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. 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

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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.

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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

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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.

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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