Course Name : FINITE ELEMENT ANALYSIS
Course Code : MEN501
Credits : 3
L T P : 3 0 0
Pre-requisite : -----

Total No. of Lectures: 42

Course objective:
The objective of this course is to enrich the student's knowledge about the FEM as applied to one and two dimensional problems of engineering and applied science.

Lecture wise breakup **No. of Lectures**

INTRODUCTION
Introduction of the FEM and its historical background, Brief overview of the steps used in FEM and various approaches to formulate elemental equations, Review of the concept of stresses, strains, equilibriums, boundary conditions, temperature effect and there relations, Concept and application of Minimum Potential energy method, Rayleigh Ritz method, Galerkin Method and Principle of Virtual Work applied to elasticity problems **[6]**

MATRIX ALGEBRA & GAUSS ELIMINATION METHOD
Matrix algebra and its different operations, Eigen values and Eigen vectors, Positive definite matrix, Gauss elimination method to solve a large linear equations **[4]**

1- DIMENSIONAL PROBLEM
Introduction, finite element modelling using bar element, shape functions, Iso, super and sub parametric types of FEM formulation, Potential energy approach and Galerkin method to solve 1-D problems, assembly of elemental equations, types and applications of boundary conditions, higher order 1-D element and their shape functions, its application to 1-D problem, Accounting of temperature effect in 1-D problems **[6]**

TRUSSES
Introduction, 2-D and 3-D trusses, concept of local and global coordinate system and its transformation matrix, solution of 2-D and 3-D trusses by the FEM, stress calculations, Accounting of the temperature effect, computer programming concepts and its implementation to FEM, sample source code of processing, pre and post processing of the FEM **[6]**

2-D PROBLEM USING CONSTANT STRAIN TRIANGLES (CST)
Introduction, finite element modelling using CST elements, its shape function, Potential energy approach, solution of the 2-D problem, Accounting of temperature effect, Problem modelling and boundary conditions for symmetrical problems **[6]**

2-D ISOPARAMATRIC ELEMENTS AND NUMERICAL INTEGRATION

Introduction, Four noded quadrilateral element based FE Modelling and its solution, Numerical integration, concept of weights and gauss points, its values for one point, two point etc. formulae, 2-D & 3-D numerical integration and its application in FEM, Higher order quadrilateral and triangular elements and it's numerical integration **[6]**

BEAMS AND FRAMES

Introduction, Potential energy based FE formulation using beam and frame elements, Boundary consideration, shear stress and bending moment calculations **[4]**

DYNAMIC PROBLEMS:

Introduction, mass matrix as used in the FEM, elemental mass matrix for different types of elements as studied above, Evaluation of Eigenvalues and Eigen vectors by FEM **[4]**

Text book:

1. Introduction to Finite Elements in Engineering: Chandrupatala & Belegundu, PHI, 3rd Ed

References:

1. Finite Element Method: J N Reddy, Mc Graw Hill, 2nd Ed
2. Concept & Application of Finite Element Analysis: Cook et al, John Wiley, 4th Ed
3. The Finite Element Method for Engineers: Huebner et al, John Wiley, 3rd Ed
4. Finite Element Analysis (Theory & programming): C S Krisnamoorthy, TMH, 2nd Ed
5. Text Book of Finite Element Analysis: P Seshu, PHI,

Course Name : COMPUTER AIDED ENGINEERING
Course Code : MEN502
Credits : 3
L T P : 3 0 0
Pre-requisites : -----

Total No. of Lectures: 42

Course Objectives: The advent of computers is now prevailing in all the phases of new product development. This has drastically changed the traditional process of product development. In fact, the complete scenario of product life management is now integrated with the development process. The purpose here will be to expose the students about the same...

Lecture wise breakup **No. of Lectures**

INTRODUCTION AND REVIEW OF CAE:
Introduction to CAD/CAM/CAE environment, Computer Hardware including Graphics hardware, input / display and output devices, Operating system, Application, Software configuration and functions.

[6]

PRIMITIVE ENTITIES:
Graphic packages, Geometric modeling, Process of drawing basic entities e.g. Line, Circle and Ellipse generating algorithms and display, Graphics standards and Engineering Databases.

[6]

THREE DIMENSIONAL TRANSFORMATIONS:
Three Dimensional Geometric Transformations, multiple transformation, Rotation about an arbitrary axis in space, Parallel projections–Matrix equations for Orthographic, Oblique and Axonometric projections, Perspective transformations, equation for one point perspective projections, Stereographic projection. **[6]**

GEOMETRIC MODELING AND APPLICATIONS:
Introduction, wire frame models and entities, Surface models and entities and Solid models.
Parametric representation of plane curves, space curves, synthetic curves, Hermite curves, Bezier curves-generation and properties, B-spline curves-generation and properties, uniform, open uniform and non uniform B-splines, Rational B-spline curves. **[6]**

SURFACE AND SOLID DESCRIPTION AND GENERATION:
Parametric representation, Surfaces of revolution, Sweep surfaces, Bilinear surface, Ruled and developable surfaces, Coons bicubic surfaces, Bezier and B-spline surfaces, Wire frame and; Sweep, Boundary and Constructive Solid Geometry of solid modeling.

[6]

CAM

Basics of NC, CNC, DNC Machine tools, Manual and Part programming, languages, Adaptive control in machining systems, Flexible manufacturing, etc Concept of Group Technology, Rapid tooling.

[8]

INTRODUCTION TO ADVANCED DESIGN CONCEPTS

Solid modeling of components using CAD software Introduction to the concepts of Computer Aided Engineering Design, Product life management, Concurrent Engineering, Robust design, Reliability, Ergonomic considerations in Design.

[6]

Text book:

1. *CAD/CAM Theory and Practice***, Ibrahim Zeid & R Sivasubramanian**, Tata McGraw-Hill.

References:

1. *Computer Graphics*, **D Hearn & M P Baker**, Prentice Hall.

2. *CAD/CAM Principles and Applications*, **P N Rao**, Tata McGraw-Hill.

3. *Computer Aided Engineering Design*, **A Saxena and B Sahay**, Anamya Publications.

4. *Mathematical Elements for Comp. Graphics*, **D F Rogers and J A Adams**, McGraw-Hill International.

5. *CAD/CAM*, **H P Groover and E W Zimmers**, Prentice Hall.

Course Name	**:**	**MATHEMATICAL MODELING AND SIMULATION**
Course Code	**:**	**MEN503**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basics of Mechanical Systems.

Total No. of Lectures: 42

Course Objectives: To make students familiar with modeling, simulation and optimization techniques coupled with the use of FEM, FDM, FVM tools with its applications in physical world.

Lecture wise breakup: **No. of Lectures:**

INTRODUCTION

Basic knowledge on Gaussian Elimination Method, Triangular and transformation of Matrix, Continuous Fourier Series, Direct Method, Newton's Divided Difference Method, Lagrange Method, Spline Method, Lurking dangers of extrapolation. Euler's method, Runge-Kutta method, Finite Difference Method, Integrations: Trapezoidal Rule, Simpson's Rule, Romberg Rule, Gauss-Quadrature Rule , Discrete Data Integration, Improper Integration.

Concept of physical modeling, Types of models, Introduction to system simulation Modeling of Mechanical System, Mathematical Modeling, Curve Fitting, linear algebraic Systems, Numerical Model for a System and Methods of Numerical Simulation. **[12]**

METHODS OF OPTIMIZATION

Problem Formulation For Optimization, Optimization Methods, Optimization of Systems, Practical Aspect in Optimal design, Calculus techniques, Search Methods, Geometric Programming, Dynamic programming, Linear Programming, single variable problem, and multi-variable constrained optimization, Applicability to thermal Systems. **[6]**

MODELING FOR DESIGN AND SYNTHESIS:

Simulation of a system of rigid bodies; Mechanical Systems and component, machine elements, Simulation of electromechanical and thermo mechanical system, Hydraulic and Pneumatic elements. Numerical modeling for design and Synthesis using computational tools. **[6]**

STATISTICAL MODELS IN SIMULATION:

Discrete, continuous, Poisson and empirical distributions, Analysis of input data, output data, overview of simulation languages, Comparing alternative system configurations, Statistical for comparing real world observations with simulation output data, generation of arriving processes, Verification and Validation of simulation models. **[8]**

SIMULATION OF MANUFACTURING AND MATERIAL HANDLING SYSTEMS

Design of simulation experiment, Modeling and analysis of manufacturing system, Simulation of Material handling systems. **[6]**

Monte Carlo Simulation and its application in Queuing models and Inventory models **[4]**

References:

1. *Simulation Modeling and Analysis*, **Averill M Law and W D Kelton**, McGraw Hill
2. *Design of Thermal Systems*, **W.F.Stoecker**, TMH
3. *Simulation of Manufacturing Systems,* **Allan Carrie,** John Wiley & Sons
4. *Discrete Modeling and Analysis*,**J Banks, John S Carson**, Prentice Hall
5. *Performance Modeling of Automated Manufactring System*, **Viswandham and Narahari**, Prentice Hall

Course Name	**:**	**DESIGN OF EXPERIMENTS AND RESEARCH METHODOLOGY**
Course Code	**:**	**MEN504**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Knowledge of basic and engineering mathematics at the BE/BTech level will be assumed.

Total No. of Lectures: 42

Course Objectives: To provide the student with an overview of the advanced mathematics, numerical analysis and optimization techniques to enhance their knowledge towards the knowledge of parameters design and optimization of process parameters.

Lecture wise breakup **No. of Lecture**

REGRESSION EQUATION AND OPTIMIZATION

Introduction to Regression, Linear Regression, Nonlinear Regression, Adequacy of Regression Models, Golden Section Search Method, Newton's Method, Multidimensional Direct Search Method, Multidimensional Gradient Method Simplex Method, Constrained extremal problems, Equality constraints, Jacobian methods, Inequality constraints, extension of Lagrangean method, the Kuhn -Tucker conditions direct search methods. **[10]**

INTRODUCTION TO DESIGN OF EXPERIMENT

Basic principles, Error analysis in experiments, Classification of experimental designs, Design and analysis of one, 2^k and 3^k factors experiments, Completely randomized and randomized complete block designs, **[8]**

TAGUCHI DESIGN AND ANOVA

Taguchi method, Design of Experiments with the help of orthogonal arrays, Selection of parameters and Taguchi's Robust parameter design, Analysis of Variance, Main effects and interactions, Two-factor and three factors interaction and analysis of variance, Noise factors, Tolerance on control factors. Formation and analysis of Signal-to-Noise Ratio. **[10]**

RESPONSE SURFACE METHOD AND OTHER APPROACHES TO PROCESS OPTIMIZE

Introduction to response surface methodology, analysis of second order response surface, blocking in response surface design, the response surface approach to robust design, problem solution. **[8]**

INTRODUCTION TO RESEARCH AND REVIEW PROCESS

Nature and objective of research, Research topic, Literature review, Formulation of problem, Research design, Sampling techniques, Data collection, Statistical and sensitive analysis of data, Interpretation of result and report writing. **[6]**

Text Book:

1. *Numerical Methods with Applications* by **Autar K Kaw, Egwu E Kalu, And Duc Nguyen**
2. *Design and Analysis of Experiments*, **Douglas C. Montgomery**, John Wiley & Sons (Asia) Pvt Ltd.

References:

1. *Numerical Methods for Engineers*, **Chapra and Canale**, 4th edition, 2005, Tata Mc Graw Hill.
2. *Engineering Optimization*, **S.S.Rao**, 3rd edition, 2000, New Age.
3. Probability *and Statistics for Engineers and scientists*, **Walpole, Myers, Myers and Ye**, 7th Edition, 2002, Pearson Education.
4. *Statistics in Research*, **Bernand Ostle and Richard N.Mensing** 3rd ed, 1975, Oxford & IBH Pub Co.
5. *Probability and Statistics in Engineering*, **Hines, Montgomery, Goldsman and Borrow**, 4th ed, 2003, John Wiley & Sons.
6. *Experimental design, Theory & application*, **Federer**, 1955, Oxford & IBH pub Co.Cour

Course Name	**:**	**MECHANICAL BEHAVIOUR OF MATERIALS**
Course Cod	**:**	**MEN505**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basic knowledge of Materials Science and Strength of Materials.

Total No. of Lectures: 42

Course Objectives: To introduce the students to the basic mechanical properties of the materials which are critical from the design and operation point of view. The students will also learn the practical techniques for the measurement of three-dimensional stress and strain

Lecture wise breakup **No. of Lectures**

BASIC MATERIALS SCIENCE

Imperfections in solids, diffusion mechanisms, dislocations and plastic deformation, strengthening mechanisms, Effect of various treatments on mechanical properties. Brittle fracture, Griffith theory, Ductile fracture. **[4]**

MECHANICS OF MATERIALS

Elastic and plastic Behaviour, Tensile and compressive deformation, necking, instability in tension and compression, non-linear properties, damping properties
Stress and strain concentrations, Geometric stress raisers and mitigation of stress concentration, methods for evaluation of stress concentration. **[6]**

PRACTICAL APPLICATIONS OF MECHANICS OF MATERIALS

Anelasticity and Bauschinger effect, Theories of failure, Residual stresses, their sources, effects and relief, Selection of materials for various engineering applications, Introduction to advanced engineering materials. **[4]**

MECHANICAL PROPERTIES OF MATERIALS

Fatigue, SN diagram, theories of fatigue, cumulative fatigue damage, crack initiation and propagation, Effect of different variables on fatigue. Creep, mechanisms of creep, creep fracture, choice of materials for creep resistance. Principles of Fracture Mechanics. Design considerations from fatigue point of view, material properties after heat treatment. **[8]**

BASIC ELASTICITY

Stress at a point, stress equations of equilibrium, laws of stress transformation, principal stresses and principal planes, stress invariants, Mohr's circle for three-dimensional state of stress. Strain analysis, strain equations of transformation, principal strains, stress-strain relationship, generalized Hook's law. **[8]**

EXPERIMENTAL STRESS ANALYSIS

Introduction to various stress analysis techniques, Brittle coatings, strain gauges, various types of strain gauges, details of electrical resistance strain gauges, gauge sensitivity and gauge factor, temperature compensation. Two-dimensional photoelasticity, stress optic law, photoelastic materials, optics of polariscope, plane and circular polariscope, dark and light field arrangements, isochromatic and isoclinic fringe patterns. **[12]**

Textbooks:

1. *Experimental Stress Analysis* by **Dally and Riley**
2. *Mechanical Metallurgy* by **George E. Dieter**

Additional Readings:

1. *Theory of Elasticity* by **Timoshenko & Goodier**
2. *Advanced Mechanics of Solids* by **L.S. Srinath**
3. *Materials Science and Engineering* by **William D. Callister**
4. *Experimental Stress Analysis* by **Srinath, Raghvan and Lingaiah**

Course Name	**:**	**ADVANCED MANUFACTURING PROCESSES**
Course Code	**:**	**MEN506**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Knowledge of basic manufacturing processes and machining processes – I, will be assumed.

Total No. of Lectures: 42

Course Objectives: To provide the student with an overview of the principles of metal cutting and to enhance their knowledge towards the cutting of advanced materials like composite, ceramics and super alloys.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Introduction to different advanced processes, importance and applications of advanced manufacturing processes. Overview: non-conventional machining Processes. **[2]**

MECHANICAL MACHINING PROCESSES

Abrasive jet machining, Ultrasonic machining, Abrasive flow finishing, Magnetic abrasive finishing, Water jet cutting, Abrasive water jet machining process: working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate, surface finish, analysis and modeling with practical examples. **[7]**

THERMODYNAMIC MACHINING PROCESSES

Electrical discharge machining (EDM), Electrical discharge grinding (EDG), WEDM, LBM, PAM, EBM: working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate, surface finish, analysis and modeling with practical examples. **[7]**

ELECTROCHEMICAL AND CHEMICAL MACHINING PROCESSES

Chemical machining (ChM), ECM, ECG, electrochemical stream drilling (ESD), electrochemical deburring (ECDe), shaped tube electrolytic machining (STEM): working principle, theory of material removal, process variables and parametric analysis, process performance, determination of material removal rate, surface finish, anode shape prediction and tool design for ECM. **[7]**

UNCONVENTIONAL AND MICRO SHAPING PROCESSES

Principle, types, working principles, merits, demerits and application of non-conventional advanced forming processes such as explosive, electro-magnetic, electro hydraulic, laser assisted deep drawing, laser beam bending. Micro forming: need, classification, principle and application of micro forming. Film and sheet forming and thermo forming of plastic materials. Micro casting. **[6]**

SPECIAL MANUFACTURING PROCESSES

Physical vapor deposition, chemical vapor deposition, Electroless coating and thermal metal spraying, Advanced joining processes. **[3]**

RAPID PROTOTYPING

Product development cycle and importance of prototyping, Types, Principles and advantages. Sterollthography, FDM, SLS etc., Factors concerning to RP, Consideration for adoptions, Advantages, Accuracy, Economic considerations. **[6]**

POWDER METALLURGY

Important characteristics and methods of producing powders, Different techniques to form the miniature product from metal power, Extruding, Isostatic molding, Fibre metal process, Sintering Hot pressing. **[4]**

ELECTRONIC FABRICATION

Fabrication of wafers and micro electronic circuits Machines: component Sequencing, Insertion, PCB Staffing wave soldering. **[3]**

Text Book:

1. *Advanced Manufacturing Processes* by **G.F. Benidict**, Marcel Deker publisher.

References:

1. *Non-conventional Machining Processes* by **P.K. Mishra**, Narosa Publication.
2. *Manufacturing Processes* by **B.H. Amsteal**, **Philip F. Ostwald & Myron L. Bengeman**, John Wiley & Sons, eighth edition
3. *Manufacturing Analysis* by **N. Cook**.

Laboratory Guidelines: The experiment work in this course is intended to be carried out in the area of Manufacturing such design and fabrication of dies, Hybrid machining setup, experiment on EDM, etc. with the help of Design tools in the CAD Lab and Manufacturing Lab.

Course Name	**:**	**ADVANCED VIBRATION ENGINEERING**
Course Code	**:**	**MEN521**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Knowledge of dynamics of machinery, kinematics and vibration as subjects at the BE/BTech level and it will be assumed.

Total No. of Lectures: 42

Course Objectives: The purpose of this course is to introduce the advanced concepts in the field of mechanical vibrations which presents fundamental material for a modern treatment of vibrations with an emphasis of analytical tools and computational approaches. Students will learn fundamental tools for modeling and analyzing mechanical system.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Viscous damping, Logarithmic decrement, Torsional system with viscous damping, Free vibration, Coulomb damping, Hysteretic damping, Equivalent viscous damping. Introduction to Coupled Vibrations**.** Hamiltons Principle, Galarkin Method, Shape Functions. **[6]**

TWO DEGREE OF FREEDOM SYSTEM

Introduction to free vibrations of undamped system, Torsional system, Coordinates coupling and principal coordinates, Damped free vibrations, Forced vibration of undamped system, Forced vibration with damping, Dynamic vibration absorber, Orthogonality principle. **[6]**

MULTI DEGREE OF FREEDOM SYSTEM

Equation of motion, method of influence coeffiecents, Lagrange's equation, Mode shape orthogonality, Rayleigh-Proportional damping, General Viscous damping, Harmonic excitations, Laplace transform solution, Model analysis for undamped and damped systems. Simple example on vibration in Plates and Shells, Dean and Plass Method, **[7]**

NUMERICAL TECHNIQUES TO FIND NATURAL FREQUENCIES

Rayleigh's method, Holzer's method, Matrix iteration method, Cholesky decomposition, Jacob diagonalization method, Inverse simultaneous and subspace iteration method. **[5]**

VIBRATION ANALYSIS OF CONTINUOUS SYSTEM

Transverse vibration of strings, Longitudinal vibration of rods, Torsional vibration of shaft and beams, Effects of the rotary inertia and shear deformation, Approximate solution methods: Rayleigh's, Rayleigh-Ritz, Galerken's methods. Collocation Method, Transfer Matrix. **[6]**

TRANSIENT AND RANDOM VIBRATION ANALYSIS

Response to impulse excitation, Arbitary forcing function, Base excitation, Laplace transformation method, Response to random inputs, Shock response spectrum, Non Linear Vibrations, Numerical integration methods in vibration analysis : Problem and Case Study. **[6]**

FINITE ELEMENT METHOD APPLIED TO VIBRATIONS

Equations of motions of complete system of finite elements application in the domain of vibration, Incorporation of boundary conditions, Consistent and lumped mass matrices for bar, beam etc. Model reduction problem. Holzers Method, Stodola Method, Matrix Iteration and Inversion Method. **[6]**

Textbook:

1. A textbook of Mechanical Vibration J.Srinivas & V. Dnkkipati Rao, Prentice Hall of India Pvt. Ltd. New Delhi

References:

1. *Non Linear Mechanical Vibration* by **P.Srinivasan**, New Age Publishers
2. *Elements of Mechanical Vibration Ananlysis* by **Leonard Meiorvtch**,Mc Graw Hill
3. *Theory of Vibration with Application* by **Thomas**, PHI
4. *Vibration* by **Daniel J Inman**, PHI
5. *Fundamentals of Vibration* by **Roger A Anderson.**
6. *Vibration Problems in Engineering* by **S Timoshenko**. **D. H. Young, W.Weaver**, John Wiley & sons.

Note:-One or Two expert lectures/workshop from Industry/Academia should be planned.

Course Name	**:**	**ADVANCED FLUID AND GAS DYNAMICS**
Course Code	**:**	**MEN522**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Knowledge of Partial differential equations, Basics of Heat and Mass transfer, Basics of fluid flow.

Total No. of Lectures: 42

Course Objectives: To make students familiar with different computational methods to solve flow problems in real life.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Introduction to flow around bodies, cylinders and aerofoil, prediction of velocity and pressure distribution, laminar and turbulent boundary layers, separation criterion, General differential equation of continuity, Momentum and energy applied to compressible inviscid fluids, Sonic velocity, Mach number and Propagation of disturbance in a fluid flow, Isentropic flow and Stagnation properties, models of the flow, Navier- stokes equation, physical boundary conditions. **[8]**

CHARACTERISTICS OF FLOW

Fanno, Rayleigh and isothermal flows through pipes, Normal and oblique shock waves, Prandtle-Mayer function, Refraction and intersection of oblique shock waves, Detached shock, Linearization and small perturbation theory, General solution of supersonic flow, Elements of supersonic thin airfoil theory. **[5]**

MATHEMATICAL BEHAVIOR OF GOVERNING EQUATION

Classification of quasi linear partial differential equation, General method of determining the Classification of partial differential equation, hyperbolic, parabolic, elliptic equations. Methods of characteristics for solving non-linear equations, **[6]**

DISCRITIZATION METHODS

Finite difference methods, difference equations, explicit & implicit approach, errors & analysis of stability. Basics of finite control volume method, errors & analysis of stability. **[6]**

Heat conduction problem

Solution of One dimensional heat conduction through a pin fin by F.D.M solution of two dimensional heat conductional in a plate by F.D.M. Control volume, formulation of the heat conduction problem and its solution **[6]**

HEAT CONDUCTION WITH CONVECTION & DIFFUSION

Steady state one dimensional convection and diffusion, unwinding, exact solution, exponential scheme, hybrid scheme, power law scheme, Discritization equation for two dimensions & three dimensions, false diffusion. **[5]**

FLUID FLOW PROBLEM

Viscous incompressible flow, solution of the couette flow problem by F.D.M., calculation of the flow field using stream function –vorticity method numerical algorithms for solving complete navier stokes equation – MAC method; SIMPLE method. **[6]**

Textbook:

1. *Computational fluid dynamics* by **John.d.Anderson**, Jr

References:

1. *Numerical heat transfer and fluid flow* by **suhas. V. patankar**
2. *Introduction to Computational fluid dynamics* by **Anil .W. Date**

Course Name	**:**	**AUTOMATION AND ROBOTICS**
Course Code	**:**	**MEN523**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Nil

Total No. of Lectures: 42

Course Objectives: To provide the student with an overview of the principles of automation and robotics and to enhance their knowledge towards the automation in industry.

Lecture wise breakup **No. of Lectures**

INTRODUCTION TO AUTOMATION

Automation production system, Mechanization & Automation, Types of automation, expectations from automation, reasons for automating, basic elements of an automated system, levels of automation, Automation strategies, Mechanical, electrical. Hydraulic and Pneumatic automation devices and controls, Economics of automation. **[5]**

INDUSTRIAL CONTROL SYSTEM

Process industries versus discrete manufacturing industries, continuous versus discrete control, computer process control, forms of computer process control, closed loop versus open loop control, design of control systems. Programmable logic controllers – principle of operation, ladder logic diagram. **[6]**

MANUFACTURING AUTOMATION

High Volume Manufacturing automation; classification and type of automatic transfer machines, automation in part handling and feeding, automated flow lines and analysis, design of single model, multimodel and mixed model production lines. Programmable manufacturing automation; CNC machine, programmable robots, Flexible manufacturing automation; single station manufacturing cell, group technology and cellular manufacturing, flexible manufacturing systems, transfer lines and similar automated manufacturing systems, automated assembly systems. **[8]**

ROBOT TECHNOLOGY

Automation and Robots, Robot physical configuration, Classification of Robot Basic, Manipulation of Robot Components, Degree of Freedom and Degree of Motion, Joints and Symbols, Economic and Social Issues, Principles of Robots, Applications. Robot Programming Methods, Advantages and Disadvantages of Robot, Requirement of a Robot in an Industry, Operational Capabilities level of a Robot, Modular Robot Components, Wrist Mechanism, Numericals. **[5]**

DIRECT AND INVERSE KINEMATICS

Dot and Cross Product, Coordinate Frames, Rotations, Homogeneous Coordinates, Link Coordinates, The Arm Equation and Applications. The Inverse Kinematics Problem, General properties of Solutions, Tool Configuration, Inverse Kinematics of different Robot Configurations. **[7]**

WORKPLACE ANALYSIS AND TRAJECTORY PLANNING

Workspace Analysis, Work Envelope of different Robot Configurations, Workspace Fixtures, The Pick and Place Operation, Continuous Path Motion, Interpolated Motion, Straight Line Motion. **[6]**

PRODUCTION SUPPORT MACHINES AND SYSTEMS

Industrial robots, automated material handling, transfer devices and feeders – classification, construction details and application of transfer devices and feeders used for job orienting and picking, automated guided vehicles, automated storage and retrieval. **[6]**

ADVANCED ROBOT SYSTEMS

Fuzzy logic for Robot Control, Artificial Neural Network in Robotics, Biped Robot, Robot Calibration. **[2]**

Textbook:

1. *Automation, Production system and Computer Integrated Manufacturing* by **Grover,** 3rd Edition, 2011, Pearson Education.
2. *Fundamentals of Robotics Analysis and Control* by **Robert J Schilling**, Tata Mc Graw Hill Education

References:

3. *Hydraulic Systems* by **S R Majumdar**, Tata Mc Graw Hill Education
4. *Pneumatic Systems* by **S R Majumdar**, Tata Mc Graw Hill Education.
5. *Robotics* by **Appuu Kuttan K. K.**, I K Internationals.
6. *Introduction to Robotics* by **S K Saha** , New York, Mc Graw Hill

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Laboratory Guidelines: The experiment work in this course is intended to be carried out in the area of PLC Programming, Pneumatic and Hydraulic Systems and development of robots with the implementation of mathematical concepts.

Note:-One or Two expert lectures/workshop from Industry/Academia should be planned.

Course Name	**:**	**ADVANCED HEAT TRANSFER**
Course Code	**:**	**MEN524**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basics of Heat transfer

Total No. of Lectures: 42

Course Objective: To make students familiar with multi dimensional heat transfer and its applications in the physical world.

Lecture wise breakup **No. of Lectures**

CONDUCTION

Review of the basic laws of conduction, convection and radiation. General heat conduction equation in different co-ordinates. One dimensional steady state conduction with variable Thermal conductivity and with internal distributed heat sources, extended surfaces review, Tapered fins, design considerations. Two dimensional steady-state conduction, semi-infinite and finite flat plates and cylinders, graphical method, relaxation technique. Unsteady state conduction in solids with infinite thermal conductivity, infinite thick-solids, periodic variation, and solutions using Grolber's and Heisler's charts. **[10]**

CONVECTION

Hydrodynamic and thermal boundary layers, differential equations of momentum and energy and their solutions, heat transfer in turbulent flow, eddy heat diffusivity, Reynold's analogy between skin friction and heat transfer. Free convection, empirical correlations, regimes of boiling, Nucleate and film boiling. **[10]**

HEAT EXCHANGERS

Introductions, effectiveness and number of transfer units, design of heat exchangers. **[4]**

RADIATION

Introduction, laws of radiation, heat exchange between black bodies and non-black bodies, shape factor algebra, Radiation shields, electrical net-work approach of radiation heat exchange. **[6]**

MASS TRANSFER

Introduction, Fick's law, General equation of mass diffusion steady state, diffusion through a plain membrane, diffusion of water vapour through air, Mass transfer coefficient, convective mass transfer. **[8]**

HEAT PIPE

Introduction, Working of Heat pipe, Different types of Heat Pipe, Detail of Heat Pipe components, Advantages of Heat Pipe, Application of Heat Pipe, Performance of Heat Pipe, Limitation of Heat Pipe, Analysis and Design of Heat Pipe. **[4]**

Textbook:

1. *Heat & Mass Transfer*, **Incropera & Dewtt** ,John Willey Ltd.
2. *Heat Transfer* by J.P**. Holman**, Tata McGraw Hill Ltd.

References:

3. *Fundamentals of Heat and Mass-transfer* by **D.S. Kumar**

Course Name	**:**	**PRODUCTION SYSTEM DESIGN & QUALITY CONTROL**
Course Code	**:**	**MEN525**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	**-----**

Total No. of Lectures: 42

Course Objectives:

This course provides basic understanding for the analysis, design and management of production systems. It helps in identifying different strategies employed in manufacturing and service industries to plan production activities in an effective manner and to control quality of the product or services. Quality Control (QC) ensures that products and services are designed and produced to meet or exceed customer expectations

Lecture wise breakup **No. of Lectures**

PRODUCTION SYSTEM AND PLANNING

Production system design and planning, Production flow and Life cycle, Plant and Product layout, Assembly line balancing, Design of mass production system. **[6]**

MATERIAL REQUIREMENT PLANNING AND TRANSPORTATION

Material requirement planning , MRP tool, ERP, Concept of probabilistic and deterministic inventory model, Sequencing and scheduling models, Computerized Production, Concept of Line of Balance (LOB), Transportation and assignment Models, Automated material handling techniques. **[11]**

MAN POWER AND FACILITIES PLANNING

Manpower requirement and planning, Plant Heuristics, Facilities requirement and planning, Role of advanced process planning, Supply chain management. **[9]**

INTRODUCTION TO STATISTICAL QUALITY CONTROL

Concept of Calculation of mean, Standard deviation, Probability distribution through statistical data analysis, Concept of advance sampling: single, double and multiple sampling , Sample size and economical sampling plan, Average Outgoing (AOQ), Sample number and total inspection. **[9]**

STATISTICAL PROCESS CONTROL AND CHARTS

$\overline{X}$-chart, R chart, s and Six-sigma chart, Exponential weighted Moving Average Chart, Moving Range Chart, p and np chart, c chart, u chart, Dodge demerit chart, basic methods to improve the process: Scatter diagram, Check sheet, Histogram, Kaizen Blitz. **[7]**

Textbook:

1. *Production Management* by **Buffa and Sarin**, John Wiley Publication.

References:

1. *Production and Inventory Control* by **Wallace Hopp** and **Mark Spearman**
2. *Industrial Engineering and Managemant* by **S. Dalela**
3. Statistical Quality Control by E.L.Grant
4. Quality control by M.Mahajan

Course Name	**:**	**TRIBOLOGY**
Course Code	**:**	**MEN526**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	**-----**

Total No. of Lectures: 42

Course Objectives: The course will give exposure to the students the interaction between the three basic areas of engineering i.e. friction, wear and lubrication. Tribology has now become a major domain to be addressed when one has to work / operate for product performance over throughout its projected life

Lecture wise breakup **No. of Lectures**

SURFACE INTERACTION AND FRICTION

Topography of surfaces, surface features: properties and measurement, surface interaction, adhesive theory of sliding friction, rolling friction, friction properties of metallic and non metallic materials, friction in extreme conditions, thermal considerations in sliding contact, concept on geometry for the performance analysis of bearing. **[7]**

WEAR AND SURFACE TREATMENT

Types of wears, mechanism of various types of wear, laws of wear, theoretical wear models, wear of metals and non-metals, plastics and ceramics, surface treatments, surface modifications, surface topography measurements, laser methods, instrumentation, international standards in friction and wear measurements. **[8]**

LUBRICANTS AND LUBRICATION REGIMES

Lubricants and their physical properties, viscosity and other properties of oils, additives and selection of lubricants, lubricants standards iso, sae, agma, bis standards, lubrication regimes, solid lubrication, dry and marginally lubricated contacts, boundary lubrication, hydrodynamic lubrication, elasto and plasto hydrodynamic, magneto hydrodynamic lubrication, hydro static lubrication, gas lubrication. **[8]**

CLASSIFICATION AND SELECTION OF BEARINGS

Selection criteria, dry and boundary lubrication bearings, hydrodynamic and hydrostatic bearings, electro magnetic bearings, dry bearings, rolling element bearings, bearings for precision applications, foil bearings-special bearings, selection of plain bearing materials, metallic and non-metallic bearings, tolerance on bearings. **[6]**

THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION

Reynolds equation, assumptions and limitations, one and two dimensional reynolds equation-reynolds and sommerfeld boundary conditions, pressure wave, flow, load capacity and friction calculations in hydrodynamic bearings, long and short bearings, pad bearings and journal bearings, squeeze film effects, thermal considerations, hydrostatic bearings & lubrication, design of foil bearings, air bearings. **[8]**

HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION

Rolling contacts of elastic solids**,** contact stresses, hertzian stress, spherical and cylindrical contacts, contact fatigue life, oil film effects, elasto hydrodynamic lubrication, theory-soft and hard ehl, reynolds equation for elasto hydrodynamic lubrication, film shape within and outside contact zones, film thickness and friction calculation, rolling bearings, stresses and deflections, traction drives, internal clearance, shaft and housing fit, mounting arrangements, materials for rolling bearings, manufacturing methods, ceramic bearings, rolling bearing cages bearing seals selection. **[8]**

References:

1. *Friction and Wear of materials,* **Rabinowicz E.**, UK, 1995, John Willey & Sons.

2. *Basic Lubrication Theory*, **Cameron**, **A.**, UK, 1981, Ellis Herward Ltd.

3. *Principles of Tribology*, **Halling, J**., 1984, Macmillian.

4. *Engineering Tribology*, **Williams J.A**., 1994, Oxford Univ. Press.

5. *Fundamentals of Tribology*, **S.K.Basu**, **S.N.Sengupta & B.B. Ahuja**, 2005, Prentice - Hall of India Pvt Ltd., New Delhi.

6. *Engineering Tribology*, **G.W.Stachowiak & A.W .Batchelor,** Butterworth-Heinemann, UK, 2005.

7. *Tribology Hand Book*, **Neale, M.J**. Butterworth Heinemann, 2001, United Kingdom

Course Name : **DYNAMICS OF ROTATING MACHINES**
Course code : **MEN527**
Credits : **3**
L T P : **3 0 0**
Pre-requisite : Nil

Total No. of Lectures: 42

Course objective: The objective of this course is to enrich the student's various dynamical aspects of rotating machine as applied to engineering and applied science.

Lecture wise breakup **No. of Lectures**

INTRODUCTION
Basic concept of vibration, Importance and scope, definition and terminology, representation of harmonic motions, introduction to various types of vibrations and types of excitation. **[3]**

SINGLE DEGREE OF FREEDOM SYSTEMS
D' Alemberts Principle, Energy method, Rayleigh method, simple applications of these methods, different types of damping, sub-critical, critical and over-damping, frequency of damped oscillations, force vibration due to simple harmonic excitation, steady state vibrations, base excitation, vibration isolation, transmissibility, vibration measuring instruments, whirling of shaft without friction **[9]**

TWO DEGREE OF FREEDOM SYSTEMS
Undamped, damped and forced harmonic vibrations, principal mode of vibration, normal modes, nodes, natural frequencies, mode shapes, Torsional vibrations of two rotor systems, application of Two degree of freedom in dynamic vibration absorber, centrifugal pendulum absorber, Torsional vibration absorber, Lagrangian equations and its application in vibrational analysis **[9]**

MULTI-DEGREE OF FREEDOM SYSTEMS - EXACT ANALYSIS
Undamped free vibrations, Reciprocity theorem, Matrix Inversion method, Eigenvalues & Eigenvectors, orthogonal properties of normal modes, modal analysis, torsional vibrations of multi rotor system. **[6]**

CONTINUOUS SYSTEMS
Free vibration analysis of string, longitudinal vibrations of bar, transverse vibration of beam, torsion of vibrations of circular shaft under various end conditions. **[6]**

MULTI-DEGREE OF FREEDOM SYSTEMS- NUMERICAL METHOD
Rayleigh, Dunkerley, Stodola, Holzer, Matrix Iteration and Rayleigh-Ritz methods, Hamilton's Principle, Application of the Hamilton's principles, Eigenvalues & Eigenvectors, characteristic equation and comparison of natural frequencies by these methods **[6]**

BALANCING OF RIGID ROTORS

Static and dynamic balancing of rigid rotors on rigid supports, Balancing machine, their characteristics and construction details. Importance of balancing of rotors and discs with blades.

[3]

Text book:

1. *Theory and Practice of Mechanical Vibrations* by **J. S. Rao & K. Gupta**, New Age International (Pvt.) Ltd., New Delhi

Reference books:

1. *Mechanical Vibrations* by **V. P. Singh**, Dhanpat Rai & Sons, Delhi
2. *Mechanical Vibrations* by **G. K. Grover**, Nem Chand & Bros, Roorkee
3. *Mechanical Vibration Analysis* by **P. Srinivasan**, Tata McGraw Hill, New Delhi
4. *Vibration of Engineers* by **K.K. Pujara**, Dhanpat Rai & Sons, Delhi
5. *Mechanical Vibrations* by **A. H. Church**, John Wiley & Sons, New York
6. *Fundamental of Vibration* **by Balachandran and Magrab**, Cengage Learning

Course Name	**:**	**RENEWABLE ENERGY AND ENERGY MANAGEMENT**
Course Code	**:**	**MEN528**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisite	**:**	**-----**

Total No. of Lectures: 42

Course Objectives: To make students familiar with different alternatives for energy available other than fossil fuels, Methods of their conversion in useful form.

Lecture wise breakup **No. of Lectures**

SOLAR ENERGY

The sun as a perennial source of energy, direct solar energy utilization; solar thermal applications – water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen. **[8]**

ENERGY FROM OCEANS

Wave energy generation – energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy; Tidal energy – basic principles; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation; ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation. **[6]**

WIND ENERGY

Basic principles of wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations. **[4]**

HYDRO POWER

Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations **[5]**

BIOMASS AND BIO-FUELS

Energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes. **[5]**

GEOTHERMAL ENERGY

Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environments problems. **[5]**

ENERGY CONSERVATION MANAGEMENT

The relevance of energy management profession; general principles of energy management and energy management planning; application of Pareto's model for energy management; obtaining management support; establishing energy data base; conducting energy audit; identifying, evaluating and implementing feasible energy conservation opportunities; energy audit report; monitoring, evaluating and following up energy saving measures/projects. **[9]**

Textbook:

1. *Non-conventional sources of energy* by **G.D. Rai**. Khanna Publishers, 2000.
2. *Solar Energy: Principles of Thermal Collection and Storage* by **S.P. Sukhatme**,2008

References:

3. *Renewable energy resources* by **John W Twidell and Anthony** D Weir.
4. *Renewable energy: power for sustainable future* by **Godfrey Boyle**. Oxford University Press in association with the Open University, 1996.
5. *Energy Technology* by **S.Rao and B.B. Parulekar**. Khanna Publishers, 1999.

Course Name	**:**	**MECHATRONICS**
Course Code	**:**	**MEN529**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basic Fundamentals of Electronics and Mechanical Systems.

Total No. of Lectures: 42

Course Objectives: To provide the student with an overview of the principles mechatronics and to enhance their knowledge towards the implementation of control techniques.

Lecture wise breakup **No. of Lectures**

INTRODUCTION TO MECHATRONICS

Basics fundamentals, Definition and concept, Need of Mechatronics in mechanical Engineering, Elements of Mechatronics system, Mechatronics Design process, Systems, Measurement Systems, Control systems, Microprocessor based controllers, Advantages and Disadvantages of mechatronics system. **[4]**

DYNAMIC MODELS:

Block diagrams, Laplace Transformation, Transfer Function, State Space Models, Control actions, linear system analysis. **[4]**

FLUID POWER CONTROL

Fluid power control elements and standard graphical symbols, construction and performance of fluid power generators, hydraulic and pneumatic cylinders, construction design and mountings, hydraulic and pneumatic valves for pressure, flow and direction control, servo valves and simple servo system with mechanical feedback, governing differential equation and its solution for step position input, basic hydraulic and pneumatic circuits. Design of pneumatic logic circuits for a given time displacement diagram or sequence of operations. **[8]**

SENSORS AND TRANSDUCERS

Introduction, Types of Transducers, Characteristic Parameters used in transducers, Displacement Sensors, Position Sensors, Proximity Sensors, Velocity Sensors, Motion Sensors, Force Sensors, Acceleration Sensors, Light Sensors, Piezoelectric Sensors, Selection of sensors. **[6**]

ACTUATING DEVICES AND PROCESS CONTROLLERS

Direct Current Motors, Permanent magnet stepper motors, Piezoelectric actuators Controller Principles, Two Position Controller, Proportional Controller, Derivative Controller, Integral Controller, PD Controller, PID Controller. **[6]**

SYSTEM AND FREQUENCY RESPONSE

Static Response, Poles, Zeros and Stability, Time Response, Transient response, Steady-state Response, Total Response Frequency response**:** Experimental determination of frequency response, Polar plots (Nyquist diagrams), Gain margin and Phase margin, Bode diagrams, Lead and lag compensators. **[8]**

SIGNAL CONDITIONING, DIGITAL ELECTRONICS AND SYSTEMS

Signal Conditioning, The Operational amplifier, Noise Reduction, Current to Voltage and Voltage to Current Converters, Voltage to Frequency and Frequency to Voltage Converters, Analogue to digital conversion, Sampling theorem, Digital to analogue conversion, Types of Digital filters, Digital logic control, Microprocessors and Microcontrollers, Introduction to PLC **[6]**

MECHATRONICS SYSTEM

Traditional and Mechatronics designs, Possible mechatronics design solutions, Case studies of Mechatronic systems, Application of mechatronics in manufacturing and automation (Machine tool and Automobile). **[4]**

Textbook:

1. *Mechatronics Integrated Mechanical Electronic Systems* by **K P Ramachandran & G K Vijayaraghavan & M S Balasundaram**, Wiley, 1st Edition (2011)

References:

2. *Mechatronics* by **W Bolton**, Pearson Education Publications, 3rd Edition (2007
3. *Mechatronics System Design* by **Devdas Shetty & Richard A. Kolk**, Cengage Learning, 2nd Edition (2012)

Course Name	**:**	**THERMAL POWER PLANT ENGINEERING**
Course Code	**:**	**MEN530**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisite	**:**	Basic understanding of thermal engineering.

Total No. of Lectures: 42

Course Objectives: The main objective of the course is to acquire the knowledge about thermal and nuclear power plant, their operation, safety, instrumentation and control.

Lecture wise breakup **No. of Lectures**

Types of Power plants, Vapour power cycles, Gas turbine cycle, Combined cycles, Cogeneration. **[7]**

Techno economic analysis of power plants, Feasibility studies, Variable load problem, Fuels and combustion, Fuel handling equipments. **[8]**

Oil and gas fired boilers, Steam super heaters, Steam generators of Nuclear power stations, Steam and gas turbines; Regenerative feed water heating at thermal and nuclear power plants. **[8]**

Condensers, Circulating water system, Cooling towers **[5]**

Site selection for Thermal and Nuclear power plants, Selection of power plant equipments, Environmental aspects of power generation, Flue-gas cleaning and ash removal. **[8]**

Safety systems of Nuclear Power Plants, Operation of power plants, Instrumentation of Thermal power plants **[6]**

References:

1. *Power plant engineering* by **P.K. Nag.**
2. *Power plant engineering* by ***P.C. Sharma***

Course Name : ADVANCED MECHANICS OF SOLIDS
Course code : MEN531
Credits : 3
L T P : 3 0 0
Pre-requisite : -----

Total No. of Lectures: 42

Course objective:

This subject involves the analytical methods of determining the strength, stiffness and stability of the load carrying components. By understanding these, students will be able to find the stresses, deflection, strain energy and stability of mechanical components under different types of loading. The objective of this course is to enrich the student's knowledge about the advanced topics of mechanics of solid and its principles. The concepts learned in this subject are useful to future designer when they will be crating or designing any new mechanical system.

Lecture wise breakup **No. of Lectures**

REVIEW OF BASICS OF MECHANICS OF SOLID
Rectangular and cylindrical stress component, stress components on an arbitrary plane in 3-D state of stress in rectangular stress component, Principal stresses and planes, stress invariants, Mohr's stress circle for 3-D state of stress, Cauchy's stress quadric, differential equation of equilibrium in Cartesian and cylindrical coordinate system, boundary conditions, **[5]**

ANALYSIS OF STRAIN
Deformation, change in length of a linear element and its linear components, rectangular strain components and state of strain at a point, principal axes of strain and principal strains, compatibility conditions, strain deviator and its invariants. **[5]**

STRESS-STRAIN RELATIONS FOR LINEARLY ELASTIC SOLIDS
Generalized Hooks law, stress strain relations for isotropic materials, Modulus of rigidity, Bulk modulus, Young's modulus and Poisson ratio, relations between the elastic constants, displacement equations of equilibrium **[4]**

THEORY OF FAILURE
Different theories of failures(Isotropic and Anisotropic materials), Mohr's & octahedral theories of failures, their applications and comparisons; Graphical representation and yield locus of the theories of failures **[5]**

ENERGY METHOD
Hooks law and the principle of superposition, work done by forces and elastic strain energy stored, Reciprocal relation and theorem, Castigliano's theorem, expressions for strain energy, superposition of elastic energies, Theorem of virtual work, Kirchhoff's theorem, Menabrea's theorem, Engesser's theorem, Maxwell-Mohr integrals **[6]**

BENDING OF BEAMS

Introduction, concept of principal moment of inertia planes, Stress in a beam due to the unsymmetrical bending, deflection of beam due to unsymmetrical bending, Euler-Bernoulli hypothesis, shear center, shear centre in thin walled open section, for open and other channels,

[6]

TORSION

Torsion of general prismatic solid bars, Torsion of circular, elliptical, equilateral triangular and rectangular bars, Prandtl's Membrane analogy, application of membrane analogy to thin rectangular section, hollow sections and multi-cellular sections, center of twist and flexural center **[7]**

INELASTIC ANALYSIS

Idealized plastic materials, theory of bending for fully plastic symmetrical and unsymmetrical sections, bending theory for materials with generalized stress-strain relation

[4]

Text book:

1. *Advanced Mechanics of Solid* by **L.S. Srinath** (Tata Mcgraw Hill)

Reference Books:

1. *Advanced Mechanics of Materials by* **A. P. Boresi**, et al., John Wiley & sons, 2003
2. *Advances Strength and Applied Stress Analysis by* **R. G. Budynas**, McGraw Hill, 2011
3. *Theory of Elasticity by* S. P. Timoshenko & **J. N. Goodier**, McGraw Hill,
4. *Engg. Mechanics of Solids* by **E.P. Popav**, Pearson Education
5. *Mechanics of Materials* by **FP Beer and R Johnson**, Tata-McGraw Hill Publishers

Course Name	**:**	**ADVANCE DESIGN OF MECHANICAL SYSTEMS**
Course Code	**:**	**MEN532**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	**-----**

Total No. of Lectures: 42

Course Objectives:

After undergoing this course, the students would be in a position to understand the advance design methods which are now becoming common in new product development. The course is designed to develop the capability among students to design, analyze and optimize new products in the rapidly changing scenario where customer and environment are two important entities.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

System design approach for product design, its objectives and constraints, Integrated process design for Robust product design, Managing costs. **[5]**

INTEGRATED ENVIRONMENT

Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing Processes digitally, Need for industrial design-impact, design process investigation of customer needs, conceptualization, refinement, management of the industrial design process, technology driven products, user driven products assessing the quality of industrial design. **[6]**

MATERIAL SELECTION

Working principle, Materials and Manufacturing Design principles, Possible solutions, Materials choice, Influence of materials on form design of welded members, forgings and castings. **[5]**

COMPONENT DESIGN

Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by Separation, simplification by amalgamation, Design for machinability, Redesign of castings based on line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores. **[8]**

DESIGN FOR MANUFACTURE

General design principles for manufacturability,: strength and mechanical factors, mechanisms selection, evaluation method, Process capability, Feature tolerances, Geometric tolerances, Assembly limits, Datum features, and Tolerance stacks. **[6]**

DESIGN FOR ASSEMBLY

Assembly processes, Handling and insertion process, Manual, automatic and robotic assembly, Cost of Assembly, Number of Parts, DFA guidelines. **[6]**

DESIGN FOR THE ENVIRONMENT

Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines with example / application, Lifecycle assessment, Basic method, Design to minimize material usage, Design for recyclability, Design for Energy efficiency, Design to regulations and standards. Design for sustainability. **[7]**

Guidelines: A Term Project / Case Study / Presentation must be given for Assessment (Compulsory)

Textbook:

1. *Product Design and Development*, **Karl T.Ulrich and Steven D.Eppinger**, 1999, McGraw Hill International Edns.

References:

2. *Design for Assembly Automation and Product Design* by **G. Boothroyd**, 1980, New York, Marcel Dekker.
3. *Design for Manufacture handbook* by **Bralla,** 1999, Mc Graw Hill.
4. *Product Design for Manufacture*, **Boothroyd, G, Heartz and Nike**, 1994, Marcel Dekker.
5. *Engineering Design and Design for Manufacture and Structural Approach*, **Dickson, John. R, and Corroda Poly**, 1995, Field Stone Publisher, USA.
6. *Design for the Environment* **by Fixer, J**, 1996, McGraw Hill.
7. *Design for the Environment Angle Wood Cliff*, **Graedel T. Allen By. B**, Prentice Hall.

Course Name	:	**MICRO ELECTRO MECHANICAL SYSTEMS**
Course Code	:	**MEN533**
Credits	:	**3**
L T P	:	**3 0 0**
Pre-requisites	:	-----

Total No. of Lectures: 42

Course Objectives:

This course presents the fundamentals of modeling and analysis of MEMS with a specialized focus on electro- mechanical actuated systems. Topics include fundamentals of solid mechanics, electrostatics, and analytical / numerical methods for analyzing multi-physics systems. Students will develop a basic knowledge of MEMS, sufficient enough to initiate their taking interest in this multi disciplinary area.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Introduction, MEMS definition, history, Applications and Technology development Market. **[4]**

MICRO FABRICATION

Materials - substrates, Additive materials. Fabrication techniques- Bulk micromachining, Surface micromachining, Non conventional micromachining, Deposition, Lithography, etching, Surface micro machining, Thick film, screen-printing and electroplating **[6]**

MICRO MECHANICS AND STRUCTURES

Basic mechanic, Axial stress and strain, Shear stress, Poisson's ratio, Commonly used deflection equations, Beam and torsion equations etc. **[6]**

MECHANICAL TRANSDUCTION TECHNIQUES

Piezo resistivity, Piezoelectricity, Capacitive Techniques, Optical techniques, Resonant techniques. Actuation techniques, Smart Sensors. MEMS Simulation and Design tools Behavioral model ling simulation tools and Finite element simulation tools. **[6]**

PRESSURE SENSORS

Introduction. Techniques for sensing. Physics of pressure sensing-Pressure sensor specifications. Dynamic pressure sensing. Pressure sensor types. MEMS technology pressure sensors-Micro machined silicon diaphragms, **[6]**

FORCE, TORQUE AND INERTIAL SENSORS

Introduction-Silicon based devises-Optical devises-capacitive devises-Magnetic devices-Atomic force microscope and scanning probes- micro machined accelerometer-Micro machined Gyroscope, Future inertial micro machined sensors. **[6]**

MICROFLIDICS

Fluid dynamics at micro scale, surface tension driven transport, Micro pumps, valves and mixers, lab on chip applications. **[5]**

MECHANICAL SENSOR PACKAGING

Introduction, Standard IC packages-ceramic, plastic and metal packages. Packaging process-Electrical interconnects, Methods of die attachment, sealing techniques. MEMS mechanical sensor packaging, Process integration. **[5]**

Text Book:

1. *MEMS* by **Mahalik**, Publisher, Tata McGraw Hill

Reference:

1. *MEMS Mechanical sensors*' **Stephen Beeby, Graham Ensell, Michael Kraft and Neil White**, 2003, Artech House, Inc. Boston.
2. *An introduction to Micro electro mechanical System Engineering*, **Nadim Maluf and Kirt Williams**, 2003, Artech House, Inc. Boston
3. *MEMS: Design and Fabrication* by **GAD-el-Hak.M**, Publisher CRC Tayler & Francis, Boca Raton, Florida 2006.
4. *Microfluidic Technology and Applications* by **Michael Koch**, Alan Evans, Publisher Arthur Brunnschweler

Course Name : EXPERIENTIAL STRESS ANALYSIS
Course code : MEN534
Credits : 3
L T P : 3 0 0
Pre-requisite : -----

Total No. of Lectures: 42

Course objective:

The objective of this course is to teach the students about different experiential methods of stress analysis and its digitization as applied to two and three dimensional problems of engineering and applied science.

Lecture wise breakup **No. of Lectures**

ELEMENTARY ELASTICITY
Stress at a point on an arbitrary plane in 3-D state of stress, differential equations of equilibrium, Laws of stress transformation, boundary conditions, Strain equation of transformation, displacement equations of equilibrium, compatibility conditions, Stress-strain relations **[5]**

BASIC OPTICS
The nature of light**,** passage of light through crystalline medium**,** polarization, decomposition of elliptically polarized light, reflection and refraction, polarizers, quarter and half wave plates, production of plane polarized light. **[5]**

2-DIMENSIONAL PHOTOELASTICITY
Stress optic law, plane and circular polariscopes, isochromatics and isoclinics, white and monochromatic light source, analysis of plane and circular polariscopes through trigonometric resolutions and Jones Calculus, dark and bright field arrangement of circular polariscopes, isoclinics and isochromatics fringe order at a point, methods of compensation, calibration methods, use of white light in photoelasticity. **[7]**

2-D PHOTOELASTIC DATA COLLECTION, ANALYSIS AND ITS APPLICATIONS
Photoelastic data, stress separation techniques, types of applications, properties of an ideal photoelasticity material, 2-D photoelastic data collection and its analysis, casting and machining technique of photoelastic material **[3]**

BIREFRINGENT COATING METHOD
Theory of Birefringent coatings, reflection polariscope, sensitivity of Birefringent coating, separation of principal stresses, sources of errors, Birefringent coating materials and its application **[4]**

BRITTLE COATING METHODS

Brittle coating material, Relation between the state of stress in coating and that in the model, crack detection techniques, law of failure of brittle coatings and interpretation of crack-pattern data, Isostatics and Isoentatics, Accuracy of brittle coating application, calibration of brittle coating materials **[5]**

STRAIN MEASUREMENT

Classification and brief over-view of the strain measurement devices, Electrical resistance strain gauge, its types, gauge materials, backing material of strain gauge, adhesives used, bonding of strain gauge, checking accuracy of bonding, performance of strain gauge, strain gauge circuits, strain gauge rosettes **[7]**

DIGITIZATION OF PHOTOELASTICITY

Basic concepts and methodologies of digitization of photoelasticity, formulation of problems in digital photoelasticity and the application of these techniques, data acquisition by DIP techniques, data analysis by statistical techniques, data presentation by computer graphics. **[6]**

Text book:

3. *Experimental Stress Analysis*: **L S Srinath et al**., Tata McGraw Hill

Reference Books:

1. *e-book on Experimental Stress Analysis*: **K Ramesh**, Publihsed by IIT Madras, India
2. *Experimental Stress Analysis*: **Dally and Riley**, McGraw Hill
3. *Photoelasticity***: M M Frocht**, John Wiley & Sons, New York
4. *Photoelastic stress anslysis*: **Kuske A and G Robertson**, John Wiley & Sons, London
5. *Photoelastic coatings*: **Zandman F, S Redner and J W Dally**, Iowa state university Press, Iowa
6. *Moire Fringes in strain analysis*: **P S Theocaris**, Pergamon Press, Oxford
7. *Digital Photoelasticity- Advanced technique and application*: **K Ramesh**, Springer-Verlag, 2000

Course Name : **ADVANCED METAL CUTTING**
Course Code : **MEN535**
Credits : **3**
L T P : **3 0 0**
Pre-requisites : Knowledge of basic manufacturing processes and machining processes will be assumed.

Total No. of Lectures: 45

Course Objectives: To provide the student with an overview of the principles of metal cutting and to enhance their knowledge towards the cutting of advanced materials like composite, ceramics and super alloys.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Machining fundamentals: work-tool contact, machinable surface, Kinematics of work tool interaction, kinematic elements involved in metal cutting action during different processes, Steriometry of cutting tools: basic shape of cutting tool, tool in hand and system of Tool Nomenclature, standards, Tool Geometry, tool point reference system. Method of master line for rake angle, vector method for rake angle interrelationship.

[5]

OBLIQUE CUTTING

Normal chip reduction coefficient under oblique cutting, True shear angle, effective rake, influx reg on consideration for deformation, Direction of maximum elongation, effect of cutting variables on chip reduction coefficient, Forces system in oblique cutting, effect of wear land on force system. Force system in milling, effect of helix angle, vulf's method, spaan's model for oblique cutting. **[6]**

MECHANISM OF CHIP FORMATION

Deformation of uncut layer in shear, Methods for frozen chip samples, classification of chips, mechanics of chip curl, factors involved in chip formation analysis, Dynamic shearing strain in chip formation, Effect of nose radius, effect of cutting variables on chip reduction coefficient. **[5]**

CUTTING FORCES AND DYNAMOMETER

Measurement of Forces, basic requirement in force measuring techniques, transducers for force measurement, design requirement of dynamometers, different types of force measuring instruments, dynamics of dynamometers, dynamometers for measurement of forces during turning, drilling and milling. Effect of cutting variables on cutting forces. Theoretical determination of cutting forces: Ernst and Merchants upper bond solution, Merchant's second solution and machining constant. **[6]**

FUNDAMENTAL FACTORS WHICH EFFECT TOOL FORCES

Correlation of standard mechanized test. (Abuladze-relation), nature of contact and stagnant phenomena, Rates of strains, shear strain and normal strains distribution, Kinetic coefficient of friction analysis, Built up edge phenomena, Effect of cutting variables on BUL and BUE.

[5]

FAILURE OF CUTTING TOOLS

Tool materials, tool failure, analysis of plastic failure (Form stability criterion), Analyzing failure by brittle fracture, wear of cutting tools, criterion, Flank and creature wear analysis, optimum tool life, tool life equations (Taylor's, woxen etc.) Tool life test, machining optimization predominant types of wear: flank, crater, abrasive, adhesive, diffusion wear models, wear measurements techniques, Theory of tool wear, oxidative, Mathematical modeling for wear, Test of machinability and influence of metallurgy on machinability.

[6]

ECONOMICS OF MACHINING

Economic tool life; Gilbert's Model, Optimal cutting speed for Maximum production; Maximum profit cutting speed, objective criteria for optimization, selection of optimum cutting parameters under various restrictive conditions, Brewer and Reuda;s optimization for maximum power constraint and maximum feed, Bjrcke's Generalized Model, Sensitivity analysis in Machining economics, Economy based on Non Taylorian Tool life laws; Economics of multipass cutting.

[6]

ADVANCE METAL MACHINING

Composite cutting, ceramic and super alloys cutting, cutting tool selection, process parameters and geometry effect on machinability during cutting of composite, ceramics and super alloys.

[3]

SURFACE INTEGRITY AND FINISHES

Surface metallurgy and topography, factors affecting the surface quality, the numerical assessment of the machined surface, ISO recommendation for assessment of machined surface, super finishing processes, and kinematics of super finishing. Mechanics of lapping and honing, three body abrasion. **[3]**

Text Book:

1. *Metal cutting theory and practice* by **A. Bhattacharyya**, Central book, Publisher, Calcutta-9

References:

1. *Metal cutting* by **M. Shaw**
2. *Manufacturing Science* by **Amitava Ghosh, and Asok kumar Mallik**, Affiliated East-West Press Private Limited, New Delhi

Laboratory Guidelines: The experiment work in this course is intended to be carried out in the area of various metals such as composites, ceramics, super alloy etc machining utilizing the platform of different conventional machining methods using single, double and multipoint cutting tools in the Manufacturing Lab and Production Engineering Department Lab.

Course Name	**:**	**WORK SYSTEM DESIGN AND ERGONOMICS**
Course Code	**:**	**MEN536**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	**-----**

Total No. of Lectures: 42

Course Objectives:

This course is designed to teach the fundamentals of Work Study and Ergonomics. These techniques are used in the examination of human work in all its contexts. They lead systematically to the investigation of all the factors which affect the efficiency and economy at the work place. It helps in designing and improvement in the methods and procedures which are most effective, require the least effort, and are suited to the person who uses them establish and improve work standards.

Lecture wise breakup **No. of Lectures**

WORK STUDY FUNDAMENTALS

Productivity and Work Study: Definitions, Scope and applications, Analysis of Work Content, Introduction to Industrial Engineering and Productivity, Measurement of productivity. **[4]**

METHOD STUDY

Process Analysis, Process and Activity Charts, Operation Analysis, Basic Procedure, Micro Motion Study, Principles of Motion Economy. **[3]**

WORK MEASUREMENT

Purposes and Uses, Basic Procedure, Techniques- Work Sampling, Stop-Watch Time Study, Rating and Allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Motion Systems, Job Evaluation of Merit Rating, Wage Incentive Plans, MTM(Method Time Measurement). **[6]**

ERGONOMICS

Fundamental Concepts, Issues in Work System Design, Measuring Work by Physiological Means, Work Posture, Fatigue Measurement and Evaluation, Environmental Factors and Work Systems, Industrial Product Design, Development of Ergonomics. **[8]**

DESIGN APPROACH

A new Design, Modification of Existing Design, Assessment of Design, Limitation of Man and Machine with Respect to each other, Posture-standing at work, Seated at Work, Work Station Heights and Seats Geometry, Human Anthropometry and its Use in Work place Layout, Analysis, NIOSH/OSHA/OCRA Guidelines. **[7]**

WORK LOAD

Static and Dynamic Muscular Work, Human Motor Activity, Metabolism, Physical Work Load, Measurement of Physical Work Load, Mental Work load, Measurement of Mental Work Load, Repetitive and Inspection Work, Work Duration and Rest Pauses, Principles of Motion Economy, Analysis. **[8]**

CLIMATES AND NOISE TERMINOLOGY

Heat Humidity: Body heat Balance, Effective Temperature Scales, Zones of Discomfort, effects of Heat on Body and Work Performance. Vibration: Terminology, Response of Body to Low Frequency (LF). Vibration, Vibrations and Discomfort, Effect on Health of Worker, High Frequency Vibration, Effect of H.F. Vibrations, Methods of Reducing Vibrations, Analysis. Noise Terminology, Physiological Effects of Noise, Annoyance of Noise, Speed Interference, Hearing Loss, Temporary and Permanent Threshold Shift, Effect of Noise on Performance, Reduction of Noise, Personal Noise Protection.

[9]

Practical: Any One DHM Software Complete, e.g. DELMIA HUMAN

Textbook:

1. *Work Study and Ergonomics* by **ILO**
2. *Introduction of Ergonomics* by **Bridger**, Tata McGraw Hill-1995.
3. *Sound, Noise and Vibration Control* by **Lyle, F.Yerges**, Van Nostrand-1978.

References:

4. *Method Engineering Study* by **Krick, EV**.
5. *Work Study and Ergonomics* by **Shah, H.S**. Dhanpat Rai & Sons-1992.
6. *Work Study* by **Khanna, OP** – Dhanpat Rai & Sons-1995.

Course Name	**:**	**DESIGN OF STEAM TURBINE**
Course Code	**:**	**MEN537**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisite	**:**	**-----**

Total No. of Lectures: 42

Course Objectives: To make students familiar with designing aspect of impulse and reaction turbine and their application in the physical world.

Lecture wise breakup : **No. of Lectures:**

STEAM TURBINE TYPES

Principal of operations of stream turbines, Comparison of steam engines and steam turbines, Simple impulse turbine, Compounding of steam turbines, Pressure compounded impulse turbine, Simple velocity compounded impulse turbine, Pressure-velocity compounded impulse turbine, Difference between impulse and reaction turbine.

[4]

FLOW OF STEAM THROUGH IMPULSE TURBINE BLADES

Velocity diagram for impulse turbine, multistage impulse turbine with single row wheel, optimum ratio of blade velocity to steam velocity, impulse blade section, advantages and disadvantages of velocity compounded steam turbines.

[5]

FLOW OF STEAM THROUGH IMPULSE REACTION TURBINE BLADES

Impulse reaction turbine with similar blade section and half degree reaction (Parsons' Turbine), comparison of enthalpy drop in various stages of reaction turbines, height of impulse turbine stage blading, impulse reaction turbine blade section

[5]

ENERGY LOSSES IN STEAM TURBINE

Energy losses in nozzle, moving blade, wind age, partial admission losses, losses due to wetness of steam, mechanical losses.

[4]

STATE POINT LOCUS, REAHEAT FACTOR AND DESIGN PROCEDURE

State point losses for multistage steam turbine, reheat factor, internal and other efficiencies, correction of reheat factor for finite number of stages, design procedure for impulse and impulse reaction turbines.

[4]

REGENERATIVE FEED HEATING, REHEATING AND WATER EXTRACTION CYCLE

Most ideal regenerative feed reheating cycle, advantages and disadvantages of regenerative feed heating over Rankine cycle, prevention from erosion and corrosion, case study of actual regenerative water extraction cycle. **[5]**

BACK PRESSURE, PASSOUT AND MIXED PRESSURE TURBINE CYCLE

Back pressure turbine, passout turbine, process of passout turbine with single extraction, partial extraction, throttle governing, full extraction, nozzle control, working of mixed pressure turbine.

[5]

GOVERNING AND PERFORMANCE OF STEAM TURBINE

Need of governing, comparison of throttle and nozzle control governing, by pass governing of reaction turbine, speeder gear, governing characteristics.

[5]

CONSTRUCTION, STRESS ANALYSIS, OPERATION AND MAINTENANCE OF STEAM TURBINE

Construction of nozzle and diaphram, design requirements of nozzle, construction of turbine blade, blade material, vibration of blades, rotor construction and it's balancing, stresses in turbine blading disc, aims and objective of maintenance.

[5]

Textbook:

1. *Steam and Gas Turbines* by **R. Yadav.**

References:

1. *Steam Turbines* by **P. Shylakkhin**.
2. *Steam Turbine* Theory and Practice by **W.J. Kearton**.

Course Name : FRACTURE AND FATIGUE
Course code : MEN538
Credits : 3
L T P : 3 0 0
Pre-requisite : -----

Total No. of Lectures: 42

Course objective:

The objective of this course is to enrich the student's knowledge about the theories of fracture mechanics and fatigue. This course will also teach the students how these principles can be applied as tool to engineering and applied science practical problem with lower facture of safety.

Lecture wise breakup **No. of Lectures:**

BACKGROUND
Historical aspects, kind of failure, different techniques of fracture mechanics, brittle and ductile fracture, modes of fracture, potency of crack, damage control.

[3]

ENERGY RELEASE RATE (ERR)
Introduction, dilemma of Griffith, Surface energy, Griffith's realization and analysis, Energy release rate, ERR of DCB specimen, anelastic deformation at crack tip, crack resistance, stable and unstable crack growth, R- curve for brittle crack, Thin plate v/s thick plate, critical ERR

[8]

STRESS INTENSITY FACTOR (SIF)
Introduction, Linear Elastic Fracture Mechanics (LEFM), Stress and displacement fields in isotropic elastic material, SIF and its mathematical background, Approach of Westergaard for different mode of fracture and its analysis.

[9]

SIF OF MORE COMPLEX CASES
Other application of Westergaard, application of the principles of superposition, crack in a plate of finite dimensions, Edge and embedded cracks, Relationship between ERR and SIF, critical SIF, Bending and twisting of cracked plates.

[5]

ANELASTIC DEFORMATION AT THE CRACK TIP
Investigation at the crack tip, approximate shape and size of the plastic zone, effective crack length, effect of plate thickness.

[4]

J-INTEGRAL APPROACH
Relevance, scope and definition of J-integral, path independence and stress & strain relation, Further discussion on J-integral, Engg. Approach to J integral

[5]

CRCAK TIP OPENING DISPLACEMENT (CTOD)
Introduction, relationship between CTOD, SIF and ERR, Equivalence between CTOD and J integral. **[3]**

FATIGUE FAILURE

Introduction, Terminology, S-N curve, crack initiation, crack propagation law, Fatigue life calculation, Effect of an overload, crack closure, variable amplitude fatigue loadingenvironment assisted fracture. **[5]**

Text book:

1. *Elements of Fracture Mechanics*: **Prashant Kumar**, Wheeler Publishing, New Delhi, 1999

References:

1. *Elementary Engineering Fracture Mechanics*: **David Broek**, Kluwer Academic Publishers Group, Dordrecht, Netherlands, 1982
2. *Fracture Mechanics*: **E. E. Gdoutos**, Kluwer Academic Publishers Dordrecht, Netherlands
3. *Elementary Fracture Mechanics*: **S. A. Meguid**, Elesvier Applied Science, London, 1989
4. *Introduction to Fracture Mechanics*: **Kare Hellan**, McGraw Hill Book Company, 1985

Course Name	**:**	**ADVANCED INTERNAL COMBUSTION ENGINE**
Course Code	**:**	**MEN539**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basics of Internal Combustion Engine.

Total No. of Lectures: 42

Course Objectives: To make students competitive with eyes on the leading automotive industry, by sharing with them the crucial parameters and properties like combustion, heat transfer etc.

Lecture wise breakup **No. of Lectures**

CYCLE ANALYSIS

Thermodynamic properties of gases and combustion products, combustion charts, Fuel-air cycle, calculations for Otto, Diesel and dual cycles, Losses due to dissociation, burning time and heat flow. Combustion processes for SI and CI engines; flame propagation and spray burning processes; energy release calculations; actual Vs fuel air cycle, effects of various operating conditions, two and four stroke engine cycles. **[10]**

HEAT TRANSFER

Instantaneous heat transfer calculations, engine heat transfer equations, overall heat loss-radiative and convective heat transfers. **[4]**

GAS EXCHANGE

Generalised equations for inflow and outflow processes; filling and emptying methods and wave action calculations; two stroke engines, gas exchange processes; types and phases of scavenging, Kadenacy effect. Super charging of SI and CI engines; super charger and turbocharger systems. **[10]**

FUEL INJECTION

Fuel injection: fuel line hydraulics; compressibility effects; wave and nozzle ends; mechanism of atomization and spray formation; pump characteristics. **[6]**

FUELS

Petroleum fuels, Gasoline grades, desirable properties of SI &CI engines fuels, rating of fuels, Alternative Fuels to reduce emission alcohols, natural gas, biodiesel, hydrogen, Future fuels. **[7]**

EMISSION

Trends in vehicle emission standards, Test procedures, Measurements of emission, Instrumentation for CO, HC, NOx, PM. Strategies to control emissions in SI engines, add on system to control emission inside engine. Diesel & Petrol Engine Emission characteristics. **[6]**

Textbook:

1. *I.C. Engine* Vol. 1 & II by **Taylor**

References

1. *Thermodynamics and Gas Dynamic of I.C. Engine*, Vol. I & II by **Horlock and Winterbone.**
2. *I.C. Engine*, Vol. I & II by **Benson and Whitehouse.**
3. *Thermodynamic Analysis of Combustion Engines* by **Campbell.**

Course Name : MEASUREMENT AND METROLOGY
Course Code : MEN540
Credits : 3
L T P : 3 0 0
Pre-requisites : -----

Total No. of Lectures: 42

Course Objectives:
To provide a basic understanding of the activities involved in standard measurement and calibration of measuring equipments and tools. It covers the measurement process, types and correct use of measurement and test equipment, and measurement standards. It provides an opportunity for students to learn about measurement uncertainty and risk analysis. The course includes the procedures necessary to set up and operate a calibration program.

Lecture wise breakup **No. of Lectures**

STATIC AND DYNAMIC CHARACTERISTICS OF INSTRUMENTS
Introduction to measurement and instruments, basic and auxilliary functional elements of a measurement system, mechanical versus electrical / electronic instruments, primary, secondary and tertiary working standards. Range and Span, Accuracy and Precision, Calibration, Hysteresis and Dead Zone, Sensitivity, Linearity, Threshold and Resolution, Speed of response, Lag, Dead Time, Dead Zone, Zero, First and Second order systems and their response to step, ramp and sinusoidal input signals.

[8]

ERRORS IN MEASUREMENT
Sources of errors, systematic and random errors, Fidelity and Dynamic Error, statistical analysis of test data, probable error and probability tables, rejection of test data, error propagation, design and planning of experiments and report writing.

[5]

METROLOGY
Line, end and wavelength standards, various instrument used in linear measurements. Comparators: types, relative merits and limitations, angular measurements- sine bar clinometer, angle gauge, concept and measurement of straightness and flatness by inferometery, Surface roughness: specifications and measurements. Measurement of diameter, pitch angle, internal and external threads. Gear: measurement of tooth thickness, pitch and checking of profile for spur, helical and bevel gears.

[8]

FUNCTIONAL ELEMENTS
Introduction to electromechanical sensors and transducers- variable resistance, inductance, capacity pick ups, photo cells and piezo electric transducers and application of these elements for measurement of position / displacement, speed/velocity/acceleration, force and liquid level. Resistance strain gauges, gauge factor, bonded and unbounded gauges, surface preparation and bonding technique signal conditioning and bridge circuits, temperature compensation, application of strain gauges for direct, bending and tensional loads. Introduction to amplifying, transmitting and recording devices.

[7]

PRESSURE AND FLOW MEASUREMENT

vacuum measurement- Mcleod gauge, thermal conductivity gauge and ionization gauge, Dead weight gauge tester. Electromagnetic flux meters, ultra sonic flow meters and hot wire anemometer: flow visualization techniques.

[4]

TEMPERATURE MEASUREMENT

Thermal expansion methods- bimetallic thermometers, liquid in glass thermometer and filled in system thermometers, thermoelectric sensors- common thermocouples, reference junction consideration, special materials and configurations, metal resistance thermometers and thermistors, optical and total radiation pyrometers, calibration standards.

[**5**]

SPEED, FORCE, TORQUE AND SHAFT POWER MEASUREMENT

Mechanical tachometers, vibration reed tachometer and stroboscope, proving ring, hydraulic and pneumatic load cells, torque on rotating shafts, absorption, transmission and driving dynamometers

[**5**]

Textbook:

1. *Measurement System: Application and Design* by **Doebelin E.O**; McGraw Hill Publishing Company.

References:

2. *Engineering metrology* by **Jain R.K**., Khanna publishing 2005.
3. *A textbook of Metrology* by **M. Mahajan**, Dhanpat rai and Co. Pvt. Ltd. 200
4. *Mechanical Measurement and Control* by **Kumar DS**; Metropolitan Book Co Pvt. Ltd., New Delhi.
5. *Measurement and Instrumentation Principles* by **Alan S Morris**, *Butterworth-Heinemann.*

Course Name	**:**	**MAINTENANCE ENGINEERING**
Course Code	**:**	**MEN551**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	**-----**

Total No. of Lectures: 45

Course Objectives: To expose the students about the strategies, philosophy, scheme and schedules of maintenance engineering and it applications in the industry.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Objective and importance of maintenance engineering, functions and classification, types of maintenance: corrective, renovative, preventive, breakdown, planned, proactive, predictive etc. maintenance. Quality and reliability centre maintenance, Maintenance strategy and planning, benefits and effects of maintenance. **[6]**

MAINTENANCE POLICIES AND PLANNING

Organization and structure of maintenance systems, responsibilities of maintenance engineering department, control and coordination in maintenance, Maintenance planning, Daily/monthly/annually maintenance schedule, Format/preparation of equipment history, failure analysis report, daily maintenance progress report, and materials issue note and spare parts manufacturing schedule. Total productive maintenance (TPM), 8-pillars of TPM, master plan for TPM promotion. **[8]**

SAFETY AND HOUSE KEEPING IN MAINTENANCE

Hazards: classification, important factors of hazards and causes of accidents, categories of hazards and measurement, procedure of minimizing hazard, fault tree analysis technique, different safety devices, their applications and safety checklist. Factors governing housekeeping, house keeping maintenance and inspection. Incentive payment for maintenance workers, economics and scope of incentive in maintenance, various incentive plans for maintenance people, incentive pay period and allowances for maintenance workers. **[8]**

SYSTEM RELIABILITY AND AVAILABILITY

Reliability, maintainability, failure, Bathtub hazard rate concept, availability, Reliability structure and optimum design configuration of series, parallel, combination of series and parallel, redundancy structure. Mean time to failure (MTTF), mean time between failure (MTBF), mean time to repair (MTTR). Breakdown time distribution. 5-WHY concept for root cause, Quantitative estimation of reliability: Kuder-Richardson formula, Statistical estimation of reliability. ReliaSoft's Lambda hybrid automated reliability predictor. Machine failure pattern and exponential probability. **[8]**

CONDITION MONITORING AND COMPUTER IN MAINTENANCE

Concept of inspection and testing, liquid penetration test, magnetic particle test, eddy current test, ultrasonic and radiographic test, oil analysis, vibration analysis. Methods of condition monitoring, Philosophy, Non-vibration and vibration based condition monitoring, essential equipment and measurement process for condition monitoring. Maximizing equipment effectiveness and overall equipment effectiveness (OEE), Computerized maintenance management system (CMMS), Computerized condition based maintenance (CCBM), Computerized intelligent diagnosis and prognosis system (CIDPS), Artificial intelligent based plant monitoring (AIBPM), Replacement policy, Minimize downtime.

[8]

COST ASPECT AND AUDIT IN MAINTENANCE

Lean maintenance, Economics of maintenance, 6-R & 6-σ in maintenance, 5-Z & 5-S concept in maintenance, Budget and Cost estimating in maintenance, cost of machine breakdown, estimation of life cycle cost, spare parts & raw materials budget and cast estimation. Cost control in maintenance, Maintenance performance and effectiveness analysis, performance indicator and performance measure indices in maintenance. Maintainability index, Maintenance performance inspection and audit.

[7]

Text Book:

1. *Maintenance Engineering Handbook* by Keith Mobley, Tata McGrawhill.

References:

1. *A text Book of Reliability and Maintenance Engineering*, By **Alakesh Manna**, I.K.International Publishing House Pvt.Ltd, New Delhi.
2. *Maintenance Planning and Control* by **Enthory Kelly**, 1984, EWP.N.Delhi.
3. *Principle of planned maintenance* by **Clifton R. H**, 1983, McGraw Hill.
4. Queues, inventories and maintenance by **Morse, P.M**, 1958, Wiley, N.Y.
5. *Handbook of maintenance management* by **Heintzelamam,** Prentice Ha

Course Name : **INTEGRATED PRODUCT DESIGN AND DEVELOPMENT**
Course Code : **MEN552**
Credits : **3**
L T P : **3 0 0**
Pre-requisites : **-----**

Total No. of Lectures: 42

Course Objectives: After undergoing this course, the students would be in a position to understand the systematic and integrated approach for new product development. The purpose of the subject contents is to explain the students how to survive in the competitive environment.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Need for IPPD, Strategic importance of Product development, Integration of customer, designer, material supplier and process planner, Competitor and customer: Behavior Analysis, Understanding customer-promoting customer understanding: involve customer in development and managing requirements, Organization process management and Improvement**.** Introduction to sustainable product design, Design for Six sigma.

[6]

CREATIVITY

Methods and tools for Directed Creativity, Basic Principles, Tools of Directed Creativity, Tools that prepare the mind for creative thought : stimulation of new Ideas, Development and Actions: Processes in creativity, Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation, Creativity and Motivation The Bridge between man creativity and the rewards of innovativeness Applying Directed Creativity to the challenge of quality management

[8]

CONCEPT GENERATION, SELECTION AND TESTING

Plan and establish product specifications, Task - Structured approaches, clarification, search-externally and internally, Explore systematically, reflect on the solutions and Processes, concept selection, methodology, benefits. Implications, Product change, variety, component standardization, product performance, manufacturability, Concept Testing Methodologies.

[8]

PRODUCT ARCHITECTURE

Product development management, establishing the architecture, creation, clustering, geometric layout development, Fundamental and incidental interactions, related system level design issues, secondary systems, architecture of the chunks, creating detailed Interface specifications-Portfolio Architecture.

[4]

INDUSTRIAL DESIGN AND HUMAN FACTORS.

Integrate process design, Managing costs, Robust design, Integrating CAE, CAD, CAM tool, Simulating product performance and manufacturing processes electronically, Need for industrial design: impact ,design process, investigation of customer needs, Conceptualization, refinement, management of the industrial design process, technology driven products ,user -driven products, assessing the quality of industrial design. Rapid Prototyping, Human Factors.

[8]

PRODUCT DEVELOPMENT ECONOMICS

Definition, Estimation of Manufacturing cost-reducing the component costs and assembly Costs, Minimize system complexity, Prototype basics, Principles of prototyping, Planning for prototypes, Elements of Economics analysis, Quantitative and qualitative analysis Economic Analysis process, Estimating magnitude and time of future cash inflows and out flows, Understanding and representing tasks base line project planning, accelerating the project-project execution.

[8]

INTRODUCTION TO INTELLECTUAL PROPERTY AND PATIENT PROCESS

Introduction to Intellectual property, Patent, Trademark, Trade secret and Copyright, Steps for pursuing a Patent.

[4]

Textbook:

1. *Product Design and Development*, **Karl T.Ulrich and Steven D.Eppinger**, McGraw Hill International Edns.1999.

References:

2. *Concurrent Engg./Integrated Product Development,* **Kemnneth Crow**, DRM Associates, 6/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book
3. *Effective Product Design and Development* , **Stephen Rosenthal**, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4
4. *Tool Design: Integrated Methods for successful Product Engineering*, **Stuart Pugh**, Addison Wesley Publishing,Neyourk,NY,1991, ISBN 0-202-41639-5
5. *Product Design- Techniques in Reverse Engineering and New product Development* by **Kevin Otto, Kristin Wood**, 1st Edition , Pearson

Guidelines: A Term Project / Case Study / Presentation must be given for Assessment (Compulsory)

Course Name	**:**	**TOTAL QUALITY MANAGEMENT**
Course Code	**:**	**MEN553**
Credits	**:**	**3**
L T P	**:**	**3 0 0**
Pre-requisites	**:**	Basic knowledge of probability and statistic will be assumed.

Total No. of Lectures: 45

Course Objectives: The course is intended to help students understand and utilize the concepts of Total Quality Management and Continuous Process Improvement in order to improve product's quality and competitiveness. This course provide an introduction to the fundamental concepts of statistical process control, total quality management, six sigma and the application of these concepts, philosophies, and strategies to issues arising in manufacturing and service industry.

Lecture wise breakup **No. of Lectures**

INTRODUCTION

Basic concepts in Quality, Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership: Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation. **[8]**

TQM PRINCIPLES

Customer satisfaction: Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement: Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement: Juran Trilogy, PDSA Cycle, 5S, Kaizen, Quality Circles, Quality Models for organizational excellence. Supplier Partnership, Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measure Basic Concepts, Strategy, Performance Measure. **[8]**

STATISTICAL PROCESS CONTROL (SPC)

The seven tools of quality, Statistical Fundamentals: Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Acceptance sampling methods-single, multiple and sequential sampling plans; Recent developments in inspection methods. Process capability, Six Sigma: Concepts, Steps and Tools, DMAIC, New seven Management tools. **[8]**

DESIGN OF EXPERIMENTS:

Process evaluation and imp-Improvement by Design of Experiments: Various basic designs; Special methods such as ANOVA, EVOP and ROBUST design (Taguchi Methods). Case Study of Orthogonal Array application, Robust design by Taguchi Methods, Case Study of product design by Taguchi Philosophy. **[8]**

TQM TOOLS

Benchmarking: Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD): House of Quality, QFD Process, Quality by Design (Concurrent Engineering), Total Productive Maintenance (TPM): Concept, Improvement Needs, FMEA: Stages of FMEA. **[7]**

QUALITY MANAGEMENT SYSTEMS

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System Elements, Implementation of Quality System, Documentation, Quality Auditing, TS 16949, ISO 14000: Concept, Requirements and Benefits. Certification Requirements, Evolving Standards, Benchmarking and Auditing, Reaching World Class Standards

[6]

Textbook:

1. *Total Quality Management*, **Dale H. Besterfiled, et al**., Pearson Education

References:

1. *The Management and Control of Quality*, **James R. Evans & William M. Lidsay**,Thomson Learning
2. *Six Sigma Handbook: A Complete Guide for Green Belts, Black Belts, and Managers at All Levels*.,**Pyzdek, T., & Keller, P.** McGraw-Hill
3. *Total Quality Management*, **Feigenbaum.A.V**. McGraw-Hill. .
4. *Total Quality Management* by **Oakland. J.S**, Butterworth Hcinemann Ltd., Oxford
5. *Juran on quality by design*.; **Juran, J. M**., New York, NY: The Free Press

Course Name	**:**	**COMPUTER AIDED ENGINEERING LAB-I**
Course Code	**:**	**MEN561**
Credits	**:**	**2**
L T P	**:**	**0 0 3**
Pre-requisites	**:**	**-----**

Course Objectives: To Increase the student practical and application oriented knowledge.

Course Contents:

1. Study of different tools e.g. U6/NX (HIGH END CAD), CATIA, Pro/E
2. Part and Assembly modeling (Solid three dimensional and surface modeling)
3. Drafting using API tool and Generate program
4. Data file/Transfer using CAE, CNC, CAM, Softwares
5. Solve at least three problems using FEA software
    (i) on structural problem
    (ii) on Heat transfer problem
    (iii) on Design problem
6. Study on different FEM software and their application
7. Report writing

Course Name	**:**	**ADVANCED MANUFACTURING AND MATERIAL TESTING LAB-II**
Course Code	**:**	**MEN562**
Credits	**:**	**2**
L T P	**:**	**0 0 3**
Pre-requisites	**:**	**-----**

Course Objectives: To Increase the student practical and application oriented knowledge.

. **Course Contents:**

8. Exercise: Manufacturing of Dies, Drafting, Process sheet and Generate program for tool path movement
9. Study and generate assembly drawing for different hybrid machining setup, flow chart and process sheet (at least two).
10. Manufacturing of tool for EDM, Design of tools in CAD platform
11. To study and perform tensile test on Al and Iron samples
12. To study and perform fatigue test on given materials
13. To study creep behavior of given materials
14. Study and perform testing on INSTRON dynamic testing machine
15. Report writing

Course Name	**:**	**CASE HISTORIES AND INDUSTRY EXPERIENCES**
Course Code	**:**	**MEN591**
Credits	**:**	**1**
L T P	**:**	**0 0 2**
Pre-requisites	**:**	**-----**

Course Name	**:**	**SEMINAR AND TECHNICAL WRITING**
Course Code	**:**	**MEN592**
Credits	**:**	**1**
L T P	**:**	**0 0 2**
Pre-requisites	**:**	**-----**

Course Name	**:**	**PROJECT/INDUSTRY BASED PROJECT-I**
Course Code	**:**	**MEN598**
Credits	**:**	**12**
L T P	**:**	**0 0 32**
Pre-requisites	**:**	**-----**

Course Name	**:**	**PROJECT/INDUSTRY BASED PROJECT-II**
Course Code	**:**	**MEN599**
Credits	**:**	**18**
L T P	**:**	**0 0 36**
Pre-requisites	**:**	**-----**