Course Objectives:

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

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

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

Course outcomes:

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

1. Understand the concepts behind formulation methods in FEM.

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

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

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

Module 1

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

Module II

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

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

Module III

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

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

Module IV

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

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

Module V

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

Text Books:

Reference Books:
## Computer Integrated Manufacturing

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Integrated Manufacturing</td>
<td>15ME62</td>
<td>04</td>
<td>3-2-0</td>
<td>80</td>
<td>3Hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

### Course Objectives:

<table>
<thead>
<tr>
<th>CLO1</th>
<th>To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLO2</td>
<td>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.</td>
</tr>
<tr>
<td>CLO3</td>
<td>To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.</td>
</tr>
<tr>
<td>CLO4</td>
<td>To expose students to computer aided process planning, material requirement planning, capacity planning etc.</td>
</tr>
<tr>
<td>CLO5</td>
<td>To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.</td>
</tr>
<tr>
<td>CLO6</td>
<td>To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.</td>
</tr>
</tbody>
</table>

### Module - 1

1. **Introduction to CIM and Automation:**
   **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.

Module - 3


Module - 4


Module - 5


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

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

<table>
<thead>
<tr>
<th>CO3</th>
<th>Analyze the automated flow lines to reduce down time and enhance productivity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO4</td>
<td>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.</td>
</tr>
<tr>
<td>CO5</td>
<td>Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.</td>
</tr>
</tbody>
</table>

**Text Books:**
4. Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition, by Nicolas Windpassinger, Amazon.

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

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

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

**Course learning objectives:**

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

**Module - I**

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

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

**Module - II**

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

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

**Module - III**

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

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

**Module - IV**

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

Module - V


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

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

TEXT BOOKS:

REFERENCE BOOKS:

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

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

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design of Machine Elements II</td>
<td>15ME64</td>
<td>04</td>
<td>3-2-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

Course Objectives:

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

**MODULE 1**

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

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

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.

**MODULE 4**

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

Design of Clutches: Types of clutches and their applications, single plate and multi-plate clutches.
(Numerical examples only on single and multi-plate clutches)

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

**MODULE 5**

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

Numerical examples on hydrodynamic journal and thrust bearing design.

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

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

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

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

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

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

Textbooks:


References:


Design Data Hand Book:

Computational Fluid Dynamics

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

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

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

**Module – I**
Introduction to CFD and Governing Equations
Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition.

**Module – II**
One-dimensional Euler’s equation
Introduction to Turbulence Modeling: Derivation of RANS equations and k-epsilon model.

**Module – III**
Representation of Functions on Computer

**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.

**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.

**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

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

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

E-Books:

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics of Composite Materials</td>
<td>15ME652</td>
<td>03</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

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

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

MODULE -1
Manufacturing Techniques of Composites: Fiber Reinforced Plastic (FRP) Processing: Layup and curing, fabricating process, open and closed mould process, Hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.
Fabrication Process for Metal Matrix Composites (MMC’s): Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques. 8 Hrs

MODULE -2

MODULE -3
Macromechanics of Composites: Elastic Constants of an Isotropic Material, Elastic Constants of a Lamina, Relationship between Engineering Constants and Reduced Stiffnesses and Compliances, Variation of Lamina Properties with Orientation, Analysis of Laminated
Composites, Stresses and Strains in Laminate Composites, Inter-laminar Stresses and Edge Effects. Numerical Problems. 8 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. 8 Hrs

**MODULE -5**


**Course outcomes:**

On completion of this subject students will be able to:

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

**TEXT BOOKS:**

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

**E- Learning**

- VTU, E-learning

**Scheme of Examination:**

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

MODULE -1

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.


MODULE -3

MODULE -4

MODULE -5
Powder Metallurgy: Basic steps in Powder metallurgy brief description of methods of production of metal powders, conditioning and blending powders, compaction and sintering application of powder metallurgy components, advantages and limitations. 8 Hrs

Course outcomes:
On completion of this subject, students will be:
1. Able to understand the concept of different metal forming process.
2. Able to approach metal forming processes both analytically and numerically
3. Able to design metal forming processes
4. Able to develop approaches and solutions to analyze metal forming processes and the associated problems and flaws.

TEXT BOOKS:

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

E- Learning
VTU, E-learning

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool Design</td>
<td>15ME654</td>
<td>03</td>
<td>3-0-0</td>
<td>80 20</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

Course Objectives:

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

MODULE 1
Introduction to tool design: Tooling, requirements of a tool designer, general tool design procedure, tool engineering functions and its importance to enhance productivity and quality. Review of cutting tool materials. Tool angles and signature, Carbide inserts grades - ISO designation and applications, tool holders for turning-ISO designation. Solid type tool, brazed tip tool, throwaway indexable insert types, coated carbides and chip breakers. Design of single point cutting tools: Design of shank dimensions using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry.

08 Hours

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

08 Hours

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

08 Hours

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

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

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

08 Hours

MODULE 5


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

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

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 press tools and press tool operations. |

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

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

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

References:
Course learning objectives: The student will be able to learn

- The layout and arrangement of principal parts of an automobile
- The working of transmission and brake systems
- The operation and working of steering and suspension systems
- To know the Injection system and its advancements
- To know the automobile emissions and its effects on environment

**MODULE 1**


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

8 Hours

**MODULE 2**

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

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

08 Hours

**MODULE 3**

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

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

08 Hours

**MODULE 4**

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

08 Hours

MODULE 5

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

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

08 Hours

Course Outcomes: Student will be able

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

TEXT BOOKS:

REFERENCE BOOKS:
Course learning objectives is to

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

**Module - I**


8 Hours

**Module - II**

**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**


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:

REFERENCE BOOKS:

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

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

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

Prerequisites:

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

Overview:

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

MODULE-1: INTRODUCTION TO SAFETY

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

8 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.

8 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.

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 installations. Safety procedures in electric plant.

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

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.

Course Outcomes:

At the end of the course, student is able to:

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

Text Books:


Reference books:

VISITS:

1- To visit respective Institution:
   stores, office, housekeeping area, laboratories.

2- To visit local industries, workshops, district fire fighting system facility and local electrical power stations.
Maintenance Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Engineering</td>
<td>15ME663</td>
<td>3</td>
<td>3-0-0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>

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

MODULE -1

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

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

8 hrs

MODULE -2

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

8 hrs

MODULE -3


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

8 hrs

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

8hrs

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

TEXT BOOKS:

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

E-Learning

- VTU, E-learning

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Quality Management</td>
<td>15ME664</td>
<td>03</td>
<td>3-0-0</td>
<td>80 SEE 20 CIA</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

COURSE LEARNING OBJECTIVES:
This course enables students to
1. Understand various approaches to TQM
2. Understand the characteristics of quality leader and his role.
3. Develop feedback and suggestion systems for quality management.
4. Enhance the knowledge in Tools and Techniques of quality management

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

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

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

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: Bench marking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.

COURSE OUTCOMES:
Student will be able to

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

TEXT BOOKS:

REFERENCE BOOKS:
2 A New American TQM, four revolutions in management, Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990

Reference Books:

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

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

PART - A

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

PART - B

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

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

Reading:

Scheme of Examination:
- ONE question from part -A: 25 Marks
- ONE question from part -B: 40 Marks
- Viva –Voice: 15 Marks
- Total: 80 Marks
Modeling and Analysis Lab (FEA)

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Credits</th>
<th>L-T-P</th>
<th>Assessment</th>
<th>Exam Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeling and Analysis Lab</td>
<td>15MEL68</td>
<td>02</td>
<td>1-0-2</td>
<td>80 20</td>
<td>3Hrs</td>
</tr>
</tbody>
</table>

CREDITS - 02

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

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

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

PART - A

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

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

PART - B

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

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

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

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

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