Design Engineering

Common to Design Engineering (MDE), Engineering Analysis & Design (MEA), Machine Design (MMD), Computer Aided Engineering (CAE)
APPLIED MATHEMATICS

Sub Code : 14MDE11  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objectives:

The Student will learn different mathematical concept that can be used in finding solutions to many engineering problems and in formulating mathematic models to represent engineering applications.


   06 Hours


   12 Hours


   06 Hours


   14 Hours


   12 Hours

5. Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engg


Text Books:

Reference Books:
1. Pervez Moin “Application of Numerical methods to Engineering”.

Course Outcomes:
The Student will be able to
1. Model some simple mathematical models of physical Applications.
2. Find the roots of polynomials in Science and Engineering problems.
3. Differentiate and integrate a function for a given set of tabulated data, for Engineering Applications.

FINITE ELEMENT METHOD

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Course Objectives

1. Introduce the various aspects of FEM as applied to engineering problems.
2. Apply the fundamental concepts of mathematical methods and theory of elasticity to solve simple continuum mechanics problems.

1. Introduction to Finite Element Method: Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design., Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods

6 Hours

2. One-Dimensional Elements-Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1D Bar Element, Admissible displacement function, Strain matrix, Stress recovery, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, Truss Element, Shape functions for Higher Order Elements, $C^0$, $C^1$ elements


13 Hours


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

Text Books:

Reference Books:
4. Bathe K. J. Finite Elements Procedures, PHI.

Course Outcome:

Students will be able to

1. Define the element properties such as shape function and stiffness matrix for the various elements.
2. Formulate element properties for 1D and 2D elements.
3. Develop skill to solve simple beam problems using the steps of FEM.
Course Outcome:

The course aims at aiding students with a knowledge of stress-strain relations, thermal stresses and elastic stability required in analysis of engineering components.

1. Introduction: Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and shear stresses and Mohr's diagram in three dimensions. Boundary conditions. Stress transformation, Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress, 
6 hours

2. Introduction to Strain: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation

12 hours

3. Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems

Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Pure bending of curved bar, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate. 
14 hours


Torsion of Prismatic Bars: Torsion of Circular and elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled closed tubes. 
12 hours

6 hours

Text Books


Reference Books

1. T.G.Sitharam" Applied Elasticity"- Interline publishing.

Course Outcome:

Students will be able to solve and analyse stress-strain related parameters in engineering applications
EXPERIMENTAL STRESS ANALYSIS

Sub Code : 14MDE14  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objective:

Students get an insight into photoelasticity and holographic techniques.

   Strain Analysis Methods: Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage.
   12 Hours

   Two Dimensional Photoelasticity Stress Analysis: Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.
   14 Hours

   12 Hours

   6 Hours

6 Hours

Text Books:

1. Experimental Stress Analysis - Dally and Riley, McGraw Hill.
2. Experimental Stress Analysis - Sadhu Singh, Hanna publisher.

References Books

1. Experimental Stress Analysis - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill.
5. Motion Measurement and Stress Analysis - Dave and Adams,

Course Outcome:

Students will be in a position to apply photoelasticity techniques and methods in analysis of various problems of engineering applications.
Elective-I

COMPUTER GRAPHICS

Sub Code : 14MDE151  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objective:

The course aims at equipping students with complete technique and methodology of computer graphics generation and control.


Types and Mathematical Representation of Surfaces: Surface entities- Plane, Ruled, surface of revolution, Tabulated cylinder, Bezier surface, B-spline surface, Coons patch, Offset surface. Surface representation, Parametric representation of analytic surface-plane, Ruled surface, Surface of revolution, Tabulated cylinder, Parametric representation of synthetic surfaces Hermite bicubic surface, Bezier surface, B-spline surface, Coons surface, Offset surface.

13 Hours


Scan Conversion and Clipping: Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - points, lines, Text, Polygon, Cohen, Sutherland line clipping, Sutherland, Hodgmen algorithm.

13 Hours

3. Transformations : Representation of points, Transformations: Rotation, Reflection, Scaling, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line.


5. Data Exchange / Computer Animation: Evolution of data exchange, IGES, PDES, Conventional animation-key frame, Inbetweening, Line testing, Painting, Filming, Computer animation, Entertainment and engineering animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom-pan-scrol, Cross bar, Real time play back, Animation techniques- key frame, Skelton. Path of motion and p-curves.

Text Books:


Reference Books:

2. Foley, Van- Damn, Finner and Hughes, "Computer Graphics principles and practice”-Addison Wesley. 200

Course Outcome:

Students develop expertise in various image generation techniques and transformations which are quite regularly used in computer graphics.
COMPUTER APPLICATIONS IN DESIGN

Sub Code : 14MMD152  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objective
Students are trained in CAD/CAM/CAE requiring computer applications in design.


10 Hours


8 Hours


16 Hours


12 Hours


Tutorials, Computational exercises involving Geometric Modeling of components and their assemblies

4 Hours

Text Books:

Reference Books:

Course Outcome:
Students will be able demonstrate their knowledge in concepts of graphics programming, representation and manipulation of curves and surfaces.
MECHATRONICS SYSTEM DESIGN

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Course Objective:

The course gives exposure to mechatronics system design and knowledge of MEMS and microsystems.


10 Hours


System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.

11 Hours


13 Hours


8 Hours


8 Hours

Text Books:
2. HSU “MEMS and Microsystems design and manufacture”- TMH

Reference Books:
4. Mahalik “Mechatronics”- TMH.
5. “Mechatronics”– HMT, TMH.

**Course Outcome:**
Students are able to acquaint themselves with the application of mechatronics systems in various engineering applications.

**DESIGN FOR MANUFACTURE**

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**Course Objective:**
Students will have clear understanding of factors and considerations to be considered in designing parts and components in engineering applications.


   **12 Hours**

2. **Selective Assembly:** Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples.


   **12 Hours**


   Component Design : Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations.

   **13 Hours**

7 Hours

5. Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.

6 Hours

Text Books:

Course Outcome:
Students will be able to demonstrate their understanding of tolerance specification and considerations to be given importance in design for manufacture.

Design Laboratory – Lab 1

Subject Code: 14MDE16
Hours/Week : 6
Total Hours : 84
IA Marks : 25
Exam Hours : 03
Exam Marks : 50

Note:
- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give a presentation on the same.

Experiment #1
Single edge notched beam in four point bending.
Part A : Experimental Stress Analysis using 2D Photo elasticity.
Part B : Numerical Experiments using FEM.
Part C : Correlation Studies.
Experiment #2
Torsion of prismatic bar with rectangular cross section.
   Part B: Finite Element Analysis.
   Part C: Correlation of stiffness and Surface Strains.

Experiment #3
Contact Stress Analysis diametrical compression of Two Circular Discs.
   Part A: 2D Photo elastic Investigation.
   Part B: Numerical Analysis using FEM.
   Part C: Correlation Studies.

Experiment #4
Thin walled Tube under diametrical Compression.
   Part A: Experimental studies using Strain Gauge Instrumentation.
   Part B: Non Linear FEA.
   Part C: Correlation Studies.

Experiment #5
Vibration Characteristics of a Spring Mass Damper System.
   Part A: Analytical Solutions.
   Part B: MATLAB Simulation.
   Part C: Correlation Studies.

Experiment #6
Roots of a Cubic Polynomial.
   Part A: Analytical Solutions.
   Part B: MATLAB Simulation.
   Part C: Correlation Studies.

Experiment #7
Modelling and Simulation of Control Systems using MATLAB.

Experiment #8
Fracture Toughness Testing of Glass.
II Semester

COMPOSITE MATERIALS TECHNOLOGY

Sub Code : 14MDE21
Hrs/ Week : 04
Total Hrs. : 50
IA Marks : 50
Exam Hours : 03
Exam Marks : 100

Course Objective:

1. Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. 12 Hours


Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems. 12 Hours


Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method. 14 Hours

4. Metal Matrix Composites: Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications. 6 Hours

5. Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. 6 Hours
Text Books:

Reference Books:

Course Outcome:
Students develop expertise in Composite materials application and its analysis in designing components for engineering applications.
Course Objective:
The course focuses on aspects to be considered in designing mechanical parts for various engineering applications.

1. Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr’s theory and modified Mohr’s theory, Numerical examples.

Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.


3. LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation.

Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber’s rule, Glinka’s rule, applications of fracture mechanics to crack growth at notches.

4. Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.

5. Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.
Text Books:

Reference Books:
2. Fundamentals of Metal Fatigue Analysis, Julie.A.Benantine Prentice Hall,1990

Course Outcome:
Advance Machine Design enriches the students with design methodologies available to optimally utilise the components designed to its full operating life.

DYNAMICS AND MECHANISM DESIGN

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Course Objective:
Proper understanding of dynamics and mechanisms design in producing engineering components is essential, the course aims at providing such an exposure to students.


   6 Hours


   13 Hours


Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle.
4. Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages.

Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.


Text Books:

References Books:

Course Outcome:
Students develop knowledge of dynamics and mechanism design which they can adopt in design of mechanisms used in practical situations.

ADVANCED THEORY OF VIBRATIONS

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Course Objective:
Advanced theory of vibrations aims at training students on Vibration control, modal analysis and condition monitoring

1. Review of Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.

Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation,

12 hours


11 hours


13 hours


8 hours

5. Continuous Systems: Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.

6 hours

Text Books

Reference Books

Course Outcome:
Students get the expertise in various aspects of vibration and its control which are important factors to be considered in designing an engineering application.
Course Objective:

Students get to understand various design techniques in achieving at optimum design.

1. Introduction: Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, Classical optimization techniques I: single variable optimization, Multivariable optimization with no constraints.

Classical Optimization Techniques II: Multivariable optimization with equality constraints and inequality constraints, Kuhn - Tucker conditions.

12 Hours


Interpolation Methods: Quadratic, Cubic and Direct root interpolation methods.

12 Hours


Descent Methods: Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method.

13 Hours

4. Integer Programming: Introduction, Integer linear programming:
Graphical representation, Gomory’s cutting plane method, Balas’ algorithm for zero-one programming problems, Integer nonlinear programming, Branch and Bound method, Sequential linear discrete programming, Generalized penalty function method.

7 Hours


6 Hours

Text Books:


Reference Books:

Course Outcome:
Students get awareness of factors and techniques to be considered in achieving optimum design.
Course Objective:
The Theory of Plasticity course focuses on criteria and relations of stress and strain that are to be considered in analysing a member.

1. Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Idealised stress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co-efficients Octahedral strain, Strain rate and the strain rate tensor.

Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality conditions

12 hours


Deformation of isotropic and kinematics hardening, bilinear stress-strain relationship, power law hardening, deformation theory of plasticity, $J_2$ flow theory, $J_2$ incremental theory.

12 hours

3. Upper and lower bound theorems and corollaries.

Application to problems: Uniaxial tension and compression, bending of beams, Torsion of rods and tubes, Simple forms of indentation problems using upper bounds

13 hours


6 hours

5. Slip line theory, Introduction, Basic equations for incompressible two dimensional flow, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.

7 hours

Text Books
Reference Books
1. Plasticity for Mechanical Engineers - Johnson and Mellor.

Course Outcome:
Students demonstrate the significance of application of theory of plasticity techniques in analysis and design.
ROBOTICS

Sub Code : 14MDE253  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objective:
The course aims at bringing in clear understanding of kinematics, velocity and statics of manipulators.


2. Velocity and Statics of Manipulators: Differential relationships, Jacobian, Differential motions of a frame (translation and rotation), Linear and angular velocity of a rigid body, Linear and angular velocities of links in serial manipulators, 2R, 3R manipulators, Jacobian of serial manipulator, Three DOF parallel manipulator Velocity ellipse of 2R manipulator, Singularities of serial and parallel manipulators 2R, 3R, four bar mechanism, three DOF parallel manipulator, Maipulator, Statics of serial manipulators, Static force and torque analysis of 3R manipulator, Statics of parallel manipulator, Singularity in force domain.

Dynamics of Manipulators: Inertia of a link, Recursive formulation of dynamics using Newton Euler equation, Equation of motion of 2R and 3R manipulators using Lagrangian, Newton-Euler formulation.

3. Trajectory Planning: Joint space schemes, cubic trajectory, Joint space schemes with via points, Cubic trajectory with a via point, Third order polynomial trajectory planning, Linear segments with parabolic blends, Cartesian space schemes, Cartesian straight line and circular motion planning, Trajectory planning for orientation.
Control: Feedback control of a single link manipulator- first order, second order system, PID control, PID control of multi link manipulator, Non-linear control of manipulators-computed torque method, Force control of manipulator, Cartesian control of manipulators, Force control of manipulators-force control of single mass, Partitioning a task for force and position control- lever, peg in hole Hybrid force and position controller.


Text Books:

Reference Books:

Course Outcome:
Helps Students in deciding various parameters to be considered in designing manipulators and analysing them to find its suitability for engineering application.
Course Objective:
The course helps students to understand fluid film lubrication, rotor bearing system, turborotor system stability and blade vibration.


Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.

12 Hours


Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.

6 Hours

3. Turborotor System Stability by Transfer Matrix Formulation: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.

10 Hours


14 Hours


8 Hours
**Reference Books:**


**Course Outcome:**

Students get understanding of rotor dynamics that can be used by them in analysis and design.
Design Laboratory - Lab 2

Subject Code: 14MDE26
IA Marks : 25
Exam Hours : 03
Exam Marks : 50

Note:

- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give a presentation on the same.

Experiment #1
Structural Analysis
- Part B: Buckling, Bending and Modal analysis of stiffened Panels.
- Part C: Parametric Studies.

Experiment #2
Design Optimization
- Part A: Shape Optimization of a rotating annular disk.
- Part B: Weight Minimization of a Rail Car Suspension Spring.
- Part C: Topology Optimization of a Bracket.

Experiment #3
Thermal analysis
- Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
- Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4
Thermal Stress Analysis
- Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
- Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment #5
CFD Analysis
- Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
- Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
- Part C: Experimental Investigations using a Journal Bearing Test Rig.
IV Semester

TRIBOLOGY AND BEARING DESIGN

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Course Objective:
Gives knowledge on tribology aspects and various types of bearings design.


   **7 Hours**


Experiment #6
Welded Joints.
- Part B: FE Modeling and Failure Analysis.
- Part C: Correlation Studies.

Experiment #7
Bolted Joints.
- Part B: FE Modeling and Failure Analysis.
- Part C: Correlation Studies.

Experiment #8
Adhesive Bonded Joints.
- Part B: FE Modeling and Failure Analysis.
- Part C: Correlation Studies.
of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.

12 Hours

3. Hydrostatic Bearings: Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.

EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution.

13 Hours


12 Hours


6 hours

Text Books

Reference Books
3. Pinkus '0' Stemitch. "Theory of Hydrodynamic Lubrication"
6. Hydrostatic Bearings and Hybrid Bearings, Stanfield.

Course Outcome:
Students develop skill sets to bearing design and selection, Various tribological factors to be considered in moving and rotating parts.
Elective-III

FRACTURE MECHANICS

Course Objective:
The course aims at bringing in an understanding of stress intensity factor, plasticity effects, fatigue crack propagation and application of fracture mechanics.


   12 Hours

2. Plasticity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems.


   12 Hours


   12 Hours


   6 Hours

5. Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, Means to provide fail-safety, Required information for fracture mechanics approach. Mixed mode (combined) loading and design criteria.

   8 Hours

Text Books:

Reference Books:
3. Fracture and Fatigue Control in Structures - Rolfe and Barsom, Prentice Hall.
6. Fracture –Liefbowitz Volme II.

Course Outcome:
Students will develop skills required to design products with fracture mechanics approach suiting to specialised requirements of applications.
SMART MATERIALS AND STRUCTURES

Course Objective:

Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis.


2. Smart Materials (Physical Properties) piezoelectric materials; materials, magnetostrictive electrostrictive materials, magnetoelectric materials, magnetorheological fluids, electrorheological fluids, shape memory materials, fiber-optic sensors.

3. Smart Sensor, Actuator and Transducer Technologies smart sensors: accelerometers; force sensors; load cells; torque sensors; pressure sensors; microphones; impact hammers; mems sensors; sensor arrays smart actuators: displacement actuators; force actuators; power actuators; vibration dampers; shakers; fluidic pumps; motors smart transducers: ultrasonic transducers; sonic transducers; air transducers.

4. Measurement, Signal Processing, Drive and Control Techniques quasi-static and dynamic measurement methods; signal-conditioning devices; constant voltage, constant current and pulse drive methods; calibration methods; structural dynamics and identification techniques; passive, semi-active and active control; feedback and feed forward control strategies.

5. Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products: Case studies incorporating design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products. Emphasis on structures, automation and precision manufacturing equipment, automotive, consumer products, sporting products, computer and telecommunications products, medical and dental tools and equipment.

Reference Books:


**Course Outcome:**
Students will be able to develop expertise in Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products

**ROBUST DESIGN**

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**Course Objective:**
Course aims at giving orientation to Experimental design and taguchi’s orthogonal array techniques which are predominantly used in optimization of parameters.

1. Quality by Experimental Design: Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. Robust Design: Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.

Experimental Design: Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment designs for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.


Analysis and interpretation of experimental data: Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments: YATE’s algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.

3. Taguchi’s Orthogonal Arrays: Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column

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merging method, Branching design, Strategies for constructing orthogonal arrays.

Signal to Noise ratio (S-N Ratios) : Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the – better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.

4. Parameter Design and Tolerance Design : Parameter and tolerance design concepts, Taguchi’s inner and outer arrays, Parameter design strategy, Tolerance design strategy, Illustrations through numerical examples.

5. Reliability Improvement Through Robust Design : Role of S-N ratios in reliability improvement ; Case study; Illustrating the reliability improvement of routing process of a printed wiring boards using robust design concepts.

Text Books:

Reference Books:

Course Outcome:
Students get to demonstrate clear exposure to analyse and interpret parameters of experimental design.
**THEORY OF PLATES AND SHELLS**

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**Course Objective:**
Course aims at giving fundamentals of designing of members with knowledge of theory of plates and shells.

1. Bending of long rectangular plate into a cylindrical surface, Differential equation - Bending of plated with different boundary conditions - Long plate on elastic foundation.

Pure Bending: Moment and curvature relations problems of simply supported plates- Strain energy impure bending.

Symmetrical Bending of Circular Plates: Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center. **17 Hours**

2. Rectangular Plates: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as non-central, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed. **8 Hours**

3. Bending of plate under combined action of lateral and transverse loads derivation of differential equation, simply supported rectangular plate.

Introduction to Shell Structures - General description of various types. Membrane Theory of thin shells (Stress Analysis): Cylindrical shells - Spherical Shells- Shells of double curvature, Viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. **13 Hours**

4. Membrane Deformation of Shells: Symmetrical loaded shell, symmetrically loaded spherical shell. General Theory of cylindrical shells: Circular; Cylindrical shell loaded symmetrically. **6 Hours**

5. General equation of circular cylindrical shells. Approximate investigation of: bending of circular cylindrical shell. **6 Hours**

**Text Books:**

**Reference Books:**
4. Theory and analysis of plates - R. Szilard Prentice hall

Course Objective:

Knowledge of theory of plates and shells helps students in designing mechanical members suitable for any assigned engineering application.