DESIGN AND MANUFACTURING

Under

DEPARTMENT OF MECHANICAL ENGINEERING

1st Semester

Code	Subject	L	T	P	Credit
ME 548	Principles of Industrial Design & Manufacturing	3	0	0	6
ME 527	Computer Aided Design	3	0	0	6
ME 528	Computer Aided Manufacturing	3	0	0	6
ME 5xx	Elective-I	3	0	0	6
ME 5xx	Elective-II	3	0	0	6
ME 539	Seminar	0	0	3	3

Electives – I

Code	Subject	L	T	P	Credit
ME 506	Entrepreneurship & Management	3	0	0	6
ME 529	Advanced Mechatronics	3	0	0	6
ME 530	Advanced Material Science	3	0	0	6
ME 582	Composite Materials	3	0	0	6
ME 547	Waste Management	3	0	0	6

Elective – II

Code	Subject	L	T	P	Credit
ME 581	Structural Property correlation of Engineering Materials	3	0	0	6
ME 526	Computational Methods & Computer Programming	3	0	0	6
ME 507	Optimization Technique	3	0	0	6
ME 531	Principles of Tribology	3	0	0	6
ME 575	Innovation & Product Design	2	1	0	6

2nd Semester

Code	Subject	L	T	P	Credit
ME 523	Advanced Solid Mechanics	2	1	0	6
ME 515	FEM in Engg. Applications	3	0	0	6
ME 541	Robotics & Automation	3	0	0	6
ME 5xx	Elective – III	3	0	0	6
ME 5xx	Elective – IV	3	0	0	6

ME 552	Design & Manufacturing Lab	0	0	3	3

Elective – III

Code	Subject	L	T	P	Credit
ME 540	Production and Operations Management	3	0	0	6
ME 542	Non Traditional Techniques for Optimum Design	3	0	0	6
ME 544	Modern Manufacturing Methods	3	0	0	6
ME 545	Metal Cutting	3	0	0	6
ME 595	Modelling and Simulation	3	0	0	6
ME 585	Manufacturing Management	3	0	0	6

Elective – IV

Code	Subject	L	T	P	Credit
ME 521	Theory of Elasticity	3	0	0	6
ME 546	Ergonomics & Aesthetics	3	0	0	6
ME 524	Engg. Fracture Mechanics	3	0	0	6
ME 532	Theory of Mechanical Vibration	3	0	0	6
ME 533	Theory of Plates and Shells	3	0	0	6
ME 534	Rotor Dynamics	3	0	0	6
ME 536	Theory of Plasticity	3	0	0	6

3rd Semester

Code	Subject	L	T	P	Credit
ME 603	Major Project – Part-I	0	0	14	14

4th Semester

Code	Subject	L	T	P	Credit
ME 604	Major Project – Part-II	0	0	20	20

ME 548	**Principles of Industrial Design & Manufacturing**	**L**	**T**	**P**	**C**
	First Semester (Core)	3	0	0	6

Introduction: Engineering design process and its structure, Steps in design process, Morphology of design, Mechanical engineering design, Traditional design methods, Design synthesis, Aesthetic and ergonomic considerations in design, Use of standards in design, Selection of preferred sizes, design for Maintenance (DFM), design for manufacture, assembly, shipping, maintenance, use, and recyclability. Design checks for clarity, simplicity, modularity and safety, Design organisation and communication, technical reports, drawings, presentations and models.

Materials Selection: Performance characteristics of materials, Materials selection process, Economics of materials, Evaluation methods of materials selection – cost versus performance relation, weighted index, value analysis, Materials in Design: Design for Brittle Fracture, Design for Fatigue Failure, Design for Corrosion Resistance, Design with Plastics, Design with Brittle Materials.

Manufacturing Considerations in Design: Role of processing in design, Types of manufacturing processes, Economics of manufacturing, Design for castings, Forgings, Sheet metal forming, Design for machining, Powder metallurgy, Welding, Heat treatment, Assembly, Corrosion resistance, Designing with plastic processing, Design for manufacturability.

Cost Evaluation: Categories of costs, Methods of developing cost estimates, Cost indexes, Cost-capacity factors, Estimating Plant Cost, Design to cost, Manufacturing costs, Value Analysis in Costing, Activity-Based Costing, Learning Curve, Life cycle costing.

Economic Design Making: Mathematics of time value of money, Cost comparison, Depreciation, Taxes, Profitability of investments, Inflation, Sensitivity and break-even analysis, Uncertainty in economic analysis, Benefit cost analysis.

Need for integration-commercial, economic and technological perspective; basic tools of integration; concept of a system. Introduction to information technology and its elements.

Introduction to group technology; introduction to simulation and database management systems. Elements of integration:-controllers, sensors, robots, automated machines; AGVs, AS, RS.

Introduction to computer aided process planning; selection of machine tools.

Texts/Reference:

1. George Ellwood Dieter: Engineering Design: A Materials and Processing Approach: McGraw-Hill; 4th edition
2. V. B. Bhandari: Design of Machine Elements: TMH, 3/e

ME 527	Computer Aided Design	L	T	P	C
	First Semester (Core)	3	0	0	6

Introduction: Overview of computer aided engineering design.

Transformation: Representation of points; Transformation matrix; Transformation of a point; Homogeneous coordinates; General transformation – rotation, reflexion, translation, sealing and sharing; Combined transformation; Solid body transformation; Parallel projections – orthographic, axonometric and oblique; Perspective projections – single-point, two-point, three-point and vanishing points.

Plane Curves: Curve representation – parametric and nonparametric curves, like circle, ellipse, parabola and hyperbola; Conic sections.

Space Curves: Representation of space curves; Cubic splines; Parabolic blending; Bezier curves; B-spline curves.

Surface Generation: Surfaces of revolution; Sweep surfaces; Quadric surfaces; Bilinear surfaces; Ruled and developable surfaces; Coons linear surfaces; Coons bicubic surfaces; Bezier surfaces; B-spline surfaces.

Solid Body Modeling: Designing a 3D model, like a machine part; Hidden surface removal.

References

1. Mathematical Elements for Computer Graphics. David F. Rogers and J. Alan Adams, Tata McGraw-Hill Edition.
2. Computer Graphics. Roy A. Plastock and Gordon Kalley, McGraw-Hill Book Company.

ME 528	Computer Aided Manufacturing	L	T	P	C
	First Semester (Core)	3	0	0	6

Introduction to Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), product cycle and automation in CAD/CAM, Need of CAD/CAM.

Process Planning: Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or vaiant and generative approach of CAPP, Implementation consideration of CAPP.

Numerical control of Machine tools: Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, counting devices, signal converters, interpolators, adaptive control system.

NC Part programming: Concept, format, codes, preparatory and miscellaneous coded, manual part programming, APT programming, macros, fixed cycles.

Group Technology (CT): Introduction, needs of GT, part families, classification and coding systems, GT machine cells, benefits of GT.

CIM and FMS: Introduction, hierarchical computer system, components of CIM, types of manufacturing systems, transfer lines, flexible manufacturing system (FMS), The manufacturing cell, tool management and workpiece handling system, benefits of CIM.

References:

Sl. No.	Author	Title	Publisher
1.	Groover	Automation, Production systems and computer integrated manufacturing	PHI
2.	Groover and Zimmer	CAD/CAM	PHI
3.	Chang, Wysk and Wang	Computer Aided Manufacturing	PHI
4.	YoramKoren	Computer control of manufacturing system	McGraw Hill Book Co.
5.	B.L. Jones	Computer Numerical Control	John Wiley and Sens
6.	Rao, Tiwari and Kunda	Computer Aided Manufacturing	Tata Mc.Graw Hill
7.	Vajpayee	Principles of Computer Integrated Manufacturing	PHI
8.	RadhakrishnaSubramanyan and Raju	CAD/CAM/CIM	New Age International (P) Ltd., Publishers
9.	Sharma	Fundamentals of Computer aided Manufacturing	S.K. Kataria and Sons.

ME 506	**Entrepreneurship & Management**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**3**	**0**	**0**	**6**

Introduction to Entrepreneurship: Meaning and concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, agencies in entrepreneurship management and future of entrepreneurship.

The Entrepreneur: Meaning of entrepreneur, the skills required to be an entrepreneur, the entrepreneurial decision process, and role models, mentors and support system.

Business Opportunity Identification: Business ideas, methods of generating ideas, and opportunity recognition

Preparing a Business Plan: Meaning and significance of a business plan, components of a business plan, and feasibility study

Financing the New Venture: Importance of new venture financing, types of ownership securities, venture capital, types of debt securities, determining ideal debt-equity mix, and financial institutions and banks

Launching the New Venture: Choosing the legal form of new venture, protection of intellectual property, and marketing the new venture

Managing Growth in New Venture: Characteristics of high growth new ventures, strategies for growth, and building the new venture capital

Harvesting Rewards: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy

E-Entrepreneur, Leadership, Motivation & Productivity. Decision Making, Business Plan, S.S.I., System approach, Organization as system, MIS. Quality, TQM, ISO 9000 Standards.

Texts/Reference:

1. Entrepreneurship by Hisrich, Peters, Shepherd, Manimala; McGraw Hill Education India Private Limited; 9 edition
2. Entrepreneurship by Rajeev Roy; Oxford University Press India; Second edition
3. Entrepreneurship by Alpana Trehan; Dreamtech Press
4. Management and Entrepreneurship by N.V.R. Naidu, T. Krishna Rao; I K International Publishing House Pvt. Ltd
5. Shankar: Entrepreneurship: Theory & Practice: McGraw-Hill
6. A.K. Singh: Entrepreneurship Development & Management: Laxmi Publication
7. David H. Holt: Entrepreneurship: - New Venture Creation: Prentice Hall Publication
8. Randolph &Ponker: Effective Project Planning & Management: Longman Higher Education

ME 529	**Advanced Mechatronics**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**3**	**0**	**0**	**6**

Introduction: Definition of Mechatronics, Scope, key elements, Conventional Vs Mechatronics Systems; Need of Mechatronics in Mechanical Engineering; Electrical/Electronic systems i.e. conductors, Insulators and Semiconductors, passive components used in electronics, transformers, transistors, integrated circuits, digital circuits.

Sensors: Strain gauge, Potentiometers, Tachometers, Linear variable differential transformer, piezoelectric accelerometer, Hall effect sensors, Optical Encores, Resolver, Inductosyn, Tactile and Force sensors.

Actuators: Pneumatic and Hydraulic Actuators, Electrical actuators, stepper motors, DC motors, AC motors.

Electronics fundaments: Brief review of some semiconductor devices. The operational Amplifier. Binary variable and logic, Boolean Algebra, Logic circuits. Digital-to-analog converters, analog-to-Digital converters.

Control systems: Mathematical modeling of physical systems, sensors and actuators, System equations, controllability, observability, pole placement technique, PID Controller.

Applications: Case studies of control of hydraulic, pneumatic, mechanical and electrical system, Application of CNC machines & Robotics. Applications of Mechatronics in Manufacturing and Automation Case Studies.

References

1. Analytical Robotics and Machatronics, Wolfram Stadler, McGraw Hill.
2. Robotic engineering, Rlafter, PHI.
3. Machatronics, AMT
4. Automatic Control System, B.C. Kuo, Ogata, PHI
5. Introduction to Digital computer electronics, A.P. Mahind, TMH
6. Measurement Systems, E.O. Doeblin, McGraw Hill
7. Bolton W. "Mechatronics", 2nd Edition, Pearson Education, New Delhi (1999)
8. Necsulelscu Dan, "Mechatronics", Pearson Education, New Delhi (2002)
9. Mechatronics by Mahalik, Spinger.

ME 530	Advanced Material Science	L	T	P	C
	First Semester (Elective)	3	0	0	6

Composites: Dispersion strengthened composits, particulate composites, Fiber reinforced composites, characteristics of fiber reinforced composites, Fiber reinforced system and applications, Laminar composites materials, Application of laminar composites.

Polymers: Typical Thermoplastics, structure property relationship in thermoplastics, effect of temperature on thermoplastics, Mechanical properties of thermoplastics.

Mico-electro mechanical systems (MEMS) & NANO

Micromachining, Importance of different levels of structure to the material behavior, Technological significance.

Powder metallurgy: Powder metals, P/M process, P/M materials, P/M heat treatment, P/M applications.

References

1. J.F. Shackesford and MK. Muralidhana, Introduction to Material Science, Pearson Education.

2. DR. Askeland and PP. Phule, Essentials of materials Science and Engineering, CENGAGE Learning.

ME 582	**COMPOSITE MATERIALS**	**L**	**T**	**P**	**C**
	First Semester (Elective)	3	0	0	6

UNIT I **FIBRE REINFORCED PLASTICS (FRP)**

Definition; Types; General properties and characteristics; Reinforcing materials – particles, fibers, whiskers; Properties of reinforcing materials; Matrix materials; Additives; Properties of FRP materials; Applications

UNIT II **MA NUFACTURING PROCESSES**

Open mold processes – Hand layup, Spray up, Vacuum bag, Pressure bag & autoclave, Centrifugal casting, Filament winding; Closed mold processes – Compression molding, Resin transfer molding (RTM), Injection molding, Pultrusion; SMC & DMC products, etc.

UNIT III **DESIGNING FIBRE REINFORCED PLASTICS**

Design variables; Selection of fiber-matrix and manufacturing process; Effects of mechanical, thermal, electrical and environmental properties, Fiber orientation, Symmetric and asymmetric structure; Effects of unidirectional continuous and short fibers; Lamination theory; Design equations, Design for failure; FEA design packages; Design examples & case studies in FRP.

UNIT IV **ENGINEERING CERAMICS A ND METAL MATRIX COMPOSITES**

Reinforcement materials; Matrix; Characteristics and specialized properties like – weibull modulus, high temperature strengths, wear & frictional property improvements; Selection criteria; Advantages and limitations in use of ceramics & MMCs; Fracture mechanics; Applications.

UNIT V **CERAMIC & POLYMER METAL COMPOSITES**

CMC & PMC Characteristics, Various types, Advantages & Limitations, Applications. Role of Mixtures Reinforcement – Particles – Fibres. Carbon/Carbon Composites- Advantages, Limitations- Sol-Gel techniques – Chemical Vapor Deposits. Applications.

TEXT BOOK

1. Haslehurst.S.E. "Manufacturing Technology ", ELBS, London, 1990.
2. Krishnan K. Chawle. “Composite Material: Science and Engineering” Second Edition, Springer, 1998
3. T.W.Clyne, P.J. Withers, “An Introduction to metal matrix composites”, Cambridge University Press, 1993.
4. F.C. Campbell “Structural Composite Materials”, Materials Park,ASM International,2010

ME 547	Waste Management	L	T	P	C
	First Semester (Elective)	**3**	**0**	**0**	**6**

Types of wastes, Sources, Factory waste, Municipal waste: waste category, Treatment of waste, Applicable legislation, Waste to wealth, Energy recovery from waste, Plastics waste, paper waste, Recycling, Methodology of waste reduction, Case studies

Reference

1. Waste Management: A Reference Handbook - Jacqueline Vaughn, ABC-Clio, 2008
2. Handbook of Solid Waste Management - George Tchobanoglous, Frank Kreith,Questia online library

ME 581	Structural Property Correlation Of Engineering Materials	L	T	P	C
	First Semester (Elective)	3	0	0	6

UNIT I Introduction

Stiffness, Strength, and Toughness, Types of mechanical behaviour, Relevance, Measurement, data, Macroscopic, continuum behaviour, Physical mechanisms controlling behaviour.

UNIT II **Elasticity**

Introduction, Stress, strain, compliance and stiffness tensors, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, designing for modulus and Composites.

UNIT III **Continuum Plasticity**

True stress-true strain, Necking and Considerer's Criterion, Yield Criteria and yield locus, Normality, Isotropic and kinematic hardening, Plastic stress-strain relations.

UNIT IV **Fracture**

Importance of Fracture Mechanics, Griffith Fracture Theory, Crack Driving Force & Energy Release Rate, Modes of fracture, Stress intensity factors, Similitude, Role of Crack-tip Plasticity--Plastic Zone Size & Shape, K-dominance, Fracture Toughness-Microstructural Issues.

UNIT V **Fatigue**

Total life approaches, Fatigue design approaches, HCF and LCF, Fatigue crack inhibition, Fatigue crack growth, Paris law and models, Threshold, Damage tolerant approach, Striations, Different stages of fatigue crack growth, Examples.

UNIT VI Mechanical Testing Behaviour

Mechanical Characterization: Mechanical Property characterization- Principles & characterization techniques related to tensile, compressive, hardness, fatigue, and fracture toughness properties. Deformation, Super plasticity Stress-strain diagram, Determination of YS, UTS, MoE, %E, %RA, Hardness testing, true stress-strain diagram, stretcher strain characteristics, effects of cold working, & n values, poison's ratio, Deep drawn quality of sheets, Impact test, bend test, shear test, Significances

of property evaluation, SN curves and fatigue life, non-destructive testing, residual stress measurements, corrosion testing, wear & tear characteristics, slow strain rate characteristics.

References

1. GE Dieter, Mechanical Metallurgy, McGraw-Hill
2. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons
3. MF Ashby and DRH Jones, Engineering Materials 1, Butterworth-Heinemann
4. D Hull and DJ Bacon, Introduction to Dislocations, Pergamon
5. Fracture Mechanics – T.L. Anderson, CRC Press.

Additional Readings

2. MA Meyers and K Chawla, Mechanical Behavior of Materials, Prentice Hall
3. S Suresh, Fatigue of Materials, Cambridge University Press
4. JP Hirth and J Lothe, Theory of Dislocations, John Wiley & Sons

And Handouts from time to time.

ME 526	**Computational Methods & Computer Programming**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**3**	**0**	**0**	**6**

Introduction to computer Programming: Discussion on at leastone programming language, like C, C++ JAVA, MATLAB, etc.

Error analysis in numerical computation: Absolute error; Relative error; Round-off error and Truncation error.

Solution of Single variable nonlinear equations: Bracketing method – graphical method, incremental method, bisection method and false position method; Open methods – fixed point iteration, Newton-Raphson method and Secant method.

Roots of singe variable polynomials: Polynomial deflation; Bairstow's method and Muller method.

Solution of a system of multi-variable equations: Linear system of equations-Gauss elimination method. Gauss-Jordan method, matrix inversion, LU decomposition, Jacobiiteration and Gauss-Seidel iteration; Nonlinear system of equations-fixed point iteration. Newton's method, Jacobian matrix and Seidel iteration.

Curve fitting: Least-square line fitting; Exponential curve fitting; polynomial curve fitting – Lagrange polynomial and Newton's polynomial; Interpolation by piecewise spline function – linear spline, quadric spline and cubic spline.

Eigenvalues and Eigenvectors: Eigenvalues of a homogenous matrix and eigenvalues of a symmetric matrix.

Numerical differentiation: Finite difference methods-forward, backward and centre.

Numerical integration: Newton-Cotes quadrature-trapezoidal rule and Simpson's rules; Romberg integration and Gauss quadrature.

Solution of ordinary differential equations: Initial value problem-Euler's methods and Gunge-Kutta methods; Boundary value problems-shooting method, finite difference methods.

Solution of partial differential equations: Elliptic equations and parabolic equations.

References:

1. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canade, Tata McGraw-Hill Publishing Company Ltd.
2. Numerical Methods for Mathematics Science and Engineering. John H. Mathews. Prentice-Hall of India Pvt. Ltd.
3. Applied Numerical Analysis. Curtis F. Gerald and Patrick O. Wheatley, Addison Wesley.

ME 507	**Optimization Technique**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**3**	**0**	**0**	**6**

Introduction: Definition of optimization and its importance; Basic terminologies – design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems – based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point – exhaustive search method and bounding phase method; Refining the bracketed optimum point through region elimination methods – interval halving method, Fibonacci search method and golden section search method; Gradient based methods – bisection method. Newton-Raphson method and secant method.

Multi-variable unconstrained optimization: Optimality criteria; Undirectional search; Direct methods – simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods – Cauchy's steepest descent method, Newton's method, Marquardt's method, conjugate gradient method and variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for less-than-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods – interior penalty function method, exterior penalty function and method of multipliers; Direct methods – variable elimination method, complex search method and

random search method; Gradient based methods – cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

References:

1. Optimization for Engineering Design – Algorithms and Examples. Kalyanmoy Deb, Prentice Hall of India Pvt. Ltd.
2. Introduction to Optimum Design, Jasbir S. Arora, McGraw-Hill International Editions.
3. Optimization Concepts and Applications in Engineering. Ashok D. Belegundu and Tirupathi R. Chandrupatla, Pearson Education.

ME 531	**Principle of Tribology**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**3**	**0**	**0**	**6**

Introduction: History, Industrial Importance.

Engineering Surfaces: Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description, and Fractal Description.

Surface Contact: Non-conforming Surface Contact Geometry, Stresses in Non-conforming Contacts, Contact of Rough Surfaces, Numerical Surface Contact Models.

Adhesion: Adhesion at Solid-Solid Contact, Basic Models, Factors influencing Adhesion, Adhesion produced by Surface Tension, Stiction, Adhesion at the Contact between Rough Surfaces.

Friction: Measurement Methods, Origin of Friction, Friction Theories, Mechanisms, Friction of Metals, Non-metallic Materials: Ceramics, Polymers, Solid Lubricants.

Wear: Types: Adhesive, Abrasive, Corrosive, Fatigue, Minor Forms: Fretting, Erosion, Percussion, Delamination Theory, Wear Debris Analysis, Wear Testing Methods, Wear of Metals, Ceramics, Polymers, Systems Approach for Wear Reduction.

Thermal Considerations in Sliding Contact: Measurement of Surface Temperature in Sliding: Thermocouples, Thin Film Sensors, Radiation Detectors, Metallographic Observation, Liquid Crystals etc., Theoretical Analyses: Archard's Approach, Multiple Heat Input Considerations.

Surface Engineering: Surface Treatments: Microstructural and Thermochemical Treatments, Surface Coatings: Hard Facing, VapourDeposition Processes: PVD, CVD, PECVD etc., Selection of Surface Treatment / Surface Coatings.

Nanotribology: Measurement Tools: Surface Force Apparatus, Scanning Tunnelling Microscope, Atomic / Friction Force Microscope, Measurements, Fabrication

Techniques for MEMS / NEMS, Atomic Scale Simulations.

Reference:

1. B. C. Majumdar: Introduction to Tribology of Bearings: A. H. Wheeler & Co. Ltd., New Delhi,1999
2. A. Cameron and C. M. McEttles: Basic Lubrication Theory: Wiley Eastern Ltd., New Delhi, 1987.

3. P. Sahoo: Engineering Tribology, PHI Learning, 2005.

ME 575	**Innovation & Product Design**	**L**	**T**	**P**	**C**
	First Semester (Elective)	**2**	**1**	**0**	**6**

Introduction: History of design and innovation. Use of technology in day to day life, in agriculture, manufacturing, sanitation, medicine, transportation, information processing, and communications. Comparison of the work of past and current designers across a range of settings.

Fundamentals of Design: Perception of gap and need in user experience. Concepts and ideas. Visualization of ideas through drawing. Computer generated design using auto CAD software.

Optimisation in Design: Introduction, Siddal's Classification of Design Approaches, Optimisation by Differential Calculus, Langrange Multipliers, Linear Programming (Simplex Method), Geometric Programming[3], Johnson's Method of Optimum Design.

Human engineering Consideration in Product Design: Introduction, Human Being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine information Exchange.

Components: Study of basic Electrical, Mechanical, and Electronics components, materials and their properties.

Tools and Manufacturing: Use of basic tools such as milling machine, drill presses, band saws, grinders, Manufacturing processes such as welding techniques and tool making.

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD)

Case studies: Constructing prototype and testing.

Reference Books:

S.N.	**Author**	**Name of Book**	**Publisher**
1.	Bryan Lawson	What Designers Know	ELSEVIER
2.	Karl T. Ulrich	Design: creation of artifacts in society	University of Pennsylvania
3.	Lucienne T.M. Blessing, AmareshChakrabarti	DRM, a Design Research Methodology	SPRINGER
4.	John Heskett	Design: A very short Introduction	OXFORD
5.	John Kolko	Exposing the Magic of Design	OXFORD
6.	AK Chitale& RC Gupta	Product Design & Manufacturing	PHI

ME 523	**Advanced Solid Mechanics**	**L**	**T**	**P**	**C**
	Second Semester (Core)	**2**	**1**	**0**	**6**

Advanced Strength of Materials: Beam Bending and Stability problems, Analysis of Thick Cylinder and Rotating Disk etc., Application of Energy Methods. Equation of Stress Equilibrium: Cauchy's

Equation, Stress Quadratic, Principle stresses; Strain Compatibility: Strain Displacement Relations, Principle Strains; Stress and Strain Invariants. Generalized Hook's law, Lame's Equation of Equilibrium. Introduction to Theory of Plasticity. Experimental stress analysis: basic concept of measuring systems. Causes and types of experimental errors, models and scale factors. Strain gauges: mechanical, optical, electrical etc., Rosette analysis, dynamic applications, strain gauge circuits, recording and indicating devices, digital interfacing, data acquisition and processing. Introduction to theory of photo elasticity.

Reference:

1. L.S. Srinath, Advanced Mechanics of Solids, THM Publishing Co. Ltd., New Delhi.
2. R.G. Budynas, Advanced Strength and Applied Stress Analysis, McGraw Hill Publishing Co.
3. A.P. Boresi, R.J. Schmidt, Advanced Mechanics of Materials, John Willey and Sons Inc.
4. S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, McGraw Hill Publishing Co.
5. P. Raymond, Solid Mechanics for Engineering, John Willey & Sons.
6. J.W. Dally and W.F. Riley, Experimental Stress Analysis, McGraw Hill Publishing Co., New York.

ME 515	**FEM in Engg Applications**	**L**	**T**	**P**	**C**
	Second Semester (Core)	3	0	0	6

Introduction to FEM. Theory for 1-D element and 2-D element. Focus on software development and usage for 1-D, 2-D and 3-Delements. Variational methods. Element types and properties. Boundary conditions. Stress-strain determination. Solution techniques. Mesh refinement. Convergence criterion. Frames, beams and axial element. Plane stress. Plain strain. Ax symmetric problems. Plate bending. Fluid mechanics and Heat transfer, Modules modeling and elastic analysis. Super elements. Structural instability of frames and beams.

Pre Processing, Mesh generation, element connecting, boundary conditions, input of material and processing characteristics – Solution and post processing - Overview of application packages such as ANSYS/ SIMULIA (Abaqus)/Nastran/Altair-HyperWorks. Applications of FE analysis in metal casting, cutting tools, structural analysis of parts, heat transfer etc.

Reference:

1. J. N. Reddy, An Introduction to the Finite Element Method, Tata McGraw-Hill
2. K.J. Bathe, Finite Element Procedures, Klaus-Jurgen Bathe
3. O.C. Zienkiewicz , The Finite Element Method.
4. C.S. Krishnamurthy, Finite Element Analysis: Theory &Programming,TMH Publishing Co.
5. S.S. Rao , The Finite Element Method in Engineering, Pergamon Press.

ME 541	**Robotics & Automation**	**L**	**T**	**P**	**C**
	Second Semester (Core)	**3**	**0**	**0**	**6**

Introduction: Development of industrial robotics, definition of robot and its classification.

Robot Anatomy: Configuration of robots, robot work volume, geometric analysis of robot.

Robot Kinematics: Positions representations, forward and inverse kinematics of multi degree of freedom of robot. Concept of object oriented programming and its application in robotics.

Robot Dynamics: Introduction to mathematical modeling for forward and inverse kinematics analysis, inverted pendulum and its application in biped motion analysis.

Robot Peripherals: End effectors, grippers, sensors, machine vision and their industrial applications.

Automation: Introduction, types of automation, applications of automation, transfer systems, feeders, feed tracks, trays and pallets, escapements, parts placing mechanisms, application of robot in automation and manufacturing operations like welding, spray coating, cutting operations, moulding, machine loading, pick and place, assembly and inspection.

References:

Sl.No.	Author	Title	Publisher
1.	M.P. Groover	Industrial Robotics	Mc.Graw Hill Book Co.
2.	M.P. Groover	Automation, Production systems and computer integrated manufacturing	PHI
3	G. Boothroyd. C. Poli, L.E Murch	Automatic Assembly	Marcel Dekker Inc.
4.	J.J. Craig	Introduction to Robotics	Addition Wesley

ME 540	**Production and Operations Management**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Product development: Principal of good product design, Component and tolerance design, Efficiency, quality and cost construction, Product life cycle. Standardization, simplification, diversification.

Supply chain management

Quality management – Quality analysis and control,Total Quality Management, TQM and continuous improvement, customer focus, Quality awards and concepts, PDCA cycles, Bench marking, Quality function deployment, Taguchi Method, Design of Experiments, Zero defects and six sigma, Quality circle.

Forcasting techniques – Forecasting, Casual and time series models, moving average, exponential smoothening, trend and seasonality.

Aggregate Production Planning: Master scheduling, bills of materials and MRP, Purpose and scope, Basic strategies, Disaggregating methods, Order control and flow control, Routing, Scheduling and priority dispatching, Operations scheduling.

Logistic and facility Design: Facility location factors, evaluation of alternatives, Types of plant layout, evaluation, Computer aided layout, Assembly line balancing.

JIT, Kanban pull system, Bottleneck scheduling and theory of constraints.

Management information system: Value of information, Information storage and retrieval system-data base and data structure, Interactive system, and knowledge base systems.

References:

1. Production & Operations Management by Panneerselvam R Publisher: PRENTICE HSecond Edition.
2. Theory And Problems In Production And Operations Management by Chary, S N Publisher: Tata McGraw-Hill
3. Production Management – a New Concept by V K Dubey Publisher: Commonwealth Publishers
4. Production And Operations Management by KanishkaBedi Publisher: Oxford University Press.

ME 542	**Non Traditional Techniques for Optimum Design**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Introduction: Definition and importance of a nontraditional technique. Advantages over a classical technique.

Genetic Algorithm (GA): Introduction; Chromosome representation and initialization- binary and real representation; GA operators – selection, crossover and mutation; Elite preserving mechanism; Schema theory; Constraints handling; GA for combinatorial problems – permutation representation and real-coded representation; Multi-objective optimization – concept of dominance, non-dominated sorting, ranking and crowding distance.

Differential Evolution (DE): Introduction; Chromosome representation; Target, base and trail vectors; Mutation and crossover; DE for combinatorial problems; Differences between DE and other nontraditional techniques.

Particle Swarm Optimization (PSO): Introduction; Chromosome representation; Global, population and local best solutions; Velocity and position of a solution; PSO for combinatorial problems; Differences between PSO and other nontraditional techniques.

Introduction to other nontraditional techniques: Like simulated annealing, tabu search algorithm, artificial neural network, and ant colony optimization.

References:

1. *Optimization for Engineering Design-Algorithms and Examples* – Kalyanmoy Deb; Prentice Hall of India Pvt. Ltd., New Delhi; 1995.
2. Multi-Objective Optimization using Evolutionary Algorithms – Kalyanmoy Deb; John Wiley & Sons Ltd, England; 2001.
3. *Differential Evolution: A Practical Approach to Global Optimization* – Kenneth V. Price, Rainer M. Storn and Journi A. Lampinen; Natural Computing Series, Springer; 2005.
4. Particle Swarm Optimization – Maurice Clerc; ISTE Publishing Company; 2006.

ME 544	**Modern Manufacturing Methods**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Introduction to Modern Manufacturing Methods, their needs in today's manufacturing scenario, identification and characteristics of these processes, conventional versus modern manufacturing methods.

Mechanical Processes: Abrasive jet machining, Water jet machining, Abrasive water jet machining, Abrasive flow machining, Ultrasonic machining, Ultrasonic welding, their working principles, equipments, process capabilities, applications, advantages and limitations.

Chemical and Electrochemical Processes: Chemical machining, Photo chemical machining, Electrochemical machining, drilling, grinding, deburing, their working principles, equipments, process capabilities, applications, advantages and limitations.

Electrothermal Processes: Electrodischarge machining (EDM), Electrodischarge wire cutting or wire EDM, Electrodischarge grinding, Electrochemical discharge grinding, their working principles, equipments, process capabilities, applications, advantages and limitations.

Electron Beam Machining, Electron Beam welding, Plasma arc cutting, Ion beam machining.

Laser Processing: Process principle, type of laser, equipments, and laser processes: drilling, cutting, machining, welding, heat treating, cladding; applications, advantages and limitations.

High energy rate forming: Electromagnetic forming, explosive forming, electrohydraulic forming, their process principles, applications.

Introduction to some emerging trends in manufacturing: Micromanufacturing, manufacturing processes lead towards micro-manufacturing, micro electro mechanical systems (MEMS), Rapid prototyping, concept of nanotechnology.

References:

Sl.No.	Author	Title	Publisher
1.	V.K. Jain	Advanced Machining Processes	Allied Publilshing Pvt. Ltd.
2.	G.F.Benedict	Nontraditional Manufacturing Processes	Marcel Dekker Inc

3.	P.K. Mishra	Nonconventional Machining	Narosa Publishing House
4.	A. Ghosh & A.K. Mallik	Manufacturing Science	Affiliated East-West Press Pvt. Ltd.
5.	G. Boothroyd& W.A. Knight	Fundamentals of Machining and Machine Tools	CRC Press Taylor & Francis Group
6.	J.A McGeogh	Advanced Methods of Machning	Chapman & Hall
7.	N.P. Mahalik	Micromanufacturing and Nanatechnology	Springer

ME 545	**Metal Cutting**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Introduction: Essential features in metal cutting, the chip, the chip tool interface, Chip flow under conditions of seizure, the built up edge, machined surface.

Forces in metal cutting: Stress on shear plane, Forces in metals and alloys, Stresses on tool, Stress distribution.

Heat in metal cutting: Heat in chip formation, Heat in the tool work interface, Heat in the absence of flow zone, Methods of tool temperature measurement, Tool/work thermocouple, Inserted thermocouples, Changes in hardness and microstructures in steel tool, measured temperature distribution in tools.

Cutting tool materials: Different type of cutting tool materials and relecant characteristic features.

Reference:

1. Metal cutting – E.M. Trent
2. Metal cutting: Theory and Practice – A. Bhattacharyya
3. Manufacturing Processes – B.H. Amstead, Phillipe Ostwald. Myron L. Begeman

ME 595	**MODELLING AND SIMULATION**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	3	0	0	6

UNIT I

Introduction to systems and modeling - discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation and their applications in queueing and inventory problems.

UNIT II

Random number generation an their techniques - tests for random numbers.

UNIT III

Random variable generation.

UNIT IV

Analysis of simulation data. - Input modeling – verification and validation of simulation models – output analysis for a single model.

Simulation languages and packages - FORTRAN, C , C++, GPSS, SIMAN V, MODSIM III,ARENA,QUEST,VMAP - Introduction to GPSS – Case studies - Simulation of manufacturing and material handling system.

References:

1. Jerry Banks and John S, Carson II "Discrete Event system Simulation", Prentice Hall, 1984.
2. Geoffrey Gordon, "System Simulation", Prentice Hall, 1978.
2. Francis Neelamkovil, "Computer Simulation and Modelling", John Willey and sons, 1987.

ME 585	**MANUFACTURING MANAGEMENT**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	3	0	0	6

STRATEGY PLANNING

Nature of production-inventory management systems. Strategic, Tactical and Operational decisions. General discrete location-allocation problems - features and formulations. Facility location models - median model - distribution model - brown and Gibson model

TACTICAL PLANNING

Aggregate production planning - ways to absorb demand fluctuations - costs relevant to aggregate production planning - aggregate production planning models - Inventory management - EOQ decision rules - costs in an inventory system - simple lot size model

SCHEDULING

Operations scheduling - Flow shop - n jobs – 2 machine Johnson's rule, 2 Jobs –M machine, N-Jobs M machine Sequencing Job on parallel machine - Assembly Line Balancing- Project Scheduling-crashing of project network with cost trade off

MRP & MRP-II

Material Requirement Planning (MRP) - working of MRP - Use of MRP system - evolution from MRP to MRP II - master production scheduling - rough cut capacity planning - capacity requirement planning - Lot sizing in MRP II system.

SCM & QUALITY MANAGEMENT

Concept of supply management and SCM, Flow in supply chains, Key issues in supply chain management, Decision phases in supply chain, concept of quality management - standards for quality management - statistical process control - Taguchi method of quality control.

References

1. H.G. Menon, "TQM in New Product Manufacturing", McGraw Hill, 1992.
2. Hax and Candea, "Production and Inventory Management", Prentice Hall, 1984.

3. Buffa. "Modern Production Management", John Welley, 1983.

ME 522	**Rapid Prototyping and Tooling**	L	T	P	C
	Second Semester (Elective)	3	0	0	6

UNIT I

Introduction: Need - Development of RP systems – RP process chain - Impact of Rapid Prototyping and Tooling on Product Development – Benefits- Applications – Digital Prototyping - Virtual prototyping-Introduction to RP Softwares.

UNIT II

CAD Modelling and Data Processing for RP: CAD model preparation, Data Requirements, Data formats (STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP), Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation

UNIT III

Liquid Based and Solid Based Rapid Prototyping System

Stereolithography Apparatus, Fused deposition Modeling, Laminated object manufacturing, Three dimensional printing: Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

UNIT IV

Powder Based Rapid Prototyping Systems

Selective Laser Sintering, Direct Metal Laser Sintering, Three Dimensional Printing, Laser Engineered Net Shaping, Selective Laser Melting, Electron Beam Melting: Processes, materials, products, advantages, applications and limitations – Case Studies.

UNIT V

Rapid Tooling: Rapid Tooling: Conventional Tooling Vs. Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods

UNIT VI

RP Applications: Design, Engineering Analysis and planning applications, Rapid Tooling, Reverse Engineering, Medical Applications of RP

TEXT BOOKS:

1. Rapid prototyping: Principles and applications, second edition, Chua C.K., Leong K.F., and Lim C.S., World Scientific Publishers, 2003
2. Rapid Tooling: Technologies and Industrial Applications, Peter D.Hilton, Hilton/Jacobs, Paul F.Jacobs, CRC press, 2000.

REFERENCES:

1. Rapid prototyping, Andreas Gebhardt, Hanser Gardener Publications, 2003

2. Rapid Prototyping and Engineering applications: A tool box for prototype development, LiouW.Liou, Frank W.Liou, CRC Press, 2007.
3. Rapid Prototyping: Theory and practice, Ali K. Kamrani, EmadAbouel Nasr, Springer, 2006

ME 521	Theory of Elasticity	L	T	P	C
	Second Semester (Elective)	3	0	0	6

Surface and Body forces, Stress and Strain Tensor, Transformation Laws, Lagrangian and Eulerian Description, Equation of Elasticity (Equilibrium, Constitutive law and Boundary Conditions), Cauchy's formula, Principle of Stresses, Lami's stress Ellipsoid, Cauchy stress quadratic, octahedral stress, Stress-strain relationship, Uniqueness of Solutions, St. Venant's Principle, Strain Energy functions, Two-dimensional problems in rectangular coordinates (polynomial solution, bending of beam, Fourier series solution). Two-dimensional problems in polar coordinates (axisymmetric problems – rotating discs, Cylindrical shells, plate with a hole, infinite plate with point load, curved beams). Two-dimensional problems in curvilinear coordinates using stress functions. Torsion (circular and non-circular cross section, membrane analogy, thin walled members, hydrodynamic analogy). Scalar and Vector potentials, Strain potentials. Plane state of stress and strain (Two & Three Dimensional), Airy's stress function for problems, Representation of biharmonic function using complex variables, kolosoff-Mushkelishvili method. Thermal stress and its Applications to problems of curved beam, thick cylinder and rotating disc, stress concentration.

Reference

1. S. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw Hill International Publication.
2. Vitor Dias da Silva, Mechanics and Strength of Materials, Springer.
3. I.S. Sokolnikoff, Mathematical Theory of Elasticity, McGraw-Hill International Publication
4. A.E. Green and W. Zerna, Theoretical Elasticity, Dover Publications
5. L.D. Landau and E.M. Lifschitz, Theory of Elasticity, Pergamon Press

F.P. Beer, E.R. Johnston and J.T. DeWolf, Mechanics of Materials, McGraw-Hill International Publication.

ME 546	Ergonomics & Aesthetics	L	T	P	C
	Second Semester (Elective)	3	0	0	6

Introduction: Ergonomics, Social significance of ergonomics

Posture and Movement: Biomechanical, physiological and anthropometric background, Human biological, ergonomic and psychological capabilities and limitation. Sitting, standing, Hand and arm postures, change of postures; lifting, carrying, pulling and pushing movement.

Information and operation: Visual, Hearing and other senses/information, Controls, types of controls, Relation between operation and operation, Expectation, User friendliness, Different forms of Dialogue.

Environmental Factors: Noise, Vibration, Illumination, Climate, Chemical Substances.

Work Organisation: Analysis and design of job requirements, work place arrangements, materials handling devices systems and machine controls for the improvement of human work place.

The Ergonomics Approach: Project Management, Advances in applied bio-mechanics and ergonomics.

Aesthetics: Aesthetic judgement, Aesthetic universals, Principles of aesthetics, Aesthetic in Marketing, Information technology, Industrial design.

Reference:

1. Work Study and Ergonomics by S. Dalela, Publisher: Standard Publishers
2. An Introduction to Human Factors Engineering By Wickens Christopher D, Publisher: Prentice Hall
3. Human Factors Engineering by Chandler Allen Phillips, Publisher: John Wiley and sons inc.
4. Human Factors in Engineering and Design by Sanders Mark S, Publisher: McGraw Hill
5. Ergonomics for beginners: A quick reference guide by Jan Dul, Bernard A, Weerdmeester, 2nd Edition, CRC press.

ME 524	**Engg. Fracture Mechanics**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Introduction Historical perspective, Fracture mechanics approach to design, Overview and Classification.

Linear Elastic Fracture Mechanics

Griffith Energy balance, R- curve instability, Stress field around crack, Stress Intensity Factor K, Crack tip plasticity, K- controlled fracture, Relationship between K & G.

Elastic-plastic Fracture Mechanics

Elastic - Plastic fracture parameters, CTOD, J-Contour Integral, Different methods of measurement of J-CTOD relationship, J-R curve, J - controlled fracture. EPRI method, Failure assessment diagram, Fatigue crack propagation

Dynamic fracture: Dynamic crack propagation and crack growth arrest, Dynamic fracture toughness (K_{ID}), Determination of K_{ID}.

Fracture Mechanisms in metal and non-metals.

Reference:

1. Engineering Fracture Mechanics – T.L. Anderson, CRC Press.
2. Fracture Mechanics – Nestor Perez, Kluwer Academic Publishers
3. Fracture Mechanics, Theory and Applications – Majid Mirzaei, TMU.

ME 532	Rotor Dynamics	L	T	P	C
	Second Semester (Elective)	3	0	0	6

Rotor-bearing interaction. Flexural vibration, critical speeds of shafts, Effects of anisotropic bearings, unbalanced response of an asymmetric shaft. Gyroscopic effects. Aerodynamic effects. Equivalent discrete system. Geared and branched systems. Fluid film bearings: Steady state characteristics of bearings. Rigid and flexible rotor balancing. Condition monitoring of rotating machinery. Measurement techniques.

Textbooks:

1. J. S. Rao, Rotor Dynamics, Third ed., New Age, New Delhi, 1996
2. M. J. Goodwin, Dynamics of Rotor-Bearing Systems, Unwin Hyman, Sydney, 1989.

ME 533	Theory of Mechanical Vibration	L	T	P	C
	Second Semester (Elective)	3	0	0	6

Scope of the subject. SDOF systems-review of SDOF problem (Free and forced vibration, response to harmonic excitation, rotating unbalance and support excitation, vibration isolation and transmissibility, critical speed, equivalent viscous damping). Response to periodic and arbitrary excitation - Duhamel's integral and impulse response function, Fourier transforms, frequency response function, Nyquist plot, phase plane technique, energy methods, MDOF systems-2dof system, Lagrange equation, matrix formulation of free and forced vibration, beat phenomenon, damped and undamped vibration absorbers, stiffness and flexibility influence coefficients, eigen value problem, normal modes and properties, matrix interaction techniques, modal analysis. Continuous system - axial vibration of bar, torsional vibration of shafts, transverse vibration of string and bending vibration of beams, free and forced vibration and normal mode theory.

Approximate methods - Rayleigh-Ritz method, Galerkin's method.

Reference

1. L Meirovitch, Elements of Vibration Analysis, McGraw Hill, Second edition, 1986.
2. Meirovitch, Principles & Techniques of Vibrations, Prentice Hall International (PHIPE), New Jersey, 1997.
3. W T Thomson, Theory of Vibration with Applications, CBS Publ., 1990.
4. F S Tse, I E Morse and R T Hinkle, Mechanical Vibrations, CBS Publ., 1983.
5. J S Rao and K Gupta, Theory and Practice of Mechanical Vibrations, New Age Publication, 1995.

ME 534	Theory of Plates and Shells	L	T	P	C

	Second Semester (Elective)	**3**	**0**	**0**	**6**

Classical bending theory of plates, rectangular and circular plates with various edge conditions and loading, plates of various shapes, strain energy method, approximate method in the theory of plates, introduction to differential geometry, various theory of thin elastic shells and fundamental equations. Static analysis of shells – membrane analysis of shells of revolution, bending analysis of shells of revolution, approximate solutions. Dynamic analysis of shells – free and forced vibration of shells, Buckling of shells. Use of numerical methods on shells under static and dynamic loading.

Textbooks:

[1] S. Timoshenko and S. K. Woinowsky, "Theory of Plates and Shells", McGraw-Hill International, 2007

[2] J. N. Reddy, "Theory and Analysis of Elastic Plates and Shells", CRC Press, 2006.

References:

[1] E. Ventsel and T. Krauthammer, "Thin Plates and Shells", Marcel Dekker, Inc., 2001.

[2] A. Ugural, "Stresses in Plates and Shells", McGraw Hill, 1999.

[3] P. L. Gould, "Analysis of Shells and Plates", Springer-Verlag, 1988.

[4] C. L.Dym., "Introduction to the Theory of Shells", Hempshire Publishing Corp., 1990.

ME 536	**Theory of Plasticity**	**L**	**T**	**P**	**C**
	Second Semester (Elective)	**3**	**0**	**0**	**6**

Introduction to theory of plasticity, relevant stress strain analysis, equations of plastic states, elastic plastic equilibrium problems, elastic plastic bending and torsion, beams and frames, problem with spherical and cylindrical symmetry. Plastic instability, mechanism of metal forming. Theory of slip line field, Steady and non-steady problem in plane stress and strain. Dynamic problems. Viscoplasticity, creep. Introduction with numerical application.

Reference

1. Popov EP: Introduction of Mechanics of Solids: PHI Pvt. Ltd, New Delhi
2. Chakraborty J.: Applied Plasticity: Springer, 2nd ED.
3. Kachanov L.M.: Foundations of The Theory of Plasticity, North Holand Publishing Company.
4. Hill R.: The Mathematical Theory of Plasticity, Oxford University Press Inc, MewYork.