ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. CAD / CAM

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 and materials engineering techniques to design and optimize sustainable production systems.
PSO2	Integrate smart technologies and sustainable practices for innovative product development and lifecycle management.

ANNA UNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., CAD / CAM **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 per week			TCP	Credits	Category
				L	T	P			
1.	MA25C06	Applied Mathematical and Statistical Modelling	T	3	1	0	4	4	BS
2.	CD25C01	Computer Graphics	LIT	3	0	2	5	4	ES (PC)
3.	CC25101	Applied Materials Engineering	T	3	0	0	3	3	ES (PC)
4.	CC25102	Computer Aided Manufacturing	LIT	3	0	2	5	4	ES (PC)
5.	ED25C07	Design for Sustainability	T	3	0	0	3	3	ES (PC)
6.	ED25C06	Integrated Product Design and Development	T	3	0	0	3	3	ES (PC)
7.	CC25103	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**25**	**22**	

Semester II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	ED25C08	Finite Element Methods	LIT	2	0	4	6	4	ES (PC)
2.	CC25201	Additive Manufacturing	LIT	2	0	2	3	3	ES (PC)
3.	CD25C03	Product Life Cycle Management	T	3	0	0	3	3	ES (PC)
4.		Programme Elective – I	T	3	0	0	3	3	ES (PE)
5.		Programme Elective – II	T	3	0	0	3	3	ES (PE)
6.	CC25202	Advanced Computing Laboratory	L	0	0	4	4	2	ES (PC)
7.		Industry-Oriented Course I	--	1	0	0	1	1	SD
8.		Self-Learning Course	--	-	-	-	-	1	-
Total Credits							**23**	**20**	

Semester III

S. No.	Course Code	Course Title	Type	Periods per week			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.		Industrial Training	--	--	--	--	--	2	SD
6.		Industry-Oriented Course II	--	1	0	0	1	1	SD
7.	CC25301	Project Work I	PW	0	0	12	12	6	SD
Total Credits							**25**	**21**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	CC25401	Project Work II	PW	0	0	24	24	12	SD
Total Credits							**24**	**12**	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods per week			Total Contact Periods	Credits
			L	T	P		
1.	CC25001	Computer Integrated Manufacturing	3	0	0	3	3
2.	CC25002	Mechatronics and Automation	3	0	0	3	3
3.	CC25003	Industrial Robotics and Artificial Intelligence	3	0	0	3	3
4.	CC25004	Advanced Optimization Techniques	3	0	0	3	3
5.	CC25005	Design for Manufacturing and Assembly	3	0	0	3	3
6.	CC25006	Sensors for Manufacturing and Condition Monitoring	3	0	0	3	3
7.	ED25C12	Composite Materials and Mechanics	3	0	0	3	3
8.	CC25007	Industrial Automation	3	0	0	3	3
9.	CC25008	Machine Learning for Intelligent Systems	3	0	0	3	3
10.	CC25C01	Digital Twin and Industry 5.0	3	0	0	3	3
11.	CC25009	Quality and Reliability Engineering	3	0	0	3	3
12.	ED25C11	Design with Advanced Materials	3	0	0	3	3
13.	CC25010	Mechanical Behaviour of Materials and their Measurements	3	0	0	3	3
14.	ED25C14	Design of Hydraulic and Pneumatic Systems	3	0	0	3	3
15.	CC25011	Design of Hybrid and Electric Vehicles	3	0	0	3	3

Semester I

MA25C06	Applied Mathematical and Statistical Modelling	L	T	P	C
		3	1	0	4

Course Objectives:

- To equip students with advanced mathematical techniques, specifically Fourier Transforms, for formulating and solving partial differential equations that model fundamental mechanical engineering phenomena such as heat transfer, vibrations, and fluid flow.
- To provide a strong foundation in statistical inference, enabling students to estimate population parameters (like material properties and process capabilities) from experimental data and assess the quality and reliability of these estimators.
- To enable students to design efficient, structured experiments and apply appropriate statistical tests to make valid, data-driven decisions for comparing processes, optimizing designs, and solving complex engineering problems.

Fourier Transform: Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity, Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

Estimation Theory: Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.

Testing of Hypothesis: Sampling distributions, Small and large samples, Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, independent of attributes.

Design of Experiments: Analysis of variance, One way and two-way classifications, Completely randomized design, Randomized block design, Latin square design, 2^2 Factorial design.

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

References:

1. Andrews, L. C., & Shivamoggi, B. K. (2003). Integral transforms for engineers. Prentice Hall of India.
2. Devore, J. L. (2014). Probability and statistics for engineering and the sciences, Cengage Learning.
3. Johnson, R. A., Miller, I., & Freund, J. (2015). Miller and Freund's probability and statistics for engineers, Pearson Education Asia.

E-resources:

1. https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data
2. https://www.itl.nist.gov/div898/handbook/
3. https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008

CD25C01	Computer Graphics	L	T	P	C
		3	0	2	4

Course Objectives:

The primary objective of this course is to equip students with a comprehensive understanding of computer graphics principles, algorithms, and modeling techniques essential for engineering applications. The course aims to build foundational knowledge in 2D and 3D graphics, scan-conversion algorithms, and geometric transformations. It develops the ability to model curves, surfaces, and solids using analytical and synthetic methods, including advanced tools such as NURBS. Students will gain proficiency in visibility determination and rendering techniques to simulate realistic graphics. Additionally, the course introduces concepts of assembly modeling, tolerance analysis, and product lifecycle management to integrate design, simulation, and visualization skills relevant to modern computer-aided design environments.

Fundamentals of Computer Graphics and Scan Conversion: Introduction to Computer Graphics, Scan-conversion of Lines: Digital Differential Analyzer (DDA) Algorithm, Bresenham's Line Drawing Algorithm, Scan-conversion of Circles and Ellipses: Bresenham's Circle Drawing Method, Midpoint Circle Algorithm, Drawing Ellipses and Other Conics

Activities: Manual Implementation of Bresenham's Line and Circle Algorithms: Plot pixels on graph paper and replicate the same using code; observe the difference in pixel placement and accuracy.

2D and 3D Transformations and Clipping: Introduction to 2D and 3D Transformations, Transformation Matrix, 2D Transformations: Identity, Scaling, Rotation, Translation, Reflection, Shear, Rotation about Arbitrary Point, Combined Transformations. Clipping Techniques: 2D Clipping: Point, Line, Polygon Clipping, 3D Viewing and Clipping, Text Clipping

Activities: Hands-on 2D Transformations Using Paper Cutouts: Physically perform translation, rotation, scaling, reflection, and clipping on shape cutouts to understand transformation matrices.

Curve and Surface Modeling: Introduction to Curves: Analytical Curves: Line, Circle, Conics, Synthetic Curves: Hermite Cubic Spline, Bézier Curve, B-Spline Curve, Curve Manipulations, Introduction to Surfaces: Analytical Surfaces: Plane, Ruled, Revolution, Tabulated Cylinder, Synthetic Surfaces: Hermite Bicubic, Bézier, B-Spline, Surface Manipulations

Activities: Sketching and Interpreting Bézier Curves: Manually construct Bézier curves using control points and then compare results with simulation using MATLAB or Python.

Nurbs and Solid Modeling Techniques: NURBS Basics: Curves, Lines, Arcs, Circle, Bilinear Surface, Solid Modeling Techniques: Regularized Boolean Set Operations, Primitive Instancing, Sweep Representations, Boundary Representations, Constructive Solid Geometry (CSG) Comparison of Solid Representations, User Interface for Solid Modeling

Activities: Solid Modeling Using Free CAD Tools: Design simple components by applying Boolean operations and sweep features to reinforce constructive solid geometry concepts.

Visibility, Rendering, and Shading Techniques: Visible and Hidden Surface Removal: Coherence, Bounding Volumes, Back Face Culling, Painter's Algorithm, Z-Buffer, Floating Horizon, Roberts Algorithm, Object Rendering: Lighting and Illumination Models, Shading Techniques: Flat, Gouraud, Phong, Polygon Mesh Shading, Advanced Effects: Transparency, Shadows, Texture Ray Tracing, Ray Casting, Radiosity, Color Models

Activities: Shadow and Visibility Demonstration Using 3D Block Models: Use a torchlight on physical models to simulate surface visibility, shading, and hidden surface removal principles.

Assembly Modeling and Product Lifecycle: Assembly of Parts: Design for Manufacture (DFM), Design for Assembly (DFA), Computer-Aided DFMA, Position & Orientation Inferences, Tolerance Analysis, Center of Gravity & Mass Property Calculation, Mechanism Simulation, Product Lifecycle Management (PLM): Product Development and Management, Models for New Product Development, Graphics & Computing Standards, Data Exchange Standards

Activities: CAD activity: Assemble 2–3 parts with constraints and generate exploded views**.,** Case study discussion: How PLM integrates design, manufacturing, and lifecycle management**.**

List of Experiments:

Cad Module

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 3Dmodel.
6. Exercise on. STL file Preparation, Slicing, Support Structure Generation & Build setup Preparation.

List of items (hardware/software) required:

1. Computers 24 Nos. 2. CAD software Package 3. Open source CAD software for Additive Manufacturing 4. CAE Software package

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. Boothroyd, G. (1991). Assembly automation and product design. Marcel Dekker.
2. Chitale, A. K., & Gupta, R. C. (2023). Product design and manufacturing (7th ed.). PHI Learning Private Limited.
3. Rogers, D. F., & Adams, J. A. (2017). Mathematical elements for computer graphics (2nd ed.). Tata McGraw-Hill.
4. Hearn, D. D., & Baker, M. P. (1997). Computer graphics C version (2nd ed.). Prentice Hall.
5. Zeid, I. (2006). Mastering CAD/CAM (2nd ed.). McGraw Hill.
6. Newman, W. M., & Sproull, R. F. (2001). Principles of interactive computer graphics (1st ed.). McGraw Hill.

E-Resources:

1. Bhattacharya, S. (2025). Computer Graphics [NPTEL Online Course]. Indian Institute of Technology Guwahati. Retrieved from https://onlinecourses.nptel.ac.in/noc25_cs133
2. Indian Institute of Technology Delhi, Department of Computer Science & Engineering. (2023). Introduction to Computer Graphics [NPTEL Course No. 106102065]. National Programme on Technology Enhanced Learning (NPTEL). Retrieved from https://nptel.ac.in/courses/106/102/106102065
3. Das, S. (2008). Lecture Series on Computer Graphics [YouTube Video Lectures]. Indian Institute of Technology Madras. Retrieved from https://www.youtube.com/watch?v=_f_pHgRQPPE

	Description of CO	PO	PSO1	PSO2
CO1	Understand and implement fundamental computer graphics algorithms such as scan-conversion, 2D/3D transformations, and clipping techniques.	PO3 (3)	2	2
CO2	Model curves, surfaces, and solids using analytical and synthetic methods, including NURBS and solid modeling techniques.	PO3 (3)	3	2
CO3	Apply visibility determination, rendering, and shading techniques to generate realistic images and simulations.	PO3 (3)	3	2
CO4	Integrate CAD assembly modeling, tolerance analysis, and product lifecycle management concepts for effective product design and visualization.	PO1 (2), PO2 (2), PO3 (3)	3	3

CC25101	Applied Materials Engineering	L	T	P	C
		3	0	0	3

Course Objectives:

- To provide knowledge in the areas of elastic and plastic behavior of materials, and fracture behavior of materials.
- To elaborate the theories on plastic forming and applications of advanced materials.
- To study about the selection of material.

Elastic and Plastic Behaviour: Deformation Mechanisms: Elastic, plastic, and viscoelastic behavior; mechanisms of elastic and plastic deformation.Crystalline Deformation: Shear strength of perfect and real crystals; deformation by slip and twinning. Strengthening Mechanisms: Solid solution strengthening, grain boundary strengthening, polyphase mixture strengthening, precipitation strengthening, particle, fiber, and dispersion strengthening; work hardening.

Fracture Behaviour: Fracture: Types of fracture (ductile, brittle), Griffith's theory, ductile-to-brittle transition in steel.

Fatigue of Metals: Strain-life equation, low and high cycle fatigue tests, crack initiation and propagation mechanisms.

High Temperature Fracture: Creep and stress rupture; characteristics of high-temperature alloys; brittle-fracture problem.

Activities: Calculate elastic strain energy, yield strength, and plastic strain for given stress–strain data. Use software (ANSYS/ABAQUS/CAE tools) to visualize crack propagation under cyclic load, Paper clip bending experiment → students observe crack initiation and failure.

Plastic Forming of Metals: Fundamentals of Metal Working: Mechanics of metal working, flow-stress distribution, residual stresses, temperature effects in metal working.

Forging: Forging in plane strain, open and closed die forging.

Rolling: Forces and geometrical relationships in rolling, theories of cold and hot rolling.

Sheet Metal Forming: Bending and stretch forming.

Activities: Sheet metal bending with simple fixtures to observe spring-back.

Advanced Materials: Advanced Metallic Alloys: High strength ferrous and non-ferrous alloys; properties and applications.

Engineering Plastics: Properties and applications of various engineering plastics.

Composites: Introduction to composite materials, types, properties, and applications.

Emerging Materials: Functionally gradient materials (FGMs), Smart materials (e.g., shape memory alloys, piezoelectric materials), Nano materials, Biomaterials.

Activities: Case Study**:** Students research and present applications of smart materials

(SMA in medical stents, piezoelectric in sensors, nanomaterials in coatings), Prepare comparison tables for engineering plastics vs composites vs biomaterials**.**

Selection of Materials: Fundamentals of Material Selection: Motivation for material selection, cost basis, and service requirements.

Selection Criteria: Selection for mechanical properties (strength, stiffness, toughness), selection for surface durability (wear, corrosion, fatigue).

Processing-Selection Relationship: Relationship between materials processing and material selection.

Case Studies: Practical examples of materials selection with relevance to diverse applications such as aerospace, automotive, marine, machinery, and nuclear sectors.

Activities: Case Study Problems**:** Select materials for an aircraft wing, car body, ship propeller, and biomedical implant, Rank materials based on strength-to-weight ratio and cost efficiency.

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. ASM International. (2002). ASM handbook, volume 11: Failure analysis and prevention. ASM International.
2. ASM International. (1990). ASM handbook, volume 02: Properties and selection: Nonferrous alloys and special-purpose materials. ASM International.
3. Dieter, G. E., & Bacon, D. (2021). Mechanical metallurgy (4th ed.). McGraw Hill Education.
4. Smallman, R. E., & Ngan, A. H. W. (2007). Physical metallurgy and advanced materials. Butterworth-Heinemann.
5. Crane, F. A. A., Charles, J. A., & Furness, J. A. G. (2006). Selection and use of engineering materials. Reed Elsevier India.

E-Resources:

1. "Introduction to Materials Science and Engineering" by Prof. Rajaraman G. (IIT Madras): https://nptel.ac.in/courses/112106198 (Covers fundamentals, structure, properties, and some processing).
2. "Mechanical Behavior of Materials" by Prof. S. Sankaran (IIT Madras): https://nptel.ac.in/courses/112106290 (Directly relevant to Unit I and II).
3. "Fundamentals of Manufacturing Processes" by Prof. D. K. Dwivedi (IIT Roorkee): https://nptel.ac.in/courses/112107212 (Covers metal forming processes relevant to Unit III).
4. "Advanced Engineering Materials" by Prof. B.S. Murty (IIT Madras): https://nptel.ac.in/courses/113106032 (Covers advanced materials, relevant to Unit IV).

Other Resources:

Science and Technology of Materials": https://ocw.mit.edu/courses/3-016-science-and-technology-of-materials-fall-2009/

	Description of CO	PO	PSO1	PSO2
CO1	Understand and explain the elastic, plastic, and fracture behavior of engineering materials.	PO1 (3), PO3 (3)	1	1
CO2	Analyze and apply theories of plastic deformation and metal forming processes such as forging, rolling, and sheet metal forming.	PO1 (3), PO3 (3)	2	1
CO3	Evaluate the properties and applications of advanced materials including composites, engineering plastics, smart materials, and biomaterials.	PO1 (3), PO3 (3)	3	3
CO4	Develop skills in selecting appropriate materials based on mechanical properties, surface durability, cost, and processing considerations for various engineering applications.	PO1 (3), PO2 (2), PO3 (3)	2	3

CC25102	Computer Aided Manufacturing	L	T	P	C
		3	0	2	4

Course Objectives:

- To introduce the evolution of CAD, CAM, CIM, engineering product specification and interpreting geometric specifications.
- To train the candidates on the integration of Computer Aided Design and Computer Aided Manufacturing and to introduce with the implementation of CAD and CAM in manufacturing process
- To impart knowledge on manual part program and generation of CNC part program using Computer Aided Manufacturing packages and to introduce the importance of Internet of Things in Computer Aided Manufacturing

Introduction to CAM and CAD/CAM Integration: Introduction to CAD, CAM, CAE, CIM, system configuration for CAM including hardware and software, evolution of product realization, historical development, engineering product specification, geometric tolerancing – ASME, ISO and DIN standards, interpreting geometric specifications, multiple part features and datum. Introduction to CAD and CAM integration, networking – techniques, components, interface cards, network standards, graphics standards – graphical kernel system, data exchange formats – IGES and STEP, integration of CAD and CAM in CNC turning center and machining center.

Activities: Students create a simple CAD model in SolidWorks/AutoCAD and apply GD&T symbols, Group Activity**:** Explore different CAD–CAM–CAE software (AutoCAD, SolidWorks, CATIA, NX, ANSYS) and present integration capabilities.

Process Planning and Enterprise Systems: Process planning, computer-aided process planning (CAPP), product life cycle management (PLM), enterprise resource planning (ERP).

Activities: Use a CAPP software/demo version to generate process routes, Simulate how PLM/ERP integrates design, manufacturing, and supply chain in a classroom scenario.

CNC Machines and Hardware Components: CNC machine building, structural details, guide ways – friction, anti-friction and other types, motion conversion elements – screw and nut, recirculating ball screw, spindle assembly, torque transmission elements – gears, timing belts, flexible couplings, bearings, spindle and feed drives, linear motors –

open loop and closed loop control, axis measuring systems – grating, linear scale, encoder, laser interferometer, spindle cooling systems, coolant types – through and shower coolant, integral spindle with HSK & Big Plus spindle, double ball screws, grease lubricating system, probing for zero offsets and first-off inspection, tool breakage detecting system, in-process gauging system, ATC, APC

Activities: Disassemble and assemble a ball screw or spindle bearing (if lab facility exists), : Use online CNC simulator (e.g., FANUC Simulator, NC Viewer) to understand hardware/software interaction.

CNC Programming and IoT in CAM: Structure of CNC program, coordinate system, G & M codes, cutter radius compensation, tool nose radius compensation, tool wear compensation, canned cycles, mirroring features, manual part programming for CNC turning and machining center, macro programming, wire EDM, abrasive water jet cutting, bulk and sheet metal forming, generation of CNC program using CAM software. Introduction to IoT in CAM, overview of IoT-enabled manufacturing systems, real-time and multi-source manufacturing information sensing, IoT-enabled smart assembly station, cloud computing-based manufacturing resources configuration, real-time key production performance analysis, real-time information-driven production scheduling.

Activities: Write G & M code manually for turning and milling operations, Students create a cloud-based dashboard mock-up for real-time machine status visualization.

List of Experiments:

1. Programming and simulation for various operations using canned cycle for CNC turning Centre.
2. Programming and simulation for machining of internal surfaces in CNC turning Centre
3. Programming and simulation for profile milling, circular and rectangular pocket milling operations
4. Programming and simulation using canned cycle for CNC Milling such as peck drilling and tapping cycle
5. CNC code generation using CAM software packages – Milling and Turning
6. Study on RDBMS and its application in problems like inventory control MRP.

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., Soh, K., Ong, Y. G., & Wang, Y. (2012). Computer applications in near net shape operations (softcover reprint of 1st ed.). Springer Nature.
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. (2009). Computer aided manufacturing Pearson Prentice Hall.
5. HMT. (c. 2011). Mechatronics. Tata McGraw Hill Publishing Company.
6. Rao, P. N. (2010). CAD/CAM: Principles and applications. Tata McGraw Hill.

E-Resources:

1. Chawla, A., & Madhusudan Rao, P. V. (2012). *Computer Aided Design and Manufacturing* [Video lectures]. National Programme on Technology Enhanced Learning (NPTEL), IIT Delhi. Retrieved from https://nptel.ac.in/courses/112102101
2. Ramkumar, J., & Singh, A**.** (2021). *Computer Integrated Manufacturing (CIM)* [Online course]. National Programme on Technology Enhanced Learning (NPTEL), IIT Kanpur. Retrieved from https://onlinecourses.nptel.ac.in/noc21_me65/preview
3. Ramkumar, J. (2022). *Automation in Manufacturing* [Online course]. National Programme on Technology Enhanced Learning (NPTEL), IIT Kanpur. Retrieved from https://onlinecourses.nptel.ac.in/noc22_me123/preview

Other Resources:

1. Subirana, B., & Malone, T. W. (2003). *Information Technology as an Integrating Force in Manufacturing* (Course No. 15.566). MIT OpenCourseWare, Massachusetts Institute of Technology. Retrieved from https://ocw.mit.edu/courses/15-566-information-technology-as-an-integrating-force-in-manufacturing-spring-2003/
2. Boning, D. S., & Hardt, D. E. (2008). *Control of Manufacturing Processes* (Course No. 2.830J). MIT OpenCourseWare, Massachusetts Institute of Technology. Retrieved from https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-spring-2008/

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1	Understand the fundamentals of CAD, CAM, CIM, and their integration in manufacturing processes, including geometric tolerancing standards.	PO1 (3), PO3 (3)	1	1
CO2	Develop and simulate CNC part programs manually and using CAM software for turning and milling operations.	PO1 (3), PO3 (3)	2	1
CO3	Analyze CNC machine components, their functions, and control systems including tool compensation and probing systems.	PO1 (3), PO3 (2)	3	2
CO4	Apply Internet of Things (IoT) concepts in CAM for smart manufacturing, real-time monitoring, and production optimization.	PO1 (3), PO2 (2), PO3 (3)	2	3

ED25C07	Design for Sustainability	L	T	P	C
		3	0	0	3

Course Objective:

The main learning objective of this course is to prepare the students for understanding the design for sustainable behaviour and design practices.

Foundations of Sustainable Design: Understanding sustainability through design**-** Challenges and evolution toward sustainable solutions**-** Product lifecycle design and eco-efficient product-service systems (PSS)**-** Eco-design principles, strategies, and green design methodologies

Activities: Lifecycle Mapping and Eco-Design Redesign

Design for Sustainable Behaviour (DSB): Behavioral change through design**-** Comprehensive Action Determination Model (CADM), Methods and tools to support sustainable behaviour**-** Individual cognitive vs context-driven approaches**-** Frameworks and future research in DSB

Activities: Designing for Sustainable User Behavior Using CADM

Design for Environment (DE): Global, regional, and local environmental objectives**-** Lifecycle assessment (LCA) methods and tools, Environmentally responsible product assessment (e.g., AT&T method), Design techniques: minimizing material use, disassembly, recyclability, energy efficiency.

Activities: Lifecycle Assessment of Competing Product Designs

Product-Service Systems and Systemic Sustainability Design: Transition from product to integrated product-service design- Categories and practices of PSS for sustainability- Systemic design at regional/territorial levels- Regulatory frameworks, innovation levels, and evolution of sustainable design.

Activities:

Conceptualizing a Sustainable Product-Service System (PSS)
Systemic Design Case Study: Regional Sustainability in Practice

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

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

References:

1. Ceschin, F., & Gaziulusoy, I. (2020). Design for sustainability: A multi-level framework from products to socio-technical system. Routledge.
2. Boothroyd, G. (1980). Design for assembly automation and product design. Marcel Dekker.
3. Bralla, J. G. (1999). Design for manufacture handbook. McGraw-Hill.
4. Boothroyd, G., Heartz, W., & Nike, P. (1994). Product design for manufacture. Marcel Dekker.

5. Dickson, J. R., & Corroda, P. (1995). Engineering design and design for manufacture: A structural approach. Field Stone Publishers.
6. Fixel, J. (1996). Design for the environment. McGraw-Hill.
7. Graedel, T. E., & Allenby, B. R. (1996). Design for the environment. Pearson.
8. Otto, K., & Wood, K. (2009). Product design (4th impression). Pearson.

E-resources:

1. Massachusetts Institute of Technology, Department of Civil & Environmental Engineering. (2006). *Design for Sustainability* (Course No. 1.964, Fall 2006). MIT OpenCourseWare. Retrieved from https://ocw.mit.edu/courses/1-964-design-for-sustainability-fall-2006/
2. University of Melbourne, Department of Mechanical Engineering. (2023). *Sustainable and Life Cycle Engineering* (Subject Code: MCEN90060). University of Melbourne Handbook. Retrieved from https://handbook.unimelb.edu.au/2023/subjects/mcen90060
3. Jolliet, O. (2023). *Life Cycle Assessment*. University of Michigan. Coursera Online Course. Retrieved from https://www.coursera.org/learn/life-cycle-assessment

Other Resources:

Science and Technology of Materials": https://ocw.mit.edu/courses/3-016-science-and-technology-of-materials-fall-2009/

	Description of CO	PO	PSO1	PSO2
CO1	Understand the foundations of sustainable design, including eco-design principles, lifecycle thinking, and sustainable product-service systems.	PO1 (3), PO3 (3)	1	1
CO2	Analyze and apply design strategies to influence sustainable behavior using models like the Comprehensive Action Determination Model (CADM).	PO1 (3), PO3 (3)	2	3
CO3	Conduct lifecycle assessment (LCA) and environmentally responsible product evaluations to minimize environmental impact in design.	PO1 (3), PO3 (3)	3	2
CO4	Develop sustainable product-service systems and systemic design approaches addressing regional and global sustainability challenges.	PO1 (3), PO2 (2), PO3 (3)	2	3

ED25C06	Integrated Product Design and Development	L	T	P	C
		3	0	0	3

Course Objective:

This course aims to provide a comprehensive understanding of the generic product development process, including product planning and customer need analysis. It enhances students' abilities to set product specifications and effectively generate, select, and test design concepts. Emphasis is placed on product architecture, industrial design, and Design for Manufacturing (DFM) principles. The course also introduces prototyping techniques, robust design through Design of Experiments (DoE), and the importance of patenting innovations. Additionally, it integrates economic principles and project management practices essential for successful new product development.

Introduction to Product Development: Overview of Product Development, Characteristics of Successful Products, Product Development Teams and Organizations- Challenges, Duration and Cost of Product Development, Product Development Process (Generic and Front-End), Process Flows and Opportunity Identification.

Activities: Brainstorming Session: Identifying latent vs stated needs for a new product

Product Planning and Customer Needs: Product Planning Process, Identifying and Understanding Customer Needs, Importance of Latent Needs, Establishing Target and Final Specifications

Activities: Design Review Meeting: Present and defend a selected product concept

Concept Generation, Selection and Testing: Concept Generation Activities- Concept Selection: Screening and Scoring- Concept Testing Techniques and Caveats

Activities: Use mind maps to visually expand product features and functions

Product Architecture and Industrial Design: Product Architecture, Definition, Planning, and System, Level Design; Delayed Differentiation and Platform Planning; Industrial Design, Need, Process, Management, Quality Assessment.

Activities: Product Platform Case Study: Explore delayed differentiation in brands (e.g., Dell, Toyota)

Design for Manufacturing (DFM) Principles: DFM Process Overview- Integration of Design and Manufacturing Early in the Development Cycle- Cost and Complexity Considerations; Cross-functional Collaboration for Manufacturability.

Activities: Presentation: Pros and cons of different DFM strategies in a selected industry

Prototyping, Economics & Project Management: Prototyping: Principles, Planning, and Technologies, Product Development Economics, Cost Estimation and Analysis, Project Management: Task Representation, Planning, Execution, Postmortem Evaluation of Projects. **Activities:** Prototype Demo: Create and explain a low-fidelity prototype (paper or digital)
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. Ulrich, K. T., Eppinger, S. D., & Goyal, A. (2012). Product design and development, McGraw-Hill Education (India) Pvt. Ltd. 2. Crow, K. (n.d.). Concurrent engineering/integrated product development [Workshop book]. DRM Associates. 3. Otto, K. N., & Wood, K. L. (2016). Product design: Techniques in reverse engineering and new product development. Pearson Education, Inc. 4. Rosenthal, S. (1992). Effective product design and development. Business One Irwin. 5. Pugh, S. (1991). Total design: Integrated methods for successful product engineering. Addison Wesley Publishing.

	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply the generic product development process including product planning, customer needs analysis, and specification setting.	PO3 (3)	1	2
CO2	Generate, select, and test product concepts effectively using brainstorming, screening, scoring, and testing techniques.	PO1 (3), PO3 (2)	2	3
CO3	Apply principles of product architecture, industrial design, and Design for Manufacturing (DFM) to optimize product development for manufacturability and cost.	PO1 (3), PO3 (3)	3	2
CO4	Plan and manage product prototyping, economic analysis, and project execution using tools such as Design of Experiments (DoE) and project management techniques.	PO1 (3), PO2 (2), PO3 (3)	2	3

Semester II

ED25C08	Finite Element Methods	L	T	P	C
		2	0	4	4

Course Objective:

The objective of this course is to equip students with a fundamental understanding of the finite element method and its applications in solving engineering problems. It aims to develop the ability to formulate, model, and analyze one- and two-dimensional boundary value problems using variational and weighted residual methods. The course emphasizes isoparametric formulation, numerical integration, and the application of FEM in dynamic and nonlinear systems, enabling students to critically evaluate structural and thermal problems with appropriate meshing and solution strategies.

Fundamentals of Finite Element Analysis and 1D Problems

Historical background – Basic concepts of FEM – Weighted residual methods – Variational formulation of boundary value problems – Ritz method – Finite element modeling – Element equations – Linear and higher-order shape functions – Bar and beam elements – Applications to one-dimensional heat transfer problems.

2D Finite Element Problems and Elasticity

Boundary value problems in two dimensions – Linear and higher-order triangular and quadrilateral elements – Poisson’s and Laplace’s equations – Weak formulation – Element matrices and vectors – Scalar variable problems – Introduction to theory of elasticity – Plane stress, plane strain, and axisymmetric formulation – Principle of virtual work – Energy method for matrix formulation.

Isoparametric Formulation and Numerical Integration

Natural coordinate systems – Lagrangian interpolation polynomials – Isoparametric formulation – Shape functions for 1D and 2D elements – Serendipity elements – Jacobian transformation – Numerical integration using Gauss quadrature – One-point, two-point, and three-point integration.

Eigenvalue and Nonlinear Finite Element Analysis

Dynamic analysis – Equations of motion – Consistent and lumped mass matrices – Free vibration of bars, beams, and shafts – Eigenvalue problem solutions – Introduction to transient field problems – Nonlinear analysis: solution techniques – Material nonlinearity (plasticity, visco-plasticity) – Geometric nonlinearity – Contact problems – Stress stiffening – Meshing strategies: free and mapped – Mesh quality and error estimation.

Lab exercises:

1. Formulation and Solution of 1D Bar Problems Using Finite Element Method
2. Analysis of 1D Beam Elements under Static Loading using FEM Software
3. Temperature Distribution in a 1D Fin Geometry using Weighted Residual Method
4. Stress Analysis of 2D Plane Structures Using Triangular and Quadrilateral Elements
5. Iso-parametric Mapping and Jacobian Calculation for 2D Elements

6. Implementation of Gauss Quadrature for Numerical Integration in FEM
7. Modal Analysis of a Cantilever Beam to Determine Natural Frequencies
8. Nonlinear Static Analysis of a Component with Contact Interfaces using FEM Tools

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

Assessment Methodology:

1. Assessment Test 1 – 30%
2. Assessment Test 2 – 30%
3. Laboratory – 40%

References:

1. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall, 1990.
2. David Hutton, “Fundamentals of Finite Element Analysis”, Tata Mc Graw Hill, 2005.
3. Rao, S.S., “The Finite Element Method in Engineering”, 6th Edition, Butterworth Heinemann,2018.
4. Reddy,J.N. “Introduction to the Finite Element Method”, 4th Edition, Tata Mc Graw Hill,2018.
5. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., New Delhi, 2012.
6. Tirupathi R.Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain FEM fundamentals, 1D/2D problems, isoparametric formulation, and nonlinear analysis	PO1 (3), PO3 (2)	3	2
CO2	Apply FEM techniques to model and solve structural and thermal problems	PO1 (3), PO2 (3)	3	3
CO3	Estimate errors, meshing needs, and eigenvalues in FEM solutions	PO1 (3), PO3 (3)	3	3
CO4	Analyze FEM results for accuracy, optimization, and problem-solving	PO3 (3)	3	3

CC25201	Additive Manufacturing	L T P C 2 0 2 3

Course Objectives:

- Gain knowledge of design considerations, software tools, processes, and techniques for creating customized physical components and understand their medical and industrial applications using
- Additive Manufacturing (AM).

Introduction to Additive Manufacturing

Overview, Distinction between Traditional Manufacturing and Additive Manufacturing (AM), Evolution of AM, AM Process Workflow, Classification of AM Processes, Benefits of AM, AM Standards, AM Considerations, Business and Societal Implications of AM, Economic Aspects of AM

Design for Additive Manufacturing (Dfam)

AM Unique Capabilities, Need for DfAM, Design Considerations in AM, Part Consolidation, Topology Optimization, Generative Design, Lightweight Structures, DfAM for Part Quality Improvement, CAD Model Preparation, File Formats for AM (STL, PLY, VRML, AMF), Part Orientation and Support Structure Generation, Model Slicing, Tool Path Generation

Photopolymerization & Extrusion-Based Processes

Stereolithography Apparatus (SLA): Materials, Process, Capabilities, Applications, Digital Light Processing (DLP): Materials, Process, Capabilities, Applications, Continuous Liquid Interface Production (CLIP): Materials, Process, Capabilities, Applications, Fused Deposition Modeling (FDM): Process, Types, Materials, Applications

Powder Bed Fusion Processes

Selective Laser Sintering (SLS): Process, Materials, Applications, Multijet Fusion, Selective Laser Melting (SLM): Principles, Materials, Process, Capabilities, Applications, Electron Beam Melting (EBM): Principles, Materials, Process, Capabilities, Applications

Sheet Lamination, Ded & Jetting Processes

Laminated Object Manufacturing (LOM): Principle, Bonding Mechanisms, Materials, Applications, Limitations, Laser Engineered Net Shaping (LENS): Process, Material Delivery, Parameters, Materials, Applications, Wire Arc Additive Manufacturing (WAAM): Process, Parameters, Materials, Applications, Binder Jetting and Material Jetting: 3DP Physics, Process, Types, Materials, Capabilities, Applications, Hybrid Additive Manufacturing: Need, Principles, Synergy, Materials, Part Quality, Process Efficiency

Applications of Additive Manufacturing

Rapid Tooling: Direct, Indirect, Soft, Rigid Tooling, Rapid Tooling for Investment Casting, Sand Casting, Injection Molding, Case Studies and Applications in Aerospace, Automotive, Medical and Healthcare, Architecture and Construction, Food Printing, Printed Electronics, Consumer Products, Fashion

Lab Experiments:

1. Modeling creative designs in CAD Software
2. Generating STL files from the CAD Models and repairing STL file
3. Part orientation, support, and Tool path generation using 3D printing Software.
4. Build-time calculation, amount of model and support material consumption using 3D printing Software.
5. Fabrication of physical part on an extrusion-based AM machine using tool path data with polymer material.
6. Fabrication of physical part on an extrusion-based AM machine using tool path data with composite material.
7. Fabrication of physical part on photo-polymerization based AM machine using tool path data.
8. Converting CT/MRI scan data into STL file using Medical Imaging software **(Demo)**

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

Assessment Methodology:

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

References:

1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020, ISBN- 978-1-4822-2360-6.
3. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.
4. Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, Second Edition, CRC Press., United States, 2020, ISBN 9781032238593.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021.

E-Resources:

Fundamentals of Additive Manufacturing Technologies:
Link: https://nptel.ac.in/courses/112103306
Metal Additive Manufacturing:
Link: https://nptel.ac.in/courses/112104312

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals, workflow, classification, and applications of additive manufacturing (AM)	PO1 (3), PO3 (2)	3	2
CO2	Apply CAD modeling, DfAM principles, part orientation, slicing, and tool path generation in AM	PO2 (3), PO3 (2)	3	2
CO3	Estimate material usage, build time, support requirements, and performance of AM parts	PO2 (3), PO3 (2)	3	2
CO4	Analyze AM processes, select suitable methods, and evaluate applications in medical, industrial, and aerospace domains	PO3 (3), PO5 (2)	3	3

CD25C03	Product Lifecycle Management	L	T	P	C
		3	0	0	3

Course Objective:

To understand and apply the principles and concepts in Product Life-Cycle Management for Product Design and Development.

Introduction to PLM

Definition of PLM; PLM Initiative; PLM Paradigm – P, L and M of PLM – Scope of PLM – PLM Paradigm – Benefits of PLM – Spread of PLM – Overcoming Problems & Enabling Opportunities – PLM Environment – Issues in the Traditional Environment – Product Data Issues – A Complex, Changing Environment – Example from "Before PLM" – Product Pains: Aerospace Products; Power Plants; Automotive Products – Product Opportunities.

PLM Environment: Business Process and Product Data

Business Processes in the PLM Environment – Relevance of Business Processes in PLM – Definitions & Introductions for Business Process – Business Process Reality in a Typical Company – Business Process Activities in the PLM Initiative – Learning from Experience with Business Process- Product Data in the PLM Environment – Relevance of Product Data in PLM – Product Data Reality in a Typical Company – Product Data Activities in the PLM Initiative – Learning from Experience with Product Data.

PLM Environment: Information Systems

Information Systems in the PLM Environment – Relevance of Information Systems Applications in PLM – PLM Applications in the Product Lifecycle – Generic and Specific PLM Applications – PDM System: A Special Application – Importance of the PDM System in PLM – Reality in a Typical Company – Application Activities in the PLM Initiative – Best Practice PDM System Selection – Learning from Experience with Information Systems.

PLM Environment: Project Management

Project/Program Management in the PLM Environment – Skills and Relevance – Definitions and Introduction with Project Management – Project Management Reality in a Typical Company – Project Management Activities in the PLM Initiative – Learning from Experience with Project Management.

Activities Based Learning:

1. Getting Started with PLM software's Engineering BOM
2. Working with CAD Parts
3. Creating and Attaching Specifications
4. Creating Engineering Bill of Materials
5. Releasing Parts Using the ECM Process
6. Use Matrix Query Language (MQL) to fetch the info from Database (DB) and test queries on PLM.

*(**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. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
2. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
3. Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management, Springer Publisher, 3rd Ed., 2008.
4. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.
5. IvicaCrnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain PLM concepts, paradigms, benefits, business processes, and PLM environment	PO1 (3), PO3 (2)	3	2
CO2	Apply PLM software tools for CAD parts, specifications, and engineering BOM creation	PO1 (3), PO2 (3)	3	3
CO3	Estimate product data requirements, project timelines, and process efficiency in PLM initiatives	PO1 (3), PO3 (3)	3	3
CO4	Analyze PLM processes, project management activities, and database queries for optimization and decision-making	PO3 (3)	3	3

CC25202	Advanced Computing Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

- Make students generate the part models using cad software.
- Make students generate the surface models using cad software.
- Prepare students with advanced modeling concepts using CAD software.
- Make students create automated drawing and apply proper annotations on them.
- Make students generate the assembly models using cad software

List of Experiments:

1. Sketch based Part modeling of components.

2. Feature based Modeling of components.

3. Assembly modeling of components using different constraints

4. Drafting – standard views, dimensioning, layouts, GD&T, Bill of materials, exploded views.

5. Assembly modeling of components of drill jig and study of assembly interference

6. Surface modeling of a soap bottle with its plastic tool design

7. Surface modeling of a mobile phone case

8. Surface modeling of automobile outer surface

9. Surface reconstruction from cloud point data from reverse engineering tools.

10. Solid modeling, assembly and drafting with GD&T of a tool post

11. Solid modeling, assembly and drafting with GD&T of a Gate Valve

12. CAD model preparation of an aerofoil for FE/CFD analysis.

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

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain fundamentals of CAD, part modeling, surface modeling, and assembly concepts	PO1 (3), PO3 (2)	3	2
CO2	Apply 2D/3D part modeling, surface modeling, and assembly constraints using CAD software	PO2 (3), PO3 (2)	3	2
CO3	Estimate dimensions, tolerances, material allocation, and interference in assemblies	PO2 (3), PO3 (2)	3	2
CO4	Analyze complex assemblies, drafting standards, GD&T, and CAD models for FE/CFD integration	PO3 (3), PO5 (2)	3	3

Semester III

CC25301	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

CC25401	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

CC25001	Computer Integrated Manufacturing	L	T	P	C
		3	0	0	3

Course Objectives:

- The course aims to empower students to effectively apply the concepts of computer integrated manufacturing and its principles in production industry

Introduction to CIM and Automation

Introduction to CAD, CAM, CAD/CAM and CIM, evolution of CIM, CIM wheel and cycle, production concepts and mathematical models, simple problems in production models, CIM hardware and software, major elements of CIM system, three-step process for implementation of CIM, computers in CIM, computer networks for manufacturing, the future automated factory, management of CIM, safety aspects of CIM, advances in CIM, automated manufacturing systems, automated production line – system configurations, work part transfer mechanisms, fundamentals of automated assembly system, system configuration, part delivery at workstations, design for automated assembly.

Material Handling and Storage Systems

Overview of material handling equipment, considerations in material handling system design, the 10 principles of material handling, conveyor systems – types, operations and features, automated guided vehicle system – types and applications, vehicle guidance technology, vehicle management and safety, storage system performance, storage location strategies, conventional storage methods and equipment, automated storage/retrieval system, carousel storage system.

Group Technology and Flexible Manufacturing Systems

Part families – visual, parts classification and coding, production flow analysis, grouping of parts and machines by rank order clustering method, benefits of group technology, case studies, components of FMS, workstations, FMS layout configurations, computer control systems, FMS planning and implementation issues, architecture of FMS, flow chart showing various operations in FMS, FMS applications, benefits.

Process Planning and Control Systems

Activities in process planning, information required from design to process planning, classification of manufacturing processes, selection of primary manufacturing processes, sequencing of operations according to anteriorities, forming of matrix of anteriorities, typical process sheet, case studies in manual process planning, computer aided process planning – process planning module and database, variant process planning – two stages in VPP, generative process planning – flow chart, semi-generative process planning, comparison of CAPP and manual process planning, process model formulation, linear feedback control systems, optimal control, adaptive control, sequence control and PLC & SCADA, computer process control, computer process interface, interface hardware, computer process monitoring, direct digital control, supervisory computer control,

automatic identification methods, bar code technology, automatic data capture technologies, quality management (SPC), automated inspection.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Mandated Activities with weightage: Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%).
Assessment Methodology: Quiz - 10% Assignments - 20% Virtual Demonstration - 15% Flipped Classroom - 5% Internal Examinations - 50%
References: 1. Gideon Halevi and Ronald D. Weill, "Principles of Process Planning", Chapman Hall, 1995 2. Mikell P. Groover, "Automation, Production system and Computer integrated Manufacturing", Prentice Hall of India Pvt. Ltd., 4thEdition, 2014. 3. Shivanand H K, Benal M M and Koti V, "Flexible Manufacturing System", New Age International Publishers, 2021 4. Wilhelm Scheer, "CIM - Computer Integrated Manufacturing: Computer Steered Industry" Springer - Verlag Berlin and Heidelberg GmbH & Co. K, 2012. 5. Alavudeen A and Venkateshwaran N, "Computer Integrated Manufacturing", PHI Learning Pvt. Ltd., New Delhi, 2010.
E-Resources: 1. https://onlinecourses.nptel.ac.in/noc21_me65/preview 2. https://www.classcentral.com/course/swayam-computer-integrated-manufacturing17550

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of CIM, automation, CAD/CAM integration, and automated production systems	PO1 (3), PO3 (2)	3	2
CO2	Apply knowledge of material handling, storage systems, and automated assembly for efficient production	PO2 (3), PO3 (2)	3	2
CO3	Estimate part families, production flow, and FMS layout configurations for process optimization	PO2 (3), PO3 (2)	3	2
CO4	Analyze process planning, process control systems, and CIM-based monitoring for production efficiency	PO3 (3), PO5 (2)	3	3

CC25002	Mechatronics and Automation	L	T	P	C
		3	0	0	3

Course Objectives:

Upon completion of this course, students will be able to:

- Acquire an overview of multi-domain engineering integration relevant to mechatronics.
- Become familiar with sensors and transducers, including their interfacing techniques.
- Understand and apply various types of actuators and their drives for system interfacing.
- Apply modeling principles to basic mechanical system elements and recognize the necessity of control systems.
- Gain knowledge of microcontroller fundamentals for effective interfacing and control.
- Develop exposure to the design and development of mechatronic systems.

Mechatronics Systems and Sensors

Introduction to Mechatronics Systems: Definition, key elements, and methods of integration (hardware and software).

Sensors: Static and dynamic characteristics, classification (linear, rotational, velocity, acceleration, force, torque, flow, temperature, proximity, optical, micro, and nano sensors), and selection criteria.

Signal Conditioning: Analog and digital signals, signal conditioning modules (amplifiers - inverting, non-inverting, instrumentation amplifiers), filters, Analog-to-Digital (A/D) and Digital-to-Analog (D/A) converters.

Actuators

Electrical Actuators: Characteristics of DC motors, AC motors (servo motors, stepper motors).

Drives and Switching Devices: AC drives, H-Bridge circuits, stepper motor driving circuits, mechanical switches, solenoids, and relays.

Fluid Power Actuators: Overview of hydraulic and pneumatic actuators and their control, types and characteristics of micro and nano actuators.

System Modeling and Control

System Representation: Transfer functions for mechanical systems.

System Response: Characterization of system time response, stable and unstable systems.

Control Systems: Open-loop and closed-loop control systems.

Controllers: Proportional (P), Proportional-Derivative (PD), Proportional-Integral (PI), and Proportional-Integral-Derivative (PID) controllers.

Control Realization: Comparison of control realization using microprocessors, microcontrollers, and Programmable Logic Controllers (PLCs).

Microcontrollers

8051 Microcontroller: Architecture, addressing modes, instruction sets, and programming exercises.

Memory and I/O: Different types of memories, various I/O devices.

Interfacing: Stepper and servo motor interfacing.

Advanced Microcontrollers: Overview of advanced microcontroller architectures and typical applications.

Mechatronics System Design and Applications

Mechatronics Design Process: Stages in designing mechatronics systems, comparison of traditional and mechatronic design approaches.

Applications: Mechatronic system elements and architecture of CNC machines, serial manipulators, engine management systems, and car production/assembly line automation.

Lab Experiments for Mechatronics and Automation

Here are 8 relevant lab experiments designed to complement the Mechatronics and Automation syllabus:

Characterization of Sensors and Signal Conditioning:

Objective: To understand the working principles and characteristics of various sensors (e.g., LVDT, RTD, Thermocouple, Load Cell, Proximity sensor) and to perform signal conditioning (amplification, filtering) for effective data acquisition.

Activity: Measure the output of different sensors under varying conditions, design and implement basic amplifier circuits for sensor outputs, and analyze the effects of noise.

Control of DC Motor using H-Bridge Driver:

Objective: To study the operation of DC motors and implement speed and direction control using an H-bridge driver circuit interfaced with a microcontroller.

Activity: Write microcontroller code to control the DC motor's direction and speed (using PWM), observe the motor's response, and analyze the H-bridge functionality.

Stepper Motor Control and Interfacing:

Objective: To understand the working principle of stepper motors and control their angular position and speed using a microcontroller.

Activity: Interface a stepper motor with a microcontroller, implement full-step and half-step sequencing, and control the motor's rotation for specific angles.

PID Controller Implementation for a Thermal System:

bjective: To implement and tune a Proportional-Integral-Derivative (PID) controller for a temperature control system using a microcontroller.

Activity: Set up a heating element and temperature sensor, write code for a PID algorithm, and experiment with different Kp, Ki, and Kd values to achieve desired temperature control and analyze system response (overshoot, settling time).

Traffic Light Control System using 8051 Microcontroller:

Objective: To apply 8051 microcontroller programming for real-world automation, specifically a sequential control system like a traffic light.

Activity: Design the logic for a four-way traffic light, program the 8051 microcontroller to control LEDs representing traffic lights, and incorporate timing delays.

Data Acquisition and Display using A/D Converter:

Objective: To understand the process of converting analog sensor signals to digital data using an A/D converter and displaying them.

Activity: Interface an analog sensor (e.g., potentiometer, LDR) to a microcontroller's A/D input, convert the analog voltage to a digital value, and display it on an LCD or serial monitor.

Modeling and Simulation of a Mechanical System (e.g., Mass-Spring-Damper):

Objective: To understand how to mathematically model a basic mechanical system and simulate its dynamic response using software tools.

Activity: Derive the differential equation for a mass-spring-damper system, create a simulation model, analyze its step response for different damping ratios, and relate it to stable/unstable system concepts.

Design and Control of a Simple Automated System (e.g., Pick-and-Place Robot Arm):

Objective: To integrate sensors, actuators, and a microcontroller to create a functional mechatronic system.

Activity: Design a miniature pick-and-place robot arm using small servo motors, incorporate limit switches as sensors, program a microcontroller to execute a simple pick-and-place sequence, demonstrating integrated system operation.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%),Virtual demonstration (15%), Flipped Classroom (5%)

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

References:

1. Mazidi, M. A., Mazidi, M. J., & MCkinlay, R. D. (2008). The 8051 Microcontroller and Embedded Systems Using Assembly and C (2nd ed.). Pearson India.
2. Patranabis, D. (2005). Sensor and Actuators (2nd ed.). Prentice Hall of India Pvt Ltd.
3. Vijayaraghavan, G. K., Balasundaram, M. S., & Ramachandran, K. P. (2008). Mechatronics: Integrated Mechanical Electronic Systems. Wiley.
4. Bentley, J. P. (2005). Principle of Measurement Systems (4th ed.). Pearson Prentice Hall.
5. Ogata, K. (2005). Modern Controls Engineering. Prentice Hall of India Pvt. Ltd.

E-Resources: 1. "Mechatronics" by IIT Guwahati: https://nptel.ac.in/courses/112107298 (Covers sensors, actuators, microcontrollers, modeling, and control). 2. "Automation in Manufacturing" by IIT Guwahati: https://archive.nptel.ac.in/courses/112/103/112103293/ (Strong emphasis on industrial automation, CNC, hydraulic/pneumatic systems). 3. "Mechatronics and Manufacturing Automation" by IIT Guwahati: https://nptel.ac.in/courses/112103174 (Another relevant course, check for updated versions).
Other Resources: https://www.arm.com/resources/education/online-courses/mechatronics-and-robotics

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of mechatronics systems, sensors, transducers, actuators, and interfacing	PO1 (3), PO3 (2)	3	2
CO2	Apply microcontroller programming, motor control, and signal conditioning for automation tasks	PO2 (3), PO3 (2)	3	2
CO3	Estimate system behavior through modeling of mechanical and thermal systems and implement PID control	PO2 (3), PO3 (2)	3	2
CO4	Analyze mechatronic system design, including integration of sensors, actuators, and controllers in applications	PO3 (3), PO5 (2)	3	3

CC25003	Industrial Robotics and Artificial Intelligence	L	T	P	C
		3	0	0	3

Course Objectives:

- To develop the ability to design, program, and control industrial robotic systems for automated manufacturing applications.
- To integrate vision systems, sensors, and automation tools for enhanced perception and control in robotic systems.
- To apply artificial intelligence and machine learning techniques for autonomous decision-making and problem-solving in industrial robotics.

Introduction to Robotics and Artificial Intelligence

Overview of Robotics: History, types, architecture of robots, robot components and structure, robot coordinate systems and workspace, sensors and actuators, applications.
Overview of Artificial Intelligence (AI): Evolution of AI, types of AI, basic concepts in AI, relationship between robotics and AI, applications and impact on various industries.

Robot Kinematics, Dynamics, Vision Systems and Sensors

Kinematics of Robots: Forward kinematics, inverse kinematics. Robot Dynamics: Newton-Euler and Lagrange methods, dynamic equations of motion.
Trajectory Planning: Path planning techniques, motion control. Introduction to Machine Vision: Concept and image processing techniques. Vision Systems for Robots: Camera calibration, 3D vision, object recognition and tracking.
Integration of Sensors: Types of sensors (proximity, tactile, ultrasonic), sensor fusion techniques, applications.

Robot Programming and Control

Robot Programming Languages: Programming languages (e.g., Python, C/C++, ROS), programming paradigms (teach-pendant, offline programming, online programming).
Control Systems for Robots: Types of control (open and closed loop), PID control, advanced control techniques (adaptive, robust, model predictive control). Simulation and Modeling Tools: Software tools, simulation techniques.

Machine Learning and Applications of Robotics and AI

Introduction to Machine Learning: Supervised, unsupervised, and reinforcement learning, key algorithms (decision trees, SVM, neural networks). Deep Learning in Robotics: Convolutional neural networks (CNNs), recurrent neural networks (RNNs), applications in perception and control.
AI Techniques for Robotics: Planning and decision-making, natural language processing (NLP) in human-robot interaction, AI in autonomous systems. Applications of Robotics and AI: Robotic assembly and welding, material handling and logistics, surgical robots, rehabilitation and assistive robots, domestic robots, professional service robots (cleaning, delivery), emerging applications in agriculture, space exploration, and disaster response.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%)

Assessment Methodology:

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

References:

1. K.S. Fu, R.C. Gonzalez, and C.S.G. Lee "Robotics: Control, Sensing, Vision, and Intelligence". McGraw-Hill, 1st Edition, 1987.
2. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar "Robot Modeling and Control". Wiley, 1st Edition,2005.
3. John J. Craig "Introduction to Robotics: Mechanics and Control". Pearson, 4th Edition,2017.
4. Stuart Russell and Peter Norvig "Artificial Intelligence: A Modern Approach". Pearson, 4th Edition, 2020.
5. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, and Nicholas G. Odrey "Industrial Robotics: Technology, Programming, and Applications". McGraw-Hill, 2nd Edition,2012

E-Resources:

1. **MIT OpenCourseWare – Robotics**
   https://ocw.mit.edu
   Offers free lecture notes, assignments, and video lectures on robotics and AI topics from MIT courses.
2. **Coursera – Robotics Specialization (by University of Pennsylvania)**

https://www.coursera.org/specializations/robotics
A comprehensive series covering robot mechanics, mobility, perception, and planning with hands-on projects.

3. **ROS Tutorials – The Robot Operating System (ROS)**
http://wiki.ros.org/Tutorials
Official tutorials and documentation for learning robot programming and control using ROS, a widely used robotics middleware.

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the fundamentals of industrial robotics, robot architecture, components, and AI integration concepts	PO1 (3), PO3 (2)	3	2
CO2	Apply robot kinematics, dynamics, programming, and control methods to real-world automation tasks	PO2 (3), PO3 (2)	3	2
CO3	Estimate and simulate robot trajectories, motion planning, and sensor-based perception systems	PO2 (3), PO3 (2)	3	2
CO4	Analyze AI and machine learning techniques for robotic decision-making, vision systems, and industrial applications	PO3 (3), PO5 (2)	3	3

CC25004	Advanced Optimization Techniques	L	T	P	C
		3	0	0	3

Course objectives:

- To impart knowledge to model and solve Integer programming problems.
- To model and solve problems using dynamic programming.
- To solve single- and multiple-variable unconstrained and constrained nonlinear.
- To solve non-linear problem using KKT condition, quadratic programming and separable programming.
- To apply meta heuristics for solving engineering problems

Integer Programming and Goal Programming

Branch and Bound technique, cutting plane algorithm method, Traveling Salesman Problem (TSP), Branch and Bound Algorithms for TSP, Heuristics for TSP, Goal Programming – formulation and algorithms, The weights method, Pre-emptive method.

Dynamic Programming and Applications

Characteristics of dynamic programming problems, deterministic dynamic programming, forward and backward recursion, applications of dynamic programming – investment model, inventory model, replacement model, reliability model, stagecoach problem.

Nonlinear Programming

Types of nonlinear programming problems, one-variable unconstrained optimization, multivariable unconstrained optimization, Lagrangian multiplier method, Karush-Kuhn-Tucker (KKT) conditions for constrained optimization.

Advanced Nonlinear Programming and Meta-Heuristics

Quadratic programming, separable programming, convex programming, non-convex programming, combinatorial optimization, NP-Hard problems, classification of meta-heuristic algorithms, genetic algorithm, ant colony optimization, simulated annealing, case studies.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%)

Assessment Methodology:

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

References:

1. Hamdy A Taha, “Operations Research – An Introduction”, Pearson, 2017.
2. Philips, Ravindran and Solberg, “Operations Research principles and practices”,
3. John Wiley, 2007
4. Ronald L Rardin, “Optimisation in Operations Research”, Pearson, 2018
5. Deb. K, “Optimization for Engineering Design: Algorithms and Examples”, PHI, 2012
6. Panneerselvam R, “Operations Research”, PHI, 2009
7. Srinivasan G., “Operations Research Principles and Applications”, PHI, 2017.
8. Singiresu S. Rao, “Engineering Optimization: Theory and Practice”, WILEY, 2019

E-Resources:

1. **NPTEL – Optimization in Engineering**
   https://nptel.ac.in/courses/112/106/112106134
   Offers free video lectures and notes on linear, nonlinear, and dynamic programming, with practical engineering applications.
2. **MIT OpenCourseWare – Introduction to Optimization**
   https://ocw.mit.edu
   Comprehensive course material including lecture notes, problem sets, and solutions on topics like LP, IP, and heuristic methods.
3. **Coursera – Discrete Optimization (University of Melbourne)**
   https://www.coursera.org/learn/discrete-optimization
   Covers integer programming, constraint programming, and meta-heuristics like genetic algorithms and simulated annealing.

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles and formulation of integer, dynamic, and nonlinear programming problems.	PO1 (3), PO3 (2)	3	2
CO2	Apply dynamic programming, integer programming, and nonlinear optimization techniques to engineering problems.	PO2 (3), PO3 (2)	3	2
CO3	Estimate solutions of constrained and unconstrained optimization problems using KKT conditions, quadratic and separable programming methods.	PO2 (3), PO3 (2)	3	2
CO4	Analyze and implement meta-heuristic algorithms like genetic algorithms, ant colony optimization, and simulated annealing for complex engineering optimization problems.	PO3 (3), PO5 (2)	3	3

CC25005	Design for Manufacturing and Assembly	L	T	P	C
		3	0	0	3

Course Objectives:

- To teach manufacturing issues that must be considered in the mechanical engineering design process.
- To Discuss on tools and methods to facilitate development of manufacturable mechanical designs.
- To make the students to Understand the importance of Assembly, Reliability and
  Quality for improving design process approach.

Introduction to Design for Manufacturing and Assembly (DFMA)

Overview of DFMA, product design and process design, conceptual and configuration design of products and assemblies, criteria and concepts in design, introduction to limits, fits, and tolerances, dimensional management and tolerance analysis, geometric dimensioning and tolerancing (GD&T), datum features, stack-up analysis, need identification and problem definition, concept generation and evaluation, embodiment design.

Material and Shape Selection

Overview of engineering materials, standards for materials selection, physical and mechanical properties of engineering materials, selection of materials – case studies, selection of shapes, co-selection of materials and shapes, effect of composition, processing, and structure on material properties – case studies.

Process Selection and Manufacturability

Review of manufacturing processes, concept of manufacturability, limitations of manufacturing, design for casting – processes, defects and remedies, recommendations for quality casting design, design for bulk deformation processes, sheet metal forming, and machining – advantages, disadvantages, and design guidelines, design for powder metallurgy, design for polymer processing, co-selection of materials and processes – case studies, design of jigs and fixtures, mathematical modeling and finite element analysis, simulation, rapid prototyping.

Design for Assembly, Reliability, and Quality

Review of assembly processes, design for welding – defects and rectification, design for brazing and soldering – recommendations for quality joints, design for adhesive bonding, design for joining of polymers, design for reliability – reliability theory and FMEA, design for heat treatment – case studies, design for corrosion resistance, wear resistance, design for quality, robust design approach, design for optimization, safety, and environment

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%)

Assessment Methodology:

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

References:

1. Geoffrey Boothroyd, Peter Dewhurst, and Winston A. Knight, "Product Design, for Manufacture, and Assembly", 3rd Edition, CRC Press., United States,2011, ISBN 9781420089271.
2. Peck H., "Designing for manufacture", Sir Isaac Pitman & Sons Ltd., United States 1973.
3. James G. Bralla, "Design for manufacturability handbook", McGraw Hill., United States, 1999,
4. David M. Anderson, "Design for manufacturability ", CRC Press., United States, 2014,ISBN 9781482204926.
5. G. Dieter, Engineering Design - a materials and processing approach, 4th Edition, McGraw Hill, NY, 2009.
6. Molloy O., Tilley S., and Warman E., "Design for Manufacturing and Assembly Concepts, architectures and implementation", Springer., United Kingdom, 1998, Reprint 2012, ISBN: 978- 1461376507.
7. M. F. Ashby and K. Johnson, Materials and Design - the art and science of material selection in product design, Butterworth Heinemann, 2003.

E-Resources:

1. **NPTEL – Design for Manufacture and Assembly (IIT Guwahati)**
   https://nptel.ac.in/courses/112/103/112103019
   Offers in-depth lectures on DFMA concepts, process planning, material selection, and real-world case studies.
2. **MIT OpenCourseWare – Product Design and Development**
   https://ocw.mit.edu
   Includes lecture notes, assignments, and project guidelines focused on conceptual design, prototyping, and manufacturing processes.
3. **Coursera – Materials Science and Engineering Specialization (Georgia Tech)**
   https://www.coursera.org/specializations/materials-science-engineering
   Covers materials selection, structure-property relationships, and processing, useful for DFMA-related decisions.

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain the principles of Design for Manufacturing and Assembly (DFMA), material selection, and geometric tolerancing (GD&T).	PO1 (3), PO3 (2)	3	2
CO2	Apply design guidelines for manufacturability, process selection, and assembly techniques to mechanical components.	PO2 (3), PO3 (2)	3	2
CO3	Estimate effects of material, process, and assembly choices on product reliability, quality, and performance.	PO2 (3), PO4 (2)	3	2
CO4	Analyze mechanical designs using DFMA principles, FMEA, robust design approaches, and optimization for quality, safety, and environment.	PO3 (3), PO5 (2), PO6 (2)	3	3

CC25006	Sensors for Manufacturing and Condition Monitoring	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand the fundamentals of sensors and their importance in condition monitoring.
- Learn about various types of sensors and their working principles.
- Explore the applications of sensors in monitoring the health and performance of machines and systems

Here's your syllabus content reorganized into **four balanced modules** (without hours), ensuring logical grouping of topics:

Introduction to Sensors and Condition Monitoring

Role of sensors in manufacturing and condition monitoring, measurement of position, displacement, angles, mechanical, fluidic, thermal, imaging parameters, principles and classification of sensors, direct and indirect methods, applications, basic requirements of sensors, signal processing and decision-making, types of maintenance – reactive, preventive, predictive.

Sensors for Workpiece and Machine Tool Monitoring

Sensors for workpiece monitoring – mechanical, electrical, electro-mechanical, opto-electrical, optical, pneumatic, capacitance, eddy current, magnetic sensors, case studies. Sensors for machine tool monitoring – position measurements using linear, angular, and velocity sensors, calibration of machine tools, collision detection measurements, structural health monitoring, case studies.

Sensors in Machining Processes

Sensors for condition monitoring in machining – force, torque, power, temperature, vibration, acoustic emission, tool sensors, chip control sensors, tool condition monitoring systems, adaptive control systems, intelligent systems for machining processes, case studies.

Advanced Sensors and Monitoring Methods

Optical sensors, machine vision sensors, smart/intelligent sensors, integrated sensors, robot sensors, micro-sensors, nano-sensors, sensor networks, IoT-enabled condition monitoring methods, case studies.

Let me know if you need **e-resources**, **course objectives**, **COs**, or a **PDF/Word version** of this.

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. Tönshoff H.K. and Inasaki I., "Sensors in Manufacturing: Sensors ApplicationsVolume1", Wiley-VCH Verlag GmbH, Weinheim, 2001, ISBN (13) :9783527295586.
2. Hesse, S., Sensors in Production Engineering, Blue Digest on Automation:Sensorics. Manufacturing, Festo AG & Company, 2001
3. Mohanty A. R., "Machinery Condition Monitoring: Principles and Practices", CRC Press, U.S.A, 2017, ISBN (13): 9781138748255.
4. Sinclair I., "Sensors and Transducers", Elsevier, Newnes, Reprint 2012, ISBN: 9780750649322.
5. Wang L. and Gao, R.X., "Condition Monitoring and Control for Intelligent Manufacturing", Springer-Verlog London Limited, United Kingdom,2006, ISBN (13):978-1-84628-268-3.

E-Resources:

1. https://nptel.ac.in/courses/112/106/112106285 – NPTEL: Condition Monitoring of Mechanical Systems (IIT Kharagpur)
2. https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/lecture-notes/ – MIT OpenCourseWare: Introduction to Robotics (includes sensor technologies)
3. https://www.coursera.org/learn/intelligent-machining – Coursera: Intelligent Machining (includes sensor-based condition monitoring)

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain sensor principles, classification, measurement techniques, and applications in manufacturing and condition monitoring	PO1, PO3	2	1
CO2	Apply appropriate sensors and monitoring techniques for workpiece, machine tool, and machining process evaluation	PO1, PO2, PO3	3	2
CO3	Estimate sensor performance, calibration requirements, accuracy, and effectiveness in predictive maintenance systems	PO1, PO3	3	2
CO4	Analyze sensor data and monitoring systems for fault diagnosis, optimization, and intelligent manufacturing decision-making	PO1, PO3	3	3

ED25C12	Composite Materials and Mechanics	L	T	P	C
		3	0	0	3

Course Objectives:

- The main learning objective of this course is to prepare the students for understanding the design for sustainable behaviour and design practices.

Introduction to Composite Materials

Definition of composite materials, matrix materials – polymers, metals, ceramics; reinforcements – particles, whiskers, inorganic fibers, metal filaments, advanced fibers – carbon and graphite fibers, ceramic fibers, fiber fabrication, natural composites – wood, jute. Advantages and drawbacks of composites over monolithic materials, mechanical properties and applications of composites. Particulate-reinforced composites, dispersion-strengthened composites, fiber-reinforced composites, rule of mixtures, characteristics of fiber-reinforced composites, manufacturing of fibers and composites.

Manufacturing of Composites

Manufacturing process of epoxy resins and fibers, polymer matrix composites (PMCs) – hand lay-up, spray technique, filament winding, pultrusion, resin transfer moulding (RTM), bag moulding, injection moulding, sandwich mould composites (SMC). Manufacturing of metal matrix composites (MMCs) – solid state, liquid state, vapor state processing. Ceramic matrix composites (CMCs) – hot pressing, reaction bonding process, infiltration technique, direct oxidation. Interfaces in composites.

Lamina Constitutive Equations

Lamina assumptions – macroscopic viewpoint, generalized Hooke's Law, reduction to homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix (Qij), stress and moment resultants, strain-displacement relations. Basic assumptions of laminated anisotropic plates, laminate constitutive equations – coupling interactions, balanced laminates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli. Evaluation of lamina properties from laminate tests, quasi-isotropic laminates, determination of lamina stresses within laminates, laminate analysis using computer tools.

Lamina Strength Analysis and Laminated Plate Analysis

Maximum stress and strain criteria, Von-Mises yield criterion for isotropic materials, Hill's criterion for anisotropic materials, Tsai-Hill and Tsai-Wu failure criteria, tensor polynomial criterion. Prediction of laminate failure, equilibrium equations of motion, energy formulations, governing equations for plates – static bending analysis, buckling analysis, free vibration analysis, natural frequency prediction.

Thermo-Structural Analysis of Laminates

Fabrication and residual stresses in FRP laminated composites, coefficient of thermal expansion (CTE), modification of Hooke's Law and laminate constitutive equations, orthotropic lamina CTEs. Stress and moment resultants due to cooling during fabrication, calculations for thermo-mechanical stresses in FRP laminates, thermally quasi-isotropic laminates, case studies on classical laminate theory (CLT) for evaluating residual stresses in multi-layered isotropic structures such as electronic packages.

Applications and Advanced Topics in Composite Design

Real-world case studies and applications of composite material design, implementation of classical laminate theory (CLT), impact and fatigue behavior, durability analysis, hybrid composites, smart composites with embedded sensors, environmental considerations and recycling of composites.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%)

Assessment Methodology:

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

References:

1. Agarwal BD and Broutman LJ, "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York, 1990.
2. Gibson R F, Principles of Composite Material Mechanics, McGraw-Hill, 1994,CRC press, 4^{th} Edition, 2015.
3. Hyer MW and Scott R White, "Stress Analysis of Fiber – Reinforced Composite Materials", McGrawHill, 1998
4. Issac M Daniel and OriIshai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007 Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
5. Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press, 3rd Edition,2007.

E-Resources:

https://nptel.ac.in/courses/112/104/112104251

NPTEL Course: Composite Materials by IIT Kanpur – Covers mechanics, manufacturing, and applications of composite materials. https://www.coursera.org/learn/composite-materials Coursera: Introduction to Composite Materials – Offers practical understanding and analysis tools for composite structures. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-20-structural-mechanics-spring-2003/ MIT OpenCourseWare: Structural Mechanics – Includes advanced topics on composite and anisotropic materials.

CO	Course Outcome (CO)	PO Mapping	PSO1	PSO2
CO1	Explain fundamentals, lamina theory, laminated plates, thermo-structural effects, and applications	PO1 (2), PO3 (1)	2	1
CO2	Apply lamina/laminate analysis, failure criteria, and thermo-mechanical calculations	PO2 (2), PO3 (2)	2	2
CO3	Estimate stresses, strength, residual stresses, and natural frequencies	PO1 (2), PO3 (2)	2	2
CO4	Analyze performance, failure, and durability of composite structures	PO3 (1), PO4 (2)	1	2

CC25007	Industrial Automation	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the importance of automation in industry and various industrial standard sensors and process parameters to control the production process.
- To learn PLC hardware, and practice the PLC programming and simulation in real systems.
- To get knowledge on industrial standard data communication protocols, SCADA, centralized and decentralized control.
- To get introduced to factory layout, Total Integrated Automation on factory and Industry 4.0.
- To get exposure on building automation using sensors, controllers and actuators

Industrial Instrumentation and Control Systems

Introduction and need for automation, instrumentation system for measurement of process parameters, overview of flow, level, pressure, temperature, speed, current and voltage measurements, proximity and vision-based inspection systems, process control systems – continuous and batch processes, overview of feedback control systems.

Programmable Logic Controllers and Communication Systems

Fundamentals and functions of programmable logic controllers (PLCs), features and selection of PLCs, PLC architecture, basics of PLC programming, logic ladder diagrams, communication in PLC, programming timers and counters, data handling, PLC modules, advanced PLC features. Industrial data communication – fiber optics, Modbus, HART, DeviceNet, Profibus, Fieldbus.

Supervisory Control and Factory Automation

Introduction to supervisory control systems – SCADA, distributed control system (DCS), safety systems, man-machine interfaces, total integrated automation (TIA). Factory layout, tools and software-based factory modelling, case studies on automated manufacturing units, assembly units, inspection systems, PLC-based automated systems, introduction to factory automation monitoring software, building automation system software.

Smart Technologies and Industry 4.0

Introduction to Industry 4.0, challenges in Industry 4.0, big data and its characteristics, artificial intelligence, machine-to-machine technologies, Internet of Things (IoT), digitization, digital twin.

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. Frank D, Petruzella, "Programmable Logic Controller" McGraw – Hill Publications, 2016.
2. Lucas, M.P., "Distributed Control System", Van Nastrand Reinhold Company, 1986.
3. Mackay S., Wrijut E., Reynders D. and Park J., "Practical Industrial Data Networks
4. Design, Installation and Troubleshooting", Newnes Publication - Elsevier, 2004.
5. Patranabis. D, "Principles of Industrial Instrumentation", Tata McGraw-Hill Publishing Ltd.2nd edition, 2016.
6. Shengwei Wang, "Intelligent Buildings and Building Automation", Routledge Publishers,2009.

E-resources:

1. https://nptel.ac.in/courses/108/105/108105062 – NPTEL: Industrial Automation and Control (IIT Kharagpur)
2. https://ocw.mit.edu/courses/mechanical-engineering/2-14-analysis-and-design-of-feedback-control-systems-fall-2004/ – MIT OpenCourseWare: Feedback Control Systems
3. https://www.coursera.org/learn/industry40 – Coursera: Industry 4.0 – University at Buffalo & The State University of New York

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Describe the architecture of industrial automation systems, instrumentation methods, feedback control strategies, and Industry 4.0 concepts	PO1 (2), PO3 (2)	2	2
CO2	Develop PLC programs using ladder logic and implement industrial communication protocols for automated control applications	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate the performance of process control systems, PLC configurations, and communication networks in centralized and decentralized environments	PO1 (3), PO3 (2)	3	2
CO4	Integrate SCADA, DCS, IoT, and digital technologies to design and analyze smart factory and building automation systems	PO1 (3), PO3 (3)	3	3

CC25008	Machine Learning for Intelligent Systems	L	T	P	C
		3	0	0	3

Course Objectives:

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

Fundamentals of Machine Learning and Classification

Introduction to learning – types of machine learning, classification vs regression, evaluation metrics and loss functions for classification and regression, linear regression. Applications of AI in robotics. Support Vector Machine (SVM) algorithm, learning with trees – decision trees, constructing decision trees, classification examples. Ensemble learning – boosting, bagging, random forests.

Clustering and Dimensionality Reduction

Introduction to clustering, types of clustering – agglomerative and k-means clustering, application study of k-means clustering. Principal Component Analysis (PCA), feature selection using PCA – case study in robot guidance.

Neural Networks and Applications

Neural networks – perceptron, multi-layer perceptron (MLP), backpropagation of error, deriving backpropagation, practical implementation of MLP. Application case study of neural networks in robotics.

Deep Learning and Reinforcement Learning

Introduction to deep learning – convolutional neural networks (CNN), recurrent neural networks (RNN). Reinforcement learning – examples, Markov decision process, major components of reinforcement learning (RL). Application case study of RL in robotics.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%).

Assessment Methodology:

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

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. Ethem Alpaydin, “Introduction to Machine Learning”, Adaptive Computation and Machine Learning Series, MIT Press, 4 th Edition, 2020.

E-Resources:

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine-learning-fall-2006/ — MIT OpenCourseWare “Machine Learning” course featuring lectures on deep learning, reinforcement learning, and robotics case studies.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamental machine learning concepts, classification algorithms, clustering methods, neural networks, and reinforcement learning techniques	PO1 (2), PO3 (2)	2	2
CO2	Apply machine learning algorithms such as SVM, decision trees, clustering, PCA, and neural networks to solve intelligent system problems	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Estimate model performance using appropriate evaluation metrics, loss functions, and dimensionality reduction techniques	PO1 (3), PO3 (2)	3	2
CO4	Analyze deep learning and reinforcement learning models for intelligent decision-making and robotics applications	PO1 (3), PO3 (3)	3	3

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

CC25009	Quality and Reliability Engineering	L	T	P	C
		3	0	0	3

Course Objectives:

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

Quality Concepts and Statistical Process Control

Quality definition, quality assurance, variation in processes, factors causing variation, process capability, tolerance design. Introduction to control charts: variables ($\bar{X}$, R, and $\bar{X}$–S charts), attributes (P, C, and U charts). Establishing and interpreting control charts, charts for variables, quality rating, and short run SPC.

Acceptance Sampling and Quality Assessment

Lot-by-lot sampling: types and probability of acceptance in single, double, and multiple sampling plans. Operating Characteristic (OC) curves, producer's risk and consumer's risk, concepts of AQL, LTPD, AOQL. Standard sampling plans for AQL and LTPD and their usage.

Reliability Concepts and Monitoring

Definition of reliability, reliability mathematics and functions, hazard rate, design life, reliability measures, a priori and posteriori probabilities. Mortality of a component and mortality curve, useful life, redundancy, k-out-of-n systems, complex systems using Reliability Block Diagrams (RBD), Bayes' approach, cut and tie sets, fault trees, standby systems.

Life testing methods: failure-terminated, time-terminated, and sequential testing. Reliability growth monitoring, reliability allocation, software reliability, and human reliability.

Reliability Improvement and Maintainability

Downtime analysis, repair time distribution, system repair time, maintainability prediction, maintainability measures. Inspection decisions, system availability, and strategies for improving system reliability and maintainability.

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. 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.

E-Resources:

Here are **three top-notch e-learning resources (2025)** for your course in **Quality and Reliability Engineering**:

1. NPTEL – Introduction to Reliability Engineering (IIT Kharagpur, via Swayam) – Covers reliability fundamentals, system modeling, maintainability and availability (onlinecourses.nptel.ac.in)
2. NPTEL – Statistical Learning for Reliability Analysis (IIT Kharagpur) – Focuses on advanced statistical methods like hypothesis tests, ANOVA, MLE for reliability estimation (onlinecourses.nptel.ac.in)
3. Udemy – Introduction to Reliability Engineering – A beginner-friendly, on-demand course covering reliability basics, failure analysis, and practical maintenance strategies (classcentral.com)

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain quality concepts, statistical process control techniques, acceptance sampling methods, and reliability fundamentals	PO1 (2), PO3 (1)	2	1
CO2	Apply control charts, sampling plans, reliability models, and life testing methods to assess product and system performance	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate process capability indices, reliability measures, hazard rates, and system availability using appropriate mathematical models	PO1 (3), PO3 (2)	3	2
CO4	Analyze reliability block diagrams, fault trees, maintainability strategies, and improvement techniques to enhance system reliability	PO1 (3), PO3 (3)	3	3

ED25C11	Design with Advanced Materials	L	T	P	C
		3	0	0	3

Course Objective:

This course is designed to equip students with a comprehensive understanding of metallic materials and their applications. It aims to develop the ability to analyse various strengthening and failure mechanisms in metals and to apply metallurgical parameters effectively in the design of advanced materials. Students will gain insight into the relationship between material selection and processing methods, enabling informed decisions in engineering design. The course also fosters innovation by encouraging the development of novel materials through a deep understanding of the properties and behaviour of existing metallic systems. Additionally, students will critically analyse the use of different materials across a range of engineering applications.

Basic Concepts of Material Behavior

Engineering Design process and the role of materials; materials classification and their properties, Strengthening mechanisms-grain size reduction, solid solution strengthening, strain hardening, grain boundary strengthening, precipitation, particle, fibre and dispersion strengthening, Effect of temperature, strain and strain rate on plastic behavior – Super plasticity –Failure of metals

Activities Based Learning:

1. Case study discussion on material behavior in real-world engineering failures
2. Virtual presentation on microstructural changes during strengthening
3. Group presentation on strengthening mechanisms with example materials

Behavior Under Cyclic Loads and Failure Design

Stress intensity factor and fracture toughness – Fatigue-low and high cycle fatigue test, fracture mechanisms and Paris law.- Effect of surface and metallurgical parameters on fatigue – Safe life, Stresslife, strain-life and fail - safe design approaches- Fracture of nonmetallic Materials – Failure analysis, sources of failure, procedure of failure analysis.

Activities Based Learning:

1. Simulation on fatigue crack propagation and S-N curves
2. Numerical analysis on fracture toughness and fatigue design
3. Failure analysis report based on a real-world case
4. Mind map creation on design approaches under fatigue loading

Materials Selection and Design Integration

Material selection based on function, objectives, constraints, and service requirements- Free variables in selection- Relationship between material selection and processing- Case studies in advanced materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

Activities Based Learning:

1. Project on material selection for a specific engineering product
2. Interactive seminar on Ashby's material selection charts
3. Group debate on trade-offs in materials selection
4. Industry-based mini-case analysis of material choice and processing

Advanced Steels and Intermetallics

Steels-Advanced high strength steel, Dual phase (DP) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel and Q&P steels- Nitrogen steels, austenitic steels- ntermetallic compounds: Ni and Ti aluminides- Overview of alloy families: Al, Mg, Cu- Introduction to superalloys: iron, cobalt, and nickel base.

Activities Based Learning:

1. Comparative chart activity on different advanced steels
2. Individual assignment on intermetallic properties and applications
3. Video-based discussion on heat treatment of steels
4. Discussion on superalloy classifications and usage

Metal Matrix Composites (MMC) and Emerging Metallic Systems

Definition, characteristics, and applications of MMCs- Fabrication techniques and challenges-Performance evaluation of MMCs-Examples of MMCs used in aerospace, automotive, and military applications.

Activities Based Learning:

1. Case study: MMCs in aerospace structural components
2. Design task: Choose MMCs for a lightweight structure
3. Presentation: Comparison between conventional metals and MMCs
4. Poster creation on fabrication methods of MMCs

Non-Metallic and Composite Materials

Polymers: structure formation, properties, applications, environmental impact-Advanced ceramics: WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN, diamond- Fracture and deformation of ceramics- Glasses, clay products, and refractory ceramics-Composite materials: GFRP and CFRP laminated composites

Activities Based Learning:

1. Industrial visit to observe polymer and ceramic manufacturing
2. Case analysis of failure in ceramic-based components
3. Team presentation on CFRP and GFRP in automotive or aviation
4. Comparative table on mechanical properties of metals vs non-metals

(**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%

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%).

Assessment Methodology:

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

Internal Examinations - 50%

References:

1. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988.
2. Thomas H. Courtney, Mechanical Behavior of Materials, (2nd Edition), McGraw Hill, 2000.
3. Willam D. CallisterJr.and David G. Rethwisch, Callister's Materials Science and Engineering,(2nd Edition) Wiley Editorial, 2018.
4. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials,(34d edition), Butterworth-Heiremann, 1997.
5. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999.
6. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.
7. Ashby M.F., Materials Selection in Mechanical Design, 2nd Edition, Butter worth.
8. www.astm.org/labs/pages/131350.htm..

E-Resources:

www.astm.org/labs/pages/131350.html

CO	Course Outcome	POs	PSO1	PSO2
CO1	Explain fundamental material behavior, strengthening mechanisms, and failure modes	PO1 (2), PO3 (1)	2	1
CO2	Apply fatigue, fracture, and failure analysis techniques to engineering components	PO1 (2), PO3 (2)	2	2
CO3	Estimate material performance and select suitable materials for design applications	PO2 (2), PO3 (2)	2	2
CO4	Analyze advanced steels, intermetallics, MMCs, and composites for engineering applications	PO2 (2), PO3 (2)	2	2

CC25010	Mechanical Behaviour of Materials and their Measurements	L	T	P	C
		3	0	0	3

Course Objectives:

- The main learning objective of this course is to prepare the students
- To study about the elastic deformation of the materials
- To describe about the plastic deformation of the materials
- To study the typical techniques of evaluation of fracture and fracture mechanics of materials.
- To familiarize Fatigue testing methods.
- To summarize the Creep testing methods.

Elastic Deformation and Sensor Technologies

Stresses, strains, and displacements – Determination of principal stresses and strains in 2D & 3D – Maximum shear stress. Strain measurement using mechanical extensometers, strain gauges (principle, types, performance, uses). Introduction to photoelasticity – principle and applications – Moiré fringe – Digital Image Correlation (DIC). Load cells and force sensors. Structural vibration characteristics – LVDT – transducers for velocity and acceleration – sensor calibration.

Plastic Deformation and Advanced Measurement Techniques

Dislocation theory – dislocations in FCC, BCC, HCP lattices – stress fields, energies, forces on/between dislocations, climb, jogs, pile-ups. Dislocation sources and multiplication. Slip and twinning mechanisms – Yield criteria. Introduction to holography – use of laser in structural testing. Brittle coatings for stress analysis.

Fracture Mechanics and Testing

Fracture types and mechanisms – ductile and brittle fracture. Griffith's theory and Orowan's modification. Impact tests (Izod and Charpy), DBTT – factors and determination. Fracture mechanics – modes of fracture, defect characterization, crack inspection. Non-Destructive Evaluation (NDE): acoustic emission, ultrasonic (pulse-echo), fractography. Stress intensity factor, strain energy release rate, fracture toughness (K_IC), COD, J-integral concepts.

Fatigue Behavior and Life Prediction

Stress cycles, S-N curves, mean stress effects, fatigue factors, structural changes, cumulative damage. High-cycle fatigue (HCF), low-cycle fatigue (LCF), thermo-mechanical fatigue. Application of fracture mechanics in fatigue crack growth. Fatigue testing equipment. Paris Law. NDE techniques: eddy current testing, X-ray radiography. Residual life prediction under fatigue.

Creep Behavior and Testing Methods

Creep curve and stages, structural changes during creep, creep mechanisms. Metallurgical factors affecting creep, high-temperature alloys. Stress rupture testing, creep testing machines. Parametric extrapolation methods. Deformation Mechanism Maps.

High-Temperature Measurement Techniques
High-temperature strain gauges, load cells, and temperature sensors. Integration of measurement systems in high-temperature deformation testing.

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. Courtney, T. H. (2005). *Mechanical behavior of materials* (2nd ed.). Waveland Press.
2. Dieter, G. E., & Bacon, D. (2021). *Mechanical metallurgy* (4th ed.). McGraw-Hill Education.
3. Hertzberg, R. W., Vinci, R. P., & Hertzberg, J. L. (2020). *Deformation and fracture mechanics of engineering materials* (6th ed.). Wiley.
4. Nakra, B. C., & Chaudhry, K. K. (2013). *Instrumentation, measurement and analysis* (4th ed.). McGraw-Hill Education.
5. Rao, S. S. (2017). *Mechanical vibrations* (6th ed.). Pearson Education.
6. Boyd, J. D., & Grant, N. J. (2008). *High temperature mechanical behaviour of materials* (2nd ed.). Cambridge University Press.

E-Resources:

1. **[NPTEL – Advanced Materials and Processes (IIT Kanpur)]** https://nptel.ac.in/courses/113/104/113104115
   Covers mechanical behavior of materials, including dislocation theory, fatigue, creep, and fracture mechanics, ideal for advanced mechanical behavior understanding.
2. **[MIT OpenCourseWare – Materials in Human Experience (3.091)]** https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
   Offers foundational insights into material properties, stress-strain behavior, and testing approaches.
3. **[Coursera – Failure Mechanisms in Materials (by University of Illinois)]** https://www.coursera.org/learn/failure-mechanisms
   Focuses on fatigue, fracture, creep, and testing – directly relevant to your course modules.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain elastic and plastic deformation mechanisms, fracture mechanics principles, fatigue and creep behavior, and associated measurement techniques	PO1 (2), PO3 (1)	2	1

CO2	Apply stress–strain analysis, deformation theories, fracture testing, fatigue testing, creep testing, and sensor-based measurement techniques in material evaluation	PO1 (3), PO2 (2), PO3 (2)	3	2
CO3	Estimate mechanical properties, fracture toughness, fatigue life, creep life, and residual life using analytical and experimental methods	PO1 (3), PO3 (2)	3	2
CO4	Analyze material behavior under elastic, plastic, fatigue, creep, and high-temperature conditions using advanced testing and NDE techniques	PO1 (3), PO3 (3)	3	3

ED25C14	Design of Hydraulic and Pneumatic Systems	L	T	P	C
		3	0	0	3

Course Objective:

The main learning objective of this course is to prepare the students for imparting knowledge on fluid power principles and inculcating the skills to design and develop hydraulic and Pneumatic circuits.

Fluid Power Principles and Hydraulic Pumps

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque- Problems, Sources of Hydraulic power : Pumping Theory-– Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

Hydraulic Actuators and Control Components

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary Actuators – Hydraulic motors - Control components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories: Reservoirs, Accumulators, Pressure Intensifiers, Heat Exchangers, Pressure Gages - Pressure Switches– Filters –types and selectionApplications – Fluid Power ANSI Symbols – Problems.

Hydraulic Circuits and Systems

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications- Mechanical, hydraulic servosystems – Maintenance of Hydraulic Systems.

Pneumatic Systems

Properties of air –Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit –classification single cylinder and multi cylinder circuits – Cascade method.

Electro Pneumatic Systems

Electro Pneumatic System – Elements – Relay ladder diagram – timer circuits – Problems, PLC – Logic ladder diagram – Controlling Fluid power actuators.

Trouble Shooting and Applications

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Conditioning of hydraulic fluids Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs.

Activities Based Learning:

1. Hands-on experiment or simulation to demonstrate pressure transmission and mechanical advantage using Pascal's principle.
2. Disassemble or simulate various hydraulic actuators to understand internal construction and function.
3. Teams troubleshoot faulty hydraulic circuits presented via simulation or physical trainer kits.
4. Create pneumatic circuits for a given task using single/multi-cylinder setups.
5. Students sketch and explain a low-cost pneumatic/hydraulic system for a given industrial task.
6. Students build or simulate a small working model integrating hydraulic and pneumatic components.
7. Final presentation and demonstration of integrated system with documented learning outcomes.

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

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (20%), Internal Examinations (50%)

References:

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. James A. Sullivan, "Fluid Power Theory and Applications", Prentice Hall, 1997.
3. Shanmuga Sundaram. K., "Hydraulic and Pneumatic Controls". Chand & Co, 2006.
4. Jagadeesha. T., "Pneumatics Concepts, Design and Applications ", Universities Press, 2015.
5. Joshi.P., Pneumatic Control", Wiley India, 2008.
6. Srinivasan.R., "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008.
7. Majumdar, S.R., "Oil Hydraulics Systems – Principles and Maintenance",Tata McGraw Hill, 2001.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamental principles of fluid power, hydraulic and pneumatic systems	PO1 (1), PO2 (1)	1	1
CO2	Apply hydraulic and pneumatic components, circuits, and electro-pneumatic systems	PO2 (2), PO3 (2)	2	2
CO3	Estimate system performance, sizing, and selection of pumps, actuators, and valves	PO3 (2), PO4 (2)	2	2
CO4	Analyze hydraulic/pneumatic circuits, troubleshoot faults, and optimize designs	PO4 (2), PO5 (1)	2	1

CC25011	Design of Hybrid and Electric Vehicles	L	T	P	C
		3	0	0	3

Course Objectives:

- The main learning objective of this course is to prepare the students for designing hybrid and electric vehicles.

Fundamentals of Electric Vehicles

Electric vehicle system overview – history and advantages of EVs – EV market trends – vehicle mechanics: roadway fundamentals, laws of motion, vehicle kinetics, and dynamics – propulsion power, velocity, and acceleration – propulsion system design – introduction to hybrid vehicles and their classifications.

Energy Sources and Storage Systems

Engine powertrain basics – battery fundamentals: lead-acid, lithium-ion, and alternative batteries – battery parameters and characteristics – battery power estimation – battery thermal management systems – introduction to alternative energy sources – fuel cell types and their characteristics.

Series and Parallel Hybrid Drive Train Design

Series hybrid electric drivetrain: operation patterns, control strategies, component sizing, traction motor sizing, gear ratio design, acceleration and gradability verification, engine/generator design, power and energy capacity, fuel consumption analysis. Parallel hybrid electric drivetrain: control strategies, drive train parameters, engine and motor power capacity, transmission and energy storage design.

Electric Vehicle Drive Train and Transmission Design

EV transmission configurations – components of EV transmission – ideal gearbox concepts – gear ratios – torque-speed characteristics – EV motor sizing – performance criteria: initial acceleration, rated velocity, maximum velocity, and gradability.

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

Mandated Activities with weightage:

Assignments (20%), Quiz (10%), Virtual demonstration (15%), Flipped Classroom (5%).

Assessment Methodology:

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

References:

1. Ehsani, M, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2005
2. "Hybrid Electric Vehicle Technology Assessment: Methodology, Analytical Issues, and Interim Results," Center for Transportation Research Argonne National Laboratory, United States, Department of Energy.
3. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press,2011.
4. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.

E-Resources:

1. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000
   http://nptel.ac.in/courses/108103009/.
2. **NPTEL – Electric Vehicles (IIT Madras)**
   https://nptel.ac.in/courses/108/106/108106170
   A detailed course covering electric vehicle architecture, batteries, drive trains, and control strategies.
3. **SAE MOBILUS – Electric & Hybrid Vehicle Engineering**
   https://www.sae.org/learn/vehicle-electrification
   Offers technical papers, webinars, and training modules on EV technologies (registration may be required).
4. **DOE Energy.gov – Vehicle Technologies Office (VTO)**
   https://www.energy.gov/eere/vehicles/vehicle-technologies-office
   Access to government-funded research, publications, and resources on EV batteries, motors, and hybrid systems.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Describe the architecture, components, and working principles of electric and hybrid vehicles, including propulsion, energy storage, and drivetrain systems	PO1 (2), PO3 (2)	2	2
CO2	Implement vehicle design calculations for motor sizing, battery selection, and drivetrain configuration in hybrid and electric vehicles	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate vehicle performance metrics such as acceleration, gradability, energy efficiency, and fuel consumption using analytical and simulation methods	PO1 (3), PO3 (3)	3	3
CO4	Integrate series and parallel hybrid drivetrain components and control strategies to optimize system efficiency, reliability, and performance	PO1 (3), PO3 (3)	3	3