Form: **MP 06 (i)**
(Clause 9.5.1)

**Motilal Nehru National Institute of Technology Allahabad**

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

**I Semester:**

| S. No. | Subject Name | Code | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | Computer Aided Design | ME21101 | 4 | 0 | 0 | 4 |
| 2. | Material Modeling for Design | ME21102 | 4 | 0 | 0 | 4 |
| 3. | Elective I | | 4 | 0 | 0 | 4 |
| 4. | Elective II | | 4 | 0 | 0 | 4 |
| 5. | Elective III | | 4 | 0 | 0 | 4 |

**Total Credits = 20**

**II Semester:**

| S. No. | Subject Name | Code | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | Dynamic Design of Mechanical Systems | ME22103 | 4 | 0 | 0 | 4 |
| 2. | Design Engineering Lab | ME22201 | 0 | 0 | 6 | 4 |
| 3. | Elective IV | | 4 | 0 | 0 | 4 |
| 4. | Elective V | | 4 | 0 | 0 | 4 |
| 5. | Elective VI | | 4 | 0 | 0 | 4 |

**Total Credits = 20**

**III Semester:**

| S. No. | Subject Name | Code | Credits |
|---|---|---|---|
| 1. | State of the art Seminar / Special Study / Term Project | ME23651 | 4 |
| 2. | Thesis | ME23601 | 16 |

**IV Semester:**

| S. No. | Subject Name | Code | Credits |
|---|---|---|---|
| 1. | Thesis | ME24601 | 20 |

**Note: The distribution of thesis evaluation marks will be as follows**.

1. Supervisor (s) evaluation component: 60%
2. Oral Board evaluation component: 40%

**List of Electives for M. Tech Mechanical Engineering (Design Engineering)**

| **Elective-I** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21301 | Finite Element Analysis for Mechanical Design |
| 2 | ME21302 | Ergonomics for Mechanical Design |
| 3 | ME21303 | Design of Pressure Vessels |

| **Elective-II** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21304 | Mechatronic Product Design |
| 2 | ME21305 | Tribological System Design |
| 3 | ME21306 | Design of Robotic System |

| **Elective-III** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21307 | Lubrication and Rotor Dynamics |
| 2 | ME21308 | Design of Electronically Controlled Automobiles |
| 3 | ME21309 | Design of Micro-Electro-Mechanical System |

| **Elective-IV** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22310 | Design Against Fatigue and Fracture |
| 2 | ME22311 | Design for Manufacturing and Assembly |
| 3 | ME22312 | Designing with Advanced Materials |

| **Elective-V** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22313 | Optimization Methods for Mechanical Design |
| 2 | ME22314 | Design of Turbo Pumps |
| 3 | ME22315 | Machinery Fault Diagnostics and Signal Processing |

| **Elective-VI** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22316 | Rapid Product Development |
| 2 | ME22317 | Product Design and Development |
| 3 | ME22318 | Reverse Engineering |

**Mechanical Engineering Department**

# Course Code:**ME21101**

# Course Name: **Computer Aided Design**

1. **Introduction:** Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.
2. **Design of Curves:** Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Parametric cubic curve, Blending functions, Truncation, extention, and subdivision, composite curve: continuty requirements, Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves,NURBS.
3. **Geometric Transformations:**Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations. Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.
4. **Design of Surfaces:** Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of aSurface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfacesof Revolutions, Bezier Surface, B-Spline and NURBS Surface.
5. **Design of Solids**: Parametric Solid, Tricubic Solid, Curves and surfaces embedded in a Solid, Generalized notion scheme and higher dimension elements. Instances and parametric shpaes, Sweep Solids, Controlled Deformable solids.Complex model construction: Topology of Models: Euler's formula, connectivity number, genus, Euler-Poincare formula, topological atlas, Orientation, non-orientable surface, topology of closed curved surfaces, Gauss-Bonnet theorem, Euler operators, Euler object, topological disc, nets.Graph based models, Boolean aljebra, Boolean model construction, Constructive Solid Geometry, Boundary Models.Data transfer in a collaborative environment.
6. **Geometric Properties:** Local and global properties of a curve, Local and global properties of a surface, Global properties of complex solids, Relational properties, intersections.

Applications in Product Development and other areas.

**References:**


1. Geometric Modeling: Michael E. Mortenson, Third Edition, Industrial Press Inc.2006.
2. Mathematical Elements of Computer Graphics, Rogers and Adams, McGraw Hill. 1994
3. CAD CAM Theory and Prectice: I. Zeid, Tata-McGraw Hill, 2006
4. Computer-Aided Engineering Design, B Sahay and ASaxena, Springer, 2005.
5. Differential Geometry of Curves and Surfaces, Thomas F. Banchoff and Stephen T. Lovett, Thomas Banchoff-Stephen Lovett, 2010.
6. Computaional Geometry for Design and Manufacture, I.D. Faux and M.J. Pratt, John Wiley, 1980.
7. Lectures on Classical Differential Geometry, Dirk J. Struick, Addison Wesley, 1980.

**Mechanical Engineering Department**

# Course Code:**ME21102**
# Course Name: **Material Modeling for Design**

1 **Mathematical Preliminaries:** Definition of scalar, vector and tensor, index notation, kroneckar delta and permutation symbol, dyadic product, transformation oftensors, tensor algebra, calculus of catesian tensor, orthogonal curvilinear coordinates

2 **Analysis of strain**: introduction, engineering strain and true strain, kinematics of continuous medium, material derivative, deformation gradient tensor, spin tensor, finite strain and deformation, lagrangian and eulerian formulations, geometric measures of strain, relative deformation gradient, rotation and stretch tensor

3 **Analysis of stress:**Body forces and surface forces, traction or stress vector, stress components, stress transformation principal stresses, stress invariants, spherical and deviatoric stress tensors

4 **General principles:** Integral transformation, flux, conservation of mass, continuity equation, momentum principle, equation of motion and equilibrium, couple stresses,enrgy balance, first law of thermodynamics, energy equation, principle of virtual displacement , entropy and the second law of thermodynamics, the clausiusduhem Inequality, thermodynamic tensions, thermodynamic potentials, dissipation function.

5 **Constitutive equations:** Ideal Materials, classical elasticity, generalized Hooke's law, isotropy, hyperelasticty, the strain energy function, Material symmetry, Stress and Strain Transformations, Stiffness and Compliance Transformations

6 **Plane problems**: Plane stress and strain, antiplane strain, Airy stress function, Polar coordinate formulation, Solution of two dimensional plane problems

7 **Plasticity:** Plastic behavior of metals, theories neglecting work hardening: Levy-Mises perfectly plastic, Prandtle-Reuss Elastic perfectly plastic, Yield condition, Plastic Potential Theory, hardening assumptions, deformation theory.

8 **Viscoelasticity:** Linear viscoelastic response: glass transition teperature,creep, stress relaxation and periodic response, constitutive equation based on analogies to spring and dashpot models

9 **Advance topics:** Dislocation modeling, singular stress states, elasticity theory with voids, homogenization,

**References:**


**1.** Theory of Elasticity, Timoshenko and Goodier, McGraw hill.

2. Elasticity: Theory, Applications, and Numerics, Martin H. Sadd, Elsevier.

**3.** Introduction to the Mechanics of a Continuous Medium, Lawence Malvern, Prentice-Hall Inc.

**4.** Micromechanics: Overall Properties of Heterogeneous Materials, Nemat-Nasser S. and Hori M, Elsevier, Oxford.

**5.** Micromechanics of defects in solids, Mura T, MartinusNijhoff, The Hague.

**Mechanical Engineering Department**

Course Code: **ME22103**

Course Name: **Dynamic Design of Mechanical Systems**

1 **Introduction to modal testing**: Presentation and properties of FRF data for SDOF system, Undamped multi degree of freedom system (MDOF), Damped Systems, proportional damping, hysteretic damping, viscous damping, characteristics and presentation of MDOF FRF data.

2 **FRF measurement techniques**: Basic measurement system, structure preparation, excitation of the structure. Transducers and amplifiers, analyzers, digital signal processing. Use of different excitation types, calibration, mass cancellation.

3 **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.

4 **Modal parameter modification methods:** Discrete mass modification, Stiffener/ spring element modification Beam element modifications

5 **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.

6 **Application**: Comparison of experiment and predication. Correction or adjustment of models. Structural modification, response predication and force determination.

**References**


1. Modal Analysis: by Jimin He and Zhi-Fang Fu, 2001, Butterworth-Heinemann, Woburn, MA, USA.
2. Modal testing; Theory, Practice and application, second edition, D J Ewins, research studies Press Ltd., Balddock Hertfordshire, England.
3. Fundamental of mechanical Vibration, 1993, S Grahm Kelly, McGraw-Hill Intl. Editions.
4. Mechanical Vibration, 1990, S S Rao, Addition-Wesley publishing company.
5. Introductory course on Theory and Practice of Mechanical Vibration, 2004,J S Rao and K Gupta, New Age International Publication.

**Mechanical Engineering Department**

Course Code:**ME22201**

Course Name: **Design Engineering Lab**

**Details of Experiments:**

1. Mechanical Design of crankshaft, CAD modeling and FE analysis and its validations.
2. Mechanical Design of a piston, CAD modeling and FE analysis and validations.
3. Testing of material properties using MTS, Hardness Tester, DMA and wear test rig.
4. Dissembly and assembly of a reciprocating compressor and pump. Learning volve operations.
5. Dissembly and Assembly of a machine tool gear box and design for various speed and Drawing ray diagram.
6. Study and identification of various structural components of a vehicle
7. Chassis and dynamic modeling and comfort analysis.
8. Design and development of cam profile for valve operations.
9. Finite element modeling of a truss and solution for a given configurations and loadings.
10. Dynamic modeling of milling machine or radial drilling machine and vibrational structural analysis and vibration suppression case studies.
11. Industrial visits

**References:**

Text books on CAD, FEM, Machine Tool Dynamica, Automobile Text books and Lab manuals.

**Mechanical Engineering Department**

# Course Code: **ME21301**
# Course Name: **Finite Element Analysis for Mechanical Design**

Concept, History, Packages and Range of applications and Steps of FEA; Approaches of FEA
*Direct Approach FEA:*Elemental Equations for simple Discrete systems: Spring Network, Plane Trusses and Plane Frames; Assembly Procedure; Imposition of Boundary Conditions and Solver Technology for linear equations

*Mathematical Approach FEA*:Galerkin's and Raleigh-Ritz Approaches for stress determination
*1D FE Stress Analysis:* Governing Equation and Boundary Conditions for 1D FEA of Bar extension and Beam bending Problems; Weak Formulation and Functional; Polynomial Approximation, Standard 1-D Shape Functions of $C^0$ and $C^1$ Continuity Elements; Derivation of Element Matrices and Vectors; Assembly, Imposition of Boundary Conditions and Nodal Solution; Co-ordinate Transformation and Numerical Integration; Eigen value bar vibration problem;

*Plane 2D and Axisymmetric FE Stress Analysis*: Governing Equation and Boundary Conditions for Torsion of Rod problem; Plane Stress and Plane Strain Problems, Weak Formulation and Functional; Polynomial Approximation, Standard 2-D Shape Functions of $C^0$ Continuity Elements; Derivation of Element Matrices and Vectors; Assembly, Imposition of Boundary Conditions and Nodal Solution; Mapping and Numerical Integration;

*3D FE Stress Analysis:*Governing equation and Boundary conditions 3D Stress Analysis Problems, Weak Formulation and Functional, Polynomial Approximation, Standard 3-D Shape Functions of $C^0$ Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition of boundary conditions and Nodal Solution; Mapping and Numerical Integration FE

*ANSYS Software Applications:* Introduction; general solid modeling using 2D and 3D primitives available in ANSYS;Basic concepts of finite elements, with applications to problems confronted by mechanical designers; Application in analyzing design problems. Issues: solution methods, modeling techniques, basic problem definition. Individual projects focus on the interplay of analysis and testing in product design/development.

**References:**


1. An Introduction to Finite Element Method by J.N. Reddy, TMH, New Delhi
2. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
3. Introduction to Finite Elements in Engineering by Chandrupatla, and Belegundu, PHI Pvt. Ltd., New Delhi
4. The Finite Element Method for Engineers by Huebner, Dewhirst, Smith, and Byrom, John Wiley and Sons (Asia) Pte Ltd, Singapore
5. The Finite Element Method Using MATLAB by Kwon and Bang**,** CRC Press, NY 1999

**Mechanical Engineering Department**

Course Code: **ME21302**
Course Name: **Ergonomics for Mechanical Design**

Introduction to ergonomics and relevance to mechanical design, Anthropometric measures and use of anthropometric data.

Physiology, Anatomy, Biomechanics, Kinesiology, Work-related musculoskeletal disorders.

Design of workspace, Manual material handling, Hand tool design.

Human information processing, Design of controls and displays. Graphic-user interface. Tactile interface and Haptic interface. Kansei engineering.

Design process involving ergonomics check and ergonomic design evaluation.

**References:**


1. Sanders, S. M. and McCormick, E. J., Human Factors in Engineering and Design, McGraw Hill.
2. Bridger, R. S., Introduction to Ergonomics, McGraw Hill.
3. Kroemer, K., Kroemer, H., and Kroemer-Elbert, K. E., Ergonomics - How to design for ease and efficiency, Prentice Hall.
4. Dix, A., Finlay, J., Abowd, G. D. and Beale, R., Human – Computer Interaction, Pearson Education.
5. Cacha, C. A., Ergonomics and safety in hand tool design, Lewis Publishers.

**Mechanical Engineering Department**

# Course Code: **ME21303**
# Course Name: **Design of Pressure Vessels**

***Cylindrical Shell and Various Closures:*** membrane theory for thin shells, stresses in cylindrical, spherical and conical shells, dilation of above shells, general theory of membrane stresses in vessel under internal pressure and its application to ellipsoidal and torispherical end closures. bending of circular plates and determination of stresses in simply supported and clamped circular plate. Introduction to ASME code and formulae

***Junction Stresses, Opening and Reinforcements***: Discontinuity stresses. stress concentration in plate having circular hole due to bi-axial loading. theory of reinforced opening and reinforcement limits.

***Support Design:*** Supports for vertical & horizontal vessels. design of base plate and support lugs. types of anchor bolt, its material and allowable stresses. design of saddle supports.

***Buckling in Vessels:*** Buckling of vessels under external pressure. elastic buckling of long cylinders, buckling modes, collapse under external pressure. design for stiffening rings. buckling under combined external pressure and axial loading.

***Piping stress analysis:*** Flow diagram, piping layout and piping stress analysis. flexibility factor and stress intensification factor.

**References:**

1. Harvey J F , 'Pressure Vessel Design' Cbs Publication
2. Brownell. L. E & Young. E. D , 'Process Equipment Design', Wiley Eastern Ltd., India
References:
3. Henry H Bednar, Pressure Vessel Design Hand Book, Cbs Publishers And Distributors
4. Stanley M Wales, Chemical Process Equipment, Selection And Design, Butterworths, Series In Chemical Engineering,1988.

**Mechanical Engineering Department**

Course Code: **ME21304**

Course Name: **Mechatronic Product Design**

Introduction to key elements of Mechatronic products; Principles of basic electronics - Digital logic, number system logic gates, Sequence logic flip flop systems; Sensors and Actuators, Signals and Systems, 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 tools 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;

**References**:


1. Mechatronics by W. Bolton, published by Addison Worley Longman Pvt. Ltd.,
2. Mechatronics System Design by Devdas Shetty and Richard A. Kolk

Course Code: **ME21305**

Course Name: **Tribological System Design**

Lubrication, Friction and Wear aspects in Design; Tribological Surfaces – Measures of Roughness and associated mechanisms of Lubrication, Regimes of Lubrication; Boundary lubrication and lubricants. Friction and wear at different length scales. Viscosity - its representation and measurement, apparent viscosity. Selection of Bearings - Rubbing, Fluid Film, Rolling Element. Lubricants - Types and Selection, Bearing Design - Rubbing, Fluid Film Journal and Thrust, Dynamically Loaded, Rolling Element, Design of lubrication Systems. Introduction to maintenance of Bearings, Seals, Linear Bearing Design, Slideways. Material considerations for selected tribological applications.

**References:**

1. Friction, Wear, Lubrication: A Textbook in Tribology by Kenneth C Ludema, CRC press
2. History of Tribology by Dowson D, Longman London, 1979.
3. Experimental methods in Tribology by Stachowiak, Batchelor and Stachowick
4. Applied Tribology (Bearing Design and Lubrication) by Michael M Khonsari
5. Principles of Tribology by J Halling

**Mechanical Engineering Department**

# Course Code: **ME21306**

# Course Name: **Design of Robotic System**

**Introduction:** Past, Present & Future; Robot Terminology; Applications, Components and Subsystems; Classification of Robot, End Effectors, Different types of grippers and design concepts.

**Motion Analysis:** Homogeneous transformations as applicable to rotation and translation – problems

**Robot Kinematics:** Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems. Differential transformation and manipulators, Jacobians – problems.

**Dynamics:** Lagrange – Euler and Newton – Euler formations – Problems. **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

**References**


1. Robotics by Fu K S, McGraw Hill.
2. An Introduction to Robot Technology by Coiffet and Chaironze, Kogam Page Ltd. London.
3. Robotic Engineering by Richard D. Klafter, Prentice Hall
4. Robot Analysis and Intelligence by Asada and Slow time, Wiley Inter-Science.
5. Introduction to Robotics by John J Craig, Pearson Edu.
6. Robot Dynamics & Control by Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pte Ltd.

**Mechanical Engineering Department**

# Course Code: **ME21307**
# Course Name: **Lubrication and Rotor Dynamics**

**Introduction:** Tribology Needs for the 2000's. Performance Objective. Lubrication principles: types of bearings. The need of a rotor dynamic analysis. The fundamental equations of lubrication

**Classical Lubrication:** Laminar Flow Fluid Film Bearings. The Reynolds Equation. Magnitude of fluid inertia effects. Boundary conditions and the notion of liquid cavitation

**1-Dimensional bearings:** Evaluation of pressure field and forces for slider, Rayleigh-step bearings and simple dampers; Evaluation of pressure field and forces for ideal tilting pad bearings.

**Kinematics of motion in cylindrical journal bearings:** Reynolds equation for journal bearings. Fixed & rotating coordinates. Pure squeeze film vector. Impedance formulation

**Static load performance of plain journal bearings:** Long and short JB models. Pressure and forces for short JBs. Equilibrium condition, attitude angle and Somerfield Number

**Dynamics of rigid rotor-fluid film bearing system:** Eqns. of motion. The concept of force coefficients. Stability and synchronous response. Effect of cross-coupled stiffness.

**Rotordynamics basics:** Objectives of rotordynamic analysis, spring-mass model, synchronous and nonsynchronous whirl, analysis of Jeffcott rotor, some damping definitions, effect of flexible supports, rotordynamic instability, the gravity critical, added complexities.

**Rotordynamic considerations in turbomachinery design:** rotor design, bearing selection and support design, rotordynamic design evaluation, scaling of existing designs, torsional vibration considerations, synchronous electric motor drive trains, torsional stabilityconsiderations, the roles of analysis and testing

**Critical Speeds and Response to Imbalance:** Methods of analysis and the equations of motion, the long rigid symmetric rotor, Forward/backward whirl, Finite Element modeling of rotor, free and forced lateral vibration response of rotor, Eigen value/critical speed analysis, Campbell diagram, balancing of rotor.

**References**


1. Modern Lubrication Theory by San Andres, L., Texax A&M University Digital Libraries
2. Rotordynamics of Turbomachinery byVance, J. M., John Wiley & Sons, Inc. New Jersey
3. Dynamics of Rotating Machines by Friswell, Penny, Garvey, and Lees, Cambridge University Press
4. Rotating Machinery Vibration by Adams, M. L., Marcel Dekker, Inc.

**Mechanical Engineering Department**

# Course Code: **ME21308**
# Course Name: **Design of Electronically Controlled Automobiles**

**Introduction of automobile system:** Current trends in automobiles with emphasis on increasing role of electronics and software, overview of generic automotive control ECU functioning, overview of typical automotive subsystems and components, AUTOSAR.

**Engine management systems:** Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle position sensors, Fuel metering/ vehicle speed sensors, flow sensor, temperature, air mass flow sensors, throttle position sensor, solenoids etc., algorithms for engine control including open loop and closed loop control system, electronic ignition, EGR for exhaust emission control.

**Vehicle power train and motion control:** Electronic transmission control, adaptive power Steering, adaptive cruise control, safety and comfort systems, anti-lock braking, traction control and electronic stability, active suspension control.

**Active and passive safety system:** Body electronics including lighting control, remote keyless entry, immobilizers etc., electronic instrument clusters and dashboard electronics, aspects of hardware design for automotive including electro-magnetic interference suppression, electromagnetic compatibility etc., (ABS) antilock braking system, (ESP) electronic stability program, air bags.

**Automotive standards and protocols:** Automotive standards like CAN protocol, Lin protocol, flex ray, OBD-II, CAN FD, automotive Ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262).

**System design and energy management**: BMS (battery management system), FCM (fuel control module), principles of system design, assembly process of automotive and instrumentation systems.

**References**


1. Understanding Automotive Electronics by W.B. Ribbens, Butterworth Heinemann Woburn
2. Sensors for Automotive Technology by Jiri Marek, Hans Peter Trah, Wiley
3. Automotive Control Systems by U. Kiencke, and L. Nielson, Springer Verlag Berlin
4. Automotive Electrical Equipment by Young A.P., Griffiths, ELBS & New Press
5. Automobile Electrical Equipment by Crouse W.H., McGraw Hill Co. Inc., New York,
6. Automotive Hand Book by Robert Boshe, Bentely Publishers, 5th ed. Germany

**Mechanical Engineering Department**

# Course Code: **ME21309**
# Course Name: **Design of Micro-Electro-Mechanical System**

1. **Overview of Micro Electro Mechanical systems (MEMS) and Microsystems:** MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-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

2. **Working Principles of Microsystems:** Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics

3. **Engineering Science for Microsystems 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

4. **Engineering Mechanics for Microsystems Design:** Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, fracture mechanics

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

6. **Materials for MEMS and Microsystems:** Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials

7. **Microsystems Fabrication and manufacturing Processes:** Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process

8. **Microsystems Design:** Design Constraints: Selection of Materials, manufacturing processes, signal transduction, electromechanical system, 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.

**References**


1. MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering by Hsu, T.R., John Wiley & Sons, Inc. New Jersey
2. Fundamentals of Microfabrication by Madau, M. J., Taylor &Fransis CRC Press, Boca Ratan
3. Handbook of MEMS: Introduction and Fundamentals by Gad-el-Hak, M., Taylor &Fransis CRC Press, Boca Ratan

**Mechanical Engineering Department**

# Course Code: **ME22310**
# Course Name: **Design Against Fatigue and Fracture**

1 **Linear Elastic Fracture Mechanics (LEFM):** stress concentration effect of flaws, Cracks as stress raisers**;** The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve, Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials**;** Effects of Cracks on Strength**;**

2 Effect of Cracks on 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 $K_{IC}$ with material; Effects of Temperature and loading rate.; Microstructural Influences on $K_{IC}$; Mixed mode fracture.

3 **Elastic-Plastic Fracture Mechanics (EPFM):** Crack tip opening displacement (CTOD),The 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

4 **Fatigue of Materials**: Micromechanism 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 (ε-N) approach, Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect,

5 Experimental 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.

**References:**


1. Fracture Mechanics by Michael Janssen, Jan Zuidema and Russell WanhillSpon Press
2. Metal Fatigue in Engineering by R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs
3. Fracture Mechanics: Fundamentals and Applications by T.L.Anderson, CRC Press
4. Fundamentals of Fracture Mechanics by J.F.Knott , Butterworths
5. Metal Fatigue in Engineering by Stephens, Fatemi, Fuchs and Stephens
6. Fatigue Damage, Crack Growth and Life Prediction by F.Ellyin
7. Elementary Engineering Fracture Mechanics *by* D. Broek, Kluwer Academic
8. Fracture Mechanics with an introduction to micromechanics by Gross and Seelig
9. Elements of Fracture Mechanics by Prashant KumarTata McGraw Hill
10. Deformation and Fracture Mechanics of Engineering, Materials R.W. Hertzberg

**Mechanical Engineering Department**

# Course Code: **ME22311**
# Course Name: **Design for Manufacturing and Assembly**

**1** Introduction to DFMA**,** Implementation of Concurrent Engineering, Issues involved in introducing DFMA, Current state of commercial DFMA packages, Requirements for a new generation of DFMA systems, Knowledge-based approaches to DFMA, Interfacing Design (CAD) and DFMA systems.

**2** Tools for total Design: Quality Function Deployment, Failure Modes and Effects Analysis (FMEA),Axiomatic Design, DFM Guidelines, Design Science, Design for assembly, Robust Design, The Taguchi Method for Robust Design, Manufacturing Process Design Rules, Computer-Aided DFM, Value –Engineering.

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

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

**Metal Joining:**Appraisal of various welding processes, Factors in design of weldaments — general design guidelines — pre and post treatment of welds — effects of thermal stresses in weld joints — design of brazed joints.

**Forging:**Design factors for Forging — Closed die forging design — parting lines of die, drop forging die design — general design recommendations.

**Extrusion & Sheet Metal Work:**Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing — Keeler Goodman Forming Line Diagram — Component Design for Blanking.

**5** **Assembly Advantages:** Development of the assembly process, choice of assembly method, assembly advantages, social effects of automation.

**Automatic Assembly Transfer Systems:** Continuous transfer, intermittent transfer, indexing mechanisms, and operator-paced free-transfer machine.

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

**References:**


1. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, Product Design for Manufacture and Assembly, Third Edition, CRC Press
2. Geoffrey Boothroyd, Assembly Automation and Product Design, Book World Enterprises
3. Product Design and Development by Karl T. Ulrich, Steven D. Eppinger, TMH-Publication
4. Computer Integrated Design and Manufacturing by David D. Bedworth, Mark R. Henderson, Philip M. Wolfe, McGraw-Hill Publication
5. James Bralla, Design for Manufacturability Handbook, McGraw-Hill Professional
6. O. Molloy, E. A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, architectures and implementation, Chapman & Hall, London

**Mechanical Engineering Department**

Course Code: **ME22312**
Course Name: **Designing with Advanced Materials**

Introduction to polymers, composites and smart materials. Polymer microstructure and mechanical properties. Thermosets and thermoplastics. Viscoelastic creep and relaxation behavior, mechanical models, and polymer failure. Design considerations and practices for polymeric components with case studies. Composite materials and their applications. Micro and macro mechanics of lamina, failure criteria of lamina, classical laminate theory, strength of laminates. Design considerations and practices for composite structures with case studies. Structure, applications and design considerations of smart materials such as shape memory alloys and piezoelectric materials.

**References**


1. Introduction to Composite Materials Design by Ever J. Barbero, CRC Press
2. Engineering Design with Polymers and Composites by Gerdeen and Rorrer, CRC Press
3. Engineering Materials 2: An introduction to Microstructure and Processing by Jones and Ashby, Butterworth-Heinemann
4. Polymer Engineering Science and Viscoelasticity by Brinson and Brinson, Springer
5. Mechanics of Composite Materials by Jones, CRC Press

**Mechanical Engineering Department**

Course Code: **ME22313**
Course Name: **Optimization Methods for Mechanical Design**

Introduction to Optimal Design: feasibility and boundedness, topography of search space, classification of methods. Single variable optimization problems, Gradient and Direct search based methods. Constrained and unconstrained problems, problems with non-linear constraints. (With emphasis on applications to Machine Design/Product Design, Vibration control). Nontraditional optimization methods. Optimization with parameter uncertainties; Robust Optimization, formulation, algorithms, applications. Methods of Multi-Disciplinary Optimization (MDO) with case studies in automotive engineering. Optimization for modular design.

**References**


1. Engineering Optimization by S. S. Rao
2. Optimization for Engineering Design by Kalyanmoy Deb

**Mechanical Engineering Department**

# Course Code: **ME22314**
# Course Name: **Design of Turbo Pumps**

1 **Fundamental of impeller pump:**Historical development of rotodynamics pumps and Fundamental definition, Classification of impeller pumps, Comparison of properties of impeller and displacement type pumps. Hydrodynamic equations, Conversion of energy in a flowing of liquid, Basics of theory of impeller pumps.

2 **Basic quantities in the energy balance of pumps:**
Suction, delivery and total heads, Discharge, Power, Efficiencies, Calculation of the head and the power of the motive unit driving a pump.

3 **Flow through impeller:** The phenomenon of the flow through the impeller, Euler's fundamental equations, theoretical head, energy equation for relative flow through an impeller, theoretical head for infinite number of blades, impulse and reaction types of pumps and choice for outlet angle of blades.

4 **Impeller shape:** Geometrical velocity fields, evolution of impeller shapes, choice of number of impeller blades, Range of application of impeller pumps, Relationship between overall efficiency, hydraulic efficiency and the specific speed.

5 **Impeller with blades of single curvature:** General remarries on the design of impellers, Calculation of the dimensions of the impeller.Impeller with blades of double curvature: method of designing impeller, shaping of blade surface, Basic design procedure of impeller for centrifugal boiler feed pump.

6 **Inlet and outlet elements:** type of suction element and construction of volute suction chambers. Vane-less guide-ring. Annular-type recuperators of constants and volute type, vaned diffuser rings on return passages.

**References:**


1. Impeller Pumps by Stephen Lazariciewicz& Adam T. Troscolanski,Rersaman Press, Oxford London
2. Turbopumps and Pumping Systems by Nourbakhsh, A., Jaumotte, A., Hirsch, C., Parizi, H.B, Springer

**Mechanical Engineering Department**

# Course Code: **ME22315**
# Course Name: **Machinery Fault Diagnostics and Signal Processing**

**Principles of Maintenance:** Reactive Maintenance, Preventive Maintenance, Predictive Maintenance, Enterprise Resource Planning, Bath Tub Curve, Failure Modes Effects and Criticality Analysis (FMECA)

**Digital Signal Processing:** Classification of Signals, Signal Analysis, Frequency Domain Signal Analysis, Fundamentals 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 Measurements, Rotational Speed, Noise Measurements, Temperature Measurements, Laser-Based Measurements, Current Measurements, 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 Defects, Gear Fault, Faults in Fluid Machines

**Noise Monitoring:** Acoustical Terminology, Noise Sources, Sound Fields, Anechoic Chamber, Reverberation Chamber, Noise Measurements, Noise Source Identification

**Electrical Machinery Faults:** Construction of an Electric Motor, Faults in Electric Motor, Fault Detection in Electric Motors, MCSA for Fault Detection in Electrical Motors, Instrumentation 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 Switchgear Devices

**Thermography:** Thermal Imaging Devices, Use of IR Camera, Industrial Applications of Thermography, Applications of Thermography in Condition Monitoring

**Wear Debris Analysis:** Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis

**Other Methods in Condition Monitoring:** Eddy Current Testing, Ultrasonic Testing, Radiography, Acoustic Emission

**Machine Tool Condition Monitoring:** Tool Wear, Sensor Fusion in Tool Condition Monitoring, Sensors for Tool Condition Monitoring, A Tool Condition Monitoring System

**References**


1. Machinery Condition Monitoring: Principles and Practices by A.R. Mohanty, Taylor and Francis, CRC Press
2. Mechanical fault diagnosis and condition monitoring by R.A. Collacott, John Wiley, New York
3. Handbook of condition monitoring by A. Davis, Springer Science Business Media
4. Machinery malfunction diagnosis and correction by R.C. Eisenmann, Prentice Hall

**Mechanical Engineering Department**

# Course Code: **ME22316**
# Course Name: **Rapid Product Development**

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 given application, Status of outstanding issue in RP- accuracy, speed, materials (strength, 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 BRep modeling, Introduction to STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering

**References**


1. John Vince, Virtual Reality Systems, Addison-Wesley. 1995
2. Linda Jacobson, Garage Virtual Reality, Sams Publishing, 1994.
3. Chua Chee Kai and Leong Kah Fai, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 1997
4. Paul F. Jacobs, Stereo-lithography and Other RP&M Technologies: from Rapid Prototyping to Rapid Tooling, SME/ASME, 1996
5. Peter D. Hilton and Paul F. Jacobs (Editors), Rapid Tooling: Technologies and Industrial Applications, Marcel Dekker, 2000.

**Mechanical Engineering Department**

# Course Code: **ME22317**
# Course Name: **Product Design and Development**

1. Introduction to Product Design: Characteristics of successful product Development.
2. Who designs & develops products- Industrial & Practical Examples.
3. Creative thinking- Invention- innovation & inventiveness in a society.
4. Development Process & Organization.
5. A Generic Development Process & Concept Development.
6. Identifying Customer Needs.
7. Concept Generation, Concept Selection
8. Product Architecture, Industrial Design.
9. Human Factors & System Information Input- Text graphics, symbols and codes,
10. Work Place Design- case studies.
11. Human Factors Application – case studies.
12. Human Errors – accidents and safety. Techno legal issues
13. Intellectual Property Rights.

**References**:


1. Product Design & Development- Karl T. Ulrich, Steven D Eppinger, McGraw Hill Publishers.
2. The Mechanical Design Process – by David G. Ullman
3. Human Factors in Engineering Design- Mark S sanders & Ernst J. Mc Cornick McGraw Hill Publishers.
4. Product Design & Process Engineering – Benjamin W Nishel& Alan B Draker- McGraw Hill Publishers.
5. Any other reference discussed in class for specific topics

**Mechanical Engineering Department**

# Course Code: **ME22318**
# Course Name: **Reverse Engineering**

1 Introduction: Need of Reverse Engineering, definition, application

2 Data acquisition technique- contact method, coordinate measurement machine and robotic arms

Non-contact methods, triangulation , Structured Light etc.

3 Pre- processing technique – need of pre-processing, import of the point cloud data, registration , data reduction and filtering

4 Triangular mesh modelling – need of triangular mesh model and its definition , topological characteristics, Euler formula for triangular mesh model, various methods of construction of triangular mesh model

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

6 Curve and Surface modelling- Parametric form of curves and a surfaces , Hermite curve and surface, Bezier curve and Surface, B-spline curve and Surface, Introduction of NURBS

**References:**


1. Reverse Engineering and Industrial Prospective by Raja, Vinesh , Fernandes, Kiran J., Springer Series in advanced Manufacturing
2. Reverse Engineering- Recent Advances and Applications by Alexander C Telea, Intech Janeza trotline
3. Smart Product Engineering by Michael Abramovici , Rainer Stark, Springer Berlin Heidelberg