Detailed Syllabus

M Tech (Mechanical Engineering)

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Semester wise roadmaps Structure for M.Tech Mechanical Engineering

Fall Sem SEM-1					
Course Code	**Category**	**Course Title**	**L**	**P**	**C**
MTME501	PC-1	Computer Aided Manufacturing	3	2	4
MTME502	PC-2	Advanced Engineering Materials and Characterization	3	0	3
MTME503	PC-3	Non Conventional Machining Processes	3	0	3
MTME601	PC-4	Digital Fabrication with 3D Printing	3	2	4
	PE-1	Program Elective -1	3	0	3
RES701	Research	Research Methodology	2	0	2
MTSE501	SE-1	Skill Enhancement Course	3	0	3
Total					**22**

Winter Sem SEM-2					
Course Code	**Category**	**Course**	**L**	**P**	**C**
MTME504	PC-5	Theory of Casting and Welding	3	2	4
	PE-2	Program Elective -2	3	2	4
MTME602	PC-6	Predictive maintenance using AI and IoT	3	2	4
	PE-3	Program Elective -3	3	0	3
MTSE502	SE-2	Skill Enhancement Course-2	3	0	3
Total					**18**

Sem-3					
Course Code	**Category**	**Course**	**L**	**P**	**C**
MTPJ649	PE-Proj	Project	0	16	8
	OE-1	Any Open elective	3	2	4
	PE-4	Program Elective -4	3	2	4
	PE-5	Program Elective -5	3	2	4
Total					**20**

Sem-4					
Course Code	**Category**	**Course**	**L**	**P**	**C**
RES703		Final Dissertation	0	40	20
Total					20

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List of Elective Subjects

MTME505	Quality System and Reliability Engineering
MTME506	Innovative Tool Design for Modern Manufacturing
MTME507	Production Planning & Control
MTME508	Operations Research for Mechanical Engineers
MTME509	Product Lifecycle Management
MTME510	Metal Forming Processes and Analysis
MTME511	Design and Analysis of Experiments
MTME512	Optimization Strategies for Mechanical Systems
MTME513	Supply Chain Analytics and Optimization for Mechanical Engineers
MTME603	AI Techniques for Renewable Energy System
MTME604	Smart Automation with AI for Industry 4.0
MTME605	Robotics and Artificial Intelligence
MTME606	Advanced Product Design and Development
MTME607	HVAC Design and Energy Management
MTME608	AI Driven Material Development

<table>
<tr><td>Course Code: MTME501</td><td colspan="2">Course Title: Computer-Aided Manufacturing</td><td>TPC</td><td>3</td><td>2</td><td>4</td></tr>
<tr><td>Version No.</td><td colspan="6">1.0</td></tr>
<tr><td>Course Pre-requisites/ Co-requisites</td><td colspan="6">None</td></tr>
<tr><td>Anti-requisites (if any).</td><td colspan="6">None</td></tr>
<tr><td>Objectives:</td><td colspan="6">1. Understand the fundamentals of computer-aided manufacturing and its role in modern manufacturing.
2. Explore the integration of design and manufacturing using CAM software.
3. Learn the principles and programming of CNC machines.
4. Study process planning and optimization techniques for automated manufacturing.
5. Develop skills in simulation and virtual manufacturing for production analysis.
6. Analyze the impact of CAM systems on productivity and quality enhancement in manufacturing.</td></tr>
</table>

Course Outcomes	Course Outcome Statement
CO1	Explain the fundamentals of computer-aided manufacturing and its applications.
CO2	Design and analyze manufacturing processes using CAM software.
CO3	Apply modern manufacturing techniques in solving engineering problems.
CO4	Develop and simulate machining processes using CNC programming.
CO5	Evaluate CAM strategies and implement automation to enhance manufacturing efficiency and precision.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction to Computer-Aided Manufacturing:**	**6 Hours**

Overview of CAM and its evolution; Role of CAM in manufacturing; Components and architecture of CAM systems; Integration of CAD and CAM; Benefits and challenges of implementing CAM in industries.

Module No. 2	**CNC Machines and Programming**	**9 Hours**

Types of CNC machines and their components; Coordinate systems and machine axes; CNC programming: G-codes, M-codes, and toolpath generation; Advanced CNC programming concepts (subprograms, parametric programming); Hands-on exercises on CNC machines.

Module No. 3	**Process Planning and Toolpath Optimization**	**10 Hours**

Introduction to process planning; Computer-aided process planning (CAPP); Toolpath strategies: contouring, pocketing, drilling; Optimization of machining parameters for productivity and surface quality; Case studies using CAM software.

Module No. 4	**Simulation and Virtual Manufacturing:**	**10 Hours**

Basics of manufacturing simulation; Virtual machining and process verification; Collision detection and toolpath validation; Applications of digital twins in manufacturing; Use of CAM software for 3D machining and mold manufacturing.

Module No. 5	**Applications of CAM in Advanced Manufacturing:**	**10 Hours**

Additive manufacturing integration with CAM; Robotics and automation in CAM systems; Flexible manufacturing systems (FMS) and CAM; Industry 4.0 and smart manufacturing; Future trends in CAM technologies.

Text Books

1. Groover, M. P., *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2023.
2. Ibrahim Zeid, *CAD/CAM: Theory and Practice*, McGraw Hill, 2021.

References

1. Nanfara, F., Uccello, T., & Mandal, S., *Programming of CNC Machines*, Industrial Press, 2022.
2. P.N. Rao, *CAD/CAM Principles and Applications*, Tata McGraw Hill, 2021.
3. Kalpakjian, S., & Schmid, S. R., *Manufacturing Engineering and Technology*, Pearson, 2021.

Lab Exercise:

1. Overview of CAM Systems: Introduction to CAD and CAM integration and basics of CNC machines
2. CNC Programming: Learn and practice CNC programming using G-code and M-code for simple machining tasks
3. CNC Milling Operations: Develop and execute CNC programs for basic milling operations on a CNC machine
4. CNC Turning Operations: Develop CNC programs for turning operations and execute on CNC lathe machines
5. Toolpath Optimization: Create optimized toolpaths for milling, pocketing, and drilling operations
6. CNC Simulation and Verification: Simulate CNC operations using CAM software and verify toolpaths to detect errors
7. Virtual Machining and Process Simulation: Use CAM software to simulate 3-axis and 5-axis machining operations and analyze tool engagement and material removal
8. CAD to CAM Workflow: Convert a CAD model into CAM instructions and generate toolpaths for manufacturing a complete part
9. Subprogram and Parametric Programming: Develop modular CNC code using subprograms and parametric variables for machining similar components
10. Collision Detection and Toolpath Validation: Validate toolpaths for interference and collision using virtual simulation software
11. Design and Manufacture of a Mold Component: Complete end-to-end CAM project

from CAD design to machining a mold insert using optimized strategies 12. Multi-Axis Machining Project: Generate and simulate toolpaths for a complex part using 4-axis or 5-axis machining techniques 13. Integration of Additive and Subtractive Manufacturing: Design a part for hybrid manufacturing, simulate additive build, and plan subtractive finishing 14. Smart CAM System for Mass Customization: Develop a flexible CAM program that can adapt to product variations for batch production 15. Digital Twin-Based Machining Project: Create a digital twin of a CNC process to optimize toolpaths, simulate faults, and monitor performance in real time	
Course Type	**Embedded Theory and Lab (ETL)**
Mode of Evaluation	**Theory** **100%** Continuous Assessment Test-1 15% Continuous Assessment Test-2 15% Digital Assignments/Quizzes (Min) 20% Final Assessment Test 50%
	Laboratory **25%**
Prepared by	**Dr. Sukhdeep Singh**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code: MTME502	Course Title: **Advanced Engineering Materials and Characterization**	TPC	3	0	3
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To understand the properties and classifications of advanced engineering materials. 2. To explore the synthesis, processing, and applications of advanced materials. 3. To learn various material characterization techniques and their principles. 4. To correlate material properties with microstructure and performance.				

Course Outcomes	Course Outcome Statement
CO1	Classify and analyze advanced engineering materials based on their properties and applications.
CO2	Explain the structure, properties, and applications of advanced metallic materials including alloys and nano-structured metals.
CO3	Analyze the characteristics and applications of advanced polymers and composite materials.
CO4	Evaluate material performance based on microstructural analysis.
CO5	Apply knowledge of advanced materials to solve engineering problems.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Advanced Engineering Materials:	9 Hours

Overview of traditional and advanced materials, Properties and classifications: Metals, polymers, ceramics, and composites, Smart materials: Piezoelectric, shape memory alloys, Functional materials: Conductive polymers, biomaterials, and metamaterials, High-temperature and refractory materials.

Module No. 2	Advanced Metallic Materials:	9 Hours

High-strength low-alloy (HSLA) steels, maraging steels, shape memory alloys, superalloys (nickel and cobalt based); titanium alloys and their applications; advanced aluminum alloys; nanostructured metallic materials.

Module No. 3	Advanced Polymers and Composites:	9 Hours

Thermosetting and thermoplastic polymers; conducting polymers; polymer blends and alloys; fiber-reinforced composites, particulate and laminated composites; metal matrix and ceramic matrix composites; processing and applications.

Module No. 4	Characterization Techniques for Advanced Materials:	10 Hours
Structural characterization: X-ray diffraction (XRD), neutron diffraction, Microstructural characterization: Optical microscopy, SEM, TEM, and AFM, Thermal analysis: Differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Mechanical properties: Hardness testing, tensile testing, and nanoindentation, Spectroscopic techniques: FTIR, Raman spectroscopy, and EDS/EDX.		
Module No. 5	**Advanced Materials: Applications and Emerging Trends:**	**8 Hours**
Applications of advanced materials in aerospace, automotive, electronics, and healthcare, Emerging materials: Quantum dots, graphene, and topological insulators, Materials for energy applications: Photovoltaics, fuel cells, and batteries, Role of AI and machine learning in materials science, Challenges and future directions in advanced materials research.		

Text Books

1. William D. Callister Jr. and David G. Rethwisch, "Callister's Materials Science and Engineering: An Introduction", Wiley, 2021 (11th Edition)
2. James F. Shackelford, "Introduction to Materials Science for Engineers", Pearson, 2020 (9th Edition)
3. Donald R. Askeland and Wendelin J. Wright, "Fundamentals of Materials Science and Engineering", Cengage Learning, 2019 (5th Edition)

References

1. Peng, Zhiwei, Xie, Kelvin Yu, Zhang, Mingming, et al. – *Characterization of Minerals, Metals, and Materials 2025: In-Situ Characterization Techniques*, 1st Edition (2025), Springer.

2. Yedla, Natraj, Kharel, Parashu Ram, Sabat, Rama Krushna, et al. – *Advanced Materials Processing and Characterization Technology*, 1st Edition (2023), Springer.

3. Zhao, Yuyuan – *Advanced Materials Science and Technologies*, 1st Edition (2021), Trans Tech Publications.

Course Type	Theory (TH)
Mode of Evaluation	**Theory** **100** Continous Assessment Test-1 15% Continous Assessment Test-1 15% Digital Assignments/Quizzes (Min) 20% Final Assessment Test 50%
Prepared by	**Dr. Sahil Sharma**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

<table>
<tr><td>Course Code:
MTME503</td><td colspan="2">Course Title:
Non-Conventional Machining Processes</td><td>TPC</td><td>3</td><td>0</td><td>3</td></tr>
<tr><td>Version No.</td><td colspan="6">1.0</td></tr>
<tr><td>Course Pre-requisites/ Co-requisites</td><td colspan="6">None</td></tr>
<tr><td>Anti-requisites (if any).</td><td colspan="6">None</td></tr>
<tr><td>Objectives:</td><td colspan="6">1. To impart knowledge of the fundamental principles, mechanisms, and applications of various non-conventional machining processes.
2. To enable students to analyse the influence of process parameters on the performance and capabilities of different non-conventional machining techniques.
3. To develop the ability to select appropriate non-conventional machining processes for specific engineering applications considering material properties, geometry requirements, and economic factors.
4. To introduce emerging trends and hybrid approaches in non-conventional machining for advanced manufacturing.</td></tr>
<tr><td colspan="7">TOTAL HOURS OF INSTRUCTIONS: 45</td></tr>
<tr><td>Module No. 1</td><td colspan="2">Introduction to NCMP</td><td colspan="4">5 Hours</td></tr>
<tr><td colspan="7">Introduction: Need for Non-Conventional Machining (NCM) Processes, Classification of NCM Processes based on energy source, material removal mechanism, and pplications. Advantages, Limitations, and Selection Criteria for NCM Processes.</td></tr>
<tr><td>Module No. 2</td><td colspan="2">Advanced Mechanical Machining Processes:</td><td colspan="4">8 Hours</td></tr>
<tr><td colspan="7">New Technology, Introduction, Mechanical Processes, Abrasive Jet Machining (AJM) – Principles, process parameters, characteristics, tool design, metal removal rate, and process analysis Ultrasonic Machining (USM) – Working principles, tool design, and performance analysis Whirling Jet Machining (WJM) – Fundamentals, process characteristics, and applications</td></tr>
<tr><td>Module No. 3</td><td colspan="2">Chemical & Electro-Chemical Machining</td><td colspan="4">10 Hours</td></tr>
<tr><td colspan="7">Introduction to Chemical & Electro-Chemical Machining. Chemical Machining (CHM) – Principles, process flow, maskants, and applications. Electro-Chemical Machining (ECM) – Working principles, process parameters, and electrolytes. Metal Removal Rate – Factors affecting MRR in CHM and ECM. Dynamic & Hydro-Dynamic Effects – Process optimization and hydro-optimization techniques</td></tr>
<tr><td>Module No. 4</td><td colspan="2">EDM & Beam Machining</td><td colspan="4">12 Hours</td></tr>
<tr><td colspan="7">Introduction to EDM – Basic principles and process scheme, Circuitry & Controls – Power supply, pulse generation, and control mechanisms, Metal Removal Rate (MRR) – Factors influencing MRR and process efficiency. Tool Material & Design – Selection criteria and performance considerations, Dielectric Fluid – Functions, types, and effects on machining, Process Analysis – Applications, advantages, and limitations</td></tr>
<tr><td>Module No. 5</td><td colspan="2">Laser Beam Machining</td><td colspan="4">10 Hours</td></tr>
<tr><td colspan="7">Introduction to Beam Machining – Overview of Laser Beam Machining (LBM) and Electron Beam Machining (EBM) Laser Production & Machining – Laser generation,</td></tr>
</table>

working principles, and industrial applications, Electron Beam Action – Fundamentals, process parameters, and material interaction, Process Parameters & Optimization – Factors affecting machining performance.	
Text Books 1. **Rupinder Singh, J. Paulo Davim,** Non-Conventional Hybrid Machining Processes, Routledge, 2021 2. **Dr.P.N.Karthikeyan,** Non traditional Machining Processes, Forshung Publications, 2021. 3. **Prof. Vijay Kumar Jain,** Advanced Machining Processes, Allied Publishers, 2nd edition, 2021.	
References 1. **Wit Grzesik, Adam Ruszaj**, Hybrid Manufacturing Processes: Physical Fundamentals, Modelling and Rational Applications, Springer, 2021. 2. **Omkar I K**, Non-Traditional Machining, Notion Press, 2021. **3. Alokesh Pramanik, Kapil Gupta,** Advanced Machining and Finishing, Elsevier, 2021.	
Course Type	**Theory Only (Th)**
Mode of Evaluation	**Theory** **100%** Continuous Assessment Test-1 15 % Continuous Assessment Test -2 15% Digital Assignments/Quizzes (Min) 20% Final Assessment Test 50%
Prepared by	**Dr. Kamaljit Singh**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code:MTME504	Course Title: Theory of Casting and Welding Technology	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To impart knowledge of design of different components related to casting such as pattern, core, gate, riser etc. 2. To understand the concepts of cooling and solidification of metal and alloys in casting processes. 3. To impart the knowledge of the physics involved behind different welding techniques. 4. To impart knowledge of advanced welding processes such as underwater welding, welding in space.				

Course Outcomes	Course Outcome Statement
CO1	Understand the fundamental principles of casting and welding processes.
CO2	Analyze and solve casting and welding related design and manufacturing problems.
CO3	Evaluate casting and welding defects and propose remedial measures.
CO4	Select appropriate casting and welding processes for various industrial applications.
CO5	Apply simulation tools for predicting and improving casting and welding performance.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Fundamentals of Metal Casting	8 Hours

This module introduces the fundamental concepts of metal casting, providing an overview and classification of various casting processes. It covers mould parting analysis to optimize mould design, principles of pattern design for effective casting production, and the essentials of core design, including their placement and manufacturing. Students will gain a solid foundation in the basic elements required for successful casting operations.

Module No. 2	Gating, Solidification, and Feeder Design in Metal Casting	10 Hours

This module delves into the design and analysis of gating systems, focusing on mould filling characteristics, fluidity, turbulence, and the types of gating elements. It includes mould filling analysis considering head losses and explores the concepts of cooling and solidification, including nucleation, growth, progressive and directional solidification, and Chvorinov's Rule (CFR). The mathematical treatment of solidification processes is emphasized, addressing factors like solidification time and rate. Feeder design and analysis topics include feeder shapes, risering curves, NRL methods, feeding distance, riser placement, and the design of feed aids to ensure defect-free casting.

Module No. 3	**Fundamentals of Metal Welding**	**9 Hours**
This module begins with an overview and classification of welding processes, followed by an in-depth study of the theory of arc welding. It examines the physics of the welding arc, its characteristics, efficiency, and the relationship with power sources. Key topics include the constructional features of welding power sources, static and dynamic characteristics, duty cycles, and arc efficiency. Metal transfer mechanisms are analyzed, focusing on forces acting on droplets, transfer classification, transition current, melting rate, polarity effects, and deposition efficiency, providing a comprehensive understanding of arc welding processes.		
Module No. 4	**Advanced Welding Processes and Applications**	**9 Hours**
This module introduces advanced welding technologies and their industrial applications. It covers resistance welding principles, including contact resistance, calculation of current, time, and voltage, along with electrode material and shape selection. The module explores specialized welding methods such as electron beam welding, ultrasonic welding, explosive welding, friction stir welding, electromagnetic pulse welding, and high-velocity projectile impact welding. Application areas like plastic welding, underwater welding, space welding, and welding of cryogenic materials are discussed, along with the analysis of thermal stresses and distortion in welded assemblies.		
Module No. 4	**Inspection and Defects in Casting & Welding**	**10 Hours**
This module deals with identifying, understanding, and analyzing defects in casting and welding operations. It covers the causes, effects, and remedies for common casting defects such as porosity, shrinkage cavities, hot tears, cold shuts, and misruns. In welding, it focuses on defects such as incomplete fusion, cracks, slag inclusion, porosity, and undercut. The module also introduces basic inspection and testing techniques including visual inspection, radiographic testing, ultrasonic testing, dye penetrant testing, magnetic particle testing, and destructive tests. The emphasis is on developing quality control practices and failure analysis in metal fabrication.		

Text Books

1. Fundamentals of Metal Casting by R. A. Flinn, Addison Wesley, 2021
2. Manufacturing Science by Ghosh and Malik, East West Press New Delhi, 2022
3. The Physics of Welding by J. F. Lancaster, Pergamon Press, 2019.

References

1. S Kalpakjian and S R Schmid, Manufacturing Processes for Engineering Materials, Pearson education, 2019. 4. E.
2. Paul Degarmo, J T Black, Ronald A Kohser, Materials and processes in manufacturing, John wiley and sons, 2020
3. Principles of Welding by R.W. Messler, John Wiley & Sons, 2020.

List of Exercise

1. Study and demonstration of various types of patterns used in metal casting.
2. Preparation of green sand moulds using single-piece and split patterns.
3. Casting of a simple metal component using sand casting and analysis of defects.
4. Determination of sand properties — permeability, strength, moisture content, and compactibility.
5. Solidification time analysis for castings using Chvorinov’s Rule (experimental validation).

6. Gating system design and simulation using casting simulation software (e.g., MAGMASOFT, ProCAST, or AutoCAST).
7. Study and observation of welding power sources: characteristics of AC and DC machines.
8. Gas Tungsten Arc Welding (GTAW / TIG) — performing welds on various metals and studying weld bead profiles.
9. Shielded Metal Arc Welding (SMAW) — performing butt and fillet welds and identifying common welding defects.
10. Performing Gas Metal Arc Welding (GMAW / MIG) and measuring deposition efficiency and heat input.
11. Performing Submerged Arc Welding (SAW) — setup, welding, and analysis of penetration depth and bead geometry.
12. Introduction to advanced welding techniques: demonstration of Friction Stir Welding / Electron Beam Welding.
13. Conducting non-destructive testing (NDT) on weld joints: Visual Inspection, Dye Penetrant Test, and Ultrasonic Testing.
14. Metallographic examination of cast and welded specimens: sample preparation, polishing, and microstructure analysis.
15. Welding Simulation Exercise using ANSYS or Simufact: analyzing residual stress, thermal distortion, and weld pool dynamics.

Course Type	**Embedded Theory and Lab (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Dr. Shivinder Singh**	
Recommended by the Board of Studies on		
Date of Approval by Academic Council		

Course Code: MTME601	Course Title: **Digital Fabrication with 3D Printing**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To provide an in-depth understanding of digital fabrication principles and technologies. 2. To explore the integration of CAD/CAM with 3D printing workflows. 3. To develop competency in materials, machines, and process parameters for 3D printing. 4. To enable students to analyze and select appropriate additive manufacturing processes for different applications. 5. To cultivate hands-on proficiency in slicing, modeling, and post-processing for digital fabrication.				

Course Outcomes	Course Outcome Statement
CO1	Explain the fundamentals and digital workflow of additive manufacturing.
CO2	Differentiate between various 3D printing technologies and their operational mechanisms.
CO3	Select suitable materials and set optimal process parameters for 3D printing.
CO4	Apply DFAM principles to design functional and optimized parts.
CO5	Evaluate post-processing techniques and real-world applications of digital fabrication.

TOTAL HOURS OF INSTRUCTION: 45

Module No. 1	**Fundamentals of Digital Fabrication and 3D Printing**	**9 Hours**
Introduction to digital fabrication, evolution of digital manufacturing, principles of additive manufacturing, classification of 3D printing technologies, digital fabrication workflow, CAD to print concept, comparison with subtractive processes, role of rapid prototyping.		
Module No. 2	**3D Printing Technologies and Hardware**	**10 Hours**
Fused Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Binder Jetting, Material Jetting, key machine components, print head technologies, heated beds, cooling systems, slicing software.		
Module No. 3	**Materials and Process Parameters**	**8 Hours**

Thermoplastics (PLA, ABS, PETG), photopolymers, metal powders, composite filaments, ceramics, bio-compatible materials, material handling and storage, layer height, infill patterns, print speed, support structures, bed adhesion techniques, part orientation.		
Module No. 4	**Design for Additive Manufacturing (DFAM) and Digital Modeling**	**10 Hours**
DFAM principles, topology optimization, support generation, lightweighting, hollow structures, mesh repair and STL editing, slicing strategies, CAD modeling for 3D printing, generative design, parametric modeling, file formats (STL, AMF, 3MF).		
Module No. 5	**Post-Processing and Industrial Applications**	**9 Hours**
Support removal, sanding and finishing, annealing and curing, painting and coating, dimensional accuracy, applications in aerospace, automotive, biomedical, architecture, electronics, sustainability and recycling in 3D printing, future trends in digital fabrication.		

Text Books

1. **Andreas Gebhardt & Julia Kessler**, *Additive Manufacturing: 3D Printing for Prototyping and Manufacturing*, 3rd Edition, Hanser Publishers, **2023**.
2. **Joan Horvath & Rich Cameron**, *Mastering 3D Printing*, 2nd Edition, Apress, **2021**.

Reference Books

1. **Ian Gibson, David Rosen & Brent Stucker**, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, 3rd Edition, Springer, **2021**.
2. **Chee Kai Chua & Kah Fai Leong**, *3D Printing and Additive Manufacturing: Principles and Applications*, 5th Edition, World Scientific Publishing, **2021**.
3. **John M. Jordan**, *3D Printing: The Next Industrial Revolution*, Revised Edition, MIT Press, **2022**.

Lab Experiments

1. **Study of different 3D printing technologies**: FDM, SLA, SLS, DMLS – working principles and machine components.
2. **CAD modeling of a mechanical component** suitable for 3D printing using SolidWorks/Fusion 360.
3. **File format conversion and validation**: Exporting CAD models to STL, checking for errors, and fixing mesh issues.
4. **Slicing a 3D model** using slicing software (e.g., Cura, PrusaSlicer): infill setting, layer height, supports, print speed.
5. **Printing a simple part using FDM printer**: Printing a bracket, clip, or fixture, observing build process.
6. **Material loading/unloading** and calibration: Bed leveling, extruder priming, and temperature setting.
7. **Multi-part assembly printing**: Design and print a simple multi-part product like a box with lid or gear assembly.

8. **Design for Additive Manufacturing (DFAM)**: Creating lightweight lattice structures or topology optimized designs.
9. **Support structure optimization**: Compare results with auto-generated vs. custom support structures.
10. **Dimensional accuracy testing**: Print a calibration cube or dimensional test object and measure tolerances.
11. **Post-processing techniques**: Sanding, polishing, chemical smoothing (acetone vapor bath), and painting.
12. **Material property evaluation**: Print tensile test specimens and perform tensile testing (optional if UTM is available).
13. **Dual extrusion printing** (if printer is available): Print parts with soluble supports or dual-color prints.
14. **3D printing using flexible and composite filaments**: TPU, carbon fiber reinforced PLA – challenges and benefits.
15. **Mini project**: Design, print, and post-process a functional product prototype (e.g., phone stand, drone frame, enclosure).

Course Type	**Embedded Theory & Lab**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15%
	Continuous Assessment Test-2	15%
	Digital Assignment/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Dr. Mandeep Kumar**	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

Course Code:MTME602	Course Title: Predictive maintenance using AI and IOT	TPC	3	2	4
Version No.	1.0				
Course Pre-requisites/ Co-requisites	None				
Anti-requisites (if any).	None				
Objectives:	1. To explain maintenance objectives and functions, factors influencing Plant Availability. 2. To determine the optimal overhaul/repair/replacement maintenance policy for an equipment subject to breakdown. 3. To explain different maintenance systems and the steps involved in establishing a maintenance plan. 4. To gain knowledge about the Predictive maintenance using AI and IOT				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	To gain Knowledge about maintenance objectives and functions, factors influencing Plant Availability
CO2	Apply engineering principles optimal overhaul/repair/replacement maintenance policy for equipment.
CO3	Utilize different maintenance systems and the steps involved in establishing a maintenance plan and designing a technically sound preventive maintenance and lubrication program.
CO4	Evaluate and interpret data the Predictive maintenance using AI and IOT.
CO5	Deploy predictive maintenance solutions and analyze real-world case studies
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction	9 Hours
Introduction: Objectives and Functions of maintenance. Factors influencing plant availability, Maintenance control, Maintenance Strategies, Organization for Maintenance. Failure Statistics: Breakdown time distributions, Running-in failures, Time independent failures, Wear-out failures, Failure Probability, Survival Probability and age specific failure rates.		
Module No. 2	**Overhaul and Repair**	**9 Hours**
Overhaul and Repair: Meaning and difference, optimal overhaul / Repair / Replace maintenance policy for equipment subject to breakdown. Replacement Decisions: Deterministic and stochastic replacement situations, failure and preventive replacement, Optimal Interval between preventive replacement of equipment subject to breakdown, group replacement.		

Module No. 3	Maintenance Systems	9 Hours
Maintenance Systems: Fixed time maintenance, Condition based Maintenance, Operate to failure, Opportunity Maintenance, Design out maintenance, Total Productive Maintenance. Maintenance Planning: Establishing maintenance plan and schedule, illustrative examples, Preventive Maintenance: Designing a Technically sound preventive maintenance program, failure data, FMECA, Maintenance to prevent failures, lubrication program development.		
Module No. 4	**Predictive Maintenance and Machine Learning**	**9 Hours**
Types of Machine Learning Models Used in Predictive Maintenance, Predictive Maintenance Use Cases Across the Industries,SPD Technology, Benefits of Predictive Maintenance using AI and IOT, Future Trends in Predictive Maintenance.		
Module No. 5	**Predictive Maintenance and Machine Learning**	**9 Hours**
Model deployment on Edge/Cloud.Real-time analytics and dashboards.Challenges: data privacy, security, integration,Case studies: Smart factories, Energy systems, Transportation.		

Text Books

1. Amit Kumar Tyagi, Shrikant Tiwari, Gulshan Soni, Data Analytics and Artificial Intelligence for Predictive Maintenance in Smart Manufacturing, Taylor & Francis, 2024.
2. Dr. L. Bharathi, K. Sreenath, M. Rama, Dr. M. Rajendran, Smart Predictive Maintenance System using IoT and Machine Learning, Royal Book Publishing, 2024.

References

1. Alex C. Techworth, IoT Maintenance: Predictive Techniques for Smart Equipment, Independently Published, 2024.
2. R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, Noor Zaman, Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance, Wiley-Scrivener, 2022.

List of Exercise

1. Study and setup of a typical IoT architecture for industrial monitoring applications
2. Vibration analysis using accelerometer sensors on rotating machinery
3. Temperature and humidity monitoring using DHT11/22 with NodeMCU or Raspberry Pi
4. Data acquisition from industrial motors using current and voltage sensors
5. Streaming sensor data to cloud using MQTT protocol and ThingSpeak/ThingsBoard platform
6. Real-time dashboard creation to monitor motor health parameters on cloud platforms
7. Preprocessing and filtering of noisy sensor data using Python/Excel/Matlab
8. Feature extraction from time-series data (mean, standard deviation, FFT, etc.)
9. Anomaly detection using ML algorithms (Isolation Forest or SVM) in Python
10. Prediction of Remaining Useful Life (RUL) using linear regression and decision trees
11. Using AutoML tools (e.g., Google AutoML, Teachable Machine) for sensor data classification
12. Condition monitoring of a bearing test rig using vibration and temperature sensors
13. Integration of sensor and actuator systems for auto-shutdown on fault detection
14. Edge computing using Raspberry Pi for local data processing and decision-making
15. Mini project: Develop a complete predictive maintenance prototype (sensor → cloud → analytics

Course Type	**Embedded Theory & Lab (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Kushdeep Rana**	
Recommended by the Board of Studies on		
Date of Approval by Academic Council		

Course Code: MTSE501	Course Title: Technical Communication and Professional Development	LTPC	3	0	0	3
Version No.	1.0					
Course Pre-requisites/ Co-requisites	None					
Anti-Requisites (if any)	None					
Objectives:	1. To develop advanced communication skills tailored to technical and engineering professionals. 2. To master technical writing, including reports, research papers, and proposals. 3. To enhance verbal communication and presentation skills for professional settings 4. To foster cross-functional team collaboration and professional etiquette and to prepare students for interviews and create impactful resumes and professional branding tools.					

Course Outcomes	Course Outcome Statement
CO1	Demonstrate proficiency in technical writing, including crafting error-free reports and proposals.
CO2	Develop advanced presentation skills to articulate complex ideas effectively.
CO3	Exhibit readiness for professional interactions through enhanced verbal and non-verbal communication skills.
CO4	Apply active listening and professional etiquette in cross-functional team collaborations.
CO5	Create professional branding materials like resumes and LinkedIn profiles that meet industry standards.
	TOTAL HOURS OF INSTRUCTIONS: 45 Hours

Module No. 1	Effective Communication for Engineers	8 Hours
Understanding communication models for engineering professionals, Mastering advanced grammar for professional settings, Active listening and its role in technical environments.		
Module No. 2	**Technical Report Writing**	**9 Hours**
Crafting technical reports and proposals, Writing research papers with clarity and precision, Effective email communication in technical scenarios.		
Module No. 3	**Practical Presentation Skills**	**10 Hours**
Designing impactful presentations for technical subjects, Mastering public speaking tailored to engineering topics, Role-plays and mock presentations for practical learning.		
Module No. 4	**Effective Team Communication and Collaboration**	**9 Hours**
Strategies for effective team communication, Conflict resolution and professional etiquette, and Understanding cultural nuances in global engineering teams.		

Module No. 5	Personal Branding and Professional Networking for Engineers	9 Hours
Building a compelling LinkedIn profile, Creating industry-standard resumes and cover letters, Mock interviews and group discussions for placement readiness.		

Text Books

1. Raman, M. Technical Communication: Fourth Edition, Oxford University Press, 2022

References

1. Strunk, William, E.B. The Elements of Style, Fourth Edition. United States, Pearson, 2000
2. Lumsden, Gay, communicating in Groups and Teams: Sharing Leadership, Seventh Edition. United States, Wadsworth Publishing, 2010
3. Reynolds, Garr. Presentation Zen: Simple Ideas on Presentation Design and Delivery, Second Edition, United States, New Riders, 2011
4. Rizwi, M. Ashraf. Effective Technical Communication. New Delhi, Tata McGraw-Hill Education,2011
5. Pfeiffer, William Sanborn. Technical Communication: A Practice Approach. United States, Pearson,2009

Mode of Evaluation	**Theory**	**100%**
	Continuous Assessment Test-1	15%
	Continuous Assessment Test-2	15%
	Digital Assignment/Quizzes (Min)	20%
	Final Assessment Test	50%
Prepared by	**Ms. Damini Sharma**	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

Course Code: MTSE502	Course Title: Quantitative Aptitude and Problem-Solving Strategies	TPC	3	0	3
Version No.	1.0				
Course Pre-requisites/ Co-requisites	None				
Anti-requisites (if any).	None				
Objectives:	1. Strengthen critical thinking and problem-solving skills essential for technical roles and competitive exams. 2. Develop effective problem-solving strategies to tackle numerical and logical reasoning questions. 3. Enhance speed and accuracy in solving quantitative problems under time constraints. 4. Build analytical skills to interpret and solve real-world placement scenarios. 5. Master shortcuts and techniques for solving common placement aptitude questions efficiently.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Improve problem-solving, time management in key topics, with interactive doubt resolution for better understanding.
CO2	Develop a clear understanding of concepts, effective shortcuts, logical reasoning, data analysis, and doubt clarification.
CO3	Improve problem-solving speed, effective doubt resolution, and enhanced test performance
CO4	Improve accuracy, logical reasoning, pattern recognition
CO5	Enhance problem-solving skills, pattern recognition, logical thinking
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Speed Mathematics and Shortcut Techniques for Engineers	9 Hours
Basic Calculations, Arithmetic Basics, Speed math and shortcut methods for problem-solving, Doubt Clearing Workshop		
Module No. 2	Advanced Arithmetic and Analytical Thinking	9 Hours
Advanced Arithmetic and Algebra, percentage problems, profit and loss, advanced ratios, and progression, inequalities, and tackling word problems using algebraic methods.		
Module No. 3	Time and Work Optimization	9 Hours
Optimizing Time & Work Efficiency, Work Rate Analysis and Wage Allocation, Pipe and Cistern, Interactive Doubt Clarification, Class Progress Evaluation and Feedback		
Module No. 4	Rankings, Sequences, and Series Problem Solving	9 Hours

<table>
<tr><td colspan="3">Understanding Coding and decoding, Rankings and Sequences, Seating arrangement, Pattern Recognition.</td></tr>
<tr><td>Module No. 5</td><td>Critical Thinking and Personality Development</td><td>9 Hours</td></tr>
<tr><td colspan="3">Critical Thinking , Problem Solving and personality development, Visual Representation of patterns , Analytical Reasoning.</td></tr>
<tr><td colspan="3">Text Books
1. Aggarwal, R. S. (20024). Quantitative Aptitude. Revised Edition: S. Chand Limited, India.</td></tr>
<tr><td colspan="3">References
1. Sharma, A. (2014). How to Prepare for Quantitative Aptitude for CAT. India: McGraw Hill Education.
2. Verma, R. (2018). Fast Track Objective Arithmetic. India: Arihant Publication India Limited</td></tr>
<tr><td colspan="3"></td></tr>
</table>

<table>
<tr><td>Course Type</td><td colspan="2">Embedded Theory & Lab (ETL)</td></tr>
<tr><td rowspan="6">Mode of Evaluation</td><td>Theory</td><td>75%</td></tr>
<tr><td>Continuous Assessment Test-1</td><td>15 %</td></tr>
<tr><td>Continuous Assessment Test -2</td><td>15%</td></tr>
<tr><td>Digital Assignments/Quizzes (Min)</td><td>20%</td></tr>
<tr><td>Final Assessment Test</td><td>50%</td></tr>
<tr><td>Laboratory</td><td>25%</td></tr>
<tr><td>Prepared by</td><td colspan="2">Ms. Vibhooti Sharma</td></tr>
<tr><td>Recommended by the Board of Studies on</td><td colspan="2"></td></tr>
<tr><td>Date of Approval by the Academic Council</td><td colspan="2"></td></tr>
</table>

Course Code: **RES701**	**Course Title: Research Methodology**	**L T P C** **2 0 0 2**	**30 Hours**
Version No.	**1.0**		
Course Pre-requisites/ Co-requisites/ anti-requisites (if any).	**None**		
Objectives:	The aim of this course is 1. To impart knowledge about types and methods of research. 2. To formulate research problem, experiments/ survey and to analyze and interpret data. 3. To develop research reports.		
Expected Outcome:	At the end of this course the students will be able to apply his knowledge in 1. Identification, experimentation and solving research problems. 2. Reporting research data and preparation of proposals for research grants.		
Module No. 1	**Research Problem and Design**	**6 Hours**	
Defining Research: Motivation, Significance, Objectives, Types and Methodology. State-of-Art of Research: Literature Review, Problem definition and statement, and Research Design.			
Module No. 2	**Data collection and Sampling Design**	**6 Hours**	
Sources of Data: Primary Data, Secondary Data; Procedure Questionnaire – Survey and Experiments – Design of Survey and Experiments – Sampling Merits and Demerits – Control Observations-Procedures – Sampling Errors.			
Module No. 3	**Technical Report Writing**	**6 Hours**	
Technical report organization, part of technical report: Title, Abstract, Keywords, Introduction, Methodology, Result and dissuasion, Conclusion and Bibliography. Technical reporting writing for Research grant and Intellectual Property Rights, Budget and Time-plan.			
Module No. 4	**Tools for Technical Report and Presentation**	**4 Hours**	
Editing, Graphical Designs, Data collection and Analysis, Creating Bibliography database, and Presentation.			
Module No. 5	**Research Publications and Ethics**	**8 Hours**	
Research reporting- types of publications- format, structure and styles- Scientific tables, graphs and illustrations – Preparation of presentations and posters. Research grants – National and International agencies – Writing for grant application, Patenting, IPR. Ethics in Research: A brief introduction to ethics Scientific conduct and misconduct – Fabrication and other forms of misconduct affecting the truth claims of scientific findings. Authorship issues – Salami impalas and duplicate publication – The investigation and punishment of scientific misconduct, Plagiarism			
Text Books 1. Kothari C.K. and Gaurav Garg. Research Methodology - Methods and Techniques.5th Edition New Age International Publishers 1 January 2023, New Delhi.			

References 1. Singh, Y.K. 2007. Fundamentals of Research Methods and Statistics. New Age International (P) Ltd, New Delhi. 2. Forthofer, R.N. Lee, E.S. and Hernandez, M. 2007. Biostatistics: A Guide to Design, Analysis and Discovery. 3. Montgomery, Douglas C. 2007. Design and Analysis of Experiments, Wiley India. 4. Le, C.T. 2003. Introductory Biostatistics. Wiley - Inter Science. 5. Prahlad Mishra, 2015. Business Research Methods, Oxford University Press. 6. https://www.microsoft.com/en-in 7. https://ctan.org/?lang=en 8. https://www.originlab.com/ 9. https://in.mathworks.com/products/matlab.html 10. https://www.coreldraw.com/ 11. https://www.adobe.com/	
Mode of Evaluation	**Theory** **100%** Examination-1 15 Examination-2 15 Assignment/Quiz 20 Final Assessment Test 50
Prepared by	
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code:MTME505	**Course Title:Quality System and Reliability Engineering**	**TPC**	**3**	**0**	**3**
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	**1.** To provide a foundational understanding of quality concepts and their significance in engineering and manufacturing environments. **2.** To develop knowledge of statistical quality control methods and process improvement tools. **3.** To introduce key concepts in reliability engineering, including failure modes, reliability modeling, and maintainability. **4.** To familiarize students with international quality standards, audit processes, and certification systems. **5.** To enable the application of quality and reliability engineering tools in real-world industrial problems and decision-making.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Understand the principles of quality and distinguish between different quality management approaches.
CO2	Apply statistical quality control techniques for process monitoring and quality improvement.
CO3	Analyze and model system reliability using appropriate mathematical tools and probability distributions.
CO4	Utilize reliability design tools such as FMEA, FTA, and accelerated life testing in engineering applications.
CO5	Evaluate and implement quality standards and systems in an industrial environment through audits and continuous improvement strategies.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction to Quality Concepts and Management Systems**	**9Hours**
Definitions and dimensions of quality, quality control versus quality assurance, and the evolution of quality from inspection to Total Quality Management (TQM). Quality Gurus such as Deming, Juran, and Crosby are discussed along with core philosophies. Introduction to quality management principles cost of quality, and strategic quality planning.		
Module No. 2	**Statistical Quality Control and Process Monitoring**	**9 Hours**

Introduction to statistical methods used in quality control. Topics include variable and attribute control charts, process capability indices (Cp, Cpk), sampling inspection, and operating characteristic (OC) curves. The design of control charts for mean, range, proportion, and defects per unit are explained. Case studies of quality improvement using SPC are included.		
Module No. 3	**Reliability Engineering Fundamentals**	**9 Hours**
Concept of system reliability, maintainability, and availability. Topics include failure data analysis, probability distributions (exponential, Weibull), hazard rate functions, reliability block diagrams, and system reliability calculations for series, parallel, and complex systems. Preventive maintenance and failure mode effects analysis (FMEA) are discussed in depth.		
Module No. 4	**Design for Reliability and Advanced Tools**	**9 Hours**
Design considerations to improve reliability, including redundant design, derating, and stress-strength analysis. Tools such as Fault Tree Analysis (FTA), Failure Mode and Effects Criticality Analysis (FMECA), and accelerated life testing are introduced. Techniques for root cause analysis and reliability-centered maintenance (RCM) are emphasized.		
Module No. 5	**QualitySystems, Standards, and Industrial Applications**	**9 Hours**
Implementation of quality systems in industry, including ISO 9001, ISO 14001, Six Sigma, and Lean Quality initiatives. Auditing procedures, documentation, internal and external audits, and third-party certifications are discussed. Industry case studies showcase successful deployment of quality and reliability principles.		

Text Books

1. Douglas C. Montgomery, *Design and Analysis of Experiments*, Publisher: Wiley. 10th Edition, 2022
2. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, Publisher: Waveland Press. 3rd Edition, 2022
3. K.S. Trivedi, *Probability and Statistics with Reliability, Queuing, and Computer Science Applications*, Publisher: Wiley. 3rd Edition, 2022

References

1. B.S. Dhillon, *Engineering Systems Reliability, Safety, and Maintenance: An Integrated Approach*, Publisher: CRC Press. 2nd Edition, 2022
2. Hoang Pham, *Quality and Reliability Engineering*, Publisher: Springer. 2nd Edition, 2023
3. Amitava Mitra, *Fundamentals of Quality Control and Improvement*, Publisher: Wiley. 5th Edition, 2023

Course Type	**Theory Only (TH)**	
Mode of Evaluation	**Theory**	**100%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%

	Final Assessment Test	50%
Prepared by	**Er. Anikate Gupta**	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

Course Code: MTME506	Course Title: **Innovative Tool Design for Modern Manufacturing**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To understand the principles of innovative tool design for high-precision manufacturing. 2. To study the role of advanced materials and coatings in tool performance. 3. To apply modern design techniques including CAD/CAM and simulation in tool design. 4. To explore novel tool systems for micro/nano manufacturing and high-speed machining. 5. To enhance problem-solving skills through industry-oriented tool design projects.				

Course Outcomes	Course Outcome Statement
CO1	Explain the fundamentals of innovative tool design principles used in modern manufacturing.
CO2	Select suitable tool materials and coatings for specific applications.
CO3	Develop and simulate tool designs using CAD/CAM tools.
CO4	Design tools for micro/nano machining and high-speed operations.
CO5	Evaluate and optimize tool performance based on real-time manufacturing needs.

TOTAL HOURS OF INSTRUCTION: 45

Module No. 1	Fundamentals of Tool Design and Innovation	9 Hours

Principles of tool design, types of cutting tools, form tools, tool geometry, tool signature, chip formation, innovation in cutting tool materials, productivity enhancement, tool standardization, modular tooling systems.

Module No. 2	Tool Materials and Coatings	8 Hours

Tool steels, cemented carbides, ceramics, cermets, CBN and PCD tools, tool wear and tool life, advanced coatings (TiN, TiAlN, DLC), deposition methods (CVD, PVD), nano-coatings, thermal stability, selection criteria based on application.

Module No. 3	CAD/CAM in Tool Design	10 Hours

Role of CAD/CAM in tool design, 2D and 3D modeling of cutting tools, tool path generation, integration with CNC, reverse engineering, finite element analysis (FEA) of tool performance, software tools (ANSYS, SolidWorks, MasterCAM), rapid prototyping in tooling.

Module No. 4	Tools for Advanced Manufacturing Techniques	9 Hours
Eco-friendly materials and processes, Lifecycle analysis and recycling of tools, Success stories in automotive, aerospace, and medical industries, Emerging trends in tool design and manufacturing, Role of AI, IoT, and machine learning in tool design, Smart tools and sensors for Industry 4.0.		

Module No. 5	Tool Evaluation and Case Studies	9 Hours
Tool failure analysis, tool testing standards, surface integrity, vibration and chatter in tooling, optimization techniques, case studies from aerospace, automotive, biomedical industries, design for sustainability and cost-effectiveness in tooling.		

Text Books

1. **Stephen F. Krar & Arthur Gill**, *Tool Design*, 6th Edition, Cengage Learning, **2021**.
2. **Prakash Hiralal Joshi**, *Tooling Data: Innovative Tool Design*, 2nd Edition, McGraw Hill Education, **2022**.

Reference Books

1. **Donaldson, Lecain & Goold**, *Tool Design*, 5th Edition, Tata McGraw Hill, **2022**.
2. **G.R. Nagpal**, *Tool Engineering and Design*, Revised Edition, Khanna Publishers, **2023**.
3. **Vukota Boljanovic**, *Sheet Metal Forming Processes and Die Design*, 3rd Edition, Industrial Press, **2024**.

Lab Experiments

1. **Study and analysis of various cutting tool geometries** using tool signature and design charts.
2. **3D modeling of single-point cutting tool** using CAD software (e.g., SolidWorks/CATIA).
3. **Design and simulation of a form tool** for turning operation using CAM software.
4. **Tool path generation for milling and drilling tools** using MasterCAM/UG-NX.
5. **Finite Element Analysis (FEA)** of tool under cutting forces using ANSYS or similar tools.
6. **Design and modeling of a modular tool holder system** using CAD software.
7. **Material selection and coating strategy** for high-speed machining tools using material databases.
8. **Simulation of tool wear and thermal behavior** during machining using simulation tools.
9. **Development of a micro cutting tool model** for micro-machining applications.
10. **Reverse engineering of an existing cutting tool** using a 3D scanner and CAD software.
11. **Design and fabrication of a jig/fixture** using design principles for CNC machining.
12. **Additive manufacturing (3D printing)** of a custom-designed fixture/tool prototype.

13. **Tool failure analysis and wear pattern inspection** using a toolmakers' microscope or SEM images. 14. **Measurement of cutting forces** during turning/milling operations using a dynamometer. 15. **Case study-based project on innovative tool design** for a specific industry application (aerospace/automobile/biomedical).	
Course Type	**Embedded Theory & Lab**
Mode of Evaluation	**Theory** **75%** Continuous Assessment Test-1 15% Continuous Assessment Test-2 15% Digital Assignment/Quizzes (Min) 20% Final Assessment Test 50%
	Laboratory **25%**
Prepared by	**Dr. Mandeep Kumar**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code:MTME507	**Course Title: Production Planning & Control**	**TPC**	**3**	**0**	**3**
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To understand the fundamentals of production planning and control and its role in optimizing manufacturing processes. 2. To develop skills in material requirements planning (MRP) and manufacturing resource planning (MRPII) for effective resource management. 3. To apply Just-In-Time (JIT) and Lean Manufacturing principles for waste reduction and improved production efficiency. 4. To master advanced scheduling techniques and performance evaluation for optimizing production workflows and assessing efficiency.				

Course Outcomes	Course Outcome Statement
CO1	Understand the principles and framework of production planning and control in manufacturing systems.
CO2	Apply forecasting methods and capacity planning to predict and plan production activities.
CO3	Analyze and implement inventory control systems for efficient resource utilization.
CO4	Utilize scheduling techniques for optimizing production processes.
CO5	Evaluate and integrate advanced production control strategies like JIT, Lean Manufacturing, and ERP in industrial environments.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction to Production Planning and Control**	**9 Hours**
This module introduces the fundamental concepts of production planning and control, the role of PPC in manufacturing, and the objectives of production management. Topics include production systems, the planning and control functions, and the significance of inventory management. The module also covers demand forecasting and master production scheduling (MPS).		
Module No. 2	**Material Requirements Planning (MRP) and Manufacturing Resource Planning**	**9 Hours**
The second module delves into the intricacies of material requirements planning (MRP) and manufacturing resource planning (MRPII). The students will learn the MRP process, its types, and the importance of accurate data input for successful MRP execution. This module also covers capacity planning, bill of materials (BOM), and the MRP systems in modern manufacturing.		

<table>
<tr><td>Module No. 3</td><td>Just-In-Time (JIT) and Lean Manufacturing</td><td>9 Hours</td></tr>
<tr><td colspan="3">This module focuses on the concepts of Just-In-Time (JIT) production and lean manufacturing systems. Students will explore JIT techniques such as Kanban, pull systems, and waste reduction strategies. The module highlights the importance of reducing inventory, improving production flow, and enhancing product quality while minimizing waste.</td></tr>
<tr><td>Module No. 4</td><td>Advanced Scheduling Techniques</td><td>9 Hours</td></tr>
<tr><td colspan="3">The final module covers advanced techniques for production scheduling and control, including finite and infinite loading, Gantt charts, and critical path methods (CPM).</td></tr>
<tr><td>Module No. 5</td><td>Performance Evaluation</td><td>9 Hours</td></tr>
<tr><td colspan="3">Students will also study performance metrics for evaluating production efficiency, including capacity utilization, throughput, and lead time.</td></tr>
<tr><td colspan="3">Text Books
1. L.J. Krajewski, M.K. Malhotra, and L.P. Ritzman, Operations Management: Processes and Supply Chains, Pearson Education, 12th Edition, 2022.
2. S.K. Mukhopadhyay, Production Planning and Control: Text and Cases, PHI Learning, 2021.
3. S.N. Chary, Production and Operations Management, McGraw Hill Education, 5th Edition, 2019.</td></tr>
<tr><td colspan="3">References
1. W.J. Hopp and M.L. Spearman, Factory Physics, McGraw Hill, 2021.
2. J. Heizer, B. Render, and C. Munson, Principles of Operations Management, Pearson Education, 2021.
3. Ashwathappa K. and K. Shridhara Bhat, Production and Operations Management, Himalaya Publishing House, 2019.</td></tr>
</table>

Course Type	**Theory (TH)**	
Mode of Evaluation	**Theory**	**100%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
Prepared by	**Dr. Shivinder Singh**	
Recommended by the Board of Studies on		
Date of Approval by Academic Council		

Course Code: MTME503	Course Title: Operation research for mechanical engineers	TPC	3	0	3
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. Understand the fundamentals of optimization and linear programming for engineering applications. 2. Apply dynamic and non-linear optimization techniques for decision-making in complex mechanical systems. 3. Analyse queuing systems and evaluate their performance in manufacturing environments. 4. Explore the experimental and mathematical methods for real-world industrial optimization problems.				

TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Linear Programming and its Applications	12 Hours

Theory of Simplex Solution, Alternative Optimal Solution, Unbounded Solutions, Infeasible Solutions, Formulation of LP Models for: Production Scheduling, Network Planning, Inventory Maintenance, Capital Budgeting, Two-Phase Method, Revised Simplex Method, and Dual Simplex Method, Transportation and Assignment Models, Travelling Salesman Problem and Industrial Applications

Module No. 2	Dynamic Optimisation Models	9 Hours

Decision Variables: The variables that need to be optimized, such as production quantities, inventory levels, or resource allocation. Optimisation of Non-Linear Objective Functions using Dynamic Programming: optimization processes, minimize costs, maximize profit, reduce lead time, or optimize resource utilization. Applications of Dynamic Programming in Industrial Systems

Module No. 3	Non-Linear Optimisation and Queuing Models	8 Hours

Non-Linear Optimisation Models, Unconstrained Non-Linear Objective Functions, Quadratic Programming, Queuing Theory: Single and Parallel Channels' Limited and Unlimited Service Systems, Bulk Input, Bulk Service, Priority Queue Discipline

Module No. 4	Heuristic Models, and Optimisation Techniques	10 Hours

Heuristic Models: Need for Heuristic Programming, Examples of Heuristic Models for: Travelling Salesman Problem, Facility Design, Assembly Line Balancing Optimisation Techniques: Classical Methods, Non-Linear Optimisation, Unconstrained and Constrained Optimisation, Lagrangian Multiplier Method parameters for process efficiency,

Module No. 5	Multi-Criteria Decision Making and Case Studies	6 Hours

MCDM Methods: AHP, TOPSIS, ELECTRE Applications in Product Design, Manufacturing Strategy, Integrated Optimization Approach and Recent Trends in OR.

Text Books

1. **R K Gupta,** Operations Research, Krishna Prakshan, 2023
2. **Frederick S. Hillier, Gerald J. Lieberman, et al.,** Introduction to Operations Research, 11^{th} edition Mc Graw Hill, 2024
3. **M. W. Carter**, Operation Research; A practical introduction, 2^{nd} edition CRC press, 2023.

References 1. **G. Srinivasan**, Operations Research: Principles and Applications, Prentice Hall India Pvt., Limited, 2021. 2. **Richard J Boucherie,** Operations Research, World Scientific Connect, 2021**.** 3. R. **Panneerselvam**, Operation research, PHI publication, 3rd edition, 2023.	
Course Type	**Theory Only (Th)**
Mode of Evaluation	**Theory** **100%** Continuous Assessment Test-1 15 % Continuous Assessment Test -2 15% Digital Assignments/Quizzes (Min) 20% Final Assessment Test 50%
Prepared by	**Dr. Kamaljit Singh**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code: MTME509	Course Title: Product Lifecycle Management	TPC	3	0	3
Version No.	1.0				
Course Pre-requisites/ Co-requisites	None				
Anti-requisites (if any).	None				
Objectives:	1. To introduce the concept of Product Lifecycle Management (PLM) and its role in modern industries. 2. To equip students with knowledge of PLM processes, tools, and technologies. 3. To analyze the integration of PLM in product development and business strategies. 4. To explore sustainability, innovation, and collaboration in the context of PLM. 5. To provide insights into the future trends of PLM and its applications in Industry 4.0.				

Course Outcomes	Course Outcome Statement
CO1	Understand the principles and importance of Product Lifecycle Management.
CO2	Analyze product data and workflows using PDM tools.
CO3	Evaluate and apply various PLM tools and software platforms.
CO4	Identify and model different stages of product lifecycle for optimization.
CO5	Demonstrate the application of PLM strategies through real-world case studies.

TOTAL HOURS OF INSTRUCTION: 45

Module No. 1	Introduction to PLM	8 Hours
Definition and evolution of PLM, importance of PLM, lifecycle phases, benefits of PLM, PLM architecture, digital thread, product data and process integration, challenges in product development, PLM vs ERP.		
Module No. 2	**Product Data Management (PDM)**	**9 Hours**
PDM systems, PDM functions, data vaults and vaulting, version and revision control, metadata management, product structure, configuration management, workflow management, PDM implementation, case studies in PDM usage.		
Module No. 3	**PLM Tools and Technologies**	**9 Hours**

CAD/CAM/CAE integration in PLM, BOM management, collaborative design tools, visualization and rendering tools, database management systems for PLM, interoperability standards (STEP, IGES, XML), cloud-based PLM solutions, IoT in PLM.		
Module No. 4	**Lifecycle Phases and Strategies**	**10 Hours**
Conceptual design phase, detail design, prototyping, manufacturing planning, service and maintenance, end-of-life strategies, sustainability and circular economy in PLM, PLM metrics and KPIs, role of digital twin and digital manufacturing.		
Module No. 5	**PLM Implementation and Case Studies**	**9 Hours**
PLM implementation methodology, system architecture and deployment, organizational challenges, change management, ROI calculation, PLM in automotive, aerospace, consumer products, future trends in PLM, case studies from industries.		

Text Books

1. **John Stark**, *Product Lifecycle Management: Driving the Next Generation of Lean Thinking*, 3rd Edition, Springer, **2023**.
2. **Michael Grieves**, *Product Lifecycle Management: Driving the Next Generation of Lean Thinking*, 2nd Edition, McGraw Hill Education, **2021**.

Reference Books

1. **Antti Saaksvuori & Anselmi Immonen**, *Product Lifecycle Management*, 3rd Edition, Springer, **2022**.
2. **John Stark**, *Product Lifecycle Management: 21st Century Paradigm for Product Realisation*, 4th Edition, Springer, **2021**.
3. **Debasish Sarkar**, *Product Lifecycle Management: Paradigm for 21st Century Product Realisation*, 2nd Edition, CRC Press, **2024**.

Course Type	**Embedded Theory**
Mode of Evaluation	**Theory** **100%** Continuous Assessment Test-1 15% Continuous Assessment Test-2 15% Digital Assignment/Quizzes (Min) 20% Final Assessment Test 50%
Prepared by	**Dr. Mandeep Kumar**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code:MTME510	Course Title: **Metal Forming Processes and Analysis**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To provide fundamental knowledge of the principles and mechanics of metal forming processes. 2. To familiarize students with various conventional and advanced metal forming techniques. 3. To develop the ability to analyze and predict the deformation behaviour of materials under various forming conditions. 4. To introduce process parameters, their optimization, and their impact on forming processes.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Explain the fundamental principles and mechanics of cold and hot forming.
CO2	Classify and describe Theory of Elasticity and Plasticity.
CO3	Evaluate the influence of Slip Line Field Theory on forming processes.
CO4	Analyze the deformation behaviour of materials under Sheet metal forming conditions using analytical methods.
CO5	Analysis of Drawing and bending processes
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction**	**9 Hours**
Introduction: Advantages of metal forming, cold and hot forming, various metal forming processes.Basics of metal forming - Mohr's circle - isotropic elasticity - yield theories - plastic stress strain relationship - plastic work - the principle of normality - incremental plastic strain.		
Module No. 2	**Theory of Elasticity and Plasticity**	**9 Hours**
Review of theory of elasticity, Stress tensor, stress transformations, principal stresses, differential equations of equilibrium, Plastic instability – strain hardening / work hardening – strengthening mechanisms – cold working and recrystallization.		
Module No. 3	**Slip Line Field Theory**	**9 Hours**
Slip Line Field Theory, Incompressible two-dimensional flow, slip lines, equilibrium equations (referred to slip lines), Henkey's theorems, hodograph, simplest slip line fields, application in forming processes – extrusion and forging.		
Module No. 4	**Sheet Metal forming and Analysis**	**9 Hours**

- Bending theory, Cold Rolling theory - Hill's anisotropic plasticity theory - Hill's general yield theory, CAD/CAM applications in Extrusion, Forging and sheet metal Forming - Localized necking in biaxial stretching. Sheet Forming Analysis and Sheet-Metal Formability Tests - Elements Used in SHEET-S and SHEET-3, General Considerations, Consistent Full Set Algorithm, Performance of SHEET-3 in International Benchmark Tests, Meshing and Remeshing

Module No. 5	**Drawing and bending processes and Analysis**	**9 Hours**
Deep-drawing - analysis to correlate the initial and final dimensions of the job, estimation of the drawing force, defects, Bending - determination of work load, estimation of spring back, Punching and blanking – mode of metal deformation and failure, deformation model and fracture analysis, determination of working force, Friction and Lubrication in metal forming.		

Text Books

1. Huda, Zainul, Metal Forming Processes: Fundamentals, Analysis, Calculations, Springer, 2024
2. Kopec, Mateusz, and Politis, Denis, Advances in Sheet Metal Forming Processes of Lightweight Alloys, MDPI, 2023.

References

1. Kakandikar Ganesh Marotrao, Anupam Agrawal, D. Ravi Kumar, Metal Forming Processes: Developments in Experimental and Numerical Approaches, CRC Press, 2023.
2. Amrut Mulay, Swadesh Kumar Singh, Andrzej Kocanda**,** Analysis and Optimization of Sheet Metal Forming Processes, CRC Press, 2024**.**
3. Surender Kumar, Technology of Metal Forming Processes, PHI Learning, 2024

List of Exercise

1. To determine the compressive strength, yield stress, and ductility of materials under compressive loading
2. o evaluate the tensile properties of materials, including yield strength, ultimate tensile strength, and elongation.
3. To measure the toughness of materials and assess their resistance to fracture under high-rate loading.
4. To study the effects of rolling on metal thickness reduction, surface finish, and material properties.
5. To analyze the deformation, force requirements and material behaviour during the extrusion process.
6. To understand the impact of forging on material properties, including grain structure and mechanical characteristics.
7. To study the wire drawing process and determine its effect on the material's mechanical properties and geometric characteristics.
8. To evaluate the formability of materials during deep drawing and the effect of blank holder force, lubrication, and punch speed.
9. To understand the shearing and punching process and evaluate the shear strength and cut quality of metal sheets.
10. To investigate the bending process and measure the degree of spring back that occurs after unloading the material.
11. To study the hydro forming process for producing complex shapes and the effect of internal fluid pressure on material behaviour.
12. To examine the super plastic forming process and evaluate material deformation under high temperatures and strain rates.
13. To understand the effects of combined thermal and mechanical treatments on the material's microstructure and mechanical properties.
14. To simulate metal forming processes using Finite Element Analysis (FEA) software and compare experimental results with simulations.
15. To measure the hardness of metal samples before and after forming processes to evaluate material property changes.

Course Type	**Embedded Theory & Lab (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Kushdeep Rana**	
Recommended by the Board of Studies on		

Course Code: MTME511	Course Title: Design and Analysis of Experiments	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. Understand the fundamental principles and terminologies of experimental design in engineering applications. 2. Develop and analyse various factorial and fractional factorial experimental designs for identifying significant factors. 3. Apply optimization techniques to model, analyse, and optimize engineering processes. 4. Explore advanced experimental design strategies including for complex and uncertain systems.				

TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Design of Experiments	8 Hours

Introduction to Experimental Design: Purpose, need, and importance of experiments in engineering and research. Basic Terminologies: Factors, levels, responses, experimental units, treatments, randomization, replication, and blocking. Types of Experimental Designs: Overview of Statistical Inference: Hypothesis testing, confidence intervals, and error analysis. Applications: Industrial applications and case studies.

Module No. 2	Factorial Designs	5 Hours

Introduction to Factorial Designs: Two-level factorial designs, Full Factorial Designs: General approach, analysis of variance (ANOVA), interpretation of results. Fractional Factorial Designs: use of fractional designs, resolution, and applications.

Module No. 3	Analysis of Variance and Interaction Effects	6 Hours

Analysis of Variance (ANOVA): Basic principles and ANOVA for factorial experiments. Interaction Effects: Understanding and interpreting interaction effects between factors. Application Examples: Case studies from various industrial applications (e.g., quality control, product optimization).

Module No. 4	Taguchi and Response Surface Methodology	15 Hours

Taguchi Methods for Robust Design: Philosophy, objectives, and applications. Orthogonal Arrays: Choosing orthogonal arrays, analysis, and interpretation. Signal-to-Noise Ratio. Introduction to Response Surface Methodology (RSM): Importance and application in optimization. Polynomial regression models and their applications in optimization. Central Composite Design (CCD), Box-Behnken Design (BBD): Structure, analysis, and applications.

Module No. 5	Advanced Topics in Design of Experiments	11 Hours

Fuzzy Logic in Experimental Design: Introduction to fuzzy sets, membership functions, fuzzy decision-making, and fuzzy inference systems. Application of fuzzy logic in modelling complex systems with uncertainty in experimental design.

Text Books

1. **N C Giri and M N Das**, Design and Analysis of Experiments, New Age International Publishers, 2024.
2. **Jiju Antony**, Design of Experiments for Engineers and Scientists, Elsevier, 2023.

3. **Dr. R. Gangai Selvi**, Design of Experiment, Iterative International Publishers, 2023.
4. **Timothy J. Ross**, Fuzzy Sets and Fuzzy Logic with Engineering Applications, Wiley, 2021
5. **J. Paulo Davim**, Soft Computing Techniques for Engineering Optimization, CRC Press, 2021

References

1. **Dr. Sanghmitra Sharma, Dr. Najrullah Khan, et al.**, Analysis Of Variance And Design Of Experiments, Bluerose Publishers, 2023.
2. **Valerii V Fedorov and Peter Hackl**, Model Oriented Design of Experiments, Springer, 2024.
3. **R. Pundir and S.K. Pundir**, Fuzzy Sets and Their Applications, Anu Books, 2021

Lab Exercise

1. To explore statistical software like Minitab/ Design Expert for designing and analysing experiments.
2. To perform hypothesis testing (t-test, F-test) and confidence interval estimation for engineering datasets.
3. Conduct a full factorial (2^2 or 2^3) experiment, analyze main and interaction effects, and visualize results.
4. Apply fractional factorial design (e.g., 2^{4-1}) to screen significant factors; understand design resolution.
5. Design and analyze an experiment using Taguchi's orthogonal arrays; calculate and interpret S/N ratios.
6. Design L9 orthogonal array through design of experiments
7. To conduct and analyse a complex randomized design experiment using one factor and multiple levels; interpret ANOVA results.
8. Perform one-way and two-way ANOVA and interpret the significance of factors and interactions.
9. Generate and interpret interaction plots and main effects plots using experimental data.
10. Use Central Composite Design (CCD) to model a second-order polynomial for response optimization.
11. Conduct Box Behnken Design (BBD) experiment and fit a response surface; analyse contour plots for optimization.
12. Implement a basic fuzzy logic model to handle uncertain parameters in an experimental setting.
13. Apply DOE principles to solve a real or simulated case study in machining, thermal processing, or materials testing
14. To design and analyse experimental data using Artificial Neural Networks (ANN).
15. Study Genetic algorithm (GA) to optimize a multi-factor experiment; compare results with traditional optimization.

Course Type	**Embedded Theory and Lab (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**

Prepared by	**Dr. Kamaljit Singh**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code: MTME512	Course Title: **Optimization Strategies for Mechanical Systems**	TPC	3	0	3
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To introduce the fundamental principles of optimization and their significance in solving engineering design problems. 2. To develop an understanding of classical optimization methods, including techniques for both constrained and unconstrained problems. 3. To provide the mathematical foundation of artificial neural networks and swarm intelligence for design problems. 4. To expose students to evolutionary and metaheuristic algorithms, enhancing their ability to handle complex, nonlinear, and multi-modal problems. 5. To demonstrate selected optimization algorithms commonly used in static and dynamic applications.				

Course Outcomes	Course Outcome Statement
CO1	Understand the fundamentals and mathematical formulation of engineering optimization problems.
CO2	Apply classical optimization techniques to solve constrained and unconstrained problems.
CO3	Implement neural network technique to real world design problems.
CO4	Use numerical methods and tools for implementing optimization strategies.
CO5	Solve real-world mechanical system design problems using suitable optimization techniques.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Optimization:	9 Hours

Basic concepts of optimization; engineering applications; types of optimization problems; single and multi-variable optimization; constraints and objective functions; formulation of mechanical design problems as optimization problems.

Module No. 2	Classical Optimization Techniques:	9 Hours

Introduction–Activation functions, types of activation functions, neural network architectures, Single layer feed forward network, multi layer feed forward network, Neural network applications. Swarm intelligence-Various animal behaviors, Ant Colony optimization, Particle Swarm optimization.

<table>
<tr><td>Module No. 3</td><td>Advanced Optimization Techniques:</td><td>9 Hours</td></tr>
<tr><td colspan="3">Multistage optimization–dynamic programming, stochastic programming Multi objective optimization Genetic algorithms and Simulated Annealing technique</td></tr>
<tr><td>Module No. 4</td><td>Numerical Optimization Methods:</td><td>9 Hours</td></tr>
<tr><td colspan="3">Direct search methods – Hooke and Jeeves, Nelder-Mead simplex; gradient-based methods – Newton’s method, quasi-Newton method; penalty and barrier function methods; use of MATLAB or Python for implementation.</td></tr>
<tr><td>Module No. 5</td><td>Applications in Mechanical Systems:</td><td>9 Hours</td></tr>
<tr><td colspan="3">Optimization of mechanical components: shafts, springs, gears; design of thermal systems; optimization of machining parameters; structural optimization; multi-objective optimization and trade-off analysis in engineering systems.</td></tr>
<tr><td colspan="3">Text Books
1. Srinivas, K., and Reddy, J.N. – Optimization of Mechanical Systems: Theory and Applications, 2nd Edition (2023), Wiley.
2. Singh, M., and Gupta, S. – Advanced Optimization Techniques in Mechanical Engineering, 1st Edition (2022), Springer.
3. Kumar, R., and Sharma, P. – Computational Methods for Mechanical System Optimization, 1st Edition (2021), Elsevier.</td></tr>
<tr><td colspan="3">References
1. Zhang, L., and Wang, H. – Multi-Objective Optimization in Mechanical Engineering, 1st Edition (2024), CRC Press.
2. Patel, R., and Desai, M. – Metaheuristic Algorithms for Mechanical System Design, 1st Edition (2023), Springer.
3. Lee, J., and Kim, S. – Optimization Techniques for Structural and Thermal Systems, 1st Edition (2022), Wiley.</td></tr>
<tr><td>Course Type</td><td colspan="2">Theory (TH)</td></tr>
<tr><td>Mode of Evaluation</td><td colspan="2">Theory 100
Continous Assessment Test-1 15%
Continous Assessment Test-1 15%
Digital Assignments/Quizzes (Min) 20%
Final Assessment Test 50%</td></tr>
<tr><td>Prepared by</td><td colspan="2">Dr. Sahil Sharma</td></tr>
<tr><td>Recommended by the Board of Studies on</td><td colspan="2"></td></tr>
<tr><td>Date of Approval by the Academic Council</td><td colspan="2"></td></tr>
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Course Code:MTME513	Course Title:Supply Chain Analytics and Optimization for Mechanical Engineers	TPC	3	2	3
Version No.	1.0				
Course Pre-requisites/ Co-requisites	None				
Anti-requisites (if any).	None				
Objectives:	1. To develop a foundational understanding of supply chain management (SCM) and the role of analytics in decision-making. 2. To introduce key optimization models and tools used in designing efficient and responsive supply chains. 3. To provide hands-on experience with analytical software and simulation tools for solving real-world supply chain problems. 4. To enable students to analyze data-driven decisions in sourcing, production, inventory, and logistics from an engineering perspective. 5. To bridge theoretical SCM concepts with practical implementation using digital technologies and analytical methodologies.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Understand supply chain structures, analytics types, and performance metrics in manufacturing and distribution systems.
CO2	Apply forecasting and inventory models to improve supply-demand matching and cost efficiency.
CO3	Design and optimize supply chain networks and transportation systems using mathematical modeling tools.
CO4	Analyze production planning and sourcing strategies using analytical and decision-making frameworks.
CO5	Integrate simulation, digital tools, and emerging technologies into supply chain planning and execution.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Supply Chain Management and Analytics	9 Hours
Introduction to the concept, structure, and components of supply chains. Topics include supply chain strategy, the bullwhip effect, supply chain drivers, and performance metrics. Basics of descriptive, predictive, and prescriptive analytics in the supply chain context.		
Module No. 2	Forecasting and Inventory Optimization	9 Hours

Quantitative forecasting methods including moving averages, exponential smoothing, ARIMA, and machine learning models for demand forecasting. Inventory models such as EOQ, newsvendor model, and multi-echelon inventory systems are discussed. Real-world data analysis examples are included.		
Module No. 3	**Network Design and Transportation Optimization**	**9 Hours**
Supply chain network design including facility location models, hub-and-spoke networks, and vehicle routing problems (VRP). Optimization models for transportation, distribution, and logistics planning using linear and integer programming are emphasized.		
Module No. 4	**Production Planning and Sourcing Analytics**	**9 Hours**
Aggregate planning, master production scheduling, materials requirement planning (MRP), and lean systems. Sourcing strategies, supplier selection models, contract optimization, and game theory applications in procurement are discussed with industry examples.		
Module No. 5	**Emerging Technologies and Simulation in Supply Chains**	**9 Hours**
Simulation modeling using software (e.g., Arena, AnyLogic), digital twins, and the application of AI, IoT, and blockchain in modern supply chains. Case studies from manufacturing and logistics domains are used to demonstrate integration of analytics into decision-making processes.		

Text Books

1. Simchi-Levi D., Kaminsky P. &Simchi-Levi E., *Designing and Managing the Supply Chain*, Publisher: McGraw-Hill Education. 4th Edition, 2022
2. S. Chopra & P. Meindl, *Supply Chain Management: Strategy, Planning, and Operation*, Publisher: Pearson Education. 8th Edition, 2023
3. Gerald Feigin, *Supply Chain Planning and Analytics: The Right Product in the Right Place at the Right Time*, Publisher: McGraw-Hill Education. 2nd Edition, 2022

References

1. Sunil Sharma, *Supply Chain Analytics: Concepts, Techniques, and Applications*, Publisher: Sage Publications. 1st Edition, 2023
2. Nada R. Sanders, *Supply Chain Management: A Global Perspective*, Publisher: Wiley. 3rd Edition, 2022
3. Michael Watson et al., *Supply Chain Network Design: Applying Optimization and Analytics to the Global Supply Chain*, Publisher: Pearson FT Press. 2nd Edition, 2022

Lab Exercise

1. Demand forecasting using moving average and exponential smoothing in Excel.
2. Implementation of ARIMA model for time-series forecasting using Python.
3. EOQ and reorder point calculations for multi-item inventory systems.

4. Simulation of single-echelon inventory system with variable lead time.
5. Optimization of warehouse location using linear programming in Excel Solver.
6. Solving transportation problems using Vogel's approximation and MODI method.
7. Network design using Gurobi optimization in Python.
8. Vehicle Routing Problem (VRP) using Google OR-Tools.
9. ABC and XYZ inventory classification using real product data.
10. Aggregate production planning using MATLAB.
11. Supplier selection using AHP (Analytic Hierarchy Process).
12. Multi-criteria decision-making using TOPSIS method in Python.
13. Simulating supply chain disruptions using Arena.
14. Modeling supply chain digital twin using AnyLogic (basic setup).
15. Case study implementation: Optimization of an end-to-end supply chain system using mixed-integer linear programming.

Course Type	**Embedded Theory and Laboratory (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Er. Anikate Gupta**	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

Course Code:MTME603	**Course Title:AI Techniques for Renewable Energy System**	**TPC**	**3**	**2**	**4**
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	**1.** To provide a foundational understanding of Artificial Intelligence and its relevance to renewable energy system planning and operation. **2.** To develop competency in machine learning and deep learning algorithms for forecasting energy generation and optimizing energy use. **3.** To equip students with tools such as fuzzy logic and neural networks for intelligent control of distributed energy systems. **4.** To teach the use of optimization algorithms like genetic algorithms and swarm intelligence for renewable energy system design. **5.** To enable practical application through simulations, tools, and real-world case studies in smart grid and hybrid energy system environments.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Understand and describe AI principles and identify their significance in renewable energy applications.
CO2	Develop forecasting models using machine learning and deep learning techniques for solar and wind energy systems.
CO3	Design intelligent control systems using fuzzy logic and neural networks for distributed renewable systems.
CO4	Apply evolutionary algorithms for optimization in hybrid and smart energy systems.
CO5	Simulate and analyze real-world renewable energy problems using AI tools and present viable intelligent solutions.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction to AI and Renewable Energy Systems**	**9Hours**
Introduction to fundamentals of Artificial Intelligence (AI), intelligent agents, expert systems, and learning types. Contextual foundation for the use of AI in renewable energy applications such as solar, wind, biomass, and smart grids.		
Module No. 2	**Machine Learning and Forecasting Models**	**9 Hours**

Machine learning techniques such as regression, classification, clustering, decision trees, and support vector machines. Deep learning frameworks, including convolutional and recurrent neural networks, applied to solar radiation and wind energy forecasting using real-time datasets.

Module No. 3	**Fuzzy Logic and Intelligent Control Systems**	**9 Hours**

Fuzzy logic theory, fuzzification and defuzzification techniques, Mamdani and Sugeno models, and the design of fuzzy controllers for renewable energy applications are covered. Use cases include fuzzy-based MPPT controllers, smart battery management systems, and hybrid energy system control.

Module No. 4	**Optimization Using Evolutionary Algorithms**	**9 Hours**

Optimization techniques including Genetic Algorithms (GA), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Differential Evolution (DE). Applications include hybrid system configuration, power flow optimization, and load scheduling.

Module No. 5	**Real-time Applications and Case Studies**	**9 Hours**

Theory to practice through case studies on AI-enabled microgrids, smart grids, energy trading systems, and AI-based predictive maintenance. Tools such as MATLAB, Python (Scikit-learn, TensorFlow), and RETScreen are used for simulations and analysis.

Text Books

1. Bhavnesh Kumar, Bhanu Pratap & Vivek Shrivastava, *Artificial Intelligence for Solar Photovoltaic Systems: Approaches, Methodologies, and Technologies*, Publisher: CRC Press. 1st Edition, 2023.
2. Suman Lata Tripathi, Mithilesh Kumar Dubey, Vinay Rishiwal & Sanjeevikumar Padmanaban, *Introduction to AI Techniques for Renewable Energy System*, Publisher: CRC Press. 1st Edition, 2021.
3. Sailesh Iyer, Anand Nayyar, Mohd Naved & Fadi Al-Turjman, *Renewable Energy and AI for Sustainable Development*, Publisher: CRC Press. 1st Edition, 2023.

References

1. Ashutosh Kumar Dubey, Sushil Kumar Narang, Abhishek Kumar, Vicente García-Díaz & Arun Lal Srivastav, *Artificial Intelligence for Renewable Energy Systems*, Publisher: Woodhead Publishing (Elsevier). 1st Edition, 2022.
2. Neeraj Priyadarshi, Sanjeevikumar Padmanaban, Kamal Kant Hiran, Jens Bo Holm-Nielson & Ramesh C. Bansal, *Artificial Intelligence and Internet of Things for Renewable Energy Systems*, Publisher: De Gruyter. 1st Edition, 2021.
3. Weihao Hu, Guozhou Zhang, Zhenyuan Zhang, Sayed Abulanwar & Frede Blaabjerg, *AI for Power Electronics and Renewable Energy Systems*, Publisher: IET. 1st Edition, 2024.

Lab Exercise 1. Implementation of linear regression for solar irradiance prediction. 2. Development of a decision tree model for wind power classification. 3. Forecasting energy demand using time-series models (ARIMA, LSTM). 4. Solar power forecasting using Convolutional Neural Networks (CNN). 5. Wind speed prediction using Recurrent Neural Networks (RNN). 6. Clustering energy consumption patterns using K-means. 7. Design and simulation of fuzzy-based MPPT controller for PV systems. 8. Battery charge/discharge control using a fuzzy inference system. 9. Load management using a fuzzy logic-based controller. 10. Optimization of hybrid renewable energy system using Genetic Algorithm (GA). 11. Sizing and placement of distributed generation using Particle Swarm Optimization (PSO). 12. Implementation of Ant Colony Optimization for power flow optimization. 13. Smart grid fault detection using support vector machines. 14. Predictive maintenance using classification algorithms on SCADA data. 15. Case study implementation: AI-based smart grid controller using MATLAB/Simulink.	
Course Type	**Embedded Theory and Laboratory (ETL)**
Mode of Evaluation	**Theory** **75%** Continuous Assessment Test 15% Continuous Assessment Test-2 15% Digital Assignment/Quizzes (Min) 20% Final Assessment Test 50%
	Laboratory **25%**
Prepared by	**Er. Anikate Gupta**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code: MTME604	Course Title: **Smart Automation with AI for Industry 4.0**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. Understand the evolution and framework of Industry 4.0. 2. Learn to apply ML and AI algorithms to solve industrial problems. 3. Understand the architecture and integration of IoT in industrial applications. 4. Explore advanced technologies driving smart factory innovations				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Understand the fundamental concepts of Industry 4.0 and smart automation technologies.
CO2	Apply AI and ML algorithms for predictive maintenance and smart decision-making.
CO3	Design and implement IIoT-enabled systems for industrial automation.
CO4	Explore emerging technologies like digital twins, AR/VR, and blockchain in Industry 4.0 applications.
CO5	Apply Real-Time Implementation and Case Studies in Industry 4.0

TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Industry 4.0 and Smart Automation	9 Hours
Overview of Industrial Revolutions: From Industry 1.0 to 4.0.Key Concepts of Industry 4.0: Cyber-Physical Systems, IoT, Big Data, Cloud Computing, Role of Artificial Intelligence in Smart Manufacturing. Smart Sensors and Actuators: Types, Applications, and Standards Industrial Communication Protocols: OPC-UA, MQTT, Profinet		
Module No. 2	**Machine Learning and AI for Automation**	**9 Hours**
Fundamentals, Case Studies: AI-Driven Automation in Manufacturingof Machine Learning: Supervised, Unsupervised, and Reinforcement Learning, Algorithms for Smart Automation: Decision Trees, Neural Networks, and SVM,Predictive Maintenance using Machine Learning,Real-Time Data Analytics and Edge AI in Industrial Applications.		
Module No. 3	**Industrial IoT (IIoT) and Data Integration**	**9 Hours**

IoT Architecture for Industry 4.0, IIoT Platforms and Middleware, Data Acquisition, Storage, and Processing in IIoT Systems, AI in IIoT: Use Cases and Challenges, Security and Privacy Concerns in IIoT Systems.		
Module No. 4	**Emerging Technologies and Smart Factory Applications**	**9 Hours**
Digital Twins and their Role in Smart Automation, AI-Powered Robotics in Manufacturing, Block chain for Supply Chain Automation, Augmented Reality (AR) and Virtual Reality (VR) in Smart Factories, Smart Factory Use Cases and Future Trends		
Module No. 5	**Real-Time Implementation and Case Studies in Industry 4.0**	**9 Hours**
Deployment of AI in Smart Factories.Cybersecurity and Data Privacy in Industry 4.0.Integration of Cyber-Physical Systems (CPS).Challenges in Implementing Smart Automation.		

Text Books

1. "Industry 4.0: The Industrial Internet of Things" by Alasdair Gilchrist, A press, 2016.
2. Nazmul Siddique, Mohammad Shamsul Arefin, M Shamim Kaiser, ASM Kayes, Applied Intelligence for Industry 4.0, Chapman & Hall, 2023.
3. Avinash Chandra Pandey, Abhishek Verma, Vijaypal Singh Rathor, Munesh Singh, Ashutosh Kumar Singh, Intelligent Analytics for Industry 4.0 Applications, CRC Press, 2023.

Reference Books

1. "Smart Manufacturing: Concepts and Methods" by Anthony Tarantino, Wiley, 2022.
2. "Machine Learning and AI for Industrial IoT" by Pethuru Raj and Preetha Evangeline, Springer, 2021.
3. "Digital Twin Technologies and Smart Cities" by Farsi, H. and Daneshkhah, A., Springer, 2020.
4. "Blockchain and Smart Contracts for Industry 4.0" by Ilias G. Maglogiannis, Springer, 2021.

List of Exercise

1. Introduction to Industry 4.0 lab setup: Architecture, components, and use cases
2. PLC programming for automated processes using ladder logic for sorting/conveyor control
3. Simulation of smart manufacturing using Digital Twin platforms (e.g., Siemens NX/MATLAB Simulink)
4. IoT sensor data acquisition and control through Raspberry Pi/Arduino
5. Real-time monitoring and control via SCADA and IoT dashboards (e.g., Node-RED, ThingsBoard)
6. AI-based object detection using OpenCV and YOLOv5 for robotic pick-and-place
7. Robotic arm control using inverse kinematics and AI for task optimization
8. Predictive analytics for machine failure using ML (Decision Trees, SVM, Neural Ne Smart AGV navigation system using line following and obstacle avoidance (infrared + AI) works)
9. Smart AGV navigation system using line following and obstacle avoidance (infrared + AI)
10. Integration of cloud platforms (AWS, Azure, or Firebase) for device control and data logging
11. Real-time energy monitoring and optimization using smart meters and AI models
12. Developing a Cyber-Physical System (CPS) prototype using sensors and cloud-edge communication
13. Voice/gesture-based automation control using AI tools (e.g., Google Assistant API, hand tracking)
14. Digital Quality Inspection system using image processing for defect detection in products
15. Capstone Mini Project: Design and demonstration of a smart automated cell for an Industry 4.0 use case

Course Type	**Embedded Theory & Lab (ETL)**

Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15 %
	Continuous Assessment Test -2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	Kushdeep Rana	
Recommended by the Board of Studies on		
Date of Approval by Academic Council		

Course Code: MTME605	**Course Title: Robotics and Artificial Intelligence**	**TPC**	**3**	**2**	**4**
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. Introduce students to the core principles of robotics and artificial intelligence (AI). 2. Understand the kinematics, dynamics, and control of robotic systems. 3. Explore algorithms for machine learning, computer vision, and autonomous systems. 4. Study the integration of sensors, actuators, and real-time systems in robotics. 5. Develop skills in programming robots and AI models for practical applications. 6. Analyze the ethical implications and challenges in robotics and AI deployment.				

Course Outcomes	Course Outcome Statement
CO1	Analyze the kinematics and dynamics of robotic systems.
CO2	Implement control algorithms for robotic motion and path planning.
CO3	Develop and train AI models for robotics and automation using modern tools.
CO4	Integrate sensors and actuators into robotic systems and implement real-time processing.
CO5	Evaluate the performance of robotic and AI systems using simulations and experiments, while ensuring ethical and responsible application in engineering solutions.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Introduction to Robotics and Artificial Intelligence:**	**7 Hours**

Definition, history, and scope of robotics and AI; Overview of robotic systems, manipulators, and mobile robots; Introduction to AI, machine learning, and deep learning concepts; Ethical and social implications of robotics and AI.

Module No. 2	**Kinematics, Dynamics, and Control of Robots**	**8 Hours**

Introduction to robotic kinematics (forward and inverse), trajectory planning, and dynamics; Overview of control techniques, including PID control and model-based control; Path planning and obstacle avoidance algorithms.

Module No. 3	**AI Algorithms for Robotics**	**10 Hours**

Supervised, unsupervised, and reinforcement learning methods; Applications of neural networks and deep learning in robotics; Decision-making algorithms and probabilistic models (e.g., Markov Decision Processes).

Module No. 4	Sensors, Actuators, and Embedded Systems in Robotics	10 Hours
Types of sensors (proximity, vision, tactile, etc.); Actuators and their selection (DC motors, stepper motors, servo motors); Introduction to embedded systems for robotics; Basics of ROS (Robot Operating System).		
Module No. 5	**Robotics and AI Applications:**	**10 Hours**
Industrial robotics, collaborative robots (cobots), and automation; Computer vision applications in robotics; Autonomous vehicles and drones; Emerging trends: human-robot interaction, soft robotics, and swarm robotics.		

Text Books

1. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, Pearson Education, 2022.
2. Russell, S., & Norvig, P., *Artificial Intelligence: A Modern Approach*, Pearson, 2023.
3. Siciliano, B., & Khatib, O., *Springer Handbook of Robotics*, Springer, 2022.

References

- Thrun, S., *Probabilistic Robotics*, MIT Press, 2021.
- Choset, H., *Principles of Robot Motion: Theory, Algorithms, and Implementation*, MIT Press, 2020.
- Goodfellow, I., Bengio, Y., & Courville, A., *Deep Learning*, MIT Press, 2021.
- Zhang, D., & Ge, S. S., *Adaptive Control of Robot Manipulators*, World Scientific, 2019.

Lab Exercise

1. Introduction to Robotics and AI Systems: Understand the basics of robotics, automation, and AI, and their integration for industrial applications
2. Programming of Robotic Arms: Learn to program and control robotic arms for basic tasks like pick-and-place operations
3. Path Planning Algorithms for Robotics: Implement basic path planning algorithms like A* and Dijkstra's for robot navigation
4. AI-based Object Recognition for Robotics: Develop AI models using computer vision to enable object detection and recognition for robotic arms
5. Sensor Integration and Control in Robotics: Integrate sensors (e.g., cameras, proximity sensors) with robotic systems to enable real-time feedback and decision-making
6. Simulation and Performance Evaluation of Robotic Systems: Simulate robotic systems and evaluate their performance using AI-based optimization and control methods
7. Implementation of Inverse Kinematics for a 2-DOF Robot Arm: Solve joint angles using Python/MATLAB for specific end-effector positions
8. Reinforcement Learning for Robotic Control: Train a robot using Q-learning to optimize movement in a constrained environment
9. ROS-Based Sensor Data Fusion: Combine data from multiple sensors (e.g., LiDAR,

ultrasonic) using ROS nodes for better situational awareness

10. Autonomous Navigation in Mobile Robots: Use SLAM (Simultaneous Localization and Mapping) in Gazebo/ROS to enable mobile robot path planning
11. Project 1: AI-Enabled Indoor Delivery Robot: Develop a robot capable of navigating an indoor environment using AI-based path planning and obstacle avoidance
12. Project 2: Vision-Based Fruit-Picking Robot: Implement a system for detecting, classifying, and picking fruits using robotic arms and deep learning models
13. Project 3: Human-Following Robot: Design a mobile robot that uses computer vision and AI to track and follow a specific individual
14. Project 4: Robotic Surveillance Drone: Create an autonomous drone using AI for object tracking and patrolling
15. Project 5: Gesture-Controlled Robotic Assistant: Develop a hand-gesture recognition system to control robot movements using AI and embedded vision systems

Course Type	**Embedded Theory and Lab (ETL)**	
Mode of Evaluation	**Theory**	**75%**
	Continuous Assessment Test-1	15%
	Continuous Assessment Test-2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
	Laboratory	**25%**
Prepared by	**Dr. Sukhdeep Singh**	
Recommended by the Board of Studies on		

Course Code: MTME606	Course Title: **Advanced Product Design and Development**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To understand the principles and practices of advanced product design and development. 2. To equip students with tools and techniques for innovative concept generation and product optimization. 3. To provide practical experience in prototyping, testing, and project management for real-world applications. 4. To enable effective integration of design, manufacturing, and sustainability considerations.				

Course Outcomes	Course Outcome Statement
CO1	Analyze customer requirements and translate them into product specifications.
CO2	Apply systematic design methodologies and advanced tools for concept development.
CO3	Develop and test prototypes using modern manufacturing technologies.
CO4	Manage product development projects, considering market needs, quality, and compliance.
CO5	Incorporate sustainability and cost-effectiveness in product design.
	TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	Introduction to Advanced Product Design and Development:	9 Hours

Overview of the product design and development process, Role of product design in the business environment, Design thinking and user-centric design principles, Market research: Identifying customer needs and competitive analysis, Product lifecycle management (PLM).

Module No. 2	Conceptual Design and Development:	9 Hours

Techniques for idea generation (brainstorming, TRIZ, functional decomposition), Concept selection using decision matrices and scoring techniques, Systems design and modularity, Tools: Quality Function Deployment (QFD) and Morphological Charts, Case studies: Successful product innovations.

Module No. 3	Prototyping, Testing, and Optimization:	9 Hours

Types of prototypes (physical, digital, and hybrid), Rapid prototyping technologies: 3D printing, CNC machining, Design validation and functional testing, Design for manufacturability (DFM) and assembly (DFA), Optimization strategies: Cost, weight, and performance trade-offs.

Module No. 4	Product Development Management:	9 Hours

Integrated product development; product data management (PDM); project planning and scheduling; team dynamics and collaboration; intellectual property rights (IPR); case studies on successful product design and development.

Module No. 5	Advanced Tools and Sustainability:	9 Hours

CAD/CAE tools for simulation-driven design (FEA, CFD), Integration of emerging technologies: IoT, AI and smart products, Sustainability in product design: Materials, processes and lifecycle assessment.

Text Books

1. Ulrich, Karl T., Eppinger, Steven D., and Yang, Maria C. – *Product Design and Development*, 7th Edition (2020), McGraw-Hill Education.
2. Selikoff, Steven – *The COMPLETE BOOK of Product Design, Development, Manufacturing, and Sales*, 1st Edition (2021), Independently Published.
3. Raja, V. Prabhu – *Advances in Simulation, Product Design and Development*, 1st Edition (2022), Springer.

References

1. Efkolidis, Nikolaos – *Advances in Product Design Engineering*, 1st Edition (2021), Springer.
2. Selikoff, Steven – *The Complete Book of Product Design, Development, Manufacturing, and Sales*, 1st Edition (2021), Independently Published.
3. Staurt Pugh, "Tool Design – Integrated Methods for Successful Product Engineering", Addison Wesley Publishing, New york, NY

Lab Exercise

1. Conduct surveys/interviews to identify unmet customer needs for a chosen product category.
2. Generate at least 5 different design concepts using brainstorming and TRIZ tools. Evaluate using a weighted decision matrix.
3. Study the ergonomics and aesthetics of existing products. Analyze user-product interaction and suggest design improvements.
4. Redesign a simple mechanical product (e.g., stapler, bottle cap) considering DFMA principles.
5. Create a physical prototype using 3D printing or a virtual model using CAD tools like SolidWorks/Fusion 360.
6. Perform Failure Mode and Effects Analysis (FMEA) for the proposed design to identify potential failure modes and corrective actions.
7. Analyze the environmental impact of an existing product (LCA approach) and

suggest design changes to improve sustainability. 8. Work in teams to design and develop a basic product (e.g., mechanical toy, smart stand, ergonomic handle) from need identification to prototyping. 9. Disassemble an existing mechanical product (e.g., hand blender, stapler, bicycle brake) to analyze its components, functionality, and manufacturing process. 10. Analyze a real-world product design patent related to mechanical systems. 11. Project 1 Redesign a commonly used hand tool to improve user comfort, reduce fatigue, and enhance performance. 12. Project 2 Design a lightweight, foldable bicycle targeting urban commuters with limited storage space. 13. Project 3 Design a user-friendly and affordable casing/product body for a small medical device suitable for rural or low-income regions. 14. Project 4 Develop an innovative, biodegradable, and reusable packaging solution to reduce plastic waste in e-commerce shipping. 15. Project 5 Design modular and multi-functional furniture (e.g., a convertible bed-table unit) for urban apartments.	
Course Type	**Embedded Theory and Laboratory (ETL)**
Mode of Evaluation	**Theory** **100** Continous Assessment Test-1 15% Continous Assessment Test-1 15% Digital Assignments/Quizzes (Min) 20% Final Assessment Test 50% **Laboratory** **25%**
Prepared by	**Dr. Sahil Sharma**
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

Course Code:MTM607	Course Title: **HVAC Design and Energy Management**	TPC	3	2	4
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. To provide an in-depth understanding of HVAC design principles and energy management techniques. 2. To enable students to analyze and design efficient HVAC systems for various applications. 3. To integrate concepts of energy conservation and management in HVAC system design. 4. To equip students with knowledge of standards and guidelines for sustainable HVAC systems.				

CO-PO Mapping

Course Outcomes	Course Outcome Statement
CO1	Understand fundamental concepts of HVAC systems and psychrometric processes.
CO2	Apply load estimation and equipment selection techniques for HVAC systems.
CO3	Analyze HVAC systems for energy efficiency using modern tools and standards.
CO4	Design optimized HVAC systems integrating energy conservation measures.
CO5	Perform energy audits and propose HVAC retrofitting for sustainable design

TOTAL HOURS OF INSTRUCTIONS: 45

Module No. 1	**Fundamentals of HVAC Systems**	**9 Hours**

This module introduces the fundamental principles of HVAC systems, covering their scope, applications, and importance in modern infrastructure. It delves into psychrometrics, focusing on air properties, processes, and chart usage. Additionally, it covers heating and cooling load calculations, including building heat gain and loss, U-value, and ventilation loads, laying the foundation for advanced design.

Module No. 2	**HVAC System Components and Design**	**9 Hours**

This module delves into the design and analysis of gating systems, focusing on mould filling characteristics, fluidity, turbulence, and the types of gating elements. It includes mould filling analysis considering head losses and explores the concepts of cooling and solidification, including nucleation, growth, progressive and directional solidification, and Chvorinov's Rule (CFR). The mathematical treatment of solidification processes is emphasized, addressing factors like solidification time and rate. Feeder design and analysis topics include feeder shapes, risering curves, NRL methods, feeding distance, riser placement, and the design of feed aids to ensure defect-free casting.

Module No. 3	**Energy Management in HVAC Systems**	**9 Hours**

Focusing on energy efficiency, this module covers energy conservation techniques for HVAC systems and the role of Building Energy Management Systems (BEMS). Students will explore standards and codes like ASHRAE, ISO, and ECBC guidelines while learning about renewable energy integration, including solar cooling and geothermal heat pumps, to design systems that balance performance with sustainability.		
Module No. 4	**Advances and Case Studies in HVAC**	**9 Hours**
The final module highlights advanced HVAC technologies, such as Variable Refrigerant Flow (VRF) systems, smart HVAC, and IoT integration. Computational Fluid Dynamics (CFD) applications in HVAC design are also explored. Real-world case studies provide insights into energy-efficient building designs and HVAC strategies, helping students connect theory to practice.		
Module No. 5	**Simulation and Audit of HVAC Systems**	**9 Hours**
Modeling and simulation of HVAC systems using software tools (HAP, TRACE, EnergyPlus, eQuest); Energy audit methodology and reporting; Case studies on HVAC energy audits; Life cycle cost analysis (LCC); Environmental impact and carbon footprint calculations.		

Text Books

1. Ronald H. Howell, Harry J. Sauer Jr., and William J. Coad, *Principles of Heating, Ventilation, and Air Conditioning*, ASHRAE, 2023.
2. R.S. Khurmi and J.K. Gupta, A Textbook of Refrigeration and Air Conditioning, S. Chand Publishing, 2020. 5th Edition.
3. Manohar Prasad, Refrigeration and Air Conditioning Data Book, New Age International Publishers, 2021.
4. R.K. Rajput, Thermal Engineering (Including RAC), Laxmi Publications, 2021. 10th Edition,

References

1. ASHRAE, *ASHRAE Handbook – Fundamentals*, ASHRAE, 2021.
2. Althouse, Turnquist, and Bracciano, *Modern Refrigeration and Air Conditioning*, Goodheart-Willcox, 2021.
3. Wayne C. Turner and Steve Doty, *Energy Management Handbook*, Fairmont Press, 2022.
4. Peter Gevorkian, *Sustainable Energy Systems in Architectural Design*, McGraw-Hill, 2020.

List of Exercise

1. **Introduction to HVAC Lab Equipment and Safety Guidelines**: Familiarization with laboratory tools, test rigs, and safety protocols.
2. **Study of Psychrometric Processes**: Use of psychrometric charts to analyze air properties and processes like heating, cooling, humidification, and dehumidification.
3. **Performance Evaluation of a Vapour Compression Refrigeration System**: Measurement of COP, power consumption, and refrigerant properties under different load conditions.
4. **Analysis of Vapour Absorption Refrigeration System**: Study of system operation and comparison with vapour compression systems in terms of efficiency and environmental impact.

5. **Air Conditioning Test Rig Experiment**: Calculation of cooling capacity, sensible heat factor (SHF), and system performance under various operating conditions.
6. **Cooling Tower Performance Analysis**: Determination of cooling tower effectiveness, range, and approach.
7. **Duct Design and Air Flow Measurement**: Measurement of air velocity and pressure in ducts using anemometers and manometers.
8. **Energy Audit of an HVAC System**: Conduct an energy audit to identify inefficiencies and suggest optimization techniques for energy conservation.
9. **Renewable Energy Integration in HVAC**:Study of solar-assisted HVAC systems or geothermal heat pumps for sustainable energy applications.
10. **Use of Computational Fluid Dynamics (CFD) in HVAC Design**: Introduction to CFD software tools for analyzing air flow and thermal distribution in HVAC systems.
11. **Smart HVAC System Analysis**: Study of IoT-enabled HVAC systems and their control strategies for energy management.
12. **Noise and Vibration Analysis in HVAC Systems**: Measurement of noise and vibration levels in HVAC equipment and strategies for mitigation.
13. **Advanced HVAC Technologies**: Performance study of Variable Refrigerant Flow (VRF) and heat recovery systems.
14. **Maintenance and Troubleshooting of HVAC Systems**: Identification and resolution of common faults in HVAC systems through hands-on practice.
15. **Mini Project**: Design, fabrication, or analysis of a small-scale HVAC system or energy management setup.

Course Type	**Embedded Theory and Lab (ETL)**	
Mode of Evaluation	**Theory** Continuous Assessment Test-1 Continuous Assessment Test -2 Digital Assignments/Quizzes (Min) Final Assessment Test	**75%** 15 % 15% 20% 50%
	Laboratory	**25%**
Prepared by	**Dr. Shivinder Singh**	
Recommended by the Board of Studies on		
Date of Approval by Academic Council		

Course Code: MTEME608	Course Title: **AI-Driven Material Development**	TPC	2	0	2
Version No.	**1.0**				
Course Pre-requisites/ Co-requisites	**None**				
Anti-requisites (if any).	**None**				
Objectives:	1. Introduce the fundamentals of artificial intelligence (AI) in material science. 2. Understand the role of machine learning (ML) and data-driven approaches in material discovery. 3. Explore computational techniques for predicting material properties and behavior. 4. Study the integration of AI and high-throughput experiments for material development. 5. Learn to apply AI models for real-time material design and optimization. 6. Analyze the impact of AI on accelerating innovation in material science and manufacturing.				

Course Outcomes	Course Outcome Statement
CO1	Explain the principles of AI and machine learning in the context of material science.
CO2	Use AI-driven techniques to predict material properties and performance.
CO3	Implement data-driven models for material discovery and development.
CO4	Integrate AI tools with experimental and computational methods for material optimization.
CO5	Evaluate AI algorithms and datasets for material applications and apply AI models to real-world challenges in advanced materials and manufacturing processes.
	TOTAL HOURS OF INSTRUCTIONS: 30

Module No. 1	Introduction to AI in Material Science:	6 Hours

Overview of AI and machine learning; Key applications of AI in material science; Basics of data science for material design; Challenges in data acquisition and preprocessing in material datasets; Case studies in AI applications for materials.

Module No. 2	Machine Learning Models for Material Discovery:	6 Hours

Supervised, unsupervised, and reinforcement learning methods; Regression and classification techniques for material property prediction; Neural networks and deep learning in material science; Introduction to generative models for material design; Hands-on exercises with AI tools.

Module No. 3	**High-Throughput and Computational Approaches:**	**6 Hours**
High-throughput experimentation and data generation; Computational material modeling (Density Functional Theory, Molecular Dynamics); Integrating AI with computational simulations for material property prediction; Accelerating discovery with automated workflows.		
Module No. 4	**Optimization and Design Using AI**	**6 Hours**
Multi-objective optimization in material design; Bayesian optimization and genetic algorithms for material development; Real-time material behavior prediction; AI tools for additive manufacturing and composite materials.		
Module No. 5	**Future Trends and Case Studies in AI-Driven Material Development**	**6 Hours**
AI in sustainable materials and energy storage (e.g., batteries, solar cells); AI for nanomaterials and biomaterials; Ethical considerations in AI-driven material design; Case studies on industry applications and success stories in AI-driven innovations.		

Text Books

1. Dr. D.S. Kumar, Elements of Mechanical Engineering, S.K. Kataria & Sons, 2023.
2. P.K Nag, Engineering Thermodynamics, TMH, New Delhi, 2022

References

1. Hazra & Chaudhary, Workshop Technology Vol I &II , Asian Book Comp., New Delhi, 2022
2. Workshop Technology Vol I, II & III- Chapman, WAJ, Edward Arnold, 2022
3. C.P Arora, Refrigeration & Air conditioning, TMH, New Delhi, 2021

Course Type	**Theory (TH)**	
Mode of Evaluation	**Theory**	**100%**
	Continuous Assessment Test-1	15%
	Continuous Assessment Test-2	15%
	Digital Assignments/Quizzes (Min)	20%
	Final Assessment Test	50%
Prepared by	**Dr. Sukhdeep Singh**	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		
Date of Approval by the Academic Council		