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 Geometric Design	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 is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/Week	Credit
			L	T	P		
1	ME-641	Modal Analysis and Dynamic Design	4	0	0	4	4
2	ME-642	Design Against Fatigue and Fracture	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-7MN	Programme Elective-IV	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 & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME-800	M.Tech. Dissertation	--	20
Total			**--**	**20**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME-800	M.Tech. Dissertation	--	20
Total			**--**	**20**

Total Credits of the Programme = 84

Annexure
List of Programme Electives

Programme Elective-I

ME 701: Product Design and Development
ME-702: Optimization Methods in Engineering
ME-703: Soft Computing Methods in Engineering

Programme Elective-II

ME-706: Mechatronic Product Design
ME-707: Design of Micro-Electro-Mechanical System
ME-708: Design of Robotic System

Programme Elective-III

ME-711: Fault Diagnostics and Signal Processing
ME-712: Bearing Design and Lubrication
ME-713: Vibrations and Noise Control

Programme Elective-IV

ME-718: Rapid Product Development
ME-719: Concurrent Engineering
ME-720: Reverse Engineering

Course Name: **Advanced Mechanics of Solids**
Course Code: **ME-631**
Course Type: Core

Contact Hours/Week: **4L**	Course Credits: **04**

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 Analysis: 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.

Strain Analysis: 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.

Failure Theories: 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.

Energy Methods: 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: 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.

Course Name: **Computer Aided Geometric Design**
Course Code: **ME-632**
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To understand the basic fundamentals of computer aided geometric design.
- To learn the fundamentals of design of Curves.
- To understand different geometric modeling techniques like solid modeling, surface modeling, feature based modeling etc., and to visualize how the components look like before its manufacturing or fabrication.

Course Content

Introduction: Historical development, explicit and implicit equations, intrinsic equations, parametric equations, coordinate systems.

Curve Design: Fundamentals of curve design, parametric space of a curve, blending functions, re-parameterization, space curves, straight lines, spline curves, Bezier curves, b-spline curve, rational polynomials, rational curves, and NURBS.

Geometric Transformations: Transformations: translation, rotation, scaling symmetry and reflection, homogeneous transformations. Orthographic projections, axonometric projections, oblique projections, perspective transformation.

Design of Surfaces: Fundamentals of surface design, parametric space of a surface, re-parameterization of a surface patch, sixteen point form, four curve form, plane, cylindrical, and ruled surfaces, surface of revolution, Bezier surface, b-spline and NURBS surface.

Design of Solids: Solid models and entities and representation, fundamentals, half spaces, B-rep, CSG, Sweep, ASM, organization of modelers, manipulations.

Geometric Properties: Local and global properties of a curve, local and global properties of a surface, global properties of a complex solids, relational properties, intersections, application in product development and other areas.

Course Outcomes

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

CO1: Design various Curves, Surfaces and understand inherent mathematics.
CO2: Perform various types of geometric transformations.
CO3: Design various solids and understand inherent mathematics.

Books and References

1. Geometric Modeling by Michael E. Mortenson, Third addition, Industrial Press Inc.
2. Mathematical Elements of Computer Graphics by Hearn & Becker, Pearson.
3. CAD CAM Theory and Practice by I. Zeid, McGraw Hill.
4. Computer Aided Engineering Design by Saxena and Sahay, Anamaya N. Delhi.

Course Name: **Finite Element Analysis for Mechanical Design**
Course Code: **ME-633**
Course Type: Core

Contact Hours/Week: **4L** | Course Credits: **04**

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

Introduction: 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.

FEA of 1D Elastic Stress Analysis Problems: 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.

FEA of Plane 2D and Axisymmetric Elastic Stress Analysis Problems: 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.

FEM based Software Applications for Mechanical Design Problems: 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.

Course Name: **Modal Analysis and Dynamic Design**
Course Code: **ME-641**
Course Type: Core

Contact Hours/Week: **4L**	Course Credits: **04**

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

Introduction to Modal Testing: 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.

FRF Measurement Techniques: Basic measurement system, structure preparation, excitation of structure. Transducers and amplifiers, analyzers, digital signal processing, use of different excitation types, calibration, mass cancellation.

Modal Parameter Extraction Methods: 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.

Modal Parameter Modification Methods: Discrete mass modification, stiffener/ spring element modification beam element modifications.

Derivation of Mathematical models: Modal models, display of modal model, response models, spatial models, mobility skeletons and system models, building of modal model from FRF models.

Applications: 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.

Course Name: **Design Against Fatigue and Fracture**
Course Code: **ME-642**
Course Type: Core

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To impart knowledge about the fracture mechanics approach to design, effects of cracks on strength.
- To introduce the fundamental concepts relevant to linear elastic fracture mechanics (LEFM) and application to fatigue growth.
- To enable the students to understand the factors causing/affecting fatigue and fracture.

Course Content

Linear Elastic Fracture Mechanics (LEFM): Stress concentration effect of flaws, cracks as stress raisers, the Griffith energy balance, energy release rate, crack growth instability analysis and R-curve, stress analysis of cracks: generalized in-plane Loading (Williams' approach), Westergaard stress function, behavior at crack tips in real materials, effects of cracks on strength**.**

Effect of Cracks: Brittle versus ductile behaviors, the stress intensity factor K, effect of size, principle of superposition, weight functions, crack tip plasticity, fracture toughness, K as a failure criterion, trends of KIC with material, effects of temperature and loading rate., microstructural influences on KIC, mixed mode fracture.

Elastic-Plastic Fracture Mechanics (EPFM): Crack tip opening displacement (CTOD), J contour integral, J as a nonlinear energy release rate, the HRR singularity, J as a path-independent line integral, J as a stress intensity parameter, the large strain zone, laboratory measurement of J, relationship between J and CTOD.

Micro-mechanism of Fatigue, Introduction, Fatigue Design Criteria: Infinite life design, safe life design, fail-safe design, damage tolerant design, fatigue tests and the stress-life (S-N) approach, cyclic deformation and the strain-life (e-N) approach, fundamentals of LEFM and application to fatigue crack growth: LEFM concepts, cyclic plastic zone size, fatigue crack growth, mean stress effect.

Experimental Measurements: Measurement of fatigue crack growth, fatigue from variable amplitude loading: spectrum loading, cumulative damage theories, load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.

Course Outcomes

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

CO1: Identify the mechanics behind the fatigue and fracture.
CO2: Describe the effect of cracks on strength.

Books and References

1. Fracture Mechanics: Fundamentals and Applications by T. L. Anderson, CRC Press.
2. Elementary Engineering Fracture Mechanics by David Broek, Kluwer Academic Publisher
3. Fatigue and Fracture: Understanding the Basics by F.C Campbell, ASM International
4. Fatigue Damage, Crack Growth and Life Prediction by F.Ellyin, Springer.

Course Name: **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 causes the wear and friction.

Course Content

Topography of Surfaces and its theories: Surface topography and measurement, topography of engineering surfaces, quantifying surface roughness, surface interactions, mechanics of solid contacts, theories of asperity contacts.

Laws of Friction: Theories of friction, friction of Metals, lamellar solids and polymers.

Sliding Wear: 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.

Lubrication: Boundary lubrication, solid film lubrication, mixed lubrication, hydrodynamic lubrication, hydrostatic lubrication, elasto-hydrodynamic lubrication, materials for bearings.

Tribological Testing: Common geometries, instrumentation and method used for testing, influences of test parameters, novel methods of improving tribological behavior 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.

Course Name: **Product Design and Development**
Course Code: **ME-701**
Course Type: Programme Elective-I

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

Introduction: 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.

Product and Tolerance Specifications: Taguchi loss factor concepts, quality function deployment, functional specifications of products, form and function, development of alternatives, design for manufacture.

Design for Assembly and Economy: Prototyping and analytical prototyping, stage-gate process of product development, holistic product development approaches-form product concept to decommissioning.

Environment Requirements: Life cycle design, product data management and product life cycle management systems, dependency and concurrent engineering in development of products.

Internet Based Approach: 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 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.

Course Name: **Optimization Methods in Engineering**
Course Code: **ME-702**
Course Type: Programme Elective-I

Contact Hours/Week: **4L** Course Credits: **04**

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

Optimization Problem Formulation: 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.

Gradient Based Methods: 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.

Constrained Optimality criterion: 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.

Geometric Programming: 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.

Non-traditional Optimization: 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 fundamental of optimization and its implementation.
CO2: Apply the optimization techniques for engineering problem solution.
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.

Course Name: **Soft Computing Methods in Engineering**
Course Code: **ME-703**
Course Type: Programme Elective-I

Contact Hours/Week: **4L**	Course Credits: **04**

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

Introduction: Soft computing and its usefulness, Concept of computing systems, soft vs hard computing, characteristics of soft computing, some applications of soft computing techniques

Introduction to Fuzzy logic: 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,

ANN: 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, perceptron-linear 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.

Unsupervised Learning: 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.

Associated Models: 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.

Course Name: **Mechatronic Product Design** Course Code: **ME-706** **Course Type: Programme Elective-II**
Contact Hours/Week: **4L** Course Credits: **04**
Course Objectives • To impart knowledge about the fundamental of mechatronics, various hardware components related to the mechatronics. • To introduce the fundamental concepts relevant to field of mechatronics. • To enable the students to understand the real time interface.
Course Content
Definition of Mechatronics: Mechatronics in manufacturing, products and design, review of fundamentals of electronics. **Introduction to Key Elements of Mechatronic Product:** Principles of basic electronics- digital logic, number system logic gates, sequence logic flip flop systems, sensors and actuators, signals and system, computers and logic systems, software and data acquisition. **Mechatronic Design Approach:** System interfacing, instrumentation and control systems, microprocessor based controllers and microelectronics, product functional block diagram, PCB design, product enclosure design, microcontroller interfacing and programming, interfacing with sensors and actuators, driver circuits and motion control, stepper and servo motion control, software and hardware tool to build mechatronic systems. **Design and Selection of Mechatronic Elements:** Namely sensors like encoders and resolvers, stepper and servomotors, ball screws, solenoid like actuators, and controllers with applications to CNC systems, robotics, and consumer electronic products. **Hydraulic Systems**: Flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps, design of hydraulic circuits. **Pneumatics:** Production, distribution and conditioning of compressed air, pneumatic system controllers, system components and graphic representations, design of systems.
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the various components related to the mechatronics. CO2: Understand the real time interfacing, sensor for condition monitoring.
Books and References 1. Mechatronics by W. Bolton, Addison Wesley Longman Pvt. Ltd. 2. Mechatronics system design by Devdas Shetty and Richard A. Kolk, Cengage Learning. 3. Automation Production System and CIMS by Mikel P Groover, Prentice Hall. 4. Mechatronics by G. Hegde, Jones and Bartlett.

Course Name: **Design of Micro-Electro-Mechanical System**
Course Code: **ME-707**
Course Type: Programme Elective-II

Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the micro-electro-mechanical systems (MEMS).
- To introduce the fundamental concepts relevant to fabrications processes and MEMS material.
- To enable the students to understand use of micro sensor, actuator and micro fluidics.

Course Content

Overview of Micro-Electro Mechanical systems (MEMS) and Microsystems: MEMS and microsystem products: micro gears, micro motors, micro turbines, micro-optical components, application of microsystems in automotive industry, application of microsystems in other industries: health care, aerospace, industrial products, consumer products, telecommunications, scaling laws in miniaturization. Working principles of microsystems: micro sensors, micro actuation, MEMS with micro actuators, micro actuators with mechanical inertia, microfluidics.

Engineering Science for Microsystem Design and Fabrication: Atomic structure of matter, ions and ionization, molecular theory of matter and intermolecular forces, doping of semiconductor, diffusion process, plasma physics, electrochemistry.

Engineering Mechanics for Microsystems Design: Static bending of thin plates, design theory of accelerometer, micro accelerometer, thin film mechanics: thermos mechanics, fracture mechanics.

Thermo-fluid Engineering and Microsystems Design: Fluid flow in micro conduits, heat conduction in multilayered thin films and in solids at sub-micrometer scale.

Materials for MEMS and Microsystems: Substrates and wafers, active substrate material, silicon and its compounds, polymers, packaging materials.

Microsystems Fabrication and Manufacturing Process: Photolithography, ion implantation, diffusion, oxidation, chemical vapour deposition, physical vapour deposition, etching, bulk micro manufacturing, surface micro machining LIGA process.

Microsystems Design: Design constraints: selection of materials, manufacturing processes, signal transduction, electromechanical system, and packaging. Process design: photolithography, thin film fabrications, geometry shaping, mechanical design: geometry of MEMS components, thermo mechanical loading, stress analysis, dynamic analysis, interfacial fracture analysis, mechanical design using FEM, FEM formulation, simulation of micro fabrication processes, design of silicon die of a micro pressure sensor, design of micro fluidic network systems, design of micro gas turbine rotor, bearings.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the fundamentals of MEMS.
CO2: Describe the best material and fabrication process for the MEMS.
CO3: Apply the principles various sensors and actuators in real time application.
CO4: Assess the developments and design of Microsystem and electromechanical system.

Books and References

1. MEMS & MICROSYSTEMS: Design & Manufacture, by Hsu, Tai-Ran, TMH.
2. Fundamental of micro fabrication by Madau, M.J., Taylor & Fransis CRC press.
3. Micro manufacturing & Nanotechnology by N. P. Mahalik, Springer India Pvt. Ltd.
4. Handbook of MEMS: Introduction and Fundamental by Gad-el-Hak, M., Taylor and Francis.

Course Name: **Design of Robotic System**
Course Code: **ME-708**
Course Type: Programme Elective-II

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To impart knowledge about the basics of robotics, their anatomy, their common configurations, work envelop.
- To introduce the fundamental concepts specification of robots, applications etc.
- To enable the students to understand the various systems that is used in the robotics.

Course Content

Introduction: Past, present and future, robot terminology, applications, components and subsystems, classification of robot, end effectors, different type of grippers and design concepts.

Robot Kinematics: Mathematical fundamentals of position and orientation, coordinate transformations and Euler angles, homogenous transformations, open kinematic chain, D-H representation, equation dealing with kinematic aspects, modeling of instantaneous motion, inverse instantaneous kinematics, 5-R-1-P manipulator.

Statics: Balancing of force and torque, equivalent joint torques, duality, transformations of force and torque, stiffness.

Dynamics: Lagrange-Euler and Newton-Euler formations-problems, inverse dynamics with emphasis on LWP algorithms, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion, straight line motion – robot programming, languages and software packages.

Robot Actuators and Feedback Components: Actuators: pneumatic, hydraulic actuators, electric & stepper motors, feedback components: position sensors-potentiometers, resolvers, encoders.

Course Outcomes

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

CO1: Describe the history of the robotics.

CO2: Various laws regarding the robotics, common robot configurations, coordinate system and work envelop
and actuators.

CO3: Understand Mathematics behind Robots.

Books and References

1. Robotics by Fu K S, Mc Graw Hill.
2. An introduction to robot technology by Coiffet and Chaironze, Kogam Page ltd. London.
3. Robotic engineering by Richards D. Klafter, Prentice Hall.
4. Introduction to robotics by John J Craig, Pearson.

Course Name: **Fault Diagnostics and Signal Processing**
Course Code: **ME-711**
Course Type: Programme Elective-III

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 field of noise, vibration and condition monitoring.
- To enable the students to understand about fault diagnostics systems of machines.

Course Content

Principles of Maintenance: Reactive maintenance, preventive maintenance, predictive maintenance, enterprise resource planning, bath tub curve, failure modes effect and criticality analysis (FMECA)

Digital Signal Processing: Classification of signals, signal analysis, frequency domain signals analysis, fundamental of fast Fourier transform, computer aided data acquisition, signal conditioning, signal demodulation, cepstrum analysis.

Instrumentation: 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.

Vibration Monitoring: 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.

Noise Monitoring: Acoustical terminology, noise source, sound fields, anechoic chamber, reverberation chamber, noise measurement, noise source identification.

Electrical Machinery Fault: 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 switch gear devices.

Thermography: Thermal imaging devices use of IR camera, industrial applications of thermography, applications of thermography in condition monitoring.

Machine Tool 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 maintainece of the system with faulty diagonosis and prognosis of the system.
CO3: Apply the principles on various machine health monitoring systems.
CO4: Assess the developments 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.

Course Name: **Bearing Design and Lubrication**
Course Code: **ME-712**
Course Type: Programme Elective-III

Contact Hours/Week: **4L** Course Credits: **04**

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

Lubrication: 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, Pertoff's equation, generalized Reynolds equation, simplification of full Reynolds equation, boundary conditions, energy equation. Impact of temperature and pressure on lubricants.

Fluid Film Bearings: 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.

Bearing Materials: Fundamentals of tribology, wear mechanisms, selection of bearing materials, metal bearings, non-metallic bearings.

Rolling Element 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.

Orthopaedic Joint Implants: 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.

Course Name: **Vibrations and Noise Control**
Course Code: **ME-713**
Course Type: Programme Elective-III

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the basic concepts and principles of vibration in mechanical systems.
- To introduce the fundamentals of various materials.
- To enable the students to understand basic principle of noise engineering.

Course Content

Overview of Vibration Control: Introduction, vibration, main causes, quantitative description of vibration, methods of vibration control, basic system parameters.

Harmonically Excited Vibration: One degree of freedom- forced harmonic vibration, vector representation of forces, excitation due to rotating and reciprocating unbalance, vibration isolation, force and motion transmissibility, absolute and relative motion of mass, whirling motion and critical speed: whirling motion and critical speed : definitions and significance, critical –speed of a vertical, light –flexible shaft with single rotor: with and without damping, critical speed of a shaft carrying multiple discs (without damping), secondary critical speed.

Vibration Control and Vibration Absorbers: Damping models and measures, damping-stress relationship, combined fatigue-strength damping criteria, free layer damping, constrained layer damping, bonded rubber springs, introduction- absorbers, auxiliary mass with damper, gyroscopic absorber, impact absorber, and absorbers attached to continuous systems.

Noise Engineering: Subjective response of sound: frequency and sound dependent human response, the decibel scale, relationship between, sound pressure level (SPL), sound power level and sound intensity scale, relationship between addition, subtraction and averaging, sound spectra and octave band analysis, loudness, weighting networks, equivalent sound level, auditory effects of noise, hazardous noise, exposure due to machines and equipment, hearing conservation and damage risk criteria, daily noise doze.

Noise Sources, Isolation and Control: Major sources of noise on road and in industries, noise due to construction equipment and domestic appliances, industrial noise control, strategies- noise control at source (with or without sound enclosures), noise control along the path (with or without partitions and acoustic barriers), noise control at the receiver, ear defenders, earplugs, semi-insert protectors.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify the fundamentals of mechanical vibration systems and their control.
CO2: Describe the role of various vibration control methods.
CO3: Apply the principles of vibration isolation and vibration absorbers.
CO4: Assess the noise engineering and noise isolations.

Books and References

1. Mechanical Vibrations and Noise Engineering by Ambekar A.G., PHI.
2. Element of Vibration Analysis by Meirovitch Leonard, TMH.
3. Active and Passive Vibration Control by Mallik and Chatterjee, Affiliated East-West Press.
4. Mechanical Vibrations by Den Hartog, Dover Publications.

Course Name: **Rapid Product Development**
Course Code: **ME-718**
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To take an overview of rapid prototyping, product development and its relationship with rapid prototyping.
- To understand the data interface for the rapid prototyping, about the STL files, model slicing and contour data organization, part building and rapid tooling and manufacturing.

Course Content

Overview of Rapid Product Development: Product developing cycle and rapid product development, virtual prototyping and rapid manufacturing technologies, physical prototyping & rapid manufacturing technologies.

Synergic Integration Technologies: Rapid prototyping, principal of rapid prototyping, various RP technologies, selection of a suitable RP process for a homogeneity and isotropy.

Rapid Tooling: Introduction to rapid tooling, indirect rapid tooling processes, direct rapid tooling processes, emerging trends in rapid tooling reverse engineering: data extraction and data processing.

Applications and Case Studies: Engineering applications, medical applications, processing of polyhedral data: polyhedral b-rep modeling, introduction to STL format, defects and repair of STL files, overview of the algorithms required for RP & T and reverse engineering.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand about the various techniques to generate the STL files.
CO2: Understand how model slicing and contour data can be organized.
CO3: Know about the description of rapid tooling and manufacturing.
C04: Know the applications of RP in Medicine and Dentistry.

Books and References

1. Virtual Reality Systems by John Vince, Addison-Wesley.
2. Garage Virtual Reality by Linda Jacobson, Sams Publishing.
3. Rapid Prototyping: Principles and Applications in Manufacturing by Chua Chee Kai and Leong Kah Fai, JohnWiley & Sons.
4. Stereo-lithography and Other RP&M Technologies from Rapid prototyping to rapid tooling by Paul F Jacobs, SME/ASME.

Course Name: **Concurrent Engineering**
Course Code: **ME-719**
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To impart knowledge about Concurrent Engineering (CE).
- To understand how to design product for customer, design for manufacture, quality by design.

Course Content

Introduction: Product development objectives and product development cycle, background and challenges faced by modern production environment, sequential engineering process.

Concurrent Engineering: Definition need and utility, objectives of CE, benefits of CE, life cycle design of products, life cycle costs, support for CE: classes of support for CE activity, CE organizational, structure CE, team composition and duties, computer based support, CE implementation process.

Design Product for Customer: Industrial design, quality function deployment, translation process of quality function deployment (QFD). Modeling of concurrent engineering design: compatibility approach, compatibility index, implementation of the compatibility model, integrating the compatibility concerns.

Design for Manufacture (DFM): Introduction, role of DFM in CE, DFM methods, e.g. value engineering, DFM guidelines, design for assembly, creative design methods, product family themes, design axioms, robust design: Taguchi design methods, computer based approach to DFM, evaluation of manufacturability.

Quality by Design: Quality engineering & methodology for robust product design, parameter and tolerance design, quality loss function and signal to noise ratio for designing the quality, experimental approach, design for reliability, life cycle serviceability design, design for maintainability, design for economics, decomposition in concurrent design, concurrent design case studies.

Course Outcomes

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

CO1: To know about the background and challenges faced by modern production.
CO2: Understand the need of concurrent engineering and design.
CO3: Understand Quality loss functions.

Books and References

1. Concurrent Engineering by Menon, Chapman & Hall.
2. Integrated Product Development by M.M. Anderson and L Hein, IFS Publications.
3. Design for Concurrent Engineering by J. Cleetus, CE Research Centre, Morgantown.
4. Concurrent Engineering Fundamentals: Integrated Product Development by Prasad, PHI.

Course Name: **Reverse Engineering**
Course Code: **ME-720**
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the reverse engineering, phases of reverse engineering, Methodologies and techniques of reverse engineering.
- To acquaint the students about the importance of part/product creation through reverse Engineering.

Course Content

Introduction: Need of reverse engineering, definition, application.

Data Acquisition Techniques: Contact method, coordinate measurement machine and robotic arms, on contact methods, triangulation, Structured light etc.

Pre-processing technique registration: Need of pre-processing, import of point cloud data reduction and filtering.

Triangular mesh Modeling: Need filtering of triangular mesh model and its definition, topological characteristics, Euler formula for triangular mesh model, various methods of construction of triangular mesh model.

Segmentation: Definition and need of segmentation, various methods used for segmentation like edge based and face based method of segmentation.

Curve and Surface Modeling: Parametric form of curves and a surfaces, Hermite curve and surface, Bezier curve and surface, B-spline curve and surface, introduction of NURBS.

Course Outcomes

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

CO1: Understand the need of reverse engineering.

CO2: Evaluate the importance of computer aided reverse engineering and use of various hardware and software of reverse engineering.

CO3: Develop an understanding on the relationship between the reverse engineering and rapid prototyping.

CO4: Analyze the use of reverse engineering in creating and storing the details of artifacts.

Books and References

1. Reverse Engineering: An Industrial Perspective by V. Raja and K. Fernandes, Springer- Verlag.
2. Reverse Engineering by K. A. Ingle, McGraw-Hill.
3. Reverse Engineering, 1st edition by L. Wills and P. Newcomb, Springer-Verlag.
4. Smart Product Engineering by Michael Abramovici, Rainer stark, Springer Berlin Heidelberg.

Course Name: **Design Engineering Lab-I** Course Code: **ME- 634** **Course Type: Core**	
Contact Hours/Week: **04P**	Course Credits: **02**

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 crank shaft, 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

- Understand design of various mechanical components.
- Generate various geometric models, Apply FE analysis.

Course Name: **Design Engineering Lab-II**
Course Code: **ME-644**
Course Type: Core

Contact Hours/Week: **04P** Course Credits: **02**

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 sliding wear test on POD and estimate wear coefficient for a standard specimen.
2. To perform 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 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 develop a show-piece and a key chain model using 3-D printer.
10. To perform study on Coordinate Measuring Machine and understand its functions.
11. To study a CIM set-up.
12. To study a Flexible manufacturing System.

Course Outcomes

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

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