ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. MANUFACTURING ENGINEERING

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Apply advanced manufacturing technologies, computational tools, and intelligent systems for design, analysis, and optimization of manufacturing processes.
PSO2	Develop sustainable, innovative, and industry-oriented solutions in manufacturing with emphasis on quality, reliability, and emerging technologies.

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E. Manufacturing Engineering **Regulations:** 2025

Abbreviations:

BS –Basic Science (Mathematics)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**))

SD – Skill Development

TCP – Total Contact Period(s)

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods			TCP	Credits	Category
				L	T	P			
1.	MF25101	Computational Methods in Engineering	T	3	0	0	3	3	ES (PC)
2.	MF25102	Advanced Materials Technology	T	3	0	0	3	3	ES (PC)
3.	MF25103	Metrology and Computer Aided Inspection	LIT	3	0	2	5	4	ES (PC)
4.	MF25104	Computer Aided Design in Manufacturing	LIT	3	0	2	5	4	ES (PC)
5.	MF25105	Computer Numerical Control and Adaptive Control	LIT	2	0	2	4	3	ES (PC)
6.	MF25106	Advances in Welding and Casting Technology	T	3	0	0	3	3	ES (PC)
7.	MF25107	Advanced Manufacturing Laboratory	L	0	0	4	2	2	ES (PC)
8.	MF25108	Technical Seminar	-	0	0	2	2	1	SD
						Total	**27**	**23**	

Semester II

S. No.	Course Code	Course Title	Type	Periods			TCP	Credits	Category
				L	T	P			
1.	MF25201	Finite Element Applications in Manufacturing	LIT	3	0	2	5	4	ES (PC)
2.	MF25202	Thin Film Technology	T	3	0	0	3	3	ES (PC)
3.	MF25203	Quality and Reliability Engineering	LIT	3	0	2	5	4	ES (PC)
4.	MF25204	Machine Learning for Intelligent Systems	LIT	3	0	2	5	4	ES (PC)
5.		Programme Elective I	T	3	0	0	3	3	ES (PE)
6.		Programme Elective II	T	3	0	0	3	3	ES (PE)
7.	MF25205	Advanced Machining and Forming Laboratory	L	0	0	2	2	1	ES (PC)
8.	MF25206	Finite Element Analysis Laboratory	L	0	0	4	2	2	ES (PC)
9.		Industry Oriented Course I	---	1	0	0	1	1	SD
10.		Self Learning Course	---	-	-	-	-	1	-
						Total	**29**	**26**	

Semester III

S. No.	Course Code	Course Title	Type	Periods			TCP	Credits	Category
				L	T	P			
1.		Programme Elective III	T	3	0	0	3	3	ES (PE)
2.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
3.		Programme Elective V	T	3	0	0	3	3	ES (PE)
4.		Programme Elective VI	T	3	0	0	3	3	ES (PE)
5.		Industry Oriented Course II	---	1	0	0	1	1	SD
6.	MF25301	Project Work I	-	0	0	12	12	6	SD
						Total	**25**	**19**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods			TCP	Credits	Category
				L	T	P			
1.	MF25401	Project Work II	---	0	0	24	24	12	SD
						Total	**24**	**12**	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1.	MF25001	Laser Processing of Materials	3	0	0	3	3
2.	CD25C02	Solid Freeform Manufacturing	3	0	0	3	3
3.	MF25002	Manufacturing Systems and Models	3	0	0	3	3
4.	MF25003	Micro and Nano Manufacturing	3	0	0	3	3
5.	MF25004	Bio-inspired Manufacturing	3	0	0	3	3
6.	MF25005	Operations Management	3	0	0	3	3
7.	MF25006	Lean Six Sigma	3	0	0	3	3
8.	MF25007	Green Manufacturing	3	0	0	3	3
9.	MF25008	Supply Chain Systems and Management	3	0	0	3	3
10.	MF25009	Smart Materials	3	0	0	3	3
11.	MF25010	Material Testing and Characterization	3	0	0	3	3
12.	MF25011	Manufacturing Metrology	3	0	0	3	3
13.	MF25012	Powder Metallurgy Processing	3	0	0	3	3
14.	MF25013	Mechatronics in Manufacturing	3	0	0	3	3
15.	MF25014	Industrial Robotics	3	0	0	3	3
16.	CC25C01	Digital Twin and Industry 5.0	3	0	0	3	3
17.	MF25015	System Simulation for Manufacturing Engineers	3	0	0	3	3
18.	MF25016	Fluid power automation	3	0	0	3	3
19.	MF25017	Bio Materials	3	0	0	3	3

Semester I

MF25101	**Computational Methods in Engineering**	L	T	P	C
		3	0	0	3

Course objectives:

The main objective of this course is to equip students with fundamental knowledge of integer programming, problem-solving skills using dynamic and non-linear programming, and familiarity with factorial design and Taguchi's design of experiments. It also aims to develop an understanding of decision-making tools applied in manufacturing.

Integer Programming: Branch and bound technique, Cutting plane algorithm method, Travelling Salesman Problem, 0/1 Knapsack Problem, Chinese Postman Problem, Vehicle Routing Problem.

Activities: Solve a 0/1 knapsack problem using branch and bound, Implement a heuristic for the Travelling Salesman Problem (TSP).

Dynamic Programming: Characteristics of Dynamic Programming Problems, Deterministic Dynamic Programming, Forward and Backward recursive recursion, selected dynamic programming application, investment model, inventory model, replacement model, reliability model, stagecoach problem.

Activities: Solve an inventory model using forward recursion, Find shortest route using backward recursion in the stagecoach problem.

Nonlinear Programming: Types of Nonlinear Programming Problems, One-Variable Unconstrained Optimization, Multivariable Unconstrained Optimization, The Karush-Kuhn-Tucker (KKT), Quadratic Programming, Separable Programming

Activities: Use gradient descent to minimize a single-variable nonlinear function, Apply KKT conditions to a constrained optimization problem.

Design of Experiments: Fundamentals, fractional, factorial experiments, 2^k factorial design – 3 level and mixed level factorials, Response Surface Methods and Designs, Robust Parameters Design and Process Robustness Studies

Activities: Conduct a 2^3 factorial design and analyze effects, Use Taguchi's L9 array to identify robust parameters.

Decision Making: Fundamentals of Decision Making, Decision Tables, Types of decision making environments, Under certainty, under uncertainty, under risk, Expected Value of Perfect Information, Decision Trees, Poker Decision Process

Activities: Build a decision tree and calculate expected values, Create a decision table for scheduling under uncertainty.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%):

References:

1. Hillier, F. S., & Lieberman, G. J. (2021). *Introduction to operations research*. McGraw Hill Inc.
2. Deb, K. (2012). *Optimization for engineering design*. PHI Learning Private Ltd.
3. Ravindran, A., Phillips, D. T., & Solberg, J. J. (2007). *Operations research: Principles and practice*. John Wiley India.
4. Rao, S. S. (2020). *Engineering optimization: Theory and practices*. John Wiley & Sons.
5. Krishnaiah, K., & Shahabudeen, P. (2012). *Applied design of experiments and Taguchi methods*. PHI Learning.
6. Heizer, J., & Render, B. (2019). *Operations management*. Pearson.

	Description of CO	**Mapped POs**	**PSO1**	**PSO2**
CO1	Apply optimization techniques (integer and dynamic programming) to solve manufacturing and engineering problems.	PO1 (3), PO3 (2)	3	–
CO2	Analyze nonlinear programming problems and design of experiments (Taguchi/factorial) for process improvement.	PO1 (3), PO2 (2)	3	2
CO3	Apply decision-making tools under certainty, risk, and uncertainty to develop sustainable manufacturing solutions.	PO1 (3), PO2 (3)	–	3

MF25102	Advanced Materials Technology	L	T	P	C
		3	0	0	3

Course objectives:

This course aims to provide a strong foundation in metallic and non-metallic materials, covering atomic structure, crystal defects, strengthening, phase diagrams, and heat treatment, while analyzing their properties, processing, and applications. It also emphasizes material characterization techniques such as mechanical testing, microscopy, X-ray diffraction, and thermal analysis for effective material selection, quality control, and performance evaluation.

Metallic Materials: Fundamental of metallic materials; Atomic structure and Crystal structure, Imperfection of Solids-Slip systems-Strengthening mechanisms-Phase diagrams Heat treatment processes, iron-carbon-equilibrium diagrams, Advanced Steels and cast irons Transformation hardening in steels-TTT diagrams-CCT diagrams.

Modern Metallic Materials 8 Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel, Intermetallics, Ni and Ti aluminides, smart materials, shape memory alloys, Metallic glass and nano crystalline materials

Activities: Analyze iron-carbon phase diagrams and interpret TTT/CCT diagrams for steels, Compare strengthening mechanisms in dual-phase and TRIP steels, Study properties and applications of shape memory alloys and metallic glasses, Research the microstructure and uses of maraging and nitrogen steels.

Non Ferrous materials:

Structure, physical metallurgy, manufacturability and properties of Al, Cu, Mg and Ti alloys.

Activities: Investigate the physical metallurgy of Al and Ti alloys with case studies, Compare manufacturing processes of Mg and Cu alloys.

Non Metallic Materials:

Composites with polymer matrix- metal matrix and ceramic matrix, Fabrication methods of in-situ, ex-situ and Nano composites-Mechanics of composites Machining and joining of composites, Polymers, types of polymer, commodity and engineering polymers, Properties and applications, Engineering Ceramics, Properties and applications

Activities: Design a composite using polymer, metal, or ceramic matrices and discuss fabrication methods, Examine properties and applications of engineering ceramics and polymers.

Characterization:

Principle, Application and Applied theory of: Hardness testing, Tensile testing-Fatigue testing, Optical Microscopy, Electron microscopy techniques and XRD analysis, Thermal Analysis:
Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA), Principles and measurement analysis.

Activities: Perform a hardness or tensile test on a metallic sample and analyze results, Use XRD or thermal analysis data (DSC/TGA) to identify phase changes or material properties.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Callister, W. D., Jr., & Rethwisch, D. G. (2024). Materials science and engineering: An introduction. Wiley.
2. Advani, S. G., & Hsiao, K.-T. (2022). Manufacturing techniques for polymer matrix composites (PMCs). CRC Press.
3. Dieter, G. E., & Schmidt, L. C. (2023). Engineering materials: Properties and selection. Pearson.
4. Raghavan, V. (2022). Materials science and engineering: A first course. PHI Learning.
5. Zhang, S., Li, L., & Kumar, A. (2022). Materials characterization techniques. CRC Press.
6. Shackelford, J. F. (2023). Introduction to materials science for engineers. Pearson.

	Course Outcomes (COs)	**Mapped POs**	**PSO1**	**PSO2**
CO1	Explain the fundamentals of metallic, non-metallic, and modern advanced materials including their structures, mechanisms, and treatments.	PO1 (3), PO3 (2)	3	–
CO2	Analyze the properties, processing, and applications of alloys, composites, polymers, ceramics, and smart materials.	PO1 (3), PO2 (2)	3	2
CO3	Apply material characterization techniques (mechanical, microscopy, XRD, thermal analysis) for selection, quality control, and performance evaluation.	PO1 (3), PO2 (3)	–	3

MF25103	Metrology and Computer Aided Inspection	L	T	P	C
		3	0	2	4

Course objectives:

This course aims to impart knowledge of metrology concepts, train students in surface roughness, form measurement and interferometry, and introduce fundamental principles of CAI, laser metrology, and machine vision-based image processing.

Metrology concepts, Abbe’s principle-need for high precision measurements, problems associated with high precision measurements.

Standards for length measurement, Shop floor standards and their classification, Light interference, Method of coincidence, Slip gauge calibration-measurement errors.

Various tolerances and their specifications, gauging principles, selective assembly, comparators.

Practical:

1. Calibration of comparators using slip gauges and assessment of gauge surfaces using optical flats

Flatness, Straightness, Roundness and Angular measurements, principles and Instruments, Gear and Thread measurements.

Practical:

1. Roundness and cylindricity measurement of components
2. Study on flatness measurement of surface using autocollimator

Surface and form metrology, Flatness, roughness, waviness, roundness, cylindricity, etc. Computer Aided Metrology, principles and interfacing, software metrology.

Practical:

1. Measurement of Surface roughness of specimens using contact method
2. Non-contact surface roughness measurement of specimens

Laser metrology, Applications of lasers in precision measurements, Laser interferometer, speckle measurements, laser scanners.

Coordinate Measuring Machine, Non contact CMM Electro optical sensors for dimensional metrology, Non contact sensors for surface finish measurements

Image processing and its application in metrology.

Practical:

1. Measurement of dimensional features of a specimen - Contact type using CMM.
2. Measurement of dimensional features using machine vision system

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%):

References:

1. ASTE Handbook of Industries Metrology. (1992). Prentice Hall of India Ltd., India.
2. Bewoor, A. K., & Kulkarni, V. A. (2009). *Metrology and Measurement*. Tata McGraw-Hill, India.
3. Galyer, J. F. W., & Shotbolt, C. R. (1990). *Metrology for Engineers*. Cassell.
4. Jain, R. K. (2022). *Engineering Metrology*. Khanna Publishers, India.
5. Smith, G. T. (2016). *Machine Tool Metrology: An Industrial Handbook*. Springer, Switzerland

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of metrology, precision measurement, standards, tolerances, and gauging methods.	PO1 (3), PO3 (2)	3	–
CO2	Apply surface roughness, form, and geometrical measurement techniques using conventional and modern instruments.	PO1 (3), PO2 (2), PO4 (2)	3	2
CO3	Utilize laser metrology, CMM, and non-contact methods for dimensional and surface measurements.	PO1 (3), PO2 (3), PO4 (2)	–	3
CO4	Implement computer-aided inspection, image processing, and machine vision systems for advanced quality control applications.	PO2 (3), PO3 (2), PO5 (2)	3	3

MF25104	Computer Aided Design in Manufacturing	L	T	P	C
		3	0	2	4

Course objectives:

This course aims to provide fundamental knowledge of computer graphics and geometric modeling, develop clear understanding of CAD systems for 3D modeling and viewing, and build strong skills in assembly modeling to enable effective use of CAD standards.

Fundamentals of Computer Graphics & 2D/3D Transformations, Graphic display fundamentals; Line and circle drawing algorithms; Filled area primitives and their attributes; Two-dimensional geometric transformations; Viewing and clipping; Coordinate transformations; Three-dimensional transformations

Activities: Implement line and circle drawing algorithms using CAD software or programming tools, Perform and visualize 2D and 3D geometric transformations on simple shapes.

Curves, Surfaces, and NURBS Modeling, Curves: Hermite cubic spline, Bezier curve, B-spline curve, curve manipulations; Analytical surfaces: Plane, ruled, surface of revolution, tabulated cylinder; Synthetic surfaces: Hermite bicubic, Bezier surface, B-spline surface, surface manipulations; NURBS basics: curves, lines, arcs, circles, bilinear surfaces.

Activities: Create and manipulate Bezier and B-spline curves for a given profile, Model analytical and synthetic surfaces like planes, ruled surfaces, and Bezier surfaces.

Solid Modeling and Visual Realism, Solid modeling: Regularized Boolean set operations, primitive instancing, sweep representations, boundary representations, constructive solid geometry (CSG), comparison of representations, user interfaces for solid modeling; Visual realism: Hidden line removal, hidden surface removal, hidden solid removal algorithms; Shading and coloring techniques; Animation: Conventional, computer animation, engineering animation – types and techniques.

Activities: Build solid models using Boolean operations and primitive instancing, Apply hidden line and surface removal algorithms to a complex 3D model.

Assembly Modeling and Product Life Cycle Management, Mass properties and assembly modeling; Product data exchange; Geometric tolerances and tolerance practices in drafting and manufacturing; Tolerance modeling, analysis, and synthesis; Product life cycle management principles and tools.

Activities: Assemble multiple parts using constraints and check for interferences, Draft detailed assembly drawings with GD&T (Geometric Dimensioning & Tolerancing) standards.

LIST OF EXPERIMENTS:

1. Sketching and Part modelling (Solid modelling, Surface modelling, Feature manipulation) of mechanical components using CAD software package.

2. Assembly (Constraints, Exploded Views, Interference check) and Drafting (Layouts, Geometric Dimensions &Tolerance Standards, Sectional Views, & Detailing) of mechanical components using CAD software package.
3. Working with CAD Data Exchange formats: IGES, PDES, PARASOLID, DXF and STL.
4. Study and exercise on freeform modelling.
5. Reverse engineering the given product/component and convert the data into 3D model.
6. Exercise on. STL file Preparation, Slicing, Support Structure Generation & Build setup Preparation

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Zeid, I. (2004). Mastering CAD/CAM. McGraw-Hill.
2. Rogers, D., & Adams, J. A. (1976). Mathematical elements for computer graphics. Tata McGraw-Hill.
3. Boothroyd, G. (2005). Assembly automation and product design. CRC Press (Taylor & Francis).
4. Chitale, A. K., & Gupta, R. C. (2023). Product design and manufacturing. PHI Learning Private Limited.
5. Hearn, D. D., & Baker, M. P. (1996). Computer graphics C version. Prentice Hall, Inc.
6. Newman, W. M., & Sproull, R. F. (1979). Principles of interactive computer graphics. McGraw-Hill Book Co.

	Course Outcomes (COs)	**Mapped POs**	**PSO1**	**PSO2**
CO1	Apply fundamentals of computer graphics, 2D/3D transformations, and visualization for engineering design.	PO1 (3), PO2 (2)	3	–
CO2	Develop geometric models of curves, surfaces, solids, and apply shading and rendering techniques.	PO1 (3), PO2 (3), PO3 (2)	3	–
CO3	Perform assembly modeling, tolerance analysis, and product data exchange using CAD tools.	PO2 (3), PO3 (3), PO4 (2)	–	3
CO4	Integrate CAD with PLM, reverse engineering, and 3D printing workflows for manufacturing applications.	PO3 (2), PO4 (3), PO5 (2)	3	3

MF25105	Computer Numerical Control and Adaptive Control	L	T	P	C
		2	0	2	3

Course objectives:

This course provides a comprehensive understanding of CAM, CAE, and CIM systems in product realization and process planning, develops knowledge of CNC machines and their control systems, imparts skills in CNC programming with CAM software, and introduces IoT-enabled control systems for smart manufacturing and intelligent production management.

Introduction to CAM, CAE, CIM; System configuration for CAM including hardware and software; Geometric tolerancing, ASME, ISO, DIN standards; Interpreting geometric specifications; Multiple part features and datum; Integration of CAD and CAM in CNC turning and machining centers.

Activities: Interpret and apply geometric tolerancing (ASME/ISO standards) to sample parts, Demonstrate CAD-CAM integration by exporting a CAD model and generating a basic CAM toolpath.

Process planning; Computer Aided Process Planning (CAPP); Product Life Cycle Management (PLM), Enterprise Resource Planning (ERP).

Activities: Create a simple Computer Aided Process Plan (CAPP) for a given component, Discuss the role of PLM and ERP systems in managing manufacturing workflows.

CNC machine building and structural details; Guide ways, friction, anti-friction, and other types; Rotary-to-linear motion conversion, screw and nut, recirculating ball screw; Spindle assembly; Torque transmission elements, gears, timing belts, flexible couplings; Bearings; Spindle drives and feed drives, Linear motors;

Activities: Identify and explain the function of key CNC machine parts (e.g., ball screws, spindles), Compare open-loop vs closed-loop control systems using real CNC examples.

Open-loop and closed-loop control; Axis measuring systems – grating, linear scale, encoder, laser interferometer; Axes & spindle cooling system; Probing for zero offsets and first-off inspection; Tool breakage detecting system; In-process gauging system; Automatic Tool Changer (ATC) and Automatic Pallet Changer (APC).

Activities: Write and simulate basic G-code for turning and milling operations (e.g., facing, drilling), Use CAM software to generate CNC code for a 3-axis machining operation.

Structure of CNC program; Coordinate system; G and M codes; Cutter radius compensation; Tool nose radius compensation; Tool wear compensation; Canned cycles; Mirroring features; Manual part programming for CNC turning and machining centers; Macro programming; CNC programming using CAM software.

Activities: Write and simulate a G-code program for a turning operation that includes:

- Facing, turning, and thread cutting, Use of canned cycles (e.g., G71, G76), Tool nose radius and wear compensation

Use a CAM software package to, Generate CNC code for a 2.5D milling profile, Include mirroring, pocketing, and drilling operations, Post-process and simulate the toolpath

Practical:

1. Programming and simulation for turning, taper turning, circular interpolation, thread cutting, facing and parting operations using canned cycles for CNC Lathe.
2. Programming and simulation for 2D profile milling, drilling, tapping, circular & rectangular pocket milling and mirroring operations.
3. CNC code generation using CAM software package – CNC Lathe, 3 and 5 Axis Machining centre.
4. Programming for CNC Wire cut EDM.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Radhakrishnan, P. (2014). Computer numerical control machines and computer aided manufacture. New Academic Science.
2. Nee, Y. C., Ong, K., & Wang, Y. G. (2012). Computer applications in near net-shape operations. Springer.
3. Zhang, Y., & Tao, F. (2017). Optimization of manufacturing systems using the Internet of Things. Academic Press.
4. Chang, T. C., Wysk, R. A., & Wang, H. P. (2006). Computer aided manufacturing. Pearson Prentice Hall.
5. HMT. (2005). Mechatronics. Tata McGraw-Hill Publishing Company Limited.
6. Rao, P. N. (2021). CAD/CAM. Tata McGraw-Hill Publishing Company Limited.

	Course Outcomes (COs)	**Mapped POs**	**PSO1**	**PSO2**
CO1	Explain CAM, CAE, CIM concepts, standards, and their role in product realization and process planning.	PO1 (3), PO2 (2)	3	–
CO2	Analyze CNC machine construction, drives, measuring systems, and adaptive control elements.	PO1 (3), PO2 (3), PO3 (2)	3	2
CO3	Develop CNC part programs using G/M codes, tool compensations, canned cycles, macros, and CAM software.	PO2 (3), PO3 (3), PO4 (2)	–	3
CO4	Apply IoT-enabled control, smart manufacturing, and PLM/ERP integration for intelligent production.	PO3 (2), PO4 (3), PO5 (2)	2	3

MF25106	Advances in Welding and Casting Technology	L	T	P	C
		3	0	0	3

Course objectives:

This course provides knowledge on welding metallurgy, design, and special welding processes, explains gating system design and casting metallurgy with special casting processes, and introduces automation, environmental aspects, and standards.

Welding Design: Heat Flow in Welding: Welding Thermal Cycle (WTC), Effect of WTC and Cooling Rate in Welding, Cooling Rate- Peak Temperature and Solidification Rate, Residual Stress, Residual Stress, Design of Weld Joints: Introduction to Design of Weld Joints, Types of Joints and Welds, Edge Preparation, Design for Static and Fatigue Loading, Fatigue Fracture of Weld Joints, Fatigue Fracture of Weld Joints, Understanding Weldability-Reactions in Weldment, Failure Analysis and Prevention Testing of Welding joints, Case Studies.

Activities: Analyze a weld joint for residual stress and fatigue failure using a given thermal cycle, Design a welded structure under static and fatigue loading and propose suitable joint types.

Special Welding Processes: Micro joining And Nano joining, Wire Bonding; Fundamentals and Types of Laser Welding Including Hybrid Processes, Laser Properties; Stud Welding And Mechanical Fasteners; Magnetically Impelled Arc Welding; Advanced Gas Tungsten Arc Welding; Flux Cored Arc Welding; Electron Beam Welding; Cold Pressure Welding; Ultrasonic Welding; Explosive Welding; Diffusion Bonding; Friction Stir Welding; Electromagnetic Pulse Welding; High Velocity Projectile Impact Welding-Under water welding-Diffusion bonding.

Activities: Compare various advanced welding techniques (e.g., laser, friction stir, ultrasonic) based on application, material, and heat input, Case study analysis: Identify the best welding method for a lightweight aerospace component.

Casting Design and Solidification: Introduction, Pattern allowances, Introduction of gating design, Types of gate-Pouring time calculation, Aspiration effects in gating system, Problem solving on gating design, Solidification analysis-Risering methods-Shape factor, Feeding & Chills effect-Problem related to riser design, Design of thin and unequal sections, mechanism of solidification, Rapid solidification processing (RSP), Melt spinning, Roll quenching, Vibratory solidification, Splat cooling, Thixoforming, Rheocasting, Single crystal growing, Casting defects, inspection, diagnosis and rectification, Case studies.

Activities: Solve problems on gating and riser design, including pouring time and solidification analysis, Analyze a casting defect scenario, identify root causes, and suggest rectification measures.

Special Casting Processes: Evaporative Pattern Casting Process and full mould process, Vaccum sealed moulding, vacuum casting, Magnetic Moulding, Squeeze Casting-types, Mega Casting-Plaster mould casting, Ceramic mould casting.

Activities: Compare traditional and special casting methods (e.g., vacuum casting, squeeze casting) with respect to quality and cost, Research-based presentation: Benefits and challenges of mega casting in automotive industries.

Automation Environmental Aspects, Specification and Standards: Fundamentals of Foundry automation-: Sand Plant, Material Handling, Mould and Core Making- Pollution control, energy and waste management in foundries. Fundamentals of welding automation, Principles of robotic welding, Welding robots, Positioners and Manipulators, Welding sensors and data acquisition Arc sensing, Weld Seam Tracking-Vision system, Microprocessor based control, Effects of welding fumes on environment. Codes, Specifications and Standards: American Society of Mechanical Engineers (ASME), American Petroleum Institute, American Society for Testing Materials (ASTM).

Activities: Simulate or analyze automation flow in a foundry: material handling, mould/core making, and pollution control, Review and interpret welding codes and standards (ASME, ASTM, AWS) for a specific application.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%):

References:

1. American Welding Society. (2019). Welding handbook .
2. Radaj, D. (1990). Design and analysis of fatigue resistant welded structures. Woodhead Publishing.
3. Campbell, J. (2015). Complete casting handbook: Metal casting processes, metallurgy, techniques and design. Butterworth-Heinemann.
4. Sahoo, M., & Sahu, S. (2017). Principles of metal casting. McGraw-Hill Education.
5. Tuttle, R. B. (2012). Foundry engineering: The metallurgy and design of castings. CreateSpace Independent Publishing Platform.
6. Singh, R. (2012). Applied welding engineering: Processes, codes and standards. Elsevier.

	Course Outcomes (COs)	**Mapped POs**	**PSO1**	**PSO2**
CO1	Apply welding metallurgy concepts to analyze weld thermal cycles, stresses, joint design, and failures.	PO1 (3), PO2 (2), PO3 (2)	3	–
CO2	Evaluate advanced welding processes, their principles, applications, and suitability for modern industries.	PO1 (3), PO3 (3)	3	2
CO3	Design and analyze gating, risering, and solidification behavior in casting systems including special processes.	PO1 (3), PO2 (3), PO3 (2)	3	2
CO4	Assess automation, environmental aspects, codes, and standards in welding and foundry practices.	PO3 (2), PO4 (3), PO6 (2)	2	3

MF25107	Advanced Manufacturing Laboratory	L	T	P	C
		0	0	4	2

Course objectives:

The course aims to familiarize students with manual part programming and CAM-based program generation, provide knowledge of robot programming, traditional and non-traditional micromachining processes, and composite material fabrication, while also introducing them to additive manufacturing technologies.

LIST OF EXPERIMENTS:

1. CNC Machining Experiment: Perform a machining operation using a CNC (Computer Numerical Control) machine, such as milling or turning.
2. Surface Roughness Measurement: Measure the surface roughness of machined components using instruments like a profilometer or surface roughness tester.
3. Tool Wear Analysis: Analyze the wear characteristics of cutting tools used in machining operations.
4. Metal Forming Experiment: Perform a metal forming operation, such as bending, deep drawing, incremental forming and superplastic forming.
5. EDM (Electrical Discharge Machining) and WEDM (Wire Electrical Discharge Machining: Perform EDM experiments to understand the principles of material removal through electrical discharges.
6. Additive Manufacturing: Explore additive manufacturing processes using 3D printing machines.
7. Laser Processing Experiments – Laser cutting, laser drilling, laser engraving, laser surface hardening, laser cladding, laser welding, laser marking.
8. Cutting of different materials during abrasive water jet machining
9. Manufacturing of Polymer based composites using Resin Transfer Moulding Machine (RTM) Fabrication of metal matrix composite using stir casting setup
10. Topology optimisation and fabrication of components using additive manufacturing process
11. Experiments on incremental forming

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Develop and execute CNC part programs, CAM-based machining, and evaluate tool wear and surface roughness.	PO1 (3), PO2 (3), PO3 (2)	3	–
CO2	Apply non-traditional and hybrid processes (EDM, WEDM, AWJM, laser processing, incremental forming) for advanced manufacturing.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO3	Fabricate polymer/metal matrix composites and additive manufactured parts, integrating design optimization and automation concepts.	PO3 (3), PO4 (2), PO5 (2)	2	3
CO4	Develop and execute CNC part programs, CAM-based machining, and evaluate tool wear and surface roughness.	PO1 (3), PO2 (3), PO3 (2)	3	–

Semester II

MF25201 Finite Element Applications in Manufacturing

L	T	P	C
3	0	2	4

Course objectives:

The main learning objective of this course is to prepare the students to

1. Understand and apply mathematical models for one-dimensional problems and employ numerical methods to solve them effectively.
2. Analyze and solve two-dimensional scalar and vector variable problems to determine field variables, using appropriate mathematical techniques.
3. Apply iso-parametric transformation and numerical integration methods to accurately evaluate element matrices in finite element analysis
4. Utilize various solution techniques to effectively solve eigenvalue problems encountered in finite element analysis.
5. Demonstrate knowledge of key factors, pre-processing and post-processing steps, and the utilization of computer tools in the implementation of finite element analysis.

Introduction

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational Formulation of B.V.P. – Ritz Method – Finite Element Modelling – Element Equations – Linear and Higher order Shape functions – Bar, Beam Elements – Applications to Heat Transfer problems.

Finite element analysis of two-dimensional problems

Basic Boundary Value Problems in two-dimensions – Linear and higher order Triangular, quadrilateral elements – Poisson's and Laplace's Equation – Weak Formulation – Element Matrices and Vectors – Application to scalar variable problems - Introduction to Theory of Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work– Element matrices using energy approach.

ISO-Parametric Formulation

Natural Coordinate Systems – Lagrangian Interpolation Polynomials – Iso-parametric Elements –Formulation – Shape functions -one dimensional, two dimensional triangular and quadrilateral elements -Serendipity elements- Jacobian transformation - Numerical Integration – Gauss quadrature – one-, two- and three-point integration.

Eigenvalue problems

Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration –Solution of Eigenvalue problems - Introduction to transient field problems.

Computer Implementation and FE Analysis

Pre Processing, mesh generation, elements connecting, boundary conditions, input of material and processing characteristics – Solution and post processing – Overview of application packages – Development of code for one dimensional analysis and validation - FE analysis of metal casting – special considerations, latent heat incorporation, gap element –Time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure – Basic concepts of plasticity and fracture – Solid and flow formulation – small incremental deformation formulation – Fracture criteria – FE analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency – FE analysis of welding.

References:

1. Amar Khennane, “Introduction to Finite Element Analysis using MATLAB and Abaqus”, CRC Press, 1stEdition, 2013.
2. Kobayashi S, Soo-ik-Oh and Altan T, “Metal Forming and the Finite Element Methods”, Oxford University Press, 4th Edition,1989.
3. Lewis R.W. Morgan K, Thomas H.R and Seetharaman K.N, “The Finite Element Method in Heat Transfer Analysis”, John Wiley, 1stEdition, 1996.
4. Rao S.S, “Finite Element method in engineering”, Butterworth-Heinemann, 6th Edition, 2018.
5. Reddy J.N, “An Introduction to the Finite Element Method”, McGraw Hill, Fourth Edition ,2020.
6. Seshu P, “Textbook of Finite Element Analysis”, PHI Learning Pvt. Ltd, 2014.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain FEM concepts, formulations, elements, and numerical techniques	PO1 (2), PO2 (2), PO3 (2)	2	1
CO2	Apply FEM modeling, shape functions, iso-parametric methods, and computational tools	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate field variables, element matrices, frequencies, and transient responses	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze scalar/vector field problems, structural/thermal systems, and advanced manufacturing	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25202	Thin Film Technology	L	T	P	C
		3	0	0	3

Course objectives:

The main learning objective of this course is to prepare the students to

1. Acquiring a comprehensive knowledge on the basics of thin films technology
2. Introduce various types of physical vapour deposition techniques for thin film
3. Introduce various types of chemical vapour deposition techniques for thin film
4. Means to control and monitor thin film and properties of thin film.
5. Applications of thin films in various fields.

Introduction to Thin Films and Vacuum Technology

Definition of thin films - Formation of thin films (sticking coefficient, formation of thermodynamically stable cluster - nucleation) - Environment (Gas phase and plasma) for thin film deposition; Deposition parameters and their effects on film growth, Substrates – overview of various substrates utilized - Concept of different vacuum pumps: rotary, diffusion, Turbo molecular pump, Cryogenic-pump, Ti-sublimation pump, Concept of different gauges: Pirani, penning, Pressure Control – Mass flow controllers.

Physical Vapour Deposition (PVD) Techniques

Evaporation- Thermal evaporation, Electron beam evaporation; Laser ablation; Ion beam evaporation and Cathodic arc deposition, Molecular Beam Epitaxy. Glow discharge Sputtering- DC and RF Sputtering; Magnetron sputtering; Ion beam sputtering – Reactive sputtering. Nucleation and growth of thin films (qualitative study only): Four stages of film growth.

Chemical Vapour Deposition (CVD) Techniques

Advantages and disadvantages of Chemical vapour deposition (CVD) techniques over PVD techniques, Different kinds of CVD techniques: Metallo Organic (MO) CVD, thermally activated CVD, Plasma enhanced CVD, Atomic layer deposition (ALD)-Importance of ALD technique. Epitaxy – Introduction: Epitaxial growth- Growth kinetics of epitaxy, Growth modes – illustration of crystallographic relations with thin film to substrate, characterization of epilayers (in situ and ex situ)

Deposition Monitoring, Control and Properties of Thin Film

Microbalance, Crystal oscillator thickness monitor, optical monitor, Resistance Monitor. Thickness measurement: Multiple Beam Interferometer, Fizeau (Tolansky) technique - Fringes of equal chromatic order (FECO) method - Ellipsometry (qualitative only). Sheet resistance - size effect - Electrical conduction in thin metallic films. Effect of Ageing and Annealing - Oxidation - agglomeration. Dielectric properties: DC conduction mechanism - Low field and high field conduction. Breakdown mechanism in dielectric films - AC conduction mechanism. Temperature dependence of conductivity. Optical properties: Optical constants and their determination - Spectrophotometer method.

Anti-reflection coatings. Interference filters. Thin film Solar Cells CuInSe2 solar cell

Application of Thin Films

Thin film resistors: Materials and Design of thin film resistors (Choice of resistor and shape and area) - Trimming of thin film resistors - sheet resistance control - Individual resistor trimming. Thin film capacitors: Materials - Capacitor structures - Capacitor yield and capacitor stability. Thin film field effect transistors: Fabrication and characteristics - thin film diodes.

References:

1. Goswami A, "Thin Film Fundamentals", New Age International (P) Ltd., 2006.
2. K. L. Chopra, "Thin Film Phenomena", McGraw-Hill, 1985.
3. AichaElshabini - Riadaud Fred D Barlow III, "Thin Film Technology Hand book", McGraw Hill Company, 1998.
4. Anders H, "Thin Films in Optics", Focal press, 1973.
5. Guthrie A, "Vacuum Technology", Krieger, Malabar, 1990.
6. MaisselL.I and Glang R, "Handbook of Thin Film Technology", McGraw Hill, 1970.
7. Rao V. V, Ghosh, T. B, Chopra, K. L, "Vacuum Science and Technology", Allied Publications, 1998.
8. Schwartz B and Schwartz N, "Measurement Techniques for Thin Films", John Wiley & Sons, 1968.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of thin films, vacuum technology, deposition environment, and substrate selection.	PO1 (2), PO3 (2)	2	1
CO2	Apply physical and chemical vapour deposition techniques (PVD, CVD, ALD) and understand nucleation, growth mechanisms, and epitaxy.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate, monitor, and control thin film thickness, electrical, optical, and dielectric properties using modern techniques.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze applications of thin films in devices such as resistors, capacitors, FETs, diodes, and solar cells.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25203	Quality and Reliability Engineering	L	T	P	C
		3	0	2	4

Course objectives:

The main learning objective of this course is to prepare the students

1. To study the approaches and techniques to assess quality by statistical process control.
2. To study the methodology to assess and sampling of parameters
3. To Impart knowledge in reliability concepts and assess the various configurations
4. To Impart knowledge in reliability monitoring methods
5. To analyze effectively various techniques to improve reliability of the system.

Quality and Statistical Process Control

Quality – Definition – Quality Assurance – Variation in process – Factors – process capability –control charts – variables X, R and X, - Attributes P, C and U-Chart tolerance design. Establishing and interpreting control charts – charts for variables – Quality rating – Short run SPC

Acceptance Sampling

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer 's risk and consumer 's risk. AQL, LTPD, AOQL, Concepts – standard sampling plans for AQL and LTPD – use of standard sampling plans

Reliability Concepts and Assessment

Reliability definition – Reliability mathematics – Reliability functions – Hazard rate – Measures of Reliability – Design life –A priori and posteriori probabilities – Mortality of a component – Mortality curve – Useful life-Different configurations – Redundancy – k out of n system – Complex systems: RBD – Baye's approach – Cut and tie sets – Fault Trees – Standby systems.

Reliability Monitoring

Life testing methods: Failure terminated – Time terminated – Sequential Testing –Reliability growth monitoring – Reliability allocation – Software reliability-Human reliability.

Reliability Improvement

Analysis of downtime – Repair time distribution – System repair time – Maintainability prediction – Measures of maintainability – Inspection decisions –System Availability.

References:

1. AmitavaMitra, "Fundamentals of Quality Control and Improvement", Pearson Education, 5th Edition, 2021.
2. Charles E Ebling, "An Introduction to Reliability and Maintainability Engineering", Tata-McGraw Hill, Third Edition, 2019.
3. David J Smith, "Reliability, Maintainability and Risk: Practical Methods for Engineers", Butterworth, Tenth Edition, 2022.
4. Dhillon, "Engineering Maintainability – How to design for reliability and easy maintenance", PHI, 2008.

5. Patrick D T O'Connor, Andre Kleyner, "Practical Reliability Engineering", John-Wiley and Sons Inc, 5th edition ,2015.
6. Roy Billington and Ronald N. Allan, "Reliability Evaluation of Engineering Systems", Springer, 2007.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain quality, SPC, sampling, and reliability concepts.	PO1 (2), PO3 (2)	2	1
CO2	Apply SPC, sampling plans, and reliability assessment techniques.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate process capability, system reliability, and maintainability metrics.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze quality and reliability data to improve system performance.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25204 **Machine Learning for Intelligent Systems**

L	T	P	C
3	0	2	4

Course objectives:

The main learning objective of this course is to prepare the students

1. To introduce basic of machine learning techniques
2. To learn about classification methods
3. To familiarize about clustering methods
4. To summarize the basics of neural networks
5. To impart knowledge on Deep learning and Reinforcement learning.

Introduction to Machine Learning

Learning – Types of Machine Learning, Classifications vs Regression, Evaluation metrics and loss functions in Classification, Linear Regression, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.

Classification Methods

Support Vector Machine Algorithm, Learning with Trees-Using Decision trees-Constructing Decision Trees-Classification example-Decision by committee: Ensemble Learning-Boosting-Bagging-Random Forests.

Clustering

Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, K-means clustering application study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance.

Neural Networks

Neural Networks – Perceptron, The Multi-Layer Perceptron – Back Propagation of Error-Multi-layer Perceptron in Practice – Deriving Backpropagation –Application Case Study of Neural Networks in Robotics.

Deep Learning and Reinforcement Learning

Deep learning introduction – CNN – RNN, Reinforcement learning, Examples for reinforcement learning, Markov decision process, Major components of RL, Application Case Study of reinforcement learning in Robotics.

Lab Experiments:

1. Basic programs in python
2. Implementation of Linear regression
3. Implementation of SVM model
4. Implementation of Decision tree model
5. Implementation of K-means clustering algorithm
6. Implementation of MLP model

7. Implementation of CNN model
8. Implementation of Q-Learning algorithm

References:

1. Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, Second Edition, 2023.
2. Tom M Mitchell, “Machine Learning”, McGraw Hill Education, 2021.
3. Peter Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, Cambridge University Press, First Edition, 2017.
4. Jason Bell, “Machine learning – Hands on for Developers and Technical Professionals”, Wiley , First Edition, 2020.
5. EthemAlpaydin, “Introduction to Machine Learning”, Adaptive Computation and Machine Learning Series, MIT Press, 4 th Edition, 2020.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain ML concepts: regression, classification, clustering, neural networks, and RL.	PO1 (2), PO3 (2)	2	1
CO2	Apply ML algorithms: Linear Regression, SVM, Decision Trees, K-means, MLP, CNN, Q-Learning.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate model performance using metrics, loss functions, PCA, and feature selection.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze ML models, ensembles, and RL strategies for robotics applications.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25205	Advanced Machining and Forming Laboratory	L 0	T 0	P 2	C 1

Objectives:

The main learning objective of this course is to prepare the students to

1 .Analyze and evaluate the effects of different machining parameters on the quality of machined components, such as dimensional accuracy and surface finish
2. Apply appropriate techniques and instruments to measure and analyze surface roughness of machined components, demonstrating proficiency in using surface roughness testers or profilometers.
3. Evaluate the quality, dimensional accuracy, and mechanical properties of the printed parts and propose improvements

LIST OF EXERCISES

1. CNC Machining Experiment: Perform a machining operation using a CNC (Computer Numerical Control) machine, such as milling or turning.
2. Surface Roughness Measurement: Measure the surface roughness of machined components using instruments like a profilometer or surface roughness tester.
3. Tool Wear Analysis: Analyze the wear characteristics of cutting tools used in machining operations.
4. Metal Forming Experiment: Perform a metal forming operation, such as bending, deep drawing, incremental forming and superplastic forming.
5. EDM (Electrical Discharge Machining) and WEDM (Wire Electrical Discharge Machining: Perform EDM experiments to understand the principles of material removal through electrical discharges.
6. Additive Manufacturing: Explore additive manufacturing processes using 3D printing machines.
7. Laser engraving process
8. Cutting of different materials during water jet machining
9. Experiments on Ultrasonic Machining
10. Experiments on hydroforming
11. Micro hole drilling in ECM
12. Experiments on incremental forming

(Any 10 for Conduct of end semester examination)

CO	Description	Mapped POs	PSO1	PSO2
CO1	Analyze effects of machining parameters on dimensional accuracy, surface finish, and component quality.	PO1 (3), PO3 (2)	3	2
CO2	Apply measurement techniques and instruments to evaluate surface roughness of machined components.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Evaluate quality, dimensional accuracy, and mechanical properties of printed/additive manufactured parts and suggest improvements.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25206 **Finite Element Analysis Laboratory** L T P C

0 0 4 2

Objectives

The main learning objective of this course is to prepare the students to

1. Apply the principles of finite element analysis to design and analyze elements used in manufacturing processes, demonstrating proficiency in utilizing finite element techniques for engineering design.
2. Develop skills in the application of finite element analysis for designing and evaluating manufacturing components, structures, and systems, including the ability to design and optimize elements through numerical simulations.
3. Evaluate and interpret the results obtained from finite element analysis simulations, critically analyzing the performance and behavior of manufacturing systems, and making informed decisions based on the simulation outcomes.

LIST OF EXERCISES

1. One Dimensional FEA Problem like beam, Truss etc.
2. Two Dimensional FEA Problems like plane stress, plane strain, axisymmetric and vibration.
3. Three Dimensional FEA Problems like shell and contact.
4. FEA Application in metal forming like superplastic forming, deep drawing etc
5. FEA Application in Metal cutting
6. FEA Application in casting process
7. 3D Modelling and Assemble of Engine
8. Modelling of Crack Shaft
9. Modelling of Connecting Rod
10. Modelling of Cotter Joint
11. Modelling of Plummer Block and Coupling

(Any 10 for Conduct of end semester examination)

CO	Description	Mapped POs	PSO1	PSO2
CO1	Apply FEA to 1D, 2D, and 3D problems.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO2	Develop FEA skills for manufacturing processes and component modeling.	PO1 (3), PO2 (3), PO3 (3)	3	2
CO3	Evaluate and interpret FEA simulation results for performance and optimization.	PO1 (3), PO2 (2), PO3 (3)	3	2

Semester III

MF25301	Project Work I	L	T	P	C
		0	0	12	6

Course Objectives:

- The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

  Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

Semester IV

MF25401	**Project Work II**	L	T	P	C
		0	0	24	12

Course Objectives:

- The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

Note: A project topic must be selected by the students in consultation with their guides. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

PROGRAMME ELECTIVE COURSES

MF25001	Laser Processing of Materials	L	T	P	C
		3	0	0	3

Course objectives:

The main learning objective of this course is to prepare the students to

1. Obtain an overview type of laser and optics
2. Acquire knowledge about all the possible interaction of materials with laser.
3. Get an insight to the joining of materials by laser.
4. Study the process of laser surface modification and forming
5. Get an exposure to laser optics and control for texture, marking, drilling and cutting.

Introduction to Lasers and Optics

Laser medium (solid state medium: crystals, glass, semiconductor, gaseous medium: CO2, N2, Ar, He-Ne, liquid: die solution, other organic materials). Phenomenon of population inversion. Laser cavity (fiber laser, and other cavities), generation of coherent beam, Q-switching, short pulse generation, power amplification. Laser Beam Characteristics, Wavelength, Coherence, Mode and Beam Diameter, Polarisation, Focusing with a Single Lens, Final Spot Size, Depth of Focus, Optical Components, Lens Doublets, Depolarisers, Collimators, Metal Optics, Diffractive Optical Elements - Holographic Lenses, Laser Scanning Systems, Fibre Delivery Systems.

Laser Material Interaction

Heating by Laser, temperature distribution, Thermo liaison and heat flow, impact of absorption on temperature. Melting & solidification: Regimes of laser remelting, interference characteristics Evaporation & Plasma formation – its fundamentals, Hydrodynamics, ionization of vapour, gas breakdown evaporation at moderate irradiance levels, beam heating and evaporation, vapour expansion and recoil. Laser supported combustion waves, plasma enhanced coupling, effects of laser supported detonation waves on beam material interaction- -Laser Safety.

Laser Joining

Laser Welding Parameters: Beam Power, Spot diameter and Traverse Speed;, Effect of Beam Characteristics: Beam Mode, Beam Stability, Beam Polarization, Pulsed Beams, Plasma Formation, Gas Shielding, and Effect of Ambient Pressure, Beam Size and Focal Point Location, Joint Configuration; Welding Efficiency; Mechanism of Laser Welding: Conduction Mode Welding, Keyhole Welding; Material Considerations; ferrous, Nonferrous alloys, Ceramics, Polymers, Dissimilar Materials; Weldment Discontinuities: Porosity, Humping, Spiking; Advantages and Disadvantages of Laser Welding; Special Techniques; Heat Treatment; Specific Applications.

Laser Surface Modifications and Forming

Laser Surface Heat Treatment: Process parameters; Temperature Field;

Microstructural Changes in Steels; Nonferrous Alloys; Hardness Variation; Residual Stresses; Advantages and Disadvantages of Laser Surface-Treatment; Laser Surface Melting; Laser Direct Metal Deposition: Processing Parameters, Methods for Applying the Coating Material, Dilution; Advantages and Disadvantages of Laser Cladding; Laser Physical Vapor Deposition (LPVD); Laser Shock Peening: Analysis, Advantages and Disadvantages of Laser Shock Peening. Laser Forming: Principle of Laser Forming, Process Parameters; Laser Forming Mechanisms: Temperature Gradient, Mechanism, Buckling Mechanism, Upsetting Mechanism; Process Analysis; Advantages and Disadvantages; Applications

Laser Machining

Forms of Laser Cutting: Fusion Cutting, Sublimation Cutting, Photochemical Ablation-Laser instrumentation for cutting and drilling, cut quality and process characteristics methods of cutting material consideration, practical performance, process variations, Dot matrix marking, Engraving, Image micromachining- Micromachining

References:

1. Elijah kannatey-Asibu, Jr., “Principles of Laser Materials processing “, Wiley, 2nd Edition, 2023.
2. William M. Steen, “Laser Material Processing”, Springer, 3rd Edition, 2013
3. Jacques Perriere, Eric Millon, Eric Fogarassy, “Recent Advances in Laser Processing of Materials”, Elsevier Science, 2006
4. Jonathan R. Lawrence,” Advances in Laser Materials Processing: Technology, Research and Application”, Elsevier Science,2nd Edition 2017
5. KamleshwarUpadhya, “Plasma and Laser Processing of Material”, TMS, 1991
6. Peter Schaaf, “Laser Processing of Materials: Fundamentals, Applications and Developments”, Springer Science & Business Media,2010

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain laser fundamentals, optics, beam characteristics, and optical components.	PO1 (2), PO3 (2)	2	1
CO2	Apply laser–material interaction principles for heating, melting, evaporation, and plasma formation.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Evaluate laser joining, welding parameters, and material considerations for different alloys and dissimilar materials.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze laser surface modification, forming, machining, and micromachining processes for industrial applications.	PO1 (3), PO2 (2), PO3 (3)	3	2

CD25C02	Solid Freeform Manufacturing	L	T	P	C
		3	0	0	3

Course Objective:

This course imparts knowledge on the evolution of Solid Freeform Manufacturing (SFM) and the role of Design for Additive Manufacturing (DfAM) in enhancing quality. It covers various SFM technologies and hybrid processes. Emphasis is laid on material science and its influence on manufacturing. Applications across industries like aerospace, automotive, and biomedical are also explored.

Introduction

Introduction to solid freeform manufacturing (SFM) - Need- SFM evolution, Distinction between SFM & CNC machining- Development of SFM systems — Hierarchical structure of SFM - SFM process chain — Classification. SFM Supply chain - Economics aspect: Strategic aspect- Operative aspect.

Design for Additive Manufacturing (DfAM)

Concepts and Objectives- General Guidelines for DfAM - DfAM tools, Requirements of DfAM methods, - Additive Manufacturing (AM) Unique Capabilities –Design Consideration in AM- Part Consolidation – Computational tools for design analysis- Topology Optimization - Lightweight Structures – Generative design- DfAM for Part Quality Improvement - CAD Modeling - Model Reconstruction - Data Processing for AM - Data Formats: STL, AMF,PLY, VRML- Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation.

Vat Polymerization, Material Extrusion & Sheet Lamination Technologies

Vat polymerization: Stereolithography Apparatus (SLA): Principles — Photo Polymerization of SL Resins - Pre Build Process — Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Capabilities - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process – Capabilities and Applications. Continuous Liquid Interface Production (CLIP)- Materials - Process - Capabilities and Applications. Material extrusion: Fused deposition Modeling (FDM): Working Principles - Process - Materials – Capabilities and Applications. Design Rules for FDM. Sheet lamination processes: Laminated Object Manufacturing (LOM): Working Principles - Process – MaterialsCapabilities- Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters –Capabilities- Applications. Case Studies.

Powder Bed Fusion, Binder Jetting, Material Jetting

Powder Bed Fusion: Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure -Materials - Surface Deviation and Accuracy –

Capabilities- Applications. Multi-jet Fusion Principles – Processes - Materials — Capabilities and Applications. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles — Processes — Materials — Capabilities - Limitations and Applications. Binder Jetting: Three dimensional Printing (3DP): Principles - Process - Physics of 3DP - Process — Materials - Capabilities - Limitations - Applications. Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Capabilities and Application.

Direct Energy Deposition Technologies

Direct Energy Deposition: Laser Engineered Net Shaping (LENS): Processes- Materials- Capabilities - Limitations and Applications. Hybrid Additive Manufacturing – Need - Principles - Part Quality and Process Efficiency. Wire Arc Additive Manufacturing (WAAM) Processes- Materials- Capabilities - Limitations and Applications. Case Studies.

Materials and Applications of SFM

Materials science for SFM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship. Application of SFM in Automotive-Aerospace-Bio Medical-Bio printing- Food Printing- Electronics printing — Rapid Tooling - Building printing.

Activities Based Learning:

1. Use an online tool or simulation software to visualize load behavior in different bearing types.nge
2. Calculate dimensions and load-carrying capacity of a pivoted journal bearing.
3. Plot fatigue life vs. load for different rolling bearing types.
4. Apply Rayleigh’s method for shaft critical speed using MATLAB.
5. Process vibration data from rotor test rigs using FFT.
6. Choose appropriate sensors for balancing flexible rotors in a machine.
7. Analyze real or simulated vibration data to detect fault patterns.
8. Brainstorm potential machine learning models for fault prediction in bearings.
9. Simulate or review an industry’s rotary equipment and suggest integration of condition monitoring systems.
10. Design a predictive maintenance plan using vibration sensors and IoT.

*(**Note:** Split the activities among the students (Maximum of three/ group) such that all the activities are covered)*

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Poster Presentation - 10%

Assignment – 20%

Report preparation for Case Study – 20%

Internal Examinations – 50%

References:

1. Ian Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer - New York, USA, 3rd Edition, 2021. ISBN978- 3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hotter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications Munchen, Germany, 2016. ISBN: 978-1-56990-582-1.
3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
4. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 1°t Edition, 2019 FL, USA. ISBN- 9780429029721
5. Ben Redwood, Brian Garret, Filemon Schoffer, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017. ISBN-13: 978- 9082748505.
6. Milan Brandt., "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Woodhead Publishing, UK, 2016. ISBN-9780081004333.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain SFM evolution, DfAM concepts, AM technologies, materials, and applications	PO1 (3), PO3 (2)	3	2
CO2	Apply DfAM guidelines, CAD modeling, process planning, and SFM techniques to design and simulate parts	PO1 (3), PO2 (3)	3	3
CO3	Estimate process parameters, part quality, material behavior, and load/fatigue in AM components	PO1 (3), PO3 (3)	3	3
CO4	Analyze SFM processes, hybrid techniques, material applications, and simulation/monitoring data for optimization	PO3 (3)	3	3

MF25002 Manufacturing Systems and Models

L	T	P	C
3	0	0	3

COURSEOBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand various measure the performance of manufacturing system
2. To Know how to apply DTMC model to a Manufacturing system
3. To Know how to apply CTMC model to a Manufacturing system
4. To understand Queuing networks and to model queuing network for a Manufacturing system
5. To understand and apply the Petri net model to a Manufacturing system

MANUFACTURING SYSTEMS- PERFORMANCE MEASURES

Manufacturing systems- Types, Concepts. Performance measures- types. Manufacturing Models Types. Factory Models- Single Workstation Factory Models-Developing Rate Balance Equations-Assembly Lines- Transfer Lines

DISCRETE TIME MARKOV CHAINS

Introduction to Markov Chains, DTMC, Properties of DTMC, Sojourn Times in DTMC Models, Applications of DTMC Models in Manufacturing Systems

CONTINUOUS TIME MARKOV CHAINS

Introduction to CTMC, Properties of CTMC, Sojourn Times in CTMC Models, Applications of CTMC Models in Manufacturing Systems

QUEUING MODELS

Birth and death process, performance measures in queuing models, open queuing networks and closed queuing networks- applications in manufacturing systems

PETRINET MODELS

Introduction to Petri-net models-Representational powers of Petri-Nets- Reachability graphs, Markings, Applications of Petri-Nets models in manufacturing systems- Timed and Colored Petri-Nets

REFERENCES:

1. Viswanadham, N., &Narahari, Y., Performance modeling of automated manufacturing systems, Prentice Hall, 1992
2. Ronald G. Askin Charles R. Stand ridge, Modelling and analysis of manufacturing systems, John Wiley and son’s .Inc, 1993.
3. Guy L. Curry., Richard M. Feldman “Manufacturing Systems Modeling and Analysis”, Springer, 2011.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain performance measures, DTMC, CTMC, queuing networks, and Petri net models in manufacturing systems.	PO1 (2), PO3 (2)	2	1
CO2	Apply DTMC, CTMC, queuing networks, and Petri net models to solve manufacturing system problems.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate performance metrics and reliability of manufacturing systems using modeling techniques.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze manufacturing system behavior and model results for decision making and optimization.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25003	Micro and Nano Manufacturing	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To introduce Meso, Micro and Nano manufacturing and their respective applications.
2. To familiarize the students with diamond, turn machining, advanced micro machining and nano finishing methods.
3. To familiarize the students with synthesis of nanomaterials and types of characterization techniques to be used.

INTRODUCTION

Introduction to Meso, Micro and Nano manufacturing, Miniaturization and applications,classification- subtractive, additive, mass containing processes, Theory of micromachining, micro turning, micro drilling, micro milling- Micro stereo lithography - micro forming, micro moulding, micro casting- micro joining, Applications of Micro and Nano products in IT and telecommunications, Automotive, Medicine.

DIAMOND TURNING

Diamond turn machining-need, classification, components, material removal mechanisms,Tooling for diamond turning, Process parameters and optimization - Molecular Dynamicsimulation to study nanoscale cutting-tool path strategies in surface generations- symmetric,asymmetric and freeform, applications of DTM products.

ADVANCED MACHINING / FINISHING PROCESSES

Introduction to mechanical and beam energy based micro machining processes- Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining, Pulsed water drop micromachining, Micro/ Nano finishing processes- Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Hybrid micro/nano machining – Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic In Process Dressing Grinding.

SYNTHESIS OF NANOMATERIALS

Introduction to nano materials, Methods of production of Nanoparticles, Sol-gel synthesis, Inert gas condensation, High energy Ball milling, Plasma synthesis, Electro deposition and other techniques. Synthesis of Carbon Nanotubes – Solid carbon source based production techniques, Gaseous carbon source based production techniques – Diamond Like Carbon coating. Nano wires.

CHARACTERISATION TECHNIQUES

Metrology for micro machined components -Optical Microscopy, White Light Interferometry, Molecular Measuring Machine, Micro CMM- Atomic Force

Microscopy.
Scanning Probe Microscopy (SPM) – Scanning Electron Microscope, Transmission Electron Microscope, Scanning Thermal Microscopy, Tribological characteristics - Micro abrasion wear - 3D surface roughness measurement- Nano indentation- Ellipsometric Analysis.

REFERENCES:

1. Jain, V.K, "Micro manufacturing Processes", by CRC Press, ISBN: 9781439852903, 2013.
2. Bhushan, B., "Handbook of Nanotechnology", Springer, Germany, ISBN-13: 978-3662543559, 2017.
3. Jain, V.K "Introduction to Micromachining", Narosa publishing house, ISBN: 978-81-7319-915-8, 2014.
4. Balasubraminan, R., RamaGopal, V., SarepakaSathyanSubbiah "Diamond Turn Machining: Theory and Practice" by CRC Press, ISBN-13:978-1-4987-8758-1,2018.
5. DehongHuo, Kai Cheng "Micro-Cutting: Fundamentals and Applications (Microsystem and Nanotechnology)" by Wiley, ISBN-13: 978-0470972878, 2013.
6. Yang Leng "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods" by Wiley-VCH, ISBN-13: 978-3527334636, 2013
7. Bandyopadhyay, A.K., "Nano Materials", New Age International Publishers, New Delhi, SBN 8122422578, 2008.
8. Grundy, P.J. and Jones, G.A."Electron Microscopy in the Study of Materials", Edward Arnold Limited, 1976.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain concepts of Meso, Micro, Nano manufacturing, diamond turning, advanced machining, synthesis, and characterization techniques.	PO1 (2), PO3 (2)	2	1
CO2	Apply micro/nano machining, diamond turning, and nanomaterial synthesis methods to practical problems.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate performance, dimensional accuracy, and surface quality in micro/nano manufacturing processes.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze machining processes, tool behavior, and characterization results for process optimization and decision making.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25004 Bio-Inspired Manufacturing

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To examine and mimic the natural hierarchical structure.
2. To understand nature specific surface characteristics and replicate them.
3. To introduce to toughness mechanism in nature and apply them for composite fabrication
4. To understand the sensors/actuators in nature and bio inspired MEMS
5. To educate the use information flow and functionality of nature for manufacturing systems

MANUFACTURING BIO INSPIRED HIERARCHICAL STRUCTURE

Nature hierarchical structure- levels (dense and porous) – improved properties- bone – bamboo- cellular structure-honeycomb- negative Poisson ratio structure- sandwich structure- hierarchical order – strength ratio- Manufacturing: Layered manufacturing-Mould and gel casting- Particulate Leaching-Foaming-Compression moulding and hot pressing-Low-pressure injection moulding and extrusion- ultrasonic cavitation – Applications.

MANUFACTURING BIO INSPIRED SURFACES

Nature dry adhesion (Gecko effect -Attaching/detaching mechanisms)- Wet adhesion (tree frogs)- Super-hydrophobicity (Lotus effect) –super hydrophilic (plant) - Antibiofouling (shark skin)- Optical tuning (Iridescent peacock feathers) – hard and tough (Teeth)- hydrodynamic drag (shark skin, boxfish)-Manufacturing: soft lithography-hot-embossing- Plasma etching- Electron-beam lithography- Porous alumina membrane molding- sputtering- Electrodeposition-Thermal Evaporation-Electrostatic spray coating-Chemical surface modification-laser texturing- atomic layer deposition-photocurable resin-UV exposure Applications.

MANUFACTURING BIO INSPIRED COMPOSITES

Nature – Seashells- abalones- toughening mechanisms – interlocking of nano-asperities – weak organic interfaces, inter-lamellar mineral bridges, plastic deformation of individual tile –multiple cracking large-scale crack bridging- Lobster - armadillo’s dermal shells- Sandwich structure of turtle carapace- Diatoms-plant stem –self healing composites- freeze casting method- clay/polyimide composites fabricated from centrifugal - additive manufacturing- Applications

MANUFACTURING BIO INSPIRED SENSORS AND ACTUATORS

Thermal sensor (beetle, snakes) – Echolocation (crickets, bats) – Vision (Avian eyes, honeybees' eye) – microelectromechanical system (MEMS) sensor based on piezoresistive, capacitive, triboelectric, and piezoelectric – display – muscles – artificial muscles- electrothermal- capacitive- piezoelectric based MEMS actuators.

BIOINSPIRED MANUFACTURING SYSTEMS

Multi-Agent Systems (MAS)-Holonic Manufacturing Systems (HMS) –Bionic Manufacturing Systems (BMS)-swarm intelligence-positive and negative feedback-Self-Organization-Self-configuration, Self-optimization, Self-healing. Ant Colony Optimization (ACO), Artificial Bee Colony (ABC)Algorithm and Particle Swarm Optimization (PSO). MAS- Distributed nature- Division of labor- Emergence from collective simple behavior. Biologicalisation in Manufacturing- Alternative or fail-safe mechanisms: Modularity Decoupling -–Case Studies–Case Studies.

REFERENCES:

1. Yoseph Bar-Cohen, "Biomimetics: Biologically Inspired Technologies", CRC Press, 2016.
2. Bhushan Bharat, "Biomimetics: lessons from nature–an overview", Phil. Trans. R. Soc. A., 2009.
3. Po-Yu Chen, Joanna McKittrick, Marc André Meyers, "Biological materials: Functional adaptations and bioinspired designs", Progress in Materials Science, Volume 57, Issue 8, 2012, Pages 1492-1704.
4. Gerald Byrne, Dimitri Dimitrov, Laszlo Monostori, Roberto Teti, Fred van Houten, Rafi Wertheim, "Biologicalisation: Biological transformation in manufacturing", CIRP Journal of Manufacturing Science and Technology, Volume 21, 2018, Pages 1-32.
5. Ilami, M., Bagheri, H., Ahmed, R., Skowronek, E. O., Marvi, H., "Materials, Actuators, and Sensors for Soft Bio Inspired Robots". Adv. Mater. 2021.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain bio-inspired hierarchical structures, surfaces, composites, sensors, actuators, and manufacturing systems.	PO1 (2), PO3 (2)	2	1
CO2	Apply bio-inspired manufacturing techniques for structures, surfaces, composites, and sensors/actuators.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate performance, properties, and effectiveness of bio-inspired materials and systems.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze and optimize bio-inspired systems using MAS, HMS, BMS, and swarm intelligence algorithms.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25005	Operations Management	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. Todescribe the concepts in facility planning.
2. To summarize the types of plant layout and capacity planning methods
3. To impart the knowledge about the concepts of Project management.
4. Tofamiliarize the concepts and methods in production planning and control.
5. To study the concepts in Inventory and maintenance management.

FACILITY PLANNING

Facility planning – Factors affecting selection of plant location, Factor rating analysis: Break – even analysis, Load distance model, closeness ratings– case study.

CAPACITY & LAYOUT PLANNING

Plant layout types, criteria for good layout, Process layout, Assembly line balancing. Computer based solutions to layout problems such as CRAFT, ALDEP, CORELAP and PREP. Capacity planning–Analysis of designed capacity, installed capacity, commissioned capacity, utilized capacity, factors affecting productivity and capacity expansion strategies.

PROJECT MANAGEMENT

Demand forecasting – Quantitative and qualitative techniques, measurement of forecasting errors, Project management – its role in functional areas of management, network representation of a project, CPM and PERT techniques–case study.

PRODUCTION PLANNING & CONTROL

Aggregate production planning, production planning strategies, Disaggregating the aggregate plan, Materials Requirement Planning (MRP), MRP-II, Supply chain management, Operation scheduling, prioritization.

INVENTORY AND MAINTENANCE MANAGEMENT

Introduction to EOQ models, Inventory control techniques – ABC, FSN, VED etc. Types of inventory control – Perpetual, two-bin and periodic inventory system – JIT, SMED, Kanban, zero inventory, Maintenance strategies and planning, Maintenance economics: quantitative analysis, optimal number of machines, Replacement strategies and policies – economic service life, opportunity cost, replacement analysis using specific time period.

REFERENCES:

1. CharyS. N, “Production and Operations Management”, SIE, TMH, 6th Edition, 2019.

2. Chase. R B, N. J. Aquilano, & F. R. Jacobs, "Operations Management – ForCompetitiveAdvantage", SIE, TMH, 11th Edition, 2008.
3. James. B. Dilworth, "Operations Management – Design, Planning and Control for Manufacturing and Services", McGraw HillInc. Management Series, 3rd Edition, 2000.
4. KanishkaBedi, "Production and Operations Management", Oxford HigherEducation, 2nd Edition, 2016.
5. Lee. J. Krajewski, L. P. Ritzman, & M. K. Malhothra, "Operations Management – Process and Value Chains", Prentice Hall Professional, 8th Edition, 2015.
6. Melnyk, Denzler,"Operations Management –A Value Driven Approach", Irwin McGrawHill, 1996.
7. Pannererselvam, R "Production and Operations Management",PHI, 3rd Edition, 2012.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain concepts in facility planning, plant layout, capacity planning, project management, production planning, inventory and maintenance management.	PO1 (2), PO3 (2)	2	1
CO2	Apply methods for plant layout, capacity planning, forecasting, MRP, scheduling, and inventory control.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate production capacity, demand, inventory levels, and maintenance requirements.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze production systems, project networks, layout efficiency, and maintenance strategies for optimization.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25006 Lean Six Sigma

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1.	To understand Lean production principles, eliminate waste, and improve efficiency through case studies.
2.	To learn steps for Value Stream Mapping, apply Lean metrics, and implement improvements in value streams.
3.	To explore Six Sigma's relationship with Lean Manufacturing, cultural changes, quality assessment, and cost implications.
4.	To gain knowledge of various Six Sigma tools and techniques for problem-solving and project management.
5.	To evaluate Six Sigma quality economics, focus on continuous improvement using Lean principles, Kaizen, and 5S methodologies.

LEAN MANUFACTURING
Evolution of Mass production, Traditional versus Mass production, Evolution of Toyota (Lean) Production System, Business Dynamics of Lean production, Principles of Lean production – Value, Value stream, Flow, Pull, Perfection- 3Ms – Muda, Mura, Muri, 7 Wastes in Manufacturing, Lean Tools to eliminate Muda - 5S, Standardised work, TPM, SMED, Jidoka – Poka Yoke, JIT, Heijunka, Kanban, One piece production, Case studies.
VALUE STREAM MAPPING
Need for Value Stream mapping; Steps involved in Value stream mapping – Choose value stream – PQ and PR analysis, Current State map, Lean Metrics, Future State Map, Kaizen plans; Lean implementation - Cultural change, Hoshin planning; Lean in the Supply chain.
SIX SIGMA
Six sigma - lean manufacturing and six sigma- six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments - implications of quality levels, Cost of Poor Quality (COPQ)
SIX SIGMA SCOPE OF TOOLS AND TECHNIQUES
Tools for definition – IPO diagram, SIPOC diagram, Flow diagram, CTQ Tree, Project Charter – Tools for measurement – Check sheets, Histograms, Run Charts, Scatter Diagrams, Cause and effect diagram, Pareto charts, Control charts, Flow process charts, Process Capability Measurement, Tools for analysis – Process Mapping, Regression analysis, RU/CS analysis, SWOT, PESTLE, Five Whys, interrelationship diagram, overall equipment effectiveness, TRIZ innovative problem solving – Tools for improvement – Affinity diagram, Normal group technique, SMED, 5S, mistake proofing, Value stream Mapping, forced field analysis – Tools for control – Gantt chart, Activity network diagram, Radar chart, PDCA cycle, Milestone tracker diagram, Earned value management.
EVALUATION AND CONTINUOUS IMPROVEMENT METHODS

Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen – 5S

REFERENCES:

1. Michael L.George, David Rownalds, Bill Kastle, What is Lean Six Sigma, McGraw – Hill 2003
2. Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill,2000
3. Fred Soleimannejed , Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004
4. Forrest W. Breyfogle, III, James M. Cupello, Becki Meadows, Managing Six Sigma:A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success, John Wiley & Sons, 2000
5. James P. Womack, Daniel T.Jones, Lean Thinking, Free Press Business, 2003

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain principles of lean manufacturing, 3Ms, wastes, value stream, Six Sigma concepts, and tools.	PO1 (2), PO3 (2)	2	1
CO2	Apply lean tools, value stream mapping, Six Sigma measurement and improvement techniques.	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate process capability, cost of poor quality, and project ROI using Six Sigma metrics.	PO1 (3), PO2 (2), PO3 (3)	3	2
CO4	Analyze processes for waste reduction, continuous improvement, and Lean-Six Sigma implementation.	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25007	Green Manufacturing	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To expose the students to the basics of environmental sustainability and impact assessment objectives
2. To incorporate knowledge about the environmental based improvements towards lean manufacturing systems
3. To analyze various machineries with intent to conserve energy
4. To analyze hazardous and solid wastes with intent to point out areas of adverse environmental impact and how this impact could be minimized or prevented.
5. To impart the knowledge about the need, procedure and benefits of Green-Co-rating

ENVIRONMENTAL SUSTAINABILITY AND IMPACT ASSESSMENT

Environmental impact assessment objectives – Legislative development – European community directive – Hungarian directive. Strategic environmental assessment and sustainability appraisal. Regional spatial planning and environmental policy.

LEAN MANUFACTURING AND GREEN ENERGY SYSTEM

Conventional Manufacturing versus Lean Manufacturing – Principles of Lean Manufacturing. World energy consumption – Greenhouse effect, Global warming. Energy conservation and measurement principles with their applicability in engineering and process industries.

ENERGY SAVING MACHINERY AND COMPONENTS

Electricity Billing: Components and Costs – kVA – Need and Control – Determination of kVA demand and Consumption. Selection of fans, pumps and Compressors – Performance Evaluation – Cause for inefficient operation – scope for energy conservation.

HAZARDOUS AND SOLID WASTE MANAGEMENT

Hazardous waste: definition, terminology, classification and Sources – Need for hazardous waste management: Need, Handling, methods of collection, storage and transport with suitable examples. Solid waste management: Need, Waste prevention and Life cycle assessment. Collection, storage, reuse and recycling of solid waste with suitable examples.

GREEN CO-RATING

Ecological Footprint - Need for Green Co-Rating – Green Co-Rating System – Intent – System Approach – Weightage- Assessment Process – Types of Rating – Green Co-Benefits – Case Studies of Green Co-Rating.

REFERENCES:

1. Dornfield David, “Green Manufacturing”, Springer,2013
2. Davim J Paulo, “Green Manufacturing Processes and Systems”, Springer,2013
3. Cairncross and Francis, “Costing the earth”, Harvard Business School Press, 2009
4. World Commission on Environment and Development (WCED) “Our Common Future”, Oxford University Press, 1987.
5. “Green Co Case Study Booklet”, CII–Sohrabji Godrej Green Business Centre,2015.

CO	Description	Mapped POs	PSO1	PSO2
CO1	Explain sustainability, lean, energy, waste, Green Co-Rating	PO1 (2), PO3 (1)	2	1
CO2	Apply lean, energy conservation, waste & Green Co-Rating	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate energy, efficiency, and environmental impact	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze impact, performance, and optimization	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25008 Supply Chain Systems and Management L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To describe the role and drivers of and supply chain management in achieving competitiveness.
2. To explain about Supply Chain Network Design.
3. To illustrate about the issues related to inventory in Supply Chain.
4. To appraise about transportation and sourcing in Supply Chain.
5. To application of Information Technology and Emerging Concepts in Supply Chain.

INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

Definition and Objective of Supply Chain, The importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process View of Supply Chains. Competitive and Supply Chain Strategies, Achieving Strategic fit, Expanding Strategic Scope. Drivers of Supply Chain Performance, Frame work for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics

DISTRIBUTION NETWORK DESIGN IN SUPPLY CHAIN

The Role of Distribution in the Supply Chains, Factors influencing Distribution Network design, Design Options for a Distribution Network, Online sales and the Distribution network, Distribution Networks in practice. Factors influencing network design decisions, Framework for Network design decisions, The impact of uncertainty on network design, The impact of Globalization on Supply Chain networks, Risk Management in Global Supply Chains, Discounted cash flow analysis, Evaluating Network Design Decisions

INVENTORY IN SUPPLY CHAIN

The Role of Cycle inventory in a Supply Chain, Economies of Scale to Exploit Fixed costs, Managing Multi-echelon Cycle Inventory. The Role of Safety Inventory in a Supply Chain, Determining appropriate level of Safety inventory, Impact of supply Uncertainty on Safety inventory, Impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, Managing Safety Inventory in a Multi-echelon Supply Chain, The Role of IT in inventory management.

TRANSPORTATION AND SOURCING IN SUPPLY CHAIN

The role of transportation in a Supply chain, Modes of transportation and their performance characteristics, Transportation infrastructure and policies, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation, The role of IT in transportation, Problems. Sourcing Decisions In A Supply Chain: The role of sourcing in a supply chain, in-house or outsource, Third-and Fourth-party logistics providers, Total cost of Ownership, Supplier selection, Auctions and Negotiations, Sharing Risk and Reward in the supply chain.

INFORMATION TECHNOLOGY IN SUPPLY CHAIN

The role of IT in a supply chain, The supply chain IT framework, The supply chain macro processes, Lack of Supply Chain co-ordination and the Bullwhip effect, managerial levers to achieve coordination, continuous replenishment and vendor-managed inventories, collaborative planning, forecasting and replenishment (CPFR).

REFERENCES:

1. Sunil Chopra, Peter Meindl and D.V. Kalra, “Supply Chain Management: Strategy, Planning, and Operation", Pearson Education, 2016.
2. Sarika Kulkarni & Ashok Sharma, Supply Chain Management – Creating Linkages for Faster Business Turnaround, 1st Edition, TATA Mc Graw Hill, 2004.
3. David Simchi Levi, Philip Kaminsky, Edith Simchi Levi & Ravi Shankar, Designing & Managing the Supply Chain – Concepts Strategies and Case Studies, McGraw-Hill higher education, 3rd Edition, 2008.
4. Jeremy F Shapiro, Modelling the Supply Chain, 2nd Edition, Cengage Learning,2009.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain supply chain fundamentals, drivers, distribution, inventory, transportation, IT	PO1 (2), PO3 (1)	2	1
CO2	Apply supply chain design, inventory, transportation, and sourcing techniques	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate inventory levels, safety stocks, and network performance	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze strategies, network design, risk management, and coordination in supply chains	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25009	Smart Materials	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To introduce smart and intelligent materials and its principles.
2. To impart knowledge on materials exhibiting piezoelectricity and their applications.
3. To familiarise the synthesis and application of Electro/ Magneto rheological fluids and their applications.
4. To summarise various shape memory alloys and polymers, their production methods and applications.
5. To introduce smart materials that reconfigure structure based on stimulus and other emerging materials.

INTRODUCTION TO SMART AND INTELLIGENT MATERIALS

Intelligent / Smart materials –classification- Culshaw information- hybrid smart materials - an algorithm-for synthesising smart materials – active, passive reactive actuator based smart structures - Functional materials – Polyfunctional materials – Structural materials -Electrical materials- electro-restrictive and magneto-restrictive materials- Principles of Piezoelectricity, Perovskyte- Bingham body model –electro-rheological fluids(ERF)- Shape Memory Effect-– thermoelastic martensitic transformations- Biomimetics.

PIEZOELECTRIC MATERIALS

Piezo ceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers- - Overview of production method-poling- Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications-Piezoelectric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern-Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials

MAGNETO/ELECTRO-RHEOLOGICAL FLUIDS

Suspensions- Overview of production method- electro-rheological fluids - principal characteristics of electro-rheological fluids (ERF) –mechanism for the dispersed phase – electrorheological fluid domain – fluid actuators- design parameter – application of Electro-rheological- fluids – Basics, Principles and instrumentation and application of Magnetorheological fluids (MRF)- applications of ERF/MRF

SHAPE MEMORY MATERIALS

Shape Memory Alloys, Nickel – Titanium alloy (Nitinol) —– classification of SMA alloys- mechanism of magnetic SMA –Shape Memory Polymers- mechanism of shape memory- types and applications - Overview of production method- Primary moulding – secondary moulding- Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

STIMULI RESPONSIVE MATERIALS AND EMERGING MATERIALS
Halochromic materials, pH-sensitive polymers, Chromogenic-systems, photochromic- Thermochromic- electrochromic- high entropy alloys- bulk metallic glass- metamaterials- topological materials- self healing materials- Autophagias Materials- Overview of production method – Application of smart material incorporated structures – health monitoring- vibration mitigation.

REFERENCES:

1. M Shahinpoor and Hans-Jorg Schneider, “Intelligent Materials”, Royal Society of Chemistry Press 2009.
2. Inderjit Chopra, Jayant Sirohm, “Smart structures theory”, Cambridge University Press, First edition, 2014.
3. K. Otsuka and C. M. Wayman, “Shape Memory Materials”, Cambridge Press 2002..
4. Culshaw, B., “Smart Structures and Materials,” Artech House, Inc., First Edition, 1996.
5. Mark Madou, “Fundamentals of Microfabrication '', CRC Press, Third Edition, 2018.
6. Donald J.Leo,.“EngineeringAnalysis of Smart Materials Systems”, John Wiley publications, 2011.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain fundamentals, classification, and principles of smart and intelligent materials	PO1 (2), PO3 (1)	2	1
CO2	Apply knowledge of piezoelectric, magneto-/electro-rheological, and shape memory materials in design	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate performance, actuation, and sensing parameters of smart materials	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze stimuli-responsive and emerging materials for structural, vibration, and health monitoring applications	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25010	Material Testing and Characterization	L 3	T 0	P 0	C 3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To provide understanding of techniques of microstructure and crystal structure evaluation
2. To introduce electron microscopic tools for analysis of material topography and compare to atomic force microscopy
3. To understand the typical techniques of evaluation of chemical composition and thermal analysis of materials.
4. To familiarise advanced static mechanical testing methods.
5. To summarise the various dynamic mechanical testing methods.

MICRO AND CRYSTAL STRUCTURE ANALYSIS

Principles of Optical Microscopy – Specimen Preparation – Polishing and Etching of common metal alloys – Polarization – Phase contrast – Differential interference Contrast- Microscopy- Quantitative Metallography – X- ray Diffraction – Bragg's law – Diffractometer – analysis of diffraction patterns – Interplanar spacing – Determination of grain size, crystal structure, phase, indexing of peaks - Introduction to estimation of residual stress- orientation- texture.

ELECTRON MICROSCOPY

Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation – Imaging Techniques – BF & DF – Selected Area Electron Diffraction– Electron Probe Microanalysis – Scanning Electron Microscopy – Construction & working of SEM– imaging modes–-electron backscattered diffraction-preparation for biological samples-Applications- Atomic Force Microscopy- Construction & working of AFM Contact and Non-Contact modes Applications.

CHEMICAL AND THERMAL ANALYSIS

Basic Principles, Practice and Applications of Energy dispersive Spectroscopy and Wave Dispersive Spectroscopy, X-ray Photoelectron spectroscopy- Auger Spectroscopy, Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES)-Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)-Raman Spectroscopy- Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) –Thermogravimetric metric Analysis (TGA)-Dynamic Mechanical Analysis (DMA).

MECHANICAL TESTING – STATIC TESTS

Micro Hardness –Nanoindentation test- Scratch test - Tensile Test – Stress – Strain plot – for plastic deformation under different strain rate and temperature – Instrumented Charpy Test – Fracture Toughness Test- Typical testing of laminate composites.

MECHANICAL TESTING – DYNAMIC TESTS

Fatigue – Low & High Cycle Fatigue tests – SN curve – Crack Growth studies – Creep Tests – Larson-Miller Parameter– Indentation creep test – Acoustic emission Tests-modal analysis – Applications for Life Estimation-Ballistic impact- Wear Test.

REFERENCES:

1. Cullity B.D, Stock S. R, Stock S, “Elements of X ray Diffraction”, Prentice Hall, 3rd Edition, 2015.
2. Angelo P. C, “Materials Characterisation”, Cengage Publication, 1st Edition,2016.
3. Dieter G.E., “Mechanical Metallurgy”, McGraw Hill, (3rd Edition), 2017. ISBN: 0070168938,
4. Suryanarayana A. V. K, “Testing of metallic materials”, BS publications, 2nd Edition ,2018.
5. Yang Leng, “Materials Characterization: Introduction to Microscopic andSpectroscopic Methods”, Wiley, 2nd Edition, 2013.
6. “ASM Handbook – Materials Characterization”, Vol-10, 2019.
7. C. Suryanarayana, “Experimental Techniques in materials and Mechanics”, CRC Press, 2011.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain principles of microstructure, crystal structure, and material characterization techniques	PO1 (2), PO3 (1)	2	1
CO2	Apply optical, electron, and chemical/thermal analysis methods to characterize materials	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate mechanical properties of materials from static and dynamic testing data	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze and interpret experimental results for microstructure, residual stress, and material performance	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25011	Manufacturing Metrology	L	T	P	C
		3	0	0	3

OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To teach the students about the concepts of metrology.
2. To train the students in the field of surface roughness measurement
3. To acquire knowledge on form measurements and interferometry.
4. To introduce some fundamental principles of CAI, Laser metrology
5. To understand Image processing on Machine vision.

CONCEPTS OF METROLOGY

Introduction - Terminologies - Standards of measurement - Interchangeability - Selective assembly - Accuracy and Precision – Calibration of instruments – Errors in measurements –Limits – Fits - Tolerances – Process capabilities - Laboratory accreditation, Basics of dimensional metrology and Form metrology – Form, Fits, functions, Clean room - Maintenance and handling of metrology equipment's - Standard practices of inspection rooms – Linear and Angular measurements – Comparators.

SURFACE ROUGHNESS

Fundamentals of GD & T - Conventional vs Geometric tolerance, Interpretation of GD&T Symbols in engineering drawings, Datums, Inspection of geometric parameters, Material conditions - concept of bonus tolerance. Surface Roughness Measurement Methods - parameters, Contact and Non-Contact type, 3D Surface Roughness Measurement - Nano Level Measurement, Atomic Force Microscopy (AFM).

INTERFEROMETRY AND FORM MEASUREMENTS

Introduction - Principles of Interferometry - Optical flats in assessing surface contours - Interferometers – Measurement and Calibration - Laser Interferometry - Engineering applications of interferometry - Form measurements - flatness, straightness, roundness, cylindricity.

COMPUTER AIDED INSPECTION AND LASER METROLOGY

Introduction – Computer Aided Inspection Techniques - Tool Makers Microscope – Coordinate Measuring Machines - Advantages, limitations– Applications- Straightness- Alignment: Ball bar tests – Advanced Laser gauging techniques – Lasers in precision Measurements – Laser Scanners for Reverse Engineering - In-process inspection -Industrial case studies. DIC (digital image correlation), Perceived quality.

MACHINE VISION AND IMAGE PROCESSING

Overview of Machine Vision systems-Elements-Image Acquisition, Image enhancement and Analysis-Vision based GD&T- Image processing Software- 3D reconstruction techniques for measurements and their integration with vision systems.

REFERENCES:

1. “ASTE Handbook of Industries Metrology”, Prentice Hall of India Ltd., India,1992.
2. Bewoor A.K. and Kulkarni V.A.,”Metrology and Measurement”, Tata McGraw-Hill, India, 2009.
3. Galyer F.W. and Shotbolt C.R., “Metrology for engineers”, ELBS, Germany, 1990.
4. Jain R.K., “Engineering Metrology”, Khanna Publishers, India, 2008.
5. Smith G.T., “Industrial Metrology”, Springer, United States, 2002.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain concepts of metrology, surface roughness, form measurements, and machine vision principles	PO1 (2), PO3 (1)	2	1
CO2	Apply surface roughness measurement, interferometry, CAI, and laser metrology techniques	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate dimensional accuracy, form errors, and quality using metrology tools and image processing data	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze measurements and inspection results to improve precision, quality, and process capability	PO1 (3), PO2 (2), PO3 (3)	3	2

MF25012 Powder Metallurgy Processing

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

The main learning objective of this course is to prepare the students

1 To understand the fundamental of characterization of powders and particulates.
2 To understand methods for the production of powder
3 To introduce to particle interaction, mixing and sintering
4 To understand the powder transport and rheology of powder solution
5 To introduce the methods of production of nano sized powders

POWDER CHARACTERIZATION

Powder size – distribution- shape- surface charges – BET surface area analysis– dynamic light scattering – flowability- apparent and tap density- Cohesiveness- internal powder porosity- powder characteristic suitable for additive manufacturing- Powder satellite content

POWDER PRODUCTION

Water- Gas- plasma- centrifugal -atomization- hydride-dehydride- rapid spinning cup process (RSC), vacuum (soluble gas) atomization (VA), rapidsolidification rate (RSR) process for rotating disk atomization, (free-fall) gas (Ar)atomization (GA), and rotating electrode process (REP)- induction melting gas atomization (EIGA)- comparison of powder characteristics by various methods- selective laser beam melting of polymers (LBM)

PARTICLE INTERACTIONS

Solid-Solid Mixing - Interparticle Forces- Mixing – mechanism of mixing, types of mixers – batch and continuous mixers – pan mixer, shaft mixer, U mixer, muller mixer and other mixers, liquid mixers – mechanism, blungers, agitators - particle-gas interaction- Nucleation, condensation, evaporation, and hygroscopicity-– Reprocessing of powders- Theory of Sintering, Sintering of Single- Mixed Phase Powder, Liquid Phase Sintering.

POWDER TRANSPORT AND RHEOLOGY OF SOLUTION

Conveying – solid conveying-types of conveyors, Vibrational Microfeeding- criteria for selecting a conveyor; liquid conveying- condition for liquid conveying- Brownian motion- Characteristics on Rheological Properties of suspension/ solution- Pneumatic Conveying of particulate Solids- - Gas Fluidization different types of pumps. Storage methods for different ceramic powders. Problems in bin storage.Colloids – Types – Surface forces – Stabilisation – Colloidal suspension – Electrostatic, steric and electrosteric – structure and Rheology of colloidal suspensions

NANOSIZED POWDER PRODUCTION

Processes for producing ultrafine powders Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol gel process; Gas Phase synthesis of Nano-materials Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation (CVC)- comparison of powder characteristics by various methods – Safety measures

REFERENCES

1. P.C.Angelo and R.Subramanian.,“ Powder Metallurgy: Science, Technology and
   Application” Prentice Hall, 2008
2. Anish Upadhya and G S Upadhaya, “ Powder Metallurgy: Science, Technology and
   Materials, Universities Press, 2011
3. Advances in Powder Metallurgy: Properties, Processing and Applications, Isaac Chang, Yuyuan Zhao, Woodhead Publishing Series in Metals and Surface Engineering, Elsevier, 2013.
4. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International
5. J. S. Hirschhorn, Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976
6. G. S Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 2002. 2nd Edition

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain powder characterization, production methods, particle interactions, and transport	PO1 (2), PO3 (1)	2	1
CO2	Apply powder production, mixing, transport, and rheology techniques	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate powder properties, flowability, density, and nanoscale characteristics	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze powder behavior in production, handling, and additive manufacturing applications	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25013	Mechatronics in Manufacturing	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1.	To Understand and apply the principles of mechatronics in modern manufacturing
2.	To Develop proficiency in selecting and integrating sensors, transducers, drives, and actuators for mechatronic systems
3.	To Design and optimize manufacturing processes using mechatronic principles and techniques
4.	To Gain practical skills in programming and interfacing microcontrollers for controlling mechatronic systems
5.	To Analyze and evaluate the performance of mechatronic systems in manufacturing operations for continuous improvement

INTRODUCTION TO MECHATRONICS IN MODERN MANUFACTURING

Introduction to Process Parameters in Conventional Manufacturing – Assembly – Inspection –Transportation - Introduction to basic elements of Mechatronics Systems- Entities in Modern Manufacturing - Mechanical, Fluid, Thermal, Electrical, Electronics, Communication, Control systems and Software Integration for Manufacturing - Classification of Manufacturing based on Mechatronics – CNC based Subtractive Manufacturing –Rapid Prototyping based Additive Manufacturing- Automated Assembly Stations – Modern Quality Inspection and Transportation Systems

SENSORS AND TRANSDUCERS

Introduction – Performance Terminology – Resistive Transducers – Inductive Transducers - Capacitance Transducers – Optical Sensors – Contact and Non-Contact Temperature Sensors – Eddy Current Sensor – Hall Effect Sensor – Piezo Electric Sensor - Ultrasonic Sensors – Proximity Sensors – Chemical and Gas Sensors - Signal Conditioning - Condition Monitoring

DRIVES AND ACTUATORS

Role of Linear and Rotary Actuators - Electrical Actuators- Servo Concepts and Stepper Motors - Fluid Power – Piezo Actuators – Solenoids - Function of Drives - Mechanical Switching Devices – Solid State drives for various actuators

MICROPROCESSORS AND MICROCONTROLLERS

Requirement for Processor – Comparison of 8085 Microprocessor and 8051 Microcontrollers– 8051 Microcontrollers Architecture -Assembly Language Programming- Instruction Set, Addressing Modes, Basic Programming – Interfacing - Sensors, Keyboard, LED, LCD, A/D and D/A Converters, Actuators – Embedded Systems

INTEGRATION OF MANUFACTURING SYSTEMS

Design Process - Stages of Design Process – Skeletal Structure and Block Diagram of

CNC Based - Vertical Machining Centre, turning centre, Water Jet Machine, Electrical Discharge Machine, Serial Manipulator, hydraulic press, 3 D printers– Coordinate Measuring Machine –Automated conveyors - Extended Transportation System – Total Integration of Manufacturing Systems for Production Automation

REFERENCES:

1. Bolton .W.,“Mechatronics” ,Pearson Education Limited, 5th Edition, 2011.
2. Mazidi. M.A and Mazidi .M.J., MCkinlay.R.D, “The 8051 Microcontroller and Embedded
   Systems Using Assemblyand C”, Pearson India, 2nd Edition, 2008.
3. Patranabis D., “Sensor and Actuators”, Prentice Hall of India Pvt Ltd., 2nd edition 2005.
4. Vijayaraghavan G.K., BalasundaramM.S , Ramachandran K.P. , Mechatronics: IntegratedMechanical Electronic Systems, Willey, 2008.
5. John P. Bentley., “Principle of Measurement systems”, Pearson Prentice Hall, Fourth edition,2005.
6. K. Ogata, “Modern Controls Engineering “, Prentice Hall of India Pvt. Ltd., New Delhi, 2005.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain mechatronics systems, sensors, actuators, microcontrollers, and integration	PO1 (2), PO3 (1), PO4 (1)	2	1
CO2	Apply sensors, transducers, actuators, and microcontrollers for manufacturing systems	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate system parameters, actuator performance, and process capabilities	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze integration of CNC, additive, and automated systems for production automation	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25014	Industrial Robotics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To know the basic terminologies, classification, configurations and components of serial manipulator.
- To understand the mechanical design and robot arm kinematics
- To learn and understand the various linear control techniques on manipulators
- To learn and understand the various non-linear control techniques on manipulators
- To learn the robot programming and demonstrate the robot in various applications

INTRODUCTION TO SERIAL MANIPULATORS

Types of Industrial Robots, Definitions – Classifications Based on Work Envelope – Generations Configurations and Control Loops - Coordinate Systems – Need for Robot – Basic Parts and Functions – Specifications – Robotic Sensor - Position and Proximity's Sensing – Tactile Sensing – Sensing Joint Forces.

MECHANICAL DESIGN OF ROBOT SYSTEM

Robot Motion – Linkages and Joints – Mechanism – Method for Location and Orientation of Objects - Kinematics of Robot Motion – Direct and Indirect Kinematics Homogeneous Transformations – D-H Transformation – Drive Systems – End Effectors – Types, Selection, Classification and Design of Grippers – Gripper Force Analysis.

ROBOT DYNAMICS AND TRAJECTORY PLANNING

Trajectory planning – joint space, Cartesian space description and trajectory planning – third order, fifth order - Polynomial trajectory planning-control overview, Dynamic equations- control - Types of Programming – Teach Pendant Programming –Robotic Cell Layouts – Inter Locks-control overview

MOBILE ROBOTICS

Wheeled Robot and Legged Robot – Architecture - Configurations and Stability - Design Space and Mobility Issues - Teleportation and Control – Localization – Navigation – AGV – AMR

APPLICATIONS OF ROBOTS

Architecture and working - Manufacturing Industries - Material Handling, Assembly, Inspection. Surgical robot – Haptics technology– Space vehicle and unmanned aerial vehicle – Underwater- ROV, AUV – Robot in Nuclear industry – Humanoid Robots – special type of robots

REFERENCES

1. Saeed B. Niku, “Introduction to Robotics: Analysis, Control, Applications”, 3rd edition, John Wiley & sons, Inc., 2019.
2. John J. Craig, "Introduction to Robotics – Mechanics and control”, 3rd edition, Pearson Higher Education 2014.
3. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987.
4. Groover,M.P., Weis,M., Nagel,R.N. and Odrey,N.G., “Industrial Robotics Technology, Programming and Applications”, Mc Graw-Hill, Int., 2012.
5. Klafter,R.D., Chmielewski, T.A. and Negin,M., “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 1988.
6. Kevin M Lych and frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, First Edition, 2017.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain types, configurations, sensors, and architecture of industrial robots	PO1 (2), PO3 (1), PO4 (1)	2	1
CO2	Apply kinematics, trajectory planning, gripper design, and programming for robot tasks	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate robot forces, motion parameters, stability, and path planning	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze integration of robotic systems for manufacturing, mobile robots, and applications	PO1 (3), PO2 (2)	3	2

CC25C01	Digital Twin and Industry 5.0	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the fundamental principles and concepts of digital twin technology.
- To apply digital twin techniques to analyze and optimize complex systems.
- To develop skills in designing and implementing digital twin models for real-world applications.
- To evaluate the benefits and limitations of digital twin technology in various industries.
- To critically analyze and interpret data obtained from digital twin simulations.

Introduction to Digital Twin and Enabling Technologies

Definition of Digital Twin, types of industry and key requirements, importance and applications in process, product, and service industries, history of Digital Twin, role of Digital Twin Technology (DTT) in industrial innovation, technologies and tools enabling Digital Twin, virtual CAD models, control parameters, real-time systems, handshaking through internet, cyber-physical systems.

Digital Twin in Discrete and Process Industries

Basics and trends in discrete industry, control system requirements in discrete industry, digital twin of a product, digital thread in discrete industry, data collection and analysis for product and production improvements, automation simulation, digital enterprise. Basics and trends in process industry, control system requirements in process industry, digital twin of a plant, digital thread in process industry, data collection and analysis for process improvements, process safety, automation simulation, digital enterprise.

Industry 5.0 and Smart Manufacturing

Industrial revolutions overview, definition and principles of Industry 5.0, applications of Industry 5.0 in process and discrete industries, benefits and challenges of Industry 5.0, smart manufacturing, Internet of Things 5.0, industrial gateways, basics of communication requirements, cognitive systems in Industry 5.0.

Benefits and Applications of Digital Twin

Improvement in product quality, enhancement of production processes and process safety, identifying bottlenecks and improving efficiency, achieving production flexibility, continuous prediction and tuning of processes through simulation, reducing time to market.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Quiz - 10%
Assignments - 20%
Virtual Demonstration - 15%
Flipped Classroom - 5%
Internal Examinations - 50%

References:

1. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing the Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2018
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019
3. Uthayan Elangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press,2022.
4. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress., United States ,2015

E-Resources:

1. https://nptel.ac.in/courses/110/106/110106169 – NPTEL: Digital Transformation Strategy (IIT Roorkee) – includes modules on Digital Twin and smart industry practices.
2. https://www.coursera.org/learn/digital-twin – Coursera: Digital Twins: Implementation (by University of Colorado) – practical insights into Digital Twin applications.
3. https://www.edx.org/course/industry-4-0-how-to-revolutionize-your-business – edX: Industry 4.0 – covers evolution to Industry 5.0, smart factories, and Digital Twin technology.

CO	Course Outcome (CO)	POs Mapped	PSO1	PSO2
CO1	Explain concepts, enabling technologies, and applications of Digital Twin	PO1 (2), PO3 (1)	2	1
CO2	Apply Digital Twin in discrete and process industries for simulation and process improvements	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate performance improvements, efficiency gains, and bottleneck resolutions using Digital Twin	PO1 (3), PO2 (2), PO3 (2)	3	2
CO4	Analyze Industry 5.0 principles, smart manufacturing systems, and real-time integration of Digital Twin	PO1 (3), PO2 (2), PO3 (2)	3	2

MF25015	System Simulation for Manufacturing Engineers	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To teach the concept of system simulation and their importance in industries and the various techniques used for generating the random numbers.
2. To discuss about the generation techniques and the use of the random numbers in simulation, tests, validity, verification, models of simulation and analysis.
3. To train the students to solve the real time problems in the discrete systems by using a simulation software.

PREAMBLE TO SYSTEM SIMULATION

Systems, general systems theory, Functions/Relationship, concept of simulation, Stochastic activities, Types of Models, Principles used in Modeling, simulation as a decision-making tool, types of simulation, Important measures of performance, Advantages and disadvantages of simulation, Steps in simulation model building.

RANDOM NUMBERS

Methods of generating random numbers, Desirable attributes of random numbers, manual methods, computerized methods, Pseudo random numbers and random variates, discrete and continuous random probability distributions, tests for random numbers, Need for testing random numbers, Application of random numbers in simulation models

DESIGN OF SIMULATION

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation, validation. Monte Carlo method of simulation, Manual simulation techniques

SIMULATION SOFTWARE AND DATA HANDLING

Study and selection of simulation languages, Animation based Simulation packages, Selection of Simulation language / package, Use of any one of the simulation software for simulation model building, programmable blocks, Creation of database, Data handling and reporting, terminating conditions, Interpretation of results using statistical analysis

ADVANCED HEURISTICS AND AREAS OF APPLICATION

Ear deaf Analysis - Development of simulation models for Manufacturing and production systems, inventory optimization techniques, Advanced Sequencing and Scheduling problems, queuing systems - Problems,
Heuristics for scheduling - Single pass heuristics, multipass heuristics, Evolutionary Optimization techniques - Genetic algorithm, Ant Colony algorithm, Particle Swarm optimization - Case studies.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Quiz - 10%
Assignments - 20%
Virtual Demonstration - 15%
Flipped Classroom - 5%
Internal Examinations - 50%

REFERENCES:

1. Banks J., Nelson B.L., Nicol D.M and Shahabudeen. P, "Discrete event system simulation", 4th edition Prentice Hall, India, 2005.
2. R. Pannerselvam and P. Senthilkumar, 'System Simulation, Modelling and languages, PHI Learning Pvt, Ltd, 2013
3. Law A.M. and Kelton W.D., "Simulation Modeling and Analysis", 2nd edition, McGraw Hill Inc. (2015), New York.
4. Geoffrey Gordon, "System Simulation", second edition, Prentice Hall, India, 2005.
5. Shannon R.E., "systems simulation – The art and Science", Prentice Hall, 1975.
6. Hardbound by Altaf Q. H. Badar,'Evolutionary Optimization Algorithms' 1st Edition 2021 , CRC Press

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the concepts, types of simulation, random numbers, and simulation design	PO1 (2), PO4 (2)	2	1
CO2	Apply simulation techniques, Monte Carlo methods, and software tools to model systems	PO1 (3), PO3 (3)	3	2
CO3	Estimate performance measures, experimental results, and validate simulation models	PO1 (3), PO2 (3), PO3 (3)	3	2
CO4	Analyze advanced heuristics, scheduling, queuing, and optimization in manufacturing systems	PO1 (3), PO2 (3), PO3 (3)	3	2

MF25016	Fluid Power Automation	L	T	P	C
		3	0	0	3

Course Objectives:

- To make the students to learn the basic concepts of hydraulics and pneumatics and their controlling elements in the area of manufacturing process.
- To train the students in designing the hydraulic and pneumatic circuits using various design procedures.
- To understand the concept and principle operation of automation systems and their controls.
- To provide knowledge levels needed for PLC programming and operating
- Ability to implement automation systems in Industry

Introduction

Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatics – Selection criteria.

Fluid Power Generating/Utilizing Elements

Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-Drive characteristics – Linear actuator – Types, mounting details, cushioning – power packs – construction. Reservoir capacity, heat dissipation, accumulators – standard circuit symbols, circuit (flow) analysis.

Control and Regulation Elements

Direction flow and pressure control valves-Methods of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and underlapped spool valves-operating characteristics-electro hydraulic servo valves, Digital valves -Different types-characteristics and performance.

Circuit Design

Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method-truth tableKarnaugh map method-sequencing circuits-combinational and logic circuit.

Electro Pneumatics & Electronic Control of Hydraulic and

Pneumatic Circuits

Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram. Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology:

Quiz - 10%

Assignments - 20% Virtual Demonstration - 15% Flipped Classroom - 5% Internal Examinations - 50%

References:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2. Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967.
3. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978
4. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
5. Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.
6. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979
7. W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education, 2003.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of fluid power systems, ISO symbols, and comparison of hydraulic & pneumatic systems	PO1 (2), PO3 (2)	2	1
CO2	Apply selection criteria for pumps, motors, actuators, valves, and design industrial circuits	PO1 (3), PO2 (3), PO3 (3)	3	2
CO3	Estimate performance, sizing, and operating parameters of hydraulic and pneumatic elements	PO1 (3), PO2 (3), PO3 (3)	3	2
CO4	Analyze electro-pneumatic and electronic control circuits including PLC-based systems	PO1 (3), PO2 (3), PO3 (3)	3	2

MF25017	Biomaterials	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the fundamentals of biomaterials, biocompatibility, and the structure–property relationships of metallic, ceramic, and polymeric materials used in biomedical applications.
- To analyze the biomechanics of joints and the mechanical behavior of hard and soft tissues for the design and evaluation of biomedical implants and devices.

Introduction to Biomaterials:
Introduction - Property requirement of biomaterials; Concept of biocompatibility

Activities: Biomaterial selection chart for medical applications, Case study on biocompatibility failure, Video demo on implant–tissue interaction

Bio materials:

Metals: Introduction - Titanium alloys, Stainless steel, Co-Cr-Mo alloys, Magnesium alloys, Aluminium based alloys, and Nickel based alloys - Metal manufacturing – Casting , Powder metallurgy, Metal forming.

Activities: Layout drawing of metallic implant manufacturing routes, Comparative study of Ti alloys vs SS vs Co–Cr alloys, Lab demo or video on metal casting and powder metallurgy

Ceramics – Introduction - processing of bio ceramics- ceramics, bio ceramics and glassessintering and mechanical properties of bio ceramics-fracture and toughening of ceramic composites.- Ceramics manufacturing , Ceramic powder processing, casting, Extrusion and Injection molding , Compaction.

Activities: Process flow diagram of bioceramic manufacturing, Comparative analysis of ceramics vs bioglasses, Video demo on sintering and fracture behavior of bioceramics

Polymers – Introduction – classification of polymers - Structure and properties of polymer – Importance of Biodegradable polymers- Types of Biodegradable polymers - Polymers manufacturing, polymer processing – compression moulding – powder injection moulding – extrusion.

Activities: Classification chart of biomedical polymers, Performance comparison of biodegradable polymers, Lab demo or video on extrusion and injection moulding of polymers

Biomechanics of Joints: Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, mechanics of the elbow, mechanics of shoulder, Spinal column, mechanics of hip, knee and ankle.

Activities: Free-body diagram and force analysis of human joints, Numerical problems on elbow and knee mechanics, Animation/video demo on joint motion and load transfer

Tissue Mechanism:

Hard: Bone structure & composition, mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models- anisotropy, Electrical properties of bone, fracture mechanisms.

Activities: Microstructure sketch of cortical and cancellous bone, Stress–strain analysis using Maxwell and Voigt models, Case study on bone fracture mechanisms

Soft: Pseudo elasticity, nonlinear stress-strain relationship, Viscosity, Structure, Function and mechanical properties of skin, ligaments and tendons.

Activities: Stress–strain curve plotting for soft tissues, Comparative study of ligaments vs tendons vs skin, Video demo on viscoelastic and nonlinear behavior of soft tissues

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Ratner, Hoffman, Schoet and Lemons, "Biomaterials Science: An introduction to Materials in Medicine", Second Edition: Elsevier Academic Press, 2004.
2. B. Basu, D. Katti and Ashok Kumar; "Advanced Biomaterials: Fundamentals, Processing and Applications", John Wiley & Sons, Inc., USA, 2009.
3. Fredrick H. Silver and David L Christiansen, "Biomaterials Science and Biocompatibility", Springer, 1999
4. Jonathan Black, "Biological Performance of Materials: Fundamentals of Biocompatibility" Fourth Edition: CRC Taylor & Francis Group, London, 2006.

E-resources and Other Resources:

1. https://nptel.ac.in/courses/113104009/
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-00sc-introduction-to-materials-science-fall-2010/
3. https://www.coursera.org/learn/biomaterials
4. https://www.edx.org/learn/biomaterials
5. https://www.classcentral.com/subject/biomaterials
6. https://www.khanacademy.org/science/health-and-medicine/orthopedics-biomechanics
7. https://www.ncbi.nlm.nih.gov/books/NBK482434/
8. https://www.materialsproject.org/
9. https://www.uio.no/english/subjects/engineering/materials-science/courses/biomaterials/
10. https://learncheme.com/biomaterials-courses/

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand biomaterial fundamentals, biocompatibility, and structure–property relationships of metals, ceramics, and polymers	PO1 (3), PO3 (2)	3	2
CO2	Apply knowledge of biomaterial processing and manufacturing techniques for biomedical applications	PO1 (3), PO2 (2)	3	3
CO3	Analyze biomechanics of joints and mechanical behavior of hard and soft tissues	PO1 (3), PO3 (3)	2	3
CO4	Evaluate material selection and tissue response for the design and performance of biomedical implants	PO2 (2), PO3 (3)	3	3