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

<table>
<thead>
<tr>
<th>Code</th>
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Total contact hours/credits: **15 0 5 18**

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Total contact hours/credits: **15 0 5 18**

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Total contact hours/Credits: **- - - 14**

### Electives–I

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</table>
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
5. B.L. Jones, “Computer Numerical Control” John Wiley and Sons
8. Radhakrishna Subramanyan and Raju, “CAD/CAM/CIM” New Age International (P) Ltd.

**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.

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.


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

Texts/References:

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
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:

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.

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.

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<th>ME 5110</th>
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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.

<table>
<thead>
<tr>
<th>ME 5131</th>
<th>Optimization Technique</th>
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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:**
2. S. Rao, Engineering Optimization: Theory and Practice

**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.

<table>
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<tr>
<th>ME 5132</th>
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**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.


**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

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.

<table>
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<tr>
<th>ME 5133</th>
<th>Innovation &amp; Product Design</th>
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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.


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
3. Lucienne T.M. Blessing, Amaresh Chakrabarti, “DRM, a Design Research Methodology” SPRINGER
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. Identify the requirement of basic tools for product developments

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Texts/References

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

<table>
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<th>ME 5142</th>
<th>Mechatronic Systems</th>
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**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.

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### ME 5301 Advanced Material Science

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**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:**

4. Powder metallurgy. B K Datta, PHI.

**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.

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture</th>
<th>Tutorial</th>
<th>Practical</th>
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<tbody>
<tr>
<td>ME 5147</td>
<td>MEMS Technology</td>
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<td>M.Tech. (CAD-CAM &amp; Automation), First Semester (Elective-II)</td>
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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:**

**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.

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<td>ME 5150</td>
<td>Tribology</td>
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**Texts/References**

**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

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<tr>
<th>ME 5154</th>
<th>Enterprise Resource Planning</th>
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**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**

**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.

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<tr>
<th>ME 5155</th>
<th>Metrology and Computer Aided Inspection</th>
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**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.


**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:**

**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.
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:
2. K.J. Bathe, Finite Element Procedures, Klaus-Jurgen Bathe

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.

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:**

**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

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**ME 5109**

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<th>CAD-CAM &amp; Automation Lab – II</th>
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</table>

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
M.Tech. (CAD-CAM & Automation), Second Semester (Core)  L  T  P  C
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
M.Tech. (CAD-CAM & Automation), Second Semester (Elective-III)  L  T  P  C
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,


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:**
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.

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<tr>
<th>ME 5137</th>
<th>Product Lifecycle Management</th>
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Texts/References:

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.

<table>
<thead>
<tr>
<th>ME 5138</th>
<th>Additive Manufacturing</th>
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<td>M.Tech. (CAD-CAM &amp; Automation), Second Semester (Elective-III)</td>
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</table>

1 Introduction

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

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:**
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

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<tr>
<th>ME 5139</th>
<th>Engineering Fracture Mechanics</th>
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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, intergranular fracture.


Applications of theories of fracture mechanics in design and materials development.

Texts/References:
5. T. Rolfe and J. M. Barson: Fracture and Fatigue Control in Structures: PHI.

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.

<table>
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<tr>
<th>ME 5140</th>
<th>Mechanical Behavior of Materials</th>
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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:
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

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<tr>
<th>ME 5134</th>
<th>Non-Destructive Testing of Materials</th>
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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**

**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

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<tr>
<th>ME 5307</th>
<th>Modern Manufacturing Methods</th>
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<td>M.Tech. (CAD-CAM &amp; Automation), Second Semester (Elective-IV)</td>
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**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
6. J.A McGeogh Advanced Methods of Machining, Chapman & Hall

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.

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

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  

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**Texts/References:**
1. Nigg, B.M.and Herzog, W., “Biomechanics of Musculo skeleton system”, John Willey & Sons, 1st

**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  

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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:

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

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<tr>
<th>ME 5148</th>
<th>Ergonomics &amp; Aesthetics</th>
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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.


Texts/References:
2. Wickens Christopher D, “An Introduction to Human Factors Engineering” Prentice Hall
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

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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 non-traditional techniques.

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

Texts/References:
2. Kalyanmoy Deb “Multi-Objective Optimization using Evolutionary Algorithms” John Wiley & Sons Ltd
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

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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:

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

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.
Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

Texts/References:

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.

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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:**

**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.