M. Tech. in "CAD-CAM and Automation"

Four Semester Course: Two Years

Semester-I

Code	Subject Name	L	T	P	Credit
ME 526	Computational Methods & Computer Programming	3	0	0	6
ME 561	Geometric Modeling for CAD	3	0	0	6
ME 528	Computer Aided Manufacturing	3	0	0	6
ME 562	Design for Manufacturing and Assembly	3	0	0	6
ME 5xx	Elective – I	3	0	0	6
ME 563	CAD-CAM & Automation Lab - I	0	0	2	2
ME 564	Seminar/ Mini Project	0	0	2	2
	Total	**15**	**0**	**4**	**34**

Semester-II

Code	Subject Name	L	T	P	Credit
ME 515	FEM in Engg Applications	3	0	0	6
ME 541	Robotics & Automation	3	0	0	6
ME 566	Computer Integrated Manufacturing	3	0	0	6
ME 567	Product Lifecycle Management	2	0	0	4
ME 5xx	Elective - II	3	0	0	6
ME 568	CAD-CAM & Automation Lab - II	0	0	2	2
ME 569	CAD-CAM & Automation Lab - III	0	0	2	2
	Total	**14**	**0**	**4**	**32**

Semester-III

Code	Subject Name	L	T	P	Credit
ME 605	Project Work Phase - I	0	0	-	--

Semester-IV

Code	Subject Name	L	T	P	Credit
ME 606	Project Work Phase - II	0	0	34	34

Grand Total Credits 100

Electives

Code	Subject Name	L	T	P	Credit
	Elective – I				
ME 507	Optimization Techniques	3	0	0	6
ME 530	Advanced Material Science	3	0	0	6
ME 529	Advanced Mechatronics	3	0	0	6
ME 571	Product Design and Development	3	0	0	6
ME 574	Virtual Reality	3	0	0	6
ME 575	Innovation & Product Design	2	1	0	6
	Elective – II				
ME 573*	MEMS Technology	3	0	0	6
ME 546	Ergonomics & Aesthetics	3	0	0	6
ME 544	Modern Manufacturing Methods	3	0	0	6
ME 542	Non Traditional Techniques for Optimum Design	3	0	0	6
ME 540	Production and Operations Management	3	0	0	6
ME 572	Reverse Engineering	3	0	0	6

Department of Mechanical Engineering, National Institute of Technology, Silchar

Syllabus scope for M.Tech. (CAD-CAM and Automation)

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

Introduction to computer Programming: Discussion on at least one 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.

Text books and references:

Author	**Title**	**Publisher**
Steven C. Chapra and Raymond P. Canade	Numerical Methods for Engineers	Tata McGraw-Hill Publishing Company Ltd.
John H. Mathews	Numerical Methods for Mathematics Science and Engineering	Prentice-Hall of India Pvt. Ltd.

Curtis F. Gerald and Patrick O. Wheatley,	Applied Numerical Analysis	Addison Wesley

ME 561	**Geometric Modeling for CAD**	**L**	**T**	**P**	**C**
	First Semester	3	0	0	6

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Transformation: Representation of points; Transformation matrix; Transformation of a point; Homogeneous coordinates; General transformation – rotation, reflexion, translation, scaling 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: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Representation of space curves; Cubic splines; Parabolic blending; Bezier curves; B-spline curves, Rational Polynomials, NURBS.

Surface Generation: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, surfaces of revolution; Sweep surfaces; Quadric surfaces; Bilinear surfaces; Ruled and developable surfaces; Coons linear surfaces; Coons bicubic surfaces; Bezier surfaces; B-spline surfaces.

Solids: Fundamental of Solid Design, Parametric Space of a Solid; Surface and Curves in a Solid.

Solid Modeling: Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Mechanical Engineering Design.

CAD Standards: Standardization of graphics, Graphical kernel system (GKS), other graphic standards, data exchange standards for modelling data.

Text books and references:

Author	**Title**	**Publisher**
David F. Rogers and J. Alan Adams	Mathematical Elements for Computer Graphics	Tata McGraw-Hill Edition
Mantyla M.	An Introduction to Solid Modeling,	Computer Science Press

Ibrahim Zeid	CAD/CAM Theory and Practice	Tata McGraw-Hill
P.N.Rao	CAD/CAM Principles and Applications	TATA McGraw Hill
Michael E. Mortenson	Geometric Modeling	John Wiley, 1992.
Anupam Saxena, Birendra Sahay	Computer Aided Engineering Design	Springer; 2005 edition

ME 528	**Computer Aided Manufacturing**	**L**	**T**	**P**	**C**
	First Semester	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.

Text books and references:

Author	**Title**	**Publisher**
Groover	Automation, Production systems and computer integrated manufacturing	PHI
Groover and Zimmer	CAD/CAM	PHI
Chang, Wysk & Wang	Computer Aided Manufacturing	PHI
Yoram Koren	Computer control of manufacturing system	McGraw Hill Book Co.
B.L. Jones	Computer Numerical Control	John Wiley and Sons

Rao, Tiwari & Kunda	Computer Aided Manufacturing	Tata Mc.Graw Hill
Vajpayee	Principles of Computer Integrated Manufacturing	PHI
Radhakrishna	CAD/CAM/CIM	New Age International
Subramanyan & Raju		(P) Ltd., Publishers
Sharma	Fundamentals of Computer aided Manufacturing	S.K. Kataria and Sons.

ME 562	**Design for Manufacturing and Assembly**	**L**	**T**	**P**	**C**
	First Semester	2	0	1	5

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

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

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

METAL JOINING: Appraisal of various welding processes, Factors in design of weidments — 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 die5 drop forging die design — general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing — Keeler Goodman Forming Line Diagram — Component Design for Blanking.

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

AUTOMATIC ASSEMBLY TRANSFER SYSTEMS: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

DESIGN OF MANUAL ASSEMBLY: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency,

classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

Text books and references:

Author	**Title**	**Publisher**
Geoffrey Boothroyd	Assembly Automation and Product Design	Marcel Dekker Inc., NY
George E. Deiter	Engineering Design – Material & Processing Approach	McGraw Hill Intl
Geoffrey Boothroyd	Hand Book of Product Design	Marcel and Dekken, N.Y.

ME 515	**FEM in Engg Applications**	**L**	**T**	**P**	**C**
	Second Semester	**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.

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ME 541	Robotics & Automation	L	T	P	C
	Second Semester	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.

Text books and references:

Author	Title	Publisher
M.P. Groover	Industrial Robotics	Mc.Graw Hill Book Co.
M.P. Groover	Automation, Production systems and computer integrated manufacturing	PHI
G. Boothroyd. C. Poli, L.E Murch	Automatic Assembly	Marcel Dekker Inc.
J.J. Craig	Introduction to Robotics	Addition Wesley

ME 566	Computer Integrated Manufacturing	L	T	P	C
	Second Semester	3	0	0	6

Introduction: Fundamental concepts in Manufacturing and Automation, Automation Strategies, Economic analysis in production, fundamentals of CAD / CAM, product cycle and CAD/CAM, Automation and CAD/CAM, Scope of CIM, Automated flow lines, Transfer mechanisms, methods of Line balancing.

Shop floor control and Introduction to Flexible Manufacturing Systems: Shop floor control, phases-factory data collection system, automatic identification methods – Bar code technology – automated data collection system, Components of FMS Work stations, Material Handling Systems, and Computer Control system, FMS layout configurations and benefits of FMS, Application of CNC in FMS.

Computer aided planning systems: Approaches to Computer aided Process Planning (CAPP) – Generative and Retrieval CAPP systems, benefits of CAPP, Material Requirement Planning (MRP), mechanism of MRP, benefits, and Capacity Planning.

Computer integrated manufacturing: Adaptive control machining systems. adaptive control optimization system, adaptive control constraint system, applications to machining processes, computer process monitoring, hierarchical structure of computers in manufacturing, and computer process control.

CIM Data Base and Communication: Introduction to database, Data Base Terminology, Data base management, Communication fundamentals, local area networks, network management and installations, Tools & Techniques.

CIM Management and Personnel: Role of management in CIM, Conventional Wisdom challenged, Cost justification, Expert Systems, Participative Management, Impact of CIM on Personnel, Role of Manufacturing Engineers, Role of Institutions.

Text books and references:

Author	**Title**	**Publisher**
Mikel P.Groover	Automation, Production systems and Computer Integrated Manufacturing Systems	PHI Publishers
Mikell P.Groover, and Emory W.Zimmers.Jr	CAD/CAM	PHI Publishers
K.Lalit Narayan, K. MallikarjunaRao, MMM Sarcar	Computer Aided Design and Manufacturing	PHI Publishers
Radhakrishnan and Subramanian	CAD/CAM/CIM	New Age Publishers
S. Kant Vajpayee	Principles of Computer Integrated Manufacturing	PHI Publishers

ME 567	**Product Lifecycle Management**	**L**	**T**	**P**	**C**
	Second Semester	2	0	0	4

Product Life Cycle Environment : Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM.

Product Development Process : Integrated Product development process - **Conceive** – Specification, Concept design, **Design** - Detailed design, Validation and analysis (simulation), Tool design, **Realize** - Plan manufacturing , Manufacture, Build/Assemble , Test (quality check) , **Service -** Sell and Deliver , Use , Maintain and Support, Dispose.

Product Development Approaches: Bottom-up design, Top-down design, Front-loading design workflow, Design in context, Modular design. Concurrent engineering, partnership with supplier, collaborative and Internet based design, work structuring and team deployment, Product and process systemization, problem, identification and solving methodologies, improving product development solutions

Product Modelling: Product Modelling - Definition of concepts - Fundamental issues – Role of Process chains and product models -Types of product models – model standardization efforts-types of process chains - Industrial demands. Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration),

Product Data Management (PDM) Technology - Product Data Management – An Introduction to Concepts, Benefits and Terminology, PDM functions, definition and architectures of PDM systems, product data interchange, portal integration, PDM acquisition and implementation. Information authoring tools (e.g., MCAD, ECAD, and technical publishing), Core functions (e.g., data vaults, document and content management, workflow and program management), Functional applications (e.g., configuration Management)

Recent Advances: Intelligent Information Systems - Knowledge based product and process models - Applications of soft computing in product development process.

Text books and references:

Author	**Title**	**Publisher**
Grieves, Michael	Product Lifecycle Management	McGraw-Hill
Antti Saaksvuori, Anselmi Immonen	Product Life Cycle Management	Springer
Stark, John	Product Lifecycle Management: Paradigm for 21st Century Product Realisation	Springer-Verlag
Fan, D. (Ed.)	Virtual Reality for Industrial Applications	Springer

ME 507	Optimization Technique	L	T	P	C
	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.

Text books and references:

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

ME 530	Advanced Material Science	L	T	P	C
	Elective	3	0	0	6

OBJECTIVES

Atomic structure and interatomic bonding. Lattices, basic idea of symmetry. Bravais lattices, unit cells, crystal structures, crystal planes and directions, co-ordination number. Single crystals, polycrystalline, non-crystalline, nano crystalline materials. Imperfections in solids: point defects, line defects, surface defects. Solid solutions, phases, phase diagrams. Diffusion henomenon, phase transformations. Strengthening mechanisms. Classification of materials, properties of materials. Structure, properties and applications of different metals and alloys, ceramics and polymers.

REFERENCES

1. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
2. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

ME 529	Advanced Mechatronics	L	T	P	C
	Elective	3	0	0	6

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

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

Actuators: Pneumatic and Hydraulic Actuators, Electrical actuatofs, 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.

Text books and references:

Author	Title	Publisher
Wolfram Stadler	Analytical Robotics and Machatronics	McGraw Hill
Rlafter	Robotic engineering	PHI
	Machatronics	AMT
B.C. Kuo, Ogata	Automatic Control System	PHI
A.P. Mahind	Introduction to Digital computer electronics	TMH
E.O. Doeblin	Measurement Systems	McGraw Hill
Bolton W.	Mechatronics	2nd Edition, Pearson Education, New Delhi
Necsulelscu Dan	Mechatronics	Pearson Education,
Mahalik	Mechatronics	Spinger

ME 571	Product Design And Development	L	T	P	C
	Elective	3	0	0	6

Introduction: Significance of product design, product design and development process, sequential engineering design method, the challenges of product development.

Product Planning and Project Selection: Identifying opportunities, evaluate and prioritize projects, allocation of resources.

Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.

Product Specifications: Establish target specifications, setting final specifications.

Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output.

Industrial Design: Assessing need for industrial design, industrial design process, management, assessing quality of industrial design.

Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Theory of inventive problem solving (TRIZ): Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model based technology for generating innovative ideas.

Concept Testing: Elements of testing: qualitative and quantitative methods including survey, measurement of customers' response.

Intellectual Property: Elements and outline, patenting procedures, claim procedure.

Design for Environment: Impact, regulations from government, ISO system.

Text books and references:

Author	Title	Publisher
Ulrich K. T, and Eppinger S.D	Product Design and Development	Tata McGraw Hill
Otto K, and Wood K	Product Design	Pearson
Semyon D. Savransky	Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving	CRC Press
Michael A. Orloff	Inventive thinking through TRIZ: a practical guide	Springer
John Terninko, Alla Zusman	Systematic innovation: an introduction to TRIZ ; (theory of inventive Problem Solving)	CRC Press

ME 574	Virtual Reality	L	T	P	C
	Elective	3	0	0	6

Introduction to Virtual Reality (VR): Virtual vs Interactive vs Immersive, Virtual Reality (VR) vs Augmented Reality (AR), Real vs Virtual.

Benefits of VR: 3D Visualization, Navigation, Interaction, Physical Simulation, Virtual environments.

3D Computer Graphics: From Computer Graphics to VR, Modelling Objects, Dynamic Objects, Constraints, Collision Detection, Perspective Views, 3D Clipping, Stereoscopic Vision, Rendering the Image, Texture Mapping, Bump Mapping, Environment Mapping, Shadow, Radiosity, Other Computer Graphics Techniques.

Human Factors: Human factor in virtual environments, Vision, Vision and Display Technology, Hearing, Tactile, Equilibrium.

VR Hardware: Computers, Tracking Devices, Input Devices, Output Devices, Glasses, Displays, Audio. Head Mounted Display (HMD), Motion Trackers, BOOM, CAVE, Sensor Glove, Haptic Feedback devices.

VR Software: VR Software Features, Web-Based VR, Division's dVISE, Blueberry3D, Boston Dynamics, MultiGen.

VR and AR Applications: Industrial, Training Simulators, Entertainment, VR/AR Centres.

Text books and references:

Author	Title	Publisher

John Vince	Introduction to Virtual Reality	Springer
Greg Kipper, Joseph Rampolla	Augmented Reality: An Emerging Technologies Guide to AR	Syngress Media,U.S.
Fan, D. (Ed.)	Virtual Reality for Industrial Applications	Springer

ME 575	**Innovation & Product Design**	**L**	**T**	**P**	**C**
	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, Amaresh Chakrabarti	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 573	**MEMS Technology**	**L**	**T**	**P**	**C**
	Elective	3	0	0	6

Overview of MEMS and microsystems, microelectronics, microfabrication, miniaturization, typical MEMS and microsystems products.

Working principles of microsystems: microsensors, microactuation, MEMS with microactuators, microfluidics, microvalves, micropumps, micro-heatpipes.

Overview of materials for MEMS and microsystems: atomic structure of matter, ions and ionization, doping of semiconductors, diffusion process, electrochemistry.

Microsystem fabrication: photolithography, ion implantation, diffusion, oxidation, chemical vapor deposition, physical vapor deposition, sputtering, etching.

Micromanufacturing: bulk micromanufacturing, surface micromanufacturing, LIGA process.

Assembly, packaging and testing of microsystems: overview of microassembly, microassembly processes, major technical problems of microassembly, microsystem packaging and its levels, essential packaging technologies, reliability and testing in MEMS packaging.

Reference books:

1 MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering, Tai-Ran Hsu, John Wiley & Sons, Inc.

2 Micro manufacturing and Nanotechnology, N. P. Mahalik, Springer

2 An Introduction to Microelectromechanical Systems Engineering, Nadim Maluf, Kirt Williams, Artech House, Inc.

4 Nanotechnology, Mark Ratner, Danier Ratner, Pearson Education Inc.

5 Introduction to Nanotechnology, Charles P. Poole Jr. & Frank J. Owens, John Wiley & Sons, Inc.

6 Nanotechnology Understanding Small systems, Roger, Pennathur, Adams, CRC Press

7. MEMS Mechanical Sensors, Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, Artech House, Inc.

8 MEMS Introduction and Fundamentals, Mohamed Gad-el-Hak, CRC Press

ME 546	Ergonomics & Aesthetics	L	T	P	C
	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.

Text books and references:

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

ME 544	Modern Manufacturing Methods	L	T	P	C
	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.

Text books and references:

Author	**Title**	**Publisher**
V.K. Jain	Advanced Machining Processes	Allied Publilshing Pvt. Ltd.
G.F.Benedict	Nontraditional Manufacturing Processes	Marcel Dekker Inc
P.K. Mishra	Nonconventional Machining	Narosa Publishing House
A. Ghosh& A.K. Mallik	Manufacturing Science	Affiliated East-West Press Pvt. Ltd.
G. Boothroyd & W.A. Knight	Fundamentals of Machining and Machine Tools	CRC Press Taylor & Francis Group
J.A McGeogh	Advanced Methods of Machning	Chapman & Hall
N.P. Mahalik	Micromanufacturing and Nanatechnology	Springer

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

Introduction: Definition and importance of a non-traditional 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 non-traditional 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 non-traditional techniques: Like simulated annealing, tabu search algorithm, artificial neural network, and ant colony optimization.

Text books and references:

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

ME 540	**Production and Operations Management**	**L**	**T**	**P**	**C**
	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.

Text books and references:

Author	**Title**	**Publisher**
Panneerselvam R	Production & Operations Management	Prentice H Second Edition
Chary, S N	Theory And Problems In Production And Operations Management	Tata McGraw-Hill
V K Dubey	Production Management – a New Concept	Commonwealth Publishers
Kanishka Bedi	Production And Operations Management	Oxford University Press

ME 572	**Reverse Engineering**	**L**	**T**	**P**	**C**
	Elective	3	0	0	6

Introduction of Reverse and concurrent engineering. Elements of concurrent engineering. Advantage and applications.

Theory of measurements: Linear, angular, curved surfaces, methods of advanced Measuring devices, Coordinate Measuring machine. Elements to CMM. Data accumulation, retrieval.

Geometric Modeling: 2D and 3D Graphics, concepts of various transformations of Geometric Models, Wireframe surface and solid modeling techniques, representation of parametric and non-parametric curves and surfaces, Mathematical representation of solid and solid modeling- based applications. CAD/CAM data exchanges. Visual realism and Graphics Tools.

Applications: Auto-CAD, Auto-surt, Auto-Mil., and UNIGRAPHICS. CAD/CAM interfaces, process planning, computer aided production planning systems. Capacity planning. Part Programming. APT, CAPPS programming, Geometry definition, Tool Path generation.

Rapid Prototyping: Concurrent Engineering, Need of Rapid Prototyping. Techniques, Resins, (Laser engines) Laser, Laser production and control. Post curing, Data retrieval from CAD, MIC codes generation, Apparatus for quality measurement (CMM).