**B.E. Mechanical Engineering**

**III SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15MAT31 | Engineering Mathematics – III | 04 | | | 03 | 80 | 20 | 100 | 4 |
| 2 | 15ME32 | Materials Science | 04 | | | 03 | 80 | 20 | 100 | 4 |
| 3 | 15ME33 | Basic Thermodynamics | 03 | 02 | | 03 | 80 | 20 | 100 | 4 |
| 4 | 15ME34 | Mechanics of Materials | 03 | 02 | | 03 | 80 | 20 | 100 | 4 |
| 5 | 15ME35A/ 15ME35B | Metal Casting and Welding / Machine Tools and Operations | 04 | | | 03 | 80 | 20 | 100 | 4 |
| 6 | 15ME36 A/ 15ME36B | Computer Aided Machine Drawing / Mechanical Measurements and Metrology | 02 / 04 | | 4 | 03 | 80 | 20 | 100 | 3 |
| 7 | 15MEL37A/ 15MEL37B | Materials Testing Lab/ Mechanical Measurements and Metrology Lab | 1 | | 2 | 03 | 80 | 20 | 100 | 2 |
| 8 | 15MEL38A/ 15MEL38B | Foundry and Forging Lab / Machine Shop/ | 1 | | 2 | 03 | 80 | 20 | 100 | 2 |
| **TOTAL** | | | **22/24** | **04** | **08/04** | | **640** | **160** | **800** | **27** |

**MATERIAL SCIENCE**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Material Science | 15ME32 | 04 | 4-0-0 | 80 | 20 | 3Hrs |

**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.

**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**

Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Substitutional and interstitial solid solutions, Intermediate phases, Gibbs phase rule Effect of non- equilibrium cooling, Coring and Homogenization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, Cast metal structures Solidification of Steels and Cast irons. Numerical on lever rule

10 Hours

**MODULE 3**

**Heat Treatment, Ferrous and Non-Ferrous Alloys**

Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Annealing: Recovery, Recrystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability, Factors affecting it hardenability, surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron, SG iron and steel,

10 Hours

**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

**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.

**TEXT BOOKS:**


1. Smith, Foundations of Materials Science and Engineering, 4th Edition, McGraw Hill, 2009.
2. William D. Callister, Material science and Engineering and Introduction, Wiley, 2006.


**REFERENCE BOOKS**


1. V.Raghavan, Materials Science and Engineering, , PHI, 2002
2. Donald R. Askland and Pradeep.P. Phule, The Science and Engineering of Materials, Cengage Learning, 4lh Ed., 2003.
3. George Ellwood Dieter, Mechanical Metallurgy, McGraw-Hill.
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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Basic Thermodynamics | 15ME33 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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

**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:** Clasius 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, 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

**COURSE OUTCOMES**

The student will be able to

| | Course Outcomes | PO's | Course Level |
|---|---|---|---|
| CO 1 | Explain thermodynamic systems, properties, Zeroth law of thermodynamics, temperature scales and energy interactions. | PO1 | U |
| CO 2 | Determine heat, work, internal energy, enthalpy for flow &non flow process using First and Second Law of Thermodynamics. | P01, PO2 | Ap |
| CO3 | Interpret behavior of pure substances and its applications to practical problems. | PO1,PO2 | U |
| CO4 | Determine change in internal energy, change in enthalpy and change in entropy using TD relations for ideal gases. | PO1,PO2 | Ap |
| 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. | PO1,PO2 | Ap |
| **Total Number Lecture hours** | | **50** | |

**TEXT BOOKS:**

1. Basic Engineering Thermodynamics, A.Venkatesh, Universities Press, 2008
2. Basic and Applied Thermodynamics, P.K.Nag, 2nd Ed., Tata McGraw Hill Pub. 2002

**REFERENCE BOOKS:**

1. Thermodynamics, An Engineering Approach, YunusA.Cenegal and Michael A.Boles, Tata McGraw Hill publications, 2002
2. Engineering Thermodynamics, J.B.Jones and G.A.Hawkins, John Wiley and Sons..
3. Fundamentals of Classical Thermodynamics, G.J.VanWylen and R.E.Sonntag, Wiley Eastern.
4. An Introduction to Thermodynamcis, 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.

**MECHANICS OF MATERIALS**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanics of Materials | 15ME34 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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.

**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 tress, Mohr circle for plane stress conditions.

**Cylinders:** Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations.

10 Hours

**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).

10 Hours

**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.

10 Hours

**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. 10 Hours

**COURSE OUTCOMES:**

The student shall be able to

| | Course Outcomes | POs | CL |
|---|---|---|---|
| CO1 | Understand simple, compound, thermal stresses and strains their relations, Poisson's ratio, Hooke's law, mechanical properties including elastic constants and their relations | PO1 | U |
| CO2 | Determine stresses, strains and deformations in bars with varying circular and rectangular cross-sections subjected to normal and temperature loads | PO1, | Ap |
| CO3 | Determine plane stress, principal stress, maximum shear stress and their orientations using analytical method and Mohr's circle | PO1, | Ap |
| CO4 | Determine the dimensions of structural members including beams, bars and rods using Energy methods and also stress distribution in thick and thin cylinders | PO1, | Ap |
| 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 | PO1, | Ap |
| 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 | PO1, | Ap |
| CO7 | Determine slopes and deflections at various points on beams subjected to UDL, UVL, Point loads and couples | PO1, | Ap |
| 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 | PO1, | Ap |
| | **Total Hours of instruction** | **50** | |

**TEXT BOOKS:**


1. James M Gere, Barry J Goodno, Strength of Materials, Indian Edition, Cengage Learning, 2009.
2. R Subramanian, Strength of Materials, Oxford, 2005.


**REFERENCE BOOKS:**


1. S S Rattan, Strength of Materials, Second Edition, McGraw Hill, 2011.
2. Ferdinand Beer and Russell Johston, Mechanics of materials, Tata McGraw Hill, 2003.


**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Metal Casting and Welding | 15ME35 A /45A | 04 | 4-0-0 | 80 | 20 | 3Hrs |

**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.

**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

10 Hours

**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), 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.

**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

**COURSE OUTCOMES**

| CO No. | Course Outcomes | Blooms level | PO |
|---|---|---|---|
| CO1 | Describe the casting process, preparation of Green, Core, dry sand molds and Sweep, Shell, Investment and plaster molds. | U | PO1 |
| CO2 | Explain the Pattern, Core, Gating, Riser system and Jolt, Squeeze, Sand Slinger Molding Machines. | U | PO1 |
| CO3 | Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces. | U | PO1 |
| CO4 | Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings. | U | PO1 |
| CO5 | Explain the Solidification process and Casting of Non-Ferrous Metals. | U | PO1 |
| CO6 | Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes used in manufacturing. | U | PO1 |
| CO7 | Explain the Resistance spot, Seam, Butt , Projection, Friction, Explosive, Thermit, Laser and Electron Beam Special type of welding process used in manufacturing. | U | PO1 |
| CO8 | Describe the Metallurgical aspects in Welding and inspection methods for the quality assurance of components made of casting and joining process. | U | PO1 |
| **Total Hours of instruction** | | **50** | |

**TEXT BOOKS**:


1. **"Manufacturing Process-I",** Dr.K.Radhakrishna, Sapna Book House,5th Revised Edition 2009.
2. **"Manufacturing & Technology**: Foundry Forming and Welding",P.N.Rao, 3rd Ed., Tata McGraw Hill, 2003.


**REFERENCE BOOKS**:


1. **"Process and Materials of Manufacturing**", Roy A Lindberg, 4th Ed.Pearson Edu. 2006.
2. **"Manufacturing Technology**", SeropeKalpakjian, Steuen. R. Sechmid,Pearson Education Asia, 5th Ed. 2006.
3. **"Principles of metal casting"**, Rechard W. Heine, Carl R. LoperJr.,Philip C. Rosenthal, Tata McGraw Hill Education Private Limited Ed.1976.


**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Machine Tools and Operations | 15ME35 B / 45B | 04 | 4-0-0 | 80 | 20 | 3Hrs |

**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 MACHNING 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

**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.

**TEXT BOOKS:**


1. Fundamentals of metal cutting and Machine Tools, B.L. Juneja, G.S. Sekhon and Nitin Seth, New Age International Publishers 2nd Edition, 2003
2. All about Machine Tools, Heinrich Gerling, New Age International Publishers revised 2nd Edition, 2006


**REFERENCE BOOKS:**


1. Fundamental of Machining and Machine Tools, Geoffrey Boothroyd and Winston A. Knight, CRC Taylor& Francis, Third Edition.
2. Metal cutting principles, Milton C. Shaw, Oxford University Press, Second Edition,2005.


**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Computer Aided Machine Drawing | 15ME36 A / 46A | 04 | 2-4-0 | 80 | 20 | 3Hrs |

**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.

**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. 04 Hours

**Orthographic views:**Conversion of pictorial views into orthographic projections of simple machine partswith 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.

08Hours

**PART B**

**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 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.

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

**COURSE OUTCOMES**

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

| | Course Outcome | Cognitive Level | POs |
|---|---|---|---|
| CO1 | Sections of pyramids, prisms, cubes, cones and cylinders resting on their bases in 2D | U | PO1, PO5, |
| CO2 | Orthographic views of machine parts with and without sectioning in 2D. | U | PO1, PO5, |
| CO3 | Sectional views for threads with terminologies of ISO Metric, BSW, square and acme, sellers and American standard threads in 2D. | U | PO1, PO5, |
| 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 | U | PO1, PO5, |
| CO5 | Parallel key, Taper key, and Woodruff Key as per the ISO standards in 2D | U | PO1, PO5, |
| CO6 | single and double riveted lap joints, butt joints with single/double cover straps, cotter and knuckle joint for two rods in 2D | U | PO1, PO5, |
| CO7 | Sketch split muff, protected type flanged, pin type flexible, Oldham's and universal couplings in 2D | U | PO1, PO5, |
| 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 | U | PO1, PO5, PO12 |
| **Total Hours of instruction** | | **50** | |

**TEXT BOOKS:**


1. 'A Primer on Computer Aided Machine Drawing-2007', Published by VTU, Belgaum.
2. 'Machine Drawing', N.D.Bhat&V.M.Panchal, Published by Charotar Publishing House, 1999.
3. 'Machine Drawing', N.Siddeshwar, P.Kannaih, V.V.S. Sastri, published by Tata Mc.Grawhill, 2006.


**REFERENCE BOOK:**


1. "A Text Book of Computer Aided Machine Drawing", S. Trymbakaa Murthy, CBS Publishers, New Delhi, 2007.
2. 'Machine Drawing', K.R. Gopala Krishna, Subhash publication.

**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 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.

| | | |
|---|---|---|
| Part A 1 x 15 | = | 15 Marks |
| Part B 1 x 15 | = | 15 Marks |
| Part C 1 x 50 | = | 50 Marks |
| Total | = | 80 Marks |

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanical Measurements and Metrology | 15ME36 B / 46B | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.

**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.

System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars(Numericals), standardization.

**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**

**COURSE OUTCOMES**

***At the end of the course students will be able to –***

| | Description | CL | POs |
|---|---|---|---|
| CO1 | Understand the objectives of metrology, methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars. | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| CO3 | Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design. | U | PO1, PO6 |
| CO4 | Understand the principle of Johnson Mikrokator, sigma comparator, dial indicator, LVDT, back pressure gauges, Solex comparators and Zeiss Ultra Optimeter | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| CO7 | Understand laser interferometers and Coordinate measuring machines. | U | PO1, PO6 |
| CO8 | Explain measurement systems, transducers, intermediate modifying devices and terminating devices. | U | PO1, PO6 |
| CO9 | Describe functioning of force, torque, pressure, strain and temperature measuring devices. | U | PO1, PO6 |

**TEXT BOOKS:**

1. **Mechanical Measurements,** Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2. **Engineering Metrology,** R.K. Jain, Khanna Publishers, Delhi, 2009.

**REFERENCE BOOKS:**

1. **Engineering Metrology and Measurements,** Bentley, Pearson Education.
2. **Theory and Design for Mechanical Measurements,III edition,** Richard S Figliola, Donald E Beasley, WILEY India Publishers.
3. **Engineering Metrology,** Gupta I.C., Dhanpat Rai Publications.
4. **Deoblin's Measurement system**, Ernest Deoblin, Dhanesh manick, McGraw –Hill.
5. **Engineering Metrology and Measurements,**N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.

**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Materials Testing Lab | 15MEL37 A / 47A | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**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.

2. Heat treatment: Annealing, normalizing, hardening and tempering of steel.
   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.
3. Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.
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.
8. Izod and Charpy Tests on Mild steel and C.I Specimen.
9. To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10. Fatigue Test (demonstration only).

**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. 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.

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:**

| | |
|---|---|
| **ONE question from part -A:** | **25 Marks** |
| **ONE question from part -B:** | **40 Marks** |
| **Viva -Voice:** | **15 Marks** |
| **Total :** | **80 Marks** |

## MECHANICAL MEASUREMENTS AND METROLOGY LAB

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanical Measurements and Metrology Lab | 15MEL37 B / 47B | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**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

**COURSE OUTCOMES**

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

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

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Foundry and Forging Lab | 15MEL38A / 48A | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**PART A**

1. **Testing of Molding sand and Core sand**

   Preparation of sand specimens and conduction of the following tests:

   1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.
   2. Permeability test
   3. Sieve Analysis to find Grain Fineness Number(GFN) of Base Sand
   4. Clay content determination in 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.

**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.

## 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 | |
| Calculation of length for Forging | 10 Marks |
| Viva – Voce | 20 Marks |
| Total | 20 Marks |

## MACHINE SHOP

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Machine Shop | 15MEL38B / 48B | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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

**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

**COURSE OUTCOMES**

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

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

| | |
|---|---|
| One Model from Part – A | 40 Marks |
| One Model from Part – B | 20 Marks |
| Viva – Voce | 20 Marks |
| Total | 80 Marks |

**B.E. Mechanical Engineering**

**IV SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15MAT41 | Engineering Mathematics – III | 04 | | | 03 | 80 | 20 | 100 | 04 |
| 2 | 15ME42 | Kinematics of Machinery | 03 | 02 | | 03 | 80 | 20 | 100 | 04 |
| 3 | 15ME43 | Applied Thermodynamics | 03 | 02 | | 03 | 80 | 20 | 100 | 04 |
| 4 | 15ME44 | Fluid mechanics | 03 | 02 | | 03 | 80 | 20 | 100 | 04 |
| 5 | 15ME45A/ 15ME45B | Metal Casting and Welding / Machine Tools and Operations | 04 | | | 03 | 80 | 20 | 100 | 04 |
| 6 | 15ME46 A/ 15ME46B | Computer Aided Machine Drawing | 02 | | 4 | 03 | 80 | 20 | 100 | 03 |
| | | Mechanical Measurements and Metrology | 04 | | | | | | | |
| 7 | 15MEL47A / 15MEL47B | Materials Testing Lab/ Mechanical Measurements and Metrology Lab | 1 | | 2 | 03 | 80 | 20 | 100 | 02 |
| 8 | 15MEL48A / 15MEL48B | Foundry and Forging Lab / Machine Shop/ | 1 | | 2 | 03 | 80 | 20 | 100 | 02 |
| **TOTAL** | | | **19/21** | **06** | **08/04** | | **640** | **160** | **800** | **27** |

# KINEMATICS OF MACHINES

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Kinematics of Machines | 15ME42 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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.

**MODULE - 1**

**Introduction:** Definitions: Link, kinematic pairs,kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classifiction 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**

**Velocity and Acceleration Analysis of Mechanisms (Analytical Method):** Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method.

**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

**Gear Trains:** Simple gear trains, compound gear trains. Epicyclic gear trains:aAlgebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.

**10 Hours**

**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.***

**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.

**TEXT BOOKS:**

1. Rattan S.S, Theory of Machines,Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014.
2. Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.

**REFERENCE BOOKS:**

1. Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.
2. Sadhu Singh, **Theory of Machines,** Pearson Education (Singapore)Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006.

# APPLIED THERMODYNAMICS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Applied Thermodynamics | 15ME43 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Courselearning 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 thermodymic 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

**Gas Power Cycles :**Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles.

Jet propulsion: Introduction to the principles of jet propulsion, turbojet, turboprop, Ramjet and turbofan engines and their processes . Principles of rocket propulsion, Introduction to rocket engine.10 Hours

## Module –II

**Vapour Power Cycles: Carnot** vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in Vapour power cycles, Binary Vapour cycles

10 Hours

## Module –III

**Combustion Thermodynamics**: Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.

**I.C.Engines:** Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels. Automotive Pollutions and its effects on environment.

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.

**Pscychrometrics and Air-conditioning Systems:**Properties ofAtmospheric air, and Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of twomoist air streams. Cooling towers.

10 Hours

**Module –V**

**Reciprocating Compressors: Operation** of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.

**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:

1. Thermodynamics an engineering approach, by Yunus A. Cenegal and Michael A. Boles. Tata McGraw hill Pub. Sixth edition, 2008.

2. Basic and Applied Thermodynamics" by P .K. Nag, Tata McGraw Hill, 2nd Edi. 2009
3. Fundamentals of Thermodynamics by G.J. Van Wylen and R.E. Sonntag, Wiley Eastern. Fourth edition 19993.

Reference Books:

1. Thermodynamics for engineers, Kenneth A. Kroos and Merle C. Potter, Cengage Learning, 2016
2. Principles of Engineering Thermodynamics, Michael J,Moran, Howard N. Shapiro, Wiley, 8th Edition
3. An Introduction to Thermo Dynamics by Y.V.C.Rao, Wiley Eastern Ltd, 2003.
4. Thermodynamics by Radhakrishnan. PHI, 2nd revised edition.
5. I.C Engines by Ganeshan.V. Tata McGraw Hill, 4rth Edi. 2012.
6. I.C.Engines by M.L.Mathur & Sharma. Dhanpat Rai& sons- India

**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.

# FLUID MECHANICS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Fluid Mechanics | 15ME44 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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**: Totalpressure 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 heightits 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, stram 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 Hrs

## MODULE -3

**Laminar and turbulent flow**: Reynods 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.

10 Hrs

## 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.

10 Hrs

**MODULE -5**

**Compressible Flows:** Introduction, thermodynamicrelations of perfect gases, internal energy andenthalpy, 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.

08 Hrs

**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:**


1. Fluid Mechanics (SI Units), Yunus A. Cengel John M.Cimbala, 3rd Ed., Tata McGraw Hill, 2014.
2. Fluid Mechanics, F M White, McGraw Hill Publications Eighth edition. 2016
3. Mechanics of Fluids, Merle C. Potter, Devid C. Wiggerrt, Bassem H. Ramadan, Cengage learning, Fourth editions 2016.


**Reference Books:**


1. Fundamentals of Fluid Mechanics by Munson, Young, Okiishi& Huebsch, John Wiley Publications.7th edition.
2. Fluid Mechanics, Pijush.K.Kundu, IRAM COCHEN, ELSEVIER, 3rd Ed. 2005.
3. Fluid Mechanics, John F.Douglas, Janul and M.Gasiosek and john A.Swaffield, Pearson Education Asia, 5th ed., 2006.
4. Introduction to Fluid Mechanics by Fox, McDonald, John Wiley Publications,8th edition.


**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Metal Casting And Welding | 15ME35A / 45A | 04 | 4-0-0 | 80 | 20 | 3Hrs |

**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.

**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

10 Hours

**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), 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.

**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

**COURSE OUTCOMES**

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

**TEXT BOOKS**:


1. **"Manufacturing Process-I",** Dr.K.Radhakrishna, Sapna Book House,5th Revised Edition 2009.
2. **"Manufacturing & Technology**: Foundry Forming and Welding",P.N.Rao, 3rd Ed., Tata McGraw Hill, 2003.
3. **" Introduction to Manufacturing Process**" – John A.Schey , 3rd Edition ,McGraw Hills Education.


**REFERENCE BOOKS**:


1. **"Machining And Machine Tools"** – A.B.Chattopadhyay, FNA (E) Wiley.
2. **"Process and Materials of Manufacturing**", Roy A Lindberg, 4th Ed.Pearson Edu. 2006.
3. **"Manufacturing Technology,** Vol 1, P N Rao, McGraw Hill Education, 4th Edition
4. **"Principles of metal casting"**, Rechard W. Heine, Carl R. LoperJr.,Philip C. Rosenthal, Tata McGraw Hill Education Private Limited

Ed.1976.

## MACHINE TOOLS AND OPERATIONS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Machine Tools and Operations | 15ME35B / 45B | 04 | 4-0-0 | 80 | 20 | 3Hrs |

**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.

**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 MACHNING 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

**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.

**TEXT BOOKS:**

1. Fundamentals of metal cutting and Machine Tools, B.L. Juneja, G.S. Sekhon and Nitin Seth, New Age International Publishers 2nd Edition, 2003
2. All about Machine Tools, Heinrich Gerling, New Age International Publishers revised 2nd Edition, 2006

**REFERENCE BOOKS:**

1. Fundamental of Machining and Machine Tools, Geoffrey Boothroyd and Winston A. Knight, CRC Taylor & Francis, Third Edition.
2. **"Manufacturing Technology,** Vol 2, P N Rao, McGraw Hill Education, 3rd Edition
3. Metal cutting principles, Milton C. Shaw, Oxford University Press, Second Edition,2005.

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Computer Aided Machine Drawing | 15ME36A / 46A | 03 | 2-0-4 | 80 | 20 | 3Hrs |

**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.

**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.

04 Hours

**Orthographic views :**Conversion of pictorial views into orthographic projections of simple machine partswith 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 (assemly) 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.

08Hours

**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.

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 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.

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

17 Hours

## 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.

**Text Books :**

1. 'A Primer on Computer Aided Machine Drawing-2007', Published by VTU, Belgaum.
2. 'Machine Drawing', N.D.Bhat & V.M.Panchal, Published by Charotar Publishing House, 1999.
3. 'Machine Drawing', N.Siddeshwar, P.Kannaih, V.V.S. Sastri, published by Tata Mc.Grawhill, 2006.

**Reference Book :**

1. "A Text Book of Computer Aided Machine Drawing", S. Trymbakaa Murthy, CBS Publishers, New Delhi, 2007.
2. 'Machine Drawing', K.R. Gopala Krishna, Subhash publication.

**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.

| | | |
|---|---|---|
| Part A | 1X15 | = 15 Marks |
| Part B | 1X15 | = 15 Marks |
| Part C | 1X50 | = 50 Marks |
| Total | | = 80 Marks |

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanical Measurements and Metrology | 15ME36B / 46B | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.

**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.

System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars(Numericals), standardization.

**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**

**COURSE OUTCOMES**

***At the end of the course students will be able to –***

| | Description | CL | POs |
|---|---|---|---|
| CO1 | Understand the objectives of metrology, methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars. | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| CO3 | Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design. | U | PO1, PO6 |
| CO4 | Understand the principle of Johnson Mikrokator, sigma comparator, dial indicator, LVDT, back pressure gauges, Solex comparators and Zeiss Ultra Optimeter | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| 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. | U | PO1, PO6 |
| CO7 | Understand laser interferometers and Coordinate measuring machines. | U | PO1, PO6 |
| CO8 | Explain measurement systems, transducers, intermediate modifying devices and terminating devices. | U | PO1, PO6 |
| CO9 | Describe functioning of force, torque, pressure, strain and temperature measuring devices. | U | PO1, PO6 |

**TEXT BOOKS:**


1. **Mechanical Measurements,** Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2. **Instrumentation, Measurement and Analysis,** B C Nakra, K K Chaudhry, 4th Edition**,** McGraw –Hill
3. **Engineering Metrology,** R.K. Jain, Khanna Publishers, Delhi, 2009.


**REFERENCE BOOKS:**


1. **Engineering Metrology and Measurements,** Bentley, Pearson Education.
2. **Theory and Design for Mechanical Measurements,III edition,** Richard S Figliola, Donald E Beasley, WILEY India Publishers.
3. **Engineering Metrology,** Gupta I.C., Dhanpat Rai Publications.
4. **Deoblin's Measurement system**, Ernest Deoblin, Dhanesh manick, McGraw –Hill.
5. **Engineering Metrology and Measurements,** N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.


**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Material Testing Lab | 15MEL47A / 47B | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**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.

2. Heat treatment: Annealing, normalizing, hardening and tempering of steel.
   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.
3. Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.
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.
8. Izod and Charpy Tests on Mild steel and C.I Specimen.
9. To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10. Fatigue Test (demonstration only).

**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. 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.

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:**

| | |
|---|---|
| **ONE question from part -A:** | **25 Marks** |
| **ONE question from part -B:** | **40 Marks** |
| **Viva -Voice:** | **15 Marks** |
| **Total :** | **80 Marks** |

**MECHANICAL MEASUREMENTS AND METROLOGY LAB**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanical Measurements and Metrology Lab | 15MEL37B / 47B | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**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

**COURSE OUTCOMES**

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

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

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Foundry And Forging Lab | 15MEL38A / 48A | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.

**PART A**

1. **Testing of Molding sand and Core sand**

   Preparation of sand specimens and conduction of the following tests:

   1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.
   2. Permeability test
   3. Sieve Analysis to find Grain Fineness Number(GFN) of Base Sand
   4. Clay content determination in 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.

**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.

## 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 | |
| Calculation of length for Forging | 10 Marks |
| Viva – Voce | 20 Marks |
| Total | 20 Marks |

## MACHINE SHOP

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Machine Shop | 15MEL38b / 48B | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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

**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

**COURSE OUTCOMES**

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

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

| | |
|---|---|
| One Model from Part – A | 40 Marks |
| One Model from Part – B | 20 Marks |
| Viva – Voce | 20 Marks |
| Total | 80 Marks |

**B.E. Mechanical Engineering**

**V SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15ME51 | Management and Engineering Economics | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 2 | 15ME52 | Dynamics of Machinery | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 3 | 15ME53 | Turbo Machines | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 4 | 15ME54 | Design of Machine Elements - I | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 5 | 15ME55X | Professional Elective-I | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 6 | 15ME56X | Open Elective-I | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 7 | 15MEL57 | Fluid Mechanics & Machinery Lab | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| 8 | 15MEL58 | Energy Lab | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| **TOTAL** | | | **21** | **06** | **04** | | **640** | **160** | **800** | **26** |

| Professional Elective-I | | Open Elective-I | |
|---|---|---|---|
| 15ME551 | Refrigeration and Air-conditioning | 15ME561 | Optimization Techniques |
| 15ME552 | Theory of Elasticity | 15ME562 | Energy and Environment |
| 15ME553 | Human Resource Management | 15ME563 | Automation and Robotics |
| 15ME554 | Non Traditional Machining | 15ME564 | Project Managemet |

**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. OpenElective**: Electives from other technical and/or emerging subject areas.

## MANAGEMENT AND ENGINEERING ECONOMICS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Management And Engineering Economics | 15ME51 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**MODULE – 1**

**Management:** Introduction - Meaning - nature and characteristics ofManagement, Scope and Functional areas of management - Management as ascience, art of profession - Management & Administration - Roles ofManagement, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches.

**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. **10 Hours**

**MODULE - 2**

**Organizing And Staffing:** Nature and purpose of organization Principles oforganization - Types of organization - Departmentation Committees- Centralization Vs Decentralization of authority and responsibility - Span ofcontrol - MBO and MBE (Meaning Only) Nature and importance of staffing--:Process of Selection & Recruitment (in brief).

**Directing & Controlling:** Meaning and nature of directing Leadershipstyles, 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) **10 Hours**

**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**

**Present, future and annual worth and rate of returns**: Basic present worth comparisons, Present worth-equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons.
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**

**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.

**TEXT BOOKS**


1. Principles of Management by Tripathy and Reddy
2. Mechanical estimation and costing, T.R. Banga& S.C. Sharma, 17th edition 2015
3. Engineering Economy, Riggs J.L. McGraw Hill, 2002
4. Engineering Economy, Thuesen H.G. PHI , 2002


**REFERENCE BOOKS**


1. Management Fundamentals- Concepts, Application, Skill Development - RobersLusier - Thomson
2. Basics of Engineering Economy, Leland Blank & Anthony Tarquin, McGraw Hill Publication (India) Private Limited
3. Engineering Economics, R.Paneerselvam, PHI publication
4. Fundamentals of Management: Essential Concepts and Applications, Pearson Education, Robbins S.P. and Decenzo David A.
5. Economics: Principles of Economics, N Gregory Mankiw, Cengage Learning
6. Modern Economic Theory, By Dr. K. K. Dewett& M. H. Navalur, S. Chand Publications

## DYNAMICS OF MACHINERY

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Dynamics of Machinery | 15ME52 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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.

**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.

**Dynamic force Analysis:**D'Alembert's principle, Inertia force, Inertia torque. Dynamic force analysis of four-bar mechanism and Slider crank mechanism without friction, numerical problems. **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**

**Governors:** Types of governors, force analysis of Porter and Hartnell governors. Controlling force, Stability, Sensitiveness, Isochronism, Effort and Power.

**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**

**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.

**Text Books:**


1. Theory of Machines, Sadhu Singh, Pearson Education, 2nd Edition. 2007.
2. Mechanism and Machine Theory, A. G. Ambekar PHI, 2007
3. Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company,
4. Mechanical Vibrations, G. K.Grover, Nem Chand and Bros.


**Reference Books:**


1. Theory of Machines, Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009.
2. Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4edition, 2003.

## TURBO MACHINES

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Turbo Machines | 15ME53 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Course Objectives:**

- The course aims at giving an overview of different types of turbomachinery used for energy transformation, such as pumps, fans, compressors, as well as hydraulic and steam turbines.
- Explain the working principles of turbomachines and apply it to various types of machines
- It will focus on application of turbo machinery in power generation, power absorption and transportation sectors.

**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**

**Hydraulic Turbines**: Classification, various efficiencies. **Pelton turbine** – velocity triangles, design parameters, Maximum efficiency.

**Francis turbine** - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. **Kaplan and Propeller turbines** - velocity triangles, design parameters. Problems. **(10 Hours)**

**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)**

**Course Outcomes:**

- Able to give precise definition of turbomachinery
- Identify various types of turbo machinery
- Apply the Euler's equation for turbomachinery to analyse energy transfer in turbomachines
- Understand the principle of operation of pumps, fans, compressors and turbines.
- Perform the preliminary design of turbomachines (pumps, rotary compressors and turbines)
- Analyze the performance of turbo machinery.

**TEXT BOOKS:**

1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.
2. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002

**REFERENCE BOOKS:**

1. Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964).
2. Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier (2005).

3. Text Book of Turbo machines, M. S. Govindegouda and A. M. Nagaraj, M. M. Publications, 4Th Ed, 2008.

## DESIGN OF MACHINE ELEMENTS – I

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Design of Machine Elements | 15ME54 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Course Objectives**

1. Able to understandmechanicaldesign 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.

**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 andCombinedstresses.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.

**10Hours**

**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.

Design of Cotter and Knuckle joints, Rigid and flexible couplings, Flange coupling, Bush and Pin type coupling and Oldham's coupling. Design of keys-square, saddle, flat and father.

**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**

**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

**Text Books:**


1. Design of Machine Elements, V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.
2. Mechanical Engineering Design, Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition, 2009.


**Design Data Handbook:**


1. Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd Ed.
2. Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS Publication
3. Design Data Hand Book, S C Pilli and H. G. Patil, I. K. International Publisher, 2010.


**Reference Books:**


1. Machine Design, Robert L. Norton, Pearson Education Asia, 2001.
2. Engineering Design, George E. Dieter, Linda C Schmidt, McGraw Hill Education, Indian Edition, 2013.
3. Design of Machined Elements, S C Pilli and H. G. Patil, I. K. International Publisher, 2017.
4. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outline series) adapted by S.K Somani, tata McGraw Hill Publishing company Ltd., New Delhi, Special Indian Edition, 2008

## REFRIGERATION AND AIR-CONDITIONING
## (Professional Elective-I)

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Refrigeration And Air-Conditioning | 15ME551 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Pre-requisites:** Basic and Applied Thermodynamics

**Courseobjectives**

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

**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**

**Vapour Compression Refrigeration System(VCRS)**: Comparison of Vapour Compression Cycle and Gas cycle,Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency,Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing's construction and Gosney'smethod.Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure,Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.

**10 Hours**

**Module – III**

**Vapour Absorption Refrigeration Systems**: Absorbent – Refrigerant combinations, Water-Ammonia Systems,Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.Practical problems – crystallization and air leakage, Commercial systems

**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 azeotropicmixtures

**Refrigeration systems Equipment**: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

**8 Hours**

**Module – V**

**Air-Conditioning**: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

**Transport air conditioning Systems**:Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships. **8 Hours**

**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. Explainvapour 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

**TEXT BOOKS**


1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora C.P., Refrigeration and Air-conditioning, Tata Mc Graw –Hill, New Delhi, 2nd Edition, 2001.
3. Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, Mc Graw - Hill, New Delhi 2nd edition, 1982.


**REFERENCE BOOKS**


1. Dossat,Principles of Refrigeration Pearson-2006.
2. McQuistion,Heating,Ventilation and Air Conditioning, Wiley Students edition,5th edition 2000.
3. PITA,Air conditioning 4rth edition, pearson-2005
4. Refrigeration and Air-Conditioning' by Manoharprasad
5. S C Arora& S Domkundwar, Refrigeration and Air-Conditioning DhanpatRai Publication
6. http://nptel.ac.in/courses/112105128/#


**Data Book:**


1. Shan K. Wang,Handbook of Air Conditioning and Refrigeration, 2/e,2001 McGraw-Hill Education
2. Mathur M.L. &Mehta ,Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers,2008


**E- Learning**

- VTU, E- learning, MOOCS, Open courseware

**THEORY OF ELASTICITY**
**(Professional Elective-I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Theory of Elasticity | 15ME552 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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

**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 **8 Hours**

**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. **8 Hours**

**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.

**10 Hours**

**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 ofequilibrium,thermal stresses in thin circular discs and in long circularcylinders.Euler's column buckling load: clamped-free, clamped-hinged, clamped-clamped and pin-ended, Numerical Problems

**8 Hours**

**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

**Text Books:**

1. Theory of Elasticity, S. P. Timoshenko and J. N Goodier, Mc. Graw, Hill International, 3rd Ed., 2010.
2. Theory of Elasticity, Dr. Sadhu Singh, Khanna Publications, 2004.

**References Books:**

1.Advanced Mechanics of solids, L. S. Srinath, Tata Mc. Graw Hill,2009.
2. Theory of Elastic stability, Stephen P. Timoshenko, Mc Graw Hill, 2nd Ed, 2014.

**HUMAN RESOURCE MANAGEMENT**
**(Professional Elective-I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Human Resource Management | 15ME553 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Course 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.

**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.
**Training and development:** Training v/s development, Training v/s Education, Systematic Approach to Training, Training Methods, Executive Development, Methods and Development of Management Development, Career and Succession Planning.

**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.
**Compensation:** Objectives of Compensation Planning, Job Evaluation, Compensation Pay Structure in India, Wage and Salary Administration, Factors Influencing Compensation Levels, Executive Compensation. **09 hours**

**Module – 5**

**Employee Welfare:** Introduction, Types of Welfare Facilities and Statutory Provisions.
**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**

**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.

**TEXTBOOKS**


1. Human Resource Management- Rao V.S.P, Excel books, 2010
2. Human Resource Management- Cynthia D. Fisher, 3/e, AIPD, Chennai
3. Human Resource Management: A South Asian Perspective, Snell, Bohlander&Vohra, 16th Rep., Cengage Learning, 2012
4. Human Resource Management- Lawrence S Kleeman, Biztantra, 2012
5. Human Resource Management- Aswathappa K, HPH


**REFERENCE BOOKS**


1. Human Resource Management- John M. Ivancevich, 10/e, McGraw Hill.
2. Human Resource Management in Practice- Srinivas R. Kandulla, PHI
3. Human Resource Management- Luis R Gomez-Mejia, David B. Balkin, Robert L Cardy, 6/e, PHI, 2010

**NON TRADITIONAL MACHINING**
**(Professional Elective-I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Non Traditional Machining | 15ME554 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.
**Abrasive Jet Machining (AJM):** Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD).Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish.Applications, advantages & limitations of AJM.
**Water Jet Machining (WJM):** Equipment & process, Operation, applications, advantages and limitations of WJM.

**08 hours**

**MODULE 3**
**ELECTROCHEMICAL MACHINING (ECM)**
Introduction, Principle of electro chemical machining: ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish.
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.

**10 hours**

**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. **08 hours**

**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.

**08 hours**

**Course Outcomes**

On completion of the course, the students will be able to

1. Understand the compare traditional and non-traditional machining processand 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.

**Text Books:**

1. Modern Machining Process by P.C Pandey and H S Shah, McGraw Hill Education India Pvt. Ltd. 2000
2. Production technology, HMT, McGraw Hill Education India Pvt. Ltd. 2001

**Reference Books**

1. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000
2. Modern Machining process, Aditya, 2002.

## OPTIMIZATION TECHNIQUES
**(OPEN ELECTIVE – I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Optimization Techniques | 15ME561 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

### 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 constrainedand unconstrained problems in both single and multivariable.

### MODULE I

**Introduction to Classical Optimization Techniques**
Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.
**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)
**Queuing**

Queuing Models : Essential features of queuing systems, operating characteristics of queuing system, probability distribution in queuing systems, classification of queuing models, solution of queuing M/M/1 : ∞ /FCFS,M/M/1 : N/FCFS, M/M/C : ∞/FCFS, M/M/C : N/FCFS.

**(8 Hours)**

**MODULE IV**

**Dynamic Programming**

Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

**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)**

**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.

**TEXT BOOKS**


1. Engineering optimization: Theory and practice”-by S.S.Rao, New Age International (P) Limited.
2. Operations Research: An Introduction" by H A Taha, 5th Edition, Macmillan, New York.
3. Operations Research by NVR Naidu, G Rajendra, T Krishna Rao, I K International 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
2. Operations Research – by S.D.Sharma, KedarnathRamanath& Co
3. Linear programming, G. Hadley, Narosa Publishing House, New Delhi.
4. Industrial Engineering and Production Management, M. Mahajan, Dhanpat Rai & co

## ENERGY AND ENVIRONMENT
**(OPEN ELECTIVE – I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Energy And Environment | 15ME562 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.

**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 Management:** Principles of Energy Management, Energy demand estimation, Energy pricing
**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**

**Social Issues and the Environment:** Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.

**8 Hours**

**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.

**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
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.


**REFERENCE BOOKS:**


1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. Murphy, W. R., Energy Management, Elsevier, 2007.
3. Smith, C. B., Energy Management Principles, Pergamum, 2007
4. Environment pollution control Engineering by C S rao, New Age Inytermnational, 2006, reprint 2015, 2nd edition
5. Environmental studies, by Benny Joseph, Tata McGraw Hill, 2008, 2nd edition.


**E- Learning**

- India Energy Outlook 2015(www.iea.org/.../IndiaEnergyOutlook_WEO2015.pdf)
- Open courseware

## AUTOMATION AND ROBOTICS
**(OPEN ELECTIVE – I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Automation And Robotics | 15ME563 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Module - 1**

**Automation**

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

Automated Manufacturing Systems: Components, classification and overview of manufacturing Systems, Flexible Manufacturing Systems (FMS), Types of FMS, Applications and benefits of FMS. **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**

**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.

**Text Books**


1. Automation, Production Systems and Computer Integrated Manufacturing M.P. Groover, Pearson Education.5th edition, 2009
2. Industrial Robotics, Technology, Programming and Applications by M.P. Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.


**Reference Books**


1. Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007. .
2. Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.

## PROJECT MANAGEMENT
**(OPEN ELECTIVE – I)**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Project Management | 15ME564 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**MODULE – 1**

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

**Project Selection And Prioritization** – Strategic planning process, Strategicanalysis, strategic objectives, portfolio alignment – identifying potentialprojects, methods of selecting projects, financial mode / scoring models toselect 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, estimateresource needs, creating staffing management plant, project teamcomposition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control.
**Project Risk Planning**: Risk Management Planning, risk identification, riskanalysis, risk response planning, Project Quality Planning and ProjectKickoff: Development of quality concepts, project quality management plan, project quality tools, kickoff project, baseline and communicate projectmanagement plan, using Microsoft Project for project baselines.

**08 Hours**

**MODULE –4**

**Performing Projects**: Project supply chain management: - Plan purchasingand acquisitions, plan contracting, contact types, project partnering andcollaborations, project supply chain management.

**Project Progress and Results**: Project Balanced ScorecardApproach, Internal project, customer, financial issues, Finishing the project: Terminateproject 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; PERTfor 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**

**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.

**TEXT BOOKS**


1. Project Management, Timothy J Kloppenborg, Cengage Learning, Edition 2009.
2. Project Management, A systems approach to planning scheduling and controlling by Harold kerzner, CBS publication.
3. Project Management by S Choudhury, Mc Graw Hill Education (India) Pvt. Ltd. New Delhi, 2016


**REFERENCE BOOKS**


1. Project Management, Pennington Lawrence, Mc Graw hill
2. Project Management, A Moder Joseph and Phillips New Yark Van Nostrand, Reinhold.
3. Project Management,Bhavesh M. Patal, Vikas publishing House,

## FLUID MECHANICS & MACHINERY LAB

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Fluid Mechanics & Machinery Lab | 15MEL57 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

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

1. This course will provide a basic understanding of flow measurements usingvarious 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.

### 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
5. Calibration of flow measuring devices.
6. Orifice meter
   - Nozzle
   - Venturimeter
   - 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
12. Demonstration of cut section models of Hydraulic turbines and Pumps.

**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

**Reading:**

1. K.L.Kumar."Engineering Fluid Mechanics" Experiments, Eurasia Publishing House, 1997
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995
3.George E. Totten , Victor J. De Negri "Handbook of Hydraulic Fluid Technology, Second Edition, 2011.

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Energy Lab | 15MEL58 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**Prerequisites:** Basic andApplied 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.

**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.
4. Determination of Viscosity of a lubricating oil using Redwoods, Sayboltand Torsion Viscometers.
5. Analysis of moisture, volatile matter, ash content and fixed carbon of solid and liquid fuel samples
6. Valve Timing/port opening diagram of an I.C. Engine.

**PART - B**

7. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiency, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F Ratio, heat balance sheet for
    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.
8. Measurements of Exhaust Emissions of Petrol engine.
9. Measurements of Exhaust Emissions of Diesel engine.
10. Measurement of $p\theta$ , pV plots usingComputerized 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.

**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.

**References**


1. E.F.Obert, Internal combustion engines and air pollution intext educational publishers (1973). John Heywood, Internal combustion engine fundamentals, McGraw- Hill (1988) - USA.
2. Colin R Ferguson and Allan T. Kirkpatrick Internal combustion engines Applied Thermodynamics, John Wiley & sons – 2001.
3. Richard stone, Introduction to internal combustion engines, MacMillan (1992) – USA
4. M. L. Mathur And R.P. Sharma A course in internal combustion engines, Dhanpat Rai& sons- India.
5. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
6. C. F. Taylor The internal combustion engines in theory and practice, 2 vols. by:, pub.: Wily.
7. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003
8. Bosch, Automotive hand book, 9th edition.


**Scheme of Examination:**

ONE question from part -A: 25 Marks
ONE question from part -B: 40 Marks
Viva –Voice : 15 Marks
Total: 80 Marks

**B.E. Mechanical Engineering**

**VI SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15ME61 | Finite Element Analysis | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 2 | 15ME62 | Computer integrated Manufacturing | 4 | 0 | 0 | 03 | 80 | 20 | 100 | 4 |
| 3 | 15ME63 | Heat Transfer | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 4 | 15ME64 | Design of Machine Elements -II | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 5 | 15ME65X | Professional Elective-II | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 6 | 15ME66X | Open Elective-II | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 7 | 15MEL67 | Heat Transfer Lab | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| 8 | 15MEL68 | Modeling and Analysis Lab(FEA) | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| **TOTAL** | | | **21** | **6** | **04** | | **640** | **160** | **800** | **26** |

| Professional Elective-II | | Open Elective-II | |
|---|---|---|---|
| 15ME651 | Computational Fluid Dynamics | 15ME661 | Energy Auditing |
| 15ME652 | Mechanics of Composite Materials | 15ME662 | Industrial Safety |
| 15ME653 | Metal Forming | 15ME663 | Maintenance Engineering |
| 15ME654 | Tool Design | 15ME664 | Total Quality Management |
| 15ME655 | Automobile Engineering | | |

**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. OpenElective**: Electives from other technical and/or emerging subject areas.

**FINITE ELEMENT ANALYSIS**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Finite Element Analysis | 15ME61 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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.

**Module I**

**Introduction to Finite Element Method :**General description of the finite element method. Engineering applications of finite element method. Boundary conditions: homogeneous and nonhomogeneous for structural, heat transfer and fluid flow problems.Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.

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

**10 Hours**

**Module II**

**One-Dimensional Elements-Analysis of Bars and Trusses,**
Linear interpolation polynomials in terms of localcoordinate's for1D, 2Delements. 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.

**10 Hours**

**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.

**08 Hours**

**Module IV**

**Heat Transfer:** Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored insolid, 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, Flow through hydraulic net works.

**10 Hours**

**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 surface forces, point loads, angular velocity, pressure vessels.

**Dynamic Considerations:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

**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.

**12Hours**

**Text Books:**


1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering**,** 2nd Edition, PHI, 2013.


**Reference Books:**


1. J.N.Reddy, "**Finite Element Method"-** McGraw -Hill International Edition.Bathe K. J. Finite Elements Procedures, PHI.
2. Cook R. D., et al. "**Conceptsand Application of Finite Elements Analysis"-** 4th Edition, Wiley & Sons, 2003.

# Computer Integrated Manufacturing

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Computer Integrated Manufacturing | 15ME62 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Course Objectives:**

| | |
|---|---|
| **CLO1** | To impart knowledge of CIM andAutomation 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 4.0leading to Smart Factory. |

**Module - 1**

1. **Introduction to CIM and Automation:**
   Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM.
   Mathematical models and matrices:production rate, production capacity, utilization and availability, manufacturing lead time, work-in-process, numerical problems. **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**

4. **Computerized Manufacture Planning and Control System:** Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System,computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control. **5 Hours**

**Module- 3**

5. **Flexible Manufacturing Systems:** Fundamentalsof 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/RSand Automatic parts identification systems and data capture.
   **5 Hours**

6. **Line Balancing:** Linebalancing algorithms,methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerizedline 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 inturning,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, materialextrusion, Powder bed sintering techniques, sheet lamination, directenergy 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.<br>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 linesto 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:**


1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition,2015, Pearson Learning.
2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
3. CAD/CAM/CIM, Dr. P. Radhakrishnan, 3rd edition, New Age International Publishers, New Delhi.


**Reference Books:**


1. “CAD/CAM” by Ibrahim Zeid, Tata McGraw Hill.
2. “Principles of Computer Integrated Manufacturing”, S.Kant Vajpayee, 1999, Prentice Hall of India, New Delhi.

3. “Work Systems And The Methods, Measurement And Management of Work”, Groover M. P.,Pearson/Prentice Hall, Upper Saddle River, NJ, 2007.
4. “Computer Automation in Manufacturing”, Boucher, T. O., Chapman & Hall, London, UK, 1996.
5. “Introduction to Robotics: Mechanics And Control”, Craig, J. J., 2nd Ed., Addison-Wesley Publishing Company, Readong, MA, 1989.
6. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition,by Nicolas Windpassinger, Amazon.
7. "Internet of Things: A Hands-on Approach", by ArshdeepBahga and Vijay Madisetti (Universities Press)
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 2nd Ed. (2015), Ian Gibson, David W. Rosen, Brent Stucker
9. **“Understanding Additive Manufacturing”,** Andreas Gebhardt, Hanser Publishers,

2011

10. Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

**Heat Transfer**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Heat Transfer | 15ME63 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**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 (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (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, two-dimensional steady and unsteady conduction, the difference equation, boundary conditions, solution methods, cylindrical coordinates and irregular boundaries.

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**

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions, Forced Convection Cooling of Electronic Devices.

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

**8 Hours**

**Module – V**

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts, compact heat exchangers.

Heat Transfer with Phase Change: Introduction to boiling, pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation, heat pipes, entrainment, wicking and boiling limitations. **9 Hours**

**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:**


1. Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.
2. Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition,Tata Mc Graw Hill.


**REFERENCE BOOKS:**


1. Heat nd mass transfer, Kurt C, Rolle, second edition, Cengage learning.
2. Heat Transfer, M. Necati Ozisik, A Basic Approach, McGraw Hill, New York, 2005.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5th Edition, John Wiley and Sons, New York, 2006.
4. Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.


**E-Books/Web references:**

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

**MOOCs:**

1. Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

**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.

# DESIGN OF MACHINE ELEMENTS II

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Design of Machine Elements II | 15ME64 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Course Objectives:**

| | |
|---|---|
| **CLO1** | To understand various elements involved in a mechanical system. |
| **CLO2** | To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards. |
| **CLO3** | To select transmission elements like gears, belts, pulleys,bearings from the manufacturers' catalogue. |
| **CLO4** | To design completely a mechanical system integrating machine elements. |
| **CLO5** | To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes. |

**MODULE I**

**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.

**08 Hours**

**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.

**10 Hours**

**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.

**12 Hours**

**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,selflocking of brakes, and heat generation in brakes.

**10 Hours**

**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.
Numericalexamples onhydrodynamic 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 grove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds; probability of survival.

**10 Hours**

**Course Outcomes:**
After learning the course the students should be able to:

| | |
|---|---|
| **CO1** | Apply engineering design tools to product design. |
| **CO2** | Design mechanical systems involving springs,belts and pulleys. |
| **CO3** | Design different types of gears and simple gear boxes for different applications. |
| **CO4** | Design brakes and clutches. |
| **CO5** | Design hydrodynamic bearings for different applications. |
| **CO6** | Select Anti friction bearings for different applications using the manufacturers, catalogue. |
| **C07** | Develop proficiency to generate production drawings using CAD software. |
| **C08** | Become good design engineers through learning the art of working in a team with morality and ethics. |

**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:**

[1] Richard G. Budynas,and J. Keith Nisbett,**"**Shigley's Mechanical Engineering Design**",** McGraw-Hill Education, 10th Edition, 2015.
[2] Juvinall R.C, and Marshek K.M, "Fundamentals of Machine Component Design", John Wiley & Sons, Third Edition, Wiley student edition, 2007.
[3] V. B. Bhandari, *"Design of Machine Elements",*4th Ed., Tata Mcgraw Hill, 2016.

**References:**

[1] Robert L. Norton "Machine Design- an integrated approach", Pearson Education, 2nd edition.
[2] Spotts M.F., Shoup T.E "Design and Machine Elements", Pearson Education, 8th edition,2006.
[3] Orthwein W, "Machine Component Design", Jaico Publishing Co, 2003.

[4] Hall, Holowenko, Laughlin (Schaum's Outline Series), "Machine design" adapted by S.K.Somani, Tata McGrawHill Publishing Company Ltd., Special Indian Edition, 2008.
[5] G. M. Maithra and L.V.Prasad, "Hand book of Mechanical Design", Tata McGraw Hill, 2nd edition,2004.

**Design Data Hand Book:**

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.
[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.
[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010
[4]PSG Design Data Hand Book, PSG College of technology, Coimbatore.

**Computational Fluid Dynamics**

| Course | Code | Credits | L-T-P | Assessment | | Exam duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Computational Fluid Dynamics | 15ME651 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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**

Conservative, Non conservative form and primitive variable forms of Governing equations. Flux Jacobian, Is there a systematic way to diagonalise '**A**'. Eigenvalues and Eigenvectors of Flux Jacobian. Decoupling of Governing equations, introduction of characteristic variables. Relation between the two non-conservative forms. Conditions for genuinely nonlinear characteristics of the flux Jacobian.

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

**8 Hours**

**Module – III**

**Representation of Functions on Computer**

Need for representation of functions, Box Function, Hat Function, Representation of sinx using hat functions: Aliasing, high frequency, low frequency. Representation error as a global error. Derivatives of hat functions, Haar functions, Machine Epsilon. Using Taylor series for representation of Derivatives. 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◦ 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 equations.
- 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
2. Ghoshdastidar, Computational fluid dynamics and heat transfer, Cengage learning, 2017.
3. Charles Hirsch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 & Vol 2, Butterworth- Heinemann, 2007


**Reference Books**:


1. Pletcher, r. H., Tannehill, j. C., Anderson, d., Computational fluid mechanics and heat transfer, 3rd ed., Crc press, 2011, ISBN 9781591690375.
2. Moin, p., Fundamentals of engineering numerical analysis, 2nd ed., Cambridge university press, 2010, ISBN 9780521805261 (e- book available).
3. Ferziger, j. H., Numerical methods for engineering application, 2nd ed., Wiley, 1998.
4. Ferziger, j. H., Peric, m., Computational methods for fluid dynamics, 3rd ed., Springer, 2002.
5. Leveque, r., Numerical methods for conservation laws, lectures in mathematics, eth Zurich, birkhauser,199
6. Riemann Solvers and Numerical methods for Fluid Dynamics – A
7. Practical Introduction- Eleuterio F Toro, Springer Publications.


**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:**

1. Hirsch, c., Numerical computation of internal and external flows, 2nd ed., Butterworth- Heinemann, 2007, ISBN 9780750665940 (e-book available).

**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.

## MECHANICS OF COMPOSITE MATERIALS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanics of Composite Materials | 15ME652 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Course objectives:**

The course is intended to provide basic understanding of Composite Materials to engineeringstudents 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**

**Introduction to composite materials**:Definition and classification of composite materials: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon-Carbon Composites. Reinforcements and Matrix Materials.

**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. **10 Hrs**

**MODULE -2**

**Micromechanics of Composites:** Density, Mechanical Properties; Prediction of Elastic Constants,Micromechanical Approach, Halpin-Tsai Equations, Transverse Stresses. Thermal Properties; Expression for Thermal Expansion Coefficients of Composites, Expression for Thermal Conductivity of Composites,Hygral and Thermal Stresses. Mechanics of Load Transfer from Matrix to Fiber;Fiber elastic-Matrix Elastic,Fiber Elastic-Matrix Plastic. Load transfer in Particulate Composites. Numerical Problems. **10 Hrs**

**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 Composites,Stresses and Strains in Laminate Composites, Inter-laminar Stresses and Edge Effects. Numerical Problems. **10 Hrs**

**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. **10 Hrs**

**MODULE -5**

**Failure Analysis and Design of Laminates:** Special cases of Laminates; Symmetric Laminates, Cross-ply laminates, Angle ply Laminates, Antisymmetric Laminates, Balanced Laminate. Failure Criterion for a Laminate.Design of a Laminated Composite. Numerical Problems.

**10 Hrs**

**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:**

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
2. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012
3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.

**REFERENCE BOOKS:**

1.Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004
2. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
3. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993
4. Hand Book of 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.

## METAL FORMING

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Metal Forming | 15ME653 | 3 | 3-0-0 | 80 | 20 | 3Hrs |

**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 ofmetal forming processes, advantages and limitations, stress-strainrelations 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 effecton mechanical properties. **10 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. **10 Hrs**

**MODULE -3**

**Rolling**: Classification of rolling processes. Types of rolling mills, expression for rolling load. Roll separating force. Frictional losses in bearing, power required in rolling, effects of front & back tensions, friction, friction hill. Maximum possible reduction. Defects in rolled products. Rolling variables. Simple problems.

**Drawing:** Drawingequipment & 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. **10 Hrs**

**MODULE -4**

**Extrusion:**Types of extrusion processes, extrusion equipment & dies, deformation, lubrication & defects in extrusion. Extrusion dies, extrusion of seamless tubes. Extrusion variables. Simple problems.

**Sheet Metal Forming:** Forming methods, dies & punches, progressive die, compound die, combination die. Rubber forming. Open back inclinable press (OBI press), piercing, blanking, bending, deep drawing, LDR in drawing, Forming limit criterion, defects of drawn products, stretch forming. Roll bending & contouring. Simple problems. **10 Hrs**

**MODULE -5**

**High Energy Rate Forming Methods &Powder Metallurgy:** High Energy Rate Forming Methods: Principles, advantages and applications, explosive forming, electro hydraulic forming, Electromagnetic forming.

**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. **10 Hrs**

**Course outcomes:**

**On completion of this subject, students will be:**

5. Able to understandthe concept of different metal forming process.
6. Able to approach metal forming processes both analytically and numerically
7. Able to design metal forming processes
8. Able to develop approaches and solutions to analyze metal forming processes and the associated problems and flaws.

**TEXT BOOKS:**


1. Mechanical metallurgy (SI Units), G.E.Dieter, McGraw hill Pub-2001.
2. Production Technology (Manufacturing process, technology and Automation), R.K Jain, Khanna Publishers-2004.
3. Manufacturing Science, Amithab Gosh &A.K.Malik, East-West press 2001.
4. Production Technology Vol-II by O. P. Khanna & Lal, Dhanpat Rai Publications-2012.
5. A Course in Workshop Technology Vol: 1, Manufacturing Process, B.S Raghuwanshi, Published by Dhanpat Rai & Co (P) Ltd.-2014.


**REFERENCE BOOKS:**


1. Materials & Process in Manufacturing – E.Paul, Degramo, J.T.Black, Ranold, A.K.Prentice-hall of India 2002
2. Elements of Workshop Technology Vol:1, S.K.Hajra Choudhury, Media Promoters & Publishers Pvt Ltd.-2008.
3. Fundamentals of Manufacturing Processes by Lal G K , Narosa
4. Textbook of Production Engineering by P. C. Sharma, S Chand & Company Ltd.


**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 |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Tool Design | 15ME63 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Course Objectives:**

| | |
|---|---|
| **CLO1** | To develop capability to design and select single point and multipoint cutting tools for various machining operations. |
| **CLO2** | Exposure to variety of locating and clamping methods available. |
| **CLO3** | To enable the students to design jigs and fixtures for simple components. |
| **CLO4** | To expose the students to the design/selection procedure of press tools and die casting dies. |

**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 millingfor simple components.

**08 Hours**

**MODULE 4**

**Press tools:**Classificationandworking 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.

**08 Hours**

**MODULE 5**

**Drawing dies** – Single action, double action and triple action dies, factors affecting drawing and drawing die design. Design of drawing dies for simple components.
**Die casting:**Die casting alloys, terminology-core, cavity,sprue, slug, fixed and movable cores, finger cams, draft, ejector pins and plates, gate, goosenozzle, over-flow, platten, plunger, runner, vent, water-line etc.
Types of Dies: Single cavity, multicavity 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.

**08 hours**

**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 die casting and injection moulding dies. |

**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 **ToolDesign 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 exercisesshould 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:**

[1]Cyril Donaldson, George H. Lecain,V.C.Goold, "Tool Design", Mc Graw Hill Education, 5th edition,2017.
[2]P.N.Rao, "Manufacturing technology", Mc Graw Hill Education, 4th edition, 2013.

**References:**

[1] P.H.Joshi, "Jigs and Fixtures", Mc Graw Hill Education, 3rd edition, 2010.
[2] John.G. Nee, William Dufraine, John W.Evans, Mark Hill, " Fundamentals of Tool Design", Society of Manufacturing Engineers, 2010.
[3] Frank W.Wilson, "Fundamentals of Tool Design",PHI publications.
[4] Kempester M.H.A., "An introduction to Jig and Tool design", VIVABooksPvt.Ltd., 2004.
[5] Ranganath B.J., "Metal cutting and Tool Design", Vikas publishing house.
[6] HMT, "Production Technology", TataMc Graw Hill, 2013.
[7] V. Arshinov& G. Alekseev, "Metal cutting theory and practice", MIR publishers, Moscow.
[8] Rodin, "Design and production of metal cutting tools", Beekman publishers.

**AUTOMOBILE ENGINEERING**

| Course | Code | Credits | L-T-P | Assessment | | Exam duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| **Automobile** | 15ME655 | 3 | 3-0-0 | 80 | 20 | 3 Hrs |

**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**

**ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS**: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, choice of materials for different engine components, engine positioning. Concept of HCCI engines, hybrid engines, twin spark engine, electric car.

**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. **10 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:


1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
2. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.


REFERENCE BOOKS:


1. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007
2. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
3. Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
4. Automobile Engineering, R. B. Gupta, Satya Prakashan,(4th Edition) 1984.

# Energy Auditing

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Energy Auditing | 15ME661 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Course learning objectives is to**

- Understand energy scenario and general aspects of energy audit.
- Learn about methods and concept of of energy audit
- Understand the energy utilization pattern including wastage and its management

**Module – I**

**General Aspects:** Review of energy scenario in India, General Philosophy and need of Energy Audit and Management, Basic elements and measurements - Mass and energy balances – Scope of energy auditing industries - Evaluation of energy conserving opportunities, Energy performance contracts, Fuel and Energy substitution, Need for Energy Policy for Industries, National & State level energy Policies

**8 Hours**

**Module – II**

**Energy Audit Concepts**: Need of Energy audit - Types of energy audit – Energy management (audit) approach - understanding energy costs - Bench marking – Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements - Duties and responsibilities of energy auditors - Energy audit instruments - Procedures and Techniques.

**8 Hours**

**Module – III**

**Principles and Objectives of Energy Management**: Design of Energy Management Programmes - Development of energy management systems – Importance - Indian need of Energy Management - Duties of Energy Manager - Preparation and presentation of energy audit reports - Monitoring and targeting, some case study and potential energy savings.

**8 Hours**

**Module – IV**

**Thermal Energy Management:** Energy conservation in boilers - steam turbines and industrial heating systems - Application of FBC - Cogeneration and waste heat recovery - Thermal insulation - Heat exchangers and heat pumps – HVC industries-Building Energy Management.

**8 Hours**

**Module – V**

**Electrical Energy Management**: Supply side Methods to minimize supply-demand gap - Renovation and modernization of power plants - Reactive power management – HVDC - FACTS - Demand side - Conservation in motors - Pumps and fan systems – Energy efficient motors.

**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:**


1. Murphy, W. R., Energy Management, Elsevier, 2007.
2. Smith, C. B., Energy Management Principles, Pergamum, 2007


**REFERENCE BOOKS:**


1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Interscience publication)
4. Industrial Energy Management and Utilisation –L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington, 1988)
5. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
6. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice hall1993)


**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| **INDUSTRIAL SAFETY** | 15ME662 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.

12 hours

**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. 10 hours

**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.

12 hours

**MODULE-4 :ELECTRICAL SAFETY**

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 intallations.Safety procedures in electric plant.

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

12 hours

**MODULE-5: CHEMICAL SAFETY AND OTHER SAFETY CHECKS**

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.

10 hours

**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:

1- Industrial Safety and Management by L M Deshmukh by McGraw Hill Education (India) private Limited, ISBN-13: 978-0-07-061768-1, ISBN-10: 0-07-061768-6
2- Electrical Safety, fire safety and safety management by S.Rao, R K Jain and Saluja. Khanna Publishers, ISBN: 978-81-7409-306-6

Reference books:

1- Chemical process Industrial safety by K S N Raju by McGraw Hill Education (India) private Limited, ISBN-13: 978-93-329-0278-7, ISBN-10:93-329-0278-X
2- Industrial Safety and Management by L M Deshmukh. McGraw Hill Education (India) private Limited, ISBN-13: 978-0-07-061768-1, ISBN-10: 0-07-061768-6
3- Environmental engineering by Gerard Kiely by McGraw Hill Education (India) private Limited, ISBN-13: 978-0-07-063429-9

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.

# Maintenance Engineering

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Maintenance Engineering | 15ME663 | 3 | 3-0-0 | 80 | 20 | 3Hrs |

**Course objectives:**

The course is intended to provide basic concepts of maintenance engineeringto engineeringstudents 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 costsPreventive 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.

10 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.

10hrs

**MODULE -3**

**Reliability Centered Maintenance**:principles of RCM, Benefits of RCM, application of RCMStep-by-step procedure in conducting RCM analysis. The Plant Register. Functions and Failures. Failure mode and effect analysis (FMEA). Failure consequences. Maintenance and decision making. Acturial analysis and Failure data. Perspective loops. Default action. The RCM Decision diagram. The nature of Failure and Technical history. 10 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.

10 hrs

**MODULE -5**

**Condition Monitoring:**

**Measurable phenomena from different Plant Items:**

Measurable phenomena associated with degradation from a range of plant items includingmotors/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 techniquesetc.), heat emissions (IR, cameras, direct temperature measurement, etc.), electrical charges (tan d, 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.

10 hrs

**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. Applythe principles of condition monitoring systems.
6. Apply the mechanical condition monitoring techniques and analyze the data used in condition monitoring

**TEXT BOOKS:**

1. Practical machinery Vibration Analysis & Predictive Maintenance, C. Scheffer and P. Girdhar,, IDC technologies, 2004.
2. Introduction to Machinery Analysis and Monitoring, John S. Mitchell, PennWell Books, 1993.
3. Machinery Vibration, Measurement and Analysis, Victor Wowk, Mc Craw Hill,1991

**REFERENCE BOOKS:**

1. Handbook of Condition Monitoring, B.K.N. Rao,1996
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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Total Quality Management | 15ME664 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**COURSE LEARNING OBJECTIVES:**

This course enables students to

1. Understandvarious approaches to TQM
2. Understandthe characteristics of quality leader and his role.
3. Developfeedback 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, TQMFramework, awareness, defining quality, historical review, obstacles, benefitsof TQM.

**Quality Management Systems:** Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.

08 Hours

**Module - 2**

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

08Hours

**Module - 3**

**Customer Satisfaction and Customer Involvement:**

Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs intorequirements, customer retention,casestudies.

Employee Involvement – Motivation, employee surveys, empowerment,teams, suggestion system, recognition and reward, gain sharing, performanceappraisal, 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

**Module - 5**

**Tools and Techniques:** Benching marking, information technology, quality management systems, environmental management system, and qualityfunction 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:**

1. Total Quality Management: Dale H. Besterfield, Publisher -Pearson Education India, ISBN: 8129702606, Edition 03.
2. Total Quality Management for Engineers: M. Zairi, ISBN:1855730243, Publisher: Wood head Publishing

**REFERENCE BOOKS:**

1. Managing for Quality and Performance Excellence by James R.Evans and Williuam M Lindsay,9th edition, Publisher Cengage Learning.
2 A New American TQM, four revolutions in management, ShojiShiba, Alan Graham, David Walden, Productivity press, Oregon, 1990
3. Organizational Excellence through TQM, H. Lal, New age Publications, 2008

**Reference Books:**

1. Engineering Optimization Methods and Applications, A Ravindran, K, M.Ragsdell, Willey India Private Limited,2nd Edition,2006.
2. : Introduction to Operations Research- Concepts and Cases, F.S. Hillier. G.J. Lieberman, 9th Edition, Tata McGraw Hill. 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.

**Heat Transfer Lab**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Heat Transfer Lab | 15MEL67 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a
5. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.
6. Determination of Emissivity of a Surface.
7. Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).

**PART – B**

1. Determination of Steffan Boltzmann Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
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:**

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

**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)

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Modeling and Analysis Lab | 15MEL68 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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, descritize, 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:**

1. **A first course in the Finite element method,** Daryl L Logan, Thomason, Third Edition

2. **Fundaments of FEM,** Hutton – McGraw Hill, 2004

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

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
# CHOICE BASED CREDIT SYSTEM (CBCS)
# SCHEME OF TEACHING AND EXAMINATION 2015-2016

**B.E. Mechanical Engineering**

**VII SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15ME71 | Energy Engineering | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 2 | 15ME72 | Fluid Power Systems | 4 | 0 | 0 | 03 | 80 | 20 | 100 | 4 |
| 3 | 15ME73 | Control Engineering | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 4 | 15ME74X | Professional Elective - III | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 5 | 15ME75X | Professional Elective-IV | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 6 | 15MEL76 | Design Lab | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| 7 | 15MEL77 | CIM Lab | 1 | 0 | 2 | 03 | 80 | 20 | 100 | 2 |
| 8 | 15MEP78 | Project Phase – I | - | - | - | - | - | 100 | 100 | 2 |
| **TOTAL** | | | **18** | **4** | **04** | | **560** | **240** | **800** | **24** |

| Professional Elective-III | | Professional Elective-IV | |
|---|---|---|---|
| 15ME741 | Design of Thermal Equipments | 15ME751 | Automotive Electronics |
| 15ME742 | Tribology | 15ME752 | Fracture Mechanics |
| 15ME743 | Financial Management | 15ME753 | Mechatronics |
| 15ME744 | Design for Manufacturing | 15ME754 | Advanced Vibrations |
| 15ME745 | Smart Materials & MEMS | | |

**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

## ENERGY ENGINEERING

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Energy Engineering | 15ME71 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

**Courselearning 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, Oilburners, Advantages and Disadvantages of using pulverized fuel, Equipmentfor preparation and burning of pulverized coal, unit system and bin system.Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generationof steam using forced circulation, high and supercritical pressures.Chimneys: Natural, forced, induced and balanced draft, Calculations andnumerical involving height of chimney to produce a given draft. Coolingtowers and Ponds. Accessories for the Steam generators such asSuperheaters, De-superheater, control of superheaters, Economizers, Air preheatersand re-heaters.

**9 Hours**

**Module – II**

**Diesel Engine Power System**: Applications of Diesel Engines in Power field.Method of starting Diesel engines. Auxiliaries like cooling and lubricationsystem, filters, centrifuges, Oil heaters, intake and exhaust system, Layout ofdiesel power plant.

**Hydro-Electric Energy**: Hydrographs, flow duration and mass curves, unithydrograph 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, windvelocity and power from wind; major problems associated with wind power,wind machines; Types of wind machines and their characteristics, horizontaland 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:**


1. B H Khan, Non conventional energy resources, 3rd Edition, McGraw Hill Education
2. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill. 1996


**REFERENCE BOOKS:**


1. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. C. S. Solanki, “Solar Photovoltaic’s: Fundamental A pplications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.


**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Fluid Power Systems | 15ME72 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

***Course objectives:***

| | |
|---|---|
| **CLO1** | To provide an insight into the capabilities of hydraulic and pneumatic fluid power. |
| **CLO2** | To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems. |
| **CLO3** | 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. |
| **CLO4** | Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications. |
| **CLO5** | To familiarize with logic controls and trouble shooting |

**Module 1: Introduction to fluid power systems**

Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications. Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control; heat exchangers.

**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,flowrate, and hydraulic motor performance; numerical problems. Symbolic representation of hydraulic actuators (cylinders and motors).

**10 hours**

**Module3: 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,hydrauliccylinder sequencing circuits, cylinder synchronizing circuit using different methods, hydraulic circuit for force multiplication;speedcontrol of hydraulic cylinder- metering in, metering out and bleed off circuits.Pilot pressure operated circuits.Hydraulic circuit examples withaccumulator.

**10 hours**

**Module4: 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.

**10 hours**

**Module5: 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.

**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 diagramby integrating the components selected for the given application. |

**TEXT BOOKS:**


1. Anthony Esposito, "Fluid Power with applications", Pearson edition,2000 .
2. Majumdar S.R., "Oil Hydraulics",TalaMcGRawHllL, 2002 .
3. Majumdar S.R., "Pneumatic systems - Principles and Maintenance",Tata McGraw-Hill, New Delhi, 2005


**REFERENCE BOOKS:**


1. John Pippenger, Tyler Hicks, "Industrial Hydraulics", McGraw Hill International Edition, 1980.
2. Andrew Par, Hydraulics and pneumatics, Jaico Publishing House, 2005.
3. FESTO, Fundamentals of Pneumatics, Vol I,IIandIII.
4. Herbert E. Merritt, "Hydraulic Control Systems", John Wiley and Sons, Inc.
5. Thomson, Introduction to Fluid power, PrentcieHall, 2004
6. John Watton, "Fundamentals of fluid power control", Cambridge University press, 2012.


**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 fourstudents 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: Experimentson 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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Control Engineering | 15ME73 | 04 | 3-2-0 | 80 | 20 | 3Hrs |

| | |
|---|---|
| Course Objectives | 1. Modeling of mechanical, hydraulic, pneumatic and electrical systems.<br>2. Representation of system elements by blocks and its reduction<br>3. Transient and steady state response analysis of a system.<br>4. Frequency response analysis using polar plot.<br>5. Frequency response analysis using bode plot.<br>6. Analysis of system using root locus plots.<br>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, Kalmanand Gilberts test .

(**7 Hours)**

| **Course Outcomes** |
|---|
| **CO1:** Recognize control system and its types , control actions |
| **CO2:** Determine the system governing equations for physical models(Electrical, Thermal, Mechanical, Electro Mechanical) |
| **CO3:** Calculate the gain of the system using block diagram and signal flow graph |
| **CO4:** Illustrate the response of 1st and 2nd order systems |
| **CO5:** Determine the stability of transfer functions in complex domain and frequency domain |
| **CO6:** Employ state equations to study the controllability and observability |

# DESIGN OF THERMAL EQUIPMENTS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| **Design of thermal Equipments** | 15ME741 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.**08 Hrs**

**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. **08 Hrs**

**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. Calculationprocedure 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 ofrating and sizing problems; calculation procedure for a rating problem.**08 Hrs**

**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 airsupply 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. **08 Hrs**

**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 **08 Hrs**

## 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:**

1. **Process Heat Transfer**: Donald Q. Kern, Tata McGraw –Hill Edition (1997)
2. **Compact Heat Exchangers:** W. M. Kays & A. L. London, McGraw –Hill co. (1997)
3. **Heat Pipe Theory and Practice** Chi, S. W., - A Source Book, McGraw-Hill, 1976

**REFERENCE BOOKS:**

1. **Heat Transfer – A Basic Approach:** NecatiOzsisik, McGraw – Hill International edition (1985).
2. **Heat Exchanger Design Hand Book:** Volumes 2 and 3, edited by Ernst U schlunder. et. al Hemisphere Publishing Co. (1983)
3. **Heat exchanger-** Kokac Thermal- hydraulic and design analysis.

4. **Heat Pipes** Dunn, P. D. and Reay, D. A., , Fourth Edition, Pergamon Press, 1994

# TRIBOLOGY

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Tribology | 15ME742 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**Course objectives:**

| | |
|---|---|
| **CLO1** | To educate the students on theimportance of friction, the related theories/laws of sliding and rolling friction and the effect of viscosity of lubricants. |
| **CLO2** | To expose the students to the consequences of wear, wear mechanisms, wear theories and analysis of wear problems. |
| **CLO3** | Tomake the students understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques. |
| **CLO4** | To expose the students to the factors influencing the selection of bearing materials fordifferent sliding applications. |
| **CLO5** | To introduce the concepts of surface engineering and its importance in tribology. |

**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**

**Module3**

**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'ssignificance;partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.

**10 hours**

**Module4**

**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.

**8 hours**

**Module5**

**Bearing Materials:**Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials.

**Introduction to Surface engineering:** Concept and scope of surface engineering.

Surface modification – transformation hardening, surface melting, thermo chemical processes.

Surface Coating – plating,fusionprocesses, vapor phase processes.

Selection of coating for wear and corrosion resistance.

**8 hours**

**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:**

1."Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002

2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011. 3."Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

**REFERENCES:**

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.

2. "Tribology, Friction and Wear of Engineering Material", I. M.Hutchings, Edward Arnold, London,1992.

3. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann,1992.

4. "Friction and Wear of Materials", Ernest Rabinowicz, John Wiley & sons,1995.

5. "Basic Lubrication Theory", A. Cameron, Ellis Hardwoods Ltd., UK.

6. "Handbook of tribology: materials, coatings and surface treatments", B.Bhushan, B.K. Gupta, McGraw-Hill,1997.

**FINANCIAL MANAGEMENT**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Financial Management | 15ME743 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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 expose 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**

**INTRODUCTION:** Book keeping – systems of book keeping, journal an d ledger posting. Financial Statement, Preparation of Trial balance, profit and Loss Account, Balance Sheet with adjustments.

**05HoursSTATUTORY 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 , arbitage pricing theorynumerical problems. **06 Hours**

**RATIO ANALYSIS / ACCOUNTING RATIO:** Liquidity ratio – Current ratio, quick ratio, turn over ratio, capital structure ratio- Debt – equity ratio, Coverage ratio, Profitability ratio, Profit margin, Return on assets, Activity ratios – Invento ry 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)

**TEXTBOOKS:**


1. **Financial Management,** Khan & Jain, text & problems TMH ISBN 0-07-460208-A. 20001
2. **Financial Accounting, Costing and Management Accounting,** S. M. Maheshwari, 2000
3. **Srivatsava, Radhey Mohan, Financial Decision Making** : Text Problem and Cases, New Delhi : Sterling Publishers (Private) Limited, 198*, p»H
4. Francis, Pitt, The Foundations of Financial Management, London : Arnold Heinmann, 1983, p.l

**REFERENCE BOOKS:**


2. **Financial Management,** I. M. Pandey, Vikas Publication House ISBN 0-7069-5435-1. 2002
3. **Financial Management,** Abrish Gupta, Pearson.
4. **Financial Decision Making,**Humpton. 2000
5. **Financial Management,** Theory and Practice, Prasanna Chandra TMH ISGN -07-462047-9, 3rd edition 2002
6. **Essentials of Financial Management**, Walker, Ernest W., New Delhi : Prentice Hall of India Pvt. Ltd, 1976, p.l


**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)

# Design for Manufacturing

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Design for Manufacturing | 15ME744 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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:**

Major phases of design, effect of material properties on design, effect of manufacturing processes on design. Material selection process- cost per unit property, weighted properties and limits on properties methods. Guidelines for design for manufacturability.

Review of relationship between attainable tolerance grades and different machining processes.Processcapability,mean, variance, skewness, kurtosis, process capability indices- Cp, and Cpk.
Cumulative effect of tolerance- Sure fit law and truncated normal law, problems.

**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 offeature 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**

**Module3:**

**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**

**Module4:**

Design of components with casting considerations: Pattern, mould, and parting line. Cored holes and machined holes. Identifying the possibleand probable parting lines. Castings requiring special sand cores. Designing to obviatesand cores.

Welding considerations: requirements and rules, redesign of components for welding; case studies.

**8 hours**

**Module5:**

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:

| | |
|---|---|
| **CO1** | Describe the different types of manufacturing systems and compare their suitability foreconomic production of various components and products. |
| **CO2** | 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. |
| **CO3** | Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production. |
| **CO4** | |

**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:**


1. Peck, H. "Designing for Manufacture", Pitman Publications, London, 1983.
2. Dieter, G.E. "Engineering Design: A Materials and processing Approach", McGraw Hill Co.Ltd, 2000.
3. Bralla, James G., "Handbook of Products Designfor Manufacturing: A Practical Guide to Low-cost Production", McGraw Hill, New York, 1986.


**REFERENCES:**


1. Eggert, R.J. "Engineering Design" Pearson Education, Inc., New Jersey, 2005.
2. Matousek , R. "Engineering Design", Blackie and Son Limited, Glasgow, 1967.
3. Kalandar Saheb, S.D and Prabhakar, O. "Engineering Design for Manufacture",ISPE 1999.
4. Trucks, H.E., "Design for Economical Production", 2nd ed., Mich., Dearborn, SME 1987.
5. Linberg, Roy A., "Processes and Materials of Manufacture", 4th ed., Allyn and Bacon, Boston, U.S.A., 1990.

# SMART MATERIALS and MEMS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Smart Materials and MEMS | 15ME745 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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

Unit1: 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

Unit 2: Shape Memory Alloys: Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators.

– 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. Applicationsof ER and MR fluids (Clutches, Dampers, others).

– 5hrs

Unit-4FibreOptics: 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

Unit 5: Vibration Absorbers: Introduction, Parallel Damped Vibration Absorber, Analysis, Gyroscopic Vibration absorbers, analysis & experimental set up and observations, Active Vibration absorbers. Control of Structures: Introduction, Structures as control plants, Modelling structures for control, Control strategies and Limitations.

– 6hrs

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

– 5hrs

## MODULE -4

Unit7: MEMS:History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. Microfabrication: Photolithography, Thermal oxidation, Thin film deposition, etching types, Doping, Dicing, Bonding. Microelectronics fabrication process flow, Silicon based, Process selection and design.

– 5hrs

Unit 8: Piezoelectric Sensing and Actuation: Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles, Magnetization and Nomenclatures, Fabrication and case studies,Comparison of major sensing and actuation methods.

– 5hrs

## MODULE-5

Unit 9: Polymer MEMS&Microfluidics:Introduction, Polymers in MEMS(Polyimide, SU-8,LCP,PDMS,PMMA,Parylene, Others) Applications(Acceleration, Pressure, Flow, Tactile sensors). Motivation for micro fluidics, Biological Concepts, Design and Fabrication of Selective components. Channels and Valves.

– 6hrs

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:**

1.“Smart Structures –Analysis and Design”, A.V.Srin ivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267).
2. “Smart Materials and Structures”, M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107)
3. “Foundation of MEMS, by Chang Liu. Pearson Educa tion. (ISBN:9788131764756)

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Automotive Electronics | 15ME751 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

## 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

**Automotive Fundamentals Overview** –Evolution of Automotive Electronics,

Automobile Physical Configuration, Survey of Major Automotive Systems, The Engine – Engine Block, Cylinder Head, Four Stroke Cycle, Engine Control,

Ignition System - Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition Timing, Diesel Engine, Drive Train - Transmission,

Drive Shaft, Differential, Suspension, Brakes, Steering System\, Starter Battery –Operating principle: (

**7 hours**

**The Basics of Electronic Engine Control –** Motivation for Electronic EngineControl – Exhaust Emissions, Fuel Economy, Concept of an Electronic Engine control system, Definition of General terms, Definition of Engine performance terms, Engine mapping, Effect of Air/Fuel ratio, spark timing and EGR on performance, Control Strategy, Electronic Fuel control system,

Analysis of intake manifold pressure, Electronic Ignition.

**6 hours**

## Module 2

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

**3 hours**

**Automotive Sensors** –Airflow rate sensor, Strain Gauge MAP sensor, Engine

Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (O2/EGO) Lambda Sensors, Piezoelectric
Knock Sensor.

**5 hours**

**Automotive Actuators –** Solenoid, Fuel Injector, EGR Actuator, Ignition
System

**3 hours**

**Module 3**

**Digital Engine Control Systems –** Digital Engine control features, Controlmodes for fuel Control (Seven Modes), EGR Control, Electronic Ignition Control - Closed loop Ignition timing, Spark Advance Correction Scheme, Integrated Engine Control System - Secondary Air Management, Evaporative
Emissions Canister Purge, Automatic System Adjustment, System
Diagnostics.

**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 thevehicle, 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**

**Automotive Diagnostics**–Timing Light, Engine Analyzer, On-boarddiagnostics, Off-board diagnostics, Expert Systems, Occupant Protection
Systems – Accelerometer based Air Bag systems.

**4hours**

**Future Automotive Electronic Systems** –Alternative Fuel Engines, Electricand Hybrid vehicles, Fuel cell powered cars, Collision Avoidance Radar warning Systems, Low tire pressure warning system, Heads Up display,
Speech Synthesis, Navigation – Navigation Sensors - Radio Navigation,Signpost navigation, dead reckoning navigation, Voice Recognition Cell Phone dialing, Advanced Cruise Control, Stability Augmentation, Automatic driving Control

**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:**


1. William B.Ribbens, "Understanding Automotive El ectronics", 6th Edition, Elsevier Publishing.

2. Robert Bosch Gmbh (Ed.) Bosch Automotive Electrics and AutomotiveElectronics Systems and Components, Networking and Hybrid Drive, 5th edition, John Wiley& Sons Inc., 2007.

# FRACTURE MECHANICS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Fracture Mechanics | 15ME752 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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.**
**Fracture mechanics principles:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design, NDT andVarious NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Effect of finitecracksize. Elliptical cracks, Numerical problems. **10Hrs**

**Module 2**.
**Plasticity effects:** Irwin plastic zone correction. Dugdale's approach . The shape of the plastic zone for plane stress and plane strain cases.Theplate 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,sizerequirements,etc. **08 Hrs**

**Module 3.**
**The energy release rate**, Criteria for crack growth. The crack resistance(R curve). Compliance.Tearingmodulus.Stability.
**Elastic plastic fracture mechanics:** Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. **08Hrs**

**Module 4.**
**J integral:** Use of J integral. Limitation of J integral. Experimental determination of J integral and the parameters affecting J integral.
**Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crackbranching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness**.** **08 Hrs**

**Module 5.**

**Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, Paris law, Required information for fracture mechanics approach, **08 Hrs**

**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**

1. Elements of Fracture Mechanics by Prasant Kumar, Mc Graw Hill Education, 2009 Edition
2. Anderson , “Fracture Mechanics-Fundamental and A pplication”, T.L CRC press1998.
3. David Broek, “Elementary Engineering Fracture Me chanics”, Springer Netherlands,2011

**Reference Books**

1. Karen Hellan , “Introduction to fracture mechani cs”, McGraw Hill, 2 nd Edition
2. S.A. Meguid , “Engineering fracture mechanics” E lsevier Applied Science, 1989
3. Jayatilaka, “Fracture of Engineering Brittle Mat erials”, Applied Science Publishers, 1979
4. Rolfe and Barsom , “Fracture and Fatigue Control in Structures” , Prentice Hall, 1977
5. Knott , “Fundamentals of fracture mechanisms”, B utterworths, 1973

## MECHATRONICS

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechatronics | 15ME753 | 03 | 3-0-0 | 80 | 20 | 3 Hrs |

**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 ofMechatronics.

**Transducers and sensors:**Definition and classification of transducers, Differencebetween transducer and sensor, Definition and classification of sensors, Principleof working and applications of light sensors, proximity switches and Hall Effectsensors. 10 Hours

**MODULE -2**

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

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

**MODULE -3**

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

**Integration**: Introduction & background, Advanced actuators, Pneumaticactuators, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, EndEffectors, 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 motorselection.

**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 andhydraulic systems, Classifications of Valves, Pressure relief valves, Pressureregulating/reducing valves, Cylinders and rotary actuators.

**DCV & FCV**: Principle & construction details, types of sliding spool valve,

solenoid operated, Symbols of hydraulic elements, components of hydraulicsystem, functions of various units of hydraulic system. Design of simple hydrauliccircuits for various applications. 10 Hours

**Course outcomes:**

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

1. Illustrate various components of Mechatronics systems.
2. Assess various control systems used in automation.
3. Develop mechanical, hydraulic, pneumatic and electrical control systems.

**TEXT BOOKS:**

1. NitaigourPremchandMahalik , Mechatronics-Principles, Concepts and Applications, Tata McGraw Hill, 1st Edition, 2003 ISBN.No. 0071239243, 9780071239240.
2. W.Bolton-Pearson Education, Mechatronics – Elect ronic Control Systems in Mechanicaland Electrical Engineering, 1st Edition, 2005 ISBN No. 81-7758-284-4.

**REFERENCE BOOKS:**

1. Mechatronics by HMT Ltd. – Tata McGrawHill, 1 st Edition, 2000. ISBN:9780074636435.
2. Anthony Esposito, Fluid Power , Pearson Education, 6th Edition, 2011, ISBN No.9789332518544.

**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.

**ADVANCED VIBRATIONS**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Mechanical Vibrations | 15ME754 | 03 | 3-0-0 | 80 | 20 | 3 Hrs |

**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 studentsto 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:**

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

**TEXT BOOKS:**

1. S. S. Rao, “Mechanical Vibrations”, Pearson Educ ation.
2. S. Graham Kelly, “Fundamentals of Mechanical Vib ration” - McGraw-Hill.
3. “Theory of Vibration with Application” - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education.
4. “Mechanical Vibrations”, V. P. Singh, Dhanpat Ra i & Company.
5. Mechanical Vibrations, W.T. Thomson W.T.- Prentice Hill India

**REFERENCE BOOKS:**

1. S. Graham Kelly, “Mechanical Vibrations”, Schaum ’s Outlines, Tata McGraw Hill.
2. C Sujatha, “Vibraitons and Acoustics – Measureme nts and signal analysis”, Tata McGraw Hill.
3. “Mechanical Vibrations”, G. K. Grover, Nem Chand and Bros.

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Design Laboratory | 15MEL76 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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.
3. Balancing of rotating masses.
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 ofPorter/ 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** |
| **One question from part B:** | **32 Marks** |
| **Viva- Voce:** | **16 Marks** |
| **Total:** | **80 Marks** |

**Reference Books:**


[1] "Shigley's Mechanical Engineering Design", Rich ards G. Budynas and J. Keith Nisbett, McGraw-Hill Education, 10th Edition, 2015.

[2] "Design of Machine Elements", V.B. Bhandari, TM H publishing company Ltd. New Delhi, 2nd Edition 2007.

[3] "Theory of Machines", Sadhu Singh, Pearson Educ ation, 2nd Edition, 2007.

[4] "Mechanical Vibrations", G.K. Grover, Nem Chand and Bros, 6th Edition, 1996.

# COMPTER INTEGRATED MANUFACTURING LAB

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Computer Integrated Manufacturing LAB | 15MEL77 | 02 | 1-0-2 | 80 | 20 | 3Hrs |

**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:**CademCAMLab-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:**

After studying this course, students will be able to:

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

**Scheme for Examination:**
Two Questions from Part A - 60 Marks (30 +30)
Viva-Voce - 20 Marks
Total: 80 Marks

# Project Work, Phase I

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Project Work, Phase I | 15MEP78 | 2 | 0-3-0 | 100 | - | - |

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
# CHOICE BASED CREDIT SYSTEM (CBCS)
# SCHEME OF TEACHING AND EXAMINATION 2015-2016

**B.E. Mechanical Engineering**

**VIII SEMESTER**

| Sl. No | Subject Code | Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lecture | Tutorial | Practical | Duration (Hours) | Theory/ Practical Marks | I.A. Marks | Total Marks | |
| 1 | 15ME81 | Operations Research | 3 | 2 | 0 | 03 | 80 | 20 | 100 | 4 |
| 2 | 15ME82 | Additive Manufacturing | 4 | 0 | 0 | 03 | 80 | 20 | 100 | 4 |
| 3 | 15ME83X | Professional Elective - V | 3 | 0 | 0 | 03 | 80 | 20 | 100 | 3 |
| 4 | 15ME84 | Internship / Professional Practice | Industry Oriented | | | 03 | 50 | 50 | 100 | 2 |
| 5 | 15ME85 | Project Phase – II | - | 6 | - | 03 | 100 | 100 | 200 | 6 |
| 6 | 15MES86 | Seminar | - | 4 | - | - | - | 100 | 100 | 1 |
| **TOTAL** | | | **10** | **12** | **-** | | **390** | **310** | **700** | **20** |

| 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 $6^{th}$& $7^{th}$ semester vacation or $7^{th}$& $8^{th}$ semester vacation.

**OPERATIONS RESEARCH**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Operations Research | 15ME81 | 4 | 3-2-0 | 80 | 20 | 3 Hrs |

**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 studentsto 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. SolutionstoLPP 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**

**Transportation Problem**: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

**Assignment Problem-**Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems.

Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

12 Hours

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**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. Crashingofnetworks- 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**

**Game Theory:** Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulationof games.

**Sequencing:** Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method. 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 networkdiagrams 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-3machines,n jobs-m machinesand 2 jobs-n machines using Johnson's algorithm.

**TEXT BOOKS:**

1. Operations Research, P K Gupta and D S Hira,S. Chand and Company LTD.

Publications, New Delhi – 2007

2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.

REFERENCE BOOKS:

1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.

2. Operations Research, Paneerselvan, PHI

3. Operations Research, A M Natarajan, P Balasubramani, PearsonEducation, 2005

4. Introduction to Operations Research, Hillier and Lieberman,8th Ed., McGraw Hill

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Additive Manufacturing | 15ME82 | 4 | 4-0-0 | 80 | 20 | 3 Hrs |
| | | | | | | |

**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.<br>**Classification of AM processes:** Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system.<br>**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.<br>**Guidelines for process selection**: Introduction, selection methods for a part, challenges of selection<br>**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** |
| | **Module 2** | |
| | **System Drives and devices:** Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features<br>**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** |
| | **Module 3** | |
| | **POLYMERS & POWDER METALLURGY**<br>**Basic Concepts:** Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polyesters etc. Classification of polymers, Concept of functionality, | **12 Hours** |

| | | |
|---|---|---|
| | Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD]<br>**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<br>**General Concepts:** Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM<br>**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 Friction, Compression ability, Powder Structure, Chemical Characterization<br>**Microstructure Control in Powder:** Importance of Microstructure Study, Microstructures of Powder by Different techniques<br>**Powder Shaping:** Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting.<br>**Sintering:** Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components<br>**Application of Powder Metallurgy:** Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc. | |
| **Module 4** | | |
| | **NANO MATERIALS & CHARACTERIZATION TECHNIQUES:**<br>**Introduction:** Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology<br>**Nano-materials Synthesis and Processing:** 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).<br><br>**Optical Microscopy -** principles, Imaging Modes, Applications, Limitations.<br>**Scanning Electron Microscopy (SEM) -** principles, Imaging Modes, Applications, Limitations. **Transmission Electron Microscopy (TEM) -** principles, Imaging Modes, Applications, Limitations.**X- Ray Diffraction (XRD) -** principles, Imaging Modes, Applications, Limitations.**Scanning Probe Microscopy (SPM) -** principles, Imaging Modes, Applications, Limitations.**Atomic Force Microscopy (AFM) -** basic principles, instrumentation, operational modes, Applications, Limitations. **Electron Probe Micro Analyzer (EPMA) -** Introduction, Sample preparation, Working procedure, Applications, Limitations. | **10 Hours** |
| **Module 5** | | |
| | **MANUFACTURING CONTROL AND AUTOMATION**<br>**CNC technology - An overview:** Introduction to NC/CNC/DNC machine tools, | **10 Hours** |

| | | |
|---|---|---|
| | 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)<br>**Introduction:** 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<br>**Control Technologies in Automation:** Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components. | |

**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:**


1. Chua Chee Kai, Leong Kah Fai, “Rapid Prototyping: Principles & Applications”, World Scientific, 2003.
2. G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4th edition, 2005
3. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
4. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
6. Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Prentice Hall Inc., New Delhi, 2007.


**REFERENCE BOOKS:**


1. Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000
2. Computer Aided Manufacturing - P.N. Rao, N.K. Tewari and T.K. Kundra Tata McGraw Hill 1999
3. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
4. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.

# CRYOGENICS

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Cryogenics | 15ME831 | 03 | 3-0-0 | 80 | 20 | 3Hrs |

**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:**

Liquefaction systems for Air Simple Linde –Hampson System, Claude System, Heylndt System, Dual pressure, Claude. Liquefaction cycle Kapitza System. Comparison of Liquefaction Cycles Liquefaction cycle for hydrogen, helium and Neon, Critical components of liquefactionsystems. **10hrs**

**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**

Vacuum Technology: Fundamental principles. Production of high vacuum, Mechanical vacuum pumps, Diffusion pumps, Cryo-pumping, Measurement of high vacuum level. Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation Powder &Fibers Opacified powder insulation, Gas filled powders & Fibrous materials Multilayer super-insulation, Composite insulation.

**10hrs**

**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

1. Cryogenic Systems – R.F. Barron

2. Cryogenic Engineering – R.B. Scott – D.Van Nostrand Company, 1959

REFERENCE BOOKS

1. Cryogenic Process Engineering – K.D. Timmerhaus and T.M. Flynn, Plenum Press, New York,1989

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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Experimental Stress Analysis | 15ME832 | 3 | 3-0-0 | 80 | 20 | 3 Hrs |

**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.

**03Hours**

**Electrical Resistance Strain Gages:** Strain sensitivity in metallic alloys, Gageconstruction, Adhesives and mounting techniques, Gage sensitivity and gage factor,Performance' Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits.

**05 Hours**

**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.

**04 Hours**

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

**02 Hours**

**Module –3**

**Photoelasticity:** Nature of light, Wave theory of light - optical interference, Stress optic law –effect of stressed model in plane and circuclar polariscopes, Isoclinics&Isochromatics, Fringe order determination Fringe multiplication techniques , Calibration photoelastic model materials

**06Hours**

**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

**02 Hours**

**Module - 4**

**Three Dimensional Photo elasticity**: Stress freezing method, Scattered lightphotoelasticity, Scattered light as an interior analyzer and polarizer, Scattered lightpolariscope and stress data Analyses.

**04 Hours**

**Photoelastic (Birefringent) Coatings :**Birefringence coating stresses, Effects ofcoating thickness: Reinforcing effects, Poission's, Stress separation techniques: Oblique incidence, Strip coatings

**06 Hours**

**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.

**05Hours**

**Moire Methods:** Moire fringes produced by mechanical interference .Geometrical approach, Displacement field approach to Moire fringe analysis, 0ut of plane displacement measurements, Out of plane slope measurements .Applications and advantages

**05Hours**

**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:**

1. **"Experimental Stress Analysis",** Dally and Riley, McGraw Hill.
2. **"Experimental Stress Analysis".** Sadhu Singh, Khanna publisher.
3. **Experimental stress Analysis**, Srinath L.S tata Mc Graw Hill.

**REFERENCES BOOKS :**

1. **"Photoelasticity Vol I and Vol II,** M.M.Frocht, John Wiley & sons.
2. **"Strain Gauge Primer",** Perry and Lissner,
3. **"Photo Elastic Stress Analysis",** Kuske, Albrecht & Robertson John Wiley & Sons.
4. **"Motion Measurement and Stress Analysis",** Dave and Adams,

5**. Holman, Experimental Methods for Engineers,** Tata McGraw-Hill Companies, 7th Edition, New York, 2007.

**6. B. C. Nakra and K. K. Chaudhry**, Instrumentation, Measurement and Analysis, Tata McGraw-Hill Companies, Inc, New York, 7th Edition, 2006.

**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**

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Theory of Plasticity | 15ME833 | 3 | 3-0-0 | 80 | 20 | 3 Hrs |

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

**Course objectives:**

| | |
|---|---|
| **CLO1** | To introduce the concepts of Plasticity and mechanism of plastic deformation in metals. |
| **CLO2** | To expose the students to elasto-plastic problems involving plastic deformation of beams and bars. |
| **CLO3** | To introduce the concepts of slip line field theory. |

**Module 1**

**Briefreviewof fundamentals of elasticity**:Concept of stress, stress invariants, principal Stresses, octahedralnormalandshearstresses,sphericalanddeviatoric stress,stress transformation;concept of strain,engineeringandnaturalstrains, octahedralstrain,deviator and spherical strain tensors, strainrateandstrainrate 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 diagramsfor differentmaterialmodels, empirical equations,Levy-VonMises equation, Prandtl-Reuss andSaintVenant 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 ofplasticyielding, 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.

**9 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:

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

**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:**


1. “Theory of Plasticity”, Chakraborty, 3rd Edition Elsevier.
2. “TheoryofPlasticityand Metal formingProcess”-Sadhu Singh, KhannaPublishers, Delhi.


**References Books:**


1. “EngineeringPlasticity-TheoryandApplicationto Metal FormingProcess” -R.A.C. Slater, McMillan PressLtd.
2. “Basic Engineering Plasticity”, DWA Rees, 1st Edition, Elsevier.

3. “Engineering Plasticity”, W. Johnson and P. B. Mellor, Van NoStrand Co. Ltd 2000
4. Advanced Mechanics of solids, L. S. Srinath, Tata Mc. Graw Hill, 2009.

# Green Manufacturing

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Green Manufacturing | 15ME834 | 3 | 3-0-0 | 80 | 20 | 3 Hrs |

**COURSE OBJECTIVES**

Students will be ableto

1. Acquire a broad understanding of sustainable manufacturing, green product and process
2. Understand the analytical tools, techniques in green manufacturing
3. Understand thestructures 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**

Introduction, The Social Environment—Present Atmosphere and Challenges for Green Manufacturing, The Business Environment: Present Atmosphere and Challenges, The Policy Environment—Present Atmosphere and Challenges for Green Manufacturing. **08Hrs**

**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. **08Hrs**

**Module -3**

**Closed-Loop Production Systems**

Life Cycle of Production Systems, Economic and Ecological Benefits of Closed□Loop Systems, Machine Tools and Energy Consumption, LCA of Machine Tools, Process Parameter Optimization, Dry Machining and Minimum Quantity Lubrication, Remanufacturing, Reuse, Approaches for Sustainable Factory Design.

**Semiconductor Manufacturing**

Overview of Semiconductor Fabrication, Micro fabrication Processes, Facility Systems, Green Manufacturing in the Semiconductor Industry: Concepts and Challenges, Use-Phase Issues with Semiconductors, Example of Analysis of Semiconductor Manufacturing. **08Hrs**

**Module- 4**
**Environmental Implications of Nano-manufacturing**

Introduction, Nano-manufacturing Technologies, Conventional Environmental Impactof Nano-manufacturing, Unconventional Environmental Impactsof Nano-manufacturing, Life Cycle Assessment (LCA) of Nanotechnologies.

**Green Manufacturing Through Clean Energy Supply**
Introduction, Clean Energy Technologies, Application Potential of Clean Energy Supplying Green Manufacturing **08Hrs**

**Module- 5**
**Packaging and the Supply Chain: A Look at Transportation**
Introduction, Background, Recommended Method to Determine Opportunitiesfor Improved Pallet Utilization, Discussion.

**Enabling Technologies for Assuring Green Manufacturing**
Motivation, Process Monitoring System, Applying Sensor Flows in Decision Making:Automated Monitoring, Case Study.

**Concluding Remarks and Observations about the Future**
Introduction, Evolution of Manufacturing, Leveraging Manufacturing, Energy of Labor. **08Hrs**

**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

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Product Life Cycle Management | 15ME835 | 3 | 3-0-0 | 80 | 20 | 3 Hrs |

**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. 8Hrs

**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**

New Product Development, Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program. Concept of redesign of product.

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:**

1.Stark, John. *Product Lifecycle Management: Paradigm for 21st Century ProductRealisation*, Springer-Verlag, 2004. ISBN 1852338105
2.Fabio Giudice, Guido La Rosa, Product Design for the environment-A life cycle

approach, Taylor & Francis 2006

**Reference Books:**

1.. Saaksvuori Antti / ImmonenAnselmie, product Life Cycle Management Springer,Dreamtech,3-540-25731-4

*2.* Product Lifecycle Management, Michael Grieves, Tata McGraw Hill

## Internship/ Professional Practice

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Internship/ Professional Practice | 15ME84 | 2 | Industry Oriented | 50 | 50 | 3 Hrs |

## Project Work, Phase II

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Project Work, Phase II | 15MEP85 | 6 | 0-6-0 | 100 | 100 | 3 Hrs |

## Seminar

| Course | Code | Credits | L-T-P | Assessment | | Exam Duration |
|---|---|---|---|---|---|---|
| | | | | SEE | CIA | |
| Seminar | 15MES86 | 1 | 0-4-0 | 100 | - | - |