Master of Technology

in

Mechanical Engineering

(Design)

Course Structure & Syllabus

Department of Mechanical Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Mechanical Engineering (Design)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/Week	Credit
			L	T	P		
1	ME-631	Advanced Mechanics of Solids	4	0	0	4	4
2	ME-632	Computer-Aided Design and Analysis	4	0	0	4	4
3	ME-633	Finite Element Analysis for Mechanical Design	4	0	0	4	4
4	ME-7MN	Programme Elective-I	4	0	0	4	4
5	ME-7MN	Programme Elective-II	4	0	0	4	4
6	ME-634	Design Engineering Lab - I	0	0	4	4	2
Total			**20**	**0**	**4**	**24**	**22**

Programme Elective-I & II: List of Programme Electives are given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/Week	Credit
			L	T	P		
1	ME-641	Principles of Vibrations and Passive Control	4	0	0	4	4
2	ME-642	Advanced Concepts in Design	4	0	0	4	4
3	ME-643	Tribological System Design	4	0	0	4	4
4	ME-7MN	Programme Elective-III	4	0	0	4	4
5	ME-70N	Institute Elective	4	0	0	4	4
6	ME-644	Design Engineering Lab-II	0	0	4	4	2
Total			**20**	**0**	**4**	**24**	**22**

Programme Elective-III & Institute Elective: The List of Programme and Institute Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME-798	M. Tech Dissertation	--	18
Total			**--**	**18**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME-799	M. Tech Dissertation	--	18
Total			**--**	**18**

Total Credits of the Programme = 80

Annexure

List of Programme Electives

Programme Elective-I

ME-741: Mathematical Methods in Mechanical Design

ME-742: Data-Driven Techniques for Mechanical Engineering

ME-743: Fault Diagnostics and Signal Processing

ME 744: Product Design and Development

ME-745: Smart Structures and Systems

Programme Elective-II

ME-751: Optimization Methods in Engineering

ME-752: Bearing Design and Lubrication

ME-753: Mechanics of Composite Materials

ME-754: Acoustics and Noise Control

ME-755: Theory of Mechanisms

Programme Elective-III

ME-761: Robotics

ME-762: Experimental Stress Analysis

ME-763: Modal Analysis and Dynamic System Design

ME-764: Mechatronics and Control

ME-765: Non-Destructive Testing Methods in Design

ME-766: Design of Automotive Systems

Institute Elective

Course No.	Institute Elective (Interdisciplinary)
ME-701	Thermal Managements of Electronic Systems
ME-702	Measurement and Data Acquisition System
ME-703	Optimization Methods in Engineering
ME-704	Soft Computing Methods in Engineering
ME-705	Fault Diagnosis and Signal Processing
ME-706	Introduction to Design of Experiments
ME-707	Logistics and Supply Chain Management

Advanced Mechanics of Solids

Course Code: ME-631	Course Type: Core
Contact Hours/Week: 4L	Course Credits: 4

Course Objectives

- To consolidate the solid mechanics principles presented in the student's engineering degree, and the equip the students with skills required to solve a range of engineering problems they have not faced before.
- Methods of three-dimensional stress and strain analysis shall be extended to allow the student to obtain solutions using analytical and/or numerical methods. This will include the analysis of principal stresses and strains and failure criteria

Course Content

Stress at a point, stress notations, symmetry of stress array and stress on an arbitrary oriented plane, transformation of stresses, principal stresses and other properties, Mohr's circle in 2D and 3D, differential equations of motion of a deformable body, Airy's stress function and its importance. Deformations, deformations in the vicinity of a point, strain of a line element, final direction of a linear element, the state of strain at a point, shear strain components, principal axes of strain and principal strains, plane state of strain, plane strains in polar coordinates, compatibility conditions, and strain measurements. Non-linear materials response, theories of failure and their significance, comparison of failure criterions and their interpretation for general yielding, deviatoric plane, yield locus and surfaces of Tresca and Von-Mises. Principle of stationary potential energy, Castigliano's theorem of deflection, Castigliano's theorem on the deflection for linear load-deflection relations, strain energy for axial loading, strain energies for beams, strain energy for torsion, fictitious load method, statistically indeterminate structures. Torsion of prismatic shafts, non-symmetrical bending, plane of loads, bending stresses in beams subject to non-symmetrical bending, deflection of straight beams subjected to non-symmetrical bending.

Course Outcomes

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

CO1: Understand advanced stress/strain correlations.

CO2: Obtain simple mathematical and physical relationships between mechanics and materials.

CO3: Establishing thorough understanding of Advanced methods.

CO4: Understand contemporary issues in solid mechanics research.

Books and References

1. Foundations of Solid Mechanics by Fung, Prentice Hall.
2. Elasticity by J. R. Barber, Springer.
3. Advanced Mechanics of Solids by L.S Srinath, McGraw Hill Education
4. Continuum Mechanics for Engineers by Mase and Mase, Heritage Publishers.

Computer-Aided Design and Analysis

Course Code: ME-632 | Course Type: Core
Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- Exposure to CAD tools for use in mechanical engineering design conceptualization, geometric modelling, communication, analysis
- Impart knowledge related to principles, methods and techniques of 3D modelling in parametric CAD software.
- To provide an experiential learning environment, while applying CAD, CAE tools to design of simple parts, assemblies, mechanisms and structures.

Course Content

Historical development, explicit and implicit equations, intrinsic equations, parametric equations, coordinate systems, Introduction to CAD/CAM/CAE software in product life cycle, concept of parametric modelling, feature based modelling, Introduction to drafting theory, parametric sketching and modelling, constrained model dimensioning, type of constraints, Feature and sequence of feature editing, views, annotations, Material addition and removal for extrude, revolve, blend, helical sweep, swept blend, variable section sweep, types of Fillets, draft and ribs features, types of Chamfer, types of Hole, Shell, Stiffener, basics of curves and surfaces, references and construction features of points, axis, curves, planes, surfaces, Multi-section solid, Removed multi-section solid, Introduction to multibody concept, Transformations, surfacing modelling, Types of assembly approach, Types of Constrains and DOF, placement of components in the Assembly, Manipulating Components, Top down and bottom up design approach, Assembly Drafting, Bill of material, Ballon creation, Graph Tree Reordering, Parametric relations and design optimization parameters creation, mass property analysis, design analysis for mass properties, analysis of stress, thermal stress, optimum design of machine components, Mechanism design, assembly and analysis.

Course Outcomes

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

CO1: Use parametric 3D CAD software tools for making geometric part models, assemblies and automated drawings of mechanical components and assemblies.

CO2: Evaluate design and optimize it using commercial CAD, CAE software for required mass properties/ stress, deflection / temperature distribution etc. under realistic loading and constraining conditions.

CO3: Utilize CAD software tools to assemble a mechanism from a schematic or component drawings, and perform positional, path, kinematic, and dynamic analyses of the mechanism in motion.

Books and References

1. Manuals & Tutorials on CAD/CAE packages like CATIA, ABAQUS, ANSYS etc. latest available in the lab.
2. Geometric Modeling by Michael E. Mortenson, Third addition, Industrial Press Inc.
3. CAD CAM Theory and Practice by I. Zeid, McGraw Hill.
4. Computer Aided Engineering Design by Saxena and Sahay, Anamaya N. Delhi.

Finite Element Analysis for Mechanical Design

Course Code: ME-633 | Course Type: Core
Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To learn the basic principles of finite element analysis for mechanical design.
- To learn the theory and procedures of finite elements methodology.
- To learn and apply finite element for solutions of different solid mechanics problems.

Course Content

Concept and history of FEM, steps of FEA, approaches of FEA-fundamentals of Galerkin's and Raleigh-Ritz approaches, use of FEA solution for mechanical design. Governing equation and boundary conditions for 1D FEA of bar axial deformation and beam transverse bending problems, weak formulation and functional, polynomial approximation, standard 1D shape functions of C^0 and C^1 continuity elements, derivation of element matrices and vectors, assembly procedure, imposition rule for boundary conditions and solver technology for nodal solution, co-ordinate transformation and numerical integration. Governing equation and boundary conditions for describing steady state plane and axisymmetric elastic stress analysis problems: finite element formulation following the steps of integral formulation, discretization and polynomial approximation using standard 2D elements, development and evaluation of elemental matrices, assembly of matrices using assembly rules, imposition procedure for application of essential boundary conditions and numerical solution of finite element equations, post computation of the solutions. Introduction about software packages for FEA, techniques of solid modeling using 2D and 3D primitives, meshing technique for 1D, 2D and 3D domains, methods of application of boundary conditions, analysis techniques and solution finding techniques, post-processing of FEA solutions for mechanical design, MATLAB based programming for FEA.

Course Outcomes

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

CO1: Understand the concepts behind variational methods and weighted residual methods in FEM.
CO2: Identify the application and characteristics of different FEA elements such as bar element, CST element isoparametric elements and other higher order elements.
CO3: Develop element characteristic equations and global stiffness matrices for different solid mechanics problems.

Books and References

1. Introduction to Finite Elements in Engineering by Chandrupatla, and Belegundu, PHI Pvt. Ltd., New Delhi
2. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
3. The Finite Element Method for Engineers by Huebner, Dewhirst, Smith, and Byrom, John Wiley and Sons (Asia) Pte Ltd, Singapore
4. An Introduction to Finite Element Method by J.N. Reddy, TMH, New Delhi
5. The Finite Element Method Using MATLAB by Kwon and Bang**,** CRC Press, NY.

Principles of Vibration and Passive Control

Course Code: ME-641 — Course Type: Core
Contact Hours/Week: 4L — Course Credits: 4

Course Objectives

- To understand the fundamental principles of mechanical vibration, including its sources, types, and characteristics.
- To analyze single and multi-degree-of-freedom vibrating systems using mathematical models.
- Investigate the effects of damping, stiffness, and mass on the behaviour of vibrating systems and their implications for control strategies.

Course Content

Basic Concepts of Vibrations, Classification of Vibration, Fundamentals of Vibration, Free Vibration of Undamped Systems; Free Vibration with Viscous Damping, Logarithmic Decrement, Loss Coefficient, Free Vibration with Coulomb Damping, Free Vibration with Hysteretic Damping.

Harmonically Excited Vibration – Response of an Undamped System Under Harmonic Force; Response of a Damped System Under Harmonic Force; Response of a Damped System Under the Harmonic Motion of the Base; Response of a Damped System Under Rotating Unbalance; Forced Vibration with Coulomb Damping; Forced Vibration with Hysteresis Damping. Energy Method, Rayleigh Method, Introduction to Lagrange Equations; Applications of Lagrange Equations; Free-Vibration of Undamped Systems, Semidefinite Systems; Eigen Value Problem for Undamped-Free Vibration; Orthogonality, Expansion theorem; Normal modes and their properties; Response to initial excitation; Forced harmonic vibration; Matrix Formulation, Stiffness and Flexibility Influence Coefficients, Rayleigh's Method, Rayleigh-Ritz Method; Dunkerley's Formula, Introduction to Random and Nonlinear Vibrations, Damping Models and Measures, Origin of Structural Damping, Damping-Stress Relationship, Selection Criteria for Linear Hysteretic Materials, Combined Fatigue-Strength Damping Criteria, Dynamic Vibration Neutralizers, Self-tuned Pendulum Neutralizer, Optimum Design of Damped Absorbers Vibration Isolators with Complex Stiffness, Isolators with Coulomb Damping, Suspension systems, Feedback Vibration Control.

Course Outcomes

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

CO1: Solve SDOF systems for free and forced vibrations
CO2: Model and solve Two-DOF and MDOF vibration problems.
CO3: Apply passive vibration control by structural design
CO4: Analyse and design dynamic vibration absorbers and isolators for vibration attenuation
CO5: Apply active feedback for vibration control

Books and References

1. Fundamental of Mechanical Vibration by S Grahm Kelly, MGH Intl. Edition.
2. Mechanical Vibration by S.S Rao, Wesley Publishing Company.
3. Vibration control of active structures: An Introduction by A. Preumont, Springer.
4. Vibration with control by D. J. Inman, John Wiley and Sons.

Advanced Concepts in Design

Course Code: ME-642 Course Type: Core
Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart knowledge about various aspects of design process.
- To introduce the fundamental design aspects based on manufacturing, assembly and reliability of component.
- To enable the students to explore concepts pertaining to fatigue fracture based design of component.

Course Content

Design Philosophies, Design for X: Reliability, Aesthetics and Ergonomics, General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability, Feature tolerances, Geometric tolerances, Assembly Processes-Handling and insertion process-Manual, automatic and robotic assembly, Cost of Assembly, Number of Parts, DFA guidelines**,** Introduction: The study of Reliability and Maintainability, Concepts, Terms and Definitions, Applications, The Failure Distribution: The reliability Function, Rise in stresses due to crack, Crack tip opening displacement, LEFM: Effect of crack on strength of ductile and brittle material, Crack opening modes and Griffith theory, Concept of SIF and Crack Tip Plasticity, Use of K in design and analysis, Determination of plastic zone, size and shape, Limitations of LEFM,factors affecting fatigue behaviour, Theoretical stress concentration factor and notch sensitivity factor, Fatigue under complex stresses, cumulative fatigue design, Linear damage (Miner's Rule), Manson's method, Fatigue crack propagation and life estimation for constant and variable amplitude stress. Strain Based Approach to Fatigue: Strain Vs Life Curve, Mean stress effect, Strain-Life Equation, Life estimate for structural components, Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact. Creep phenomenon, Creep Curve, Creep parameters, time-temperature parameters, and life estimate: Sherby Dorn and Larson Miller equation, Stress relaxation

Course Outcomes

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

CO1: Identify the various advanced concepts of design process as whole
CO2: Understand the importance of Manufacturing, Assembly and Reliability in Design Process
CO3: Apply concepts of Fracture, Fatigue and Creep for component-based design.

Books and References

1. Design for Manufacturing and assembly by O. Molloy, S. Tilley and E.A. Warman, Chapman & Hall, London.
2. An Introduction to Reliability and Maintainability Engineering by Charles E. Ebeling, TMH.
3. Fracture Mechanics: Fundamentals and Applications by T. L. Anderson, CRC Press.
4. Machine Design: An Integrated Approach by R L Norton Pearson Education

Tribological System Design

Course Code: ME-643	Course Type: Core
Contact Hours/Week: 4L	Course Credits: 04

Course Objectives

- To impart knowledge about the surfaces and their related terminologies.
- To introduce the fundamental concepts of friction and wear mechanisms for metals, polymers, and ceramics, including abrasive wear, erosive wear, wear of polymers and composites, and boundary lubrication and solid-film lubrication.
- To enable the students to understand the factors that cause the wear and friction.

Course Content

Surface topography and measurement, topography of engineering surfaces, quantifying surface roughness, surface interactions, mechanics of solid contacts, theories of asperity contacts, Theories of friction, friction of Metals, lamellar solids and polymers, Archards wear equation, mild and severe wear in metals, wear regime maps for metals, mechanism of sliding wear of metal, fretting wear of metals, wear of polymers, wear by hard particles: particle properties, abrasive wear and its mechanisms, erosion by solid particle impacts and its mechanisms, corrosive wear, Boundary lubrication, solid film lubrication, mixed lubrication, hydrodynamic lubrication, hydrostatic lubrication, elasto-hydrodynamic lubrication, materials for bearings, Common geometries, instrumentation and method used for testing, influences of test parameters, novel methods of improving tribological behaviour of sliding surfaces.

Course Outcomes

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

CO1: Understand about different concepts related to friction, wear and lubrication.
CO2: Determine wear rate in different conditions.
CO3: Know about the various types of wear and their identification and estimation.
CO4: Understand the need and requirement of lubrication and mechanisms.
CO5: Understand various standard tribological tests.

Books and References

1. Applied Tribology - Bearing Design and Lubrication by Michael M Khonsari, Wiley.
2. Engineering Tribology by John William, Cambridge University Press.
3. Introduction to Tribology by Bharat Bhushan, Wiley India.
4. Tribology on the Small Scale: A Bottom up Approach to Friction, Lubrication, and Wear by C. Mathew Mates, Oxford University Press.

Mathematical Methods in Mechanical Design
Course Code: ME-741   Course Type: Programme Elective Contact Hours/Week: 4L   Course Credits: 04

Course Objectives

- To impart knowledge related to mathematical concepts of linear algebra, differential equations, field theory, and numerical methods to solve engineering problems.
- To introduce the fundamental concepts about different types of PDEs and determination of approximate solutions of linear algebraic equations, ODEs, and PDEs using different numerical methods.
- To enable students to use software tools to solve ODEs numerically and compare analytical results.

Course Content

Vector Space: Dot Product, Norm, Orthogonality, Normalization; Definition of Vector Space, Inner Product Space, Span and Subspace, Linear Dependence; Bases, Expansion, Dimensions, Orthogonal Bases, Gram-Schmidt Orthogonalization. Linear Algebraic Equations – Elementary Row/Column Operations, Existence/Uniqueness of Solutions; Change of Basis, Vector Transformation. The Eigenvalue Problem – Eigenvalues and Eigenvectors of Matrices and their Properties; Diagonalization; Applications. 1st order ODEs – Integrating factor Method, Separation of Variable Technique. 2nd order ODEs – Linear Dependence and Linear Independence, General Solution of Homogeneous Equations; Solution of Homogeneous Equation with Constant Coefficients (Exponential Solutions, Higher-Order Equations ($n>2$), Repeated Roots). Solution of Homogeneous Equation with Nonconstant Coefficients (Cauchy-Euler Equation, Reduction of Order, Factoring the Operator - optional, if time permits); Solution of Nonhomogeneous Equation (General Solution, Undetermined Coefficients); Solution of Nonhomogeneous Equation (Variation of Parameters); System of Linear Differential Equations (Existence and Uniqueness for Linear First-Order Systems, Solution by Elimination); The Sturm-Liouville Theory; Power Series Solutions; Singular Points, Method of Frobenius. First order PDES – Semi linear and Quasilinear Equations in Two Independent Variables; Cauchy Problem; Monge Strip and Charpi Equations. Partial Differential Equations: Second order PDES – Classification, Modelling of Vibrating String and Wave Equation; Solution by Separation of Variables; D'Alembert's Solution of the Wave Equation, Divergence, Gradient, Curl; Divergence Theorem; Stokes' Theorem; Green's Theorem; Irrotational Fields, Numeric Linear Algebra – Gauss Elimination and Gauss-Jordan Elimination, Echelon Form, Pivoting; LU Decomposition and Cholesky Method; Gauss-Seidel/Jacobi Iterative Method; Condition Number, Minimum Norm and Least Square Error Solutions; Iterative Methods to Find Eigenvalues and Eigenvectors of Symmetric Matrices; Newton-Raphson Method for a System of Nonlinear Equations, ODEs – Euler's and Runge-Kutta Method; Predictor-Corrector Method, PDEs – Elliptic PDE, Parabolic PDE, Hyperbolic PDE.

Course Outcomes

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

CO1: Apply mathematical concepts related to differential equations, linear algebra, field theory, and numerical methods to solve engineering problems.

CO2: Utilize matrix algebra and linear transformations to solve systems of linear equations and analyze linear transformations in engineering contexts.

CO3: Use Techniques like integrating factors and separation of variables to solve first-order ODEs and Apply various analytical methods for solving second-order ODEs, including homogeneous and nonhomogeneous linear equations with constant coefficients.

CO4: Identify different types of PDEs and employ various techniques including the separation of variables to solve linear PDEs.

CO5: Determine approximate solutions of linear algebraic equations, ODEs, and PDEs using different numerical methods.

CO6: Use software tools to solve ODEs numerically, visualize solutions, and verify analytical results.

Books and References

1. Advanced Engineering Mathematics by M.D. Greenberg, Pearson Education India.
2. Advanced Engineering Mathematics by E. Kreyszig, K. Stroud and G. Stephenson, John Wiley and Sons, Inc.
3. Linear Algebra and its Applications by G. Strang, Belmont, CA: Thomson, Brooks/Cole
4. Linear Algebra by K. Hoffman and R. Kunze, PHI Learning
5. Theory of Ordinary Differential Equations by E.A.Coddington and N. Levinson, Tata McGraw-Hill
6. Partial Differential Equations by P. Prasad and R. Ravindran, New Age International
7. Elements of Partial Differential Equations by I.N. Sneddon, Courier Corporation
8. Introduction to Partial Differential Equations by K.S. Rao, PHI Learning Pvt. Ltd.
9. Applied Numerical Methods Using MATLAB by W.Y. Yang, W. Cao, T. Chung and J. Morris, Wiley
10. Numerical Methods for Engineers by S.C. Chapra, Mcgraw-hill

Data Driven Techniques for Mechanical Engineering

Course Code: ME-742 | Course Type: Programme Elective
Contact Hours/Week: 4L | Course Credits: 04

Course Objectives

- To understand the fundamental principles of data-driven techniques and their applications in mechanical engineering.
- To study machine learning algorithms and their applications in predictive maintenance, fault detection, and optimization of mechanical systems.
- To apply data-driven techniques to real-world mechanical engineering problems through hands-on projects and case studies.

Course Content

Introduction to the course, Signals and Systems; Classification of Signals; Discrete Time Signals and Systems; Classification of Discrete Time Systems; Correlation; Discrete Fourier Transform and Computation; Application of DFT; Fast Fourier Transform (FFT); Design of Digital Filters, Filter Types; Interpolation; Curve Fitting; Signal Processing Software Tools: Introduction to Matlab/Python; Signal Processing Software Tools: Signal Processing Libraries and Functions. Overview; Matrix Approximation; Mathematical Properties and Approximations; Pseudo-Inverse, Least-Squares, and Regression; Principle Component Analysis. Difference with Non-Parametric Identification; Important Techniques; Least Square Based Methods; Experimental Aspects: Experimental Schemes; Experimental Signal Processing. Sparse Identification of Nonlinear Dynamics (SINDy): Mathematical Formulation; Algorithm and Example Code. Overview, Formulating the DMD Architecture; The DMD Algorithm; Example Code and Decomposition; Limitations of the DMD Methods; Modal analysis and identification of dominant frequencies and vibration modes; Noise reduction and separation of signal components. Introduction to machine learning algorithms for signal processing; Supervised Versus Unsupervised Learning; Unsupervised Learning Techniques; Feature Extraction and Selection; Classification Trees and Random Forest Introduction to basic Machine Learning algorithms: Artificial Neural Networks, Self-Organising Maps, Support vector Machines, Introduction to artificial intelligence.

Course Outcomes

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

CO1: Analyze signals and systems in both the time and frequency domains and implement signal processing algorithms using software tools like MATLAB or programming languages like Python.

CO2: Perform SVD calculations and apply SVD-based algorithms to evaluate and interpret the results obtained from SVD-based techniques and make informed decisions based on the analysis.

CO3: Apply parametric identification techniques to analyze experimental data and model practical systems.

CO4: Apply the DMD algorithm to time-series data to extract important features, modes, and trends and interpret them in the context of the underlying system dynamics.

CO5: Apply various machine learning models and algorithms specifically designed for signal analysis.

Books and References

1. Data-driven science and engineering: Machine learning, dynamical systems, and control by S. L. Brunton and J. N. Kutz, Cambridge University Press.
2. Dynamic mode decomposition: data-driven modeling of complex systems by J. N. Kutz, S. L. Brunton, B. W. Brunton and J. L. Proctor, SIAM.
3. Digital signal processing: principles, algorithms, and applications by J. G. Proakis, Pearson Education India.
4. Machine Learning in Signal Processing Applications, Challenges, and the Road Ahead by T. Sudeep, N. Anand and R. Rudra, CRC press.

Fault Diagnostics and Signal Processing

Course Code: ME-743 Course Type: Programme Elective
Contact Hours/Week: 4L Course Credits: 04

Course Objectives

- To impart knowledge about the maintenance and faulty conditions of machinery.
- To introduce the fundamental concepts relevant to the field of noise, vibration and condition monitoring.
- To enable the students to understand fault diagnostics systems of machines.

Course Content

Reactive maintenance, preventive maintenance, predictive maintenance, enterprise resource planning, bathtub curve, failure modes effect and criticality analysis (FMECA), Classification of signals, signal analysis, frequency domain signals analysis, fundamental of fast Fourier transform, computer aided data acquisition, signal conditioning, signal demodulation, cepstrum analysis, Measurement standards, measurement errors, calibration principles, static and dynamic measurements, frequency response, dynamic range, basic measuring equipment, vibration force measurement, laser based measurement, current measurement, chemical composition measurement, ultrasonic thickness measurement, data recorders, Principles of vibration monitoring, misalignment detection, eccentricity detection, cracked shaft, bowed and bent shaft, unbalanced shaft, looseness, rub, bearing defect, gear fault, fault in fluid machines, Acoustical terminology, noise source, sound fields, anechoic chamber, reverberation chamber, noise measurement, noise source identification, Construction of an electric motor, faults in electric motor, fault detection in electric motor, MCSA for fault detection in electrical motors. Instrumentations for motor current signature analysis, Fault detection in mechanical systems by MCSA, MCSA for fault detection in any rotating machine, fault detection in power supply transformers, fault detection in any switchgear devices, Thermal imaging devices use of IR camera, industrial applications of thermography, applications of thermography in condition monitoring, Tool wear, sensor fusion in tool condition monitoring, sensor for tool condition monitoring, a tool condition monitoring system.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the fundamentals concept of faulty systems.
CO2: Describe the maintenance of the system with fault diagnosis and prognosis of the system.
CO3: Apply the principles on various machine health monitoring systems.
CO4: Assess the developments of various health monitoring systems of the machines.

Books and References

1. Mechanical Fault Diagnosis and condition monitoring by R. A Collacott, Springer.
2. Handbook of condition monitoring by A. Davis, Springer Science Business media.
3. Machinery malfunction diagnosis and correction by R.C Eisenmann, Prentice Hall.

Product Design and Development

Course Code: ME-744	Course Type: Programme Elective
Contact Hours/Week: 4L	Course Credits: 04

Course Objectives

- To acquaint the learners/students with the knowledge regarding conceptualization, design and development of a new product.
- The need of a new product, the product life cycle, the product design process, the application of Value Engineering principles in product design, various product design tools such as CAD, DFM, DFA and DFMA with relevant and specific examples/ case studies.

Course Content

Sources of new ideas, development processes, product planning, identification for customer needs and technology potentials, innovation and intellectual property rights, product and process patents, patents and patenting processes, Taguchi loss factor concepts, quality function deployment, functional specifications of products, form and function, development of alternatives, design for manufacture, Prototyping and analytical prototyping, stage-gate process of product development, holistic product development approaches-form product concept to decommissioning, Life cycle design, product data management and product life cycle management systems, dependency and concurrent engineering in development of products, Product development involving users, democratization of innovation, connecting products to services, experience innovation, robust design, patents and intellectual properties, product developments.

Course Outcomes

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

CO1: Develop the product from ideas to reality.

CO2: Apply about the design for assembly and for economy, prototyping and analytical prototyping.

CO3: Use the Internet for product development and product response.

Books and References

1. Production Design and Manufacturing by A.K. Chitale & A.K. Gupta, Prentice Hall of India.
2. Management Development by Alan Mumford, Jaico Publishing House.
3. Product design by Kevin Otto, Kristin Wood, Pearson.

Smart Structures and Systems	
Course Code: ME-745 Contact Hours/Week: 4L	Course Type: Programme Elective Course Credits: 4

Course Objectives

- To understand the fundamental principles and concepts of smart materials and structures.
- To explore the applications of smart structures and systems in various engineering fields

Course Content

Introduction to Smart Materials and Structures, Historical development and potential applications, Basics of Piezoelectricity, Transducers for Smart Structures, Piezoelectric Actuators and Sensors, Basics of control theory, 3D constitutive modeling of piezoelectric materials, actuator load line and impedance matching, Static Analysis of beams with piezoelectric patches, Introduction to energy principles for approximate solutions, Energy method based static and dynamic analysis of beams with piezoelectric patches, Fibre reinforced plastic composites - micro and macro mechanics, classical plate theory, Energy method based static and dynamic analysis of laminates with piezoelectric patches, Introduction to shape memory alloys, Constitutive models of shape memory alloys, Analysis of structures with shape memory alloy actuator and damper, Introduction to electro and magneto rheological fluids, Constitutive models of electro and magneto rheological fluids, Analysis of electro and magneto rheological dampers, Analysis of structures with electro and magneto rheological dampers, Application of Smart Structures in Engineering Practice: Shape Morphing, Vibration Control, Structural Health monitoring, Ultrasonic motors.

Course Outcomes

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

CO1: Understand the basics of different smart materials and structures.

CO2: Model the structures integrated with smart materials

CO3: Develop constitutive relations for different smart structures

Books and References

1. Smart Structures Theory by I. Chopra and J. Sirohi, Cambridge University Press.
2. Smart Structures: Analysis and Design by A. V. Srinivasan and D. Michael McFarland, Cambridge University Press.
3. Dynamics of Smart Structures by R. Vepu, Wiley.
4. Smart Structures: Physical behaviour, Mathematical Modelling and Applications by P. Gaudenzi, Wiley.

Optimization Methods in Engineering

Course Code: ME-751	Course Type: Programme Elective
Contact Hours/Week: 4L	Course Credits: 4

Course Objectives

- To understand the need and origin of the optimization methods and get a broad picture of the various applications of optimization methods in engineering.
- To introduce the principal techniques for Multivariable Optimization.
- To introduce geometric programing, integer programming, heuristic methods and optimal control methods.

Course Content

Design variables, constraints, objective function and variable, bounds single-variable. Single variable optimization algorithm: bracketing methods, point estimation method, gradient based methods, root finding optimization, region elimination methods, multivariable optimization, Fibonacci search method and golden section search method, Newton-Raphson method, bisection method, secant method, and cubic search method, computer programs for bounding phase method and golden section search method, direct search method: simplex search method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, gradient–based method: Cauchy's, Newton's and conjugate gradient method, Kuhn- Tucker conditions, penalty function method, method of multipliers, sensitivity analysis, direct search for constrained minimization, linearized search technique, feasible direction method, generalized reduced gradient method, gradient projection method, computer program for penalty function method, integer programming - penalty function method, Posynomial, unconstrained minimization problem, constrained minimization, primal dual program, GP with mixed inequality constraints, applications, integer programming: graphical representation, Gomer's cutting plane method, Balas algorithms, integer polynomial programming, branch and bound method, sequential linear discrete programing, generalized penalty function method, Genetic algorithm, simulated Annealing, working principle, difference between genetic algorithm and traditional methods, similarities between genetic algorithm and traditional methods,

Course Outcomes

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

CO1: Understand the fundamentals of optimization and its implementation.

CO2: Apply the optimization techniques for engineering problem solutions.

CO3: Understand and appreciate the advanced optimization techniques.

Books and References

1. Optimization in Engineering Design by Kalyanlnoy Deb, PHI.
2. Introduction to Optimum Design by J.S Arora, Elsevier.
3. An introduction to optimization by E.K. P Chong, S.H Zak, Wiley.
4. Engineering optimization by S.S. Rao, New Age International Publisher.

Bearing Design and Lubrication

Course Code: ME-752 — Course Type: Programme Elective
Contact Hours/Week: 4L — Course Credits:4

Course Objectives

- To impart knowledge about the bearings and their selection.
- To introduce the concepts of lubrication.
- To enable the students to select the appropriate type of bearing for machine applications.

Course Content

Fundamentals, types of lubrication, viscosity and its types, lubricants and properties of lubricants, modes and types of lubrication: hydrodynamic, hydrostatic, elasto-hydrodynamic lubrication, hydrodynamic lubrication of roughened surfaces, basic hydrodynamic equations, Petroff's equation, generalized Reynolds equation, simplification of full Reynolds equation, boundary conditions, energy equation. Impact of temperature and pressure on lubricants, Journal bearings geometry, circular and non-circular bearings, short bearing, partial journal bearings, full journal bearing, load, attitude angle, friction, pressure distribution, load carrying capacity, influence of end leakage on performance of bearings, design charts for journal bearings, thrust bearings: geometry, equations, infinite bearing, finite thrust bearing, friction, pressure distribution, center of pressure, load carrying capacity, and design charts for thrust bearings, Raimondi and Boyd charts for bearings, hydrostatic bearings: applications, features, analysis of footstep bearing, compensators, and practical considerations, Selection of bearing materials for sliding bearings, Materials for rolling element bearings, Manufacturing methods of Rolling bearings, metal bearings, non-metallic bearings, Classification, Hertz contact stress, line/ellipsoidal contact, selection and design of bearing, fatigue life calculation, bearing and mounting arrangement, noise and vibration in bearings, bearing cages and seals, Type of lubrication and theoretical background, artificial hip joint as bearing, materials for joint implants.

Course Outcomes

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

CO1: Identify the type of lubrication to be employed for a particular application.
CO2: Design the fluid film bearings and identify Bearing Materials.
CO3: Apply principles of design consideration for rolling element bearings.

Books and References

1. Bearing Design in Machinery by Harnoy, A., Marcel Dekker, Taylor & Francis.
2. Applied Tribology - Bearing Design and Lubrication by Khonsari and Booser, Wiley.
3. Fundamentals of Fluid Film Lubrication by Hamrock, Schmid, Jacobson, Marcel Dekker. CRC Press.
4. Theory of Lubrication by Ghosh, Majumdar, Sarangi, McGraw Hill Education.

Mechanics of Composite Materials

Course Code: ME-753 | Course Type: Programme Elective

Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To impart basic knowledge of composite materials and their mechanics.
- To introduce the concept of strength and failures of composites.
- To enable the students to have analytical solutions for the underlying classical lamination theory.

Course Content

Definition, Characteristics and Classification of Composites, Mechanical Behaviour and Basic Terminology, Multi-axial Stress Components and Stress Transformation; Multi-Axial Strain Components and Strain Transformation, Stress-strain relation, Stress strain relation for anisotropic materials, orthotropic materials, Lamina of arbitrary orientation, Invariant properties of orthotropic lamina, Strength of orthotropic lamina, Failure criteria, Mechanics of material approach to stiffness, Elasticity approach, Determination of elastic constants, Halpin-Tsai equation, Mechanics of material approach to strength, Classical Lamination theory, Strength of laminate, Layup arrangements for laminates and implications for elastic property of the composite, Interlaminar stresses, Stress analysis for first ply failure; Progressive and ultimate failure; Design considerations

Course Outcomes

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

CO1: Understand the composite materials, their classification and applications.
CO2: Learn the stress strain relations for anisotropic materials.
CO3: Understand the concept of strength of composites and associated failure criteria.
CO4: Understand classical lamination theory and elasticity approach to stiffness of composites.

Books And References

1. Mechanics of Composite Materials by Robert M. Jones, CRC Press.
2. Principles of Composite Material Mechanics by Ronald F. Gibson, CRC Press.
3. Mechanics of Composite Materials with MATLAB by George Voyiadjisand Peter Kattan, Springer.

Acoustics and Noise Control

Course Code: ME-754 | Course Type: Programme Elective
Contact Hours/Week: 4L | Course Credits: 04

Course Objectives

- To understand the basics of acoustics and noise control
- To introduce the concept of radiation reception absorption and transmission of acoustic waves
- To understand the impact of noise generated from various sources
- To understand the need for noise-control and measurement

Course Content

Basics of acoustics – Terminologies speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, fundamentals of noise and need for its control, principles of noise reduction, sound fields, sound level calculation, 1-D wave equation, and its solution, wave transmission line equations, standing waves, sound wave versus vibration, sense of Sound Pressure Level, linear wave equation, sound in fluids, sound reflection and transmission through walls, sound propagation in rooms, Sound analysis, Types of sound waves, reflection and transmission of waves in pipe, acoustic filters – low pass, high pass and band pass. Noise, signal detection, hearing and speech mechanism of hearing, thresholds of ear, loudness, noise, spectrum level and band level, measuring noise, fundamental properties of hearing, Simple oscillators, resonators- function and types, Sound control principle, Isolation, Absorption, Noise at workplaces, noise from machines, industrial noise, noise from road traffic, railroads and aircrafts, Noise ratings, regulations and standards, human tolerance levels, equivalent sound level and loudness contours, Noise control in Engine, muffler design, Noise control through barriers and enclosures and absorbent linings, Vehicular noise and control, Environmental noise control, Procedure for noise measurement, Instrumentation for noise measurement, types of sound measurement systems, sound pressure measurement system, sound intensity measurement system, importance of microphones for measurement, types of microphones, types of noise measurement systems, sound analysis, frequency analysis, use of octave filters for measurements

Course Outcomes

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

CO1: Understand the principles of acoustics and noise

CO2: Recognize the essential elements of sound propagation

CO3: Understand the ill effects of exposure to excessive noise and remedial measures

Books and References

1. Fundamentals of Acoustics by L. E. Kinsler, Austin, R.Frey, Alan B. Coppens, James V.Sanders, Wiley.
2. Sound Analysis and Noise Control by John E. Foreman Van Nostrand, Reinhold Publication.
3. Industrial Noise Control: Fundamentals and Applications L.H.,Bell, C.BeU, CRC Press
4. Mechanical Vibrations and Noise Engineering by Ashok G. Ambekar, PHI

Theory of Mechanisms

Course Code: ME-755 — Course Type: Programme Elective
Contact Hours/Week: 4L — Course Credits: 4

Course Objectives

- To understand the fundamental concepts of mechanisms
- To gain proficiency in analysing the motion of mechanisms using graphical, analytical, and numerical methods.
- To understand the principles of mechanism synthesis

Course Content

Introduction to mechanisms and their applications; mobility, complex mechanisms, analysis of complex mechanisms: auxiliary point method, method of normal components, Goodman's indirect method. Synthesis of planar mechanisms: graphical synthesis of planar mechanisms for rigid body guidance, path generation and function generation, Analytical synthesis of planar mechanisms: Freudenstein's equation. Introduction to path curvature theory: pole, centrode, inflection circle, Euler-Savary equation, cubic of stationary curvature, Spatial mechanisms: spherical and spatial linkages, degree of freedom, displacement equation; synthesis of a spatial cam; case studies in mechanisms, Introduction to compliant mechanisms; flexibility and deflection; pseudo-rigid body model, variety of models such as small length flexural pivots, fixed-pinned beam, fixed-guided flexible segment; methods of modeling pin joints, Q-joints, torsional hinge; examples of modeling of compliant mechanisms.

Course Outcomes

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

CO1: Perform kinematic analysis of complex planar mechanisms by graphical and analytical methods
CO2: Synthesize mechanisms by graphical and analytical methods.
CO3: Learn path curvature theory and applications of Euler-Savary equation.
CO4: Perform kinematic analysis of spatial mechanisms.
CO5: Design and analyze compliant mechanisms.

Books and References

1. Kinematic analysis and synthesis of mechanisms by A. K. Mallik, CRC Press.
2. Advanced mechanism design: Analysis and synthesis by G. N. Sandor and A. G. Erdman, Prentice-Hall.
3. Theory of machines and mechanisms by J.J. Uicker, G. Pennock, J. E. Shigley and J. M. McCarthy, Oxford University Press, New York.
4. Design of machinery: an introduction to the synthesis and analysis of mechanisms and machines by R. L. Norton McGraw-Hill/Higher Education.

Robotics

Course Code: ME-761 Course Type: Programme Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart the knowledge of robot kinematics and robot programming
- To acquaint students with different application areas of robotics.
- To impart the knowledge of components of robotics systems such as drive systems, sensors etc.

Course Content

Historical background, Definitions, Laws of Robotics, Configurations of Manipulators**:** Components of robots, Arm configuration, Wrist configurations; Classification of Robots, Specification of robots, Analysis of Precision of movement in robotics: Resolution, Accuracy and repeatability, Introduction to mobile robots, Introduction, Drive system**-**Hydraulic system. Pneumatic system, Electrical actuators, other actuating systems, Sensors: Need for sensing systems, classification of sensors, characteristics of sensors, various types of sensors, Smart Sensors, Robot vision systems and analysis, Robot cell design and Control, Robot Control system, Manipulator Control, Robot end effectors, Introduction, Coordinate frames and Transformations, Homogenous Transformations Matrix, Composite Transformations, Inverse Homogenous Transformations, Forward and Inverse Kinematic equations, Denavit Hardenberg(D-H) representation, Forward Kinematic solution of various Manipulators, Inverse Kinematic Analysis-Solvability of inverse kinematics problems, Multiple solutions, the solution to inverse Kinematics. Dynamic analysis of manipulator, Robot Trajectory planning considering velocity and acceleration, joint space and Cartesian space trajectory planning, resolved motion rate control, Methods of Programming, Motions Programming, Robot Languages **-** Textual robot languages, Generation of robot programming Languages, Robot programming Language structure, Work cell layout, Work cell design, Industrial Applications Material handling, Processing operations, Assembly and inspection, Approach for implementing robotics, safety, training, maintenance and quality, Social issues and future of robotics.

Course Outcomes

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

CO1: Explain various industrial robot configurations and economics for the implementation of robotics in industries.

CO2: Design / Simulate a robot which meets kinematic requirements.

CO3: Apply localization and mapping aspects of mobile robotics.

CO4: To understand robot programming.

CO5: To understand industrial robot applications and their impact on society

Books and References

1. Robotics-control and programming by J.Srinivas, Narosa Publication
2. Industrial Robotics by M.P. Groover, McGraw Hill Publication
3. Fundamental of Robotics: Analysis and Control by Robert J Schilling, Person Publication Education
4. Industrial Robotics by Ganesh S. Hegde, Laxmi Publication

Experimental Stress Analysis

Course Code: ME-762 | Course Type: Programme Elective
Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To understand the fundamental principles of stress analysis and its importance in engineering design and analysis.
- To gain proficiency in the operation of strain gauges for measuring strain in materials and structures.
- To study the principles of photoelasticity and its applications in visualizing stress distribution in transparent materials.

Course Content

Overview of theory of elasticity: analysis of stress at a point and strain at a point, governing equations for three-dimensional elasticity problems, solution to plane stress and plane strain problems, Airy's stress function approach for solving plane elasticity problems, forms of stress function in polar coordinates, stress concentration at a circular hole in tension field; principal stresses and principal strains, prediction of failures; overview of experimental stress analysis, Strain measurements, strain and its relation to experimental determinations, types of strain gauges: mechanical strain gauges, optical strain gauges, inductance strain gauges, electrical resistance strain gauges; strain sensitivity in metallic alloys; gauge construction-strain gauge adhesives and mounting methods; gauge sensitivities and gauge factor; performance characteristics of foil strain gauges; temperature compensation; strain gauge circuits: potentiometer, Wheatstone bridge circuits; strain rosettes: rectangular and delta rosette, Theory of brittle coating method: coating stresses, failure theories, brittle coating patterns, crack detection, ceramic-based and resin-based brittle coatings, test procedures for brittle coating analysis, and analysis of brittle coating data, Two-dimensional photo elasticity, Photo elastic materials, Concept of light, photoelastic effects, stress optic law, Transmission photoelasticity, Jones calculus, plane and circular polariscopes, Interpretation of fringe pattern, isoclines, isochromatic, effects of the stressed model in a plane polariscope and circular polariscope, dark field and light field arrangements, Calibration of photoelastic materials, Compensation and separation techniques, Introduction to three-dimensional photo elasticity, stress freezing, Introduction to digital image correction.

Course Outcomes

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

CO1: Understand analytical methods to solve elasticity problems
CO2: Measure the strains in a body using experimental methods
CO3: Understand brittle coating techniques and methods for brittle coating analysis
CO4: Measure the stresses and strains in body using photo-elastic methods

Books and References

1. Experimental Stress Analysis by J. W. Dally and W. E. Riley McGraw-Hill.
2. Advanced Strength and Applied Stress Analysis by R. G. Budynas, McGraw-Hill.
3. Experimental Stress Analysis by L. S. Sreenath, M. R. Raghavan, K. Lingaiah, G. Garghesha and B. Pant, Tata McGraw-Hill.
4. Theory of elasticity by S. Timoshenko and J. N. Goodier, McGraw-Hill.

Modal Analysis and Dynamic System Design

Course Code: ME-763 | Course Type: Core
Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To teach the basics of theory and practice of modal analysis and digital signal processing of measurements.
- To teach estimation and extraction of modal parameters (natural frequencies, damping and mode shapes) from measured data and construction of mathematical models.

Course Content

Presentation and properties of frequency response function (FRF) data for degree of freedom system (SDOF) stem, undamped multi-degree of freedom system (MDOF), Damped Systems, proportional damping, hysteretic damping, viscous damping, characteristics and presentation of MDOF FRF data, Basic measurement system, structure preparation, excitation of structure. Transducers and amplifiers, analyzers, digital signal processing, use of different excitation types, calibration, mass cancellation, Preliminary checks of FRF data, SDOF modal analysis, peak amplitude, circle-fit method, inverse method, residuals, introduction to MDOF curve-fitting procedure, extension of SDOF method, Discrete mass modification, stiffener/ spring element modification beam element modifications, Modal models, display of modal model, response models, spatial models, mobility skeletons and system models, building of modal model from FRF models, Comparison of experiment and prediction, correction or adjustment of models, structural modification, response prediction and force determination.

Course Outcomes

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

CO1: Get familiar with theoretical and practical aspects of structural dynamics and develop the ability to plan for experimental testing of structural vibrations.

CO2: Gain understanding of sensor and actuator selection and placement.

CO3: Gain understanding of the importance of digital signal processing of measurements, and its impact on quality of measured data.

CO4: Gain the ability to reconstruct mathematical models describing the structure based on experimental modal analysis.

Books and References

1. Modal Analysis by He & Fu, Butterworth-Heinemann Woburn, MA, USA.
2. Modal Testing: Theory, Practice and Application by D. J. Ewins, Wiley.
3. Fundamental of Mechanical Vibration by S Grahm Kelly, MGH Intl. Edition.
4. Mechanical Vibration by S.S Rao, Wesley Publishing Company.

Mechatronics and Control

Course Code: ME-764 — Course Type: Programme Elective
Contact Hours/Week: 4L — Course Credits: 4

Course Objectives

- Understand key elements of the Mechatronics system and representation in the block diagram.
- Understand principles of sensors and signal conditioning, its characteristics, interfacing with DAQ microcontroller
- To impart the knowledge of mechanical, pneumatic and hydraulic actuators.
- To understand the importance of each control action and how to choose a proper controller for an engineering problem.

Course Content

Definition, Systems, Measurement systems, Control systems, Programmable logic controller, Block Diagram of Mechatronic System, Functions of Mechatronic Systems, Comparison between Traditional and Mechatronics approach, Examples of Mechatronic Systems, Integration of mechanical, electronics, control and computer science engineering, Mathematical Models, Modeling of Mechanical systems, electrical systems, pneumatic and hydraulic systems, Transforming physical model to mathematical model, dynamic response of systems, System Transfer functions, Sensors and Transducers, micro and Nano-sensors, Signal conditioning, Digital signal and digital logic, Data conversion devices, signal processing devices, Data acquisition and data presentation, PID Controller, Mechanical actuation systems: Cams, Gears, Bearings, Belt and chain drives, Ratchet and pawl, Mechanical aspect of Motor selection; Pneumatic and hydraulic actuation system: Directional control Valves, Pressure control Valves, Servo and proportional control Valves, Rotary actuators; Electrical actuation systems: Mechanical and solid switches, Solenoids, D.C. Motors, Stepper motors, Servomotors, Motor selection, Laplace transformations, Block diagram reduction, Performance specifications, Transfer functions, Stability, Sensitivity of the open –loop and closed -loop systems, Types of controller, Analog to digital and digital to analog converters, Operational amplifiers, Introduction to Microcontrollers and Microprocessors.

Course Outcomes

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

CO1: Understand the basic concepts of noise and its control

CO2: Understand the noise generated from various sources

CO3: Understand the importance of sound analysis

Books and References

1. Industrial Noise Control: Fundamentals and Applications L.H.,Bell, C.BeU, CRC Press.
2. Noise Control of Hydraulic Machinery by S. Skaistis, Marcel Dekker.
3. Noise Control: From Concept to Application by C. Hansen, H. Colin, CRC Press.
4. Noise and Vibration Control by M. L. Munjal, World Scientific Press: Singapore.
5. Mechanical Vibrations and Noise Engineering by Ashok G. Ambekar, PHI.
6. Theory and Applications of Automatic Controls, B C Nakra, New Age International.

Non-Destructive Testing Methods in Design

Course Code: ME-765 Course Type: Programme Elective
Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To understand the need and origin Non-Destructive Testing in Design Process.
- To introduce the principal and concept of various Non-Destructive testing Methods.
- To introduce the concept of damage tolerance design in line with Non-Destructive testing methods

Course Content

NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided, Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism, Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation, Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique – Principle, AE parameters, Applications, Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand the fundamentals of Non-Destructive Evaluation Methods
CO2: Apply the concept of NDT methods for Damage tolerance Design Approach
CO3: Understand and appreciate the advantages of NDT Methods

Books and References

1. Handbook of Non-Destructive Evaluation by Chuck Hellier, TMH.
2. Practical Non-Destructive Testing by Baldev Raj, Narosa.
3. Non-Destructive Test and Evaluation of Materials by Prasad and Nair, Mac Graw Hill
4. Introduction to Non Destructive Testing by Paul E Mix, Wiley

Design of Automotive Systems

Course Code: ME-766	Course type: Programme Elective
Contact Hours/Week: 4L	Course credits: 4

Course Objectives

- To learn about different types of Passenger car transmission systems.
- Impart knowledge about the vehicle power requirement curve and vehicle resistance
- To study about the Automobile Body types and design for Crashworthiness
- To study about design aspect of different braking & suspension systems in an automobile

Course Content

Development of Vehicles & Drive Units: Stages in the Development of Automotive Transmissions, Development of Gear-Tooth Systems and other, Transmission Components. Basic Elements of Vehicle and Transmission Engineering, Need of Gearboxes, Functions of Vehicle Transmissions, and Fundamental Performance Features of Vehicle Transmissions, Trends in Transmission Design, Transmission Losses and Efficiency. Engine power and efficiencies: Performance characteristics, Variables affecting engine performance, Methods to improve engine performance. Basic Design Principles: Design of various clutch system components and Pressure Plate Assembly components, Hydraulic Clutch system components. Arrangement of the Transmission in Passenger / Commercial / All-Wheel Drive Passenger Cars/Transverse and Longitudinal Dynamics with All-Wheel Drive. Transmission Formats & Designs, Basic Gearbox Concept. Passenger Car Transmissions: Manual Passenger Car Transmissions (MT); Automated Manual Passenger Car Transmissions (AMT); Dual Clutch Passenger Car Transmissions (DCT); Automatic Passenger Car Transmissions (AT); Passenger Car Hybrid Drives; Continuously Variable Passenger Car Transmissions (CVT). Final Drives: Axle Drives for Passenger Cars, Axle Drives for Commercial Vehicles, Differential Gears and Locking Differentials, Hub Drives for Commercial Vehicles; Transfer Gearboxes. Passenger Vehicle Body: The Automobile Body, Description of the Automobile Body Types (space frame, central frame, Body-on-frame, Monocoque), Body Nomenclature, Body Mass Benchmarking, Steel used in passenger vehicle. Vehicle layout, Different types of Car Body Style, Automotive Body Structural Elements, Overview of Classical Beam Behavior, Design of Automotive Beam Sections, Design for Crashworthiness: Standardized Safety Test Conditions and Requirements, Front Barrier, Side Impact, Note on Rear Impact. Brakes, Suspension Systems: Type of brakes, Disc & Drum brake theory, constructional details, advantages, Brake actuating systems, Materials, and braking torque. Factors affecting brake performance, Parking & Exhaust brakes, power assisted brakes, Antilock Braking System (ABS). Testing of brakes, thermal Considerations. Construction of suspension system, Solid Axles & Independent Suspension system, four-link & multi-link, Trailing Arm, Short Long Arm (SLA), MacPherson Strut suspension system, Anti-Squat, Anti-Pitch, and Anti-Dive suspension system, Roll Center & stability Analysis.

Course Outcomes

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

CO1: Identify the need of transmission system, its function, and discuss different types of Passenger car transmission systems.

CO2: Calculate vehicle resistance, predict vehicle power requirement curve.

CO3: Calculate transmission gear ratio’s & predict vehicle performance.

CO4: Categorize different vehicles bodies & layout’s, it’s nomenclature, structural elements and synthesis it to meet vehicle crashworthiness requirements.

CO5: Describe the different braking & suspension systems in an automobile & demonstrate the vehicle safety.

Books and References

1. Automotive Transmission: Fundamentals, Selection, Design & Application by Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, Wolfgang Novak, 2nd Edition, Springer-Verlag Berlin Heidelberg.
2. Fundamentals of Automobile Body Structure Design by Donald E. Malen, SAE International Publication.
3. The Motor Vehicle by K. Newton, W. Steeds and T.K. Garret, Butterworth Heinemann.
4. Automotive Chassis by P.M. Heldt, Chilton Co., New York.
5. Mechanics of Road Vehicles by W. Steed, Illiffe Books Ltd., London.
6. Automobile Mechanics by N.K. Giri, Khanna Publishers.

Optimization Methods in Engineering

Course Code: ME-703	Course Type: Institute Elective
Contact Hours/Week: 4L	Course Credits: 4

Course Objectives

- To understand the need and origin of the optimization methods and get a broad picture of the various applications of optimization methods in engineering.
- To introduce the principal techniques for Multivariable Optimization.
- To introduce geometric programing, integer programing, heuristic methods and optimal control methods.

Course Content

Design variables, constraints, objective function and variable, bounds single-variable. Single variable optimization algorithm: bracketing methods, point estimation method, gradient based methods, root finding optimization, region elimination methods, multivariable optimization, Fibonacci search method and golden section search method, Newton-Raphson method, bisection method, secant method, and cubic search method, computer programs for bounding phase method and golden section search method, direct search method: simplex search method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, gradient–based method: Cauchy's, Newton's and conjugate gradient method, Kuhn- Tucker conditions, penalty function method, method of multipliers, sensitivity analysis, direct search for constrained minimization, linearized search technique, feasible direction method, generalized reduced gradient method, gradient projection method, computer program for penalty function method, integer programming - penalty function method, Posynomial, unconstrained minimization problem, constrained minimization, primal dual program, GP with mixed inequality constraints, applications, integer programming: graphical representation, Gomer's cutting plane method, Balas algorithms, integer polynomial programming, branch and bound method, sequential linear discrete programing, generalized penalty function method, Genetic algorithm, simulated Annealing, working principle, difference between genetic algorithm and traditional methods, similarities between genetic algorithm and traditional methods

Course Outcomes

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

CO1: Understand the fundamentals of optimization and its implementation.

CO2: Apply the optimization techniques for engineering problem solutions.

CO3: Understand and appreciate the advanced optimization techniques.

Books and References

1. Optimization in Engineering Design by Kalyanlnoy Deb, PHI.
2. Introduction to Optimum Design by J.S Arora, Elsevier.
3. An introduction to optimization by E.K. P Chong, S.H Zak, Wiley.
4. Engineering optimization by S.S. Rao, New Age International Publisher.

Soft Computing Methods in Engineering

Course Code: ME-704 | Course Type: Institute Elective

Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To cover fundamental concepts used in soft computing.
- To understand concepts of Fuzzy logic (FL) and Artificial Neural Networks (ANNs) and optimization techniques using Genetic Algorithm (GA).
- The course will provide exposure to theory as well as practical systems and software.

Course Content

Soft computing and its usefulness, Concept of computing systems, soft vs hard computing, characteristics of soft computing, some applications of soft computing techniques, Fuzzy sets and membership functions, operations on fuzzy sets, fuzzy relations, rules, propositions, implications and inferences, defuzzification techniques, fuzzy logic controller design, some applications of fuzzy logic, Biological neurons and its working, simulation of biological neurons to problem solving, different ANNs architectures, training techniques for ANNs, applications of ANNs to solve some real life problems, perceptronlinear separability, training algorithm, limitations, multi-layer networks-architecture, back propagation algorithm (BTA) and other training algorithms, applications, Adaptive multi-layer networks-architecture, training algorithms, recurrent networks, feed-forward networks, radial-basis-function (RBF) networks, Winner-takes-all networks, Hamming networks, Maxnet, simple competitive learning, Vector-Quantization, Counter propagation networks, adaptive resonance theory, Kohonen's self-organizing maps, principal component analysis, Hopfield networks, brain-in-a-box network, Boltzmann machine, evolutionary computation: different variants, genetic algorithm, hybrid systems: ANFIS, fuzzy filtered NN & neural fuzzy systems, GA tuned fuzzy system.

Course Outcomes

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

CO1: Understand Fuzzy logic and its applications.

CO2: Understand artificial neural networks and its applications.

CO3: Solve single-objective optimization problems using GAs.

CO4: Solve multi-objective optimization problems using Evolutionary algorithms (MOEAs).

CO5: Appreciate applications of soft computing to solve problems in varieties of application domains.

Books and References

1. Neural Networks: A Comprehensive Foundation by S. Haykin, Pearson.
2. Fuzzy Logic with Engineering Application by T. J. Ross, John Wiley and Sons.
3. Evolutionary Computation by D.B. Fogel, IEEE Press.

Fault Diagnostics and Signal Processing

Course Code: ME-705 | Course Type: Institute Elective

Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To impart knowledge about the maintenance and faulty conditions of machinery.
- To introduce the fundamental concepts relevant to the field of noise, vibration and condition monitoring.
- To enable the students to understand fault diagnostics systems of machines.

Course Content

Reactive maintenance, preventive maintenance, predictive maintenance, enterprise resource planning, bathtub curve, failure modes effect and criticality analysis (FMECA), Classification of signals, signal analysis, frequency domain signals analysis, fundamental of fast Fourier transform, computer aided data acquisition, signal conditioning, signal demodulation, cepstrum analysis, Measurement standards, measurement errors, calibration principles, static and dynamic measurements, frequency response, dynamic range, basic measuring equipment, vibration force measurement, laser based measurement, current measurement, chemical composition measurement, ultrasonic thickness measurement, data recorders, Principles of vibration monitoring, misalignment detection, eccentricity detection, cracked shaft, bowed and bent shaft, unbalanced shaft, looseness, rub, bearing defect, gear fault, fault in fluid machines, Acoustical terminology, noise source, sound fields, anechoic chamber, reverberation chamber, noise measurement, noise source identification, Construction of an electric motor, faults in electric motor, fault detection in electric motor, MCSA for fault detection in electrical motors. Instrumentations for motor current signature analysis, Fault detection in mechanical systems by MCSA, MCSA for fault detection in any rotating machine, fault detection in power supply transformers, fault detection in any switchgear devices, Thermal imaging devices use of IR camera, industrial applications of thermography, applications of thermography in condition monitoring, Tool wear, sensor fusion in tool condition monitoring, sensor for tool condition monitoring, a tool condition monitoring system.

Course Outcomes

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

CO1: Identify the fundamentals concept of faulty systems.

CO2: Describe the maintenance of the system with fault diagnosis and prognosis of the system.

CO3: Apply the principles on various machine health monitoring systems.

CO4: Assess the developments of various health monitoring systems of the machines.

Books and References

1. Mechanical Fault Diagnosis and condition monitoring by R. A Collacott, Springer.
2. Handbook of condition monitoring by A. Davis, Springer Science Business media.
3. Machinery malfunction diagnosis and correction by R.C Eisenmann, Prentice Hall.

Design Engineering Lab-I

Course Code: ME- 634 | Course Type: Core
Contact Hours/Week: 4P | Course Credits: 2

Course Objectives

- To understand computer added modelling (CAD) modeling and application of Finite element analysis.
- To perform various tests related to Material properties and perform various analysis.

List of Experiments

1. To perform mechanical design of crankshaft, CAD modeling and FE analysis and its validations.
2. To perform mechanical design of a piston, CAD modeling and FE analysis and its validations.
3. To perform testing of material properties using MTS, Hardness Tester, DMA and wear test rig.
4. To study disassembly and assembly of a reciprocating compressor and pump and learning about valve operations.
5. To study disassembly and assembly of a machine tool gear box and design for various speeds and drawing ray diagram.
6. To study and identification of various structural components of a vehicle.
7. To study chassis and dynamic modeling and comfort analysis.
8. To perform design and development of cam profile for valve operations.
9. To do Finite element modeling of a truss and solution for a given configurations.
10. To perform dynamic modeling of milling machine or radial drilling machine and vibrational structural analysis and vibration suppression case studies.
11. To write and execute a computer program for plotting a Bezier curve with n Points as input.
12. To write and execute a computer program for plotting a B-spline curve and the related control polygons for a sequence of arbitrary chosen control points.

Course Outcomes

After getting exposure of this Laboratory students will be able to

CO1: Understand design of various mechanical components.
CO2: Generate various geometric models, Apply FE analysis.
CO3: Perform various tests and analysis pertaining to material properties.

Note: *The concerned course coordinator will prepare the actual list of experiments/problems at the start of the semester based on above generic list.*

Design Engineering Lab-II	
Course Code: ME-644	Course Type: Core
Contact Hours/Week: 4P	Course Credits: 2

Course Objectives

- To impart knowledge about tribo-testers.
- To introduce the fundamental concepts relevant to Fracture & Fatigue.
- To enable the students to develop models on 3-D printer.

List of Experiments

1. To perform a sliding wear test on POD and estimate wear coefficient for a standard specimen.
2. To perform an abrasive wear test on a standard specimen using abrasive wear test Rig and estimate abrasive wear rate.
3. To perform solid particle erosion wear test on a standard specimen and calculate Erosion efficiency.
4. To estimate the life cycle test for a standard spur gear on a Polymer gear test-rig.
5. To estimate lubricity and extreme pressure of oil using Four ball tester.
6. To study the influence of increase/decrease of distance from the source on the sound level of a source (compressor/turbine/engine) and to plot the sound levels at 1/3 octave band frequencies.
7. To study the impact of unbalance on a shaft and to plot/monitor the vibration levels of the bearings.
8. To perform ASTM standard test for finding Linear elastic plain-strain fracture toughness K_{IC} for a metallic specimen.
9. To perform free vibration analysis of Single Degree of Freedom system.
10. To perform forced vibration analysis of Single Degree of Freedom system.
11. To understand the dynamic vibration absorber system.
12. To analyze the response for forced vibration of a system excited by support motion at different damping ratio and frequency ratio.

Course Outcomes

After getting exposure of this Laboratory, students will be able to

CO1: Identify different wear mechanisms and estimate them and estimate key properties of a lubricant.
CO2: Estimate fatigue data, develop S-N curves and K_{IC} values.
CO3: Develop rapid models for small sized specimens.

Note: *The concerned course coordinator will prepare the actual list of experiments/problems at the start of the semester based on above generic list.*