exam Marks</td>
<td>80</td>
</tr>
<tr>
<td>No of Practical Hours / Week</td>
<td>02</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

CREDITS – 02

COURSE OBJECTIVES
Students are expected-
1. To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
2. To understand mechanical behavior of various engineering materials by conducting standard tests.
3. To learn material failure modes and the different loads causing failure.
4. To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

COURSE OUTCOMES
At the end of the course, the students will be able to:
1. Acquire experimentation skills in the field of material testing.
2. Develop theoretical understanding of the mechanical properties of materials by performing experiments.
3. Apply the knowledge to analyze a material failure and determine the failure inducing agent/s.
4. Apply the knowledge of testing methods in related areas.
5. Know how to improve structure/behavior of materials for various industrial applications.

PART – A
1. Preparation of specimen for Metallographic examination of different engineering materials.
   To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.

   Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel.
   Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen.


   4. To study the defects of Cast and Welded components using
      Non-destructive tests like:
      a) Ultrasonic flaw detection
      b) Magnetic crack detection
      c) Dye penetration testing.

PART – B

   6. Torsion Test on steel bar.

   7. Bending Test on steel and wood specimens.


   9. To study the wear characteristics of ferrous and non-ferrous materials under different parameters.

   10. Fatigue Test (demonstration only).
Students should make observations on nature of failure and manifestations of failure in each of the experiments apart from reporting values of mechanical properties determined after conducting the tests.

**Scheme of Examination:**

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONE question from part -A:</td>
<td>25</td>
</tr>
<tr>
<td>ONE question from part -B:</td>
<td>40</td>
</tr>
<tr>
<td>Viva -Voice:</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>80</td>
</tr>
</tbody>
</table>
COURSE OBJECTIVES:
1. To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
2. To illustrate the use of various measuring tools measuring techniques.
3. To understand calibration techniques of various measuring devices.

COURSE OUTCOMES
At the end of the course, the students will be able to

<table>
<thead>
<tr>
<th>Description</th>
<th>CL</th>
<th>POs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 To calibrate pressure gauge, thermocouple, LVDT, load cell, micrometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO2 To measure angle using Sine Center/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO3 To demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO4 To measure cutting tool forces using Lathe/Drill tool dynamometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO5 To measure Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth vernier/Gear tooth micrometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6 To measure surface roughness using Tally Surf/ Mechanical Comparator.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
</tbody>
</table>

PART-A: MECHANICAL MEASUREMENTS
1. Calibration of Pressure Gauge
2. Calibration of Thermocouple
3. Calibration of LVDT
4. Calibration of Load cell
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.

PART-B: METROLOGY
1. Measurements using Optical Projector / Toolmaker Microscope.
2. Measurement of angle using Sine Center / Sine bar / bevel protractor
3. Measurement of alignment using Autocollimator / Roller set
4. Measurement of cutting tool forces using
   a) Lathe tool Dynamometer OR
   b) Drill tool Dynamometer.
5. Measurements of Screw thread Parameters using two wire or Three-wire methods.
6. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
7. Measurement of gear tooth profile using gear tooth Vernier /Gear tooth micrometer
8. Calibration of Micrometer using slip gauges
9. Measurement using Optical Flats

Scheme of Examination:

- ONE question from part -A: 25 Marks
- ONE question from part -B: 40 Marks
- Viva -Voice: 15 Marks
- Total: 80 Marks
FOUNDRY AND FORGING LAB
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>Exam Marks</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>15MEL38A</td>
<td>20</td>
<td>80</td>
<td>03</td>
</tr>
</tbody>
</table>

CREDITS – 02

COURSE OBJECTIVES:
- To provide an insight into different sand preparation and foundry equipment’s.
- To provide an insight into different forging tools and equipment’s.
- To provide training to students to enhance their practical skills.
- To practically demonstrate precautions to be taken during casting and hot working.
- To develop team qualities and ethical principles.

COURSE OUTCOMES
Students will be able to
- Demonstrate various skills of sand preparation, molding.
- Demonstrate various skills of forging operations.
- Work as a team keeping up ethical principles.

PART A

1. Testing of Molding sand and Core sand
   Preparation of sand specimens and conduction of the following tests:
   2. Permeability test
   3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand

PART B

2. Foundry Practice
   1. Use of foundry tools and other equipment’s.
   2. Preparation of molding sand mixture.
   3. Preparation of green sand molds using two molding boxes kept ready for pouring.
      - Using patterns (Single piece pattern and Split pattern)
      - Without patterns.
      - Incorporating core in the mold. (Core boxes).
      - Preparation of one casting (Aluminum or cast iron-Demonstration only)

PART C

3. Forging Operations:
   Use of forging tools and other equipment's
   - Calculation of length of the raw material required to prepare the model considering scale loss.
   - Preparing minimum three forged models involving upsetting, drawing and bending operations.
   - Demonstration of forging model using Power Hammer.
**Question paper pattern:**

<table>
<thead>
<tr>
<th>Section</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>One question is to be set from Part-A</td>
<td>15 Marks</td>
</tr>
<tr>
<td>One question is to be set from either Part-B or Part-C</td>
<td>35 Marks</td>
</tr>
<tr>
<td>Calculation of length of the raw material required for forging model is compulsory irrespective of the student preparing part-B or part-C model</td>
<td></td>
</tr>
<tr>
<td>Calculation of length for Forging</td>
<td>10 Marks</td>
</tr>
<tr>
<td>Viva – Voce</td>
<td>20 Marks</td>
</tr>
</tbody>
</table>

**Total** 20 Marks
MACHINE SHOP
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>15MEL38 B</th>
<th>IA Marks</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Lecture Hrs / Week</td>
<td>01</td>
<td>Exam Marks</td>
<td>80</td>
</tr>
<tr>
<td>No of Practical Hours / Week</td>
<td>02</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

CREDITS – 02

COURSE OBJECTIVES

- To provide an insight to different machine tools, accessories and attachments
- To train students into machining operations to enrich their practical skills
- To inculcate team qualities and expose students to shop floor activities
- To educate students about ethical, environmental and safety standards

COURSE OUTCOMES

At the end of the course, the students will be able to

<table>
<thead>
<tr>
<th>COs</th>
<th>Description</th>
<th>CL</th>
<th>POs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Perform turning, facing, knurling, thread cutting, tapering, eccentric</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td></td>
<td>turning and allied operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2</td>
<td>Perform keyways/slots, grooves etc using shaper</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td>CO3</td>
<td>Perform gear tooth cutting using milling machine</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand the formation of cutting tool parameters of single point</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td></td>
<td>cutting tool using bench grinder / tool and cutter grinder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO5</td>
<td>Understand Surface Milling/Slot Milling</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6</td>
<td>Demonstrate precautions and safety norms followed in Machine Shop</td>
<td>U</td>
<td>PO8</td>
</tr>
<tr>
<td>CO7</td>
<td>Exhibit interpersonal skills towards working in a team</td>
<td>U</td>
<td>PO9</td>
</tr>
</tbody>
</table>

PART – A

Preparation of three models on lathe involving
Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.

PART – B

Cutting of V Groove/ dovetail / Rectangular groove using a shaper
Cutting of Gear Teeth using Milling Machine

PART – C

For demonstration
Demonstration of formation of cutting parameters of single point cutting tool using bench grinder / tool & cutter grinder. Demonstration of surface milling /slot milling

One Model from Part – A  40 Marks
One Model from Part – B  20 Marks
Viva – Voce              20 Marks
Total                    80 Marks
Course Title: Engineering Mathematics - IV
Course Code: 15MAT41
Credits: 04
L-T-P: 4-0-0
Contact Hours/Week: 04
Total Hours: 50
Exam. Marks: 80
IA Marks: 20
Exam. Hours: 03

Course Objectives:
The purpose of this course is to make students well conversant with numerical methods to solve ordinary differential equations, complex analysis, sampling theory and joint probability distribution and stochastic processes arising in science and engineering.

<table>
<thead>
<tr>
<th>MODULE</th>
<th>RBT Levels</th>
<th>No. of Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODULE-I</td>
<td>L1 &amp; L2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Numerical Methods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULE-II</td>
<td>L3</td>
<td>10</td>
</tr>
<tr>
<td><strong>Numerical Methods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerical solution of second order ordinary differential equations, Runge-Kutta method and Milne’s method. Special Functions: Series solution-Frobenious method. Series solution of Bessel’s differential equation leading to $J_n(x)$-Bessel’s function of first kind. Basic properties and orthogonality. Series solution of Legendre’s differential equation leading to $P_n(x)$-Legendre polynomials. Rodrigue’s formula, problems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULE-III</td>
<td>L1 &amp; L3</td>
<td>10</td>
</tr>
<tr>
<td><strong>Complex Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review of a function of a complex variable, limits, continuity, differentiability. Analytic functions-Cauchy-Riemann equations in cartesian and polar forms. Properties and construction of analytic functions. Complex line integrals-Cauchy’s theorem and Cauchy’s integral formula, Residue, poles, Cauchy’s Residue theorem (without proof) and problems. Transformations: Conformal transformations, discussion of transformations: $w = z^2$, $w = e^z$, $w = z + (1/z)(z \neq 0)$ and bilinear transformations-problems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODULE-IV</td>
<td>L3</td>
<td>10</td>
</tr>
<tr>
<td><strong>Probability Distributions</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Course Outcomes:** On completion of this course, students are able to:

2. Understand the analyticity, potential fields, residues and poles of complex potentials in field theory and electromagnetic theory.
3. Describe conformal and bilinear transformation arising in aerofoil theory, fluid flow visualization and image processing.
4. Solve problems of quantum mechanics, hydrodynamics and heat conduction by employing Bessel’s function relating to cylindrical polar coordinate systems and Legendre’s polynomials relating to spherical polar coordinate systems.
5. Solve problems on probability distributions relating to digital signal processing, information theory and optimization concepts of stability of design and structural engineering.
6. Draw the validity of the hypothesis proposed for the given sampling distribution in accepting or rejecting the hypothesis.
7. Determine joint probability distributions and stochastic matrix connected with the multivariable correlation problems for feasible random events.
8. Define transition probability matrix of a Markov chain and solve problems related to discrete parameter random process.

**Question paper pattern:**
- The question paper will have **ten** full questions carrying equal marks.
- Each full question consisting of **16** marks.
- There will be **two** full questions (with a maximum of **four** sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer **five** full questions, selecting **one** full question from each module.

**Graduate Attributes (as per NBA)**
1. Engineering Knowledge
2. Problem Analysis
3. Life-Long Learning
4. Accomplishment of Complex Problems

**Text Books:**

**Reference books:**

**Web links and Video Lectures:**
1. [http://nptel.ac.in/courses.php?disciplineID=111](http://nptel.ac.in/courses.php?disciplineID=111)
KINEMATICS OF MACHINES

Subject Code : 15ME42                   IA Marks : 20
Hours/Week : 04               Exam Hours : 03
Total Hours : 50             Exam Marks : 80

Course objectives

Students will

1. Familiarize with mechanisms and motion analysis of mechanisms.
2. Understand methods of mechanism motion analysis and their characteristics.
3. Analyse motion of planar mechanisms, gears, gear trains and cams.

Course outcomes

Students will be able to

1. Identify mechanisms with basic understanding of motion.
2. Comprehend motion analysis of planar mechanisms, gears, gear trains and cams.
3. Carry out motion analysis of planar mechanisms, gears, gear trains and cams.

MODULE - 1
Introduction: Definitions: Link, kinematic pairs, kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classification of pairs based on type of relative motion, Grubler's criterion, mobility of mechanism, Groshoff’s criteria, inversions of Grashoff’s chain.
Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Oldham’s coupling, Straight line motion mechanisms Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms:Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism.

10 Hours

MODULE - 2
Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Coriolis component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing.
Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method.
Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.

10 Hours
MODULE – 3
Freudenstein’s equation for four bar mechanism and slider crank mechanism.
Function Generation for four bar mechanism.

10 Hours

Module – 4
Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, back lash, condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact


Cams: Types of cams, types of followers. displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, Uniform Acceleration Retradation, Cycloidal motion. Cam profiles: disc cam with reciprocating / oscillating follower having knife-edge, roller and flat-face follower inline and offset.

Analysis of Cams: Analysis of arc cam with flat faced follower.

10 Hours

Graphical Solutions may be obtained either on the Graph Sheets or in the Answer Book itself.

TEXT BOOKS:

REFERENCE BOOKS:
IV - SEMESTER: MECHANICAL ENGINEERING

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Thermodynamics</td>
<td>15ME43</td>
<td>04</td>
<td>3-2-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course learning objectives:

- To have a working knowledge of basic performance of Gas power cycles.
- To Calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy
- To understand and evaluate the performance of steam power cycles their various Engineering applications
- To know how fuel burns and their thermodynamic properties.
- To Understand mechanism of power transfer through belt, rope, chain and gear drives in I C Engines
- To determine performance parameters of refrigeration and air-conditioning systems.
- Evaluate the performance parameters of reciprocating air compressor as a function of receiver pressure.

Module - I


Module –II


10 Hours

Module –III

10 Hours

Module – IV

Refrigeration Cycles: Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Any one case study on cold storage or industrial refrigerator. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, Vapour absorption refrigeration system. Steam jet refrigeration.


10 Hours

Module – V


Steam nozzles: Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.

10 Hours

Course outcomes

Students will be able to

- Apply thermodynamic concepts to analyze the performance of gas power cycles including propulsion systems.
- Evaluate the performance of steam turbine components.
- Understand combustion of fuels and combustion processes in I.C engines including alternate fuels and pollution effect on environment.
- Apply thermodynamic concepts to analyze turbo machines.
- Determine performance parameters of refrigeration and air-conditioning systems.
- Understand the principles and applications of refrigeration systems.
- Analyze air-conditioning processes using the principles of psychrometry and Evaluate cooling and heating loads in an air-conditioning system.
- Understand the working, applications, relevance of air and identify methods for performance improvement.

Text Books:

Reference Books:

E- Learning
- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
IV- SEMESTER: MECHANICAL ENGINEERING

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Mechanics</td>
<td>15ME44</td>
<td>04</td>
<td>3-2-0</td>
<td></td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

Course objectives:

- To have a working knowledge of the basic properties of fluids and understand the continuum approximation
- To Calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy
- To understand the flow characteristic and dynamics of flow field for various Engineering applications
- To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand why designing for minimum loss of energy in fluid flows is so important.
- To discuss the main properties of laminar and turbulent pipe flow and appreciate their differences and the concept of boundary layer theory.
- Understand the concept of dynamic similarity and how to apply it to experimental modeling
- To appreciate the consequences of compressibility in gas flow and understand the effects of friction and heat transfer on compressible flows

MODULE -1

**Basics:** Introduction, Properties of fluids—mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc. Pressure at a point in the static mass of fluid, variation of pressure, Pascal’s law, Absolute, gauge, atmospheric and vacuum pressures. Pressure measurement by simple, differential manometers and mechanical gauges.

**Fluid Statics:** Total pressure and center of pressure for horizontal plane, vertical plane surface, and inclined plane surface submerged in static fluid. Buoyancy, center of buoyancy, meta center and meta centric height. Application in shipping, stability of floating bodies.

10Hrs
MODULE -2

Fluid Kinematics and Dynamics:

**Fluid Kinematics:** Types of Flow - steady, unsteady, uniform, non-uniform, laminar, turbulent, one, two and three dimensional, compressible, incompressible, rotational, irrotational, stream lines, path lines, streak lines, velocity components, convective and local acceleration, velocity potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

**Fluid Dynamics:**

Momentum equation, Impacts of jets - force on fixed and moving vanes, flat and curved. Numericals. Euler’s equation, Integration of Euler’s equation to obtain Bernoulli’s equation, Bernoulli’s theorem, Application of Bernoulli’s theorem such as venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc., related numericals.

12 Hours

MODULE -3

**Laminar and turbulent flow:** Reynolds Number, Entrance flow and Developed flow, Navier-Stokes Equation (no derivation), Laminar flow between parallel plates, Poiseuille equation - velocity profile, Couette flow, Fully developed laminar flow in circular pipes, Hagen - Poiseuille equation, related numericals.

Energy consideration in pipe flow, Loss of Pressure Head due to Fluid Friction, Darcy-Weishach formula, major and minor losses in pipes, Commercial pipe, Colebrook equation, Moody equation/ diagram. Pipes in series, parallel, equivalent pipe, Related Numericals and simple pipe design problems.

10Hrs

MODULE -4

**Flow over bodies:** Development of boundary layer, Prandtl’s boundary layer equations, Blasius solution, laminar layer over a flat plate, boundary layer separation and its control.

Basic concept of Lift and Drag, Types of drag, Co-efficient of drag and lift, streamline body and bluff body, flow around circular bodies and airfoils, Lift and drag on airfoil, Numericals.
Dimensional analysis: Need for dimensional analysis, Dimensions and units, Dimensional Homogeneity and dimensionless ratios, methods of dimensional analysis, Rayleigh’s method, Buckingham Pi theorem, Similitude and Model studies. Numericals.

10Hrs

MODULE -5

Compressible Flows: Introduction, thermodynamic relations of perfect gases, internal energy and enthalpy, speed of sound, pressure field due to a moving source, basic Equations for one-dimensional flow, stagnation and sonic Properties, normal and oblique shocks.

Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications.

08Hrs

Course outcomes:

Students will be able to

- CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior.
- CO2: Understand and apply the principles of pressure, buoyancy and floatation
- CO3: Apply the knowledge of fluid statics, kinematics and dynamics while addressing problems of mechanical and chemical engineering.
- CO4: Understand and apply the principles of fluid kinematics and dynamics.
- CO5: Understand the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.
- CO6: Understand the basic concept of compressible flow and CFD

Text Books:

Reference Books:

E- Learning
- Nptel.ac.in
- VTU, E-learning
- MOOCS
- Open courseware

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
METAL CASTING AND WELDING
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

Subject Code  15 ME 45 A  IA Marks  20
Number of Lecture Hrs / Week  04  Exam Marks  80
Total Number of Lecture Hrs  50  Exam Hours  03

CREDITS – 04

COURSE OBJECTIVE
• To provide detailed information about the moulding processes.
• To provide knowledge of various casting process in manufacturing.
• To impart knowledge of various joining process used in manufacturing.
• To provide adequate knowledge of quality test methods conducted on welded and casted components.

COURSE OUTCOMES

<table>
<thead>
<tr>
<th>CO No.</th>
<th>Course Outcomes</th>
<th>Blooms level</th>
<th>PO</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Describe the casting process, preparation of Green, Core, dry sand molds and Sweep, Shell, Investment and plaster molds.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO2</td>
<td>Explain the Pattern, Core, Gating, Riser system and Jolt, Squeeze, Sand Slinger Molding Machines.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO3</td>
<td>Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO4</td>
<td>Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO5</td>
<td>Explain the Solidification process and Casting of Non-Ferrous Metals.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes used in manufacturing.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO7</td>
<td>Explain the Resistance spot, Seam, Butt, Projection, Friction, Explosive, Thermit, Laser and Electron Beam Special type of welding process used in manufacturing.</td>
<td>U</td>
<td>PO1</td>
</tr>
<tr>
<td>CO8</td>
<td>Describe the Metallurgical aspects in Welding and inspection methods for the quality assurance of components made of casting and joining process.</td>
<td>U</td>
<td>PO1</td>
</tr>
</tbody>
</table>

Total Hours of instruction 50

MODULE - 1
INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY
Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.
Introduction to casting process & steps involved. Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.
Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types
**Preparation of sand molds**: Molding machines- Jolt type, squeeze type and Sand slinger. Study of important molding process: Green sand, core sand, dry sand, sweep mold, CO2 mold, shell mold, investment mold, plaster mold, cement bonded mold. Cores: Definition, need, types. Method of making cores, concept of gating (top, bottom, parting line, horn gate) and risering (open, blind) Functions and types

**MODULE -2**
**MELTING & METAL MOLD CASTING METHODS**
**Melting furnaces**: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.
**Casting using metal molds**: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes

**10 Hours**

**MODULE -3**
**SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE**
**Solidification**: Definition, Nucleation, solidification variables, Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods.
**Fettling and cleaning of castings**: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process
**Nonferrous foundry practice**: Aluminum castings - Advantages, limitations, melting of aluminum using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.

**10 Hours**

**MODULE -4**
**WELDING PROCESS**
**Welding process**: Definition, Principles, Classification, Application, Advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).
**Special type of welding**: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and electron beam welding.

**10 Hours**

**MODULE -5**
**SOLDERING, BRAZING AND METALLURGICAL ASPECTS IN WELDING**
**Structure of welds**: Formation of different zones during welding, Heat Affected Zone (HAZ), Shrinkage in welds&Residual stresses, Concept of electrodes, filler rod and fluxes. Welding defects- Detection, causes & remedy.
**Soldering, brazing, gas welding**: Soldering, Brazing, Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting.
**Inspection methods:** Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection.

10 Hours

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consisting of 16 marks.
- There will be 2 full questions (with a maximum of 4 sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.
COURSE OBJECTIVES:

- To introduce students to different machine tools in order to produce components having different shapes and sizes.
- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To develop the knowledge on mechanics of machining process and effect of various parameters on economics of machining.

COURSE OUTCOMES:

- Explain the construction & specification of various machine tools.
- Describe various machining processes pertaining to relative motions between tool & work piece.
- Discuss different cutting tool materials, tool nomenclature & surface finish.
- Apply mechanics of machining process to evaluate machining time.
- Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.

MODULE 1

MACHINE TOOLS
Introduction, Classification, construction and specifications of lathe, drilling machine, milling machine, boring machine, broaching machine, shaping machine, planing machine, grinding machine [Simple sketches showing major parts of the machines]
10 hours

MODULE 2

MACHINING PROCESSES
Introduction, Types of motions in machining, turning and Boring, Shaping, Planing and Slotting, Thread cutting, Drilling and reaming, Milling, Broaching, Gear cutting and Grinding, Machining parameters and related quantities.
[Sketches pertaining to relative motions between tool and work piece only]
10 Hours

MODULE 3

CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH
Introduction, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish.
Machining equations for cutting operations: Turning, Shaping, Planing, slab milling, cylindrical grinding and internal grinding, Numerical Problems 10 Hours

MODULE 4
MECHANICS OF MACHINING PROCESSES
Introduction, Chip formation, Orthogonal cutting, Merchants model for orthogonal cutting, Oblique cutting, Mechanics of turning process, Mechanics of drilling process, Mechanics of milling process, Numerical problems 10 Hours

MODULE 5
TOOL WEAR, TOOL LIFE: Introduction, tool wear mechanism, tool wear equations, tool life equations, effect of process parameters on tool life, machinability, Numerical problems
ECONOMICS OF MACHINING PROCESSES: Introduction, choice of feed, choice of cutting speed, tool life for minimum cost and minimum production time, machining at maximum efficiency, Numerical problems 10 Hours

TEXT BOOKS:

REFERENCE BOOKS:

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
Course Objectives:

1. To improve the visualisation skills and understand the conventions used in engineering drawing.
2. To inculcate understanding of the theory of projection and make drawings using orthographic projections and sectional views.
3. To impart fundamental knowledge of drawing of different machine parts.
4. To enable the students with concepts of dimensioning and standards related to drawings.
5. To enable the students draw the assembly of various machine components.
6. Recognize to use engineering tools, software for drawing and engage in life long learning.

Course Outcomes: Students will be able to

1. Improve their visualization skills.
2. Understand the theory of projection.
3. Make component drawings.
4. Produce the assembly drawings using part drawings.
5. Engage in life long learning using sketching and drawing as communication tool.

Introduction to Computer Aided Sketching
Review of graphic interface of the software. Review of basic sketching commands and navigational commands.

PART A

Unit I
Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on, axis inclinations, spheres and hollow solids), True shape of section.
Orthographic views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings), Hidden line conventions, Precedence of lines.

Unit II
Thread forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal and External), square, Acme and Sellers thread, American Standard thread.
Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.

PART B

Unit III
Keys and Joints: Parallel, Taper, Feather Key, Gibhead key and Woodruff key
Riveted joints: Single and double riveted lap joints, Butt joints with single/double cover straps (Chain and zigzag using snap head riveters).
Joints: Cotter joint (socket and spigot), Knuckle joint (pin joint) for two rods.

Unit IV
Couplings: Split muff coupling, Protected type flange coupling, Pin (bush) type flexible coupling, Oldham’s coupling and Universal coupling (Hook’s Joint).

PART C

Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Types of fits with symbols and applications, Geometrical tolerances on drawings, Standards followed in industry.

Assembly Drawings: (Part drawings shall be given)
1. Plummer block (Pedestal Bearing)
2. Rams Bottom Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Lathe square tool post

Text Books:

Reference Book :


Note :

Internal Assessment: 20 Marks
Sketches shall be in sketch books and drawing shall through use of software on A3/A4 sheets. Sketch book and all the drawing printouts shall be submitted.

Scheme of Evaluation for Internal Assessment (20 Marks)
(a) Class work (Sketching and Computer Aided Machine drawing printouts in A4/A3 size sheets): 10Marks.
(b) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests): 10 marks.

Scheme of Examination:

Two questions to be set from each PartA, partB and PartC.
Student has to answer one question each from PartA, PartB for 15 marks each and one question from Part C for 50 marks.

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<th>Marks</th>
</tr>
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<tbody>
<tr>
<td>A 1X15</td>
<td>15</td>
</tr>
<tr>
<td>B 1X15</td>
<td>15</td>
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<tr>
<td>C 1X50</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>

INSTRUCTION FOR
COMPUTER AIDED MACHINE DRAWING (15ME36A/46A) EXAMINATION

1. No restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.
2. It is desirable to do sketching of all the solutions before computerization.
3. Drawing instruments may be used for sketching.
4. For Part A and Part B 2D drafting environment should be used.
5. For Part C 3D part environment should be used for parts assembly drawing and extract 2D views.
MECHANICAL MEASUREMENTS AND METROLOGY
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>Number of Lecture Hrs / Week</th>
<th>Exam Marks</th>
<th>Total Number of Lecture Hrs</th>
<th>Exam Hours</th>
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<tbody>
<tr>
<td>15 ME 46B</td>
<td>20</td>
<td>04</td>
<td>80</td>
<td>50</td>
<td>03</td>
</tr>
</tbody>
</table>

CREDITS – 03

COURSE OBJECTIVES
Students are expected to –
• Understand metrology, its advancements & measuring instruments,
• Acquire knowledge on different standards of length, calibration of End Bars, linear and angular measurements, Screw thread and gear measurement & comparators.
• Equip with knowledge of limits, fits, tolerances and gauging.
• Acquire knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying and terminating devices.
• Understand the measurement of Force, Torque, Pressure, Temperature and Strain.

COURSE OUTCOMES
At the end of the course students will be able to –

<table>
<thead>
<tr>
<th>Description</th>
<th>CL</th>
<th>POs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 Understand the objectives of metrology, methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO2 Describe slip gauges, wringing of slip gauges and building of slip gauges, angle measurement using sine bar, sine center, angle gauges, optical instruments and straightness measurement using Autocollimator.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO3 Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO4 Understand the principle of Johnson Mikrokator, sigma comparator, dial indicator, LVDT, back pressure gauges, Solex comparators and Zeiss Ultra Optimeter</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO5 Describe measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2 – wire, 3 – wire methods, screw thread gauges and tool maker’s microscope.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6 Explain measurement of tooth thickness using constant chord method, addendum comparator methods and base tangent method, composite error using gear roll tester and measurement of pitch, concentricity, run out and involute profile.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO7 Understand laser interferometers and Coordinate measuring machines.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO8 Explain measurement systems, transducers, intermediate modifying devices and terminating devices.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
</tbody>
</table>
CO9 Describe functioning of force, torque, pressure, strain and temperature measuring devices. U PO1, PO6

Total Hours of Instructions 50

MODULE -1

Linear Measurement and angular measurements:
Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112). Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.

10 Hours

MODULE -2
System of Limits, Fits, Tolerance and Gauging:
Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.

Comparators:
Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical- principles, , LVDT, Pneumatic- back pressure gauges, solex comparators and optical comparators- Zeiss ultra-optimeter.

10 Hours

MODULE -3
Measurement of screw thread and gear:
Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope.
Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.

Advances in metrology:
Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructional features, applications.

10 Hours
MODULE -4

Measurement systems and basic concepts of measurement methods:
Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors. Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers.

Intermediate modifying and terminating devices: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs.

10 Hours

MODULE -5

Force, Torque and Pressure Measurement:
Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments.Pressure measurement, principle, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

Measurement of strain and temperature:
Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.
Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.

10 Hours

TEXT BOOKS:

REFERENCE BOOKS:
1. Engineering Metrology and Measurements, Bentley, Pearson Education.

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
MATERIALS TESTING LAB
[AS PER CHOICE ASEd CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>15MEL47A</th>
<th>IA Marks</th>
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<tbody>
<tr>
<td>Number of Lecture Hrs / Week</td>
<td>01</td>
<td>Exam Marks</td>
<td>80</td>
</tr>
<tr>
<td>No of Practical Hours / Week</td>
<td>02</td>
<td>Exam Hours</td>
<td>03</td>
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</tbody>
</table>

CREDITS – 02

COURSE OBJECTIVES
Students are expected:
1. To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
2. To understand mechanical behavior of various engineering materials by conducting standard tests.
3. To learn material failure modes and the different loads causing failure.
4. To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

COURSE OUTCOMES
At the end of the course, the students will be able to:
1. Acquire experimentation skills in the field of material testing.
2. Develop theoretical understanding of the mechanical properties of materials by performing experiments.
3. Apply the knowledge to analyze a material failure and determine the failure inducing agent/s.
4. Apply the knowledge of testing methods in related areas.
5. Know how to improve structure/behavior of materials for various industrial applications.

PART – A
1. Preparation of specimen for Metallographic examination of different engineering materials.
   To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.

   Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel. Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen.


4. To study the defects of Cast and Welded components using
   Non-destructive tests like:
   a) Ultrasonic flaw detection
   b) Magnetic crack detection
   c) Dye penetration testing.
PART – B
5. Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
6. Torsion Test on steel bar.
7. Bending Test on steel and wood specimens.
9. To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10. Fatigue Test (demonstration only).

Students should make observations on nature of failure and manifestations of failure in each of the experiments apart from reporting values of mechanical properties determined after conducting the tests.

**Scheme of Examination:**

<table>
<thead>
<tr>
<th></th>
<th>Marks</th>
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</thead>
<tbody>
<tr>
<td>ONE question from part -A:</td>
<td>25</td>
</tr>
<tr>
<td>ONE question from part -B:</td>
<td>40</td>
</tr>
<tr>
<td>Viva -Voice:</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
</tr>
</tbody>
</table>
COURSE OBJECTIVES:
1. To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
2. To illustrate the use of various measuring tools measuring techniques.
3. To understand calibration techniques of various measuring devices.

COURSE OUTCOMES
At the end of the course, the students will be able to

<table>
<thead>
<tr>
<th>Description</th>
<th>CL</th>
<th>POs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1 To calibrate pressure gauge, thermocouple, LVDT, load cell, micrometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO2 To measure angle using Sine Center/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO3 To demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO4 To measure cutting tool forces using Lathe/Drill tool dynamometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO5 To measure Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth vernier/Gear tooth micrometer.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6 To measure surface roughness using Tally Surf/ Mechanical Comparator.</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
</tbody>
</table>

PART-A: MECHANICAL MEASUREMENTS
1. Calibration of Pressure Gauge
2. Calibration of Thermocouple
3. Calibration of LVDT
4. Calibration of Load cell
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.

PART-B: METROLOGY
1. Measurements using Optical Projector / Toolmaker Microscope.
2. Measurement of angle using Sine Center / Sine bar / bevel protractor
3. Measurement of alignment using Autocollimator / Roller set
4. Measurement of cutting tool forces using
   a) Lathe tool Dynamometer OR
   b) Drill tool Dynamometer.
5. Measurements of Screw thread Parameters using two wire or Three-wire methods.
6. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
7. Measurement of gear tooth profile using gear tooth Vernier /Gear tooth micrometer
8. Calibration of Micrometer using slip gauges
9. Measurement using Optical Flats

**Scheme of Examination:**

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<tr>
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</tr>
<tr>
<td>Viva -Voice:</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>80</strong></td>
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</tbody>
</table>
COURSE OBJECTIVES:

- To provide an insight into different sand preparation and foundry equipment’s.
- To provide an insight into different forging tools and equipment’s.
- To provide training to students to enhance their practical skills.
- To practically demonstrate precautions to be taken during casting and hot working.
- To develop team qualities and ethical principles.

COURSE OUTCOMES
Students will be able to

- Demonstrate various skills of sand preparation, molding.
- Demonstrate various skills of forging operations.
- Work as a team keeping up ethical principles.

PART A

1. Testing of Molding sand and Core sand
   Preparation of sand specimens and conduction of the following tests:
   2. Permeability test
   3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand

PART B

2. Foundry Practice
   1. Use of foundry tools and other equipment’s.
   2. Preparation of molding sand mixture.
   3. Preparation of green sand molds using two molding boxes kept ready for pouring.
      - Using patterns (Single piece pattern and Split pattern)
      - Without patterns.
      - Incorporating core in the mold. (Core boxes).
      - Preparation of one casting (Aluminum or cast iron-Demonstration only)

PART C

3. Forging Operations:
   Use of forging tools and other equipment’s
   - Calculation of length of the raw material required to prepare the model considering scale loss.
Preparing minimum three forged models involving upsetting, drawing and bending operations.
Demonstration of forging model using Power Hammer.

**Question paper pattern:**

- One question is to be set from Part-A 15 Marks
- One question is to be set from either Part-B or Part-C 35 Marks
- Calculation of length of the raw material required for forging model is compulsory irrespective of the student preparing part-B or part-C model 10 Marks
- Viva – Voce 20 Marks

Total 20 Marks
MACHINE SHOP
[AS PER CHOICE ASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – III / IV

<table>
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<tr>
<th>Subject Code</th>
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<th>Exam Marks</th>
<th>No of Practical Hours / Week</th>
<th>Exam Hours</th>
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<td>02</td>
<td>03</td>
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</table>

CREDITS – 02

COURSE OBJECTIVES
- To provide an insight to different machine tools, accessories and attachments
- To train students into machining operations to enrich their practical skills
- To inculcate team qualities and expose students to shop floor activities
- To educate students about ethical, environmental and safety standards

COURSE OUTCOMES
At the end of the course, the students will be able to

<table>
<thead>
<tr>
<th>COs</th>
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</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Perform turning, facing, knurling, thread cutting, tapering, eccentric turning and allied operations</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td>CO2</td>
<td>Perform keyways / slots, grooves etc using shaper</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td>CO3</td>
<td>Perform gear tooth cutting using milling machine</td>
<td>A</td>
<td>PO1, PO6, PO9</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand the formation of cutting tool parameters of single point cutting tool using bench grinder / tool and cutter grinder</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO5</td>
<td>Understand Surface Milling/Slot Milling</td>
<td>U</td>
<td>PO1, PO6</td>
</tr>
<tr>
<td>CO6</td>
<td>Demonstrate precautions and safety norms followed in Machine Shop</td>
<td>U</td>
<td>PO8</td>
</tr>
<tr>
<td>CO7</td>
<td>Exhibit interpersonal skills towards working in a team</td>
<td>U</td>
<td>PO9</td>
</tr>
</tbody>
</table>

PART – A
Preparation of three models on lathe involving
Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.

PART – B
Cutting of V Groove/ dovetail / Rectangular groove using a shaper
Cutting of Gear Teeth using Milling Machine
PART –C
For demonstration
Demonstration of formation of cutting parameters of single point cutting tool using bench grinder / tool & cutter grinder. Demonstration of surface milling / slot milling

<table>
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<tr>
<td>Viva – Voce</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>


Course outcomes
On completion of this subject students will be able to
1. Understand needs, functions, roles, scope and evolution of Management
2. Understand importance, purpose of Planning and hierarchy of planning and also analyze its types
3. Discuss Decision making, Organizing, Staffing, Directing and Controlling
4. Select the best economic model from various available alternatives
5. Understand various interest rate methods and implement the suitable one.
6. Estimate various depreciation values of commodities
7. Prepare the project reports effectively.

MODULE – 1


Planning: Nature, importance and purpose of planning process Objectives - Types of plans (Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans.

MODULE - 2


Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief)
MODULE -3

Introduction: Engineering and economics, Problem solving and decision making, Laws of demand and supply, Difference between Microeconomics & Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity.

Law of Returns, Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems

10 Hours

MODULE -4


Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems

10 Hours

MODULE -5

Costing and depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time.

Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.

10 Hours

TEXT BOOKS

1. Principles of Management by Tripathy and Reddy

REFERENCE BOOKS

3. Engineering Economics, R.Paneerselvam, PHI publication
6. Modern Economic Theory, By Dr. K. K. Dewett & M. H. Navalur, S. Chand Publications
DYNAMICS OF MACHINERY

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

<table>
<thead>
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<th>Subject Code</th>
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<td>Teaching Hours / Week</td>
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<tr>
<td>Lecture 03</td>
<td>Tutorial 02</td>
</tr>
<tr>
<td>Exam Hours 03</td>
<td>CREDITS – 04</td>
</tr>
</tbody>
</table>

Course Objectives
1. To gain the knowledge static and dynamic equilibrium conditions of mechanisms subjected forces and couple, with and without friction.
2. Analyse the mechanisms for static and dynamic equilibrium.
3. To understand the balancing principles of rotating and reciprocating masses, governors and gyroscopes.
4. Analyse the balancing of rotating and reciprocating masses, governors and gyroscopes.
5. To understand vibrations characteristics of single degree of freedom systems.
6. Characterise the single degree freedom systems subjected to free and forced vibrations with and without damping.

Course outcomes
On completing the course the student will be able to
1. Determine the forces and couples for static and dynamic conditions of four bar and slider crank mechanisms to keep the system in equilibrium.
2. Determine magnitude and angular position of balancing masses under static and dynamic condition of rotating masses in same and different planes.
3. Determine unbalanced primary, secondary forces and couples in single and multi-cylinder engine.
4. Determine sensitiveness, isochronism, effort and power of porter and hartnell governors.
5. Determine gyroscopic couple and effects related to 2, 4 wheeler, plane disc, ship and aeroplanes.
6. Understand types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.
7. Determine equation of motion, natural frequency, damping factor, logarithmic decrement of damped free vibration (SDOF) systems.
8. Determine the natural frequency, force and motion transmissibility of single degree freedom systems.
9. Determine equation of motion of rotating and reciprocating unbalance systems, magnification factor, and transmissibility of forced vibration (SDOF) systems.
MODULE 1

Static force Analysis: Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism with and without friction.


10 Hours

MODULE 2

Balancing of Rotating Masses: Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.

Balancing of Reciprocating Masses: Inertia effect of crank and connecting rod, Single cylinder engine, balancing in multi cylinder-inline engine (primary and secondary forces), numerical problems.

10 Hours

MODULE 3


Gyroscope: Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic couple on plane disc, aeroplane, ship, stability of two wheelers and four wheelers, numerical problems.

10 Hours

MODULE 4

Introduction & Undamped free Vibrations (Single Degree of Freedom)

Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. Methods of analysis – (Newton’s, Energy & Rayleigh’s methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.

10 Hours

MODULE 5

Damped free Vibrations (Single Degree of Freedom)

Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.

Forced Vibrations (Single Degree of Freedom): Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems.

10 Hours

Text Books:

Reference Books:
2. Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company,
TURBO MACHINES
[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

<table>
<thead>
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<td>IA Marks</td>
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<td>Lecture</td>
<td>Tutorial</td>
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<td>03</td>
<td>02</td>
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<tr>
<td>CREDITS – 04</td>
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</tbody>
</table>

Module 1

Introduction: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies.
(Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process

(10 Hours)

Module 2

Energy exchange in Turbo machines: Euler’s turbine equation, Alternate form of Euler’s turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems.

(10 Hours)

Module 3

Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor.

Reaction turbine – Parsons’s turbine, condition for maximum utilization factor, reaction staging. Problems.

(10 Hours)
Module 4


Module 5

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling. Problems. (10 Hours)

TEXT BOOKS:

REFERENCE BOOKS:
Course Objectives
1. Able to understand mechanical design procedure, materials, codes and use of standards
2. Able to design machine components for static, impact and fatigue strength.
3. Able to design fasteners, shafts, joints, couplings, keys, threaded fasteners riveted joints, welded joints and power screws.

Course outcomes
On completion of the course the student will be able to
1. Describe the design process, choose materials.
2. Apply the codes and standards in design process.
3. Analyze the behavior of machine components under static, impact, fatigue loading using failure theories.
4. Design shafts, joints, couplings.
5. Design of riveted and welded joints.
6. Design of threaded fasteners and power screws

Module-1

Fundamentals of Mechanical Engineering Design
Mechanical engineering design, Phases of design process, Design considerations, Engineering Materials and their Mechanical properties, Standards and Codes, Factor of safety, Material selection.
Static Stresses: Static loads .Normal, Bending, Shear and Combined stresses.Stress concentration and determination of stress concentration factor. 10 Hours

Module -2

Design for Impact and Fatigue Loads
Impact stress due to Axial, Bending and Torsional loads.
Fatigue failure: Endurance limit, S-N Diagram, Low cycle fatigue, High cycle fatigue, modifying factors: size effect, surface effect. Stress concentration effects, Notch sensitivity, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. 10 Hours
Module -3

Design of Shafts, Joints, Couplings and Keys
Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under combined loads.

10 Hours

Module - 4

Riveted Joints and Weld Joints
Rivet types, rivet materials, failures of riveted joints, Joint Efficiency, Boiler Joints, Lozanze Joints, Riveted Brackets, eccentrically loaded joints.
Types of welded joints, Strength of butt and fillet welds, welded brackets with transverse and parallel fillet welds, eccentrically loaded welded joints.

10 Hours

Module - 5

Threaded Fasteners and Power Screws
Stresses in threaded fasteners, Effect of initial tension, Design of threaded fasteners under static loads, Design of eccentrically loaded bolted joints.
Types of power screws, efficiency and self-locking, Design of power screw, Design of screw jack: (Complete Design).

10 Hours

Text Books:

Design Data Handbook:
2. Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS Publication

Reference Books:
5. Design of Machine Elements -1, Dr.M.H.Anaiah, Dr. C.N. Chandrappa, Dr.J.Suresh Kumar, New Age International Publishers.
REFRIGERATION AND AIR-CONDITIONING  
(Professional Elective-I)  

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]  

SEMESTER – V  

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<td>Lecture</td>
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CREDITS – 03  

Pre-requisites: Basic and Applied Thermodynamics  

Course objectives  
1. Study the basic definition, ASHRAE Nomenclature for refrigerating systems  
2. Understand the working principles and applications of different types of refrigeration systems  
3. Study the working of air conditioning systems and their applications  
4. Identify the performance parameters and their relations of an air conditioning system  

Course Outcomes  
At the end of the course, the student will be able to:  
1. Illustrate the principles, nomenclature and applications of refrigeration systems.  
2. Explain vapour compression refrigeration system and identify methods for performance improvement  
3. Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo-acoustic refrigeration systems  
4. Estimate the performance of air-conditioning systems using the principles of psychometry.  
5. Compute and Interpret cooling and heating loads in an air-conditioning system  
6. Identify suitable refrigerant for various refrigerating systems  

Module – I  
**Introduction to Refrigeration** –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air.  
**Industrial Refrigeration** - Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous  
8 Hours  

Module – II  
10 Hours
Module – III

Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermo acoustic refrigeration systems

8 Hours

Module – IV
Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotroptic mixtures
Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

8 Hours

Module – V
Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships.

8 Hours

TEXT BOOKS
1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited

REFERENCE BOOKS
3. PITA, Air conditioning 4th edition, pearson-2005
4. Refrigeration and Air-Conditioning’ by Manohar prasad
5. S C Arora & S Domkundwar, Refrigeration and Air-Conditioning Dhanpat Rai Publication
6. http://nptel.ac.in/courses/112105128/#

Data Book:

E- Learning
• VTU, E- learning, MOOCS, Open courseware
THEORY OF ELASTICITY
(Professional Elective-I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

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CREDITS – 03

Course objectives
1. To gain knowledge of stresses and strains in 3D and their relations and thermal stresses.
2. To understand the 2D analysis of elastic structural members.
3. To gain knowledge of thermal stresses and stability of columns
4. To analysis elastic members for the stresses and strains induced under direct loading conditions.
5. To analyse the axisymmetric and torsional members.
6. To analyse the thermal stresses induced in disks and cylinders.
7. To analyse the stability of columns

Course outcomes
At the end of course student able to:
1. Describe the state of stress and strain in 2D and 3D elastic members subjected to direct loads and thermal loads.
2. Analyse the structural members: beam, rotating disks, columns
3. Analyse the torsional rigidity of circular and non-circular sections.
4. Analyse the stability of columns

Module – 1
Analysis of Stress: Definition and notation of stress, equations of equilibrium in differential form, stress components on an arbitrary plane, equality of cross shear, stress invariants, principal stresses, octahedral stress, planes of maximum shear, stress transformation, plane state of stress, Numerical problems

Module - 2
Analysis of Strain: Displacement field, strains in term of displacement field, infinitesimal strain at a point, engineering shear strains, strain invariants, principal strains, octahedral strains, plane state of strain, compatibility equations, strain transformation, Numerical Problems.

Module – 3
Two-Dimensional classical elasticity Problems: Cartesian co-ordinates - Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy’s stress functions, Investigation of Airy’s stress function for simple beams, bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of simply supported beam under UDL. General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures, Numerical Problems.
Module – 4

**Axisymmetric and Torsion problems:** Stresses in rotating discs of uniform thickness and cylinders. Torsion of circular, elliptical and triangular bars, Prandtl’s membrane analogy, torsion of thin walled thin tubes, torsion of thin walled multiple cell closed sections. Numerical Problems

8 Hours

Module -5

**Thermal stress and Elastic stability:** Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders. Euler’s column buckling load: clamped-free, clamped-hinged, clamped-clamped and pin-ended, Numerical Problems

8 Hours

**Text Books:**

**References Books:**
HUMAN RESOURCE MANAGEMENT
(Professional Elective-I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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CREDITS – 03

Objectives:
1. To develop a meaningful understanding of HRM theory, functions and practices.
2. To apply HRM concepts and skills across various types of organizations.

Course Outcomes
On completion of the course the student will be able to
1. Understand the importance, functions and principles Human Resource Management and process of Job analysis
2. Summarize the objectives of Human Resource planning, Recruitment and selection process
3. Understand the process involved in Placement, Training and development activities.
4. Understand the characteristics of an effective appraisal system and compensation planning.
5. Understand the issues related to employee welfare, grievances and discipline.

Module – 1

Human Resource Management
Introduction, meaning, nature, scope of HRM. Importance and Evolution of the concept of HRM. Major functions of HRM, Principles of HRM, Organization of Personnel department, Role of HR Manager.

Job Analysis: Meaning, process of job analysis, methods of collecting job analysis data, Job Description and Specification, Role Analysis. 08 hours

Module – 2

Human Resource Planning: Objectives, Importance and process of Human Resource planning, Effective HRP
Recruitment: Definition, Constraints and Challenges, Sources and Methods of Recruitment, New Approaches to recruitment.
Selection: Definition and Process of Selection. 08 hours
Module – 3

Placement: Meaning, Induction/Orientation, Internal Mobility, Transfer, Promotion, Demotion and Employee Separation.


08 hours

Module – 4

Performance Appraisal: Concept of Performance Appraisal, the Performance Appraisal process, Methods of Performance Appraisal, Essential Characteristic of an Effective Appraisal System.


09 hours

Module – 5


Employee Grievances: Employee Grievance procedure, Grievances management in Indian Industry.

Discipline: Meaning, approaches to discipline, essential of a good disciplinary system, managing difficult employees.

09 hours

TEXT BOOKS


REFERENCE BOOKS

## NON TRADITIONAL MACHINING
(Professional Elective-I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

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**CREDITS – 03**

### Course Outcomes
On completion of the course, the students will be able to

1. Understand the compare traditional and non-traditional machining process and recognize the need for Non-traditional machining process.

2. Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.

3. Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.

4. Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.

5. Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

### MODULE 1
**INTRODUCTION**
Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

**08 hours**

### MODULE 2
**Ultrasonic Machining (USM):** Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.


**Water Jet Machining (WJM):** Equipment & process, Operation, applications, advantages and limitations of WJM.

**08 hours**
MODULE 3
ELECTROCHEMICAL MACHINING (ECM)
Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

CHEMICAL MACHINING (CHM)
Elements of the process: Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.

MODULE 4
ELECTRICAL DISCHARGE MACHINING (EDM)
Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

PLASMA ARC MACHINING (PAM)
Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

MODULE 5
LASER BEAM MACHINING (LBM)
Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.
ELECTRON BEAM MACHINING (EBM)
Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

Text Books:

Reference Books
1. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000
OPTIMIZATION TECHNIQUES
(OPEN ELECTIVE – I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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CREDITS – 03

COURSE OBJECTIVES

Course Objective:
The general objectives of the course is to
1. Introduce the fundamental concepts of Optimization Techniques;
2. Make the learners aware of the importance of optimizations in real scenarios;
3. Provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

COURSE OUTCOMES

Upon successful completion of this course, students will be able to
1. Understand the overview of optimization techniques, concepts of design space, constraint surfaces and objective function.
2. Review differential calculus in finding the maxima and minima of functions of several variables.
3. Formulate real-life problems with Linear Programming.
4. Solve the Linear Programming models using graphical and simplex methods.
5. Formulate real-life transportation, assignment and travelling salesman problems to find the optimum solution using transportation algorithms
6. Analyze the Queuing model for effective customer satisfaction
7. Apply dynamic programming to optimize multi stage decision problems.
8. Determine the level of inventory that a business must maintain to ensure smooth operation.
9. Construct precedence diagram for series of activities in a huge project to find out probability of expected completion time using PERT-CPM networks. Also reduce the duration of project by method of crashing.
MODULE I

Introduction to Classical Optimization Techniques

Classical Optimization Techniques
Single variable Optimization, Multi variable Optimization with and without constraints, Multivariable Optimization with equality constraints - solution by method of Lagrange multipliers, Multivariable Optimization with inequality constraints - Kuhn – Tucker conditions. (8 Hours)

MODULE II

Linear Programming
Various definitions, statements of basic theorems and properties, Advantages, Limitations and Application areas of Linear Programming, Graphical method of Linear Programming problem.

Simplex Method – Phase I and Phase II of the Simplex Method, The Revised Simplex method, Primal and Dual Simplex Method, Big – M method. (10 Hours)

MODULE III

Transportation Problem
Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel’s approximation method – testing for optimality of balanced transportation problems. (Including assignment and travelling salesman problems) (No degeneracy problems)

Queueing
Queueing Models: Essential features of queueing systems, operating characteristics of queueing system, probability distribution in queueing systems, classification of queueing models, solution of queueing M/M/1 : ∞ /FCFS, M/M/1 : N/FCFS, M/M/C : ∞ /FCFS, M/M/C : N/FCFS. (8 Hours)

MODULE IV

Dynamic Programming

Integer Programming
Pure and mixed integer programming problems, Solution of Integer programming problems – Gomory’s all integer cutting plane method and mixed integer method, branch and bound method, Zero-one programming. (8 Hours)

MODULE V

Simulation Modeling
Introduction, Definition and types, Limitations, Various phases of modeling, Monte Carlo method, Applications, advantages and limitations of simulation

Inventory Models
Role of demand in the development of inventory models, objectives, inventory costs, quantity
discount, Economic Order Quantity (EOQ), EOQ when stock replenishment is not
instantaneous, Economic lot size when shortages are allowed, economic lot size with
different rate of demand in different cycles (Instantaneous replenishment). (No Dynamic
EOQ Models)

8 Hours

TEXT BOOKS

   (P) Limited.
   York.
   Publishing house, New Delhi.

REFERENCE BOOKS

1. Optimization Methods in Operations Research and systems Analysis” – by K.V.
   Mittal and C. Mohan, New Age, International (P) Limited, Publishers
4. Industrial Engineering and Production Management, M. Mahajan, Dhanpat Rai & co
ENERGY AND ENVIRONMENT
(OPEN ELECTIVE – I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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Course Objectives
1. Understand energy scenario, energy sources and their utilization
2. Learn about methods of energy storage, energy management and economic analysis
3. Have proper awareness about environment and eco system.
4. Understand the environment pollution along with social issues and acts.

Course Outcomes
At the end of the course, the student will be able to:
1. Summarize the basic concepts of energy, its distribution and general Scenario.
2. Explain different energy storage systems, energy management, audit and economic analysis.
3. Summarize the environment eco system and its need for awareness.
4. Identify the various types of environment pollution and their effects.
5. Discuss the social issues of the environment with associated acts.

Module – I
Basic Introduction to Energy: Energy and power, forms of energy, primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India’s energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment. 8 Hours

Module – II
Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems
Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries
Economic Analysis: Scope, Characterization of an Investment Project 10 Hours

Module – III
Environment: Introduction, Multidisciplinary nature of environmental studies- Definition, scope and importance, Need for public awareness.
Ecosystem: Concept, Energy flow, Structure and function of an ecosystem. Food chains, food webs and ecological pyramids, Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems, Ecological succession. 8 Hours
Module – IV

**Environmental Pollution:** Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies.  

*8 Hours*

Module – V


*8 Hours*

**TEXT BOOKS:**
1. Textbook for Environmental Studies For Undergraduate Courses of all Branches of Higher Education by University grant commission and Bharathi Vidyapeeth Institute of environment education and Research, Pune  

**REFERENCE BOOKS:**

**E- Learning**
- Open courseware
AUTOMATION AND ROBOTICS  
(OPEN ELECTIVE – I)  

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]  
SEMESTER – V  

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CREDITS – 03

Course Outcomes
On completion of the course student will be able to
1. Classify various types of automation & manufacturing systems
2. Discuss different robot configurations, motions, drive systems and its performance parameters.
3. Describe the basic concepts of control systems, feedback components, actuators and power transmission systems used in robots.
4. Explain the working of transducers, sensors and machine vision systems.
5. Discuss the future capabilities of sensors, mobility systems and Artificial Intelligence in the field of robotics.

Module - 1

Automation
History of Automation, Reasons for automation, Disadvantages of automation, Automation systems, Types of automation – Fixed, Programmable and Flexible automation, Automation strategies

08 Hours

Module - 2

Robotics
Definition of Robot, History of robotics, Robotics market and the future prospects, Robot Anatomy, Robot configurations: Polar, Cartesian, cylindrical and Jointed-arm configuration.
Robot motions, Joints, Work volume, Robot drive systems, Precision of movement – Spatial resolution, Accuracy, Repeatability, End effectors – Tools and grippers.

08 Hours

Module - 3

Controllers and Actuators
Basic Control System concepts and Models, Transfer functions, Block diagrams, characteristic equation, Types of Controllers: on-off, Proportional, Integral, Differential, P-I, P-D, P-I-D controllers. Control system and analysis.

Robot actuation and feedback components
Position sensors – Potentiometers, resolvers, encoders, velocity sensors. Actuators - Pneumatic and Hydraulic Actuators, Electric Motors, Stepper motors, Servomotors, Power
Transmission systems.  
 **09 Hours**

**Module - 4**

**Robot Sensors and Machine vision system**  
Sensors in Robotics - Tactile sensors, Proximity and Range sensors, use of sensors in robotics.

Machine Vision System: Introduction to Machine vision, the sensing and digitizing function in Machine vision, Image processing and analysis, Training and Vision systems. **08 Hours**

**Module - 5**

**Robots Technology of the future**: Robot Intelligence, Advanced Sensor capabilities, Telepresence and related technologies, Mechanical design features, Mobility, locomotion and navigation, the universal hand, system integration and networking.

**Artificial Intelligence**: Goals of AI research, AI techniques – Knowledge representation, Problem representation and problem solving, LISP programming, AI and Robotics, LISP in the factory.  
**09 Hours**

**Text Books**


**Reference Books**

PROJECT MANAGEMENT
(OPN ELECTIVE – I)

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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CREDITS – 03

Course Outcomes
On completion of the course the student will be able to
1. Understand the selection, prioritization and initiation of individual projects and strategic role of project management.
2. Understand the work breakdown structure by integrating it with organization.
3. Understand the scheduling and uncertainty in projects.
4. Students will be able to understand risk management planning using project quality tools.
5. Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.
6. Determine project progress and results through balanced scorecard approach
7. Draw the network diagram to calculate the duration of the project and reduce it using crashing.

MODULE – 1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles

Project Selection And Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects. 08 Hours

MODULE – 2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system.

Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart. 08 Hours
MODULE – 3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control.

Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kickoff: Development of quality concepts, project quality management plan, project quality tools, kickoff project, baseline and communicate project management plan, using Microsoft Project for project baselines.

08 Hours

MODULE – 4

Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management.

Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.

08 Hours

MODULE - 5

Network Analysis
Introduction, network construction - rules, Fulkerson’s rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

10 Hours

TEXT BOOKS

2. Project Management, A systems approach to planning scheduling and controlling by Harold kerzner, CBS publication.

REFERENCE BOOKS

1. Project Management, Pennington Lawrence, Mc Graw hill
3. Project Management, Bhavesh M. Patal, Vikas publishing House,
FLUID MECHANICS & MACHINERY LAB

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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CREDITS – 02

Co-requisite Courses: Turbo Machines
Prerequisites: Fluid Mechanics and Thermodynamics

Course Objectives:
1. This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
2. Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.

Course Outcomes:
At the end of this course students are able to,
1. Perform experiments to determine the coefficient of discharge of flow measuring devices.
2. Conduct experiments on hydraulic turbines and pumps to draw characteristics.
3. Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
4. Determine the energy flow pattern through the hydraulic turbines and pumps.
5. Exhibit his competency towards preventive maintenance of hydraulic machines

PART – A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of coefficient of friction of flow in a pipe.
3. Determination of minor losses in flow through pipes.
4. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
6. Orifice meter
   o Nozzle
   o Venturimeter
   o V-notch
PART – B

7. Performance on hydraulic Turbines
   a. Pelton wheel
   b. Francis Turbine
   c. Kaplan Turbines
8. Performance hydraulic Pumps
   d. Single stage and Multi stage centrifugal pumps
   e. Reciprocating pump
9. Performance test on a two stage Reciprocating Air Compressor
10. Performance test on an Air Blower

PART – C (Optional)

11. Visit to Hydraulic Power station/ Municipal Water Pump House and Case Studies

Reading:
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995

Scheme of Examination:
ONE question from part -A: 25 Marks
ONE question from part -B: 40 Marks
Viva –Voice : 15 Marks
Total: 80 Marks
ENERGY LAB

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]
SEMESTER – V

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CREDITS – 02

Prerequisites: Basic and Applied Thermodynamics

Course Objectives:
1. This course will provide a basic understanding of fuel properties and its measurements using various types of measuring devices
2. Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
3. Exhaust emissions of I C Engines will be measured and compared with the standards.

Course Outcomes: At the end of this course students are able to,
1. Perform experiments to determine the properties of fuels and oils.
2. Conduct experiments on engines and draw characteristics.
3. Test basic performance parameters of I.C. Engine and implement the knowledge in industry.
4. Identify exhaust emission, factors affecting them and report the remedies.
5. Determine the energy flow pattern through the I.C Engine
6. Exhibit his competency towards preventive maintenance of IC engines.

PART – A

1. Lab layout, calibration of instruments and standards to be discussed
2. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten’s (closed) / Cleveland’s (Open Cup) Apparatus.
3. Determination of Calorific value of solid, liquid and gaseous fuels.
5. Analysis of moisture, volatile matter, ash content and fixed carbon of solid and liquid fuel samples

PART - B

   a. Four stroke Diesel Engine
   b. Four stroke Petrol Engine
c. Multi Cylinder Diesel/Petrol Engine, (Morse test)

d. Two stroke Petrol Engine

e. Variable Compression Ratio I.C. Engine.


10. Measurement of $p\theta$, $pV$ plots using Computerized IC engine test rig

**PART – C (Optional)**

11. Visit to Automobile Industry/service stations.

12. CFD Analysis of design, development, performance evaluation and process optimization in I C Engines.

**References**


**Scheme of Examination:**

ONE question from part -A: 25 Marks

ONE question from part -B: 40 Marks

Viva –Voice : 15 Marks

Total: 80 Marks
Course Objectives:

1. To learn basic principles of finite element analysis procedure.

2. To learn the theory and characteristics of finite elements that represent engineering structures.

3. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Course outcomes:

Upon successful completion of this course you should be able to:

1. Understand the concepts behind formulation methods in FEM.

2. Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.

3. Develop element characteristic equation and generation of global equation.

4. Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi symmetric and dynamic problems and solve them displacements, stress and strains induced.

Module I

Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

Module II

One-Dimensional Elements—Analysis of Bars and Trusses,
Linear interpolation polynomials in terms of local coordinate’s for 1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 8), 2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads,

Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.

Module III

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

Module IV

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections.

Module V

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to point loads.
Dynamic Considerations: Formulation for point mass, Consistent element mass matrix of one dimensional bar element, truss element, Lumped mass matrix of bar element, truss element.

10 Hours

Text Books:

Reference Books:
Computer Integrated Manufacturing

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Course Objectives:

CLO1 To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.

CLO2 To make students to understand the Computer Applications in Design and Manufacturing (CAD / CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.

CLO3 To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.

CLO4 To expose students to computer aided process planning, material requirement planning, capacity planning etc.

CLO5 To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.

CLO6 To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

Module - 1


   5 Hours

2. Automated Production Lines and Assembly Systems: Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numerical problems.

   5 Hours

Module - 2

3. CAD and Computer Graphics Software: The design process, applications of computers in design, software configuration, functions of graphics package, constructing the geometry. Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations.

   5 Hours

Module - 3
5. Flexible Manufacturing Systems: Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture. 5 Hours

6. Line Balancing: Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerized line balancing methods. 5 Hours

Module - 4
7. Computer Numerical Control: Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations. 5 Hours

8. Robot Technology: Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics. Robot programming methods: on-line and off-line methods. Robot industrial applications: material handling, processing and assembly and inspection. 5 Hours

Module - 5
9. Additive Manufacturing Systems: Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. Recent trends in manufacturing. Hybrid manufacturing. 5 Hours

10. Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems. 5 Hours

Course Outcomes:
After studying this course, students will be able to:

| CO1 | Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts. Solve simple problems of transformations of entities on computer screen. |
| CO2 | Explain the basics of automated manufacturing industries through mathematical models |
and analyze different types of automated flow lines.

| CO3 | Analyze the automated flow lines to reduce down time and enhance productivity. |
| CO4 | Explain the use of different computer applications in manufacturing, and able to prepare part programs for simple jobs on CNC machine tools and robot programming. |
| CO5 | Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing. |

### Text Books:

### Reference Books:
1. “CAD/CAM” by Ibrahim Zeid, Tata McGraw Hill.
HEAT TRANSFER

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Transfer</td>
<td>15ME63</td>
<td>04</td>
<td>3-2-0</td>
<td>80 SEE, 20 CIA</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

Pre-requisites: Basic and Applied Thermodynamics

Course learning objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module - I

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer combined heat transfer mechanism, Types of boundary conditions. General Heat Conduction Equation: Derivation of the equation in Cartesian Coordinate System, Discussion on (ii) Polar and (iii) Spherical Co-ordinate Systems. (No derivation)

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) without heat generation, discussion and application of heat generation systems (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel. 8 Hours

Module - II

Critical Thickness of Insulation: Concept, Derivation, Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts. 9 Hours

Module - III

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction, one dimensional unsteady conduction, the difference equation, boundary conditions, solution methods. Applications and computational errors.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien’s, Rayleigh-Jeans’ and Planck’s laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff’s Laws, View factor, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield. 9 Hours

Module - IV

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

Module - V

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

• Understand the basic modes of heat transfer.
• Compute temperature distribution in steady-state and unsteady-state heat conduction
• Understand and interpret heat transfer through extended surfaces.
• Interpret and compute forced and free convective heat transfer.
• Explain the principles of radiation heat transfer and understand the numerical formula for heat conduction problems.
• Design heat exchangers using LMTD and NTU methods.

TEXT BOOKS:

REFERENCE BOOKS:

E-Books/Web references:
2. NPTEL. Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/

MOOCs:
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
Course Objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To understand various elements involved in a mechanical system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To select transmission elements like gears, belts, pulleys, bearings from the manufacturers’ catalogue.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To design completely a mechanical system integrating machine elements.</td>
</tr>
<tr>
<td>CLO5</td>
<td>To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.</td>
</tr>
</tbody>
</table>

**MODULE 1**

**Curved Beams:** Stresses in curved beams of standard cross sections used in crane hook, punching presses & clamps, closed rings and links.

**Cylinders & Cylinder Heads:** Review of Lame’s equations; compound cylinders, stresses due to different types of fit on cylinders; cylinder heads and flats.

**MODULE 2**

**Belts:** Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition.

Selection of flat and V belts- length & cross section from manufacturers’ catalogues.

Construction and application of timing belts.

**Wire ropes:** Construction of wire ropes, stresses in wire ropes, and selection of wire ropes. (Only theoretical treatment)

**Chain drive:** Types of power transmission chains, modes of failure for chain, and lubrication of chains. (Only theoretical treatment)

**Springs:** Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads.

Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs.

Introduction to torsion and Belleville springs.

**MODULE 3**

**Gear drives:** Classification of gears, materials for gears, standard systems of gear tooth, gear tooth failure modes and lubrication of gears.

**Spur Gears:** Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.
Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.

**MODULE 4**

Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Design of Clutches: Types of clutches and their applications, single plate and multi-plate clutches.

(Numerical examples only on single and multi-plate clutches)

Design of Brakes: Types of Brakes, Block and Band brakes, self locking of brakes, and heat generation in brakes.

**MODULE 5**

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated.

Numerical examples on hydrodynamic journal and thrust bearing design.

Anti friction bearings: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep groove ball bearings from the manufacturers’ catalogue; selection of bearings subjected to cyclic loads and speeds; probability of survival.

**Course Outcomes:**

After learning the course the students should be able to:

<table>
<thead>
<tr>
<th>CO1</th>
<th>Apply engineering design tools to product design.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Design mechanical systems involving springs, belts and pulleys.</td>
</tr>
<tr>
<td>CO3</td>
<td>Design different types of gears and simple gear boxes for different applications.</td>
</tr>
<tr>
<td>CO4</td>
<td>Design brakes and clutches.</td>
</tr>
<tr>
<td>CO5</td>
<td>Design hydrodynamic bearings for different applications.</td>
</tr>
<tr>
<td>CO6</td>
<td>Select Anti friction bearings for different applications using the manufacturers, catalogue.</td>
</tr>
<tr>
<td>CO7</td>
<td>Develop proficiency to generate production drawings using CAD software.</td>
</tr>
<tr>
<td>CO8</td>
<td>Become good design engineers through learning the art of working in a team with morality and ethics.</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**Assignment:**

Course work includes a Design project. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing
mounting, C-clamp, screw jack, single plate clutch, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report.

Design project should be given due credit (5 marks) in internal assessment.

**Textbooks:**


**References:**


**Design Data Hand Book:**


Computational Fluid Dynamics

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam duration</th>
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</thead>
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<tr>
<td>Computational Fluid Dynamics</td>
<td>15ME651</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
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</tbody>
</table>

Pre-requisites: Fluid Mechanics, Vector Calculus, Linear Algebra.

Course learning objectives:

- Study the governing equations of fluid dynamics
- Learn how to formulate and solve Euler’s equation of motion.
- Become skilled at Representation of Functions on Computer
- Solve computational problems related to fluid flows

Module - I
Introduction to CFD and Governing Equations

Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition. Derivation of Navier-Stokes equations in control volume (integral form) and partial differential form, Euler equations (governing inviscid equations). Mathematical classification of PDE (Hyperbolic, Parabolic, Elliptic). Method of characteristics, Introduction to Riemann Problem and Solution Techniques.

9 Hours

Module - II
One-dimensional Euler's equation


Introduction to Turbulence Modeling: Derivation of RANS equations and k-epsilon model.

8 Hours

Module - III
Representation of Functions on Computer


7 Hours

Module - IV
Finite difference method – Applied to Linear Convection equation, Laplace Equations, Convection Diffusion equations, Burgers equations, modified equations • Explicit methods and Implicit methods – as applied to applied to linear convection equation, Laplace equations, convection-diffusion equation o FTCS,FTFS,FTBS,CTCS • Jacobi Method, Gauss-Siedel, Successive Over Relaxation Method, TDMA. VonNaumann stability (linear stability) analysis. Upwind Method in Finite Difference method.

8 Hours

Module - V
Finite volume method

Finite volume method. Finding the flux at interface.

Central schemes - Lax-Friedrichs Method, Lax-Wendroff Method, Two-Step Lax-Wendroff Method and Mac Cormack Method

Upwind Method in Finite Volume methods - Flux Splitting Method Steger and Warming, vanLeer, Roe's Method and finding Roe's Averages.

8 Hours

Course Outcomes

At the end of the course, the student will be able to:

- Understand mathematical characteristics of partial differential
Explain how to classify and computationally solve Euler and Navier-Stokes equations.

Make use of the concepts like accuracy, stability, consistency of numerical methods for the governing equations.

Identify and implement numerical techniques for space and time integration of partial differential equations.

Conduct numerical experiments and carry out data analysis.

Acquire basic skills on programming of numerical methods used to solve the Governing equations.

Text Books
1. T.j.chung, Computational Fluid Dynamics, Cambridge University Press

Reference Books:
5. Leveque, r., Numerical methods for conservation laws, lectures in mathematics, eth Zurich, birkhauser, 199

MOOCs:
1. Introduction to CFD by Prof M. Ramakrishna, Aerospace Engineering, IIT Madras.
2. Computational fluid dynamics by Prof Suman Chakraborty, Mechanical Engineering, IIT Kharagpur

E-Books:

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
Course objectives:

The course is intended to provide basic understanding of Composite Materials to engineering students with following aspects:

- To acquire basic understanding of composites and its manufacturing
- To develop an understanding of the linear elastic analysis of composite materials, which include concepts such as anisotropic material behavior and the analysis of laminated plates.
- Provides a methodology for stress analysis and progressive failure analysis of laminated composite structures for aerospace, automobile, marine and other engineering applications
- The students will undertake a design project involving application of fiber reinforced laminates.

**MODULE -1**


Manufacturing Techniques of Composites:
Fiber Reinforced Plastic (FRP) Processing: Layup and curing, fabricating process, open and closed mould process, Hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.

Fabrication Process for Metal Matrix Composites (MMC’s): Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques. 8 Hrs

**MODULE -2**


**MODULE -3**

Macromechanics of Composites: Elastic Constants of an Isotropic Material, Elastic Constants of a Lamina, Relationship between Engineering Constants and Reduced Stiffnesses and Compliances, Variation of Lamina Properties with Orientation, Analysis of Laminated...
MODULE - 4
Monotonic Strength, Fracture, Fatigue and Creep: Tensile and Compressive strength of Unidirectional Fiber Composites. Fracture Modes in Composites; Single and Multiple Fracture, Debonding, Fiber Pullout and Delamination Fracture. Strength of an Orthotropic Lamina; Maximum Stress Theory, Maximum Strain Criterion, Tsai-Hill Criterion, Quadratic Interaction Criterion, Comparison of Failure Theories. Fatigue; S-N Curves, Fatigue Crack Propagation Tests, Damage Mechanics of Fatigue, Thermal Fatigue. Creep behavior of Composites. 8 Hrs

MODULE - 5

Course outcomes:
On completion of this subject students will be able to:
1. To identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
2. To predict the failure strength of a laminated composite plate
3. Understand the linear elasticity with emphasis on the difference between isotropic and anisotropic material behaviour.
4. Acquire the knowledge for the analysis, design, optimization and test simulation of advanced composite structures and Components.

TEXT BOOKS:

REFERENCE BOOKS:
3. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993

E- Learning
- VTU, E-learning

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
Course objectives:
The course is intended to provide basic understanding of Metal Forming with following aspects:
- To acquaint with the basic knowledge on fundamentals of metal forming processes
- To study various metal forming processes
- Understanding plastic deformation during forming processes

**MODULE -1**
Introduction to Metal Forming: Classification of metal forming processes, advantages and limitations, stress-strain relations in elastic and plastic deformation. Concepts of true stress, true strain, triaxial & biaxial stresses. Determination of flow stress, principal stresses, yield criteria and their significance, Tresca & Von-Mises yield criteria, concepts of plane stress & plane strain. Deformation mechanisms, Hot and Cold working processes and its effect on mechanical properties. 8 Hrs

**MODULE -2**
Effects of Parameters: Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, Effects of Temperature, strain rate, friction and lubrication, hydrostatic pressure in metalworking, Deformation zone geometry, workability of materials, Residual stresses in wrought products.

Forging: Classification of forging processes. Forging machines equipment. Expressions for forging pressures & load in open die forging and closed die forging by slab analysis, concepts of friction hill and factors affecting it. Die-design parameters. Material flow lines in forging, forging defects, residual stresses in forging. Simple problems. 8 Hrs

**MODULE -3**

Drawing: Drawing equipment & dies, expression for drawing load by slab analysis, power requirement. Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing, classification of tube drawing. Simple problems. 8 Hrs
**MODULE - 4**


**MODULE - 5**


Powder Metallurgy: Basic steps in Powder metallurgy brief description of methods of production of metal powders, conditioning and blending powders, compaction and sintering application of powder metallurgy components, advantages and limitations. 8Hrs

Course outcomes:

On completion of this subject, students will be:

1. Able to understand the concept of different metal forming process.
2. Able to approach metal forming processes both analytically and numerically
3. Able to design metal forming processes
4. Able to develop approaches and solutions to analyze metal forming processes and the associated problems and flaws.

**TEXT BOOKS:**


**REFERENCE BOOKS:**

3. Fundamentals of Manufacturing Processes by Lal G K , Narosa

E- Learning
VTU, E- learning

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
TOOL DESIGN

Course | Code    | Credits | L-T-P | Assessment | Exam | Duration
---|---------|---------|------|------------|------|---------
Tool Design | 15ME654 | 03      | 3-0-0 | 80 20      |      | 3Hrs

Course Objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To develop capability to design and select single point and multipoint cutting tools for various machining operations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>Exposure to variety of locating and clamping methods available.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To enable the students to design jigs and fixtures for simple components.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To expose the students to the design/selection procedure of press tools and die casting dies.</td>
</tr>
</tbody>
</table>

**MODULE 1**
Introduction to tool design: Tooling, requirements of a tool designer, general tool design procedure, tool engineering functions and its importance to enhance productivity and quality. Review of cutting tool materials. Tool angles and signature, Carbide inserts grades - ISO designation and applications, tool holders for turning-ISO designation. Solid type tool, brazed tip tool, throwaway indexable insert types, coated carbides and chip breakers.

Design of single point cutting tools: Design of shank dimensions using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry.

08 Hours

**MODULE 2**
Design of Multi Point Cutting Tools: Types of drills, Drill bit design - elements like back taper, web thickness, land width, margin, flute length and cross section and selection of tool geometry. Re-sharpening of drill bit.
Tool holders for milling, different tapers used for mounting tool holders in milling, ISO designation. Tool mounting systems.
Design of milling cutters: Design of elements like number of teeth and height, circular pitch, body thickness, chamfer width, fillet radius and selection of tool geometry. Profile sharpened and form relieved milling cutters. Re-sharpening of side and face milling cutter and end mill.

08 Hours

**MODULE 3**
Jigs and Fixtures: Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures.
Location: 3-2-1 Principle of location, different types of locating elements.
Clamping: Principles of clamping, types of clamping devices, and power clamping.
Drill bushes; Drill jigs: different types, exercises of designing jigs for simple components.
Fixture Design: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centers, and modular fixtures. Design exercises on fixtures for turning and milling for simple components.

08 Hours

**MODULE 4**
Press tools: Classification and working of power presses. Concept and calculations of press tonnage and shut height of a press, components of a simple die, press tool operation, die accessories, shearing action in punch & die, clearance, shear on punch and die, Centre of pressure, and strip layout.

Simple, progressive, compound, combination and inverted dies. Design problems on blanking and piercing dies for simple components.

Bending dies – Introduction, bend allowance, spring back, edge bending die design.

MODULE 5


Die casting: Die casting alloys, terminology- core, cavity, sprue, slug, fixed and movable cores, finger cams, draft, ejector pins and plates, gate, goose nozzle, overflow, platen, plunger, runner, vent, water-line etc.

Types of Dies: Single cavity, multi cavity dies, combination dies, unit dies, advantages and disadvantages of types of dies; finishing, trimming and inspection of die casting components, safety, and modern trends in die casting dies.

Course Outcomes:

After learning the course the students should be able to:

| CO1 | Selection appropriate cutting tools required for producing a component. |
| CO2 | Ability to interpret cutting tool and tool holder designation systems. |
| CO3 | Ability to design/select suitable locating and clamping devices for a given component for various operations. |
| CO4 | Capability to design a jig/fixture for a given simple component. |
| CO5 | Comprehensive understanding of various press tools and press tool operations. |
| CO6 | Classify and explain various press tools and press tool operations. |

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Assignment:

Course work includes a Tool Design project. Tool design project should enable the students to design a tooling like Jig or a fixture for a simple component, fixture for a simple component on CNC machining centers, design of a simple blanking and piercing die, progressive die, drawing die etc. Any one of these exercises should be given as an assignment. A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Tool design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report.

Design project should be given due credit (5 marks) in internal assessment.
Textbook:
References:
AUTOMOBILE ENGINEERING

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile</td>
<td>15ME655</td>
<td>3</td>
<td>3-0-0</td>
<td>SEE 80</td>
<td>CIA 20</td>
</tr>
</tbody>
</table>

Course learning objectives: The student will be able to learn
- The layout and arrangement of principal parts of an automobile
- The working of transmission and brake systems
- The operation and working of steering and suspension systems
- To know the Injection system and its advancements
- To know the automobile emissions and its effects on environment

MODULE 1

COOLING AND LUBRICATION: cooling requirements, types of cooling- thermo siphon system, forced circulation water cooling system, water pump, Radiator, thermostat valves. Significance of lubrication, splash and forced feed system.

8 Hours

MODULE 2
TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

BRAKES: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock – Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock & Numerical

08 Hours

MODULE 3
STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system.

IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system.

08 Hours

MODULE 4
SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.
FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, alternative fuels, normal and abnormal combustion, cetane and octane numbers, Fuel mixture requirements for SI engines, types of carburetors, C.D. & C.C. carburetors, multi point and single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System.

08 Hours

MODULE 5

AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.

EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act

08 Hours

Course Outcomes: Student will be able
- To identify the different parts of an automobile and it’s working
- To understand the working of transmission and braking systems
- To comprehend the working of steering and suspension systems
- To learn various types of fuels and injection systems
- To know the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

TEXT BOOKS:

REFERENCE BOOKS:
Course learning objectives is to
- Understand energy scenario and general aspects of energy audit.
- Learn about methods and concept of energy audit
- Understand the energy utilization pattern including wastage and its management

Module - I
8 Hours

Module - II
8 Hours

Module - III
8 Hours

Module - IV
8 Hours

Module - V
8 Hours

Note: A case study involving energy audit may be taken up with suggestion for energy improvements as a part of assignment.

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

- Understand the basic concepts of energy audit and energy management
- Explain different types of energy audit, maximizing and optimizing system efficiency.
- Summarize energy management systems, prepare and present energy audit report
- Identify energy saving potential of thermal and electrical systems
- Discuss Energy audit instruments, Procedures and Techniques.

TEXT BOOKS:


REFERENCE BOOKS:


E-Learning
https://beeindia.gov.in/content/energy-auditors

Scheme of Examination: Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
INDUSTRIAL SAFETY

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
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<tbody>
<tr>
<td>INDUSTRIAL SAFETY</td>
<td>15ME662</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Prerequisites:

Elements of Mechanical Engineering
Electrical Engineering
Elements of Civil Engineering
Engineering Chemistry lab
Workshop Practice
Other labs of various courses

Overview:

Accidents lead to human tragedy, economical loss to individual, company and the nation. Safe acts lead to increase in productivity. The present course highlights the importance of general safety and its prevention, extended to mechanical, electrical sand chemical safety. The Industrial safety course helps in motivating the staff and students to understand the reason for fire, its prevention. Controlling of fire by various means are highlighted. Importance of chemical safety, labeling of chemicals, hand signals during forklift operations in industrial and aerodromes will help in to understand and apply the techniques in practical field. A visit to campus, various labs, workshops, local industries and fire stations helps in analyzing the importance of safety and corrective measures through case studies.

MODULE-1 : INTRODUCTION TO SAFETY

Terms used: accident, safety, hazard, safe, safety devices, safety guard, security, precaution, caution, appliance, slip, trip, fall.
Ladders and scaffolding. Unsafe acts, reason for accidents, MSDS (material safety data sheet), OSHA, WHO.
Lockout and tag out procedures. Safe material handling and storage.
Case studies: Student should identify the unsafe acts near their surroundings like housekeeping, lab layouts, road safety, campus layout, safety signs.

MODULE-2 : FIRE SAFETY

Introduction, Class A, B, C, D and E fire. Fire triangle, Fire extinguishers, Fire hazard and analysis, prevention of fire. Fire protection and loss prevention, steps after occurrence of fire.
Portable fire extinguishers. Fire detection, fire alarm and fire fighting systems.
Safety sign boards, instruction on portable fire extinguishers.
Case studies: demonstration of fire extinguishers, visit to local fire fighting stations. Visit to fire accident sites to analyze the cause of fire and its prevention for future.

MODULE-3 : MECHANICAL SAFETY

PPE, safety guards, Safety while working with machine tools like lathe, drill press, power and band saws, grinding machines. Safety during welding, forging and pressing.
Safety while handling Material, compressed gas cylinders, corrosive substance, waste drum and containers.
Case studies: Visit to machine shop, workshops, foundry lab and local industries to record the practical observation and report the same with relevant figures and comments.

M O D U L E - 4 : E L E C T R I C A L S A F E T Y

Introduction to electrical safety, Electric hazards, effect of electric current on human body, causes of electrical accidents, prevention of electric accidents, PPE used. Electric shock. Primary and secondary electric shocks, AC and DC current shocks. Safety precautions against shocks. Safety precautions in small and residential building installations. Safety procedures in electric plant.

Case studies: To visit electrical sub stations, local distribution systems, observe and share the experience and report.

M O D U L E - 5 : C H E M I C A L S A F E T Y A N D O T H E R S A F E T Y C H E C K S

Introduction to Chemical safety, Labeling of chemicals, acid hoods. Handling of acids, eye washers and showers. Safety thinking, accident investigation, safety policy of the company, safety, loss prevention and control, check list for LPG installations, safety precautions using CNG, fire prevention and safety audit, confined space entry, risk assessment.

Case studies: To visit chemical laboratory of the college and other chemical industries like LPG, CNG facilities and report.

Course Outcomes:

At the end of the course, student is able to:
1- Understand the basic safety terms.
2- Identify the hazards around the work environment and industries.
3- Use the safe measures while performing work in and around the work area of the available laboratories.
4- Able to recognize the sign boards and its application.
5- Able to demonstrate the portable extinguishers used for different class of fires.
6- Able to write the case studies by sharing experience of the employees working in housekeeping, laboratories like workshops, electrical labs, machine shops, electronics and computer laboratories.
7- Able to understand and report the case studies from various references (text books, news report, journals, visiting industries like power stations, manufacturing and maintenance).

Text Books:

Reference books:

VISITS:
1- To visit respective Institution:
   stores, office, housekeeping area, laboratories.
2- To visit local industries, workshops, district fire fighting system facility and local electrical power stations.
Course objectives:
The course is intended to provide basic concepts of maintenance engineering to engineering students with following aspects:

- To acquire basic understanding of Maintenance systems
- To develop an understanding of the principles of Preventive Maintenance & Predictive Maintenance
- Provides a methodology for reliability & probability concepts applied to maintenance engineering
- The students will concepts and procedures for Condition Monitoring in Mechanical and Electrical systems along with the analysis and processing techniques for machine fault identification

**MODULE -1**

Maintenance systems: Maintenance objectives and scopes; Maintenance strategies & organizations; Maintenance works; life cycle costs Preventive Maintenance: Principles of preventive maintenance, procedures & selection; Preventive Maintenance planning, scheduling and control; Forms & resources; Maintenance work measurement; Modeling and analysis techniques in PM and inspections; Predictive maintenance.

Computerized Maintenance Management systems: Benefits and applications; Work order systems & plant registers; Maintenance reports, analysis and monitoring; Introduction to commercial packages Equipment maintenance: Installation, commissioning and testing of plant equipment, checking for alignment, lubrication and lubrication schedule; maintenance of typical rotating and process equipment systems like turbines, pumps and fans, centrifuges, heat exchangers, boilers and pressure vessels etc.

8 hrs

**MODULE -2**

Reliability & probability Concepts: Basic concepts of probability theory and distributions, definition of reliability, failure probability, reliability and hazard rate function, MTBF and MTTR, System reliability , series and parallel system, redundancy.

8 hrs

**MODULE -3**


8 hrs
MODULE -4
Total Productive Maintenance: Goals of TPM and methodology, TPM improvement plan & procedures. The modern role of care and asset management through TPM The use of TPM concepts consisting of Pareto ABC analysis, Fishbone diagrams, OEE and 5S. Fault analysis.

8 hrs

MODULE -5
Condition Monitoring:
Measurable phenomena from different Plant Items:
Measurable phenomena associated with degradation from a range of plant items including motors/generators, transformers, cables, bushings, connectors, capacitors and circuit breakers.
Fault diagnosis of Rotational Machines:
Unbalance, shaft and coupling misalignments, bent shafts, gear and bearing wear, oil whirls and shaft eccentricity.
Measurement Strategies and Techniques:
A wide range of strategies and associated technologies will be discussed including light emission (photo multipliers, fiber optic techniques etc.), heat emissions (IR, cameras, direct temperature measurement, etc.), electrical charges (tan δ, electrical particle discharge, etc.), force, power and vibration.
Data Processing and Analysis:
For each of the approaches, options with respect to data processing and analysis will be discussed including digital signal processing and computational techniques. Close attention will be paid through examples of the cost benefits and the reliability which can be placed on data with respect to formulating a view on the condition of a give item of plant.

8hrs

Course outcomes:
On completion of this subject students will be able to:
1. Understand maintenance objectives and evaluate various maintenance strategies for process plant application, Develop necessary planning and scheduling and control of preventive maintenance activities.
2. Evaluate reliability of a simple plant component and system.
3. Understand and apply the advanced concepts such as RCM and advantages for a company employing them
4. Understand and apply the advanced concepts such as TPM and advantages for a company employing
5. Apply the principles of condition monitoring systems.
6. Apply the mechanical condition monitoring techniques and analyze the data used in condition monitoring

TEXT BOOKS:

REFERENCE BOOKS:
2. Reliability Engineering, Srinath L S,
3. Maintenance Replacement and Reliability, Jardine AKS,
4. Practical reliability engineering, Oconnor, Patrick D T
5. , Reliability and Maintainability Engineering, Charles E Ebeling
6. Introduction to Reliability Engineering Lewis E,

E- Learning

- VTU, E- learning

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
TOTAL QUALITY MANAGEMENT

<table>
<thead>
<tr>
<th>Course</th>
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<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
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<tr>
<td>Total Quality Management</td>
<td>15ME664</td>
<td>03</td>
<td>3-0-0</td>
<td>SEE 80 CIA 20</td>
<td>3Hrs</td>
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COURSE LEARNING OBJECTIVES:
This course enables students to
1. Understand various approaches to TQM
2. Understand the characteristics of quality leader and his role.
3. Develop feedback and suggestion systems for quality management.
4. Enhance the knowledge in Tools and Techniques of quality management

Module - 1
Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM.

08 Hours

Module - 2
Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making.

08 Hours

Module - 3
Customer Satisfaction and Customer Involvement:
Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies.
Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.

08 Hours

Module - 4
Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies.
Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.

08 Hours

Module - 5
Tools and Techniques: Benchmarking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.

08 Hours

COURSE OUTCOMES:
Student will be able to
1. Explain the various approaches of TQM
2. Infer the customer perception of quality
3. Analyze customer needs and perceptions to design feedback systems.
4. Apply statistical tools for continuous improvement of systems
5. Apply the tools and technique for effective implementation of TQM.

TEXT BOOKS:

REFERENCE BOOKS:

Reference Books:

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
Co- requisite Courses: Heat Transfer

Course Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum. Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

PART – A

1. Determination of Thermal Conductivity of a Metal Rod.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a

PART – B

1. Determination of Steffan Boltzmann Constant.
3. Experiments on Boiling of Liquid and Condensation of Vapour.
4. Performance Test on a Vapour Compression Refrigeration.
5. Performance Test on a Vapour Compression Air – Conditioner.
6. Experiment on Transient Conduction Heat Transfer.
7. Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)

Course Outcomes: At the end of this course students are able to,

- Perform experiments to determine the thermal conductivity of a metal rod
- Conduct experiments to determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values.
- Estimate the effective thermal resistance in composite slabs and efficiency in pin-fin
- Determine surface emissivity of a test plate
- Estimate performance of a refrigerator and effectiveness of fin
- Calculate temperature distribution of study and transient heat conduction through plane wall, cylinder and fin using numerical approach.

Reading:

Scheme of Examination:
ONE question from part -A: 25 Marks
ONE question from part -B: 40 Marks
Viva –Voice : 15 Marks

Total: 80 Marks
Modeling and Analysis Lab (FEA)

<table>
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<th>Credits</th>
<th>L-T-P</th>
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<td>Modeling and Analysis Lab</td>
<td>15MEL68</td>
<td>02</td>
<td>1-0-2</td>
<td>80 20</td>
<td>3Hrs</td>
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CREDITS - 02

Prerequisites: Knowledge of any Modeling software, knowledge of coordinate systems and Geometric transformations etc.

Course objectives:

The course is intended to provide basic understanding of Modeling and Analysis techniques students with following aspects:

- To acquire basic understanding of Modeling and Analysis software
- To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, beams loaded with loading conditions.
- To lean to apply the basic principles to carry out dynamic analysis to know the natural frequency of different kind of beams.

PART - A

Study of a FEA package and modeling and stress analysis of:

1. Bars of constant cross section area, tapered cross section area and stepped bar
2. Trusses – (Minimum 2 exercises of different types)
3. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc (Minimum 6 exercises different nature)
4. Stress analysis of a rectangular plate with a circular hole

PART - B

1) Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)
2) Dynamic Analysis to find
   a) Fixed – fixed beam for natural frequency determination
   b) Bar subjected to forcing function
   c) Fixed – fixed beam subjected to forcing function

PART - C (only for demo and oral exam)
1) Demonstrate the use of graphics standards (IGES, STEP etc.) to import the model from modeler to solver.
2) Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
3) Demonstrate at least two different type of example to model and analyze bars or plates made from composite material.

**Course Outcomes:** At the end of the course the students are able to:
- Demonstrate the basic features of an analysis package.
- Use the modern tools to formulate the problem, and able to create geometry, discretize, apply boundary condition to solve problems of bars, truss, beams, plate to find stress with different-loading conditions.
- Demonstrate the deflection of beams subjected to point, uniformly distributed and varying loads further to use the available results to draw shear force and bending moment diagrams.
- Analyze the given problem by applying basic principle to solve and demonstrate 1D and 2D heat transfer with conduction and convection boundary conditions.
- Carry out dynamic analysis and finding natural frequencies for various boundary conditions and also analyze with forcing function.

**REFERENCE BOOKS:**
3. *Finite Element Analysis*, George R. Buchanan, Schaum Series

**Scheme for Examination:**
One Question from Part A - 32 Marks (08 Write up +24)
One Question from Part B - 32 Marks (08 Write up +24)
Viva-Voce - 16 Marks
Total 80 Marks
Course learning objectives is to

- Understand energy scenario, energy sources and their utilization
- Learn about energy conversion methods and their analysis
- Study the principles of renewable energy conversion systems
- Understand the concept of green energy and zero energy.

Module – I

Thermal Energy conversion system: Review of energy scenario in India, General Philosophy and need of Energy, Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, strokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures. Chimneys: Natural, forced, induced and balanced draft, Calculations and numerical involving height of chimney to produce a given draft. Cooling towers and Ponds. Accessories for the Steam generators such as Superheaters, De-superheater, control of superheaters, Economizers, Air preheaters and re-heaters.

9 Hours

Module – II


Hydro-Electric Energy: Hydrographs, flow duration and mass curves, unit hydrograph and numerical. Storage and pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks, gates and valves. General layout of hydel power plants.

7 Hours

Module – III

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data, Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems, Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems

8 Hours

Module – IV

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor (Numerical Examples).

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.

8 Hours

Module – V
**Biomass Energy**: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

**Green Energy**: Introduction: Fuel cells: Overview; Classification of fuel cells; Operating principles; Fuel cell thermodynamics Nuclear, ocean, MHD, thermoelectric and geothermal energy applications; Origin and their types; Working principles, Zero energy Concepts

8 Hours

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

- Summarize the basic concepts of thermal energy systems,
- Identify renewable energy sources and their utilization.
- Understand the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
- Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas.
- Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.
- Identify methods of energy storage for specific applications

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**Scheme of Examination:** Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
FLUID POWER SYSTEMS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
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<th>Assessment</th>
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<td>Fluid Power Systems</td>
<td>15ME72</td>
<td>04</td>
<td>3-2-0</td>
<td>80</td>
<td>20</td>
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</table>

Course objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To provide an insight into the capabilities of hydraulic and pneumatic fluid power.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.</td>
</tr>
<tr>
<td>CLO5</td>
<td>To familiarize with logic controls and troubleshooting.</td>
</tr>
</tbody>
</table>

Module 1: Introduction to fluid power systems


10 hours

Module 2: Pumps and actuators

**Pumps:** Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps.  
Accumulators: Types, selection/design procedure, applications of accumulators. Types of Intensifiers, Pressure switches/sensor, Temperature switches/sensor, Level sensor.  
**Actuators:** Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.  
Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flow rate, and hydraulic motor performance; numerical problems. Symbolic representation of hydraulic actuators (cylinders and motors).  

10 hours
Module 3: Components and hydraulic circuit design

**Components:** Classification of control valves, Directional Control Valves—symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves.
Pressure control valves - types, direct operated types and pilot operated types.
Flow Control Valves - compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

**Hydraulic Circuit Design:** Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, double pump hydraulic system, counter balance valve application, hydraulic cylinder sequencing circuits, cylinder synchronizing circuit using different methods, hydraulic circuit for force multiplication; speed control of hydraulic cylinder-metering in, metering out and bleed off circuits. Pilot pressure operated circuits. Hydraulic circuit examples with accumulator.

Module 4: Pneumatic power systems

**Introduction to Pneumatic systems:** Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air and air compressors. Structure of pneumatic control System, fluid conditioners-dryers and FRL unit.

**Pneumatic Actuators:** Linear cylinder – types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols.

**Pneumatic Control Valves:** DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.

Module 5: Pneumatic control circuits

**Simple Pneumatic Control:** Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling.

**Signal Processing Elements:** Use of Logic gates - OR and AND gates in pneumatic applications. Practical examples involving the use of logic gates.

**Multi- Cylinder Application:** Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method- principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).

**Electro- Pneumatic Control:** Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application.

Hours:

- 10 hours
COURSE OUTCOMES:
After studying this course, students will be able to:

| CO1 | Identify and analyse the functional requirements of a fluid power transmission system for a given application. |
| CO2 | Visualize how a hydraulic/pneumatic circuit will work to accomplish the function. |
| CO3 | Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro-pneumatics for a given application. |
| CO4 | Select and size the different components of the circuit. |
| CO5 | Develop a comprehensive circuit diagram by integrating the components selected for the given application. |

TEXT BOOKS:

REFERENCE BOOKS:
3. FESTO, Fundamentals of Pneumatics, Vol I, II and III.

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Learning Assignment:
The faculty will allocate one or more of the following experiments from group A and B to group of students (containing not more than four students in a group):

Group A: Experiments on hydraulic trainer:
  a. Speed control circuit using metering in and metering out technique
  b. Regenerative and sequencing circuits.
  c. Extend-Retract and Stop system of a linear actuator
  d. Rapid Traverse and Feed circuit.

Group B: Experiments on pneumatic trainer:
  a. Automatic reciprocating circuit
  b. Speed control circuit
  c. Pneumatic circuit involving shuttle valve/quick exhaust valve
  d. Electro pneumatic valves and circuit

Students should build up the above circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the
hydraulic/pneumatic trainer and run the circuit. Record of experiments shall be submitted in the form of journal. Due credit must be given for this assignment (5 Marks).

**List of Open Source Software/learning website:**
1. Simulink
2. SimHydraulics
CONTROL ENGINEERING

<table>
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<tr>
<th>Course</th>
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<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
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<td>Control Engineering</td>
<td>15ME73</td>
<td>04</td>
<td>3-2-0</td>
<td>80</td>
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</table>

Course Objectives

1. Modeling of mechanical, hydraulic, pneumatic and electrical systems.
2. Representation of system elements by blocks and its reduction
3. Transient and steady state response analysis of a system.
4. Frequency response analysis using polar plot.
5. Frequency response analysis using bode plot.
6. Analysis of system using root locus plots.
7. Different system compensators and variable characteristics of linear systems.

MODULE I

**Introduction:** Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.

(7 Hours)

MODULE 2

**Modeling of Physical Systems:** Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic and Pneumatic Systems.

(3 hours)

**Analogous Systems:** Direct and inverse analogs for mechanical, thermal and fluid systems.

(4 hours)

**Block diagram Algebra:** General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block dia. to obtain closed loop transfer function.

Signal flow graphs : Mason’s gain formula

(6 Hours)

MODULE 3

**Steady state operation:** Steady state analysis for general block dia. for a control system, steady state characteristics, equilibrium in a system.

(3 hours)

**Transient Response:** Transient response and steady state analysis of unit, step input, general operational representation for a differential equation of control system, distinct, repeated and
complex conjugate zeros, general form of transient response, Routh’s stability criterion for a control system. (4 hours)

**Root Locus Plots**: Root locus method: Significance of Root locus, angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation (6 Hours)

**MODULE 4**

**Frequency Domain Analysis**: Relationship between time and frequency response, Polar plot, Bode’s Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins (14 Hours)

**MODULE 5**

**System Compensation and State Variable Characteristics of Linear Systems**: Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalman and Gilberts test (7 Hours)

<table>
<thead>
<tr>
<th>Course Outcomes</th>
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<tbody>
<tr>
<td><strong>CO1</strong>: Recognize control system and its types, control actions</td>
</tr>
<tr>
<td><strong>CO2</strong>: Determine the system governing equations for physical models (Electrical, Thermal, Mechanical, Electro Mechanical)</td>
</tr>
<tr>
<td><strong>CO3</strong>: Calculate the gain of the system using block diagram and signal flow graph</td>
</tr>
<tr>
<td><strong>CO4</strong>: Illustrate the response of 1st and 2nd order systems</td>
</tr>
<tr>
<td><strong>CO5</strong>: Determine the stability of transfer functions in complex domain and frequency domain</td>
</tr>
<tr>
<td><strong>CO6</strong>: Employ state equations to study the controllability and observability</td>
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</tbody>
</table>
DESIGN OF THERMAL EQUIPMENTS

### Course Code Credits L-T-P Assessment Exam Duration

<table>
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<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>SEE</th>
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<tr>
<td>Design of thermal Equipments</td>
<td>15ME741</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
<td>3 Hrs</td>
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**Course objectives:**
1. To understand types of heat exchanger
2. To study the design shell and tube heat exchanger
3. To study types and design of steam heat condenser and compact heat exchanger
4. To comprehend and design air cooled heat exchanger
5. To understand and to design air cooled heat exchanger, furnaces

**Module I**
**Introduction To Heat Exchanger Design:** Types of heat exchangers and their applications. Flow arrangements and temperature distributions in transfer type of heat exchangers. Overall heat transfer coefficient; Clean overall heat transfer coefficient, dirt factor dirt overall heat transfer coefficient, dirt factors for various process services.

**Double Pipe Heat Exchangers:** Film coefficients for tubes and annuli, equivalent diameter of annuli, fouling factors, caloric or average fluid temperature, true temperature difference; Design calculation of double pipe heat exchanger, double pipe exchangers in series-parallel arrangements.

**Module II**
**Shell and tube heat exchangers** - tube layouts, baffle spacing, classification of shell and tube exchangers, Design calculation of shell and tube heat exchangers, flow assignments: tube side flow area calculations; viscosity correction factor, shell side equivalent diameter, calculation of shell side heat transfer coefficient, evaluation for wall temperature, evaluation of overall heat transfer coefficient, Calculation of surface area. Calculations of tube side and shell side pressure drops.

**Module III**
**Steam Condensers:** Specifications of other details as per TEMA standards. Flow arrangement for increased heat recovery: lack of heat recovery in 1-2 exchangers true temperature difference in a 2-4 exchanger. Calculation procedure for steam condensers.

**Compact Heat Exchangers:** Introduction; definition of Geometric Terms: plate fin surface geometries and surface performance data; correlation of heat transfer and friction data; Goodness factor comparisons; specification of rating and sizing problems; calculation procedure for a rating problem.

**Module IV**
**Air-Cooled Heat Exchangers:** Air as coolant for industrial processes; custom-built units; fin-tube systems for air coolers; fin-tube bundles; thermal rating; tube side flow arrangements; cooling air supply by fans; cooling air supply in natural draft towers.
Furnaces And Combustion Chambers: Introduction; process heaters and boiler; heat transfer in furnaces: - Heat source; Heat sink; refractory surfaces; heat transfer to the sink; Design methods: - Method of Lobo and Evans; Method of Wilson, Lobo and Hottel; The Orrok-Hudson equation; Wallenberg simplified method.

Module V

Heat pipes - types and applications, operating principles, working fluids, wick structures, control techniques, pressure balance, maximum capillary pressure, liquid and vapor pressure drops, effective thermal conductivity of wick structures, capillary limitation on heat transport capability, sonic, entrainment, and boiling limitations, determination of operating conditions; Heat pipe design – fluid selection, wick selection, material selection, preliminary design considerations, heat pipe design procedure, determination of heat pipe diameter, design of heat pipe containers, wick design, entertainment and boiling limitations, design problems

Course outcomes:

1. To have complete knowledge of heat exchanger and its applications
2. To be able to design shell and tube heat exchanger
3. To be able to select and design of steam heat condenser and compact heat exchanger condenser and heat pipes for various application

TEXT BOOKS:

REFERENCE BOOKS:
3. Heat exchanger- Kokac Thermal- hydraulic and design analysis.
TRIBOLOGY

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tribology</td>
<td>15ME742</td>
<td>03</td>
<td>3-0-0</td>
<td>80 20</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

Course objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To educate the students on the importance of friction, the related theories/laws of sliding and rolling friction and the effect of viscosity of lubricants.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>To expose the students to the consequences of wear, wear mechanisms, wear theories and analysis of wear problems.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To make the students understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To expose the students to the factors influencing the selection of bearing materials for different sliding applications.</td>
</tr>
<tr>
<td>CLO5</td>
<td>To introduce the concepts of surface engineering and its importance in tribology.</td>
</tr>
</tbody>
</table>

Module 1

**Introduction to tribology:** Historical background, practical importance, and subsequent use in the field.

Lubricants: Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.

8 hours

Module 2

**Friction:** Origin, friction theories, measurement methods, friction of metals and non-metals.

**Wear:** Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.

8 hours

Module 3

**Hydrodynamic journal bearings:** Friction forces and power loss in a lightly loaded journal bearing, Petroff’s equation, mechanism of pressure development in an oil film, and Reynold’s equation in 2D.

Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld’s number and it’s significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.

10 hours

Module 4
Plane slider bearings with fixed/pivoted shoe: Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples.

Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.

Module 5


COURSE OUTCOMES:
After studying this course, students will be able to:

| CO1  | Understand the fundamentals of tribology and associated parameters. |
| CO2  | Apply concepts of tribology for the performance analysis and design of components experiencing relative motion. |
| CO3  | Analyse the requirements and design hydrodynamic journal and plane slider bearings for a given application. |
| CO4  | Select proper bearing materials and lubricants for a given tribological application. |
| CO5  | Apply the principles of surface engineering for different applications of tribology. |

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module. Use of approved Design Data Handbook/charts can be permitted during the examination.

TEXTBOOKS:

REFERENCES:
5. “Basic Lubrication Theory”, A. Cameron, Ellis Hardwoods Ltd., UK.
Subject Overview: Finance is the lifeblood of any enterprise. Financial Management is imperative for efficient utilization and generation of monetary resources and funds. The subject deals with fundamental books and records of accounts with financial analysis. The subject imparts exposure to statutory levies to strengthen the understanding of government taxed and duties including the general sales tax structure. The subject includes concepts of market risks and returns to efficiently manage the cash and circumvent liquidity problems both at the individual and organizational levels. In the new CBCS scheme, topics on investment decisions and asset management decisions besides the financing decisions. The curriculum also includes costing and budgeting to enable budding engineers to make a comparative study of finance and economics and evaluate costs and revenues of engineering operations.

MODULE - 1

05 Hours STATUTORY LEVIES: Forms of organization, direct and indirect taxes. Statutory Registration- excise Duty, central sales tax, VAT, service tax, central and state general Sales tax, international fund availability.

05 Hours

MODULE - 2
WORKING CAPITAL MANAGEMENT: Definition, need and factors influencing the working capital requirement. Determination of operating cycle, cash cycle and operating cycle analysis. Calculation of gross working capital and net working capital requirement.

06 Hours

LONG TERM FINANCING: Raising of finance from primary and secondary markets. Valuation of securities, features of convertible securities and warrants. Features of debt, types of debt instruments, return on investment (ROI) and credit rating of units. Shares, debentures.

06 Hours

MODULE-3
INVESTMENT DECISIONS: Inventory investment, Strategic investment, Ownership investments, lending investment, cash equivalent investment, factors affecting investment decisions, Capital Budgeting, disinvestment methods - public offer, sale of equity, cross holding.

06 Hours

ASSET MANAGEMENT DECISIONS: Current Asset Management, Fixed Asset Management, Wealth management, engineering asset management (EAM) - asset maintenance technologies, asset reliability management, project management.

06 Hours

MODULE -4
RISK AND REQUIRED RETURN: Risk and return relationship, methods of measuring the risk, Business risk, financial risk, calculation of expected rate of return to the portfolio, financial
theories - portfolio theory, capital asset pricing model, arbitrage pricing theory numerical problems. 06 Hours

**RATIO ANALYSIS / ACCOUNTING RATIO:** Liquidity ratio – Current ratio, quick ratio, turnover ratio, capital structure ratio- Debt – equity ratio, Coverage ratio, Profitability ratio, Profit margin, Return on assets, Activity ratios – Inventory turnover ratio, Debtors Turnover ratio. Preparation of the balance sheet from various ratios. Analysis of any one published balanced sheet. 07 Hours

**MODULE - 5**

**COSTING:** Classification of costs, preparation of cost sheet, absorption and variable costing, standard costing, job costing, process costing. Classification of the variances analysis – material, labor and overhead variances. 06 Hours

**BUDGETING:** Types of budgets – Flexible budgets, preparation of cash budgets, purchase and production budgets and master budget, Budgetary control, advantages & limitations of budgeting. 06 Hours

**Course Outcomes:** Upon successful completion of the course, students will be able to:

1. Measure the returns from engineering projects of differing risks and present a risk-return tradeoff relationship (PO 4, 12)
2. Determine the financial ratios and profitability margins of projects to evaluate economic viability to accept or reject the project. (PO 11)
3. Evaluate cost break ups of engineering projects and processes to determine and control the prohibitive cost components (PO 11)
4. Apply a Engineering Asset Management techniques to evaluate the economic value of physical assets. (PO 1, 11, 12)

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**Course Outcomes:** Upon successful completion of the course, students will be able to:

1. Measure the returns from engineering projects of differing risks and present a risk-return tradeoff relationship (PO 4, 12)
2. Determine the financial ratios and profitability margins of projects to evaluate economic viability to accept or reject the project. (PO 11)
3. Evaluate cost break ups of engineering projects and processes to determine and control the prohibitive cost components (PO 11)
4. Apply a Engineering Asset Management techniques to evaluate the economic value of physical assets. (PO 1, 11, 12)
Course objectives:

| CLO1 | To educate students on factors to be considered in designing parts and components with focus on manufacturability. |
| CLO2 | To expose the students to dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture. |
| CLO3 | To impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc. |
| CLO4 | To educate the students on design rules and recommendations for processes like casting, welding, forgings powder metallurgy and injection moulding. |

Module 1:

8 hours

Module 2:
Selective Assembly: Interchangeable part manufacture and selective assembly. Deciding the number of groups -model-1: group tolerance of mating parts equal, model- 2: total and group tolerances of shaft equal. Control of axial play- introducing secondary machining operations, and laminated shims; examples.
True positional theory: Comparison between coordinate and true position method of feature location. True position tolerance- virtual size concept, floating and fixed fasteners, projected tolerance zone and functional gages. Concept of Zero true position tolerance. Simple problems on true position tolerancing.

10 hours

Module 3:
**Datum Features:** Functional datum, datum for manufacturing, changing the datum; examples.
**Component Design:** Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by
separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility. Design for assembly

8 hours

Module 4:
Design of components with casting considerations: Pattern, mould, and parting line. Cored holes and machined holes. Identifying the possible and probable parting lines. Castings requiring special sand cores. Designing to obviate sand cores.
Welding considerations: requirements and rules, redesign of components for welding; case studies.

8 hours

Module 5:
Forging considerations -requirements and rules-redesign of components for forging and case studies.
Design of components for powder metallurgy- requirements and rules-case studies.
Design of components for injection moulding- requirements and rules-case studies.

8 hours

COURSE OUTCOMES:
After studying this course, students will be able to:

<table>
<thead>
<tr>
<th>CO1</th>
<th>Describe the different types of manufacturing systems and compare their suitability for economic production of various components and products.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Identify factors and causing mechanisms of the defects likely to occur with different manufacturing processes in producing mechanical products and the relevant design approaches to rectify them.</td>
</tr>
<tr>
<td>CO3</td>
<td>Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.</td>
</tr>
<tr>
<td>CO4</td>
<td></td>
</tr>
</tbody>
</table>

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

TEXTBOOKS:

REFERENCES:
SMART MATERIALS and MEMS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Materials and MEMS</td>
<td>15ME745</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

**Course Objective:**
This course provides a detailed overview to smart materials, piezoelectric materials structures and its characteristics. The study of Smart structures and modelling helps in Vibration control using smart materials in various applications. Helps to understand the principles and concepts of using MEMS, ER & MR Fluids for various applications.

**MODULE 1**

Unit 1: Introduction: Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect-Application, Processing and characteristics.

– 5hrs


– 5hrs

**MODULE -2**

Unit-3 Electro rheological and Magneto rheological Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others).

– 5hrs

Unit-4 Fibre Optics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements.

– 5hrs

**MODULE-3**


– 6hrs
Unit 6: Biomimetics: Characteristics of Natural structures. Fibre reinforced: organic matrix natural composites, Natural creamers, Mollusks. Biomimetic sensing, Challenges and opportunities. – 5hrs

MODULE -4


MODULE-5


Unit 10: Case Studies: MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyro, MEMS Product development: Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties, Investment and competition. – 5hrs

TEXT BOOKS:


Course outcomes:

1. Describe the methods of controlling vibration using smart systems and fabrication methods of MEMS.
2. Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.
3. Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.
4. Summarize the methods and uses of Micro fabrications, Biomimetics, types of polymers used in MEMS, Fibre optics, piezoelectric sensing and actuation.
Automotive Electronics

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive Electronics</td>
<td>15ME751</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

**Course Objective**

Students will learn

1. Basics of electronic control of internal combustion engines and the drives
2. Understand principle of working of sensors and actuators used in automobiles for control
3. Diagnostics and safety systems in automobiles

**Module 1**


**Module 2**

**Control Systems** - Automotive Control System applications of Sensors and Actuators – Typical Electronic Engine Control System, Variables to be measured (3 hours)


**Automotive Actuators** – Solenoid, Fuel Injector, EGR Actuator, Ignition System (3 hours)
Module 3


6 hours

Control Units – Operating conditions, Design, Data processing, Programming, Digital modules in the Control unit, Control unit software.

3 hours

Module 4

Automotive Networking – Bus Systems – Classification, Applications in the vehicle, Coupling of networks, Examples of networked vehicles (Text 2: Pg. 85-91), Buses - CAN Bus, LIN Bus, MOST Bus, Bluetooth, FlexRay, Diagnostic Interfaces.

6 hours

Vehicle Motion Control – Typical Cruise Control System, Digital Cruise Control System, Digital Speed Sensor, Throttle Actuator, Digital Cruise Control configuration, Cruise Control Electronics (Digital only), Antilock Brake System (ABS)

3 hours

Module 5


4 hours


6 hours
Course Outcomes
1. Explain the electronics systems used for control of automobiles
2. Select sensors, actuators and control systems used in automobiles
3. Diagnose the faults in the sub systems and systems used automobile

Text Books:


FRACTURE MECHANICS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture Mechanics</td>
<td>15ME752</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course Objective:
Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures.
It provides a background for damage tolerant design.
It quantifies toughness as materials resistance to crack propagation.

Course Content:

Module 1.

Module 2.
Plasticity effects: Irwin plastic zone correction. Dugdale’s approach. The shape of the plastic zone for plane stress and plane strain cases. The plate thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors. Experimental method- Plane strain fracture toughness test, The Standard test, size requirements, etc. 08 Hrs

Module 3.

Module 4.

Module 5.
Fatigue crack propagation and applications of fracture mechanics: Crack growth and the

**Course Outcome:**

At the end of the course students will:

1. Develop basic fundamental understanding of the effects of cracklike defects on the performance of aerospace, civil, and mechanical engineering structures.
2. Learn to select appropriate materials for engineering structures to insure damage tolerance.
3. Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
4. Gain an appreciation of the status of academic research in field of fracture mechanics.

**Text Books**


**Reference Books**

HUMAN RESOURCE MANAGEMENT

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resource Management</td>
<td>15ME753</td>
<td>03</td>
<td>3-0-0</td>
<td>80 20</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

Course objectives:

- To understand the HRM concepts and theory
- To gain overview of analysis of job, Recruitment and selection process
- To obtain an overview of various HRM functions and practices
- To gain an insight into the various statutory provisions

Module 1:

Human Resource Management:
Introduction, nature, scope of HRM, Importance and Evolution of the concept of HRM - Major functions of HRM, influencing factors for future of HRM, Business ethics in HRM

Job Analysis: Meaning, process of Job Analysis, methods of collecting job analysis data, Job Description and Job Specification, Role Analysis.

09 hours

Module 2:

Human Resource Planning: Objectives, Importance and process of Human Resource Planning, Effective HRP.
Recruitment: Definition, Constraints and Challenges, Sources and Methods of Recruitment, New Approaches to recruitment.
Selection: Definition and Process of Selection.
Placement: Meaning, Induction/Orientation, Internal Mobility, Transfer, Promotion, Demotion and Employee Separation

08 hours

Module 3:

Performance Appraisal: Concept of Performance Appraisal, the Performance Appraisal Process, Methods of Performance Appraisal

08 hours

Module 4:

Discipline: Meaning, approaches to discipline, essential of a good disciplinary system, managing difficult employees.

08 hours

Module 5:

Industrial Relations and labour laws: Importance, approaches, settlement of industrial disputes, industrial disputes act 1947, payment of wages act, factories act, employees compensation act, minimum wages act 1948, payment of bonus act 1948, ESI act 1948, payment of gratuity act 1972, trade union movement in India

09 hours

**Case studies:** Discussion of HRM cases to make the student aware of case study approach.
(Not for the examination)

**Exercise:** (this study shall be made in the organisation the student is studying or in a nearby organisation)
- Give a case and ask the students to prepare the recruitment advertisement for a newspaper
- Expose students to standard selection tests followed in various sectors.
- Exploring training and development practices.
- Exploring performance appraisal practices in various sectors.
- Exploring employee separation practices.
- Give a job analysis case and ask the students to prepare job description and job specification.
- Ask the students to prepare an appointment letter for the post of office manager of a company.

**Course outcome:**
At the end of the course students will be able to:
- Synthesize information regarding the effectiveness of recruiting methods & selection procedures
- Identify the various training methods and design a training program
- Design a job description and job specification for various levels of employees.
- List out the regulations governing employee benefit practices.

**RECOMMENDED BOOKS:**

**REFERENCE BOOKS:**

**E-RESOURCES:** NPTEL online resources, VTU e-learning resources
MECHATRONICS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechatronics</td>
<td>15ME754</td>
<td>03</td>
<td>3-0-0</td>
<td>80 20</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

Course objectives:
1. Understand the evolution and development of Mechatronics as a discipline.
2. Substantiate the need for interdisciplinary study in technology education.
3. Understand the applications of microprocessors in various systems and to know the functions of each element
4. Demonstrate the integration philosophy in view of Mechatronics technology

**MODULE -1**

**Introduction:** Definition, Multidisciplinary Scenario, Evolution of Mechatronics, Design of Mechatronics system, Objectives, advantages and disadvantages of Mechatronics.

**Transducers and sensors:** Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, proximity switches and Hall Effect sensors. 10 Hours

**MODULE -2**

**Microprocessor & Microcontrollers:** Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers.

**Microprocessor Architecture:** Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data, Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel’s 8085A Microprocessor. 10 Hours

**MODULE -3**

**Programmable logic controller:** Introduction to PLC’s, basic structure, Principle of operation, Programming and concept of ladder diagram, concept of latching & selection of a PLC.

**Integration:** Introduction & background, Advanced actuators, Pneumatic actuators, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, End Effectors, Sensor & Functional requirements of robot. 10 Hours

**MODULE -4**

**Mechanical actuation systems:** Mechanical systems, types of motion, Cams, Gear trains, Ratchet & Pawl, belt and chain drives, mechanical aspects of motor selection.

**Electrical actuation systems:** Electrical systems, Mechanical switches, Solenoids, Relays, DC/AC Motors, Principle of Stepper Motors & servomotors. 10 Hours

**MODULE -5**

**Pneumatic and hydraulic actuation systems:** Actuating systems, Pneumatic and hydraulic systems, Classifications of Valves, Pressure relief valves, Pressure regulating/reducing valves, Cylinders and rotary actuators.

**DCV & FCV:** Principle & construction details, types of sliding spool valve, solenoid operated, Symbols of hydraulic elements, components of hydraulic system, functions of various units of hydraulic system. Design of simple hydraulic circuits for various applications. 10 Hours

Course outcomes:
- Illustrate various components of Mechatronics systems.
- Assess various control systems used in automation.
- Develop mechanical, hydraulic, pneumatic and electrical control systems.

**TEXT BOOKS:**

REFERENCE BOOKS:

E- Learning
- VTU, E-learning

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
MECHANICAL VIBRATIONS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Vibrations</td>
<td>15ME755</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
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<td>20</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

Course objectives:

1. To enable the students to understand the theoretical principles of vibration and vibration analysis techniques for the practical solution of vibration problems.
2. To enable the students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations.

MODULE -1

**Forced vibrations (1DOF):** Introduction, analysis of forced vibration with constant harmonic excitation, MF, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, energy dissipated due to damping and numerical problems.

**Systems with 2DOF:** Principal modes of vibrations, normal mode and natural frequencies of systems (Damping is not included), simple spring-mass systems, masses on tightly stretched strings, double pendulum, tensional systems, combined rectilinear and angular systems, geared systems and numerical problems. 10 Hours

MODULE -2

**Numerical methods for multi DOF systems:** Maxwell’s reciprocal theorem, influence coefficients, Rayleigh’s method, Dunkerley’s method, stodola method, orthogonality principle, method of matrix iteration and numerical.

**Modal analysis and condition monitoring:** signal analysis, dynamic testing of machines and structures, experimental modal analysis, machine condition monitoring and diagnosis. 10 Hours

MODULE -3

**Vibration measuring instruments and whirling of shafts:** seismic instruments, vibrometers, accelerometer, frequency measuring instruments and numerical. Whirling of shafts with and without damping.

**Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers and Vibration dampers. 10 Hours

MODULE -4

**Transient Vibration of single Degree-of freedom systems:** Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.

**Random Vibrations:** Random phenomena Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response. 10 Hours

MODULE -5

**Non Linear Vibrations:** Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.

**Continuous Systems:** Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. 10 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Understand and characterize the single and multi degrees of freedom systems subjected to free and forced vibrations with and without damping.
2. Understand the method of vibration measurements and its controlling.
3. Understand the concept of dynamic vibrations of a continuous systems.

TEXT BOOKS:
5. Mechanical Vibrations, W.T. Thomson W.T.- Prentice Hill India

REFERENCE BOOKS:

E- Learning
• VTU, E- learning

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
DESIGN LABORATORY

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Laboratory</td>
<td>15MEL76</td>
<td>02</td>
<td>1-0-2</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Prerequisites: Knowledge of Dynamics and Machines and Design of Machine Elements

COURSE OBJECTIVES:
Students are expected-
1. To understand the natural frequency, logarithmic decrement, damping ratio and damping.
2. To understand the balancing of rotating masses.
3. To understand the concept of the critical speed of a rotating shaft.
4. To understand the concept of stress concentration using Photo elasticity.
5. To understand the equilibrium speed, sensitiveness, power and effort of Governor.

PART –A
1. Determination of natural frequency, logarithmic decrement, damping ratio and damping Co-efficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2. Determination of critical speed of rotating shaft.
4. Determination of fringe constant of Photo-elastic material using Circular disk subjected diametric compression, Pure bending specimen (four point bending)
5. Determination of stress concentration using Photo elasticity for simple components like Plate with hole under tension or bending, circular disk with circular hole under compression, 2-d crane hook.

PART –B
1. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proel/Hartnell Governor. (at least one)
2. Determination of pressure distribution in Journal bearing
3. Determination of principle stresses and strain in a member subjected to combined loading using strain rosettes.
4. Determination of stresses in curved beam using strain gauge.
5. Experiments on Gyroscope (Demonstration only)

COURSE OUTCOMES
At the end of the course, the students will be able to:
1. To understand the working principles of machine elements such as Governors, Gyroscopes etc.,
2. To identify forces and couples in rotating mechanical system components.
3. To identify vibrations in machine elements and design appropriate damping methods and to determine the critical speed of a rotating shaft.
4. To measure strain in various machine elements using strain gauges.
5. To determine the minimum film thickness, load carrying capacity, frictional torque and pressure distribution of journal bearing.
6. To determine strain induced in a structural member using the principle of photo-elasticity.

Scheme of Examination:
One question from Part A: 32 Marks
<table>
<thead>
<tr>
<th>One question from part B:</th>
<th>32 Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viva-Voce:</td>
<td>16 Marks</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>80 Marks</strong></td>
</tr>
</tbody>
</table>

**Reference Books:**


COMPUTER INTEGRATED MANUFACTURING LAB

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Integrated Manufacturing LAB</td>
<td>15MEL77</td>
<td>02</td>
<td>1-0-2</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course Objectives:

| CLO1                          | To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes. |
| CLO2                          | To educate the students on the usage of CAM packages. |
| CLO3                          | To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics. |

Part A
Manual CNC part programming for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path.

CNC part programming using CAM packages. Simulation of Turning, Drilling, Milling operations.
3 typical simulations to be carried out using simulation packages like: Cadem CAMLab-Pro, Master-CAM.
Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts. Cut the part in single block and auto mode and measure the virtual part on screen. Post processing of CNC programs for standard CNC control systems like FANUC, SINUMERIC and MISTUBISHI.

Part B
(Only for Demo/Viva voce)
FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components.
(Only for Demo/Viva voce)
Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs).
Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.

Course Outcomes:

37
After studying this course, students will be able to:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>Generate CNC Lathe part program for Turning, Facing, Chamfering, Grooving, Step turning, Taper turning, Circular interpolation etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>Generate CNC Mill Part programming for Point to point motions, Line motions, Circular interpolation, Contour motion, Pocket milling- circular, rectangular, Mirror commands etc.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Use Canned Cycles for Drilling, Peck drilling, Boring, Tapping, Turning, Facing, Taper turning Thread cutting etc.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Simulate Tool Path for different Machining operations of small components using CNC Lathe &amp; CNC Milling Machine.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Use high end CAM packages for machining complex parts; use state of art cutting tools and related cutting parameters; optimize cycle time.</td>
</tr>
<tr>
<td>CLO6</td>
<td>Understand &amp; write programs for Robot control; understand the operating principles of hydraulics, pneumatics and electro pneumatic systems. Apply this knowledge to automate &amp; improve efficiency of manufacturing.</td>
</tr>
</tbody>
</table>

**Scheme for Examination:**
Two Questions from Part A - 60 Marks (30 +30)
Viva-Voce - 20 Marks
Total: 80 Marks
## Project Work, Phase I

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Work, Phase I</td>
<td>15MEP78</td>
<td>2</td>
<td>0-3-0</td>
<td>100</td>
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<table>
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<tr>
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<th>SEE</th>
<th>CIA</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>-</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
</tr>
</tbody>
</table>
OPERATIONS RESEARCH

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations Research</td>
<td>15ME81</td>
<td>4</td>
<td>3-2-0</td>
<td>80 20</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

Course objectives:

1. To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
2. To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

MODULE -1
Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).
08 Hours

MODULE -2
LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.
12 Hours

MODULE -3
12 Hours

MODULE -4
Network analysis: Introduction, Construction of networks. Fulkerson’s rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.
Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee’s notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.
10 Hours

MODULE -5


08 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Understand the meaning, definitions, scope, need, phases and techniques of operations research.
2. Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
3. Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
4. Solve problems on game theory for pure and mixed strategy under competitive environment.
5. Solve waiting line problems for M/M/1 and M/M/K queuing models.
6. Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.
7. Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson’s algorithm.

TEXT BOOKS:


REFERENCE BOOKS:

2. Operations Research, Paneerselvan, PHI

Scheme of Examination:
Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
**ADDITIVE MANUFACTURING**

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additive Manufacturing</td>
<td>15ME82</td>
<td>4</td>
<td>4-0-0</td>
<td></td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

**Course Objectives:**

**Students will be able to**

1. Understand the additive manufacturing process, polymerization and powder metallurgy process

2. Understand characterisation techniques in additive manufacturing.

3. Acquire knowledge on CNC and Automation.

---

**Module 1**

**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, **AM process chain:** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing.

**Classification of AM processes:** Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system.

**Post processing of AM parts:** Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

**Guidelines for process selection:** Introduction, selection methods for a part, challenges of selection

**AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries

10 Hours

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**Module 2**

**System Drives and devices:** Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features

**Actuators:** Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.

8 Hours

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**Module 3**

**POLYMERS & POWDER METALLURGY**

**Basic Concepts:** Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polysters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD]

**Polymer Processing:** Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques

**General Concepts:** Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM

**Powder Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes. **Characterization Techniques:** Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle

12 Hours
<table>
<thead>
<tr>
<th>Module 4</th>
<th>NANO MATERIALS &amp; CHARACTERIZATION TECHNIQUES:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction:</strong></td>
<td>Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology</td>
</tr>
<tr>
<td><strong>Nano-materials Synthesis and Processing:</strong></td>
<td>Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC).</td>
</tr>
<tr>
<td><strong>Optical Microscopy</strong></td>
<td>principles, Imaging Modes, Applications, Limitations.</td>
</tr>
<tr>
<td><strong>Scanning Electron Microscopy (SEM)</strong></td>
<td>principles, Imaging Modes, Applications, Limitations.</td>
</tr>
<tr>
<td><strong>Transmission Electron Microscopy (TEM)</strong></td>
<td>principles, Imaging Modes, Applications, Limitations.</td>
</tr>
<tr>
<td><strong>X-Ray Diffraction (XRD)</strong></td>
<td>principles, Imaging Modes, Applications, Limitations.</td>
</tr>
<tr>
<td><strong>Scanning Probe Microscopy (SPM)</strong></td>
<td>principles, Imaging Modes, Applications, Limitations.</td>
</tr>
<tr>
<td><strong>Atomic Force Microscopy (AFM)</strong></td>
<td>basic principles, instrumentation, operational modes, Applications, Limitations.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module 5</th>
<th>MANUFACTURING CONTROL AND AUTOMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CNC technology - An overview:</strong></td>
<td>Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT)</td>
</tr>
<tr>
<td><strong>Introduction:</strong></td>
<td>Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity</td>
</tr>
<tr>
<td><strong>Control Technologies in Automation:</strong></td>
<td>Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components.</td>
</tr>
</tbody>
</table>

Course Outcomes

1. Understand the different process of Additive Manufacturing. using Polymer, Powder and Nano materials manufacturing.
2. Analyse the different characterization techniques.
3. Describe the various NC, CNC machine programing and Automation techniques.
TEXT BOOKS:

REFERENCE BOOKS:
Course objectives:

1. To understand cryogenic system and gas liquefaction system
2. To analyze gas cycle cryogenic refrigeration system
3. To Comprehend gas separation and gas purification system
4. To have detailed knowledge of vacuum technology, insulation, storage of cryogenic liquids
5. To study applications of cryogenics and to embark on cryogenic fluid

Module 1

Introduction to Cryogenic Systems:

Cryogenic propellants and its applications, liquid hydrogen, liquid nitrogen, and liquid Helium
The thermodynamically Ideal system Production of low temperatures – Joule Thompson Effect, Adiabatic expansion.

Gas Liquefaction Systems:


Module 2

Gas Cycle Cryogenic Refrigeration Systems:

Classification of Cryo coolers Stirling cycle Cryo – refrigerators, Ideal cycle – working principle. Schmidt’s analysis of Stirling cycle, Various configurations of Stirling cycle refrigerators, Integral piston Stirling cryo-cooler, Free displacer split type Stirling Cryo coolers, Gifford Mcmahon Cryo- refrigerator, Pulse tube refrigerator, Solvay cycle refrigerator, Vuillimier refrigerator, Cryogenic regenerators. 10hrs

Module 3

Gas Separation and Gas Purification Systems

Thermodynamic ideal separation system, Properties of mixtures, Principles of gas separation,
Linde single column air separation. Linde double column air separation, Argon and Neon separation systems.

**Ultra Low Temperature Cryo – Refrigerators**

Magneto Caloric Refrigerator 3He-4He Dilution refrigerator. Pomeranchuk cooling. Measurement systems for low temperatures, Temperature measurement at low temperatures, Resistance thermometers, Thermocouples, Thermistors, Gas Thermometry. Liquid level sensors. 10hrs

**Module 4**

**Vacuum Technology**


**Module 5**

**Cryogenic Fluid Storage And Transfer Systems**

Design of cryogenic fluid storage vessels, Inner vessel, Outer Insulation, Suspension system, Fill and drain lines. Cryogenic fluid transfer, External pressurization, Self pressurization, Transfer pump.

**Application of Cryogenic Systems**

Cryogenic application for food preservation – Instant Quick Freezing techniques Super conductive devices, Cryogenic applications for space technology. Application of cryogenic systems, super conducting devices, space technology, cryogenic in biology and medicine. 10hrs

**Course outcomes:**

On completion of this subject students will be able to:

1. To be able to understand the cryogenic system.
2. To have complete knowledge of cryogenic refrigeration system
3. To be able to design gas separation and gas purification system
4. To able to solve the problem in insulation, storage of cryogenic liquids
5. To be able to apply cryogenic in various areas and to be able take up research in cryogenics
TEXT BOOKS


REFERENCE BOOKS


2. High Vacuum Technology – A. Guthree – New Age International Publication

3. Experimental Techniques in Low Temperature Physics – G.K. White – Osford University Press,

E- Learning

- VTU, E- learning
- NPTEL

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
EXPERIMENTAL STRESS ANALYSIS

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Stress Analysis</td>
<td>15ME832</td>
<td>3</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course Learning Objectives (CLO’s):
1. To use the method of electrical strain gauges to study and characterize the elastic behavior of solid bodies.
2. To measure displacement and perform stress strain analysis of mechanical systems using electrical resistance strain gauges.
3. To describe the photo elastic method to study and characterize the elastic behavior of solid bodies.
4. To determine stress strain behavior of solid bodies using methods of coating.
5. To conduct stress strain analysis of solid bodies using the methods Holography

Module - 1

Introduction: Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. general consideration in data analysis.


Module -2

Strain Analysis Methods: Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, Stress intensity factor gage.

Force, Torque and strain measurements: Mass balance measurement, Elastic element for force measurements, torque measurement.

Module – 3


Two Dimensional Photoelasticity: Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photoelastic model materials, Materials for 2D photoelasticity
Module - 4

Three Dimensional Photoelasticity: Stress freezing method, Scattered light photoelasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data analyses.

Photelastic (Birefringent) Coatings: Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poisson's, Stress separation techniques: Oblique incidence, Strip coatings

Module – 5

Brittle Coatings: Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications.

Moire Methods: Moire fringes produced by mechanical interference. Geometrical approach, Displacement field approach to Moire fringe analysis, Out of plane displacement measurements, Out of plane slope measurements. Applications and advantages

Course Outcomes (CO’s):

At the end of the course, the student will be able to:

1. Explain characterize the elastic behavior of solid bodies.
2. Describe stress strain analysis of mechanical systems using electrical resistance strain gauges.
3. Discuss skills for experimental investigations an accompanying laboratory course is desirable
4. Discuss experimental investigations by predictions by other methods.
5. Describe various coating techniques.

TEXT BOOKS:

REFERENCES BOOKS:
2. "Strain Gauge Primer", Perry and Lissner,
4. "Motion Measurement and Stress Analysis", Dave and Adams,

Scheme of Examination: Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.
THEORY OF PLASTICITY

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory of Plasticity</td>
<td>15ME833</td>
<td>3</td>
<td>3-0-0</td>
<td>80 20</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

Pre-requisite: This course requires sufficient solid mechanics and theory of elasticity background and basic knowledge about materials and their mechanical properties.

Course objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To introduce the concepts of Plasticity and mechanism of plastic deformation in metals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>To expose the students to elasto-plastic problems involving plastic deformation of beams and bars.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To introduce the concepts of slip line field theory.</td>
</tr>
</tbody>
</table>

Module 1

Brief review of fundamentals of elasticity: Concept of stress, stress invariants, principal stresses, octahedral normal and shear stresses, spherical and deviatoric stress, stress transformation; concept of strain, engineering and natural strains, octahedral strain, deviator and spherical strain tensors, strain rate and strain rate tensor, cubical dilation, generalized Hooke’s law, numerical problems.

8 Hours

Module 2

Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth, flow figures or Luder’s cubes.

Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criterion, geometrical representation, yield surface, yield locus (two dimensional stress space), experimental evidence for yield criteria, problems.

9 Hours

Module 3

Stress Strain Relations: Idealised stress-strain diagrams for different material models, empirical equations, Levy-Von Mises equation, Prandtl-Reuss and Saint Venant theory, experimental verification of Saint Venant’s theory of plastic flow. Concept of plastic potential, maximum work hypothesis, mechanical work for deforming a plastic substance.

8 Hours

Module 4
**Bending of Beams**: Stages of plastic yielding, analysis of stresses, linear and nonlinear stress strain curve, problems.

**Torsion of Bars**: Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, problems.

**Hours**

**Module 5**

**Slip Line Field Theory**: Introduction, basic equations for incompressible two dimensional flows, continuity equations, stresses in conditions of plain strain, convention for slip lines, geometry of slip line field, properties of the slip lines, construction of slip line nets.

**8 Hours**

**Course outcomes:**

At the end of course, student will able to:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>Understand stress, strain, deformations, relation between stress and strain and plastic deformation in solids.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>Understand plastic stress-strain relations and associated flow rules.</td>
</tr>
<tr>
<td>CLO3</td>
<td>Perform stress analysis in beams and bars including Material nonlinearity.</td>
</tr>
<tr>
<td>CLO4</td>
<td>Analyze the yielding of a material according to different yield theory for a given state of stress.</td>
</tr>
<tr>
<td>CLO5</td>
<td>Interpret the importance of plastic deformation of metals in engineering problems.</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

**Text Books:**


**References Books:**

Green Manufacturing

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Manufacturing</td>
<td>15ME834</td>
<td>3</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

**COURSE OBJECTIVES**

Students will be able to

1. Acquire a broad understanding of sustainable manufacturing, green product and process
2. Understand the analytical tools, techniques in green manufacturing
3. Understand the structures of sustainable manufacturing, environmental and management practice.

**Module-1**

**Introduction to Green Manufacturing**

Why Green Manufacturing, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing.

**The Social, Business, and Policy Environment for Green Manufacturing**


**Module-2**

**Metrics for Green Manufacturing**

Introduction, Overview of Currently Used Metrics, Overview of LCA Methodologies, Metrics Development Methodologies, Outlook and Research Needs.

**Green Supply Chain**

Motivation and Introduction, Definition, Issues in Green Supply Chains (GSC), Techniques/Methods of Green Supply Chain, Future of Green Supply Chain.

**Principles of Green Manufacturing**

Introduction, Background, and Technology Wedges, Principles, Mapping Five Principles to Other Methods and Solutions.

**Module-3**

**Closed-Loop Production Systems**

**Semiconductor Manufacturing**

**Module- 4**

**Environmental Implications of Nano-manufacturing**

**Green Manufacturing Through Clean Energy Supply**
Introduction, Clean Energy Technologies, Application Potential of Clean Energy Supply in Green Manufacturing

**Module- 5**

**Packaging and the Supply Chain: A Look at Transportation**
Introduction, Background, Recommended Method to Determine Opportunities for Improved Pallet Utilization, Discussion.

**Enabling Technologies for Assuring Green Manufacturing**

**Concluding Remarks and Observations about the Future**

**COURSE OUTCOMES**
1. Understand the basic design concepts, methods, tools, the key technologies and the operation of sustainable green manufacturing.
2. Apply the principles, techniques and methods to customize the learned generic concepts to meet the needs of a particular industry/enterprise.
3. Identify the strategies for the purpose of satisfying a set of given sustainable green manufacturing requirements.
4. Design the rules and processes to meet the market need and the green manufacturing requirements by selecting and evaluating suitable technical, managerial / project management and supply chain management scheme.
PRODUCT LIFE CYCLE MANAGEMENT

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Life Cycle Management</td>
<td>15ME835</td>
<td>3</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course objectives:
This course enables students to
1. Familiarize with various strategies of PLM
2. Understand the concept of product design and simulation.
3. Develop New product development, product structure and supporting systems
4. Interpret the technology forecasting and product innovation and development in business processes.
5. Understand product building and Product Configuration.

MODULE 1: INTRODUCTION TO PLM AND PDM
Introduction to PLM, Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study. PLM Strategies, strategy elements, its identification, selection and implementation. Product Data Management, implementation of PDM systems.

MODULE 2: PRODUCT DESIGN
Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for ‘X’ and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modelling and simulation in product

8Hrs.

MODULE 3: PRODUCT DEVELOPMENT

8Hrs.

MODULE 4: TECHNOLOGY FORECASTING
Technological change, methods of technology forecasting, relevance trees, morphological methods, flow diagram and combining forecast of technologies. Integration of technological product innovation and product development in business processes within enterprises, methods and tools in the innovation process according to the situation, methods and tools in the innovation process according to the situation.

8Hrs.

MODULE 5: PRODUCT BUILDING AND STRUCTURES
Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, digital mock-up, model building, model analysis, production (process)
planning, and product data technology. Product structures: Variant management, product configuration, material master data, product description data, Data models, Life cycles of individual items, status of items.

8Hrs

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

Course Outcomes:

Student will be able to

1. Explain the various strategies of PLM and Product Data Management
2. Describe decomposition of product design and model simulation
3. Apply the concept of New Product Development and its structuring.
4. Analyze the technological forecasting and the tools in the innovation.
5. Apply the virtual product development and model analysis

Text Books:

Reference Books:
### Internship/ Professional Practice

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### Seminar

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