Department of Mechanical Engineering
Curriculum and Syllabi for M. Tech. in CAD-CAM & Automation

With effect from 2019 entry batch

PO Statements:

Program Outcomes (POs) of the M. Tech degree in CAD-CAM & Automation are as follows-

(a) Graduates will demonstrate sound domain knowledge on wider perspective to become successful professionals.

(b) Graduates will demonstrate an ability to identify, formulate and solve Industry related problems using CAD-CAM and automation concept.

(c) Graduates will demonstrate an ability to conceptualize product designs with innovative manufacturing and evaluate them using Computer Aided Design and Computer Aided Manufacturing.

(d) Graduates will demonstrate skill of good researcher to work on a problem, starting from scratch, to research into literature, methodologies, techniques, tools, and conduct experiments and interpret data.

(e) Graduates will demonstrate research skills to critically analyse industrial production process for synthesizing new and existing information for design and manufacturing product.

(f) Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.

(g) Graduates will exhibit the traits of professional integrity and ethics and demonstrate the responsibility to implement the research outcome for sustainable development of the society.

(h) Graduates will be able to communicate effectively to comprehend and write effective reports following engineering standards.

(i) Graduates will demonstrate skills of presenting their work unequivocally before scientific community, and give and take clear instructions.

(j) Graduate will demonstrate traits of manager in handling engineering projects and related finance, and coordinate workforce towards achieving their goals.

(k) Graduates will exhibit the traits of good academician and engage in independent and reflective lifelong learning.

(l) Graduates will demonstrate an ability to work on laboratory and multidisciplinary tasks.

Course Structure

Semester I

Code	Subject	L	T	P	Credit
ME 5101	Computer Aided Manufacturing	3	0	0	3
ME 5102	Geometric Modeling for CAD	3	0	0	3
ME 5103	Product Design & Development	3	0	0	3
ME 51xx	Elective I	3	0	0	3
ME 5xxx	Elective II	3	0	0	3
ME 5104	CAD-CAM & Automation Lab - I	0	0	3	2
ME 5110	Seminar	0	0	2	1
	Total contact hours/credits	15	0	5	18

Semester II

Code	Subject Name	L	T	P	Credit
ME 5105	FEM in Engineering Applications	3	0	0	3
ME 5106	Robotics & Automation	3	0	0	3
ME 51xx	Elective-III	3	0	0	3
ME 5xxx	Elective-IV	3	0	0	3
ME 51xx	Elective-V	3	0	0	3
ME 5109	CAD-CAM & Automation Lab - II	0	0	3	2
ME 5120	Mini Project	0	0	2	1
	Total contact hours/credits	**15**	**0**	**5**	**18**

Semester: III and IV

S. N.	Code	Subject	L	T	P	Credits	Semester
1	ME 6199	Project	-	-	-	14	III and IV
		Total contact hours/Credits	-	-	-	14	---

Electives–I

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5131	Optimization Technique	3	0	0	3
2.	ME 5132	Virtual Reality	3	0	0	3

3	ME 5133	Innovation & Product Design	3	0	0	3
4.	ME 5135	Industrial Welding Applications	3	0	0	3
5.	ME 5142	Mechatronic Systems	3	0	0	3

Elective–II

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5301	Advanced Material Science	3	0	0	3
2.	ME 5147	MEMS Technology	3	0	0	3
3	ME 5150	Tribology	3	0	0	3
4.	ME 5154	Enterprise Resource Planning	3	0	0	3
5.	ME 5155	Metrology and Computer Aided Inspection	3	0	0	3

Elective-III

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5136	Reverse Engineering	3	0	0	3
2.	ME 5137	Product Lifecycle Management	3	0	0	3
3	ME 5138	Additive Manufacturing	3	0	0	3
4.	ME 5139	Engineering Fracture Mechanics	3	0	0	3
5.	ME 5140	Mechanical Behaviour of Materials	3	0	0	3

Elective-IV

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5134	Non-Destructive Testing of Materials	3	0	0	3
2.	ME 5307	Modern Manufacturing Methods	3	0	0	3
3	ME 5143	Fundamentals of Artificial Intelligence and Neural Network	3	0	0	3
4.	ME 5144	Biomechanics	3	0	0	3
5.	ME 5145	Design and analysis of experiments	3	0	0	3

Elective-V

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5148	Ergonomics & Aesthetics	3	0	0	3
2.	ME 5149	Non Traditional Techniques for Optimum Design	3	0	0	3
3	ME 5151	Industrial Automation	3	0	0	3
4.	ME 5152	Supply Chain Management	3	0	0	3
5.	ME 5153	Reliability Engineering	3	0	0	3

Detailed Syllabi

ME 5101	Computer Aided Manufacturing	L	T	P	C
	M.Tech. (CAD-CAM & Automation), First Semester (Core)	3	0	0	3

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 variant 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.

Texts/References:

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. Yoram Koren, "Computer control of manufacturing system"McGraw Hill Book Co.
5. B.L. Jones, "Computer Numerical Control" John Wiley and Sons
6. Rao, Tiwari and Kunda, "Computer Aided Manufacturing" Tata McGraw Hill
7. Vajpayee, "Principles of Computer Integrated Manufacturing" PHI
8. Radhakrishna Subramanyan and Raju, "CAD/CAM/CIM" New Age International (P) Ltd.
9. Sharma, "Fundamentals of Computer aided Manufacturing" S.K. Kataria and Sons.

Course Outcomes:

1. Describe terminologies used in computer aided manufacturing processes.
2. Develop the classification and coding techniques for part families.
3. Develop the Computer aided Process Plans for the parts to be manufactured.
4. Acquainted with NC, CNC, DNC and adaptive control in machine tools to apply in practical fields.
5. Identify the various components of CNC machines and describe their functions.
6. Write CNC Program for machining components.
7. Develop products with the use of CNC machines
8. Correlate the NC technologies with FMS, CIM systems.

ME 5102	**Geometric Modeling for CAD**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Core)	3	0	0	3

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, reflection, 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, Re-parameterization, 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, Re-parameterization 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 bi-cubic 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.

Texts/References:

1. David F. Rogers and J. Alan Adams, “Mathematical Elements for Computer Graphics” Tata McGraw-Hill Edition
2. Mantyla M. Ibrahim Zeid, “An Introduction to Solid Modeling, CAD/CAM Theory and Practice” Tata McGraw-Hill
3. P.N.Rao, “CAD/CAM Principles and Applications” Tata McGraw-Hill
4. Michael E. Mortenson, “Geometric Modeling” John Wiley
5. Anupam Saxena, Birendra Sahay, “Computer Aided Engineering Design” Springer

Course Outcomes:

1. Understand geometric transformation techniques in CAD.
2. Develop algorithms and write code for solving simple geometric transformation problems
3. Develop mathematical models to represent curves.
4. Model engineering components using solid modeling techniques.
5. Design and analysis of engineering components

ME 5103	**Product Design & Development**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Core)	3	0	0	3

Introduction to product design and development: Requirement of product development and challenges; Product life-cycle; Product development process and organizations; Product design process; Identifying customer need; concept generation; concept selection and testing; product analysis; challenges in product development.
Introduction to product design tools: quality function deployment (QFD), Computer Aided Design; Industrial Design; Robust design; Design for environment; Design for Excellence (DFX), Design for Manufacturing (DFM), Design for Assembly (DFA), Design for service, Ergonomics in product design, Prototyping
Design for Manufacturing and Assembly (DFMA) guidelines: Design guidelines for products to be manufactured by different processes such as casting, machining, injection moulding etc. Product design for assembly: types of assembly, product design for manual assembly: design guidelines; development of DFA methodology
Application of value engineering in product design and development, Patents and Intellectual Property.

Texts/References:

1. Karl T. Ulrich and Steven D. Eppinger, "Product Design and Development" McGraw Hill
2. Geoffrey Boothroyd, "Assembly Automation and Product Design" Marcel Dekker Inc., NY
3. Otto K, and Wood K, "Product Design" Pearson
4. Dan Cuffaro, Isaac Zaksenberg, Garrett Oliver, "The Industrial Design Reference & Specification Book:" Rockport

Course Outcomes:
1. Identify the different stages in product design and development.
2. Utilize the product design concept for developing a successful product.
3. Design and develop the product using the concept of DFX, DFM, DFA, Design for Service and Design for environment.
4. Apply the concept of Design for Manufacturing and Assembly in product design
5. Use value engineering concept in product design and development.

ME 5104	**CAD-CAM & Automation Lab– I**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Core)	0	0	3	2

Introduction to CAD software, 2 D drafting, Dimensioning; 3 D drafting, Geometric modelling of curves, surfaces and solid primitives, Modification of geometric models as per user's requirements. Drawing of complex machine components and assembly.
Introduction to Finite Element Analysis software, Import and FEM analysis of CAD components (stress and deflection analysis).

Course Outcomes:
Students will be able to-

1. Implement the ideas of design and manufacturing related concepts in attacking real life problems.
2. Will be able to draft 2D and 3D objects using CAD software.

ME 5110	**Seminar**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Core)	0	0	2	1

Individual students are required to choose a topic of their interest from engineering domain preferably from outside the M.Tech syllabus.
Evaluation will be executed based on Clarity on the topic, Literature review, Content, Presentation, Response to Questions.

Course Outcomes: At the end of the course the student will be able to

1. Identify and compare technical and practical issues related to Engineering domain.
2. Prepare report with proper citation.
3. Analyse technical issues and develop competence in presenting it.

ME 5131	**Optimization Technique**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-I)	3	0	0	3

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; Unidirectional 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.

Texts/References:

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. S. Rao, Engineering Optimization: Theory and Practice
3. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Engineering Optimization: Methods and Applications, Second Edition
4. Jasbir S. Arora, "Introduction to Optimum Design" McGraw-Hill International Editions
5. Ashok D. Belegundu and Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering" Pearson Education

Course Outcomes:
1. Understand basic fundamentals of optimization techniques
2. Know the limitations of different solution methodologies.
3. Identify real-world objectives and constraints based on actual problem descriptions
4. Create mathematical optimization models.
5. Work through proper solution techniques.
6. Make recommendations based on solutions, analyses, and limitations of models.

ME 5132	**Virtual Reality**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-I)	3	0	0	3

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.

Texts/References:

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

Course Outcomes:
1. Understand the concept of Virtual Reality
2. Identify and apply the VR concept through computer graphics
3. Apply the effect of human factor for virtual environment
4. Identify the requirement of computer hardware.

ME 5133	**Innovation & Product Design**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-I)	3	0	0	3

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.
Optimization in Design: Introduction, Siddal's Classification of Design Approaches, optimization 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.

Texts/References:

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

Course Outcomes:

1. Identify the necessity of product development
2. Apply the concept of design for design
3. Apply the concept of human engineering in product design
4. Identity the requirement of basic tools for product developments

ME 5135	**Industrial Welding Applications**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-I)	3	0	0	3

Application of welding in heavy engineering: Boiler manufacture - boiler drum, water wall panels, headers, economizers. Heat exchangers. Application of welding in oil & gas industries: orbital pipe welding, welding consumables, fabrication codes, inspection &testing, acceptance criteria. Application of welding in Nuclear Power: Materials, processes, fabrication codes, inspection & testing, reasons for stringent quality control measures. Application of welding in automotive industries: Thin sheet welding, selection of materials and welding processes, inspection and testing procedure, acceptance criteria. Application of welding in shipbuilding & Aerospace Industry: Materials involved, welding processes, fabrication code, inspection & testing, acceptance criteria.

Texts/References

1. American Welding Society, 'Guide for Steel Hull Welding', 1992
2. Gooch T. S; 'Review of Overlay Welding Procedure for Light Water Nuclear PressureVessels', American Welding Society, 1991
3. Winter Mark H, 'Materials and Welding in Off-Shore Constructions', Elsevier, 1986
4. Welding Institute Canada, 'Welding for Challenging Environments', Pergamon Press, 1996.
5. Mishra, R.S and Mohoney, M W, Friction stir welding and processing, ASM 2007.

Course Outcomes:

1. Apply the knowledge of welding in Heavy Engineering
2. Apply the knowledge of welding in Automotive Industries
3. Apply the knowledge of welding in Nuclear Power

ME 5142	**Mechatronic Systems**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-I)	3	0	0	3

Definition of mechatronics. Mechatronics in manufacturing, products and design. Review of fundamentals of electronics. Data conversion devices, sensors, micro-sensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs. Description of PID controllers. Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems. Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. CNC machines and part programming. Industrial Robotics.

Texts/References:

[1] Boucher, T. O., Computer automation in manufacturing - an Introduction, Chapman and Hall, 1996.

[2] HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988

References:

[1] Deb,S. R., Robotics technology and flexible automation, Tata McGraw-Hill, New Delhi, 1994.

[2] Boltan, W., Mechatronics: electronic control systems in mechanical and electrical engineering, Longman,Singapore, 1999.

Course Outcomes:

At the end of the course the student should be able to:

1. Model, analyze and control engineering systems
2. Select appropriate sensors, transducers and actuators to monitor and control the behavior of a process or product.
3. Develop PLC programs for a given task.
4. Evaluate the performance of mechatronic systems.

ME 5301	**Advanced Material Science**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-II)	3	0	0	3

Composites: Dispersion strengthened composites, 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.

Micro-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.

Texts/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.
3. Advanced Topics in Material Science and Engineering. J L Lopez, Kluwer Academic.
4. Powder metallurgy. B K Datta, PHI.
5. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
6. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

Course Outcomes:

1. Ability to apply knowledge of mathematics, science and engineering.

2. Ability to use the techniques, skills and modern engineering tools necessary to engineering practice.
3. Ability to design machining/micromachining process to meet desired needs.
4. Ability to identify, formulate and solve engineering problems to frame design rules for polymer / composite /Nano materials.

ME 5147	**MEMS Technology**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-II)	3	0	0	3

Overview of MEMS and microsystems, microelectronics, micro fabrication, miniaturization, typical MEMS and microsystems products.
Working principles of microsystems: micro sensors, micro actuation, MEMS with micro actuators, microfluidics, micro valves, micro pumps, micro-heat pipes.
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.
Micro manufacturing: bulk micro manufacturing, surface micro manufacturing, LIGA process.
Assembly, packaging and testing of microsystems: overview of micro assembly, micro assembly processes, major technical problems of micro assembly, microsystem packaging and its levels, essential packaging technologies, reliability and testing in MEMS packaging.

Texts/References:

1 Tai-Ran Hsu, "MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering" John Wiley & Sons, Inc.
2 N. P. Mahalik, "Micro manufacturing and Nanotechnology," Springer
4 Mark Ratner, Danier Ratner, "Nanotechnology" Pearson Education Inc.
5 Roger, Pennathur, Adams, "Nanotechnology Understanding Small systems" CRC Press
6 Mohamed Gad-el-Hak, "MEMS Introduction and Fundamentals" CRC Press

Course Outcomes:
Students will be able to
1. Identify the applications of MEMS.
2. Describe the working principles of microsystems.
3. Select the appropriate materials and processes for MEMS fabrication.
4. Prescribe suitable testing, assembling, packaging and handling techniques.

ME 5150	**Tribology**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-II)	3	0	0	3

Industrial significance of tribology - Strength and deformation properties of solids - physiochemical characteristics of solid surfaces –fracture-modes of fracture- ductile-brittle-Analysis of surface roughness - measurement. Friction - classification - Adhesion theory of friction - Elastic, plastic and visco - elastic effects in friction - rolling friction - friction of materials - alloys - ceramics - polymers - Interface temperature of sliding surfaces -

measurement. Wear - forms of wear-abrasive wear –adhesive wear-erosive wear-cavitation wear-corrosive wear-oxidative wear-fatigue wear-melting wear-diffusive wear-mechanisms-wear of nonmetallic materials. Lubrication –types of lubrication-hydro dynamic lubrication - Reynolds equation - hydrostatic lubrication - bearing analysis – elastohydrodynamic lubrication - solid lubrication - boundary lubrication. Micro/nano tribology - Measurement techniques - Surface Force Apparatus (SFA) - Scanning Probe Microscopy - Atomic Force Microscopy (AFM)-Nano-mechanical Properties of Solid Surfaces and Thin Films - Computer Simulations of Nanometer-Scale Indentation and Friction.

Texts/References

1. I.M. Hutchings, "Tribology: Friction and Wear of Engineering Materials", Elsevier Limited, 1992.
2. G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited, 2005.
3. K.C. Ludema, "Friction, wear, lubrication: A text book in tribology", CRC Press, 1996.
4. Bharat Bhushan, "Principles and applications of tribology", John Wiley & Sons, 1999.
5. Bharat Bhushan, "Nanotribology and Nanomechanics: An Introduction", Springer, 2008.

Course Outcomes:

Students will be able to

1. Apply the knowledge of tribology in industries
2. Identify the friction and its effect
3. Identify the surface textures

ME 5154	Enterprise Resource Planning	L	T	P	C
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-II)	3	0	0	3

Introduction to ERP: Enterprise – an overview, brief history of ERP, common ERP myths, Role of CIO, Basic concepts of ERP, Risk factors of ERP implementation, Operation and Maintenance issues, Managing risk on ERP projects.

ERP and Related Technologies: BPR, Data Warehousing, Data Mining, OLAP, PLM, SCM, CRM, GIS, Intranets, Extranets, Middleware, Computer Security, Functional Modules of ERP Software, Integration of ERP, SCM and CRM applications.

ERP Implementation: Why ERP, ERP Implementation Life Cycle, ERP Package Selection, ERP Transition Strategies, ERP Implementation Process, ERP Project Teams.

ERP Operation and Maintenance: Role of Consultants, Vendors and Employees, Successes and Failure factors of ERP implementation, Maximizing the ERP system, ERP and e-Business, Future Directions and Trends.

Texts/References

1. Alexis Leon, *Enterprise Resource Planning*, Tata McGraw Hill, Second Edition, 2008.
2. Jagan Nathan Vaman, *ERP in Practice*, Tata McGraw Hill, 2007.
3. Carol A Ptak, ERP*: Tools, Techniques, and Applications for Integrating the Supply Chain*, 2nd Edition, CRC Press, 2003.

Course Outcomes: At the end of the course, the student shall be able to:

1. Understand the concepts of ERP and managing risks.

2. Choose the technologies needed for ERP implementation.
3. Develop the implementation process.
4. Analyze the role of Consultants, Vendors and Employees.
5. Evaluate the role of PLM, SCM and CRM in ERP.

ME 5155	**Metrology and Computer Aided Inspection**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), First Semester (Elective-II)	3	0	0	3

Introduction: Accuracy, precision, limits fits and tolerances, types of assemblies, linear and angular measurements, design of limit gauges for different applications.
Surface Roughness Measurement: Definitions – Types of Surface Texture: Surface Roughness Measurement Methods- Comparison, Contact and Non-Contact type roughness measuring devices, 3D Surface Roughness Measurement, Nano Level Surface Roughness Measurement – Instruments.
Measurement Of Form Errors: Straightness, flatness, alignment errors-surface texture-various measuring instruments-run out and concentricity, Computational techniques in measurement of form errors.
Interferometry: Introduction, Principles of light interference – Interferometers – Measurement and Calibration – Laser Interferometry.
Computer Aided Laser Metrology: Tool Makers Microscope, Coordinate Measuring Machines – Applications, Laser Micrometer, Laser Scanning gauge. Computer Aided Inspection techniques - In-process inspection, Machine Vision System-Applications, LASER micrometer, Optical - LASER interferometers-applications.
Image Processing For Metrology: Overview, Computer imaging systems, Image Analysis, Pre-processing, Human vision system, Image model, Image enhancement, grey scale models, histogram models, Image Transforms – Examples.

Texts/References:
1. M. Mahajan, *A text-book of Metrology*, DhanpatRai& Co, 2009.
2. K. J. Hume, *Engineering Metrology,* 1970, Mc Donald & Co (Publishers), London
3. J.F.W. Galyer and C.R. Shotbolt, *Metrology for Engineers*, ELBS Edition, 5/e, 1993.
4. Thomas. G. G, *Engineering Metrology*, Butterworth PUB.1974.
5. R. K. Jain, *Engineering Metrology*, Khanna Publishers, 19/e, 2005.

Course Outcomes: At the end of the course, the student shall be able to:
1. Explain the significance of calibration, traceability and uncertainty.
2. Identify measurement errors and suggest suitable techniques to minimize them.
3. Analyze the methods and devices for dimensional metrology.
4. Design limit gauges.

ME 5105	FEM in Engineering Applications	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Core)	3	0	0	3

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.

Texts/References:

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.

Course Outcomes: At the end of the course, the student shall be able to:

A. Understand the concept of finite element method for solving Mechanical Engineering problems
B. Formulate and solve manually problems in 1-D structural systems involving bars, trusses, beams and frames.
C. Develop 2-D FE formulations involving triangular, quadrilateral elements and higher order elements.
D. Apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis.
E. Develop algorithms and write FE code for solving simple design problems and understand the use of commercial packages for complex problems.

ME 5106	Robotics & Automation	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Core)	3	0	0	3

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.

Texts/References:

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
4. J.J. Craig Introduction to Robotics Addition Wesley

Course Outcomes: At the end of the course, the student shall be able to:
1. Apply the concept to robotics in industry
2. Synthesis the robotic configuration
3. Synthesis the mathematical modeling with robotic motion analysis
4. Utilize the robot peripherals to enhance the capability of robot for automatic holding, sensing the object for industrial application

ME 5109	**CAD-CAM & Automation Lab – II**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Core)	0	0	3	2

1. Introduction to Solid Modeling and Installation of CAD/CAM/CAE Software
2. Solid Modeling of simple machine parts and assembly.
3. Solving problems of Trusses using FEM
4. Solving problems of Beams and Frames using FEM
5. Solving problems involving different meshing types using FEM
6. Thermal analysis of different mechanical components/machine parts

Course Outcomes:
At the end of the course the student will be able to
1. Use parametric 3D CAD software tools in the correct manner for making geometric part models, assemblies and automated drawings of mechanical components.
2. Apply CAD software tools for assembly of mechanism from schematic or component drawing and conduct position/ path/ kinematic / dynamic analysis of a mechanism in motion.
3. Perform Finite Element Analysis of structural, mechanical and thermal engineering problems.

ME 5120	Mini Project	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Core)	0	0	2	1

Introduction to sensors, open source software and controller, Rapid prototyping tools, Advanced manufacturing machine tools.

Course Outcomes:
At the end of the course the student will be able to-

1. Approach real life problem using open source tools
2. Demonstrate prototype using electro mechanical components

ME 5136	Reverse Engineering	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)	3	0	0	3

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

Reverse Engineering Techniques and Methodologies – The Potential for Automation with 3-D Laser Scanners, Reverse Engineering, Computer-aided Forward Engineering, Computer-aided Reverse Engineering, Computer Vision and Reverse Engineering Reverse Engineering–Hardware and Software: Contact Methods Noncontact Methods,

Destructive Method Selecting a Reverse Engineering System: The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" Ranging Systems, Structured-light and Stereoscopic Imaging Systems, issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Comments on Accuracy, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing

Approaches Integration between Reverse Engineering and Additive manufacturing: Modeling Cloud Data in Reverse Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation,

Reverse Engineering in Automotive, Aerospace, Medical sectors: Legal Aspects of Reverse Engineering: Copyright Law.

General Concepts: Generalized measurement system, Basic terminology, Errors in measurement, Calibration, Uncertainty

Texts/References:

1. K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall, 2001.

2. Raja and Fernandes, Reverse Engineering: An Industrial Perspective, Springer, 2008.
3. AnupamSaxena, BirendraSahay, Computer Aided Engineering Design, Springer, 2005.
4. Ali K. Kamrani and EmadAbouel Nasr, Engineering Design and Rapid Prototyping, Springer, 2010.

Course Outcomes: At the end of the course, the student shall be able to:

1. Identify and explain the steps involved in reverse engineering of a given component.
2. Apply the concepts of calibration, traceability and uncertainty for accurate and reliable measurements
3. Describe the methods and devices for dimensional metrology.
4. Assess surface roughness and form errors

ME 5137	Product Lifecycle Management	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)	3	0	0	3

Introduction: Background, Overview, Need, Benefits, and Concept of Product Life Cycle, Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. **Product life cycle environment**: Product Data and Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around 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 & methodologies:** 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. Bottom-up design, Top-down design, Front loading design workflow, Design in context, Modular design. Concurrent engineering - work structuring and team Deployment - Product and process systemization - problem, identification and solving methodologies. Product Reliability, Mortality Curve. Design for Manufacturing, Design for Assembly. Design for Six Sigma. **Product modelling**: Product Modeling - 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.
Product data management (PDM) technology: Product Data Management – An Introduction to Concepts, Benefits and Terminology, CIM Data. PDM functions, definition and architectures of PDM systems, product data interchange, portal integration, PDM acquisition and implementation.

Texts/References:

1. Michael Grieves, Product Lifecycle Management, McGraw-Hill, 2006.
2. Antti Saaksvuori, Anselmi Immonen, Product Life Cycle Management - Springer, 1st Edition

3. John Stark, Product Lifecycle Management: Paradigm for 21st Century Product Realization, SpringerVerlag, 2004.
4. Kari Ulrich and Steven D. Eppinger, Product Design & Development, McGraw Hill International Edns, 1999.

Course Outcomes:

At the end of the course, the student shall be able to:

1. Remember the reasons for adopting PLM strategies and methods
2. Identify PLM's impacts on corporate strategy, structure and operations
3. Distinguish product development processes
4. Distinguish associated engineering information with the product development process
5. Construct and manage product data using PLM/PDM technologies.

ME 5138	Additive Manufacturing	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)	3	0	0	3

1 Introduction

Overview and History of Additive Manufacturing, CAD-CAM and its integration, Traditional Prototyping Vs. Rapid Prototyping (RP), Benefits of AM, Classification of Additive Manufacturing Processes: Additive, Subtractive, Formative, Generic AM Process, Applications in Product Development.

2 Cad Modelling and Data Processing

Introduction, Data Processing for Additive Manufacturing Technology: 3D solid modeling software and their role in AM, CAD model preparation, Data interface for Additive Manufacturing: Creation of STL file, Problem with STL file, STL files Manipulation, Beyond the STL file, Additional Software to Assist AM; Part orientation, Support Structure Design, Model Slicing Algorithms and Contour Data Organization, Direct and Adaptive Slicing, Tool Path Generation; Software for Additive Manufacturing Technology: MIMICS, MAGICS.

3 Additive Manufacturing Processes

Classification, Liquid Based System: Stereo-lithography Apparatus, Solid Ground Curing, Polyjet: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Solid based system-Fused Deposition Modeling, Laminated Object Manufacturing, Contour Crafting: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Powder based system: Selective Laser Sintering, Selective Laser Melting, Laser Engineered Net Shaping, Electron Beam Melting, Three Dimensional Printing: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Other Associated Technology, Metal and Hybrid Systems.

Post Processing: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-Thermal and Thermal Techniques.

4. **Issues in Additive Manufacturing**

Variation from one AM Machine to Another, Pre- & Post processing, Metal System, Accuracy Issues in Additive Manufacturing, Strength of AM Parts, Surface Roughness Problem in Additive Manufacturing, Part Deposition Orientation and Issues like Shrinkage, Swelling, Curl and Distortion; Materials, Machine Design: Larger Scale or Smaller Scale, Layer Forming Quality, Material Delivery, Cost, Reliability, Operation and Others.

5 **Reverse Engineering**

Introduction, Measuring Device- Contact type and Non-Contact Type, CAD Model Creation from point Clouds, Preprocessing, Point Clouds to Surface Model Creation, Medical Data Processing: Types of Medical Imaging, Software for Making Medical Models, medical materials, Other Applications: Case study.

6 **Recent Advances and Applications**

Rapid Tooling (Direct and Indirect RT), New Materials Development, Bi-metallic parts, Application Examples for Aerospace, Defense, Aerospace, Automotive and Biomedical Applications of AM- Computer Aided Tissue Engineering (CATE), Case studies; Trends and Future Directions in Additive Manufacturing.

Texts/References:

1. Rapid Prototyping: Principles & Applications: C. K. Chua
2. Rapid Prototyping: Theory & Practice: A. K. Kamrani, E., A. Nasr
3. Additive Manufacturing: A. Bandyopadhyay, S. Bose
4. Rapid Prototyping: Principles and Applications in Manufacturing : R. Noorani

Course Outcomes: The students will be able to

1. Understand the broad range of AM processes, devices, capabilities and materials that are available.
2. Learn how to create physical objects that satisfy product development/prototyping requirements, using advanced/additive manufacturing processes and suitable materials.
3. Fabricate an actual multi-component object using advanced/additive manufacturing process.
4. Articulate the various trade-offs that must be made in selecting advanced/additive manufacturing processes, devices and materials to suit particular product requirements

ME 5139	**Engineering Fracture Mechanics**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)	3	0	0	3

Introduction Historical perspective, Fracture mechanics approach to design, Overview and Classification. Linear Elastic Fracture Mechanics
Griffith's theory of brittle failures; Irwin's stress intensity factors.

Linear elastic fracture mechanics: The stress analysis of crack tips, macroscopic theories in crack extension, Instability and R-curves, Crack tip plasticity, K as a failure criterion, Mixed mode of fracture, analytical and experimental methods of determining K.

Elastic plastic fracture mechanics: Crack tip opening displacement, J integrals, crack growth resistance curves, crack tip constraint under large scale yielding, creep crack growth.
Microscopic theories of fracture: Ductile and cleavage fracture, ductile-brittle transition, inter-granular fracture.
Fatigue crack propagation: Fatigue crack growth theories, crack closure, microscopic theories of fatigue crack growth.
Applications of theories of fracture mechanics in design and materials development.

Texts/References:

1. T.L.Anderson : Fracture Mechanics - Fundamentals and Applications : CRC Press.
2. G. E. Dieter: Mechanical Metallurgy: McGraw Hill.
3. R. W. Hertzberg: Deformation and Fracture Mechanics of Engineering Materials: John Wiley& Sons Inc.
4. D.Broek: Elementary Engineering Fracture Mechanics: Kluwer Academic Publishers.
5. T.Rolfe and J.M.Barson : Fracture and Fatigue Control in Structures : PHI.
6. Prashant Kumar: Elements of Fracture Mechanics: Tata McGraw Hill.

Course Outcomes:
At the end of the course the student will be able to

1. Explain reasons behind common mechanical failure.
2. Differentiate failure mechanisms under plane stress and plane strain condition.
3. Calculate theoretical fracture strength and experimental fracture strength through epfm, ctod and j-integral.
4. Interpolate the effect of crack inside brittle and ductile materials.
5. Extrapolate the effect of energy release rate on fracture of materials.

ME 5140	**Mechanical Behavior of Materials**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)	3	0	0	3

Introduction, Stress and strain relations, mechanical testing, Elements of plasticity, the flow curve, Strain hardening, Strain rate and temperature dependence of flow stress. Plastic deformation, slip in crystals, dislocations, and dislocation motion. Twins, strengthening mechanisms, grain boundaries, solid solution strengthening and strain hardening. Fracture, types of fracture, brittle fracture, Griffith theory of brittle fracture of material, ductile fracture, notch effects, and fracture mechanics. Fatigue, the S-N curve, low and high cycle fatigue, structural features, surface effects, Creep, stress rupture test, structural changes, creep mechanisms and super plasticity Embrittlement, residual stresses, mechanical behavior of Ceramics, glasses, polymeric materials, and composite materials.

Texts/References:

1. Dieter, G. E., “Mechanical Metallurgy”, 3rd Ed., McGraw Hill. 1988
2. Courtney, T.H., “Mechanical Behavior of Materials”, 2nd Ed., McGraw Hill. 1990
3. Meyers, M.A. and Chawla, K.K., “Mechanical Behavior of Materials”, Prentice Hall. 1999
4. R.W.K., “The Plastic Deformation of Metals”, Edward Arnold.

Course Outcomes:
At the end of the course the student will be able to

1. Identify the crystal structure of various materials
2. Analyse the type of fracture in materials
3. Assess the behavior of creep and fatigue in materials

ME 5134	Non-Destructive Testing of Materials	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-IV)	3	0	0	3

Introduction
Review of destructive testing, limitations of destructive testing, need for non-destructive testing, fundamentals and introduction to non-destructive testing, scope and limitations of NDT, Visual examination methods, different visual examination aids.

Dye penetrant Testing
Principle, procedure, characteristics of penetrant, types of penetrants, penetrant testing materials, fluorescent penetrant testing method– sensitivity, application and limitations

Magnetic Particle Testing
Important terminologies related to magnetic properties of material, principle, magnetizing technique, procedure, equipment, fluorescent magnetic particle testing method, sensitivity, application and limitations

Ultrasonic Testing
Basic principles of sound propagation, types of sound waves, principle of ultrasonic testing, methods of ultrasonic testing, their advantages and limitations, piezoelectric material, various types of transducers/probe, calibration methods, use of standard blocks, technique for normal beam inspection, flaw characterization technique, defects in welded products by ultrasonic testing, thickness determination by ultrasonic method, study of a, b and c scan presentations, advantage, limitations acoustic emission testing, principles of acoustic emission testing and techniques

Radiographic testing
Radiographic testing: X-ray and Gamma-Ray radiography, their principles, methods of generation, industrial radiography techniques, inspection techniques, applications, limitations, types of films, screens and penetrameters. Interpretation of radiographs, safety in industrial radiography

Leak and pressure testing
Leak and pressure testing: definition of leak and types, principle, various methods of pressure and leak testing, application and limitation

Eddy current testing
Eddy current testing: principle, instrument, techniques, sensitivity, application, limitation of thermal methods of NDT.

Materials characterization
Basic principles, interaction of radiation and particle beams with matter, diffraction methods, images, optical, scanning, transmission electron, scanning tunneling and field ion microscopy, microanalysis and spectroscopy, energy dispersive, wavelength dispersive, Auger processes,

electron, ion growth, secondary-ion mass spectrometry (SIMS), electron spectroscopy for chemical analysis (ESCA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC).

Text/Reference

1. Barry Haul, Vernon John: Non Destructive Testing, Springer – Verlag New York Inc., 2012.
2. Paul E Mix: Introduction to Nondestructive Testing: A Training Guide, Willey – Blackwell, 2005.
3. Ravi Prakash: Non-Destructive Testing Techniques, New Academic Science Ltd., 2009.
4. Baldev Raj: Practical Non Destructive Testing, Narosa Publishing House, 2009.
5. Yang Leng: Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley VCH, 2013.
6. Khangaonkar P R: An Introduction to Material Characterization, Penram International. Publishing (India) Pvt. Ltd., 2008.

Course Outcomes: Upon completion of this course, students will be able to
1. Be differentiate between destructive and non-destructive testing methods.
2. Be able to identify the types of equipment used for each nondestructive testing.
3. be able to explain the purpose of the equipment, application, and standard techniques required to perform major non-destructive testing of materials and components.
4. be able to go to specific code, standard, or specification related to each testing method.
5. Acquire the knowledge and essential skills to identify strengths and weaknesses in materials used in fabrication

ME 5307	**Modern Manufacturing Methods**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-IV)	3	0	0	3

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, equipment, process capabilities, applications, advantages and limitations.

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

Electro thermal Processes: Electro discharge machining (EDM), Electro discharge wire cutting or wire EDM, Electro discharge grinding, Electrochemical discharge grinding, their working principles, equipment, 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, equipment, 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: Micro-manufacturing, manufacturing processes lead towards micro-manufacturing, micro electro mechanical systems (MEMS), Rapid prototyping, concept of nanotechnology.

Texts/References:

1. V.K. Jain Advanced Machining Processes Allied Publishing Pvt. Ltd.
2. G.F.Benedict Non-traditional 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 McGeoghAdvanced Methods of Machining, Chapman & Hall
7. N.P. Mahalik Micro manufacturing and Nano-technology, Springer.

Course Outcomes:

After studying this course, students will be able to:

1. Explain how modern machining techniques differ from traditional machining processes.
2. Describe several advanced manufacturing processes and their principle.
3. Identify the right process parameters and envisage their effect on process performance.
4. Summarize how to perform several advanced machining techniques.
5. Identify the advantages and disadvantages of several modern machining techniques.
6. Select suitable manufacturing processes for particular application.
7. Solve problems in modern manufacturing by integrating the relevant core principles in mechanical engineering.

ME 5143	**Fundamentals of Artificial Intelligence and Neural Network**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-IV)	3	0	0	3

Artificial intelligence: History, Trends and Future; Problem Solving by search; Knowledge Representation and Reasoning; Reasoning under uncertainty; Planning; Planning, Decision Making; Decision Making; Machine Learning

Fundamentals of Neural Networks Multi-layer Feed-Forward Neural Network; Radial Basis Function Network

Self-Organizing Map; Counter-Propagation Neural Network; Recurrent Neural Networks; Deep Learning Neural Network; Concepts of Soft Computing and Computational Intelligence

Texts/References:

1. A First Course in Artificial Intelligence, Deepak Khemani, McGraw Hill Education
2. Introduction to Artificial Intelligence, D. W. Patterson,Pearson Education India
3. Fundamentals of Neural Networks: Architectures, Algorithms and Applications, L. FAUSETT, Pearson Education India.

Course Outcomes:

At the end of the course the student should be able to:

1. Apply various knowledge based techniques
2. Practice diagnosis and trouble shooting

3. Adopt various soft Computing and Computational Intelligence technique

ME 5144	**Biomechanics**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-IV)	3	0	0	3

Definition of Biomechanics, Selected Historical highlights, The Italian Renaissance, Gait century, Mechanics, Newton's laws of motion, Equation of motion for rigid Body. Biological materials, Brief Anatomy, Bone, cartilage, ligament, tendon, Muscles, their physical properties, degree of freedom of joints. Dental Biomechanics, Function of dentin, pulp, periodontal ligament. prosthodontistry, orthodontistry. Measuring techniques for force, pressure distribution, acceleration, Optical methods, strain measurement, inertial properties of human body. General considerations for modeling, types of model, validation of model, force system analysis, assumptions, free body diagrams, Simulation, Numerical solution methods, Muscle models, modeling of external forces, optimization studies, simulation as a scientific tool. Introduction Biomedical engineering, application of advanced engineering techniques to human body, case studies.

Texts/References:

1. Nigg, B.M.and Herzog, W., "Biomechanics of Musculo skeleton system", John Willey & Sons, 1st
2. Saltzman, W.L., "Biomedical Engineering: Bridging medicine and Technology", Cambridge Text, First Edition. Edition.
3. Winter, D., "Biomechanics and Motor Control of Human Movement", WILEY Interscience Second edition

Course Outcomes:

At the end of the course the student should be able to:
1. Apply a broad and coherent knowledge of the underlying principles and concepts of biomechanics, particularly in the fields of kinematics and kinetics as applied to human and projectile motion.
2. Safely and effectively use biomechanics instrumentation and equipment to record and assess human and object motion.
3. Record, extract and analyse key information about teeth, muscles, bones etc.

ME 5145	**Design and Analysis of Experiments**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-IV)	3	0	0	3

Introduction- Planning of experiments – Steps – Need, Terminology: Factors, levels, variables, experimental error, replication, Randomization, Blocking, Confounding.
Single Factor Experiments- ANOVA - Sum of squares – Completely randomized design, Randomized block design, effect of coding, Comparison of treatment means – Newman Kuel's test, Duncan's Multiple Range test, Latin Square Design.
Factorial Experiments-Main and interaction effects –Two and three Factor full factorial Designs,

2^k designs with Two and Three factors- Yate's Algorithm. Special Experimental Designs- Blocking and Confounding in 2^k design Taguchi Techniques- Fundamentals of Taguchi methods, Quality Loss function, orthogonal designs, application to Process and Parameter design.

Texts/References:

1. Montgomery, D.C. "Design and Analysis of Experiments", John Wiley and Sons, 5th Edition,2002.
2. Hicks,C.R. "Fundamental concepts in the Design of Experiments", Holt, Rinehort and Winston, 2000. 3. Bagchi, T.P. "Taguchi Methods explained", PHI, 2002.
4. Ross, P.J. "Taguchi Techniques for quality Engineering", Prentice Hall, 2000.

Course Outcomes:

At the end of the course the student should be able to:

1. Explain the practical implications of Design of experiments
2. Adopt ANOVA techniques to identify sufficient factors
3. Apply Taguchi techniques to conduct experiments in research work

ME 5148	**Ergonomics & Aesthetics**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-V)	3	0	0	3

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 Organization: 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.

Texts/References:

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

Course Outcomes:

Students will be able to

1. Learn the social significance of ergonomics
2. Apply the concept of ergonomics in product design
3. Analyse the essential environmental factor affecting the human.
4. Create effective workplace arrangement.

ME 5149	Non Traditional Techniques for Optimum Design	L	T	P	C
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-V)	3	0	0	3

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.

Texts/References:

1. Kalyanmoy Deb "Optimization for Engineering Design-Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Kalyanmoy Deb "Multi-Objective Optimization using Evolutionary Algorithms" John Wiley & Sons Ltd
3. Kenneth V. Price, Rainer M. Storn and Journi A. Lampinen "Differential Evolution: A Practical" Springer
4. Maurice Clerc "Particle Swarm Optimization" ISTE Publishing Company

Course Outcomes:

Students will be able to-

1. Distinguish between non-traditional and traditional techniques for optimum design
2. Apply the concept of GA in multi-objective problem solving
3. Select differential evolution for solving real life problems
4. Implement the concept of particle swarm optimization for solving industrial problem.

ME	Industrial Automation	L	T	P	C

5151					
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-V)	3	0	0	3

Introduction to Industrial Automation: Introduction, Elements of Automation, Type of Automation, Application of Automation, Advantages and Disadvantages of Automation, Low Cost Automation, Hierarchical levels in Factory Automation systems.

Industrial Automation: Overview of pneumatic elements/hydraulic elements, Industrial hydraulic systems, design of hydraulic, pneumatic, Hydro pneumatics, pneumatic logic controls. Electric control of fluid power. Introduction of Fluidics, Boolean Algebra, Law of Boolean Algebra, Truth Table, Logic gates, Origin and development of Fluidics, Fluidic devices, Fluidic logic devices, Fluidic sensors, Fluidics amplifier, Advantage and disadvantage of fluidic.

Programmable controller: Control Technologies in automation: Industrial control systems, process industries Vs Discrete manufacturing industries, Continuous Vs discrete control, computer process control and its form. Computer based Industrial control, Analog and Digital I/O modules, Supervisory Control and Data Acquisition Systems (SCADA) and Remote Terminal Unit(RTU). Electrical and electronics controls: Sensors and Transducers, Programming Logic Controllers (PLC), Integration of mechanical system with computer and electronics systems and case studies.

Flexible Automation: Flexible manufacturing cells and systems, Automated material handling systems, AGV, Material handling equipment, Robotic system, AS/RS, System integration, protocols and advanced communication in manufacturing system.

Material Transport and storage system, Automatic Identification and Data Capture: Shop floor control, phases factory data collection system, automatic identification methods – Bar code technology–automated data collection system. Automated production lines, Automated Assembly systems, Cellular Manufacturing.

Texts/References:

1. Mikell P. Groover. Automation Production Systems, and Computer Integrated Manufacturing – ,PHIPvt Ltd, New Delhi , 2013
2. A.K. Gupta & S.K. Arora, Industrial Automation and Robotics University Science Press, New Delhi , 2012
3. Krishna Kant, Computer-Based Industrial Control, PHI Pvt Ltd, New Delhi, 2010.
4. Jerry Bank &John.S. Carson, Discrete Event systems simulation, Pearson Education, Delhi-2010

Course Outcomes: At the end of the course the student will be able to:

1. Understand automation and its influence on Manufacturing.
2. Apply Industrial automation principles devices.
3. Analyse and develop computerized controls for programmable automation
4. Design flexible automation devices and integrate them to develop advanced Manufacturing.
5. Apply the concept of automatic data identification and collection in industry.

ME 5152	**Supply Chain Management**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-V)	3	0	0	3

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.
Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.
Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.
Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Texts/References:
1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, 4th Edition, Pearson Education Asia, 2010.
2. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill.
3. John J Coyle, et.al., 'Managing Supply Chains A Logistics Approach', , Cengage Learning,.
4. Jeremy F Shapiro, 'Modeling the Supply Chain', 2nd Edition, Cengage Learning,.

Course Outcomes: At the end of the course, the student shall be able to:
1. Understand the decision phases and apply competitive and supply chain strategies.
2. Understand drivers of supply chain performance.
3. Analyze factors influencing network design
4. Analyze the role of forecasting in a supply chain
5. Understand the role of aggregate planning, inventory, IT and coordination in a supply chain.

ME 5153	**Reliability Engineering**	**L**	**T**	**P**	**C**
	M.Tech. (CAD-CAM & Automation), Second Semester (Elective-V)	3	0	0	3

Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics;
Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time dependent & stress-dependent hazard models, bath-tub curve;
System Reliability Models: Systems with components in series, systems with parallel

components, combined series-parallel systems, k-out-of-m systems, standby models, load sharing models, stress-strength models, reliability block diagram;
Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems;
Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches;
Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

Texts/References:

1. Ebeling CE, *An Introduction to Reliability and Maintainability Engineering*, TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, *Practical Reliability Engineering*, Wiley, 2012.

Course Outcomes: At the end of the course, the student shall be able to:

1. Understand the concepts of Reliability, Availability and Maintainability
2. Develop hazard-rate models to know the behaviour of components.
3. Build system reliability models for different configurations.
4. Assess reliability of components & systems using field & test data.
5. Implement strategies for improving reliability of repairable and non-repairable systems.