DEPARTMENT OF MECHANICAL ENGINEERING
A.U. COLLEGE OF ENGINEERING (A), VISAKHAPATNAM

SCHEME AND SYLLABI OF M.TECH. (MACHINE DESIGN)
(FOR THE ACADEMIC YEAR 2025-26 ONWARDS)

M.TECH. (MACHINE DESIGN) - I SEMESTER

Course code	Course Title	Hours per week		Internal Marks	External Marks	Total Marks	Credits
		L	P				
MTMD 101	Theory of Elasticity & Plasticity	4	0	30	70	100	4
MTMD 102	Advanced Mechanics of Solids	4	0	30	70	100	4
MTMD 103	Advanced Mechanics of Machinery	4	0	30	70	100	4
MTMD 104	Mechanical Vibrations	4	0	30	70	100	4
MTMD 105	Design & Analysis of Experiments	4	0	30	70	100	4
MTMD 106	Elective Subject – 1	4	0	30	70	100	4
MTMD 107	Computer Aided Design, Modelling & Simulation Lab	0	3	50	50	100	1.5
MTMD 108	Mechanical Vibrations Lab - I	0	3	50	50	100	1.5
						Total Credits:	**27**

M.TECH. (MACHINE DESIGN) - II SEMESTER

Course code	Course Title	Hours per week		Internal Marks	External Marks	Total Marks	Credits
		L	P				
MTMD 201	Instrumental & Experimental Stress Analysis	4	0	30	70	100	4
MTMD 202	Signal Analysis & Condition Monitoring	4	0	30	70	100	4
MTMD 203	Advanced Finite Element Analysis	4	0	30	70	100	4
MTMD 204	Advanced Engineering Design	4	0	30	70	100	4
MTMD 205	Elective Subject - 2	4	0	30	70	100	4
MTMD 206	Instrumental & Experimental Stress Analysis Lab	0	3	30	70	100	1.5
MTMD 207	Mechanical Vibrations Lab - I	0	3	50	50	100	1.5
MTMD 208	Seminar	0	3	50	50	100	1
						Total Credits :	**24**

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M.TECH. (MACHINE DESIGN) - III SEMESTER

Course code	Course Title	Hours per week		Internal Marks	External Marks	Total Marks	Credits
		L	P				
MTMD 301	Elective Subject - 3	4	0	30	70	100	4
MTMD 302	Elective Subject - 4	4	0	30	70	100	4
MTMD 303	Research Methodology & IPR	-	-	-	-	-	-
MTMD 304	Internal Assessment of Project	-	-	-	-	100	4
						Total Credits :	**12**

M.TECH. (MACHINE DESIGN) - IV SEMESTER

Course code	Course Title	Scheme of Examination	Total Marks	Credits
MTMD 401	External Assessment of Project	Viva - Voce	100	16

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SCHEME AND SYLLABI OF M.TECH. (MACHINE DESIGN)
(FOR THE ACADEMIC YEAR 2025-26 ONWARDS)

M.TECH. (MACHINE DESIGN)

ELECTIVE SUBJECTS

Elective – 1

A. Advanced Optimization Techniques
B. Computer Simulation of Machines
C. Non Linear Solid Mechanics
D. Structural Health Monitoring
E. Theory of Plates and Shells

Elective – 2

A. Reliability Engineering
B. Integrated Computer Aided Design
C. Mechatronics
D. Fuzzy Logic & Neural Networks
E. Mechanical Behaviour of Engineering Materials

Elective – 3

A. Vehicle Dynamics
B. Tribology
C. Pressure Vessel Design
D. Gear Engineering
E. Advanced Mechanics of Composite Materials

Elective – 4

A. Computational Fluid Dynamics
B. Robotics
C. Vision Systems and Image Processing
D. Design for Manufacture and Assembly
E. Aerodynamics

Program outcomes:

PO1: An ability to independently carry out research /investigation and development work to solve practical problems pertaining to machine design and analysis.

PO2: An ability to write and present a substantial technical report/document.

PO3 :An ability to develop technical competence and comprehensive knowledge of analysis and design of machines to obtain optimal feasible solution considering safety, environment and other realistic constraints.

PO4 :An ability to demonstrate a degree of mastery over machine design and analysis, a level higher than the requirements in the undergraduate program of mechanical engineering.

PO5 :An ability to demonstrate skills in latest engineering tools, software and equipments to analyze and solve complex design engineering problems.

Program Specific Outcomes:

PSO1: An ability to critically analyze, design and develop mechanical systems, components and processes using modern design tools, techniques and materials.

PSO2: An ability to work as an individual and in a team with an understanding of the profession in ethical manner.

FIRST SEMESTER
MTMD 101 THEORY OF ELASTICITY AND PLASTICITY

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

To expose the students to the following

1. Understand the basic concepts of Equilibrium, Principal stresses and their directions, normal and shear stress on octahedral planes.
2. Know the concept of strain and displacement, strain displacement relations and compatibility conditions.
3. Understand the concept of principal stress and their directions.
4. Develop stress- strain relation using elastic constants and understand St.Venants and super position principle.
5. Understand the concept of Incremental stress strain relationships

Syllabus:

Elasticity: Two dimensional stress analysis - Plane stress - Plane strain - Equations of compatibility - Stress function - Boundary conditions.

Problem in rectangular coordinates - Solution by polynomials - Saint Venent's principles - Determination of displacement - Simple beam problems.

Problems in polar coordinates - General equations in polar coordinates - Stress distribution symmetrical about axis - Strain components in polar coordinates - Simple and symmetric problems.

Analysis of stress and strain in three dimensions - Principle stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain.

General theorems: Differential equations of equilibrium and compatibility - Displacement - Uniqueness of solution - Reciprocal theorem.

Bending of prismatic bars - Stress function - Bending of cantilever beam - Beam of rectangular cross-section - Beams of circular cross-section.

Plasticity: Plastic deformation of metals - Structure of metals - Deformation - Creep stress relaxation of deformation - Strain rate condition of constant maximum shear stress - Condition of constant strain energy - Approximate equation of plasticity.

Methods of solving practical problems - The characteristic method - Engineering method - Compression of metal under press - Theoretical and experimental data drawing.

Course Outcomes

After successful completion of course the student should be able to

1. Derive equations of Equilibrium for 2D and 3D state of stress, estimation of principal stress and its directions; calculate of normal and shear stress on octahedral plane.
2. Develop the strain displacement and compatibility equations, principal strains and its directions, determination of strains in arbitrary planes.
3. Describe stress- ply super position, Reciprocal and Saint vents principles to estimate stress and strain.
4. Understand the deformation theory of plasticity.
5. Know the uniqueness considerations of elastic-plastic materials.

References:

1. Theory of Elasticity by Timoshenko, S.P. and Goodier, J.N./Koakusha Publishers
2. An Engineering Theory of Plasticity by E.P. Unksov/Butterworths
3. Applied Elasticity by W.T. Wang.
4. Theory of Plasticity by Hoffman and Sacks.
5. Theory of Elasticity and Plasticity/Sadhu Singh/ Khanna Publishers
6. Theory of Elasticity and Plasticity/Harold Malcolm Westergaard/Harvard University Press

FIRST SEMESTER
MTMD 102 ADVANCED MECHANICS OF SOLIDS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

- To make students understand the advanced topics related to flat plates, torsion in rectangular and circular bars, stress concentration and experimental techniques, assumptions and analysis of contact stresses.
- To familiarize the student with 3-dimensional stress-strain relationships and relationship between various elastic constants.
- To explain techniques for solution of indeterminate structures.
- To demonstrate the response of curved beams and beams subjected to un-symmetric loading.

Syllabus:

Flat plates: Introduction - Stress resultants in a flat plate - Kinematics: Strain - Displacement relations for plates - Equilibrium equations for small displacement theory of flat plates – stress strain- temperature relations for isotropic elastic plates - Strain energy of a plate – Boundary conditions for plates - Solutions of rectangular and circular plate problems.

Torsion: Torsion of cylindrical bar of circular cross-section Saint-Venant's semi-inverse method
Linear elastic solution - The Prandtl elastic - Membrane (soap-film) analogy - Narrow rectangular cross-section - Hollow thin-wall torsion members: Multiply connected cross-section - Thin-wall torsion members with restrained ends - Fully plastic torsion.

Beams on elastic foundation: General theory - Infinite beam subjected to concentrated load: Boundary conditions - Infinite beam subjected to a distributed load segment - Semi-infinite beam subjected to loads of its end - Semi-infinite beam with concentrated load near its end - Short beams - Thin-wall circular cylinders.

Stress concentrations: Basic concepts - Nature of a stress concentration problem. Stress concentration factor - Stress concentration factor. Theory of elasticity - Stress concentration factors. Experimental techniques - Stress gradients due to concentrated load - The stationary crack - Crack propagation. Stress intensity factor. Effective stress concentration factor: Applications - Stress concentration factor. Combined loads - Effective stress concentration factors - Effective stress concentration factors. Repeated loads - Effective stress concentration factors - Other influences - Effective stress concentration factors - In-elastic strains.

Contact stresses: Introduction - The problem of determining contact stresses - Assumptions on which a solution for contact stresses is based - Notation and meaning of terms - Expressions for principal stresses - Method of computing contact stresses - Deflection of bodies in point contact - Stress for two bodies in contact over narrow rectangular area (line contact).

Loads normal to area - Stresses for two bodies in line contact. Loads normal and tangent to contact area.

Course Outcomes

- Solve problems involving stress resultants, strain, displacement relations, and boundary conditions for flat plates under various loading conditions.
- Analyze torsion in cylindrical bars and thin-walled structures using methods like Saint-Venant's semi-inverse and the Prandtl elastic-membrane analogy.
- Apply theories of beams on elastic foundations to solve problems related to concentrated and distributed loads on infinite and semi-infinite beams.
- Evaluate stress concentration factors and apply them to analyze crack propagation and stress gradients under various loading conditions.
- Determine contact stresses between bodies and calculate principal stresses, deflections, and stress distributions for point and line contact scenarios.

References:

1. Advanced Mechanics of Materials by Boresi, A.P. and Sidebottm, O.M.
2. Advanced Mechanics of Materials by Seely and Smith.
3. Advanced Strength of Materials by Den Hartog.
4. Advanced Strength of Materials by Timoshenko S.P.
5. Advanced strength of materials / Den Hortog J.P./Torrent
6. Theory of Plates /Timoshenko
7. Strength of materials / Sadhu singh/ Khanna Publishers
8. Mechanics of Materials / Beer & Jhonson / McGraw Hill
9. Theory of Plates & Shells / Timoshenko/ McGraw Hill/ 2nd Edition

FIRST SEMESTER
MTMD 103 ADVANCED MECHANICS OF MACHINERY

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To understand the kinematics of complex mechanisms, including methods for analyzing accelerations and normal accelerations.
2. To apply advanced techniques for plane motion analysis, such as the inflexion circle, Euler-Savary equation, and Hartman's construction.
3. To explore the synthesis of mechanisms using both graphical and analytical methods, including guiding points through multiple positions and function generation.
4. To apply Freudenstein’s equation and other methods in mechanism synthesis for precision and path generation.
5. To study the forces acting in mechanisms, including free body diagrams, friction, and forces in linkages.
6. To analyze cam dynamics, including the mathematical modeling of cam mechanisms and the response of followers in undamped systems.

Syllabus:

Kinematics of complex mechanisms - Complex mechanisms, Low and high degree of complexity, Goodman's indirect acceleration analysis, Method of normal accelerations, Hall and Ault's auxiliary point method, Carter's method and comparison of methods.

Advanced kinematics of plane motion - The inflexion circle - Euler-Savary equation, Analytical and graphical determination of diameter of inflection circle - Bobbileier's construction, Collineation axis - Hartman's construction, Application of inflection circle to kinematic analysis - Polode curvature - General case and special case, Polode curvature in the four-bar mechanism - Coupler motion, Relative motion of the output and input links, Freudenstein's collineation axis theorem - Carter Hall circle, Circling-point curve (general case). Introduction to synthesis (graphical methods) guiding a point through two, three and four distinct positions - Burmaster's curve, Function generation - Overlay's method, Path generation - Robert's theorem.

Introduction to synthesis (analytical methods) - Freudenstein's equation - Precision point approximation - Precision derivative approximation - Method of components - Block synthesis and Reven's method.

Forces in mechanisms - Free body diagrams - Friction in link connections - Forces in linkages. Cam dynamics - Forces in rigid systems, Mathematical models, Response of a uniform - Motion undamped cam mechanism - Analytical method, Follower response by phase - Plane method - Position error, Jump, Crossover shock - Johnson's numerical analysis.

Course Outcomes

1. Perform kinematic analysis of complex mechanisms using methods like Goodman's indirect acceleration analysis and Hall & Ault’s auxiliary point method.
2. Apply advanced plane motion analysis techniques, such as inflexion circle and Euler-Savary equation, to analyze the motion of mechanisms.
3. Synthesize mechanisms using graphical methods like Burmaster's curve and Robert's

theorem for function and path generation.

4. Solve analytical synthesis problems using Freudenstein's equation, precision point approximation, and method of components for block synthesis.
5. Analyze forces in linkages and cam mechanisms, incorporating friction and free body diagrams for accurate force calculations.
6. Model and analyze the dynamics of cam mechanisms, including follower response, phase-plane analysis, and crossover shock using Johnson's numerical analysis.

References:

1. Kinematics and Dynamics of Plane Mechanisms by J. Hirschhorn, McGraw Hill Book Co., 1962.
2. Theory of Machines and Mechanisms/ J.E Shigley and J.J . Uicker Jr./ McGraw-Hill, 1995
3. Theory of Mechanisms and Machines/ Amitabh Ghosh and Ashok Kumar Mallik/ E.W.P.Publishers.
4. Kinematics and Linkage Design/ Allen S.Hall Jr./ PHI,1964.
5. Kinematics and Dynamics of Machinery/Charles E Wilson/Pearson/3rd Edition

FIRST SEMESTER
MTMD 104 MECHANICAL VIBRATIONS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:
- To enrich the student on the concept of Mechanical vibrations.
- To make the student understand the concept of single and two degree of freedom systems.
- To make the student understand the use of damping, influence co-efficients, matrix methods and Lagrange's equations.
- To make the student understand the concept of vibrations by A.H Church.
- To make the student understand the concept of multiple degree of freedom systems.
- To make the student understand the vibration problems in daily life
- To make the student understand the principal of orthogonality classical and energy methods by Rayleigh, Ritz and Gelerkin.
- To make the student understand the concept of Transient (shock) vibrations.

Syllabus:
Fundamentals and Basic Concepts of Mechanical Vibrations: Introduction to Mechanical Vibrations-Definitions-Main Causes of Vibration-Elements of Vibratory System-Mathematical Models-Simple Harmonic Motion-Phenomena of Beats-Equivalent Springs and Dashpots when it is in series and parallel.

Free Vibrations of Single degree freedom systems -Introduction - Single degree freedom systems –Derivation of Differential Equation of Motion for Undamped free vibrations – Rayleigh's energy method-Different types of Damping- Derivation of Differential Equation of Motion for damped free vibrations- Logarithmic decrement-Viscous Dampers-Dry friction or Coulomb Damping.

Forced Vibrations of Single degree freedom systems -Introduction to forced vibration-Derivation of Differential Equation of Motion for Undamped and Damped vibrations – Force vibration with rotating and Reciprocating unbalance- Force vibration due to excitation of the support-Energy Dissipated by Damping- Vibration Isolation and transmissibility –Vibration Measuring Instruments.

Two degree freedom systems – Introduction-Principal modes of Vibration-Simple two degree freedom systems- Combined rectilinear angular modes-systems with damping-Vibration absorbers-Vibration isolation.

Multi degree freedom systems exact Analysis: Introduction- Free Vibrations Equations of motions-Influence coefficients-Generalized coordinates and coordinate coupling-Natural frequencies and mode shapes-Orthogonal properties of normal modes-Modal Analysis - Forced Vibration by matrix inversion-Torsional vibrations of multi rotor system-Continuous systems.

Multi degree freedom systems Numeral Methods: Introduction-Rayleigh's method-Dunkerley's method-Stodool's method- Rayleigh-Ritz method- Method of Matrix iteration- Holzers method.

Critical speeds of Shafts: Introduction- Critical speeds of a light shaft having a single disc with and without damping- Critical speeds of a shaft having multiple discs-Secondary Critical Speed- Critical speeds of a light cantilever shafts with a large heavy disc at its ends.

Transient Vibration: Introduction-Laplace transformation-Response to an impulsive input, Step input, Pulse input-phase Plane method-Shock spectrum

Course Outcomes:

1. The student is capable of understanding the various concepts in Mechanical vibrations.
2. The student is capable of understanding the concept of single and two degree of freedom systems.
3. The student is capable of understanding the concept of multiple degree of freedom systems.
4. The student is capable of understanding the different problems in single, two and multiple degree freedom systems.
5. The student is capable of understanding the damping, influence co-efficients, matrix methods and Lagrange’s equations.
6. The student is capable of understanding the principal of orthogonality classical and energy methods by Rayleigh, Ritz and Gelerkin.
7. The student is capable of understanding the concept of Transient (shock) vibrations and problems in it.

References:

1. Mechanical Vibrations/G.K.Groover/Nem Chand and Bros
2. Mechanical Vibrations / SS Rao/ Pearson/ 2009, Ed 4
3. Mechanical Vibrations by Den Hartog.

4 Mechanical Vibrations by R.Venkatachalam

5. Elements of Vibration Analysis by Meirovitch, TMH, 2001
6. Mechanical Vibrations/Schaum Series/ McGraw Hill
7. Vibration Problems in Engineering by Timoshenko and Young.
8. Mechanical Vibrations/Debabrata Nag/Wiley
9. Mechanical Vibrations and Noise engineering/ A.G.Ambekar/ PHI
10. Theory and Practice of Mechanical Vibrations/JS Rao & K. Gupta/New Age Intl. Publishers/Revised 2nd Edition
11. Mechanical Vibrations by A.H. Church.

FIRST SEMESTER
MTMD 105: DESIGN AND ANALYSIS OF EXPERIMENTS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

- To familiarize the basic principles and methods of statistical design of experiments. The implications of effects of different factors on a given response are determined under uncertainty using statistical principles.

- Define Design of Experiments (DOE) and describe its purpose, importance, and benefits.
- Define key terms associated with DOE and explain how to conduct a well-designed statistical experiment.
- Describe the five phases used for applying DOE and walk through the steps for each phase as we apply DOE to a sample experiment.
- Define a full factorial experiment and show how to calculate the main and interaction effects.
- Demonstrate how to analyze the results of a full factorial design.
- Explain the role of replication.
- Describe the threats to statistical validity of a designed experiment.

Syllabus:

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, historical perspective of experimental approaches , Steps in experimentation, principles of experimentation

Simple Comparative Experiments: Basic concepts of probability & statistics, comparison of two means and two variances.

Experiments with Single Factor: ANOVA, fixed effects model, model adequacy checking, determining sample size, randomized complete block design(RCBD), Statistical Analysis of RCBD.

Introduction to Factorial Designs: Two factor factorial design, general factorial design, 2k factorial design, general 2k design, single replicate of 2k design, the addition of centre point to 2k design.

Two-level Fractional Factorial Designs: Blocking and confounding, one half fraction of the 2k design, one quarter fraction of the 2k design, resolution III,IV and V designs.

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression.

Taguchi's Parameter Design: Concept of robustness, noise factor, objective function & S/N ratios , inner array& outer array design, data analysis.

Course outcomes:

- Describe how to design experiments, carry them out, and analyze the data they yield.
- Understand the process of designing an experiment including factorial and fractional factorial designs.
- Examine how a factorial design allows cost reduction, increases efficiency of

experimentation, and reveals the essential nature of a process; and discuss its advantages to those who conduct the experiments as well as those to whom the results are reported.

- Investigate the logic of hypothesis testing, including analysis of variance and the detailed analysis of experimental data.
- Formulate understanding of the subject using real examples, including experimentation in the social and economic sciences.
- Introduce Taguchi methods, and compare and contrast them with more traditional techniques.
- Learn the technique of regression analysis, and how it compares and contrasts with other techniques studied in the course.
- Understand the role of response surface methodology and its basic underpinnings.
- Gain an understanding of how the analysis of experimental design data is carried out using the most common software packages.

References:

1. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
2. Ross P J , Taguchi techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008
3. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000

FIRST SEMESTER
MTMD 106 : ELECTIVE -1
A) ADVANCED OPTIMIZATION TECHNIQUES

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. Solve unconstrained and constrained geometric programming problems using differential calculus and arithmetic methods, and understand primal-dual relationships and sufficiency conditions.
2. Explore dynamic programming concepts such as multistage decision processes, suboptimization, and the principle of optimality, along with computational procedures and tabular methods for solving dynamic programming problems.
3. Apply methods like Gomory’s cutting plane, Bala’s algorithm, branch-and-bound, and other techniques to solve integer programming problems.
4. Understand the fundamental concepts of probability theory and apply them to solve stochastic linear programming problems.
5. Study and apply non-traditional optimization techniques such as multi-objective optimization, genetic algorithms, simulated annealing, and neural network-based optimization.

SYLLABUS:

Geometric programming (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P), Complementary Geometric Programming (C.G.P)

Dynamic programming(D.P): Multistage decision processes. Concepts of sub optimization and Principal of optimality, computational procedure in dynamic programming calculusmethod and tabular methods. Linear programming as a case of D.P. and continuous D.P. **Integer programming(I.P):** Graphical representation. Gomory's cutting plane method. Bala'salgorithm for zero-one programming problem. Branch-and-bound method, Sequential lineardiscrete Programming, Generalized penalty function method.

Stochastic Programming (S.P): Basic Concepts of Probability Theory, Stochastic Linear programming.

Non-traditional optimization techniques: Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, Simulated annealing, Neural Networks based Optimization.

Course Outcomes

1. Formulate and solve geometric programming problems using both differential calculus and arithmetic methods, and apply primal-dual relationships and sufficiency conditions.
2. Use dynamic programming techniques to solve multistage decision problems, apply the principle of optimality, and use computational methods to solve dynamic and continuous programming problems.
3. Solve integer programming problems using graphical methods, Gomory’s cutting plane method, Bala’s algorithm, branch-and-bound, and other advanced techniques.
4. Apply probability theory and stochastic programming techniques to solve optimization problems involving uncertainty in a variety of decision-making contexts.
5. Utilize multi-objective optimization, genetic algorithms, simulated annealing, and neural network-based techniques to solve complex real-world optimization problems.

References:

1. Operations Research- Principles and Practice by Ravindran, Phillips and Solberg, John Wiely
2. Introduction to Operations Research by Hiller and Lieberman, Mc Graw Hill
3. Engineering Optimization - Theory and Practice by Rao, S.S., New Age International (P) Ltd. Publishers.
4. Engineering Optimization By Kalyanmanai Deb, Prentice Hall of India, New Delhi.

FIRST SEMESTER
MTMD 106 : ELECTIVE -1
B) COMPUTER SIMULATIONS OF MACHINES
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:
1) To introduce the concepts of simulations in kinematics, dynamics of mechanisms.
2) To study the methodology to obtain solutions for position analysis using MATLAB.
3) To simulate mechanisms using SIMULINK software.
4) To study the dynamics and simulation methodology.
5) To the study the kinematic and dynamic analysis of two link planar robot.

SYLLABUS:

Introduction: Introduction, Overview, Why Simulate Mechanisms, Kinematics Simulations, Dynamic Simulation of Mechanisms, Summary, Vector Loop and Vector Chain Equations – Introduction, The Planar Vector, Single Loop Equations, Derivatives of Vectors, Other Common Mechanisms, Vector Chains.

Solutions of the position problem: Overview, Numerical Solutions of Nonlinear algebraic Equations, The Position Problem of a Four-Bar Linkage, Mat lab Solution of the position of a Four-Bar Linkage.

Kinematic simulations using SIMULINK: What is a Kinematic Simulation, Velocity Solution via Kinematic Simulation, Acceleration Solution via Kinematic Simulation, The Consistency Check, Kinematic Simulation of a Four-Bar Mechanism.

Introducing dynamics: Simulating the slider on inclined plane, Adding the Pendulum, Assembling the Matrix Equation, Creating a Dynamic Simulation, Setting Initial conditions and Running Simulation

Two-link planar Robot: Overview, Vector Equations, Dynamic Equations, The Simultaneous Constraint matrix, Dynamic Simulation, Robot Coordinate Control.

Course Outcomes:
Upon the completion of course, the student will be able to
1) To Study the basic concepts simulation of kinematics and dynamics of mechanisms.
2) To obtain solutions foe complex equations of mechanisms in MATLAB software.
3) To obtain solutions foe complex equations of mechanisms in MATLAB software
4) To simulate kinematics of mechanisms in SIMULINK software
5) To simulate the dynamic simulation of mechanisms
6) To study the mathematical formulation of two link planar robot's dynamic and kinematic equations of mechanisms

References:

1. Simulation Of Machines using Mat Lab and Simulink/John F. Gardner/ India Edition (IE)
2. CAD/CAM / Ibrahim zeid/ TMH.
3. Mat Lab / Raj Kumar Bansal / Pearson Education

FIRST SEMESTER
MTMD 106: ELECTIVE -1
C) NON-LINEAR SOLID MECHANICS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objective:

1. This course focuses on nonlinear solid mechanics. Topics include mathematical preliminaries- Cartesian tensors and tensor algebra; analysis of deformation and motion; concept of stress and balance principles
2. The fundamentals of nonlinear solid mechanics is important and is essential for all branches of engineering and applied mechanics. Students learn the basics of nonlinear solid mechanics and will be able to solve some problems in engineering
3. Acquisition of knowledge of nonlinear elasticity, viscoelasticity, hyperplasticity and viscoplasticity and be able to use the indical notation and the tensorial notation

Syllabus:

Introduction to Vectors and Tensors: Algebra of Vectors, Algebra of Tensors, Higher-order Tensors, Eigenvalues, Eigenvectors of Tensors, Transformation Laws for Basis Vectors and components, General Bases, Scalar, Vector, Tensor Functions, Gradients and Related Operators, Integral Theorems.

Kinematics: Configurations and Motions of Continuum Bodies, Displacement, Velocity, Acceleration Fields, Material, Spatial Derivatives, Deformation Gradient, Strain Tensors, Rotation Tensor, Stretch Tensors, Rates of Deformation Tensors, Lie Time Derivatives.

The Concept of Stress: Traction Vectors, and Stress Tensors, Extremal Stress Values, Examples of States of Stress, Alternative Stress Tensors.

Balance Principles: Conservation of Mass, Reynolds' Transport Theorem, Momentum Balance Principles, Balance of Mechanical Energy, Balance of Energy in Continuum Thermodynamics, Entropy Inequality Principle, Master Balance Principle.

Some Aspects of Objectivity: Change of Observer, and Objective Tensor Fields, Superimposed Rigid-body Motions, Objective Rates, Invariance of Elastic Material Response.

Hyperelastic Materials: General Remarks on Constitutive Equations, Isotropic Hyperelastic Materials, Incompressible Hyperelastic Materials, Compressible Hyperelastic Materials, Some Forms of Strain-energy Functions, Elasticity Tensors, Transversely Isotropic Materials, Composite Materials with Two Families of Fibers, Constitutive Models with Internal Variables, Viscoelastic Materials at Large Strains, Hyperelastic Materials with Isotropic Damage. 32 Thermodynamics of Materials: Physical Preliminaries, Thermoelasticity of Macroscopic Networks, Thermodynamic Potentials, Calorimetry, Isothermal, Isentropic Elasticity Tensors, Entropic Elastic Materials, Thermodynamic Extension of Ogden's Material Model, Simple Tension of Entropic Elastic Materials, Thermodynamics with Internal Variables.

Variational Principles: Virtual Displacements, Variations, Principle of Virtual Work, Principle of Stationary Potential Energy, Linearization of the Principle of Virtual Work, Two-field Variational Principles, Three-field Variational Principles.

Course outcomes:

1. Understand the concept of tensor. Higher-order Tensors, Eigenvalues, Eigenvectors of Tensors

2. Analyze advanced concept of stress and strain in structural problems. The Concept of Stress: Traction Vectors, and Stress Tensors, Extremal Stress Values

3. Apply the concept of Balance Principles: Conservation of Mass, Reynolds' Transport Theorem, Momentum Balance Principles, Balance of Mechanical Energy, and Balance of Energy in Continuum Thermodynamics

4. Implement advanced concept of Hyperelastic Materials.

References:

1. Nonlinear Solid Mechanics: A Continuum Approach for Engineering by G. A. Holzapfel, John-Wiley & Sons.
2. Nonlinear Solid Mechanics: Theoretical formulations and finite element solutions by
A. Ibrahimbegovic, Springer publications.

FIRST SEMESTER
MTMD 106: : ELECTIVE -1
D) STRUCTURAL HEALTH MONITORING
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course objective:

1. To understand the structural health monitoring for structures
2. To understand the conditional assessment & techniques in order to detect defects.

Syllabus:

Introduction: Definition, Principles, Significance of SHM, Potential Applications in Civil, Naval, Aerospace and Manufacturing Engineering.

Operational evaluation: Sensor technology, Piezoelectric wafer active sensors, Data acquisition and cleansing procedures, Elastic waves in solid structures, Guided waves.

Feature extraction methods: Identify damage sensitive properties, Signal Processing, Fourier and short term Fourier transform, Wavelet analysis.

Pattern recognition: State –of –Art damage identification and pattern recognition Methods, Neural networks, Feature extraction algorithm.

Case studies: SHM based Flaw detection in mechanical structures - Integrity and damage recognition in plates and pipes, defect identification in weld joints, Wear monitoring in cutting tools.

Course outcomes:

1. Describe the principles and significance of SHM in structures
2. Investigate various sensors, data acquisition
3. Explained about fourier and short term fourier transform
4. Detail case study and monitoring of structures, plates, weld joints

References:

1. Daniel Balageas, Claus-Peter Fritzen and Alfredo Guemes, Structural Health Monitoring, John Wiley &Sons, 2006.
2. Victor Giurgiutiu,Structural Health Monitoring with Piezoelectric Wafer Active Sensors, Academic Press,2008.
3. A Review of Structural Health Monitoring Literature: 1996-2001/ Hoon Sohn/ Chales R.Farrar/Francois M.Hemez/Devin D.Shunk/Daniel W.Stinemates/Brett R. Nadler/Jerry J.Czarnecki*/Los Alamos National Laboratory
4. Damage Identification and Helath Monitoring of Structural and Mechanical Systems from Changes in Their Vibration Characteristics: A Literature Review/ Scott W. Doebling/Charles R. Farrar/Michael B.Prime/Daniel W.Shevitz

FIRST SEMESTER
MTMD 106: : ELECTIVE -1
E) THEORY OF PLATES AND SHELLS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To introduce the concept of plate theory.
2. To study the behaviour and analysis of thin plates.
3. To study the behaviour and analysis of rectangular plates and circular plates.
4. To present the foundations of the classical theory of shells based on the Kirchhoff Love assumptions.
5. To study the classification of shell surfaces

SYLLABUS:

Bending of long rectangular plates to a cylindrical surface: Differential equation for cylindrical bending of plates - Cylindrical bending of uniformly loaded rectangular plates with simply supported edges - Cylindrical bending of uniformly loaded rectangular plates with built- in edges

Pure bending of plates: Slope and curvature of slightly bent plates - Relations between bending moments and curvature in pure bending of plates - Particular cases of pure bending - Strain energy in pure bending of plates.

Symmetrical bending of circular plates: Differential equation for symmetrical bending of laterally loaded circular plates - Uniformly loaded circular plates - Circular plate with a circular hole at the center - Circular plate concentrically loaded - Circular plate loaded at the center.

Small deflections of laterally loaded plates: The differential equation of the deflection surface

- Boundary conditions - Alternate method of derivation of the boundary condition - Reduction of the problem of bending of a plate to that of deflection of a membrane.

Simply supported rectangular plates: Simply supported rectangular plates under sinusoidal load - Navier solution for simply supported rectangular plates. Rectangular plates with various edge conditions: Bending of rectangular plates by moments distributed along the edges - rectangular plates with two opposite edges simply supported and the other two edges clamped.

Continuous rectangular plates: Simply supported continuous plates - Approximate design of continuous plates with equal spans - Bending symmetrical with respect to a center.

Deformation of shells without bending: Definition and notation - Shells in the form of a surface of revolution and loaded symmetrically with respect to their axis - Particular cases of shells in the form of surfaces of revolution - Shells of constant strength.

General theory of cylindrical shells: A circular cylindrical shell loaded symmetrically with respect to its axis - Particular cases of symmetrical deformation of circular cylindrical shells - Pressure vessels.

Course Outcomes:

Upon the completion of course, the student will be able to

1) Formulate differential equations for bending of the different shaped plates with different edges.
2) Formulate the differential equations for bending of the plates with different loading conditions.
3) Obtaining solutions for differential equations and different methods for deriving the boundary conditions.
4) Obtaining the relations between different parameters of bending.
5) Study the notation and representation and classification of shells.

Reference:

1. Theory of Plates and Shells by Timoshenko, S. and Woinowsky-Krieger, S.

FIRST SEMESTER

MTMD 107 COMPUTER AIDED DESIGN, MODELLING AND SIMULATION LAB

Periods per week : 3 Examination: 50
Sessionals : 50 Credits : 1.5

Course Objectives:

The objective of the course is to enable students to

1. Provide basic foundation in computer aided design / manufacturing
2. Understand the fundamentals used to create and manipulate geometric models
3. Get acquainted with the basic CAD software designed for geometric modeling
4. To create 2D and 3D CAD models.

Syllabus:

1. 2D and 3D modeling and assembly modeling using any one modeling packages like AutoCAD/AutoDesk Mechanical desktop/CREO/IDEAS/CATIA/Unigraphics/Solid Works.

2. 1D, 2D and 3D Meshing, Linear and non-linear static and dynamic analysis using any one FEA packages like ANSYS/CAEFEM/NASTRAN/NISA.

3. 1D, 2D and 3D Steady State Thermal Analysis, Transient Thermal Analysis Couple Field (Thermal/Structural)Analysis using any one FEA packages like ANSYS/CAEFEM/ NASTRAN/NISA

COURSE OUTCOMES:

Upon completion of this course the student will be able to:

1. Describe basic structure of CAD workstation, Memory types, input/output devices and display devices and computer graphics.
2. Acquire the knowledge of geometric modeling and Execute the steps required in CAD software for developing 2D and 3D models and perform transformations.
3. Develop 2D and 3D AutoCAD models.

FIRST SEMESTER
MTMD 108 MECHANICAL VIBRATIONS LAB-I

Periods per week : 3 Examination: 50
Sessionals : 50 Credits : 1.5

Course Objectives:

- Concept of radius of bifilar and trifilar suspension systems.
- Concept of center of gravity and determining for a connecting rod.
- Natural frequency and its determination for a single rotor system, forced damped, forced undamped, free damped and free damped systems.
- To determine moment of inertia of flywheel.
- To determine of modulus of rigidity for a material.

List of Experiments:

1. To determine the radius of gyration of given bar by using bifilar and Trifiller suspension.
2. Find the CG of a connecting rod using free vibration techniques.
3. To determine natural frequency of free torsional vibrations of single rotor system.
4. Determine the moment of inertia of the given flywheel.
5. To determine the modulus of rigidity of a given wire by torsional vibration.
6. Find the Natural frequency of the forced damped vibrations of equivalent spring mass system.
7. Find the Natural frequency of the forced undamped vibrations of equivalent spring mass system.
8. Find the Natural frequency of the free damped vibrations of equivalent spring mass system.
9. Find the Natural frequency of the free un-damped vibrations of equivalent spring mass system.

Course Outcomes:
Upon completion of this course the student will be able to:
1. Determine the radius of bifilar and trifilar suspension systems.
2. Determine the center of gravity and determining for a connecting rod.
3. Calculate Natural frequency is determined for a single rotor system, forced damped, forced undamped, free damped and free damped systems.
4. Determination moment of inertia of flywheel.
5. Determination of modulus of rigidity for a material.

M.TECH. SECOND SEMESTER

MTMD 201 INSTRUMENTATION AND EXPERIMENTAL STRESS ANALYSIS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To understand fundamentals of instrumentation and learn related terminology
2. To learn about various sensing devices and understand their working principles
3. To understand the photo elastic technique for principal stress measurement on 2-D and 3-D objects
4. To provide geometric and displacement Moiré fringe techniques and interferometry concepts
5. To know the concepts and uses of strain gauges and mounting approaches

SYLLABUS:

PART - A (Instrumentation)

Basic concepts: Calibration - Standards - Basic concepts in dynamic measurements – System response - Distortion.

Sensing devices: Bridge circuits - Amplifiers - Filter circuits - Oscilloscope - Oscillograph - Transducers

- variable resistance transducers, LVDT - Capacitive and piezoelectric transducers.

Pressure measurement: Mechanical pressure measurement devices - Bourdon tube pressure gauge - Diaphragm and bellow gauges - Low pressure measurement - McLeod gauge - Pirani gauge - Ionization gauge.

Flow measurement: Positive displacement methods - Flow obstruction methods - Flow measurement by drag effect - Hot wire anemometer.

Temperature measurement: Temperature measurements by mechanical effects, Electrical effects and by Radiation - Thermocouples; Force and torque measurement - Motion and vibration measurement.

PART - B (Stress Analysis)

Brittle lacquer method of stress analysis: Application of lacquer - Stress determination - Dynamic stresses.

Strain gauges: Mechanical resistance wire gauges - Types of resistance gauges - Cements and cementing of gauges - Wheatstone bridge - Balanced and unbalanced gauge factor - Calibration of gauges - Strain gauge rosette - Evaluation and principal stresses static and dynamic instrumentation

Photo elasticity: Polariscope plane and circularly polarized light - Photo elastic materials - Calibration - Isochromatic fringes – Isoclines stress determination

Grid methods.

Course Outcomes:

Upon the successful completion of the course, learners will be able to

1. Define the principles of measurements
2. Describe the sensitivity & the construction of various measuring instruments
3. Explain experimental techniques to measure pressures, temperatures, displacements, strains and stresses on small or full scale specimens
4. Explain the stress separation methods of 3D photo elasticity
5. Describe the birefringence coating techniques and the Moiré's techniques

References:

1. Experimental Methods for Engineers by Holman, J.P., McGraw Hill Book Company.
2. Stress Analysis and Experimental Techniques/ An Introduction by J. Srinivas/ Narosa publications
3. A Course In Mechanical Measurements And Instrumentation A. K. Sawhney And P. Sawhney
4. A treatise on Mathematical theory of elasticity / LOVE A.H. / Dover Publications
5. Photo Elasticity /Frocht/ Wiley / 3rd Edition
6. Experimental Stress Analysis/Sadhu Singh / Khanna Publications.
7. Experimental Stress Analysis and Motion Measurement by Dove and Adams.
8. Experimental Stress analysis/ Dally and Riley, Mc Graw-Hill

SECOND SEMESTER

MTMD 202 SIGNAL ANALYSIS AND CONDITION MONITORING

Periods/week: 4 Th. Ses. : 30 Exam: 70

Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. Explain the basics of signal types signal analysis equipments.
2. Explainthe Practical analysis of stationary signals
3. Explain the Practical analysis of continuous non-stationary signals.
4. Explain the Practical analysis of transients.
5. Explain Condition monitoring in real systems

SYLLABUS:

Introduction: Basic concepts. Fourier analysis. Bandwidth. Signal types. Convolution.

Signal analysis: Filter response time. Detectors. Recorders. Analog analyzer types.

Practical analysis of stationary signals: Stepped filter analysis. Swept filter analysis. High speed analysis. Real-time analysis.

Practical analysis of continuous non-stationary signals: Choice of window type. Choice of window length. Choice of incremental step. Practical details. Scaling of the results.

Practical analysis of transients: Analysis as a periodic signal. Analysis by repeated playback (constant bandwidth). Analysis by repeated playback (variable bandwidth).

Condition monitoring techniques: Visual monitoring, Thermography, Vibration monitoring, Shock pulse monitoring, Wear debris monitoring, Motor current and signature analysis, Acoustic emission, Ultrasound monitoring, ISO standards, Fault detection sensors, Structural Health Monitoring (SHM), integrated Vehicle Health Monitoring (IVHM).

Condition monitoring in real systems: Diagnostic tools. Condition monitoring of two stage compressor. Cement mill foundation. I.D. fan. Sugar centrifugal. Cooling tower fan. Air separator. Preheater fan. Field balancing of rotors. ISO standards on vibrations.

Course Outcomes:

Upon successful completion of the course, the students will be able to

- Apply signal-processing methods, the principles of instrumentation and measurement systems.
- Perform practical analysis on actual machines and systems, Develop a maintenance strategy based on system response.
- Understand the advantages and limitations of a variety of techniques for condition monitoring.
- Understand the environmental benefits of condition monitoring techniques, Condition monitoring approaches, sensor types, sensor placement, data analysis.

References:

1. Condition Monitoring of Mechanical Systems by Colacat.
2. Frequency Analysis by R.B.Randall.
3. Mechanical Vibrations Practice with Basic Theory by V. Ramamurti, Narosa Publishing

House.
4. Machinery Condition Monitoring: Principles and Practices by A. R. Mohanty (ISBN: 9781466593046, CRC Press, 2014)
5. NPTEL II Video Lectures: Machinery Condition Monitoring and Signal Processing by A R MOHANTY (NPTEL, 2013)

SECOND SEMESTER
MTMD 203 ADVANCED FINITE ELEMENT ANALYSIS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To introduce the basic concepts of Finite Element Method (FEM), its historical background, and its applications in various fields of engineering.
2. To understand the fundamental principles of FEM, including displacement approach, interpolation functions, and virtual energy principles.
3. To apply the FEM to solve 1-D, 2-D, and 3-D structural problems, including axial bar elements, plane trusses, space trusses, and axi-symmetric solids.
4. To model and analyze beam and frame structures using Hermite shape functions, stiffness matrices, and load vectors.
5. To explore the steady-state scalar field problems such as heat conduction and field flow, along with dynamic considerations including modal analysis.
6. To study the analysis of plates, including bending behavior, triangular plate bending elements, and finite element analysis for plate problems.

SYLLABUS:

Introduction: Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, Finite elements of an elastic continuum - displacement approach, basic element shapes, interpolation function, generalization of the finite element concept - weighted residuals and variational approaches, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain- displacement relations. Plane stress and plane strain, Requirements of Convergence, h – refinement and p - refinement

1-D Structural Problems: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems, Plane Trusses and Space Truss elements and problems 2-D Problems: CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modelling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements.

Analysis of Beams and Frames: Hermite shape functions – stiffness matrix – Load vector – Problems related to Beams and Frames

3-D Problems: Tetrahedran element – Jacobian matrix – Stiffness matrix. Steady-state Scalar field problems – 1D. 2 D Heat conduction, electric and magnetic potentials, field flow. The time domain, semi-descritization of field and dynamic problems and analytical solution procedures.

Dynamic considerations: Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

Analysis of Plates: Introduction, Triangular Membrane element, Quadratic Triangle element, Rectangular plate element (in-plane forces), Bending behavior of plates, finite element analysis of plates in bending, triangular plate bending element.

Course Outcomes

1. Understand the foundational concepts of FEM, including the comparison with other methods and the role of stiffness matrices, boundary conditions, and shape functions.
2. Analyze 1-D structural problems using axial bar elements, quadratic shape functions,

and apply FEM for plane and space trusses.
3. Model and solve 2-D problems using CST, LST, isoparametric elements, and numerical integration techniques.
4. Analyze 3-D problems using tetrahedral elements, Jacobian matrices, and stiffness matrices for steady-state and dynamic scalar field problems.
5. Solve dynamic problems in FEM, including consistent mass matrix formulation, eigenvalues, eigenvectors, natural frequencies, and modal analysis.
6. Apply FEM to the analysis of plates, including bending and in-plane forces, and use triangular and rectangular plate elements for finite element modeling.

References:

1. Concepts and Applications of Finite Element Analysis by Cook, R.D.
2. Applied Finite Element Analysis by Segerland, L.J.
3. The Finite Element Methods in Engineering / SS Rao / Pergamon.
4. Finite Element Methods: Basic Concepts and applications, Alavala, PHI
5. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall
5. Finite Element Method – Zienkiewicz / Mc Graw Hill
6. Introduction to Fininte element analysis- S.Md.Jalaludeen, Publications, print-2012
7. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition
8. Finite Element Method – Krishna Murthy / TMH
9. Finite Element Analysis – Bathe / PHI

SECOND SEMESTER

MTMD 204 ADVANCED ENGINEERING DESIGN

Periods/week: 4 Th. Ses. : 30 Exam: 70

Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To introduce design philosophy, various design models, and the process of product design, including creativity, need analysis, and strength considerations.
2. To understand failure theories and their applications in design, including static failure theories, fatigue mechanisms, and the design for fatigue strength and life.
3. To analyze surface failures, their causes, and the effects of surface geometry, wear, corrosion, and dynamic contact stresses on the performance of materials.
4. To evaluate the economic factors influencing design, including break-even analysis, ergonomics, and modern approaches like value engineering.
5. To study the importance of fits, tolerances, and surface finish in design, and their impact on load transmission and the selection of materials and processes.
6. To promote teamwork and ethical considerations in engineering design, emphasizing the importance of collaboration and responsible decision-making in product development.
7. To explore the process of product design, including strategy development, concept generation, planning, testing, and design for manufacturing techniques.

Syllabus:

Design philosophy: Design process, Problem formation, Introduction to product design, Various design models-Shigley model, Asimov model and Norton model, Need analysis, Strength considerations -standardization. Creativity, Creative techniques, Material selections, Notches and stress concentration, design for safety and Reliability

Failure theories: Static failure theories, Distortion energy theory, Maximum shear stress theory, Coulomb-Mohr's theory, Modified Mohr's theory, Fracture mechanics theory., Fatigue mechanisms, Fatigue failure models, Design for fatigue strength and life, creep: Types of stress variation, design for fluctuating stresses, design for limited cycles, multiple stress cycles, Fatigue failure theories ,cumulative fatigue damage, thermal fatigue and shock, harmful and beneficial residual stresses, Yielding and transformation

Surface failures: Surface geometry, mating surfaces, oil film and their effects, design values and procedures, adhesive wear, abrasive wear, corrosion wear, surface fatigue, different contacts, dynamic contact stresses, surface fatigue failures, surface fatigue strength.

Economic factors influencing design: Economic analysis, Break-even analysis, Human engineering considerations, Ergonomics, Design of controls, Design of displays. Value engineering, Material and process selection in value engineering, Modern approaches in design. Importance of Fits and Tolerance influencing design: Tolerance from process and function, interchangeability and selective assembly, selection of fits for different design situations, surface finish. Load transmission, load equalization light weigh and rigid constructions.

Team work and Ethics in engineering design: Team formation, functioning, discharge, team dynamics, Ethical issues considered during engineering design process

Product Design: Product strategies, Product value, Product planning, product specifications, concept generation, concept selection, concept testing.

Design for manufacturing: Forging design, Casting design, Design process for non metallic parts, Plastics, Rubber, Ceramic, Wood, Glass parts. Material selection in machine design.

Course Outcomes

1. Demonstrate the application of various design models and the design process, considering factors such as creativity, material selection, and safety.
2. Apply failure theories to assess design strength and durability, considering static and dynamic failure mechanisms, including fatigue and creep.
3. Analyze surface failure mechanisms such as wear and corrosion, and apply this knowledge to improve material performance in real-world applications.
4. Conduct economic analysis in design, including break-even analysis and ergonomics, to optimize product design and functionality.
5. Apply principles of fits, tolerances, and surface finish to ensure proper functioning, load transmission, and manufacturing efficiency.
6. Understand the role of teamwork and ethics in the engineering design process, fostering collaboration and responsible decision-making.
7. Design products with a focus on value, product planning, and effective selection of manufacturing methods, including considerations for materials such as plastics, rubber, and ceramics.

References:

1. Machine Design An Integrated Approach by Robert L. Norton, Prentice-Hall New Jersey, USA.
2. Mechanical Engineering Design by J.E. Shigley and L.D. Mitchell published by McGraw- Hill International Book Company, New Delhi.
3. Fundamentals of machine elements by Hamrock, Schmid and Jacobian, 2nd edition, McGraw- Hill International edition.
4. Product design and development by Karl T. Ulrich and Steven D. Eppinger. 3rd edition, Tata McGraw Hill.
5. Product Design and Manufacturing by A.K. Chitale and R.C. Gupta, Prentice Hall
6. Engineering Design / George E Dieter / McGraw Hill /2008
7. Fundamentals of machine elements/ Hamrock, Schmid and Jacobian/ 2nd edition /McGraw- Hill International edition.

SECOND SEMESTER
MTMD 205 ELECTIVE SUBJECT – 2
A) RELIABILITY ENGINEERING
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To distinguish between quality of conformance and quality of performance and to model the failure of different engineering products and systems using appropriate statistical distributions.
2. To model the different engineering systems as series, parallel, combination of series and parallel and complex systems. Also to lease the evaluation of different systems reliability
3. Maker analysis of system reliability
4. To introduce the stress-strength based on reliability models and to highlight their importance over the design based on safety factors.
5. To introduce the reliability design process, lifecycle costs, reliability allocation and FMEA and FTA.
6. To introduce reliability tests methods and growth models

Syllabus:

Introduction: Concepts of quality and reliability, a brief history, terms, definitions, reliability function, MTTF, Hazard rate function, bath tub curve, conditional reliability.

Constant failure rate models: Exponential reliability, failure modes, failure modes with exponential distribution, applications, two parameter exponential distribution, Poisson process.

Time dependent failure models: Weibull distribution, burn-in screening for Weibull, three parameter Weibull distribution, Normal and Lognormal distributions

Reliability of systems: Series, parallel configurations, combined systems, k-out-of-n systems, complex configurations, common failure modes, minimal cuts and minimal paths.

State dependent systems: Markov analysis, load sharing, standby systems, degraded systems

Physical reliability models: Static models- random stress and random strength, dynamic models- periodic models, random loads.

Design for reliability: Reliability specification, Lifecycle costs, reliability allocation, design methods, failure analysis, FTA.

Course Outcomes:

1. The student under hands the importance of time based performance and its importance of time based performance and its modelling using different statistics dispute.
2. Gains the ability to model the engineering systems with different compurgation
3. Under stands the application of MAVKOV analysis to ever system reliability
4. Gains the knowledge to design the engineering products to the required reliability constraints

5. Under the reliability collocation methods and the conduct of FMEA and FTA.
6. Gain knowledge in reliability tests and growth analysis.

Text Book:

Introduction to Reliability and Maintenance engineering by Charles E Ebeling, Tata McGrawhill, India.

References:

Introduction to Reliability Engineering by E.E. Lewis, John Wiley& Sons, NewYork
Reliability based design by S.S.Rao, McGraw-Hill, New York

SECOND SEMESTER
MTMD 205 ELECTIVE SUBJECT – 2
B) INTEGRATED COMPUTER AIDED DESIGN
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To introduce the fundamentals of Computer-Aided Design (CAD), including its applications, benefits, hardware, and the role of computers in the design process.
2. To explore geometric modeling techniques and their application in creating 2D, wireframe, surface, and solid models, with an emphasis on feature recognition.
3. To develop skills in computer-aided drafting using tools like AutoCAD, focusing on 3D model building, editing, and creating multiple views, including orthogonal and isometric.
4. To understand the principles of visual realism in CAD, including shading, coloring, and the use of color models in design representation.
5. To learn graphic aids and techniques, such as geometric modifiers, naming schemes, layers, grids, and grouping, for efficient design management and manipulation.
6. To introduce computer animation in the context of CAD, including the use of animation techniques for engineering and entertainment applications.
7. To study mechanical assembly modeling, focusing on part modeling, mating conditions, assembly sequence generation, and precedence diagramming.
8. To understand mechanical tolerancing concepts, including geometric tolerances, location tolerances, drafting practices, and tolerance analysis for precision design.
9. To provide methods for mass property calculations in CAD, including formulations for geometric properties, mass, centroid, moments of inertia, and property mapping for composite objects.

Syllabus:

Fundamentals of CAD: Introduction, Design process, Application of computer for design, Creating the manufacturing database, Benefits of CAD, Design work station, CAD hardware. Geometric modeling: Geometric modeling techniques - Multiple view 2D input, Wire frame geometry, Surface models, Geometric entities - Curves and Surfaces, Solid modelers, Feature recognition.

Computer aided drafting: AutoCAD tools, 3D model building using solid primitives and boolean operations, 3D model building using extrusion, Editing tools, Multiple views: Orthogonal, Isometric.

Visual realism: Shading solids, Coloring, Color models, Using interface for shading and coloring.

Graphic aids: Geometric modifiers, Naming scheme, Layers, Grids, Groups, Dragging and rubber banding.

Computer animation: Conventional animation, Computer animation - Entertainment animation, Engineering animation, Animation types, Animation techniques.

Mechanical assembly: Assembly modeling, Part modeling, Mating conditions, Generation of assembling sequences, Precedence diagram, Liaison-sequence analysis.

Mechanical tolerancing: Tolerance concepts, Geometric tolerancing, Types of geometric tolerances, Location tolerances, Drafting practices in dimensioning and tolerancing, Tolerance analysis.

Mass property calculations: Geometrical property formulation - Curve length, Cross-sectional area, Surface area, Mass property formulation - Mass, Centroid, Moments of inertia, Property mapping. Properties of composite objects.

Course Outcomes

1. Demonstrate the use of CAD in the design process, including creating and managing manufacturing databases and utilizing CAD hardware and workstations.
2. Apply geometric modeling techniques to create and modify 2D, wireframe, surface, and solid models, recognizing features in complex designs.
3. Develop 3D models using CAD tools such as AutoCAD, and produce multiple views and edit models using standard operations like extrusion and boolean functions.
4. Implement visual realism techniques, including shading and coloring, to enhance the presentation of CAD models and ensure design clarity.
5. Utilize graphic aids such as layers, grids, and geometric modifiers to improve the organization and manipulation of CAD models.
6. Create and implement animations in CAD, applying conventional and computer animation techniques for both entertainment and engineering purposes.
7. Model and assemble mechanical parts, considering mating conditions, assembly sequences, and analysis tools like precedence diagrams and liaison-sequence analysis.
8. Apply mechanical tolerancing methods, understanding geometric tolerances, and perform tolerance analysis to ensure the accuracy and manufacturability of designs.
9. Perform mass property calculations, including those for composite objects, to determine geometric and physical properties critical for engineering analysis.

References:

1. CAD/CAM Theory and Practice by Ibrahim Zeid.
2. CAD/CAM Principles and Applications by P.N. Rao, Tata McGraw Hill Publishing Company Ltd.
3. CAD/CAM Computer Aided Design and Manufacturing by Mikell P. Groover and Emory W. Zimmer, Jr.
4. Computer Integrated Design and Manufacturing by David D. Bedworth, Mark R. Henderson, Philip M. Wolfe.

SECOND SEMESTER
MTMD 205 ELECTIVE SUBJECT – 2
C) MECHATRONICS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course objectives:

1. Understand key elements of Mechatronics system, representation into block diagram
2. Understand concept of transfer function, reduction and analysis
3. Understand principles of sensors, its characteristics, interfacing with DAQ microcontroller
4. Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application
5. Understand the system modeling and analysis in time domain and frequency domain.
6. Understand control actions such as Proportional, derivative and integral and study its Significance in industrial applications

Syllabus:

Introduction: Overview, History of mechatronics, Scope and significance of Mechatronics systems, elements of Mechatronic systems, Needs and benefits of Mechatronics in manufacturing.

Sensors: Classification of sensors basic working principles, displacement sensor – linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders, Proximity and range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, hall Effect sensor, inductive Proximity switch, Light sensors – Photodiodes, Phototransistors, Flow Sensors – ultrasonic Sensor, Laser Doppler Anemometer, Tactile Sensors – PVDF tactile sensor, micro-switch and reed switch, Piezoelectric sensors, Vision Sensor.

Actuators: Electrical Actuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo Motor, BLDC Motor, AC Motor, Stepper Motor, Hydraulic & pneumatic devices – Power supplies, valves, Cylinder sequencing, Design of hydraulic & pneumatic circuits. PiezoElectric Actuators, Shape memory alloys.

Basic System models & Analysis: Modeling of one & two degrees of freedom Mechanical, Electrical, fluid and thermal systems, block diagram representations of these systems. Dynamic Responses of System: Transfer function, modeling dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh Map, Design of combinational circuits, design of arithmetic circuits, Design of code converters, encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, multiplexer, Pulse width modulation counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of Control systems, Feedback, Closed loop and open loop systems PLC Programming: PLC Principles of operation, PLC sizes, PLC hardware components, I/O section Analog I/O section, Analog I/O modules, digital I/O modules, CPU processor memory,

module programming, Ladder Programming, ladder diagrams, Timers, Internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Advanced Applications in Mechatronics: Sensors for condition monitoring, mechatronic control in automated manufacturing, Artificial intelligence in Mechatronics, micro sensors in mechatronics, Application of Washing machine as mechatronic device.

Course outcomes:

1. Identification of key elements of mechatronics system and its representation in terms of block diagram
2. Understanding the concept of signal processing and use of interfacing systems such as ADC, DAC, digital I/O

3 Interfacing of Sensors, Actuators using appropriate DAQ micro-controller 4. Time and Frequency domain analysis of system model (for control application)

5. PID control implementation on real time systems

6 Development of PLC ladder programming and implementation of real life system.

References:

1. W. Boton, “Mechatronics”, 5th edition, Adison WesleyLongman ltd, 2010.
2. Mehatronics system design by Devdas Shetty and Richard A. Kolk, P.W.S. Publishing company, 2001.
3. Alciatore David G & Histand Michael B, “Introduction to Mechatronics and Measurement systems”, 4th edition, Tata McGraw Hill, 2006.
4. Saeed B Niku, “Introduction to Robotics: Analysis, Systems, Applications “, 2nd edition, Pearson Education India, PHI, 2003.

SECOND SEMESTER
MTMD 205 ELECTIVE SUBJECT – 2
D) FUZZY LOGIC & NEURAL NETWORKS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:
1. To understand basic concepts of fuzzy logic and relations.
2. Concepts of adaptive fuzzy systems.
3. Basic concepts of neural networks, multilayer networks and back propagation algorithm.
4. Mapping and recurring networks.
5. Application of fuzzy logic and neural networks.

Syllabus:
1. Fuzzy set theory and fuzzy logic control: Basic concepts of fuzzy sets- Operations on fuzzy sets- Fuzzy relation equations- Fuzzy logic control- Fuzzification –Defuzzification- Knowledge base- Decision making logic- Membership functions – Rule base.

2. Adaptive fuzzy systems: Performance index- Modification of rule base0- Modification of membership functions- Simultaneous modification of rule base and membership functions- Genetic Algorithms-Adaptive fuzzy system- Neuro fuzzy systems.

3. Artificial neural networks: Introduction- History of neural networks- multilayer perceptions- Back propagation algorithm and its Variants- Different types of learning, examples.

4. Mapping and recurrent networks: Counter propagation –Self organization Map- Congnitron and Neocognitron- Hopfield Net- Kohonnen Nets- Grossberg Nets- Art-I, Art-II reinforcement learning

5. Case Studies: Application of fuzzy logic and neural networks to Measurement- Control- Adaptive Neural Controllers – Signal Processing and Image Processing

Course Outcomes:
Upon the successful completion of the course, learners will be able to
1. Understand basic concepts of fuzzy logic and relations.
2. Concepts of adaptive fuzzy systems and Algorithms
3. Learn history and basic concepts of neural networks, multilayer networks and backpropagation algorithm.
4. Mapping and recurring networks.
5. Application of fuzzy logic and neural networks, signal processing and image processing.

References:

1. Vallum B.R And Hayagriva V.R C++, Neural networks and Fuzzy logic, BPB Publications, New Delhi, 1996
2. Neural Networks for control, Millon W.T, Sutton R.S and Werbos P.J, MIT Press 1992
3. Fuzzy sets Fuzzy logic, Klir, G.J anfd Yuan B.B Prentice Hall oif India Pvt. Ltd.,, New Delhi
4. Neural Networks and Fuzzy systems, Kosko.. Prentice hall of India Pvt. Ltd.,, New Delhi 1994
5. Introduction to Fuzzy control, Dirankov D. Hellendoorn H, Reinfrank M., Narosa

Publications House, New Delhi 1996
6. Introduction to Artificial Neural systems, Zurada J.M Jaico Publishing House, New Delhi 1994

SECOND SEMESTER
MTMD 205 ELECTIVE SUBJECT – 2
E) MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To understand the fracture behavior of metals and alloys, including the ductile/brittle transition temperatures for notched and un-notched components.
2. To explore ductile rupture as a failure mechanism and the effects of elevated temperatures on fracture.
3. To introduce the fundamental concepts of fracture mechanics, including the stress intensity factor and strain energy release rate, and understand the equivalence of energy and stress intensity approaches.
4. To study the use of the stress intensity factor in fracture mechanics, particularly in relation to stress concentrators and flaws, and to learn about solutions for cracks in materials.
5. To understand the principles of Linear Elastic Fracture Mechanics (LEFM), including the three loading modes, fracture energy, and the material parameters critical to fracture behavior.
6. To introduce Elastic/Plastic Fracture Mechanics (EPFM), including crack opening displacement, the J-integral approach, and R-curve analysis, and to explore testing and measurement procedures.
7. To understand the concepts of fatigue, including high cycle and low cycle fatigue, and to explore fatigue in welded structures and the effects of factors like the mean stress ratio and S-N curves.
8. To examine the micro mechanisms of fatigue damage, control of fatigue initiation and propagation, and the application of fatigue resistance in material design.
9. To study the behavior of materials under creep deformation, including the different stages of creep, the micro mechanisms of creep, and the role of diffusion in creep.
10. To explore creep-fatigue interactions, extrapolation techniques, and the use of Larson-Miller parameters for predicting material behavior under long-term stress.

SYLLABUS:

Introduction: Fracture behavior of metals and alloys. The ductile/brittle transition temperatures for notched and un-notched components, Ductile rupture as a failure mechanism Fracture at elevated temperature. Definitions of types of fracture and failure, Introduction to stress intensity factor and strain energy release rate, Equivalence of energy approach and stress intensity approach.

Stress intensity factor and its use in fracture mechanics: Early concepts of stress concentrators and flaws, Ingles solution to stress round an elliptical hole-implications of results. Stress intensity factor for a crack. Westergaard's solution for crack tip stresses. Stresses and displacement in Cartesian and polar coordinates,

Linear elastic fracture mechanics (LEFM): Three loading modes and the state of stress ahead of the crack tip, stress concentration factor, strain energy release rate, fracture energy, R. Modification for ductile materials, loading conditions. Stress intensity factor and the material parameter, the critical stress intensity factor.

Elastic/plastic fracture mechanics: The crack opening displacement and J-integral approaches, R-curve analysis Testing procedures, Measurement of these parameters, RAD, Fail sage and safe life design approaches, Practical applications. Advanced topics in EOFM.

Fatigue: definition of terms used to describe fatigue cycles, High Cycle Fatigue, Low Cycle Fatigue, Fatigue of Welded structures: Factors effecting the fatigue lives of welded joints. Mean stress R ratio, strain and load control. S-N curves. Goodman's rule and Miners rule. Micro mechanisms of fatigue damage, fatigue limits and initiation and propagation control leading to a consideration of factors enhancing fatigue resistance. Total life and damage tolerant approaches to life prediction.

Creep deformation: The evolution of creep damage, primary, secondary and tertiary creep, Micro mechanisms of creep in materials and the role of diffusion, Ashby creep deformation maps. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters, Creep-fatigue interactions, Creep integrals, Examples.

Course Outcomes

1. Analyze the fracture behavior of materials and determine the ductile/brittle transition temperatures for components.
2. Evaluate and apply fracture mechanics concepts, including stress intensity factors and strain energy release rates, to determine fracture initiation in materials.
3. Use Linear Elastic Fracture Mechanics (LEFM) to evaluate crack tip stress and predict the fracture behavior of materials under different loading conditions.
4. Apply Elastic/Plastic Fracture Mechanics (EPFM) methods, including J-integral and R-curve analysis, to predict crack propagation in ductile materials.
5. Identify and evaluate fatigue mechanisms, including high and low cycle fatigue, in the context of welded structures and their impact on the fatigue life of materials.
6. Apply S-N curves, Goodman's rule, and Miner's rule to assess the fatigue life and damage tolerance of materials.
7. Predict and control fatigue damage initiation and propagation through a damage-tolerant approach.
8. Understand and apply principles of creep deformation, including the classification of creep stages, and use Larson-Miller parameters to predict material performance under long-term stress.
9. Investigate the interaction between creep and fatigue in materials and use appropriate testing procedures for material characterization.
10. Apply knowledge of fracture mechanics, fatigue, and creep to solve real-world engineering problems in material design and component life prediction.

References:

1. Mechanical Metallurgy / Dieter / McGraw Hill
2. Fracture Mechanics: Fundamental and Applications /Anderson T.L & Boca Raton/ CRC Press, Florida, 1998.
3. Deformation and Fracture mechanics of Engineering Materials / Richard W Hertz /Wiley
4. Plasticity for structural Engineers / W.F. Chen and D.J,. Ha,
5. Engineering Fracture Mechanics/ D.R.J. Owen and A.J. Fawkes /Pincridge press, Swansea, U.K.
6. Fracture and fatigue control in structures/ S.T. Rolfe and J.M. Barsom/ Printice Hall, Eglewood cliffs, N.J..
7. Fracture of brittle solids/ B.R. Lawn and T.R. Wilshaw/ Cambridge university press.
8. Plastic deformation of Metals/ R.W.K. Honeycombe/ 2nd edition, Edward Arnold
9. Elements of Fracture Mechanics/Prasanth Kumar/TMH

SECOND SEMESTER
MTMD 206
INSTRUMENTATION AND EXPERIMENTAL STRESS ANALYSIS LAB

Periods per week : 3	Examination: 50
Sessionals : 50	Credits : 1.5

Course objectives:

1. To measure strain.
2. Calibration of rotameter and thermocouple.
3. Experiment with Hot-wire Anemometer at constant voltage/current
4. Displacement measurement by LVDT.
5. Displacement, Velocity and Acceleration determination using piezo-electric pick-up, Inductive pick-ups.
6. Flaw detection using ultrasonic piezo-electric pick-up, Inductive pick-ups.
7. Photo elastic analysis of disc, Ring under diametric compression.

List of Experiments:

1. Measurement of strain by using strain gauges.
2. Calibration of Rotameter.
3. Calibration of Thermocouples.
4. Experiment with constant voltage/current Hot-wire Anemometer.
5. Measurement of Displacement using LVDT
6. Experiments with piezo-electric pick-up, Inductive pick-ups. Determination of characteristics

- Displacement, Velocity and Acceleration.

7. Ultrasonic flaw detector.
8. Experiment on photo elastic bench (Plain polariscope, Circular polariscope).
9. Photo elastic analysis of disc under diametric compression.
10. Photo elastic analysis of Ring under diametric compression.

Course outcomes:

Upon completion of this course the student will be able to:

1. Measure strain using strain gauges.
2. Calibrate rotameter and thermocouple.
3. Conduct an experiment with Hot-wire Anemometer at constant voltage/current
4. Measure displacement by LVDT.
5. Determine displacement, Velocity and Acceleration using piezo-electric pick-up, Inductive pick-ups.
6. Detect flaw using ultrasonic piezo-electric pick-up, Inductive pick-ups.
7. Photo elastic analysis of disc, Ring under diametric compression.

SECOND SEMESTER
MTMD 207 MECHANICAL VIBRATIONS LAB-II

Periods per week : 3 Examination: 50
Sessionals : 50 Credits : 1.5

Course objectives:

1. To find damping presence in the structure using half power band width method.
2. To determine natural frequency of the simply supported beam by sweep sine wave method.
3. To determine damping coefficient using Active vibration isolator, passive vibration isolation.
4. To determine Vibration frequency with single Absorber, Double Absorber.
5. Determine frequency response of beam with oil damper.
6. Model a mechanical component and perform Modal analysis, Harmonic Analysis, Transient Dynamics Analysis.

List of Experiments:

1. Finding the damping presence in the structure using half power band width method.
2. Finding the natural frequency of the simply supported beam by sweep sine wave method.
3. Calculation of damping coefficient using Active vibration isolator.
4. Calculation of damping coefficient using Passive vibration isolator.
5. Determination of the Vibration frequency with single Absorber.
6. Determination of the Vibration frequency with Double Absorber.
7. Draw the curve representing the frequency response of the beam with an oil Damper. 8.Modelling and Modal Analysis of Mechanical Component.
9. Modelling and Harmonic Analysis of Mechanical Component. 10.Modelling and Transient Dynamics Analysis of Mechanical Component.

Course outcomes

Upon completion of this course the student will be able to:

1. Determine damping presence in the structure using half power band width method.
2. Determines natural frequency of the simply supported beam by sweep sine wave method.
3. Finds damping coefficient using Active vibration isolator, passive vibration isolation.
4. Determines Vibration frequency with single Absorber, Double Absorber.
5. Determines frequency response of beam with oil damper.
6. Model a mechanical component and perform Modal analysis, Harmonic Analysis, Transient Dynamics Analysis.

SECOND SEMESTER
MTMD 208 SEMINAR

Periods per week : 3	Examination: 50
Sessionals : 50	Credits : 1

A student has to give seminar on the topics related to his specialization.

THIRD SEMESTER
MTMD 301 ELECTIVE SUBJECT – 3
A) VEHICLE DYNAMICS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To introduce the fundamental concepts of vehicle dynamics, including the classification of different types of vehicles and their motions.
2. To explore mathematical modeling methods, focusing on multibody system approaches and Lagrangian formulations for vehicle dynamics.
3. To understand the various methods of investigating vehicle stability and its importance in vehicle design.
4. To examine the mechanics of pneumatic tires, including their construction, forces, moments, and performance under various conditions such as dry and wet surfaces.
5. To study the performance characteristics of road vehicles, including equations of motion, tractive effort, and aerodynamic forces.
6. To analyze vehicle power plant and transmission characteristics for performance prediction and evaluate fuel economy and braking performance.
7. To explore handling and stability characteristics of road vehicles, focusing on steering geometry, stability, transient response, and the effects of tire properties and vehicle mass distribution.
8. To understand vehicle ride characteristics, the human response to vibration, and how to model vehicle ride, including random vibration analysis and design for ride comfort.
9. To investigate the use of active and semi-active systems for improving ride comfort and road holding, and to optimize vehicle design for these parameters.

SYLLABUS:

Introduction to Vehicle Dynamics: Various kinds of vehicles, Motions, Mathematical modelling methods, Multibody system approach, Lagrangian formulations, Methods of investigations, Stability concepts.

Mechanics of pneumatic tyres: Tyre construction, SAE recommended practice, Tyre forces and moments, Rolling resistance of tyres, Tractive effort and longitudinal slip, Cornering properties of tyres, Performance of tyre traction on dry and wet surfaces, Ride properties of tyres.

Performance characteristics of road vehicle: Equation of motion and maximum tractive effort, Aerodynamic forces and moments, Vehicle power plant and transmission characteristics, Prediction of vehicle performance, Operating fuel economy, Braking performance.

Handling and stability characteristics of road vehicles: Steering geometry, Steady state handling characteristics, Steady state response to steering input, Testing of handling characteristics, Transient response characteristics, Directional stability, Effects of tyre factors, Mass distribution and engine location on stability of handling.

Vehicle ride characteristics: Human response to vibration, Vehicle ride models, Introduction to random vibration - 1) Road suirface profile as a random function, 2) Frequency response function, 3) Evaluation of vehicle vertical vibration in relation to ride comfort criteria, 4) Active and semi active systems, 5) Optimum design for ride comfort and road holding.

Course Outcomes

1. Apply mathematical modeling techniques, including Lagrangian formulations, to analyze and simulate the dynamic behavior of vehicles.
2. Analyze the forces and moments acting on pneumatic tires, and understand their effect on vehicle performance in various conditions.
3. Calculate and predict road vehicle performance, including tractive effort, fuel economy, braking performance, and the effects of aerodynamics on vehicle dynamics.
4. Evaluate the handling and stability characteristics of vehicles, including the impact of steering geometry and transient responses to inputs.
5. Analyze the factors affecting vehicle directional stability, including the influence of tire characteristics, mass distribution, and engine location.
6. Model and analyze vehicle ride characteristics, including human vibration responses, and evaluate vertical vibrations in relation to ride comfort.
7. Investigate the effect of road surface profiles and frequency responses on vehicle vibrations and design systems to optimize ride comfort and road holding.
8. Apply random vibration principles to assess and improve vehicle ride performance, using active and semi-active suspension systems for optimal comfort and stability.

References:

1. Theory of Ground Vehicles by Wong, J.Y., John Wiley and Sons, NY, 1993.
2. Fundamentals of Vehicle Dynamics by Gillespie, T.D., SAE Publication, Warrendal, USA, 1992.
3. Tyres, Suspension and Handling by Dixon, J.C., SAE Publication, Warrendal, USA and Arnold Publication, London, 1997.

THIRD SEMESTER
MTMD 301 ELECTIVE SUBJECT – 3
B) TRIBOLOGY

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives

1. To understand the historical background and fundamental principles of viscosity, including its dependence on temperature and pressure, and its role in lubricants.
2. To examine the physical properties of mineral oils and their impact on lubrication, and understand the generalized Reynolds equation, flow, shear stress, and the energy equation.
3. To study the mechanisms of pressure development in lubrication and how these principles apply to bearing design.
4. To explore the concepts of circumferential flow, heat generation, and lubricant temperature in bearings, with an emphasis on bearing design considerations such as journal and parallel surface bearings.
5. To analyze the principles and application of elastohydrodynamic lubrication (EHL), including theoretical solutions, film thickness equations, and the behavior of deep-groove radial bearings and angular contact bearings.
6. To investigate surface topography, surface characterization, and the effects of surface roughness on lubrication, and derive Reynolds equations for partially lubricated surfaces.
7. To understand the principles of friction, friction theories, and surface contaminants, as well as their effects on bearing performance and lubrication.
8. To study wear mechanisms, wear classification, and laws of wear, and to identify materials with high wear resistance for lubrication applications.

SYLLABUS:

Historical background: Viscosity - Viscometry - Effect of temperature on viscosity - Effect of pressure in viscosity - Other physical properties of mineral oils - The generalized Reynolds equation - Flow and shear stress - The energy equation - The equation of state - Mechanism of pressure development.

Circumferential flow: Oil flow through a bearing having a circumferential oil groove - Heat generation and lubricant temperature - Heat balance and effective temperature - Bearing design: Practical considerations - Design of journal bearings - Parallel surface bearing - Step bearing - Some situations under squeeze film lubrication - The mechanism of hydrodynamic instability - Stiffness and damping coefficients - Stability.

Elastohydrodynamic lubrication: Theoretical consideration - Grubin type solution - Accurate solution - Point contact - Dimensionless parameters - Film thickness equations - Different regimes in EHL contact - Deep-groove radial bearings - Angular contact bearings - Thrust ball bearings - Geometry - Kinematics - Stress and deformations - Load capacity.

Surface topography: Surface characterization - Apparent and real area of contact - Derivation of average Reynolds equation for partially lubricated surface - Effect of surface roughness on journal bearings - Laws of friction - Friction theories - Surface contaminants - Frictional heating

- Effect of sliding speed on friction - Classification of wear - Mechanisms of wear - Quantitative laws of wear - Wear resistance materials.

Course Outcomes

1. Understand the role of viscosity and other physical properties of lubricants in determining the performance of lubrication systems.
2. Apply the Reynolds equation and energy balance to understand oil flow, heat generation, and pressure development in bearings.
3. Design and analyze journal and parallel surface bearings, and understand the effects of squeeze film lubrication and hydrodynamic instability.
4. Apply elastohydrodynamic lubrication theories to solve practical lubrication problems, including load capacity and deformations in bearing systems.
5. Analyze the effects of surface roughness and topography on lubrication performance, and calculate the impact of partial lubrication conditions.
6. Apply the principles of friction and wear to predict performance and select materials for bearings and other lubrication applications.
7. Design and optimize bearing systems by considering factors such as lubricant temperature, heat generation, and effective temperature.
8. Understand and classify wear mechanisms, and apply this knowledge to select materials and optimize lubrication conditions for improved wear resistance.

Reference:

1. Introduction to Tribology of Bearings by Majumdar, B.C.

THIRD SEMESTER
MTMD 301 ELECTIVE SUBJECT – 3
C) PRESSURE VESSEL DESIGN

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To give exposure to the engineering problems involved in the design of a pressure vessel.
2. To learn about the tests and analysis for various components of pressure vessels.
3. To know the procedure to design pressure vessels.
4. To familiarize the buckling and fracture analysis of pressure vessel under various load conditions.
5. To learn about various fatigue concepts involved in the design of pressure vessel.

SYLLABUS:

Introduction: Materials- shapes of Vessels –stresses in cylindrical, spherical and arbitrary shaped shells. Cylindrical Vessels subjected to internal pressure, wind load bending and orqueilation of pressure vessels –conical and tetrahedral vessels.

Theory of thick cylinders: Shrink fit stresses in built up cylinders – auto frettage of thick Cylinders, Thermal stresses in Pressure Vessels.
Theory of rectangular plates: Pure bending – different edge conditions.
Theory of circular plates: Simple support and clamped ends subjected to concentrated and Uniformly distributed loads-stresses from local loads. Design of dome bends, shell connections, flat heads and cone openings.

Discontinuity stresses in pressure vessels: Introduction beam on an elastic foundation, infinitely long beam semi-infinite beam, cylindrical vessel under axially symmetrical loading, extent and significance of load deformations on pressure vessels, discontinuity stresses in vessels, stresses in a bimetallic joints, deformation and stresses in flanges.

Pressure vessel materials and their environment: Introduction ductile material tensile tests, Structure and strength of steel Leuder's lines determination of stress patterns from plastic flow Observations, behaviour of steel beyond the yield point, effect of cold work or strain hardening on The physical properties of pressure vessel steels fracture types in tension. Toughness of Materials, effect of neutron irradiation of steels, fatigue of metals, fatigue crack growth fatigue life.
Fatigue aspects of Pressure vessel: Prediction cumulative fatigue damage stress theory of failure of vessels subject to steady state and fatigue conditions.

Stress concentrations: Influence of surface effects on fatigue, effect of the environment and other factors on fatigue life thermal stress fatigue creep and rupture of metals at elevated Temperatures, hydrogen embitterment of pressure vessel steels brittle fracture effect of Environment on fracture toughness, fracture toughness relationships criteria for design with Defects, significance of fracture mechanics evaluations, effect of warm pre-stressing on the Ambient temperature toughness of pressure vessel steels.

Design features: Localized stresses and their significance, stress concentration at a Variable thickness transition section in a cylindrical vessel, stress concentration about a circular Hole in a plate subject to tension, elliptical openings, stress concentration, stress concentration Factors for position, dynamic and thermal transient conditions, theory of reinforced openings and Reinforcement, placement and shape fatigue and stress concentration.

Course Outcomes:

1. Understood the concepts of various types of pressure vessels and their applications .
2. Identify various stresses in different components of pressure vessels.
3. Design different types of pressure vessels.
4. Be thorough with buckling and fracture analysis of pressure vessels and their components.

References:

1. Theory and design of modern Pressure Vessels / John F. Harvey 'Van/ Nostrand Reihold Company/NY.
2. Pressure Vessel Design and Analysis / Bickell M. B. Ruizes / Macmillan Publishers
3. Process Equipment design / Beowll & Yound Ett.

4. Indian standard code for unfired Pressure vessels IS 2825.
5. Pressure Vessels Design Hand Book Henry H. Bednar PE / CB S Publishers / New Delhi.
6. Theory of plates and shells / Timoshenko& Noinosky / Dover Publications.
7. Stress in Beams, Plates and Shells / Ansel C. Ugural / CRC Press / 3rd Edition

THIRD SEMESTER
MTMD 301 ELECTIVE SUBJECT – 3
D) GEAR ENGINEERING

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To understand fundamentals of gear design and gear failures.
2. To learn about gear manufacturing processes and inspection of gear tooth failure modes.
3. To understand the analysis of gear train.
4. Inculcate an attitude of team work, critical thinking, communication, planning and scheduling through design projects.
5. To develop competency in understanding of theory of all types of gears.

SYLLABUS:

Introduction: Principles of gear tooth action, Generation of Cycloid and Involute gears, Involutometry, gear manufacturing processes and inspection, gear tooth failure modes, stresses, selection of right kind of gears.

Spur Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of spur gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.

Helical Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of helical gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.

Bevel Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of bevel gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.

Worm Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of worm gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Heat dissipation considerations. Design of gear shaft and bearings.

Gear failures: Analysis of gear tooth failures, Nomenclature of gear tooth wear and failure, tooth breakage, pitting, scoring, wear, overloading, gear-casing problems, lubrication failures

Gear trains: Simple, compound and epicyclic gear trains, Ray diagrams, Design of a gear box of an automobile, Design of gear trains from the propeller shafts of airplanes for auxiliary systems.

Optimal Gear design: Optimization of gear design parameters, Weight minimization, Constraints in gear train design-space, interference, strength, dynamic considerations, rigidity etc. Compact design of gear trains, multi objective optimization of gear trains. Application of Traditional and non-traditional optimization techniques.

Course Outcomes:

Upon the successful completion of the course, learners will be able to

1. Understand fundamentals of gear theory which will be the prerequisite for gear design.
2. Perform force analysis of Spur, Helical, Bevel, Worm and Worm gear.
3. Analyse speed and torque in epi-cyclic gear trains which will be the prerequisite for gear box design.
4. Understand different gear tooth failures and their causes.
5. Design an optimal gear train by considering weight, space, strength factors.

References:

1. Maleev and Hartman, Machine Design, C.B.S. Publishers, India.
2. Henry E.Merrit,Gear engineering ,Wheeler publishing,Allahabad,1992.
3. Practical Gear design by Darle W. Dudley, McGraw-Hill book company
4. Earle Buckingham, Analytical mechanics of gears, Dover publications, New York, 1949.
5. G.M.Maitha, Hand book of gear design, TaTa Mc.Graw Hill publishing company Ltd., New Delhi,1994.

THIRD SEMESTER
MTMD 301 ELECTIVE SUBJECT – 3
E) ADVANCED MECHANICS OF COMPOSITE MATERIALS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

COURSE OBJECTIVES:

1. Enlighten the students in different types of composites and reinforcements.
2. Explain the behavior of constituents in composite materials.
3. Familiarization with basic expression and methods used in mechanics of composite structures.
4. Elucidate mechanical behavior of anisotropic materials and their failure mechanisms.
5. Illuminate the knowledge and analysis skills in applying basic laws in mechanics of composite materials.

SYLLABUS:

Basic concepts and characteristics: Geometric and Physical definitions, natural and man-made composites, Aerospace and structural applications, types and classification of composites.

Reinforcements: Fibres – Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosets, Metal matrix and ceramic composites.

Micromechanics: Unidirectional composites, constituent materials and properties, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. Characterization of composite properties.

Coordinate transformation: Hooke's law for different types of materials, Hooke's law for two dimensional unidirectional lamina, Transformation of stress and strain, Numerical examples of stress strain transformation, Graphic interpretation of stress – strain relations. Off – axis, stiffness modulus, off – axis compliance.

Elastic behavior of unidirectional composites: Elastic constants of lamina, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

Strength of unidirectional lamina: Micro mechanics of failure, Failure mechanisms, strength of an orthotropic lamina, strength of a lamina under tension and shear maximum stress and strain criteria, application to design. The failure envelope, first ply failure, free-edge effects. Micros mechanical predictions of elastic constants.

Analysis of laminated composite plates: Introduction thin plate theory, specially orthotropic plate, cross and angle ply laminated plates, problems using thin plate theory.

COURSE OUTCOMES:

1. Distinguish and categorize the types of composite materials.
2. Apply the concepts of tensors and estimate the engineering constants of composite materials.

3. Identify and apply the concepts of plate theory in solving composite structural problems.
4. Interpret the cause of failure of the composite structures.
5. Apply Micromechanics principles in estimating the properties of fibrous composites

References:

1. Mechanics of Composite Materials/ R. M. Jones/ Mc Graw Hill Company, New York, 1975.
2. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.
3. Analysis and performance of fibre Composites/ B. D. Agarwal and L. J. Broutman/ Wiley- Interscience, New York, 1980.
4. Mechanics of Composite Materials/ Second Edition (Mechanical Engineering)/ Autar K. Kaw, Publisher: CRC
5. Analysis of Laminated Composite Structures/ L. R. Calcote/ Van Nostrand Rainfold, New York, 1969.
6. Advanced Mechanics of Composite Materials/ Vasiliev & Morozov/Elsevier/Second Edition

THIRD SEMESTER

MTMD 302 ELECTIVE SUBJECT – 4

A) COMPUTATIONAL FLUID DYNAMICS

Periods/week: 4 Th. Ses. : 30 Exam: 70

Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To introduce the basic concepts of the Finite Difference Method (FDM), Finite Volume Method (FVM), and Finite Element Method (FEM) for solving partial differential equations.
2. To understand the governing equations and boundary conditions for various physical problems and derive the corresponding finite difference equations.
3. To explore the solution methods for elliptic equations, including finite difference formulations, direct methods (Gaussian elimination), and interactive solution methods.
4. To study the solution techniques for parabolic equations, including explicit and implicit schemes, Von Neumann stability analysis, alternating direction implicit schemes, and fractional step methods.
5. To investigate hyperbolic equations and their solution methods, including explicit schemes, Von Neumann stability analysis, multi-step methods, and solving nonlinear problems in wave equations.
6. To learn the numerical methods for solving Burgers' equations using explicit and implicit schemes and the Runge-Kutta method.
7. To study the formulations for incompressible viscous flows using finite difference methods, pressure correction methods, and vortex methods for fluid flow simulations.
8. To explore the treatment of compressible flows, including potential equations, Euler equations, and the Navier-Stokes system of equations, along with their boundary conditions.
9. To understand and apply the Finite Volume Method (FVM) in solving fluid dynamics problems, both in two and three-dimensional settings.
10. To study standard variational methods for linear fluid flow problems and their application to steady-state and transient problems.

Syllabus:

Introduction: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

Solution methods: Solution methods of elliptical equations - finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equations- explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations.

Burgers equations: Explicit and implicit schemes, Runge-Kutta method. Formulations of incompressible viscous flows: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

Treatment of compressible flows: potential equation, Eluer equations, Navier-stokes system of equations, flowfield-dependent variation methods, boundary conditions, example problems.

Finite volume method: Finite volume method via finite difference method, formulations for two and three-dimensional problems.

Standard variational methods - 1: Linear fluid flow problems, steady state problems,
Standard variational methods - 2: Transient problems.

Course Outcomes:

1. Gain a foundational understanding of different numerical methods, including finite difference, finite volume, and finite element methods, for solving complex fluid dynamics problems.
2. Develop the ability to formulate and solve elliptic partial differential equations using finite difference methods and direct solution techniques.
3. Analyze and implement explicit and implicit schemes for solving parabolic equations, and apply stability analysis using Von Neumann's method.
4. Apply various numerical techniques to solve hyperbolic equations and understand the stability conditions for different solution schemes.
5. Solve Burgers' equations using both explicit and implicit methods, and utilize the Runge-Kutta method for more accurate solutions.
6. Develop and implement finite difference formulations for incompressible viscous flows, and understand pressure correction methods and vortex methods.
7. Apply numerical methods for solving compressible fluid flow problems, including using Euler and Navier-Stokes equations, and correctly handle boundary conditions.
8. Implement the Finite Volume Method for solving two and three-dimensional problems in computational fluid dynamics.
9. Solve steady-state and transient fluid flow problems using standard variational methods and understand their applications in real-world fluid mechanics.

References:

1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.
2. Text book of fluid dynamics, Frank Chorlton, CBS Publishers & distributors, 1985.
3. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.
4. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
5. Computational Fluid Dynamics: Basics with applications/John D. Anderson/ Mc Graw Hill.
6. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
7. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition

THIRD SEMESTER
MTMD 302 ELECTIVE SUBJECT – 4
B) ROBOTICS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

COURSE OBJECTIVES:

- To develop the student's knowledge in various robot structures and their workspace.
- To develop student's skills in performing spatial transformations associated with rigid body motions.
- To develop student's skills in perform kinematics analysis of robot systems.
- To provide the student with knowledge of the singularity issues associated with the operation of robotic systems.
- To provide the student with some knowledge and analysis skills associated with trajectory planning.
- Students will demonstrate an ability to solve inverse kinematics of simple robot Manipulators.
- Students will demonstrate an ability to obtain the Jacobian matrix and use it to identify singularities.
- Students will demonstrate an ability to generate joint trajectory for motion Planning.
- Students will demonstrate knowledge of robot controllers.
- To learn about analysing robot kinematics and robot programming

SYLLABUS:

Introduction, Transformations and kinematics: Historical development, A sense of mechanisms, Robotic systems, Classification of robots, Position, orientation and location of a rigid body, Mechanics of robot manipulators. Objectives, Homogeneous coordinates, Homogeneous transformations, Coordinate reference frames, Some properties of transformation matrices, Homogeneous transformations and the manipulator: The position of the manipulator in space, Moving the base of the manipulator via transformations, Moving the tool position and orientation.

Position analysis of serial manipulators: Link parameters and link coordinate systems, Denavit-Hartenberg homogeneous transformation matrices, Loop-closure equations, Other coordinate systems, Denavit-Hartenberg method: Position analysis of a planar 3-DOF manipulator: Direct kinematics, Inverse kinematics, Method of successive screw displacements, Wrist centre position.

Position analysis of parallel manipulators: Structure classification of parallel manipulators, Denavit-Hartenberg method versus geometric method, Position analysis of a planar 3RRR parallel manipulator, Geometry, Inverse kinematics and Direct kinematics, Position analysis of a spatial orientation mechanism.

Jacobian analysis of serial manipulators: Differential kinematics of a rigid body, Differential kinematics of serial manipulators, Screw coordinates and screw systems, Manipulator Jacobian matrix.

Trajectory generation: General considerations in path description and generation, Joint space schemes, Cartesian space schemes, Geometric problems with Cartesian paths, Path generation at run time, Description of paths, Planning paths using the dynamic model, Collision-free path planning.

Robot Programming: Robot languages: AL, AML, RAIL, RPL, VAL, Demonstration of points in space: Continuous path (CP), Via points (VP), Programmed points (PP).

Robot dynamics: Lagrange- Euler Formulation- Newton-Euler Formulations- Problems on Planar two link robot manipulators.

COURSE OUTCOMES:

Upon completion of this course, the students can able to apply the basic engineering

To learn about knowledge for the design of robotics.

Will understand robot kinematics and robot programming. Will understand application of Robots

To learn about force and torque sensing To learn about application of robot

References:

1. Robot Analysis - The Mechanics of Serial and Parallel Manipulators by Lung-Wen Tsai, John Wiley & Sons, Inc.
2. Introduction to Robotics - Mechanics and Control by John J. Craig, Addison-Wesley Longman Inc., 1999.
3. Robotic Engineering - An Integrated Approach by Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Prentice-Hall of India Private Limited, 1994.
4. Robotics: Fundamental Concepts and Analysis / Ashitava Ghosal / Oxford.
5. Introduction to Robotic Mechanics and Control / J J Craig/ Pearson / 3rd edition.
6. Robotics / Fu K S/ McGraw Hill.
7. Robot Analysis and Intelligence /Asada and Slotine / Wiley Inter-Science.
8. Robotics and Control / Mittal R K & Nagrath I J / TMH
9. Mechanics of Serial and Parallel Manipulators – Lung Wen Tsai

THIRD SEMESTER
MTMD 302 ELECTIVE SUBJECT – 4
C) VISION SYSTEMS AND IMAGE PROCESSING
Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course objectives:
On successful completion of this course, students should have the skills and knowledge to:
- This course introduces students to fundamental problems in image processing and computer vision, as well as their state-of-the-art solutions.
- Topics covered in detail include: image formation, image filtering, camera geometry, thresholding and image segmentation, edge, point and feature detection, geometric frameworks for vision, single view and two views geometry; 3D visual reconstruction, camera calibration; stereo vision, image classification and object recognition etc.
- The course features extensive practical components including computer labs and Term Research projects that provide students with the opportunity to practice and refine their skills in image processing and computer vision.

Syllabus:
Machine vision: Vision sensors - Comparison with other types of sensors - Image acquisition and recognition - Recognition of 3D objects - Lighting techniques - Machine vision applications. Image representation: Application of image processing - Image sampling, Digitization and quantization - Image transforms.
Spatial domain techniques: Convolution, Correlation. Frequency domain operations - Fast Fourier transforms, FFT, DFT, Investigation of spectra. Hough transform
Image enhancement: Filtering, Restoration, Histogram equalisation, Segmentation, Region growing.
Image compression: Edge detection - Thresholding - Spatial smoothing - Boundary and Region representation - Shape features - Scene matching and detection - Image classification.

Course Outcomes
Upon successful completion, students will have the knowledge and skills to:
- understand the need for image transforms different types of image transforms and their properties.
- develop any image processing application.
- understand the rapid advances in Machine vision.
- learn different techniques employed for the enhancement of images.
- learn different causes for image degradation and overview of image restoration techniques.
- understand the need for image compression and to learn the spatial and frequency domain techniques of image compression.
- learn different feature extraction techniques for image analysis and recognition

References:

1. Digital Image Processing by Gonzalez, R.C. and Woods, R.E., Addison Wesley Publications.
2 Robot Vision by Prof. Alan Pugh (Editor), IFS Ltd., U.K.
3. Digital Image Processing by A. Rosenfled and A. Kak, Academic Press.

4. The Psychology of Computer Vision by P. Winstan, McGraw-Hill.
5. Algorithms for Graphics and Image Processing by T. Pavidis, Springer Verlag

THIRD SEMESTER
MTMD 302 ELECTIVE SUBJECT – 4
D) DESIGN FOR MANUFACTURE AND ASSEMBLY

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs. Credits: 4

Course Objectives:

1. To introduce the design philosophy and steps involved in the design process, with an emphasis on manufacturability and designing for economical production.
2. To explore material selection criteria for design, focusing on the developments in material technology and its relationship with process selection.
3. To provide a comprehensive understanding of various machining processes, including design considerations for machining ease, dimensional tolerance, and surface roughness.
4. To evaluate metal casting processes and their design considerations, including the use of solidification simulation tools in casting design.
5. To explore different welding processes and provide design guidelines for weldments, brazed joints, and the effects of thermal stresses.
6. To understand the design factors in forging, including die design, parting lines, and general recommendations for drop forging.
7. To provide design guidelines for extrusion and sheet metal work, covering punching, blanking, bending, and deep drawing processes.
8. To understand the advantages of assembly processes, the impact of automation, and how assembly methods contribute to design efficiency.
9. To study automatic assembly transfer systems, including continuous, intermittent, and indexing mechanisms.
10. To explore design for manual assembly, including assembly fits, general design guidelines, and the systematic DFA methodology to enhance assembly efficiency.

SYLLABUS:

Introduction: Design philosophy steps in Design process - General Design rules for manufacturability - basic principles of designing for economical production - creativity in design. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection, process selection charts.

Machining process: Overview of various machining processes - general design rules for machining - Dimensional tolerance and surface roughness - Design for machining-Ease-Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

Metal casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.

Metal joining: Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints. Forging - Design factors for Forging - Closed dies forging design - parting lines of dies drop forging die design - general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

Assemble advantages: Development of the assemble process, choice of assemble method assemble advantages social effects of automation.

Automatic assembly transfer systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

Design of manual assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

Course Outcomes:

1. Understand the basic principles of the design process and its integration with manufacturing, leading to the creation of products that are easier and more economical to produce.
2. Develop skills in selecting appropriate materials for a design, considering the advancements in material technology and the relationship between material and process selection.
3. Gain an understanding of various machining processes and apply design rules to simplify machining tasks, resulting in cost-effective production and high-quality parts.
4. Ability to assess and select appropriate casting processes, with a focus on design considerations, tolerances, and solidification simulations.
5. Gain knowledge of welding processes and design considerations for weldments, improving the strength and quality of welded joints.
6. Learn to design for forging, including understanding die design and creating parts suitable for forging processes to improve efficiency and reduce costs.
7. Apply design principles for extrusion and sheet metal work, enhancing product design for mass production and efficient manufacturing processes.
8. Understand the principles of assembly processes and their impact on product design, contributing to optimized assembly and reduced production time.
9. Design efficient automatic assembly systems, including understanding transfer mechanisms, indexing, and operator-paced systems to improve automation.
10. Develop proficiency in designing products for manual assembly, optimizing handling time, insertion operations, and overall assembly efficiency using DFA techniques.

References:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed. 2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y. 1990.
4. Computer Aided Assembly London/ A Delbainbre/.
5. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight/CRC Press/2010
6. Design and Manufacturing / Surender Kumar & Goutham Sutradhar / Oxford & IBH Publishing Co. Pvt .Ltd., New Delhi, 1998.

THIRD SEMESTER
MTMD 302 ELECTIVE SUBJECT – 4
E) AERODYNAMICS

Periods/week: 4 Th. Ses. : 30 Exam: 70
Examination (Theory): 3hrs.   Credits: 4

Course Objectives:

1. To introduce the basic aerodynamic concepts including lift, drag, moment, and related coefficients and to understand their relationship in various flow regimes.
2. To review vector operations and develop a strong understanding of the conservation equations of mass, momentum, and energy in fluid dynamics.
3. To understand the concepts of streamlines, streaklines, and pathlines and to apply them in analyzing fluid flow.
4. To introduce the principles of inviscid and incompressible flow, including Bernoulli's equation, low-speed wind tunnel flows, and ideal lifting flows.
5. To analyze and solve problems related to incompressible flow over airfoils, focusing on the Kutta condition, thin airfoil theory, and vortex panel methods.
6. To study finite wing theory, including downwash, induced drag, and methods like Prandtl's lifting line theory for practical aerodynamic analysis.
7. To introduce compressible flows and the thermodynamics of compressible flow, understanding governing equations and the effects of compressibility.
8. To analyze shock waves in compressible flows, including normal and oblique shocks, expansion waves, and their effects on flow characteristics over various geometries.
9. To learn linearized theory for subsonic and supersonic flows, understanding the effects of compressibility, shockwave formation, and supercritical flow behaviors.

Syllabus:

Introduction: Lift, drag, moment and related coefficients; Vector operations (review); conservation equations (mass, momentum and energy); Streamlines, streaklines and pathlines; Velocity potential and stream function

Inviscid, Incompressible flow: Bernoulli's equation, low-speed wind tunnel flows; Governing equations and boundary conditions; Elementary flows (uniform, sources, sinks and vortex); ideal lifting flow past a circular cylinder, Kutta-Joukowski theorem and lift generation; source panel method for non-lifting flows; d' Alembert's paradox.

Incompressible flow over airfoils: Introduction; Kutta Condition; Thin airfoil theory (symmetric, cambered); Aerodynamic center; vortex panel method for lifting flows; qualitative picture of viscous flow.

Finite Wing Theory: Introduction; Downwash and induced drag; Biot-Savart Law and Helmholtz's Theorems; Prandtl's lifting line theory; Numerical lifting-line method; Some ractical aspects.

Introduction to Compressible flows (Inviscid): Thermodynamics review; Governing equations; Compressibility.

Normal Shock, Oblique Shock and Expansion Waves: Basic relations; flow over wedges and cones; shock interactions; blunt body flow; Prandtl-Meyer expansion waves; qualitative pitcute of shock wave-boundary layer interaction; quasi-one-dimensional flow through nozzles and diffusers.

Linearized Theory for Subsonic and Supersonic Flows: Introduction; Velocity potential equation and linearized form; Prandtl-Glauert correction; Improved corrections; Critical Mach number; Drag divergence; Supercritical airfoils and area rule.

Course Outcomes:

1. Understand and compute lift, drag, moments, and their associated coefficients for different aerodynamic scenarios, and relate them to practical engineering problems.
2. Apply conservation equations (mass, momentum, energy) to analyze fluid flows and derive relationships between velocity and pressure fields in various flow conditions.
3. Analyze fluid flow using streamlines, streaklines, and pathlines, and understand the significance of velocity potential and stream functions in aerodynamic applications.
4. Apply Bernoulli's equation to solve problems in low-speed wind tunnel flows, ideal lifting flow past a circular cylinder, and utilize methods like the source panel for non-lifting flows.
5. Use thin airfoil theory to analyze aerodynamic properties of symmetric and cambered airfoils, and apply vortex panel methods to simulate lifting flows and understand viscous effects.
6. Apply finite wing theory to compute induced drag, downwash, and other practical aerodynamic phenomena, including the application of Prandtl's lifting line theory for real-world problems.
7. Understand the fundamentals of compressible flow and thermodynamics, and analyze flow characteristics in compressible regimes using governing equations and the effects of compressibility.
8. Analyze and design for normal shock, oblique shock, and expansion wave behavior, and solve problems involving shock interactions and boundary layer effects in compressible flows.
9. Utilize linearized theory for subsonic and supersonic flow analysis, including calculating drag divergence, shock formation, and the design implications of supercritical airfoils.

References:

1. J. D. Anderson, Jr, Fundamentals of Aerodynamics, McGraw Hill, 2005.
2. J. J. Bertin, Aerodynamics for Engineers, Pearson Education, 2002.
3. L. J. Clancy, Aerodynamics, Himalayan Books, 1996.
4. E. L. Houghton, and N. B. Carruthers, Aerodynamics for Engg. Students, Arnold Pub, 1988.
5. M. Kuethe, and C-Y Chow, Foundations of Aerodynamics, Wiley, 1998.

THIRD SEMESTER
MTMD 304 INTERNAL ASSESSMENT OF PROJECT

Periods per week : 3 Viva : 100
Credits : 4

A student has to submit his proposal for his Project work, which includes the area of interestcoupled with literature survey.

FOURTH SEMESTER

MTMD 401 EXTERNAL ASSESSMENT OF PROJECT

Total Marks: 100 Credits: 16

A student has to submit and defend his work in the presence of Expert Committee which includes external Examiner