First Year Curriculum
Admission Year 2026-27

Master of Technology
Mechanical Engineering

Faculty of Engineering & Technology

Parul University

Vadodara, Gujarat, India

Semester 1

a. **Course Name:** Computer Graphics and Application in Design
b. **Course Code:** 03022101PC01
c. **Prerequisite:** Basic knowledge of computer, programming, geometry, engineering drawing, and CAD concepts is required for understanding Computer Graphics and Application in Design.
d. **Rationale:** This course introduces the fundamental concepts of computer graphics and their applications in engineering design and visualization. It helps students develop skills in graphical modeling, CAD tools, and digital representation techniques used in modern industries.

e. Course Learning Objective:

CLOBJ 1	To understand the basic concepts of CAD systems and engineering design processes.
CLOBJ 2	To apply computer graphics algorithms and geometric transformations in design applications.
CLOBJ 3	To develop and analyze 2D and 3D geometric models using CAD tools and techniques.
CLOBJ 4	To demonstrate the use of CAD in tolerance, assembly modeling, and design automation.
CLOBJ 5	To evaluate CAD standards, data exchange formats, and interoperability methods.
CLOBJ 6	To explore emerging technologies such as AI, VR/AR, and cloud-based CAD systems in modern design.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals of CAD and design processes.
CLO 2	Apply core algorithms for computer graphics and transformations.
CLO 3	Construct and analyze geometric models using CAD techniques.
CLO 4	Demonstrate CAD applications in tolerances, assembly, and automation.
CLO 5	Evaluate CAD standards and data exchange methods.
CLO 6	Investigate recent advances like AI, VR/AR, and cloud CAD.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain fundamentals of CAD and design processes.	2
CLO 2	Apply core algorithms for computer graphics and transformations.	3
CLO 3	Construct and analyze geometric models using CAD techniques.	4
CLO 4	Demonstrate CAD applications in tolerances, assembly, and automation.	3
CLO 5	Evaluate CAD standards and data exchange methods.	5
CLO 6	Investigate recent advances like AI, VR/AR, and cloud CAD.	4

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
2	**-**	**-**	**2**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Fundamentals of CAD & Design Process:** Introduction to CAD & Design process, CAD history, product lifecycle, CAD–CAM integration, CAD hardware, benefits and workstation setup	**15%**	**7**
2	**Computer Graphics:** DDA and Bresenham Algorithm for generation of line and circle; clipping, viewport/window mapping; 2D & 3D Transformation, Representation of curves and surfaces.	**25%**	**11**
3	**Geometry Modeling:** Geometric Modeling techniques, Wireframe Modeling, Surface Modeling & Solid Modeling, parametric and feature-based modeling	**20%**	**9**
4	**Computer Applications in Design:** Geometric Tolerances, Mass property calculations, Mechanical Assembly, System customization & design automation, Programming techniques in drafting/ modeling/ analysis, Concept of computer animation, Reverse Engineering, Capabilities of various commercially available software in the area of CAD.	**25%**	**11**
5	**CAD Standards & Data Exchange:** Drafting standards, Graphics and computing standards, unit management, layering, annotation, Data exchange standards, Design database.	**10%**	**5**
6	**Recent Research & Technological Advancements:** AI in design (generative CAD), VR/AR in design review, cloud CAD, real-time collaboration, additive manufacturing integration, simulation–optimization workflows.	**5%**	**2**

j. Text Book and Reference Book:

1. "CAD/CAM Theory and Practice" by Ibrahim-Zeid.
2. "Computer Graphics with OpenGL" by Hearn & Baker.
3. "Computer Graphics: Principles and Practice" by Foley, Van Dam, Feiner and Hughes.
4. "CAD/CAM: Computer-Aided Design and Manufacturing" by Groover & Zimmers.
5. “Digital Human Modeling”, by Broukhim & Bronzino.

a. **Course Name:** Computer Graphics and Application in Design Laboratory
b. **Course Code:** 03022101PC02
c. **Prerequisite:** Basic knowledge of computer graphics, CAD software, programming fundamentals, and engineering drawing.
d. **Rationale:** The "Computer Graphics and Application in Design Laboratory" provides practical exposure to computer graphics and CAD tools for engineering design and visualization. It helps students develop hands-on skills in modeling, drafting, transformations, and graphical analysis used in modern industrial applications.

e. Course Learning Objective:

CLOBJ 1	To understand the basic concepts of CAD systems and engineering design processes.
CLOBJ 2	To apply computer graphics algorithms and geometric transformations in design applications.
CLOBJ 3	To develop and analyze 2D and 3D geometric models using CAD tools and techniques.
CLOBJ 4	To demonstrate the use of CAD in tolerance, assembly modeling, and design automation.
CLOBJ 5	To evaluate CAD standards, data exchange formats, and interoperability methods.
CLOBJ 6	To explore emerging technologies such as AI, VR/AR, and cloud-based CAD systems in modern design.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals of CAD and design processes.
CLO 2	Apply core algorithms for computer graphics and transformations.
CLO 3	Construct and analyze geometric models using CAD techniques.
CLO 4	Demonstrate CAD applications in tolerances, assembly, and automation.
CLO 5	Evaluate CAD standards and data exchange methods.
CLO 6	Investigate recent advances like AI, VR/AR, and cloud CAD.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain fundamentals of CAD and design processes.	2
CLO 2	Apply core algorithms for computer graphics and transformations.	3
CLO 3	Construct and analyze geometric models using CAD techniques.	4
CLO 4	Demonstrate CAD applications in tolerances, assembly, and automation.	3
CLO 5	Evaluate CAD standards and data exchange methods.	5
CLO 6	Investigate recent advances like AI, VR/AR, and cloud CAD.	4

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
0	**-**	**2**	**1**	**-**	**-**	**20**	**-**	**30**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. "CAD/CAM Theory and Practice" by Ibrahim-Zeid.
2. "Computer Graphics with OpenGL" by Hearn & Baker.
3. "Computer Graphics: Principles and Practice" by Foley, Van Dam, Feiner and Hughes.
4. "CAD/CAM: Computer-Aided Design and Manufacturing" by Groover &

Zimmers.

5. "Digital Human Modeling", by Broukhim & Bronzino.

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
1	Implement algorithms for generating lines, and circles using a programming language		✓				
2	Practice basic drafting techniques and create 2D drawings using CAD software.	✓		✓			
3	Create wireframe, surface, and solid models for simple objects in CAD software.			✓			
4	Develop parametric models and apply feature-based modeling for assigned design problems		✓	✓	✓		
5	Perform assembly creation and analyze mechanical assemblies in CAD.			✓	✓		
6	Generate multiple views (front, top, side, isometric) from 3D models.	✓		✓			
7	Explore model-view associativity and calculate mass properties of solid models			✓	✓		
8	Import and export models using data exchange standards like IGES and STEP.					✓	

a. Course Name: Computer Aided Manufacturing

b. Course Code: 03022101PC03

c. Prerequisite: Basic knowledge of manufacturing processes, CAD/CAM concepts, engineering drawing, and computer applications is required for understanding Computer Aided Manufacturing

d. Rationale: This course introduces the principles and applications of computer-aided manufacturing in modern production systems. It helps students develop knowledge of CNC programming, automation, process planning, and integration of CAD/CAM technologies for efficient manufacturing.

e. Course Learning Objective:

CLOBJ 1	To understand the fundamental concepts and components of CAM, CIM, CNC, and DNC systems used in automated manufacturing.
CLOBJ 2	To identify CNC machine elements, tooling systems, drives, and control mechanisms used in manufacturing operations.
CLOBJ 3	To develop NC and CNC programs for machining operations using manual and computer-assisted techniques.
CLOBJ 4	To analyze the structure, planning, and applications of Flexible Manufacturing Systems and Group Technology.
CLOBJ 5	To compare different CAM toolpath generation strategies for automated machining from CAD models.
CLOBJ 6	To assess modern advancements such as interfacing standards, adaptive control, and

	feature-based manufacturing in CAM systems.

f. Course Learning Outcomes:

CLO 1	Describe the fundamental concepts and components of CAM, CIM, CNC, and DNC systems in automated manufacturing.
CLO 2	Identify CNC machine hardware, tooling requirements, drives, and control systems used in manufacturing.
CLO 3	Develop NC and CNC part programs using manual and computer-assisted methods for milling and turning operations.
CLO 4	Analyze the components, planning considerations, and applications of Flexible Manufacturing Systems and Group Technology.
CLO 5	Compare different toolpath strategies in CAM software for automatic NC program generation from CAD models.
CLO 6	Assess recent trends such as interfacing standards, adaptive control, and feature-based manufacturing in CAM.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Describe the fundamental concepts and components of CAM, CIM, CNC, and DNC systems in automated manufacturing.	2
CLO 2	Identify CNC machine hardware, tooling requirements, drives, and control systems used in manufacturing.	2
CLO 3	Develop NC and CNC part programs using manual and computer-assisted methods for milling and turning operations.	3
CLO 4	Analyze the components, planning considerations, and applications of Flexible Manufacturing Systems and Group Technology.	4
CLO 5	Compare different toolpath strategies in CAM software for automatic NC program generation from CAD models.	4
CLO 6	Assess recent trends such as interfacing standards, adaptive control, and feature-based manufacturing in CAM.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
3	-	-	**3**	**20**	**20**	-	**60**	-	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction to CAM, CIM, NC, CNC and DNC:** CAM Concepts, Types of Manufacturing system, Benefits of CAM, Concept of Computer Integrated Manufacturing, Role of manufacturing Engineers, CIM wheel. Introduction to NC/CNC, History, Classification of CNC Machines, Component of NC/CNC machines, Specification of CNC,	**15%**	**8**

	NC motion system, Axis Designation, tape, tape format, tape code and tape readers used in NC machine, open loop system, closed loop system, feedback devices, Controllers, Sensors and Actuators, Direct Numerical Control (DNC), Working principle of DNC, DNC components.		
2	**NC and CNC Machines:**	**25%**	**12**
	CNC hardware: Recirculating ball screw, anti-friction slides, NC/CNC tooling, Automatic tool changers (ATC), automatic pallet changers (APC). Tooling requirements of CNC machine, preset and qualified tools, work and tool holding devices in CNC machines. **System Drives And Control Systems:** Spindle Drives: DC shunt motor and 3-phase AC induction motor, Feed drives: steeper motor, servo motor, DC & AC servo motors Control system: Types of encoders, absolute and incremental optical encoders.		
3	**NC/CNC Part Programming:** Introduction, controllers, Types of controllers, structure of part programming, G & M codes, Types of format, manual part programming for lathe and milling machine operations, Concepts of tool length and radius compensation, subroutines, do loops, canned cycles for lathe & milling, sub programming. **Computer assisted part programming:** Need, list of computer assisted programming languages, Automated Programmed Tools language (APT) - its types of statement, command, Fundamentals of Macros.	**15%**	**8**
4	**Flexible Manufacturing System and Group Technology:** Introduction, Need of FMS, General Considerations for FMS, components of a FMS, types of FMS, flexibilities and types, measurement techniques, Applications of FMS, workstation, planning the FMS, Automated material handling systems; types of Application, AS/RS, AGV, Manufacturing cells, concept of cellular manufacturing, group technology and just in time. Introduction to GT, implementation considerations, benefits and applications, GT methods - visual search method, production flow analysis, Parts classification and coding.	**20%**	**10**
5	**Automated Part Programming:** Automatic NC program generation from CAD models using software, Comparison of different Toolpath strategies in CAM Software.	**15%**	**5**
6	**Recent Trends in CAM:** Interfacing standards for CAD/CAM -Types and applications, Adaptive control-definition, meaning, block diagram, sources of variability and applications, Feature Based Manufacturing.	**10%**	**2**

j. Text Book and Reference Book:

1. "Computer Numerical Control" by P. Radhakrishnan.
2. "CNC Technology and Programming" by Tilak Raj.
3. "CAD/CAM Theory & Practice" by Ibrahim Zeid.
4. "CNC Machining and Programming" by David Gibbs and Thomas Crandall.
5. “Numerical Control and Computer Aided Manufacturing”, by T.K. Kundra, P.N.Rao, N.K. Tewari.
6. “Computer Aided Manufacturing” by T.K. Kundra, P.N.Rao, N.K. Tewari.
7. “CAD/CAM and Automation” by Farazdak Haideri.
8. “Computer Aided Manufacturing” by T ien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang.
9. “Flexible Manufacturing Cells and System” by William. W. Luggen Hall.

a. **Course Name:** Computer Aided Manufacturing Laboratory
b. **Course Code:** 03022101PC04
c. **Prerequisite:** Basic knowledge of manufacturing processes, CNC programming, CAD/CAM concepts, and computer applications.
d. **Rationale:** The "Computer Aided Manufacturing Laboratory" provides practical exposure to CNC programming, CAM software, and automated manufacturing systems. It helps students develop hands-on skills in machining simulation, toolpath generation, and integration of CAD/CAM technologies used in modern industries.

e. Course Learning Objective:

CLOBJ 1	To understand the fundamental concepts and components of CAM, CIM, CNC, and DNC systems used in automated manufacturing.
CLOBJ 2	To identify CNC machine elements, tooling systems, drives, and control mechanisms used in manufacturing operations.
CLOBJ 3	To develop NC and CNC programs for machining operations using manual and computer-assisted techniques.
CLOBJ 4	To analyze the structure, planning, and applications of Flexible Manufacturing Systems and Group Technology.
CLOBJ 5	To compare different CAM toolpath generation strategies for automated machining from CAD models.
CLOBJ 6	To assess modern advancements such as interfacing standards, adaptive control, and feature-based manufacturing in CAM systems.

f. Course Learning Outcomes:

CLO 1	Describe the fundamental concepts and components of CAM, CIM, CNC, and DNC systems in automated manufacturing.
CLO 2	Identify CNC machine hardware, tooling requirements, drives, and control systems used in manufacturing.
CLO 3	Develop NC and CNC part programs using manual and computer-assisted methods for milling and turning operations.
CLO 4	Analyze the components, planning considerations, and applications of Flexible Manufacturing Systems and Group Technology.
CLO 5	Compare different toolpath strategies in CAM software for automatic NC program generation from CAD models.
CLO 6	Assess recent trends such as interfacing standards, adaptive control, and feature-based manufacturing in CAM.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Describe the fundamental concepts and components of CAM, CIM, CNC, and DNC systems in automated manufacturing.	2
CLO 2	Identify CNC machine hardware, tooling requirements, drives, and control systems used in manufacturing.	2
CLO 3	Develop NC and CNC part programs using manual and computer-assisted methods for milling and turning operations.	3
CLO 4	Analyze the components, planning considerations, and applications of Flexible Manufacturing Systems and Group Technology.	4
CLO 5	Compare different toolpath strategies in CAM software for automatic NC program generation from CAD models.	4
CLO 6	Assess recent trends such as interfacing standards, adaptive control, and feature-based manufacturing in CAM.	5

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		Total
L	T	P	C	MSE	CE	P	Theory	P	
0	-	2	1	-	-	20	-	30	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. "Computer Numerical Control" by P. Radhakrishnan.
2. "CNC Technology and Programming" by Tilak Raj.
3. "CAD/CAM Theory & Practice" by Ibrahim Zeid.
4. "CNC Machining and Programming" by David Gibbs and Thomas Crandall.
5. “Numerical Control and Computer Aided Manufacturing”, by T.K. Kundra, P.N.Rao, N.K. Tewari.
6. “Computer Aided Manufacturing” by T.K. Kundra, P.N.Rao, N.K. Tewari.
7. “CAD/CAM and Automation” by Farazdak Haideri.
8. “Computer Aided Manufacturing” by T ien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang.
9. “Flexible Manufacturing Cells and System” by William. W. Luggen Hall.

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
1	To Study about CAM and NC/CNC/DNC hardware and their axis designation.	✓	✓				
2	To study about G & M codes and part program structure.		✓	✓			
3	To prepare part program for performing simulation with and without canned cycle for given geometry of CNC milling operations.			✓		✓	
4	To perform machining of a prepared part program with and without canned cycle in CNC milling machine.		✓	✓			
5	To prepare part program for performing simulation with and without canned cycle for given geometry of CNC lathe operations.			✓		✓	
6	To perform machining of prepared part program with and without canned cycle in CNC lathe machine.		✓	✓			
7	To prepare part program for canned cycle and sub programming.			✓			
8	To study about application of APT Programming Language.	✓		✓			✓
9	To study of CAM Software.	✓				✓	✓

a. **Course Name:** Advances in Materials and Manufacturing Processes

b. **Course Code:** 03022101PC05

c. **Prerequisite:** Basic knowledge of engineering materials, manufacturing processes, material science, and mechanical engineering fundamentals

d. **Rationale:** This course introduces advanced materials and modern manufacturing techniques used in current industrial applications. It helps students understand emerging processing methods, material behavior, and sustainable manufacturing technologies for improved product performance and production efficiency.

e. Course Learning Objective:

CLOBJ 1	To understand the classification, properties, and behavior of engineering materials used in manufacturing applications.
CLOBJ 2	To analyze advanced materials such as composites, nanomaterials, smart materials, and biomaterials for modern engineering needs.
CLOBJ 3	To compare advanced machining processes and evaluate their suitability for different manufacturing operations.
CLOBJ 4	To apply modelling and simulation techniques for analysis and improvement of manufacturing processes.
CLOBJ 5	To demonstrate the concepts and applications of virtual manufacturing and digital prototyping in industry.
CLOBJ 6	To assess emerging technologies and recent advancements in materials and manufacturing

	processes.

f. Course Learning Outcomes:

CLO 1	Explain the classification, properties, phase transformations, and mechanical behavior of engineering materials.
CLO 2	Analyze advanced materials such as composites, nanomaterials, smart materials, and biomaterials for engineering applications.
CLO 3	Compare advanced machining processes and evaluate their applications in modern manufacturing.
CLO 4	Apply modelling and simulation techniques for analysis and optimization of manufacturing processes.
CLO 5	Demonstrate the concepts of virtual manufacturing, virtual reality, and digital prototyping in manufacturing systems
CLO 6	Assess emerging trends and technologies in advanced materials and manufacturing processes for industrial applications.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain the classification, properties, phase transformations, and mechanical behavior of engineering materials.	2
CLO 2	Analyze advanced materials such as composites, nanomaterials, smart materials, and biomaterials for engineering applications.	4
CLO 3	Compare advanced machining processes and evaluate their applications in modern manufacturing.	5
CLO 4	Apply modelling and simulation techniques for analysis and optimization of manufacturing processes.	3
CLO 5	Demonstrate the concepts of virtual manufacturing, virtual reality, and digital prototyping in manufacturing systems	3
CLO 6	Assess emerging trends and technologies in advanced materials and manufacturing processes for industrial applications.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
2	**1**	**0**	**3**	**20**	**20**	**50**	**60**	**-**	**150**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction to Materials** Classification of materials, properties of materials, Engineering requirements of materials, Imperfections in materials, Selection of materials for engineering applications, Plastic material, Phase Diagrams, Phase transformations in metals, Solidification in metals and alloys, Mechanical properties of materials, Failure in materials.	**10%**	**5**
2	**Advance Materials**	**25%**	**12**
	Structural Materials-Composite materials, Nanomaterials: nanotubes and nanowires, Functional Materials: Optoelectronic materials,		

	Semiconductors, Smart Materials: Shape memory alloys, functionally graded materials (FGMs), Biomaterials: Biocompatible metals, ceramics, polymers, and composites, Materials for implants and prosthetics, Bioactive and biodegradable materials, Surface modifications for enhanced biological interaction, Applications in tissue engineering and drug delivery systems.		
3	**Advances in Machining Processes** Advance machining process like Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Abrasive Flow Machining (AFM), and Water Jet Machining (WJM), Electrochemical Machining (ECM), Thermo-electrical machining techniques such as Electrical Discharge Machining (EDM) and Electrical Discharge Wire Cutting (EDWC), Electron Beam Machining (EBM), Plasma Arc Machining (PAM), Ion Beam Machining (IBM), and Laser Beam Machining (LBM), Electrochemical Grinding (ECG), Electrochemical Discharge Grinding (ECDG), and Laser-Assisted Hybrid Machining.	**25%**	**12**
4	**Modelling & Simulation of Manufacturing Processes** Introduction to Modelling, Simulation and Analytical Models. Simulation Programming Languages. Design and Analysis of Experiments.	**20%**	**8**
5	**Virtual Manufacturing** Introduction, principles of virtual reality. Architecture, Virtual reality modelling languages. Digital design, process modeling, virtual prototyping, and simulation of machining, forming, and assembly operations.	**20%**	**8**

j. Text Book and Reference Book:

1. Materials Science and Engineering: An Introduction by David G. Rethwisch and William Callister.
2. Advanced Materials and Manufacturing Processes by Albano Cavaleiro, Amar Patnaik, Ernst Kozeschnik, J. Paulo Davim, Malay Kumar Banerjee, and Vikas Ku.
3. Manufacturing Processes: Reference Guide by Robert H. Todd, Dell K. Allen, and Leo Alting.

a. Course Name: Research Methodology & IPR

b. Course Code: 03020201HM01

c. Prerequisite: Basic knowledge of research fundamentals, technical writing, analytical thinking, and engineering concepts is required for understanding Research Methodology & IPR.

d. Rationale: This course provides knowledge of research methodologies, technical documentation, and intellectual property rights essential for academic and industrial research. It helps students develop skills in problem identification, research design, data analysis, ethics, and patent-related processes.

e. Course Learning Objective:

CLOBJ 1	To understand the principles and applications of mathematical modeling in research and engineering problem-solving.
CLOBJ 2	To develop skills in experimental design, simulation techniques, and data-driven research methodologies.
CLOBJ 3	To apply statistical and computational tools for effective data analysis and interpretation of research outcomes.
CLOBJ 4	To utilize simulation methods for modeling real-world systems and validating research hypotheses.

CLOBJ 5	To understand the concepts of Intellectual Property Rights, patents, copyrights, trademarks, trade secrets, and technology transfer in research and innovation.

f. Course Learning Outcomes:

CLO 1	Understand Mathematical Modeling – Explain the principles of mathematical modeling and its applications in research and problem-solving.
CLO 2	Develop Experimental and Simulation Skills – Gain proficiency in designing and executing experiments, as well as using simulation techniques for data-driven research.
CLO 3	Perform Data Analysis and Interpretation – Apply statistical and computational tools to analyze research data and derive meaningful insights.
CLO 4	Utilize Simulation Techniques – Implement various simulation methods to model real-world scenarios and validate research hypotheses.
CLO 5	Understand Intellectual Property Rights (IPR) – Explain the importance of IPR, including trademarks, copyrights, patents (and their types), trade secrets, and technology transfer in research and innovation.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand Mathematical Modeling – Explain the principles of mathematical modeling and its applications in research and problem-solving.	2
CLO 2	Develop Experimental and Simulation Skills – Gain proficiency in designing and executing experiments, as well as using simulation techniques for data-driven research.	3
CLO 3	Perform Data Analysis and Interpretation – Apply statistical and computational tools to analyze research data and derive meaningful insights.	4
CLO 4	Utilize Simulation Techniques – Implement various simulation methods to model real-world scenarios and validate research hypotheses.	3
CLO 5	Understand Intellectual Property Rights (IPR) – Explain the importance of IPR, including trademarks, copyrights, patents (and their types), trade secrets, and technology transfer in research and innovation.	2

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
4	**-**	**-**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction:** Research: Definition, Characteristics, Motivation and Objectives, Research Methods vs Methodology, Types of Research — Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical.	**10%**	**4**
2	**Methodology:** Research Process, Formulating the Research Problem, Defining the Research Problem,	**10%**	**4**

	Research Questions, Research Methods vs. Research Methodology.		
3	**Literature Review:** Review Concepts and Theories, Identifying and Analyzing the Limitations of Different Approaches.	**20%**	**6**
4	**Formulation and Design:** Concept and Importance in Research, features of a Good Research Design, Exploratory Research Design, Concept, Types and Uses, Descriptive Research Designs, Concept, Types and Uses, Experimental Design: Concept of Independent & Dependent Variables.	**20%**	**6**
5	**Data Modeling and Simulations:** Mathematical Modeling, Experimental Skills, Simulation Skills, Data Analysis and Interpretation.	**20%**	**6**
6	**Introduction to IPR:** IPR importance, Trademark, copyright, patent and its types, Trade secret, IPR and Technology Transfer	**20%**	**6**

j. Text Book and Reference Book:

1. "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W. Creswell.
2. "Research Methodology: Methods and Techniques" by C.R. Kothari.
3. "Qualitative Research" by David Silverman.

a. Course Name: English for Research Paper Writing

b. Course Code: 03020001MC01

c. Prerequisite: Basic Knowledge about sentence formation using different words in present, past tenses and future time. Also, basic knowledge on use of suitable nouns, adjectives, verbs, preposition, etc.

d. Rationale: To provide a better insight into the effective use of grammar knowledge especially in writing and to put their own thoughts into writing.

e. Course Learning Objective:

CLOBJ 1	To develop effective academic writing skills and improve the readability of research papers.
CLOBJ 2	To understand the structure and content requirements of different sections of a research paper.
CLOBJ 3	To acquire the skills required for writing clear, concise, and impactful research paper titles.
CLOBJ 4	To ensure high-quality research paper preparation for successful first-time submission and publication.

f. Course Learning Outcomes:

CLO 1	Understand how to improve your writing skills and level of readability.
CLO 2	Learn about what to write in each section.
CLO 3	Understand the skills needed when writing a Title.
CLO 4	Ensure the good quality of paper at the very first-time submission.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand how to improve your writing skills and level of readability.	2
CLO 2	Learn about what to write in each section.	2
CLO 3	Understand the skills needed when writing a Title.	2
CLO 4	Ensure the good quality of paper at the very first-time submission.	3

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
2	-	-	0	-	50	-	-	-	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Unit 1:** Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	**16%**	**5**
2	**Unit 2:** Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.	**17%**	**5**
3	**Unit 3:** Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	**17%**	**5**
4	**Unit 4:** Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.	**17%**	**5**
5	**Unit 5:** Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, and skills are needed when writing the Conclusions.	**16%**	**5**
6	**Unit 6:** Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.	**16%**	**5**

j. Text Book and Reference Book:

1. "Writing for Science" by Goldbort R.
2. "How to Write and Publish a Scientific Paper" by Highman N.
3. "English for Writing Research Papers" by Adrian Wallwork.

a. **Course Name:** Disaster Management

b. **Course Code:** 03021601MC01

c. **Prerequisite:** Basic knowledge of Environmental Science or Geography.

d. **Rationale:** This course enables students to understand, assess, and manage various types of disasters, their impacts, and mitigation strategies, thereby fostering resilience and sustainable development.

e. Course Learning Objective:

CLOBJ 1	To understand different types of disasters, their causes, and their environmental and societal impacts.
CLOBJ 2	To analyze disaster-related damages and apply suitable disaster management strategies.
CLOBJ 3	To assess vulnerability factors and recommend effective risk reduction and mitigation measures.

CLOBJ 4	To develop hazard and vulnerability profiles using appropriate assessment tools and techniques.
CLOBJ 5	To classify structural and non-structural approaches for disaster mitigation and preparedness.

f. Course Learning Outcomes:

CLO 1	Differentiate types of disasters, identify their causes, and evaluate their impact on the environment and society.
CLO 2	Analyse disaster damage and apply effective management strategies.
CLO 3	Assess vulnerability and recommend appropriate risk mitigation measures.
CLO 4	Develop a hazard and vulnerability profile using relevant tools and techniques.
CLO 5	Classify structural and non-structural disaster mitigation strategies.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Differentiate types of disasters, identify their causes, and evaluate their impact on the environment and society.	5
CLO 2	Analyse disaster damage and apply effective management strategies.	4
CLO 3	Assess vulnerability and recommend appropriate risk mitigation measures.	5
CLO 4	Develop a hazard and vulnerability profile using relevant tools and techniques.	6
CLO 5	Classify structural and non-structural disaster mitigation strategies.	2

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
2	**-**	**-**	**0**	**-**	**50**	**-**	**-**	**-**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction to Disaster:** Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity Disaster and Development and disaster management Types (Geological Disasters, Hydro-Meteorological Disasters, Biological Disasters, Technological Disasters and Man-made Disasters) , Global Disaster Trends, Causes, Consequences and Control of Disasters.	**12%**	**20**
2	**Disaster Management Cycle and Framework:** Disaster Management Cycle -Paradigm Shift in Disaster Management, Pre-Disaster -Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster -Evacuation -Disaster Communication -Search and Rescue -Emergency Operation Centre -Incident Command System -Relief and Rehabilitation –Post disaster -Damage and Needs	**14%**	**30**

	Assessment, Restoration of Critical Infrastructure - Early Recovery - Reconstruction and Redevelopment; IDNDR, Yokohama Strategy, Hyogo Framework of Action.		
3	**Disaster Management in India:** Disaster Profile, Lessons Learnt from Major Disasters, Disaster Management Act 2005 -Institutional and Financial Mechanism National Policy on Disaster Management,	**12%**	**30**
	Roles and responsibilities of Government (States, Centre) and other stakeholders- Institutional Processes and Framework at State and Central Level-State Disaster Management Authority (SDMA).		
4	**Technology for Disaster Management & Mitigation:** Geo-informatics in Disaster Management (GIS, GPS), Disaster Communication System (Early Warning system), Land Use Planning and Development Regulations, Disaster Safe Designs and Constructions, Structural and Non-Structural Mitigation of Disasters S&T Institutions for Disaster Management in India.	**10%**	**20**

j. Text Book and Reference Book:

1. "Introduction to Disaster Management" by Modh Satish.
2. "An overview on natural & man-made disasters and their reduction" by Goel S. L.
3. "Disaster Management" by B.Narayan.

a. Course Name: Rapid Prototyping and Tooling

b. Course Code: 03022101PE01

c. Prerequisite: Basic knowledge of Manufacturing Processes, CAD/CAM, Engineering Materials, CNC Technology, and Tool Engineering.

d. Rationale: Rapid Prototyping and Tooling enable students to understand modern product development techniques using CAD/CAM and additive manufacturing technologies. The subject helps in reducing product development time, improving design flexibility, and supporting advanced manufacturing applications in industries such as automotive, aerospace, and biomedical engineering

e. Course Learning Objective:

CLOBJ 1	Define the fundamentals, evolution, and CAD integration in rapid prototyping and product development.
CLOBJ 2	Explain the working principles and processes of liquid-based, powder-based, and solid-based rapid prototyping techniques.
CLOBJ 3	Describe rapid tooling methods and their applications in manufacturing plastic and metal components.
CLOBJ 4	Apply reverse engineering techniques including 3D scanning, digitizing, and data fitting for prototype development.
CLOBJ 5	Evaluate recent advancements in additive and hybrid manufacturing with respect to AI integration, smart manufacturing, and sustainability.

f. Course Learning Outcomes:

CLO 1	Define the fundamentals of rapid prototyping, its evolution, and the role of CAD in product development.
CLO 2	Explain the principles and processes of liquid, powder, and solid-based rapid prototyping techniques.
CLO 3	Describe the methods and applications of rapid tooling for producing plastic and metal components.
CLO 4	Apply reverse engineering techniques such as 3D scanning, digitizing, and data fitting in

	prototyping.
CLO 5	Evaluate recent advancements in additive and hybrid manufacturing, including AI integration and sustainability.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Define the fundamentals of rapid prototyping, its evolution, and the role of CAD in product development.	1
CLO 2	Explain the principles and processes of liquid, powder, and solid-based rapid prototyping techniques.	2
CLO 3	Describe the methods and applications of rapid tooling for producing plastic and metal components.	2
CLO 4	Apply reverse engineering techniques such as 3D scanning, digitizing, and data fitting in prototyping.	3
CLO 5	Evaluate recent advancements in additive and hybrid manufacturing, including AI integration and sustainability.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**T**	**CE**	**P**	**Theory**	**P**	
2	**-**	**-**	**2**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction** Definitions, evolution, CAD for RPT. Product design and rapid product development. The cost and effects of design changes during conceptual modeling, detail designing, prototyping, manufacturing and product release. Fundamentals of RPT technologies, various CAD issues for RPT. RPT and its role in modern manufacturing mechanical design. 3D solid modeling software and their role in RPT. Creation of STL or SLA file from a 3D solid model.	**20%**	**9**
2	**Liquid And Powder Based RP Processes**	**20%**	**9**
	Liquid based process: Principles of STL and typical processes such as the SLA process, solid ground curing and others - Powder based process: Principles and typical processes such as selective laser sintering and some 3D printing processes.		
3	**Solid Based RP Processes** Principles and typical processes such as fused deposition modeling; laminated object modeling and others.	**20%**	**9**
4	**Rapid Tooling**	**20%**	**9**

	Principles and typical processes for quick batch production of plastic and metal parts through quick tooling		
5	**Reverse Engineering** 3D scanning, 3D digitizing and Data fitting. High-speed machining-Hardware and software - Applications: Evaluation, benchmarking and various case studies.	**15%**	**7**
6	**Hybrid And Additive Manufacturing** 4D printing, hybrid manufacturing, AI in additive manufacturing, metal AM advancements, sustainable RP, recent case studies and patents	**5%**	**2**

j. Text Book and Reference Book:

1. Rapid Prototyping: A Brief Introduction (Textbook) By Ghosh A | Affiliated East West. | 1st Edition, Pub. Year 2006
2. Rapid Manufacturing; the technologies and application of RPT and Rapid tooling By Pham D.T. and Dimov S.S. | Springer, London | 1st Edition, Pub. Year 2001
3. 3D Printing and Additive Manufacturing: Principles and Applications By Chua Chee Kai, Leong Kah Fai, Lim Chu Sing Lim | World Scientific | 5th, Pub. Year 2024
4. Rapid Prototyping Technology: Selection and Application By Kenneth G. Cooper | CRC Press | 1st Edition, Pub. Year 2019

a. Course Name: Rapid Prototyping and Tooling Laboratory

b. Course Code: 03022101PE02

c. Prerequisite: Basic knowledge of Manufacturing Processes, CAD Modeling, CAM, Engineering Materials, and fundamentals of Rapid Prototyping and Additive Manufacturing.

d. Rationale: Rapid Prototyping and Tooling Laboratory provides practical exposure to additive manufacturing, CAD/CAM integration, and rapid tooling techniques used in modern product development. The laboratory helps students develop hands-on skills in prototype fabrication, reverse engineering, and advanced manufacturing processes for industrial applications.

e. Course Learning Objective:

CLOBJ 1	Define the fundamentals, evolution, and CAD integration in rapid prototyping and product development.
CLOBJ 2	Explain the principles and working processes of liquid-based, powder-based, and solid-based rapid prototyping techniques.
CLOBJ 3	Describe rapid tooling methods and their applications in manufacturing plastic and metal components.
CLOBJ 4	Apply reverse engineering techniques such as 3D scanning, digitization, and data fitting for prototype development.
CLOBJ 5	Evaluate recent advancements in additive and hybrid manufacturing including AI integration, smart manufacturing, and sustainable production practices.

f. Course Learning Outcomes:

CLO 1	Define the fundamentals of rapid prototyping, its evolution, and the role of CAD in product development.
CLO 2	Explain the principles and processes of liquid, powder, and solid-based rapid prototyping techniques.
CLO 3	Describe the methods and applications of rapid tooling for producing plastic and metal components.
CLO 4	Apply reverse engineering techniques such as 3D scanning, digitizing, and data fitting in prototyping.

CLO 5	Evaluate recent advancements in additive and hybrid manufacturing, including AI integration and sustainability.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Define the fundamentals of rapid prototyping, its evolution, and the role of CAD in product development.	1
CLO 2	Explain the principles and processes of liquid, powder, and solid-based rapid prototyping techniques.	2
CLO 3	Describe the methods and applications of rapid tooling for producing plastic and metal components.	2
CLO 4	Apply reverse engineering techniques such as 3D scanning, digitizing, and data fitting in prototyping.	3
CLO 5	Evaluate recent advancements in additive and hybrid manufacturing, including AI integration and sustainability.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
0	**-**	**2**	**1**	**-**	**-**	**20**	**-**	**30**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. Rapid Prototyping: A Brief Introduction (Textbook) By Ghosh A | Affiliated East West. | 1st Edition, Pub. Year 2006.
2. Rapid Manufacturing; the technologies and application of RPT and Rapid tooling By Pham D.T. and Dimov S.S. | Springer, London | 1st Edition, Pub. Year 2001
3. 3D Printing and Additive Manufacturing: Principles and Applications by Chua Chee Kai, Leong Kah Fai, Lim Chu Sing Lim | World Scientific | 5th, Pub. Year 2024
4. Rapid Prototyping Technology: Selection and Application by Kenneth G. Cooper | CRC Press | 1st Edition, Pub. Year 2019

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5
1	To study about introduction to Rapid Prototyping and Tooling	✓				
2	To Study about Layered Manufacturing.		✓			
3	Study of Laminated Object Manufacturing (LOM)		✓			
4	To Study about Selective Laser Sintering.		✓			✓
5	To study of Stereo Lithography.		✓			✓
6	Case Study on Hybrid Manufacturing.					✓
7	Case Study on Additive Manufacturing.					✓

a. **Course Name:** Robotics and Industrial Automation
b. **Course Code:** 03022101PE05
c. **Prerequisite:** Basic knowledge of Manufacturing Processes, Mechatronics, Sensors and Actuators, Control Systems, Programming, and Industrial Automation concepts.
d. **Rationale:** Robotics and Industrial Automation help students understand modern automated manufacturing systems used to improve productivity, precision, quality, and safety in industries. The subject provides knowledge of robotic systems, sensors, actuators, control techniques, and automation technologies essential for smart manufacturing and Industry 4.0 applications.

e. Course Learning Objective:

CLOBJ 1	Describe the fundamentals, objectives, and hardware components of industrial automation systems and their industrial applications.
CLOBJ 2	Analyze the design, operation, and performance characteristics of hydraulic and pneumatic automation systems.
CLOBJ 3	Identify industrial robot components, configurations, and applications in automated manufacturing systems.
CLOBJ 4	Apply forward and inverse kinematic analysis to robotic manipulators and evaluate their dynamic performance.
CLOBJ 5	Evaluate emerging trends in robotics and industrial automation including collaborative robots, AI-based automation, and autonomous mobile robots.

f. Course Learning Outcomes:

CLO 1	Describe the goals, elements, and hardware components of industrial automation systems and their applications.
CLO 2	Analyze hydraulic and pneumatic systems used in industrial automation for their design and operational characteristics.
CLO 3	Identify the components, configurations, and applications of industrial robotic systems used in automated manufacturing.
CLO 4	Compute the forward and inverse kinematics of robotic arms and evaluate their dynamic behavior.
CLO 5	Evaluate recent trends in robotics and automation, including collaborative robots, AI applications, and autonomous mobile robots.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Describe the goals, elements, and hardware components of industrial automation systems and their applications.	2
CLO 2	Analyze hydraulic and pneumatic systems used in industrial automation for their design and operational characteristics.	4
CLO 3	Identify the components, configurations, and applications of industrial robotic systems used in automated manufacturing.	2
CLO 4	Compute the forward and inverse kinematics of robotic arms and evaluate their dynamic behavior.	4
CLO 5	Evaluate recent trends in robotics and automation, including collaborative robots, AI applications, and autonomous mobile robots.	5

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
2	-	0	2	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction To Automation** Introduction, applications, goals, issues of automation. Advantages, problems of automation, Low-cost automation. Elements & Hardware components. Automated work piece handling. Working principles & techniques. Construction elements of automation. Transfer lines unit build machines, special purpose machines & machining centers. Assembly automation, use of pneumatic & hydraulic system for automation.	20%	5
2	**Hydraulic & Pneumatic Control in Automation** Introduction & principles of fluid power transmission. Applications of fluid power in Industrial Automation. Study of elements of Hydraulic system. Design, analysis and study of typical hydraulic & pneumatic systems.	20%	5
3	**Fundamental Of Industrial Robotics** Specifications, Characteristics, Components, Configurations, Selection criteria & Applications.	30%	10
	Drives, Robot Motions, Actuators, Power Transmission systems. Robot Controllers & Dynamic Properties of Robots, Transducers & Sensors. End Effectors, Active & Passive Elements.		
4	**Kinematics Of Robot** Direct Kinematics and Solutions. Inverse Kinematics and Solutions. Robot Arm Dynamics, Lagrange & Newton Euler Formulations. Generalized D'Alembert's Equation of Motion.	20%	5
5	**Recent Trends in Robotics and Automation** Collaborative Robots (Cobots): Concept, features, and industrial applications, AI and Machine Learning in Robotics: Vision-based recognition, adaptive control, Mobile Robotics and Autonomous Guided Vehicles (AGVs/AMRs).	10%	5

j. Text Book and Reference Book:

1. Automation, Production Systems and Computer Integrated Mfg (TextBook) By Groover M. P., Pearson | Educational Publication.
2. Industrial Automation & Robotics By A K Gupta & S K Arora | Laxmi Publication Ltd.
3. Robot Engineering: An Integrated approach By Klafter R. D., Chmielewski T.
4. A. and Negin M., Prentice | Hall of India, New Delhi.
5. Industrial robotics Technology, programming and applications By Groover
6. M.P. | McGraw-Hill Book Co
7. Press tools Fundamentals of Robotics, Analysis & Control By Schilling, Robert J | Prentice Hall of India
8. Introduction to Robotics, Mechanics and control By John J. Craig, Addison – Wesley

a. **Course Name:** Robotics and Industrial Automation Laboratory
b. **Course Code:** 03022101PE06
c. **Prerequisite:** Basic knowledge of Robotics, Sensors and Actuators, Control Systems, Hydraulic and Pneumatic Systems, Programming, and Industrial Automation concepts.
d. **Rationale:** Robotics and Industrial Automation Laboratory provide practical exposure to robotic systems, automation components, sensors, actuators, and industrial control techniques used in modern manufacturing industries. The laboratory helps students develop hands-on skills in programming, operation, and analysis of automated and robotic systems for smart manufacturing applications.

e. Course Learning Objective:

CLOBJ 1	Describe the fundamentals, objectives, hardware components, and applications of industrial automation systems.
CLOBJ 2	Analyze the design, operation, and performance characteristics of hydraulic and pneumatic systems used in automation.
CLOBJ 3	Identify the components, configurations, and industrial applications of robotic systems in automated manufacturing.
CLOBJ 4	Apply forward and inverse kinematic analysis to robotic manipulators and evaluate their dynamic behavior.
CLOBJ 5	Evaluate recent advancements in robotics and automation including collaborative robots, AI-based systems, and autonomous mobile robots.

f. Course Learning Outcomes:

CLO 1	Describe the goals, elements, and hardware components of industrial automation systems and their applications.
CLO 2	Analyze hydraulic and pneumatic systems used in industrial automation for their design and operational characteristics.
CLO 3	Identify the components, configurations, and applications of industrial robotic systems used in automated manufacturing.
CLO 4	Compute the forward and inverse kinematics of robotic arms and evaluate their dynamic behavior.
CLO 5	Evaluate recent trends in robotics and automation, including collaborative robots, AI applications, and autonomous mobile robots

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Describe the goals, elements, and hardware components of industrial automation systems and their applications.	2
CLO 2	Analyze hydraulic and pneumatic systems used in industrial automation for their design and operational characteristics.	4
CLO 3	Identify the components, configurations, and applications of industrial robotic systems used in automated manufacturing.	2
CLO 4	Compute the forward and inverse kinematics of robotic arms and evaluate their dynamic behavior.	4
CLO 5	Evaluate recent trends in robotics and automation, including collaborative robots, AI applications, and autonomous mobile robots	5

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		Total
L	T	P	C	MSE	CE	P	Theory	P	
0	-	2	1	-	-	20	-	30	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. Automation, Production Systems and Computer Integrated Mfg (Textbook) by Groover M. P., Pearson | Educational Publication
2. Industrial Automation & Robotics by A K Gupta & S K Arora | Laxmi Publication Ltd.
3. Robot Engineering: An Integrated approach By Klafter R. D., Chmielewski T. A. and Negin M., Prentice | Hall of India, New Delhi.
4. Industrial robotics Technology, programming and applications By Groover M.P. | McGraw-Hill Book Co.
5. Press tools Fundamentals of Robotics, Analysis & Control By Schilling, Robert J | Prentice Hall of India
6. Introduction to Robotics, Mechanics and control By John J. Craig, Addison – Wesley

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5
1	Study of Automation Elements and Low-Cost Automation Systems.	✓				
2	Design, analysis and study of typical hydraulic & pneumatic systems.		✓			
3	Study and Identification of Industrial Robot Components.			✓		
4	Robot Forward and Inverse Kinematics Analysis.				✓	
5	Robot Programming and Trajectory Planning.			✓	✓	
6	Study of Integration of Sensors with Robotic Systems.	✓		✓		
7	Study of Recent Trends: Collaborative Robots and Mobile Robots.					✓

Semester 2

a. **Course Name:** Design for Manufacturing and Assembly
b. **Course Code:** 03022102PC01
c. **Prerequisite:** Basic knowledge of manufacturing processes, machine design, engineering materials, and CAD/CAM.
d. **Rationale:** The course focuses on integrating manufacturing and assembly considerations during product design to achieve reduced product cost, improved quality, reduced lead time, and enhanced manufacturability using DFMA principles and concurrent engineering approaches.

e. Course Learning Objective:

CLOBJ 1	Understand the principles and importance of Design for Manufacturing and Assembly (DFMA) in product development.
CLOBJ 2	Analyze the influence of manufacturing processes, materials, tolerances, and assembly methods on product design.

CLOBJ 3	Apply DFMA guidelines to simplify product structure, reduce part count, and improve manufacturability and assemblability.
CLOBJ 4	Evaluate product designs with respect to manufacturing cost, assembly efficiency, quality, reliability, and maintainability.
CLOBJ 5	Select suitable manufacturing and assembly processes based on product functionality, material, production volume, and economic considerations.
CLOBJ 6	Use CAD/CAM and DFMA tools for product design optimization and concurrent engineering applications.

f. Course Learning Outcomes:

CLO 1	Understand the importance of DFMA in product life cycle and concurrent engineering.
CLO 2	Apply DFM principles for various manufacturing processes.
CLO 3	Analyze products using DFA principles to reduce part count and assembly time.
CLO 4	Evaluate manufacturability and assimilability using DFMA metrics.
CLO 5	Integrate DFMA concepts with CAD/CAM tools for industrial applications.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand the importance of DFMA in product life cycle and concurrent engineering.	2
CLO 2	Apply DFM principles for various manufacturing processes.	3
CLO 3	Analyze products using DFA principles to reduce part count and assembly time.	4
CLO 4	Evaluate manufacturability and assimilability using DFMA metrics.	5
CLO 5	Integrate DFMA concepts with CAD/CAM tools for industrial applications.	6

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
2	**-**	**-**	**2**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction to DFMA and Product Design Foundations:** History and evolution of DFMA and its role in product development. Need identification, problem definition, concept generation, and embodiment design. Steps, advantages, and limitations of applying DFMA. Classification of manufacturing processes and overview of basic processes. Mechanical properties of materials and fundamentals of material selection.	**20%**	**6**
2	**Material and Shape Selection for Manufacturable Design:** Material selection strategies based on performance, cost, and manufacturability. Selection of shapes for structural efficiency and ease of manufacturing.	**20%**	**6**

	Co-selection of materials and shapes for optimized design. Influence of materials on reliability and sustainability. Case-based evaluation of material–shape combinations.		
3	**Design for Manufacturing (DFM):** Manufacturing process selection and associated cost drivers. Design for machining, casting, forging, and bulk deformation processes. Design considerations for sheet metal forming and powder metallurgy. Design for polymer processing and injection molding constraints. Co-selection of materials and manufacturing processes.	**20%**	**6**
4	**Design for Assembly (DFA) and Joining Methods:** Assembly systems: manual, semi-automated, and automated. DFA principles for handling, insertion, and fastening. Boothroyd–Dewhurst DFA methodology and assembly efficiency evaluation. Part count reduction and functional integration. Design for joining including welding, brazing, soldering, and adhesive bonding.	**20%**	**6**
5	**DFMA Analysis, Reliability, and CAD/CAM Integration:** Product structure analysis and DFMA metrics. Design simplification, standardization, and modular design. Cost estimation and manufacturing–assembly cost analysis. Design for quality, reliability, and FMEA. CAD/CAM-based DFMA analysis, including tolerance stack-up and digital evaluation tools.	**20%**	**6**

j. Text Book and Reference Book:

1. Product Design for Manufacture and Assembly,
   G. Boothroyd, P. Dewhurst, W. A. Knight; CRC Press
2. Design for Manufacturability Handbook
   Bralla, J. G. McGraw-Hill
3. Product Design and Development Ulrich,
   K. T., Eppinger, S. D. McGraw-Hill
4. Process selection: from design to manufacture K
   G Swift and J D Booker; London: Arnold, 1997.

a. Course Name: Fundamentals of Signals & Systems Lab

b. Course Code: 03022102PC02

c. Prerequisite: Basic knowledge of manufacturing processes, machine design, engineering materials, and CAD/CAM.

d. Rationale: The course focuses on integrating manufacturing and assembly considerations during product design to achieve reduced product cost, improved quality, reduced lead time, and enhanced manufacturability using DFMA principles and concurrent engineering approaches.

e. Course Learning Objective:

CLOBJ 1	Understand the principles and importance of Design for Manufacturing and Assembly (DFMA) in product development.
CLOBJ 2	Analyze the influence of manufacturing processes, materials, tolerances, and assembly methods on product design.
CLOBJ 3	Apply DFMA guidelines to simplify product structure, reduce part count, and improve manufacturability and assemblability.
CLOBJ 4	Evaluate product designs with respect to manufacturing cost, assembly efficiency, quality, reliability, and maintainability.
CLOBJ 5	Select suitable manufacturing and assembly processes based on product functionality, material, production volume, and economic considerations.
CLOBJ 6	Use CAD/CAM and DFMA tools for product design optimization and concurrent

	engineering applications.

f. Course Learning Outcomes:

CLO 1	Understand the importance of DFMA in product life cycle and concurrent engineering.
CLO 2	Apply DFM principles for various manufacturing processes.
CLO 3	Analyze products using DFA principles to reduce part count and assembly time.
CLO 4	Evaluate manufacturability and assimilability using DFMA metrics.
CLO 5	Integrate DFMA concepts with CAD/CAM tools for industrial applications.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand the importance of DFMA in product life cycle and concurrent engineering.	2
CLO 2	Apply DFM principles for various manufacturing processes.	3
CLO 3	Analyze products using DFA principles to reduce part count and assembly time.	4
CLO 4	Evaluate manufacturability and assimilability using DFMA metrics.	5
CLO 5	Integrate DFMA concepts with CAD/CAM tools for industrial applications.	6

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
0	**-**	**2**	**1**	**-**	**-**	**20**	**-**	**30**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. Product Design for Manufacture and Assembly, G. Boothroyd, P. Dewhurst, W. A. Knight; CRC Press
2. Design for Manufacturability Handbook Bralla, J. G. McGraw-Hill
3. Product Design and Development Ulrich, K. T., Eppinger, S. D. McGraw-Hill
4. Process selection: from design to manufacture K G Swift and J D Booker; London: Arnold, 1997.

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5
1	Study of DFMA Concepts and Manufacturing Process Classification.	✓				
2	Evaluation of Mechanical Properties and Material Selection for Product Design.	✓	✓			
3	Manufacturing Process and Cost Analysis for Design Decisions.		✓		✓	
4	Design for Machining: Analysis of Tolerances, Surface Finish, and Tool Accessibility		✓	✓		
5	Design Rule Evaluation for Casting, Forging, Sheet Metal Forming.		✓	✓		
6	Application of Design for Assembly Principles for Ease of Handling and Fastening.			✓	✓	
7	Boothroyd–Dewhurst DFA Method for Assembly Time and Efficiency Estimation.			✓	✓	
8	Product Structure Analysis and DFMA Metrics for Design Simplification.			✓	✓	
9	Case Study: DFMA-Based Redesign of a Mechanical Component for Cost and Part Count Reduction.		✓	✓	✓	
10	Case Study: CAD/CAM-Integrated DFMA Analysis for Manufacturability and Assembly Optimization.		✓		✓	✓

a. **Course Name:** Finite Element Analysis

b. **Course Code:** 03022102PC03

c. **Prerequisite:** Knowledge of Engineering Mathematics, Strength of Materials, Theory of Elasticity, Numerical Methods, and basic CAD/CAE concepts is required for understanding Finite Element Analysis.

d. **Rationale:** This course provides fundamental and advanced knowledge of Finite Element Analysis (FEA) for solving complex engineering problems using numerical and computational techniques. It enables students to develop finite element models, perform structural and thermal analyses, interpret simulation results, and apply CAD/CAE tools for design validation and optimization, thereby enhancing analytical, research, and industry-oriented problem-solving skills required in modern engineering applications.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamentals of finite element analysis, discretization techniques, element types, and applications in engineering design and modeling.
CLOBJ 2	Apply finite element formulations for one-dimensional, two-dimensional, and three-dimensional structural problems using appropriate element formulations and boundary conditions.
CLOBJ 3	Analyze static and dynamic behavior of engineering structures using mass, damping, stiffness matrices, and modal analysis techniques.
CLOBJ 4	Evaluate heat transfer and fluid mechanics problems using finite element and computational techniques for thermal and fluid flow analysis.
CLOBJ 5	Integrate advanced finite element techniques such as XFEM, Isogeometric Analysis (IGA), and meshless methods for solving complex engineering applications.

f. Course Learning Outcomes:

CLO 1	Apply finite element procedures to analyze one-dimensional structural elements under

	mechanical loading.
CLO 2	Develop finite element formulations for plane, axisymmetric, and three-dimensional solid problems.
CLO 3	Analyze static and dynamic structural responses using finite element–based vibration and reduction methods.
CLO 4	Evaluate specialized engineering applications and recent advancements in finite element analysis.
CLO 5	Study specialized engineering applications and recent advancements in finite element analysis.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Apply finite element procedures to analyze one-dimensional structural elements under mechanical loading.	2
CLO 2	Develop finite element formulations for plane, axisymmetric, and three-dimensional solid problems.	3
CLO 3	Analyze static and dynamic structural responses using finite element–based vibration and reduction methods.	4
CLO 4	Evaluate specialized engineering applications and recent advancements in finite element analysis.	5
CLO 5	Study specialized engineering applications and recent advancements in finite element analysis.	6

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
3	**-**	**-**	**3**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction:** Relevance of finite element analysis in design, modeling and discretization, interpolation, elements, Nodes and degrees of freedom, and applications of FEA. One-Dimensional Elements and Computational Procedures: Bar elements, Beam elements, Assembly of elements, Properties of stiffness matrices, Boundary conditions, Solution of equations, Mechanical loads and stresses.	**20%**	**9**
2	**Element Formulation:** Two dimensional equations, Types of 2D and 3D elements: triangular, quadrilateral and higher order elements, Derivation of shape functions and its properties, Formulation of elemental stiffness matrix and load vector, Assembly of elemental matrices, Properties of global stiffness matrix, Plane stress and plane strain	**20%**	**9**
	problems, Plate and shell elements. Concept of Isoparametric Elements.		
3	**Finite Elements in Structural Dynamics Applications:** Dynamic analysis:	**25%**	**11**

	Dynamic equations, Mass and damping matrices, Natural frequencies and modes, Damping, Ritz vectors, Modal Analysis, Harmonic response, Direct integration techniques, Explicit and implicit methods. Static and dynamic analysis of trusses.		
4	**Heat Transfer and Fluid Mechanics Applications:** Heat Transfer, Reduction - nonlinear problems, Transient thermal analysis, Introduction to CFD and fluid structure interaction problems.	**20%**	**9**
5	**Recent Advancements in FEA:** Extended Finite Element Method (XFEM), Isogeometric Analysis (IGA) and meshless methods.	**15%**	**7**

j. Text Book and Reference Book:

1. The Finite Element Method: Its Basis and Fundamentals
   Olek C Zienkiewicz and R. L. Taylor; Butterworth-Heinemann Ltd; 7th edition (2 October 2013)
2. Finite Element Procedures in Engineering Analysis.
   Bathe K.J., Cliffs, N.J.; PHI Learning, Eastern Economy Editions
3. An Introduction to the Finite Element Method J
   Reddy; McGraw Hill Education; 3rd edition.
4. Concepts and Applications of Finite Element Analysis R D
   Cook, D S Malkus, M E Plesha, and R J Witt; Wiley.
5. A First Course in the Finite Element Method D
   Logan; Thompson Learning
6. Introduction to Finite Elements in Engineering
   Chandrupatla T A and Belegundu A D; PHI

a. **Course Name:** Finite Element Analysis Laboratory
b. **Course Code:** 03022102PC04
c. **Prerequisite:** Knowledge of Engineering Mathematics, Strength of Materials, Theory of Elasticity, Numerical Methods, and basic CAD/CAE concepts is required for understanding Finite Element Analysis.
d. **Rationale:** This course provides fundamental and advanced knowledge of Finite Element Analysis (FEA) for solving complex engineering problems using numerical and computational techniques. It enables students to develop finite element models, perform structural and thermal analyses, interpret simulation results, and apply CAD/CAE tools for design validation and optimization, thereby enhancing analytical, research, and industry-oriented problem-solving skills required in modern engineering applications.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamentals of finite element analysis, discretization techniques, element types, and applications in engineering design and modeling.
CLOBJ 2	Apply finite element formulations for one-dimensional, two-dimensional, and three-dimensional structural problems using appropriate element formulations and boundary conditions.
CLOBJ 3	Analyze static and dynamic behavior of engineering structures using mass, damping, stiffness matrices, and modal analysis techniques.
CLOBJ 4	Evaluate heat transfer and fluid mechanics problems using finite element and computational techniques for thermal and fluid flow analysis.
CLOBJ 5	Integrate advanced finite element techniques such as XFEM, Isogeometric Analysis (IGA), and meshless methods for solving complex engineering applications.

f. Course Learning Outcomes:

CLO 1	Apply finite element procedures to analyze one-dimensional structural elements under mechanical loading.
CLO 2	Develop finite element formulations for plane, axisymmetric, and three-dimensional solid problems.
CLO 3	Analyze static and dynamic structural responses using finite element–based vibration and reduction methods.
CLO 4	Evaluate specialized engineering applications and recent advancements in finite element analysis.
CLO 5	Study specialized engineering applications and recent advancements in finite element analysis.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Apply finite element procedures to analyze one-dimensional structural elements under mechanical loading.	2
CLO 2	Develop finite element formulations for plane, axisymmetric, and three-dimensional solid problems.	3
CLO 3	Analyze static and dynamic structural responses using finite element–based vibration and reduction methods.	4
CLO 4	Evaluate specialized engineering applications and recent advancements in finite element analysis.	5
CLO 5	Study specialized engineering applications and recent advancements in finite element analysis.	6

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		Total
L	T	P	C	MSE	CE	P	Theory	P	
0	-	2	1	-	-	20	-	30	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

7. The Finite Element Method: Its Basis and Fundamentals
   Olek C Zienkiewicz and R. L. Taylor; Butterworth-Heinemann Ltd; 7th edition (2 October 2013)
8. Finite Element Procedures in Engineering Analysis.
   Bathe K.J., Cliffs, N.J.; PHI Learning, Eastern Economy Editions
9. An Introduction to the Finite Element Method J
   Reddy; McGraw Hill Education; 3rd edition.
10. Concepts and Applications of Finite Element Analysis R D
    Cook, D S Malkus, M E Plesha, and R J Witt; Wiley.
11. A First Course in the Finite Element Method D
    Logan; Thompson Learning
12. Introduction to Finite Elements in Engineering
    Chandrupatla T A and Belegundu A D; PHI

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5
1	Introduction to Commercial FEA Software.	✓				
2	Finite Element Modeling of 2D and 3D Structural Problems.	✓	✓			
3	Linear and Nonlinear Static Analysis.		✓			
4	Modal Analysis of Mechanical Components.			✓		
5	Dynamic Response Analysis of Structures.			✓		
6	Steady-State and Transient Thermal Analysis.				✓	
7	Coupled Field Analysis (Thermo-Structural / Fluid-Structural).				✓	✓
8	CAD–CAE Integrated Mini Project.		✓	✓	✓	✓

a. Course Name: Quality Engineering and Management

b. Course Code: 03022102PC05

c. Prerequisite: Knowledge of Manufacturing Processes, Engineering Statistics, Quality Control techniques, Industrial Engineering, and basic Management concepts is required for understanding Quality Engineering and Management.

d. Rationale: This course provides knowledge of quality engineering, statistical quality control, and quality management systems for improving product quality and process performance. It develops analytical and managerial skills required for process optimization, continuous improvement, reliability enhancement, and industrial quality assurance.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamental concepts of quality control, quality systems, and quality philosophies used in industrial applications.

CLOBJ 2	Apply statistical quality control techniques, sampling methods, and control charts for process monitoring and quality improvement.
CLOBJ 3	Analyze quality management tools and continuous improvement techniques such as TQM, Lean, Six Sigma, TPM, and QFD.
CLOBJ 4	Evaluate quality standards, business excellence models, and world-class manufacturing practices for organizational performance improvement.
CLOBJ 5	Assess reliability, maintenance, and failure analysis methods for enhancing system effectiveness and equipment performance.

f. Course Learning Outcomes:

CLO 1	Understand the fundamentals of quality control, quality philosophies, quality systems, and cost of quality in industrial applications.
CLO 2	Apply statistical quality control techniques, control charts, and acceptance sampling methods for process monitoring and improvement.
CLO 3	Analyze quality management tools and techniques such as TQM, Lean, Six Sigma, TPM, and QFD for continuous improvement and waste reduction.
CLO 4	Evaluate quality standards, business excellence models, and manufacturing excellence practices for organizational performance enhancement.
CLO 5	Assess reliability, maintainability, and failure analysis techniques for improving system performance and equipment effectiveness.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand the fundamentals of quality control, quality philosophies, quality systems, and cost of quality in industrial applications.	2
CLO 2	Apply statistical quality control techniques, control charts, and acceptance sampling methods for process monitoring and improvement.	3
CLO 3	Analyze quality management tools and techniques such as TQM, Lean, Six Sigma, TPM, and QFD for continuous improvement and waste reduction.	4
CLO 4	Evaluate quality standards, business excellence models, and manufacturing excellence practices for organizational performance enhancement.	5
CLO 5	Assess reliability, maintainability, and failure analysis techniques for improving system performance and equipment effectiveness.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
2	**1**	**-**	**3**	**20**	**20**	**20**	**60**	**30**	**150**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**

1	**FUNDAMENTALS OF QUALITY CONTROL** Definition and Dimensions of quality, Introduction to quality control and the quality system, Quality philosophies (Deming, Crosby, Juran), Cost of quality, Quality audit	**8%**	**2**
2	**STATISTICAL CONCEPTS AND DATA ANALYSIS**	**26%**	**8**
	Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling **Control Charts:** Statistical Process Control using control charts, Control charts for attributes and variables. **Acceptance Sampling:** Acceptance sampling for attributes and variables		
3	**QUALITY TOOLS & TECHNIQUES** Total Quality Management (TQM) and its techniques, New Seven Management Tools, Five S, kaizen, Quality Circles, Quality Function Deployment (QFD), Poka Yoke, Total Productive Maintenance (TPM), Lean Manufacturing, Six Sigma, Lean Six Sigma, etc	**46%**	**14**
4	**QUALITY STANDARDS AND BUSINESS EXCELLENCE MODELS** Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies. Manufacturing Excellence World Class Manufacturing (WCM) – Model and elements of WCM	**10%**	**3**
5	**RELIABILITY** Failure rate analysis, mean failure rate, mean time to failure, mean time between failure, systems reliability, availability, maintenance, overall equipment effectiveness, Total Productive Maintenance (TPM), Failure Mode and Effect Analysis (FMEA).	**10%**	**3**

j. Text Book and Reference Book:

1. Fundamentals of Quality Control and Improvement
   Amitava Mitra, Wiley
2. Total Quality Management
   Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield and Mary Besterfield-Sacre; Pearson
3. Introduction to statistical Quality control
   Douglas C Montgomery, John Wiley & Sons
4. Total Quality Management
   Feighan Baun

k. Mapping of Experiment List with Course Learning Outcomes :

Sr. NO.	Tutorial List	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
1	Identify any product or service and describe how the dimensions of quality influence its acceptance.	✓					
2	Formulate a customer satisfaction questionnaire for the following service: (a) Bank (b) Telephone	✓	✓				
	company (c) Hospital (d) Accounting firm (e) Law firm (f) Hotel.						
3	Visit any industry/organization from the following list and determine the quality council/assessment centre available at their end. (a) Nearby bank (b) Hospital (c) University academic	✓		✓	✓		

	department (d) University non-academic department (e) Grade school (f) Any Manufacturing facility nearby (g) Large grocery store. If the organization has quality council make a report for the same regarding the observations made and also highlight the roles and responsibilities assigned to the quality council.						
4	Make a team of three people and explore the problems that are being faced by any of the below mentioned organizations in implementing TQM (a) Large department store (b) Health-care facility (c) High Grade school (d) Industry nearby (e) Academic and non-academic parts in an Institute/organization.			✓	✓		
5	Execute any 5-employee opinion survey for any work place of your choice and analyse the results of their satisfaction and dissatisfaction in the organization.		✓	✓			
6	Make a team of three people and explore the problems in execution of Juran triology for the following organizations- (a) Hospital (b) Government offices (c) University academic department (d) University non-academic department (e) Large department store (f) Industry related to manufacturing.	✓		✓	✓		
7	Select one or more of Deming's 14 points and describe how you would achieve or implement it.	✓		✓	✓		
8	Explain with the help of an example the four improvement strategies that to be executed.		✓	✓			
9	Explain PDCA cycle pertaining to your personal or work life.	✓	✓				
10	List out the various ISO standards that are existing and mention their highlights of standards. Also specify the ISO standards that are to be				✓	✓	
	executed for the following - (a) Large bank (b) Health-care facility (c) University academic department (d) University non-academic department (e) Grade school (f) Any Manufacturing facility nearby (g) Large grocery store.						

a. **Course Name:** Pedagogy Studies
b. **Course Code:** 03020002MC01
c. **Prerequisite:** Knowledge of teaching–learning processes, communication skills, instructional methods, and basic educational practices is required for understanding

Pedagogy Studies.

d. **Rationale:** This course provides knowledge of teaching–learning methodologies, instructional planning, assessment techniques, and learner-centered educational practices. It develops communication, analytical, and pedagogical skills required for effective teaching, curriculum delivery, classroom management, and professional development in academic and training environments.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamental concepts, theories of learning, curriculum design, and pedagogical frameworks used in education systems.
CLOBJ 2	Apply appropriate pedagogical practices, instructional strategies, and teaching methodologies in formal and informal learning environments.
CLOBJ 3	Analyze the effectiveness of pedagogical approaches, curriculum practices, and teacher education systems for improving learning outcomes.
CLOBJ 4	Evaluate professional development practices, classroom support systems, curriculum alignment, and barriers affecting effective teaching and learning.
CLOBJ 5	Assess research gaps, research methodologies, and future directions in pedagogy, curriculum, and educational practices for academic improvement.

f. Course Learning Outcomes:

CLO 1	Remember key concepts, theories of learning, and pedagogical terminology relevant to curriculum and teacher education.
CLO 2	Understand diverse pedagogical practices used in formal and informal classroom contexts.
CLO 3	Apply appropriate research methodologies to evaluate the effectiveness of pedagogical practices.
CLO 4	Analyze evidence from educational studies to assess strengths, limitations, and research gaps in pedagogy.
CLO 5	Evaluate professional development models and curriculum frameworks to recommend context-sensitive improvements.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Remember key concepts, theories of learning, and pedagogical terminology relevant to curriculum and teacher education.	1
CLO 2	Understand diverse pedagogical practices used in formal and informal classroom contexts.	2
CLO 3	Apply appropriate research methodologies to evaluate the effectiveness of pedagogical practices.	3
CLO 4	Analyze evidence from educational studies to assess strengths, limitations, and research gaps in pedagogy.	4
CLO 5	Evaluate professional development models and curriculum frameworks to recommend context-sensitive improvements.	5

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
2	-	-	0	-	50	-	-	-	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction and Methodology:** Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching	**25%**	**6**
2	**Thematic overview:** Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education	**13%**	**6**
3	**Evidence on the effectiveness of pedagogical practices Methodology for the in-depth stage:** Quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change, Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches, Teacher's attitudes and beliefs and Pedagogic strategies.	**25%**	**6**
4	**Professional development:** Alignment with classroom practices and follow-up support, Peer support Support from the head teacher and the community Curriculum and assessment Barriers to learning: limited resources and large class sizes	**25%**	**6**
5	**Research Gaps:** Research gaps and future directions, Research design, Contexts Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact	**12%**	**6**

j. Text Book and Reference Book:

1. Education for All, the Quality Imperative and the Problem of Pedagogy
   Alexander, R; CREATE, University of Cambridge, 2008
2. Teaching for Quality Learning at University
3. Studying Teacher Education: The Report of the AERA Panel on Research and Teacher Education
   Cochran-Smith, M., & Zeichner, K.; Lawrence Erlbaum Associates, 2005
4. Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement
   Hattie, J.; Routledge, 2009
5. Education 2030: Incheon Declaration and Framework for Action
   UNESCO; UNESCO, 2015
6. National Curriculum Framework
   NCERT; NCERT, 2005

a. **Course Name:** Personality Development through Life Enlightenment Skills **Course Code:** 03020002MCO2

b. **Prerequisite:** Basic knowledge of communication skills, professional ethics, human values, teamwork, and self-development practices is required for understanding Personality Development through Life Enlightenment Skills.

c. **Rationale:** This course develops personality, communication skills, ethical values, leadership qualities, and emotional intelligence for personal and professional growth. It enhances self-confidence, interpersonal skills, decision-making abilities, and positive attitudes required in professional and social environments.

d. Course Learning Objective:

CLOBJ 1	Understand the concepts of goal setting, SWOT/SOAR analysis, emotional intelligence, leadership, and professional communication for personal and career development.
CLOBJ 2	Apply time management tools, decision-making techniques, conflict resolution strategies, and professional networking practices in workplace situations.
CLOBJ 3	Analyze personal strengths, workplace challenges, group discussions, and interview situations using critical thinking and communication skills.
CLOBJ 4	Evaluate alternatives, risks, leadership approaches, and interpersonal strategies for effective decision-making and team management.
CLOBJ 5	Develop professional resumes, interview skills, leadership qualities, and workplace communication abilities for career advancement and professional growth.

e. Course Learning Outcomes:

CLO 1	Remember key concepts of communication, leadership, and emotional intelligence
CLO 2	Understand principles of group discussion, interviews, and professional conduct.
CLO 3	Apply leadership, time management, and emotional intelligence skills in real-life situations.
CLO 4	Analyze personal strengths, weaknesses, opportunities, and goals for career development.

f. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Remember key concepts of communication, leadership, and emotional intelligence	1
CLO 2	Understand principles of group discussion, interviews, and professional conduct.	2
CLO 3	Apply leadership, time management, and emotional intelligence skills in real-life situations.	3
CLO 4	Analyze personal strengths, weaknesses, opportunities, and goals for career development.	4

g. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
2	**-**	**-**	**0**	**-**	**50**	**-**	**-**	**-**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**-Continuous Evaluation, **ESE-** End Semester Examination

h. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Goal Setting and Tracking 2 10** • Meaning and importance of goal setting • Types of goals	**10%**	**2**

	• SMART goal framework • Goal prioritization and alignment with career objectives • Action planning and milestone setting		
2	**SWOT & SOAR Analysis:** • Identifying personal strengths and development areas • Opportunity mapping and goal alignment • Applying analysis for career planning • Reflection and action planning	**10%**	**2**
3	**Time Management:** Time audit and productivity analysis Tools for time management (planners, digital tools) Overcoming procrastination	**10%**	**2**
4	**Emotional Intelligence:** Self-awareness and regulation Stress Management and EI at the workplace Motivation and Emotional Resilience Empathy and Social Skills Managing stress and emotions at work	**10%**	**2**
5	**Decision Making:** Problem identification and goal Setting Evaluating alternatives and choosing solutions Decision making under risk and uncertainty	**10%**	**2**
6	**Conflict Management** Conflict resolution styles and strategies Effective communication during conflict Negotiation and mediation skills Managing conflicts in teams and workplaces	**10%**	**2**
7	**Leadership Skills** Leadership styles and decision-making Team building and ethical leadership Decision-making and problem-solving skills Team motivation and delegation Ethical leadership and accountability	**10%**	**2**
8	**Personal Branding and Professional Presence** Resume structuring for technical professionals Writing impactful profiles and summaries LinkedIn optimization and professional networking Digital etiquette and online presence	**10%**	**4**
9	**Group Discussion** Types and objectives of group discussions Initiation, participation, and conclusion strategies Critical thinking and developing the argument Handling disagreement and turn-taking Evaluation criteria and common mistakes	**10%**	**6**
10	**Personal Interview** Interview preparation and strategies Answering situational and competency-based questions Non-verbal communication and professional etiquette Mock interviews and feedback	**10%**	**6**

i. Text Book and Reference Book:

1. The 7 Habits of Highly Effective People by Stephen R. Covey; Simon & Schuster, 2020
2. How to Win Friends and Influence People By Dale Carnegie; Pocket Books
3. Speak with Impact By Allison Shapira; HarperCollins Leadership, 2018
4. Effective Communication Skills By Rizvi, M.A.; New Delhi: McGraw Hill Education, 2019 By Mindset: The New Psychology of Success
   Carol S. Dweck

a. **Course Name:** Indian Cyber Law and Ethics
b. **Course Code:** 03023302MC01
c. **Prerequisite:** Knowledge of computer systems, internet technologies, information security, professional ethics, and basic cyber safety practices is required for understanding Indian Cyber Law and Ethics.
d. **Rationale:** This course provides knowledge of Indian cyber laws, digital ethics, data privacy, and cyber security practices. It develops awareness of legal responsibilities, ethical use of technology, and cyber safety required in professional and digital environments.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamentals of cyber space, cyber laws, IT Act provisions, and legal authorities governing digital activities in India.
CLOBJ 2	Apply legal and ethical principles to identify, prevent, and address cybercrimes, digital frauds, and online security issues.
CLOBJ 3	Analyze cyber ethics, digital responsibility, intellectual property rights, and emerging ethical issues in modern technologies.
CLOBJ 4	Evaluate privacy rights, data protection laws, cybersecurity policies, and regulatory frameworks for organizational and societal compliance.
CLOBJ 5	Assess cybercrime investigation methods, cyber forensics techniques, enforcement challenges, and future trends in cyber law and digital security.

f. Course Learning Outcomes:

CLO 1	Understand the evolution, scope, and foundational concepts of Indian Cyber Laws and the IT Act, 2000.
CLO 2	Analyze various types of cybercrimes and identify applicable legal sections and penalties under the IT Act and other statutory frameworks.
CLO 3	Evaluate ethical issues in cyberspace, including responsible digital behavior, cyber ethics, and intellectual property rights.
CLO 4	Interpret and apply data protection and privacy-related laws such as the Digital Personal Data Protection Act, 2023, and international standards like GDPR.
CLO 5	Demonstrate awareness of legal investigation procedures, digital evidence handling, and emerging trends such as AI regulations and cyber forensics.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand the evolution, scope, and foundational concepts of Indian Cyber Laws and the IT Act, 2000.	3
CLO 2	Analyze various types of cybercrimes and identify applicable legal sections and penalties under the IT Act and other statutory frameworks.	4
CLO 3	Evaluate ethical issues in cyberspace, including responsible digital behavior, cyber ethics, and intellectual property rights.	5
CLO 4	Interpret and apply data protection and privacy-related laws such as the Digital Personal Data Protection Act, 2023, and international standards like GDPR.	3
CLO 5	Demonstrate awareness of legal investigation procedures, digital evidence handling, and emerging trends such as AI regulations and cyber forensics.	2

h. Teaching & Examination Scheme:

Teaching Scheme	**Evaluation Scheme**

L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	0	-	50	-	-	-	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Foundations of Cyber Law** Introduction to Cyber Space and Cyber Crime, Evolution and Need for Cyber Laws in India, Overview of IT Act 2000 & Amendments (2008, 2021), Definitions under the IT Act: Data, Computer, Access, Legal Recognition of Electronic Records and Signatures, Authorities under IT Act: CERT-IN, Adjudicating Officers, Appellate Tribunal	**20%**	**6**
2	**Cyber Crimes and Legal Provisions:** Types of Cyber Crimes: Hacking, Phishing, Identity Theft, Financial Fraud, Cyber Stalking, Online Harassment, Cyber Terrorism and National Security, Social Media Abuse and Legal Liabilities, Legal Provisions, Case Studies: Avnish Bajaj (Bazee.com), Shreya Singhal v. Union of India	**20%**	**6**
3	**Cyber Ethics and Digital Responsibility:** Introduction to Cyber Ethics: Concepts & Importance, Ethical vs Unethical Hacking, Digital Citizenship and Responsible Internet Use, Ethical Issues in AI, Blockchain,	**20%**	**6**
	IoT, IPR in Cyberspace – Copyrights, Patents, Software Licensing, Global Ethical Guidelines (ACM/IEEE Codes, GDPR Principles)		
4	**Privacy, Data Protection & Regulatory Frameworks:** Understanding Privacy in the Digital Age, Right to Privacy – Puttaswamy Judgment, Digital Personal Data Protection Act (DPDP), 2023, GDPR vs. Indian Data Protection Laws – A Comparative View, Role and Responsibilities of Data Fiduciaries, Organizational Compliance – ISO 27001, Cybersecurity Policies	**20%**	**6**
5	**Investigation, Enforcement & Future Trends:** Investigation of Cyber Crimes: Processes and Tools, Cyber Forensics: Basics and Tools Used, Jurisdictional Issues in Cyberspace, Role of Law Enforcement and Challenges in Prosecution, Future of Cyber Law: Metaverse, AI Regulations, Quantum Security.	**20%**	**6**

j. Text Book and Reference Book:

1. Information Technology Law and Practice By Vakul Sharma
2. Cyberlaw in India By Pavan Duggal
3. Bare Act: Information Technology Act, 2000
4. Digital Personal Data Protection Act, 2023

a. **Course Name:** Augmented Reality and Virtual Reality
b. **Course Code:** 03020202UE01
c. **Prerequisite:** Students enrolling in this course should have fundamental knowledge of computer graphics, data structures, and object-oriented programming, along with a basic understanding of linear algebra, 3D geometry, and human–computer interaction concepts. Familiarity with game engines, computer vision, or artificial intelligence is desirable but not mandatory, as these concepts support effective understanding of immersive AR and VR systems and application development.
d. **Rationale:** Augmented Reality and Virtual Reality are emerging immersive technologies that are transforming multiple sectors such as education, healthcare, manufacturing, entertainment, and industrial training. This course is designed to equip M.Tech (CSE) students with theoretical foundations and practical exposure to AR/VR technologies by integrating interdisciplinary concepts from computer graphics, HCI, computer vision, and artificial intelligence.

e. Course Learning Objective:

CLOBJ 1	Explain the core principles and components of Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) systems.
CLOBJ 2	Analyze AR/VR hardware, tracking systems, rendering methods, and interaction techniques used in immersive environments.
CLOBJ 3	Design and develop immersive AR/VR applications using modern SDKs and development platforms.
CLOBJ 4	Apply 3D graphics, simulation, visualization, and real-time rendering techniques in virtual environments.
CLOBJ 5	Evaluate real-world applications of AR/VR technologies in healthcare, education, gaming, and industrial sectors.
CLOBJ 6	Develop mini-projects or research-based solutions utilizing emerging AR/VR technologies and innovative practices.

f. Course Learning Outcomes:

CLO 1	Explain core principles of AR, VR, and Mixed Reality systems
CLO 2	Analyze AR/VR hardware, tracking, rendering, and interaction techniques.
CLO 3	Design and develop immersive applications using AR/VR SDKs
CLO 4	Apply 3D graphics, simulation, and visualization techniques effectively.
CLO 5	Evaluate real-world AR/VR use cases in healthcare, education, gaming, and industry.
CLO 6	Undertake mini-projects or research work aligned with emerging technologies.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain core principles of AR, VR, and Mixed Reality systems	2
CLO 2	Analyze AR/VR hardware, tracking, rendering, and interaction techniques.	4
CLO 3	Design and develop immersive applications using AR/VR SDKs	5
CLO 4	Apply 3D graphics, simulation, and visualization techniques effectively.	3
CLO 5	Evaluate real-world AR/VR use cases in healthcare, education, gaming, and industry.	5
CLO 6	Undertake mini-projects or research work aligned with emerging technologies.	6

h. Teaching & Examination Scheme:

Teaching Scheme	**Evaluation Scheme**

L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	-	-	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction to AR and VR:** Reality–Virtuality Continuum, Definitions: AR, VR, MR, XR, History and evolution of immersive technologies, Applications: Education, Healthcare, Manufacturing, Gaming, Defense, Challenges and future trends, Ethical, social, and accessibility considerations (NEP focus	**20%**	**8**
2	**Virtual Reality Systems and Components:** VR system architecture, Displays: HMDs, CAVE, stereoscopic displays, Sensors and tracking: position, orientation, motion, Input devices: controllers, haptics, gloves, Rendering pipeline for VR, Performance issues: latency, frame rate, motion sickness	**20%**	**10**
3	**Augmented Reality Techniques:** AR system architecture, Marker-based and marker-less AR, Computer vision for AR, Tracking and registration techniques, AR SDKs: AR Core, AR Kit, Vuforia, Spatial mapping and environment understanding	**20%**	**10**
4	**Interaction, Modeling, and Visualization:** 3D interaction techniques, User experience (UX) and human-computer interaction (HCI),3D modeling basics, Scene graph and animation, Multimodal interaction (gesture, voice, eye-tracking),Accessibility and inclusive design (NEP emphasis)	**20%**	**8**
5	**Development Platforms and Applications 8 20 Game engines:** Unity, Unreal Engine, AR/VR application development workflow, Integration with AI, IoT, and Digital Twins, Case studies: Virtual labs, Medical simulation, Industrial training, Research trends and open problems	**20%**	**8**

j. Text Book and Reference Book:

1. Sherman, W. R., & Craig, A. B., Understanding Virtual Reality, Morgan Kaufmann
2. Cawood, S., & Fiala, M., Augmented Reality: A Practical Guide
3. LaValle, S. M., Virtual Reality, Cambridge University Press

a. Course Name: Cyber Physical Systems

b. Course Code: 03020202UE02

c. Prerequisite: Good working knowledge of C, Python and Fundamentals of computer network, Wireless Communication and Internet Technology

d. Rationale: The course aims to develop a multidisciplinary perspective by integrating IoT with domain-specific applications in areas such as industrial automation, structural health monitoring, smart energy systems, predictive maintenance, and environmental sensing. Through hands-on experience with embedded hardware, sensor networks, and cloud platforms, students will gain the ability to conceptualize, design, and implement IoT-based solutions for real-world engineering problems. The course will also emphasize data-driven decision-making, secure communication protocols, and the role of IoT in enabling Industry
4.0 and smart infrastructure

e. Course Learning Objective:

CLOBJ 1	Explain the architecture, components, and communication protocols used in Internet of Things (IoT) systems.
CLOBJ 2	Analyze the integration of IoT technologies in domain-specific applications such as smart grids, industrial automation, structural monitoring, and avionics.
CLOBJ 3	Design and develop smart engineering system prototypes using embedded platforms, sensors, and cloud-based IoT services.
CLOBJ 4	Evaluate current research trends, standards, challenges, and emerging technologies in IoT-based engineering applications.

f. Course Learning Outcomes:

CLO 1	To impart a comprehensive understanding of IoT architecture and communication protocols.
CLO 2	To analyze integration of IoT in domain-specific scenarios like smart grids, industrial automation, structural monitoring, and avionics.
CLO 3	To develop prototypes for smart engineering systems using embedded platforms and cloud services.
CLO 4	To explore current research trends, standards, and challenges in IoT applications for engineering systems.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	To impart a comprehensive understanding of IoT architecture and communication protocols.	1,2
CLO 2	To analyze integration of IoT in domain-specific scenarios like smart grids, industrial automation, structural monitoring, and avionics.	4
CLO 3	To develop prototypes for smart engineering systems using embedded platforms and cloud services.	6
CLO 4	To explore current research trends, standards, and challenges in IoT applications for engineering systems.	3

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
4	**-**	**-**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Advanced IoT Concepts**: Evolution of IoT, CPS, Edge/Fog/Cloud Computing in engineering, IoT for Industry 4.0 & 5.0, IoT-OT Convergence	**10%**	**4**
2	**IoT Reference Architecture, Sensor Nodes, Gateways, Device-to-Cloud, Data Acquisition Systems:** Domain Focus: IIoT system design for Smart Plants, Aircraft Health Monitoring, Power Distribution Automation	**15%**	**6**
3	**Communication Protocols for Engineering Applications:** MQTT, CoAP, DDS, Zigbee, LoRa, NB-IoT, 6LoWPAN, OPC-UA, SCADA Integration Use-cases: Sensor buses in aircraft, building automation, grid communication	**15%**	**6**
4	**Embedded Systems & Platform Development** : Raspberry Pi, ESP32, STM32 boards, RTOS, Linux programming Hands-on: Motor control, vibration monitoring, high-frequency data logging, integration with MATLAB/Python dashboards	**20%**	**8**
5	**Introduction to real-world IoT case studies and platforms:** Overview of domain-independent IoT applications: smart manufacturing, predictive maintenance, smart home automation, energy monitoring, healthcare, wearable IoT systems, environmental monitoring, waste	**15%**	**6**
	management, smart transportation, fleet management, asset tracking, , system-level design, sensor integration, and cloud connectivity, Evaluation of the impact of IoT on efficiency, safety, and sustainability		
6	**Advanced Data Analytics and Cloud Integration:** Cloud Platforms (AWS IoT, Azure IoT, IBM Watson), Data Logging, Visualization, Streaming Analytics, Digital Twin Concepts	**10%**	**6**
7	**Security, Standards & Research Trends:** Lightweight Cryptography, PKI, Interoperability Standards (OneM2M, ISO/IEC 30141), Research challenges, Survey methods	**15%**	**6**

j. Text Book and Reference Book:

1. Internet of Things (A Hands-on-Approach) By Vijay Madisetti and Arshdeep Bahga, | VPT
2. Industrial Internet of Things: Cybermanufacturing Systems By Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat
3. Internet of Things and Data Analytics Handbook By Hwaiyu Geng (Editor)
4. Interconnecting Smart Objects with IP: The Next Internet By Jean-Philippe Vasseur, Adam Dunkels | Morgan Kuffmann Publishers
5. Getting Started with the Internet of Things By Cuno Pfister, | O"Reilly Media

a. Course Name: Social Networking

b. Course Code: 03020202UE03

c. Prerequisite: Students should have prior knowledge of data structures, algorithms, database management systems, and basic concepts of computer networks and web technologies. Familiarity with probability, graph theory, and programming languages such as Python or Java is desirable for understanding social network analysis and application development.

d. Rationale: Social networking platforms generate massive volumes of data and play a critical role in communication, information dissemination, and decision-making in modern society. This course aims to provide M.Tech (CSE) students with theoretical

foundations and practical insights into social network structures, analysis, and applications

e. Course Learning Objective:

CLOBJ 1	Explain the core concepts, evolution, and functioning of social networking systems.
CLOBJ 2	Model and analyze social networks using graph theory and mathematical techniques.
CLOBJ 3	Apply algorithms for community detection, link analysis, recommendation systems, and influence maximization in social networks.
CLOBJ 4	Analyze social network data to derive insights and support real-world applications.
CLOBJ 5	Evaluate privacy, security, ethical, and societal challenges associated with social networking platforms.
CLOBJ 6	Develop research-oriented or industry-based mini projects related to social networking systems and applications.

f. Course Learning Outcomes:

CLO 1	Explain core concepts and evolution of social networking systems
CLO 2	Model social networks using graph theory and mathematical tools.
CLO 3	Apply algorithms for community detection, link analysis, and influence maximization.
CLO 4	Analyze social network data for real-world applications
CLO 5	Evaluate privacy, security, and ethical issues in social networking platforms.
CLO 6	Conduct research-oriented or industry-based mini projects in social networking.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain core concepts and evolution of social networking systems	2
CLO 2	Model social networks using graph theory and mathematical tools.	6
CLO 3	Apply algorithms for community detection, link analysis, and influence maximization.	3
CLO 4	Analyze social network data for real-world applications	4
CLO 5	Evaluate privacy, security, and ethical issues in social networking platforms.	5
CLO 6	Conduct research-oriented or industry-based mini projects in social networking.	6

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
4	**-**	**-**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Introduction to Social Networking:** Evolution of social networks, Types of social networks: online, offline, professional, Components and architecture of social networking platforms, Applications and societal impact, Challenges and future trends	**20%**	**8**
2	**Graph Theory and Network Models** Graph representation of social networks, Network metrics: degree, centrality, clustering coefficient,	**20%**	**10**

	Random graph models, Small-world and scale-free networks, Network visualization techniques		
3	**Social Network Analysis** Community detection algorithm, Link prediction technique, Influence and information	**20%**	**10**
	diffusion models, Opinion dynamics ,Recommendation systems in social networks		
4	**Data Mining and Machine Learning in Social Networks** Social media data collection and preprocessing, Sentiment analysis, User behavior modeling, Fake news and misinformation detection, Integration with AI and NLP	**20%**	**8**
5	**Privacy, Security, and Ethics** Privacy models and access control, Security threats in social networks, Trust and reputation systems, Legal and ethical issues,NEP-2020 perspective on responsible and inclusive technology	**20%**	**8**

j. Text Book and Reference Book:

1. Easley, D. & Kleinberg, J., Networks, Crowds, and Markets, Cambridge University Press
2. Newman, M., Networks: An Introduction, Oxford University Press
3. Aggarwal, C., Social Network Data Analytics, Springer

a. Course Name: Business Analytics

b. Course Code: 03020502UE01

c. Prerequisite: Inclination to learn machine Learning, basic knowledge of differential classification clustering and regression algorithms, Data Mining.

d. Rationale: The course will provide a strong foundation on business analytics and the basic concepts.

e. Course Learning Objective:

CLOBJ 1	Explain the concepts of business analytics and its role in organizational decision-making processes.
CLOBJ 2	Understand the fundamental principles, techniques, and domain knowledge related to business analytics.
CLOBJ 3	Analyze business intelligence systems and applications of business analytics in various business domains.
CLOBJ 4	Apply business analytics methods and tools to solve business problems and support managerial decision-making.

f. Course Learning Outcomes:

CLO 1	Explain business analytics and its role within an organization
CLO 2	Acquire domain knowledge of business analytics and its critical concepts.
CLO 3	Understand business intelligence systems and applications of business analytics.
CLO 4	Implement business problems and to support managerial decision making.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain business analytics and its role within an organization	2, 4
CLO 2	Acquire domain knowledge of business analytics and its critical concepts.	4
CLO 3	Understand business intelligence systems and applications of business analytics.	2
CLO 4	Implement business problems and to support managerial decision making.	5

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
4	-	-	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Business analytics:** Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.	15%	10
2	**Trendiness and Regression Analysis** Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	15%	10
3	**Organization Structures of Business analytics** Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modeling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modeling, nonlinear Optimization.	20%	12
4	**Forecasting Techniques** Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.	20%	12
5	**Decision Analysis** Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	20%	12
6	**Recent Trends in** Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.	10%	4

j. Text Book and Reference Book:

1. Fundamentals of Business Analytics by R.N.Prasad and Seema Acharya (TextBook)
2. Business Analytics – The Science of DataDriven Decision Making by U. Dinesh Kumar (TextBook)
3. Data Analytics by Anil Maheshwari; McGraw Hill
4. Business Analytics for Managers: Taking Business Intelligence Beyond by Jesper Thorlund & Gert H.N. Laursen
5. Business Analytics, by Sahil Raj

a. **Course Name:** Industrial Safety
b. **Course Code:** 03020602UE01
c. **Prerequisite:** Basic knowledge of safety in the field of electrical engineering, chemical engineering, civil engineering and fire safety.
d. **Rationale:** The main objective of this subject is to introduce practical knowledge of industrial safety and its maintenance considering different acts and standards related to safety. It also helps in understanding different types of hazards and safety precautions to avoid these hazards. The subject will also help in gaining field knowledge related to safety audit and policies.

e. Course Learning Objective:

CLOBJ 1	Explain the principles, importance, and practices of industrial safety and safety auditing.
CLOBJ 2	Understand and interpret standards, acts, and regulations related to health, safety management, and safety audits.
CLOBJ 3	Analyze physical and chemical hazards in industrial environments and recommend appropriate preventive measures.
CLOBJ 4	Apply fire prevention, protection, and extinguishing methods in industrial and workplace settings.
CLOBJ 5	Evaluate the role of industrial hygiene and occupational health in maintaining workplace safety and well-being.
CLOBJ 6	Explain the procedures for accident investigation, analysis, reporting, and corrective action implementation.

f. Course Learning Outcomes:

CLO 1	Explain about Industrial Safety and Safety Audit.
CLO 2	Illustrate different Standards, Acts and Rules related to Management of Health & Safety and Safety Audit
CLO 3	Discuss Physical and Chemical Hazards and Preventive Steps to avoid it.
CLO 4	Apply methods for Prevention and Extinguishing of Fire.
CLO 5	Discuss Importance of Industrial Hygiene and Occupational Health in Work Place.
CLO 6	Explain process of Accident Analysis and Reporting.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain about Industrial Safety and Safety Audit.	2
CLO 2	Illustrate different Standards, Acts and Rules related to Management of Health & Safety and Safety Audit	3
CLO 3	Discuss Physical and Chemical Hazards and Preventive Steps to avoid it.	3
CLO 4	Apply methods for Prevention and Extinguishing of Fire.	3
CLO 5	Discuss Importance of Industrial Hygiene and Occupational Health in Work Place.	2
CLO 6	Explain process of Accident Analysis and Reporting.	2

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
4	**-**	**-**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction:** Introduction to Industrial Safety, History and Development of Safety Movements, Safety Programs, Need for Safety, Different Safety Acts, Rules, Standards, Safety Organizations and Responsibilities, Safety Policy, Requirement and Responsibility of Safety Officer and Safety Committee, Safety Audit.	**12%**	**8**
2	**Health & Safety Management and Audit - Standards and Acts:** Occupational Health and Safety Audit - Code of Practice (IS 14489), Occupational Health and Safety System Elements, Occupational Health and Safety Policy, Organizational Setup, Safety Manual, Safety Culture, Hazard Identification and Job Safety Analysis, Product Safety and	**24%**	**14**
	Safety Training, The Factory Act 1948, The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989, The Central Electricity Authority Regulations, 2011, The Static and Mobile Pressure Vessels Rules, 2016, The Gas Cylinder Rules, 2016, The Explosive Rules, 2008, The Building and other Construction Workers Act, 1996		
3	**Physical and Chemical Hazard:** Machine and General Area Guarding, Material Handling, Safety in Storage, New Equipment Inspection, Electrical Hazard: Hazards related to Electrical Energy, Safe limits of Ampere & Voltage, Safe Distance from Power Lines, Means of Cutting off Power, Overload and Short Circuit Protection, Protection against Voltage Fluctuation, Protection for Electrical Equipments in Hazardous Atmosphere, Hazardous Area Classification, Criteria for Selection, Installation, Maintenance and Use of Equipment in Hazardous Areas, Electrical Safeguarding, Earthing, Importance of Earthing, Parameters related to Earthing, Earthing Design for Safety considering IEEE Standard, Chemical Hazard: Transportation of Hazardous Materials, Safety and Handling of Storage of Hazardous Chemicals, Gas Cylinders, Labelling and Colour Coding	**24%**	**14**
4	**Fire Hazard**: Fire Phenomena, Chemistry of Fire, Stages of Fire, Factors contributing to Fire, Classification of Fires, Common causes of Industrial Fires, Building, Plant and Exits Design considering Prevention of Fire and Fire Safety, Safety considering Electrical Equipments and Circuits, Fire Safety in Handling Flammable and Explosive Materials, Fire Detection and Alarm System, Fixed Water Sprinkler System, Fire Hydrant, Portable Fire Extinguishers and Types of Portable Fire Extinguishers, Fire Drill and Fire Fighting Training.	**18%**	**10**
5	**Industrial Safety, Hygiene and Occupational Health:** Industrial Hygiene & Health Definitions, Difference between Industrial Hygiene & Occupational Health, Work coordination between Industrial Hygienist, Role of Safety Officer and Factory Medical Officer, Occupational Health Hazards, Work Place Monitoring for Hazardous Chemicals, First Aid Facilities and Health Center, Personal Protection Equipment (PPE) and Emergency Equipment	**12%**	**8**
6	**Accident Analysis and Reporting:** Nature and Causes of Accidents, Accident Prevention and Control Techniques, Accident Reporting and Investigation, Accident Analysis and Recommendations.	**10%**	**6**

j. Text Book and Reference Book:

1. Indian Standard 14489:2018 - Standard for Occupational Health and Safety Audit.
2. Industrial Accident Prevention (Text Book) H.W. Heinrich, Dan Petersen, and Nestor Roos; McGraw-Hill Book Company; 5th edition (1 January 1980) ,January, 1980
3. Industrial Safety: Concepts and Practices (Text Book) K.T. Kulkarni; Vidyarthi Griha Prakashan; NF ,March, 2005
4. Fundamental of Industrial Safety & Health (Text Book) y Dr. K U Mistry; Shyamaraj Global Commerce (9 May 2022); 2022 ,June, 2006
5. Occupational Safety Management & Engineering (Text Book) Willi Hammer; Pearson; 4th edition (1 October 1988); 1 October 1988 ,April, 2022

a. Course Name: IOT and Smart Cities

b. Course Code: 03020702UE01

c. Prerequisite: Basic knowledge of programming, embedded systems, computer networks, sensors, and automation systems.

d. Rationale: This course provides knowledge of IoT technologies and smart systems used in modern industrial, manufacturing, and urban applications. It helps students understand connected devices, automation, real-time monitoring, and smart infrastructure relevant to Industry 4.0 and smart manufacturing.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamental concepts, characteristics, architecture, and applications of IoT-based smart city systems.
CLOBJ 2	Analyze IoT communication technologies, protocols, and cloud platforms used in smart city environments.
CLOBJ 3	Apply IoT-based solutions for smart transportation, energy systems, and urban infrastructure development.
CLOBJ 4	Evaluate smart city components including connectivity, monitoring systems, and sustainable urban planning strategies.
CLOBJ 5	Assess security, privacy, and blockchain-based approaches in IoT-enabled smart environments.
CLOBJ 6	Develop mini-projects or case studies demonstrating IoT applications in smart city domains.

f. Course Learning Outcomes:

CLO 1	Explain the fundamental concepts, characteristics, and architecture of IoT-based smart city systems and their applications.
CLO 2	Analyze IoT communication technologies, protocols, and cloud platforms used in smart city environments.
CLO 3	Apply IoT-based solutions for smart transportation, energy systems, and infrastructure development.
CLO 4	Evaluate smart city components including connectivity, monitoring systems, and sustainable urban planning strategies.
CLO 5	Assess security, privacy, and blockchain-based solutions in IoT-enabled smart environments.
CLO 6	Develop mini-projects or case studies demonstrating IoT applications in smart city domains.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain the fundamental concepts, characteristics, and architecture of IoT-based smart city systems and their applications.	2
CLO 2	Analyze IoT communication technologies, protocols, and cloud platforms used in smart city environments.	4

CLO 3	Apply IoT-based solutions for smart transportation, energy systems, and infrastructure development.	3
CLO 4	Evaluate smart city components including connectivity, monitoring systems, and sustainable urban planning strategies.	5
CLO 5	Assess security, privacy, and blockchain-based solutions in IoT-enabled smart environments.	4
CLO 6	Develop mini-projects or case studies demonstrating IoT applications in smart city domains.	6

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
4	-	-	4	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction to IoT for Smart Cities**: Definition and characteristics of smart cities, IoT-based solutions in domains: Smart Home, Transport & Traffic management, Smart city planning & infrastructure essentials, Role of AI/ML/DL in IoT-enabled smart cities	**18%**	**8**
2	**Technologies for IoT**: IoT communication technologies & recent protocols, Secure IoT architectures overview, Services powered by IoT within smart cities, Cellular IoT, Cloud IoT platforms, Case study: Compare MQTT, Web Socket & HTTP via Node-RED in smart-room setups	**22%**	**10**
3	**Smart Transportation and Energy Systems**: Traffic management systems & sensor networks, Electric vehicles (EVs) & EV charging infrastructure, Renewable energy integration and smart distribution, Smart grid concepts , Image-processing for traffic control & bus movement analysis case study	**18%**	**8**
4	**Smart Infrastructure and City Planning:** Fundamentals of Smart Infrastructure, Smart water management systems, Infrastructure for Connectivity & Monitoring (Wi-Fi, 5G, LPWAN, NB-IoT infrastructure), Rainwater harvesting and solar-based automation	**20%**	**9**
5	**Security, Privacy, and Blockchain in IoT**: Privacy and social values in smart urban environments, IoT information security challenges, Blockchain applications in IoT, Case studies: smart homes, building, street-lighting, parking, irrigation, & food-supply chain traceability, Threats and mitigation mechanisms	**13%**	**6**
6	**Mini Project / Case Study**: Applications & Lab-Based Work	**9%**	**4**

j. Text Book and Reference Book:

1. Internet of Things for Smart Cities Waleed Ejaz & Alagan Anpalagan; Springer, 2019
2. IoT for Smart Cities Ejaz & Anpalagan; Springer
3. Adrian McEwen, Hakim Cassimally, “Designing the Internet of things”, John Wiley and sons, 1stedition, 2014.

a. **Course Name:** Waste to Energy
b. **Course Code:** 03022002UE01
c. **Prerequisite:** Basic knowledge of environmental science, thermodynamics, and chemical engineering processes.
d. **Rationale:** This course focuses on the technological advancements and engineering principles used to convert waste materials into energy. It gives students an in-depth understanding of thermochemical, biochemical, and physicochemical conversion techniques. The course emphasizes sustainability, energy recovery efficiency, and waste management practices in line with environmental regulations.

e. Course Learning Objective:

CLOBJ 1	Understand the fundamentals of waste classification and energy conversion pathways in waste-to-energy systems.
CLOBJ 2	Analyze thermochemical, biochemical, and physicochemical methods for energy recovery from waste.
CLOBJ 3	Evaluate real-world waste-to-energy systems in terms of efficiency, feasibility, and environmental compliance.
CLOBJ 4	Design conceptual waste-to-energy (WtE) systems based on waste types and energy requirements.
CLOBJ 5	Interpret policy frameworks and perform economic assessments for waste-to-energy projects.

f. Course Learning Outcomes:

CLO 1	Understand the fundamentals of waste classification and energy conversion pathways.
CLO 2	Analyze thermochemical, biochemical, and physicochemical methods of energy recovery from waste.
CLO 3	Evaluate real-world waste-to-energy systems in terms of efficiency, feasibility, and environmental compliance.
CLO 4	Design conceptual WtE systems based on types of waste and energy needs
CLO 5	Interpret policy frameworks and perform economic assessments for waste-to-energy projects.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Understand the fundamentals of waste classification and energy conversion pathways.	2
CLO 2	Analyze thermochemical, biochemical, and physicochemical methods of energy recovery from waste.	4
CLO 3	Evaluate real-world waste-to-energy systems in terms of efficiency, feasibility, and environmental compliance.	5
CLO 4	Design conceptual WtE systems based on types of waste and energy needs	6
CLO 5	Interpret policy frameworks and perform economic assessments for waste-to-energy projects.	4

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	**Total**
4	**-**	**-**	**4**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Introduction to Waste Management and Energy Conversion** Definition of waste, types of waste, need for energy recovery, classification of waste-to-energy technologies, and energy flow in ecosystems.	**15%**	**9**
2	**Thermochemical Conversion** Incineration, pyrolysis, gasification - processes, reaction mechanisms, products, design considerations, advantages & limitations.	**25%**	**15**
3	**Biochemical Conversion** Anaerobic digestion, fermentation - microbial pathways, process parameters, biogas production, biodiesel from waste oil, landfill gas recovery.	**20%**	**12**
4	**Physicochemical Conversion** Transesterification, refuse-derived fuels (RDF), briquetting, pelletisation.	**15%**	**9**
5	**Waste to Energy Technologies and Case Studies** Overview of WTE plants, Integrated MSW systems, success stories from India and abroad	**15%**	**9**
6	**Environmental and Economic Aspects** Emissions, ash disposal, life-cycle analysis, policy and regulatory frameworks, cost-benefit analysis	**10%**	**6**

j. Text Book and Reference Book:

1. Waste to Energy Conversion Technology (Text Book) Naomi B Klinghoffer and Marco J. Castald; Woodhead Publishing, 2013
2. Waste-to-Energy Recent Developments and Future Perspectives towards Circular Economy Abd El-Fatah Abomohra, Qingyuan Wang, Jin Huang; Springer Nature, 2022
3. Biomass to Renewable Energy Processes (Text Book) Jay Cheng; CRC Press; 2nd, 2017

a. Course Name: Material Characterization and Testing

b. Course Code: 03022102PE01

c. Prerequisite: Basic knowledge of engineering mechanics, strength of materials, and fundamentals of materials science.

d. Rationale: This course provides a comprehensive understanding of engineering materials, their mechanical behavior, testing methods, and failure analysis. It enables students to relate material structure with properties and performance, apply appropriate testing and characterization techniques, and make informed material selection decisions for safe, reliable, and sustainable engineering design and manufacturing applications.

e. Course Learning Objective:

CLOBJ 1	Understand the classification of engineering materials and their structure–property–performance relationships for engineering applications.
CLOBJ 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret experimental data.
CLOBJ 3	Apply material testing procedures and failure analysis techniques to evaluate material performance and reliability.
CLOBJ 4	Examine non-destructive testing (NDT) methods and advanced evaluation techniques for material assessment.
CLOBJ 5	Evaluate recent advancements in material characterization and their applications in modern and sustainable engineering systems.

f. Course Learning Outcomes:

CLO 1	Explain the classification of engineering materials and relate structure–property–performance relationships for material selection in engineering applications.

CLO 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret stress–strain characteristics.
CLO 3	Apply material testing procedures and failure analysis techniques to evaluate material behavior and ensure structural reliability.
CLO 4	Examine non-destructive testing (NDT) and advanced evaluation techniques for assessing material integrity without damage.
CLO 5	Evaluate recent advancements in material characterization and their role in modern engineering applications and sustainability.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain the classification of engineering materials and relate structure–property–performance relationships for material selection in engineering applications.	2
CLO 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret stress–strain characteristics.	4
CLO 3	Apply material testing procedures and failure analysis techniques to evaluate material behavior and ensure structural reliability.	3
CLO 4	Examine non-destructive testing (NDT) and advanced evaluation techniques for assessing material integrity without damage.	3
CLO 5	Evaluate recent advancements in material characterization and their role in modern engineering applications and sustainability.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
L	**T**	**P**	**C**	**Internal Evaluation**			**ESE**		**Total**
				MSE	**CE**	**P**	**Theory**	**P**	
2	**-**	**-**	**2**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Overview of engineering materials and their classification**: Metals, ceramics, polymers, composites, smart and advanced materials. Structure–property–performance relationships. Material selection criteria for engineering applications. Fundamentals of material characterization. Role of material testing in design, manufacturing, sustainability, and failure prevention	**18%**	**6**
2	**Mechanical characterization of materials** Stress–strain behavior of materials: elastic, plastic, and viscoelastic deformation. Mechanical properties including strength, stiffness, hardness, toughness, ductility,	**25%**	**7**

	resilience, and fracture resistance. Standard mechanical tests: tensile, compression, flexural, shear, hardness (Brinell, Rockwell, Vickers), impact (Charpy, Izod), fatigue, and creep testing. Testing standards (IS, ASTM, ISO) and interpretation of test data		
3	**Testing procedures and failure analysis** Classification and purpose of material testing. Development of testing methodologies and role of standardization bodies. Testing of engineering materials such as metals, polymers,	**14%**	**4**
	ceramics and composites. Failure modes: brittle, ductile, fatigue, creep, and corrosion-assisted failures. Basics of fracture mechanics, crack initiation and propagation. Post-failure examination and interpretation. Industrial case studies emphasizing safety, reliability, and lifecycle assessment. Application of mechanical testing in structural integrity, product design, and quality control		
4	**Non-Destructive and advanced evaluation techniques** Principles of destructive, semi-destructive, and non-destructive testing (NDT). Common NDT techniques: rebound hammer, ultrasonic pulse velocity, radiography, magnetic particle testing, liquid penetrant testing, eddy current testing, acoustic emission, thermography, and electrochemical methods. Advantages, limitations, and field applications of NDT in infrastructure, aerospace, automotive, and biomedical sectors	**25%**	**7**
5	**Recent research and technological advancements in material characterization** Recent advances in material testing and characterization techniques. Nano- and micro-mechanical testing, Morphology, structural and chemical characterization. Additive manufacturing material characterization challenges. Sustainability-driven testing, green materials, and circular economy considerations. Interdisciplinary relevance with civil, mechanical, biomedical, and manufacturing engineering.	**18%**	**6**

j. Text Book and Reference Book:

1. Materials Science and Engineering William D. Callister; Jr, John Wiley & sons
2. Practical Non-Destructive Testing Baldev Raj, T. Jayakumar and M. Thavasimuthu; Narosa Pub. House
3. Mechanical Metallurgy George E. Dieter; McGrawhill book company

a. Course Name: Material Characterization and Testing Laboratory

b. Course Code: 03022102PE02

c. Prerequisite: Basic knowledge of engineering mechanics, strength of materials, and fundamentals of materials science.

d. Rationale: This course provides a comprehensive understanding of engineering materials, their mechanical behavior, testing methods, and failure analysis. It enables students to relate material structure with properties and performance, apply appropriate testing and characterization techniques, and make informed material selection decisions for safe, reliable, and sustainable engineering design and manufacturing applications.

e. Course Learning Objective:

CLOBJ 1	Understand the classification of engineering materials and their structure–property–performance relationships for engineering applications.
CLOBJ 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret experimental data.
CLOBJ 3	Apply material testing procedures and failure analysis techniques to evaluate material performance and reliability.

CLOBJ 4	Examine non-destructive testing (NDT) methods and advanced evaluation techniques for material assessment.
CLOBJ 5	Evaluate recent advancements in material characterization and their applications in modern and sustainable engineering systems.

f. Course Learning Outcomes:

CLO 1	Explain the classification of engineering materials and relate structure–property–performance relationships for material selection in engineering applications.
CLO 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret stress–strain characteristics.
CLO 3	Apply material testing procedures and failure analysis techniques to evaluate material behavior and ensure structural reliability.
CLO 4	Examine non-destructive testing (NDT) and advanced evaluation techniques for assessing material integrity without damage.
CLO 5	Evaluate recent advancements in material characterization and their role in modern engineering applications and sustainability.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain the classification of engineering materials and relate structure–property–performance relationships for material selection in engineering applications.	2
CLO 2	Analyze mechanical behavior and properties of materials using standard testing methods and interpret stress–strain characteristics.	4
CLO 3	Apply material testing procedures and failure analysis techniques to evaluate material behavior and ensure structural reliability.	3
CLO 4	Examine non-destructive testing (NDT) and advanced evaluation techniques for assessing material integrity without damage.	3
CLO 5	Evaluate recent advancements in material characterization and their role in modern engineering applications and sustainability.	5

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
-	**-**	**2**	**1**	**-**	**-**	**20**	**-**	**30**	**50**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

4. Materials Science and Engineering William D. Callister; Jr, John Wiley & sons;
5. Practical Non-Destructive Testing Baldev Raj, T. Jayakumar and M. Thavasimuthu; Narosa Pub. House
6. Mechanical Metallurgy George E. Dieter; McGrawhill book company

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5
1	Tensile testing of metallic or composite specimens and determination of mechanical properties.	✓	✓			
2	Compression testing of metallic or composite specimens and determination of mechanical properties	✓	✓			
3	Hardness testing using hardness testers and comparison of results.		✓	✓		
4	Impact testing to evaluate toughness and ductile–brittle transition behavior		✓	✓		
5	Non-destructive testing of materials using MPT.			✓	✓	
6	Microstructural characterization of materials using optical microscopy and correlation with mechanical properties.	✓	✓			✓
7	Non-destructive testing of materials using DPT			✓	✓	
8	Synthesis of compact using Powder metallurgy	✓	✓	✓		✓

a. **Course Name:** Advanced Simulation and Modelling

b. **Course Code:** 03022102PE05

c. **Prerequisite:** Basic knowledge of engineering mathematics (calculus, differential equations, and linear algebra) and fundamentals of physics (mechanics and thermodynamics).

d. **Rationale:** To equip students with the conceptual, mathematical, and computational foundations needed to build, validate, and interpret simulations of mechanical and manufacturing systems, while preparing them for emerging technologies such as digital twins and AI-assisted modelling.

e. Course Learning Objective:

CLOBJ 1	Develop different types of models (continuous/discrete, deterministic/stochastic) and explain the key concepts, assumptions, and limitations of modelling and simulation.
CLOBJ 2	Express governing equations for physical systems, differentiate between lumped and distributed parameter models, and analyze numerical solutions for stability, convergence, and errors.
CLOBJ 3	Apply appropriate modelling techniques to simulate kinematic, dynamic, thermal, and structural behavior in mechanical and manufacturing systems, including material behaviour..
CLOBJ 4	Use computer-based simulation tools effectively, including pre-processing (meshing), solver selection, post-processing, and parametric/optimization studies
CLOBJ 5	Evaluate the accuracy and validity of simulation results by interpreting outputs and comparing them with theoretical or expected behaviors.
CLOBJ 6	Identify and discuss recent advancements in simulation technology, including digital twins, AI-assisted simulation, cloud platforms, and Industry 4.0 integration, with reference to research papers and case studies.

f. Course Learning Outcomes:

CLO 1	Interpret fundamental principles of engineering simulation and system modelling.
CLO 2	Construct mathematical and computational models of mechanical and manufacturing systems.
CLO 3	Simulate physical systems using numerical and software-based simulation techniques.
CLO 4	Validate simulation results through analytical, experimental, or benchmark comparisons.
CLO 5	Investigate recent research trends and advanced applications in simulation and modelling.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		Bloom's Level
CLO 1	Interpret fundamental principles of engineering simulation and system modelling.	2
CLO 2	Construct mathematical and computational models of mechanical and manufacturing systems.	3,6
CLO 3	Simulate physical systems using numerical and software-based simulation techniques.	3
CLO 4	Validate simulation results through analytical, experimental, or benchmark comparisons.	5
CLO 5	Investigate recent research trends and advanced applications in simulation and modelling.	4

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		
L	T	P	C	MSE	CE	P	Theory	P	Total
2	-	0	2	20	20	-	60	-	100

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**-Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**Fundamentals of Simulation and Modelling:** Concepts of modelling and simulation, classification of models, continuous and discrete systems, deterministic and stochastic models, system abstraction, modelling assumptions and limitations.	**15%**	**5**
2	**Mathematical and Numerical Modelling:** Governing equations for physical systems, lumped and distributed parameter models, numerical solution techniques,stability and convergence concepts, error analysis in simulations.	**20%**	**6**
3	**Simulation of Mechanical and Manufacturing Systems:** Modelling of kinematic and dynamic systems, simulation of machining and forming processes, material behaviour	**15%**	**7**
	modelling, thermal and structural simulations, introduction to multiphysics simulation.		
4	**Computer-Based Simulation Tools:** Overview of commercial and open-source simulation software, pre-processing, meshing strategies, solver selection, post processing and result interpretation, parametric and optimization-based simulations.	**30%**	**7**
5	**Recent Research and Technological Advancements in Simulation:** Digital twins, real-time and co-simulation, AI-assisted and data-driven simulation, cloud-based simulation platforms, Industry 4.0 integration, review of recent research papers and industrial case studies.	**20%**	**5**

j. Text Book and Reference Book:

1. "Modelling and Simulation: Exploring Dynamic System Behaviour" by Louis G. Birta & Gilbert Arbez.
2. " Modeling and Simulation Fundamentals" by John A. Sokolowski (Wiley)

a. **Course Name:** Advanced Simulation and Modelling Laboratory
b. **Course Code:** 03022102PE06
c. **Prerequisite:** Basic knowledge of engineering mathematics, mechanics, numerical methods, programming fundamentals, and familiarity with CAD/CAE concepts.
d. **Rationale:** This course provides hands-on experience in mathematical modeling and computer-based simulation of mechanical systems, enabling students to analyze, predict, and optimize engineering behavior using modern CAE tools and numerical techniques relevant to design and manufacturing applications.

e. Course Learning Objective:

CLOBJ 1	Develop mathematical models for mechanical systems to represent real-world engineering problems.
CLOBJ 2	Perform numerical simulations using MATLAB or Python-based computational tools.
CLOBJ 3	Conduct structural and thermal simulations using commercial CAE software.
CLOBJ 4	Simulate manufacturing processes such as machining and forming using appropriate modeling techniques.
CLOBJ 5	Apply parametric analysis and optimization methods to improve system performance.
CLOBJ 6	Validate simulation results using analytical solutions or published experimental data.
CLOBJ 7	Design and implement a mini-project based on real-world or research-oriented mechanical engineering problems.

f. Course Learning Outcomes:

CLO 1	Develop mathematical models for mechanical systems to represent real-world engineering problems.
CLO 2	Apply numerical methods using MATLAB or Python for simulation and analysis of engineering systems.
CLO 3	Perform structural, thermal, and manufacturing process simulations using CAE tools.
CLO 4	Analyze and optimize mechanical systems using parametric and performance-based simulation techniques.
CLO 5	Validate simulation results using analytical solutions, experimental data, or published references.
CLO 6	Design and implement a mini-project based on real-world or research-oriented mechanical engineering problems.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Develop mathematical models for mechanical systems to represent real-world engineering problems.	6
CLO 2	Apply numerical methods using MATLAB or Python for simulation and analysis of engineering systems.	3
CLO 3	Perform structural, thermal, and manufacturing process simulations using CAE tools.	5
CLO 4	Analyze and optimize mechanical systems using parametric and performance-based simulation techniques.	4
CLO 5	Validate simulation results using analytical solutions, experimental data, or published references.	5
CLO 6	Design and implement a mini-project based on real-world or research-oriented mechanical engineering problems.	6

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		Total
L	T	P	C	MSE	CE	P	Theory	P	
-	-	2	1	-	-	20	-	30	50

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Text Book and Reference Book:

1. Rao, S. S., "The Finite Element Method in Engineering", Elsevier Butterworth-Heinemann.
2. Logan, D. L., "A First Course in the Finite Element Method", Cengage Learning.
3. Hutton, D. V., "Fundamentals of Finite Element Analysis", McGraw-Hill Education.
4. Kwon, Y. W. & Bang, H., "The Finite Element Method Using MATLAB", CRC Press.
5. Bathe, K. J., "Finite Element Procedures", Prentice Hall.

j. Mapping of Experiment List with Course Learning Outcomes:

Exp. No.	Name of the Experiment	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
1	Development of mathematical models for mechanical systems.	✓					
2	Numerical simulation using MATLAB / Python-based tools.	✓	✓				
3	Structural or thermal simulation using commercial CAE software.		✓	✓			
4	Simulation of manufacturing processes (machining/forming)			✓	✓		
5	Parametric and optimization-based simulation study.		✓		✓	✓	
6	Validation of simulation results with analytical or published data.		✓			✓	
7	Mini-project based on real-world or research-oriented problem.	✓	✓	✓	✓	✓	✓

a. Course Name: - Product Design and Development

b. Course Code: 03022102PE09

c. Prerequisite: Basic knowledge of engineering design, manufacturing processes, materials engineering, CAD/CAM concepts, and engineering drawing. Familiarity with product development fundamentals, machine design principles, and industrial engineering concepts will be beneficial.

d. Rationale: Advanced knowledge of product design and development methodologies required for modern engineering applications. Enables students to understand customer-driven design approaches, value engineering, product development strategies, and emerging technologies such as AI, additive manufacturing, digital twins, and Industry 4.0 concepts.

e. Course Learning Objective:

CLOBJ 1	Provide understanding of the fundamental concepts, methodologies, and strategies involved in product design and product life cycle management.
CLOBJ 2	Develop the ability to identify and analyze customer needs using structured design tools such as QFD and Kano Model..
CLOBJ 3	Enable students to apply product development strategies and systematic design methods for generating and evaluating design concepts.
CLOBJ 4	Impart knowledge of value engineering principles and techniques for enhancing product functionality and reducing overall cost.
CLOBJ 5	Familiarize students with modern design and manufacturing technologies for developing innovative and sustainable engineering products.

f. Course Learning Outcomes:

CLO 1	Explain fundamental concepts and methodologies of product design considering product life cycle and organizational strategy
CLO 2	Analyze customer needs using structured tools such as QFD and Kano model to convert them into design requirements
CLO 3	Apply product development strategies and design methods to generate and evaluate feasible design concepts
CLO 4	Evaluate products using value engineering techniques to improve functionality and reduce cost
CLO 5	Integrate modern design and manufacturing technologies to develop innovative and sustainable products

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Explain fundamental concepts and methodologies of product design considering product life cycle and organizational strategy	2
CLO 2	Analyze customer needs using structured tools such as QFD and Kano model to convert them into design requirements	4
CLO 3	Apply product development strategies and design methods to generate and evaluate feasible design concepts	3
CLO 4	Evaluate products using value engineering techniques to improve functionality and reduce cost	5
CLO 5	Integrate modern design and manufacturing technologies to develop innovative and sustainable products	6

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**MSE**	**CE**	**P**	**Theory**	**P**	
2	**1**	**-**	**3**	**20**	**20**	**50**	**60**	**-**	**150**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**CONCEPTS OF PRODUCT DESIGN :**	**20%**	**5**

	Definition and scope of product design, Essential factors influencing product design, Classification and specifications of products, Product life cycle, Product strategies and product policy of an organization, Design by evolution and design by innovation, Product selection based on profitability considerations, Standardization and simplification, Product design process and design methodology, Product analysis and morphology of design		
2	**CUSTOMER NEEDS AND CONCEPT GENERATION** Customer needs, satisfaction, and market-driven design, Voice of Customer (VoC), Quality Function Deployment (QFD), House of Quality (HoQ), Kano Model and Kano Diagram, Organizing and prioritizing customer needs, Affinity diagrams and need hierarchy, determining importance of needs, Customer need documentation and information gathering tools	**25%**	**7**
3	**PRODUCT DEVELOPMENT STRATEGIES** Creative thinking and ideation techniques, Functional decomposition and functional representation, Physical	**25%**	**7**
	decomposition of products, Morphological analysis and concept selection, TRIZ methodology, Conceptual and embodiment design, Product architecture and modular design, Parametric design, Geometric Dimensioning and Tolerancing (GD&T), Material selection methodologies. Ergonomic and aesthetic considerations, DFM, DFA, and DFMA Principles in Design		
4	**VALUE ENGINEERING** Concept of value: Value vs Cost, Value analysis and value engineering, Value Engineering Job Plan (VEJP), Value engineering tools and techniques, Function–cost relationship, Functional Analysis System Technique (FAST), Case studies on value engineering applications in product design and development	**20%**	**7**
5	**RECENT RESEARCH AND TECHNOLOGICAL ADVANCEMENTS IN PRODUCT DESIGN AND DEVELOPMENT** Additive manufacturing and digital product development, AI and Machine Learning applications in product design, Digital twins in design and manufacturing, Smart products and IoT-enabled design, Applications of Virtual Reality (VR) and Augmented Reality (AR) in product development, Sustainable and circular product design approaches, Industry 4.0 and Industry 5.0 perspectives in product development.	**10%**	**4**

j. Text Book and Reference Book:

1. Product Design and Manufacturing, By A. K. Chitale and R. C. Gupta, PHI Learning Pvt. Ltd.
2. Product Design & Development, By Karl T. Ulrich, Steven D. Eppinger, and Anita Goyal, Tata McGraw Hill Education Private Limited.
3. Engineering Design - A Material Processing Approach, By G. E. Dieter, McGraw Hill.

k. Mapping of Experiment List with Course Learning Outcomes :

Sr. NO.	Experiment List	CLO1	CLO2	CLO3	CLO4	CLO5
1	Understanding Product Design Process and Life Cycle	✓				
2	Analysing Product Strategies and Design Morphology	✓		✓		
3	Identifying Customer Needs Using Voice of Customer Tools.		✓			
4	Translating Customer Requirements Using QFD and Kano Model.		✓	✓		
5	Applying Functional Decomposition for Concept Generation.			✓		
6	Developing Design Concepts Using TRIZ and Axiomatic Design	✓		✓		
7	Evaluating Products Using Value Engineering and FAST Diagram				✓	
8	Implementing DFM, DFA, and DFMA Principles in Design			✓	✓	✓
9	Reviewing Recent Research and Emerging Technologies in Product Design					✓

a. **Course Name:** - Design of Mechanical Systems

b. **Course Code:** 03022102PE11

c. **Prerequisite:** Fundamentals of Engineering Mechanics, Strength of Materials, Theory of Machines, Machine Design, Manufacturing Processes, Engineering Materials, CAD/CAE, and basic knowledge of fatigue, vibrations, reliability, and numerical analysis.

d. **Rationale:** This course provides advanced knowledge of mechanical system design philosophies by integrating reliability, optimization, computational methods, CAD/CAE tools, and modern technologies to develop robust, sustainable, and high-performance engineering systems for industrial applications..

e. Course Learning Objective:

CLOBJ 1	Understand advanced mechanical system design philosophies, system architecture, and design methodologies for complex engineering systems.
CLOBJ 2	Analyze mechanical systems under static, dynamic, impact, and fatigue loading conditions using modern failure theories.
CLOBJ 3	Apply reliability, safety, maintainability, and sustainable design principles in mechanical system development.
CLOBJ 4	Formulate and solve engineering design optimization problems using computational and evolutionary techniques.
CLOBJ 5	Utilize CAD/CAE tools for modeling, simulation, validation, and verification of mechanical systems.
CLOBJ 6	Evaluate emerging technologies such as AI, digital twins, additive manufacturing, and Industry 4.0 in advanced mechanical system design.

f. Course Learning Outcomes:

CLO 1	Analyze and design complex mechanical systems using system-level design approaches
CLO 2	Apply advanced stress, fatigue, and reliability concepts for safe and efficient system design
CLO 3	Evaluate mechanical systems based on reliability, safety standards, and sustainability
CLO 4	Use optimization, CAD/CAE tools, and emerging technologies for system validation and innovation.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		Bloom's Level
CLO 1	Analyze and design complex mechanical systems using system-level design approaches	4
CLO 2	Apply advanced stress, fatigue, and reliability concepts for safe and efficient system design	3
CLO 3	Evaluate mechanical systems based on reliability, safety standards, and sustainability	5
CLO 4	Use optimization, CAD/CAE tools, and emerging technologies for system validation and innovation.	2

h. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
				Internal Evaluation			ESE		Total
L	T	P	C	MSE	CE	P	Theory	P	
2	1	-	3	20	20	50	60	-	150

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	**ADVANCED MECHANICAL SYSTEM DESIGN PHILOSOPHY** Mechanical systems vs component-level design, Functional decomposition and system architecture, Design requirements, constraints, and performance metrics, Design for robustness and uncertainty, Systems engineering approach in mechanical design, Failure modes and effects analysis (FMEA) at system level	15%	5
2	**DESIGN UNDER STATIC, DYNAMIC & FATIGUE LOADING** Multiaxial stress and fatigue theories, Variable amplitude loading and cumulative damage, Probabilistic fatigue design, Impact and shock loading, Introduction to fracture mechanics	20%	6
3	**RELIABILITY, SAFETY & SUSTAINABLE DESIGN** Reliability concepts and failure models, System reliability (series/parallel systems), Maintainability and availability Design standards (ISO, ASME), Sustainable and life-cyclebased design	15%	5
4	**OPTIMIZATION & COMPUTATIONAL DESIGN METHODS** Design optimization problem formulation, Single and multi-objective optimization, Evolutionary algorithms (GA, PSO –	20%	6
	overview), Design sensitivity analysis, Introduction to topology and generative design		
5	**CAD/CAE-BASED SYSTEM DESIGN & VALIDATION** System-level CAD modeling strategies, Structural, modal, and thermal analysis, Coupled-field analysis, Digital twin concept, Validation and verification techniques	15%	4

6	**RECENT RESEARCH AND TECHNOLOGICAL ADVANCEMENTS** AI and machine learning in mechanical system design, Digital twins and Industry 4.0, Additive manufacturing-driven system design. Smart and adaptive mechanical systems	**15%**	**4**

j. Text Book and Reference Book:

1. Mechanical Engineering Design By Shigley, J.E., and Mischke, C.R. | Tata McGraw-HillProduct
2. Fundamentals of Machine Component Design By R C Juvinall | 1/e PHI
3. Machine Design: An Integrated Approach By R L Norton | Pearson Education. |

k. Mapping of Experiment List with Course Learning Outcomes :

Sr. NO.	Experiment List	CLO1	CLO2	CLO3	CLO4
1	Case study discussion on industrial mechanical systems	✓		✓	✓
2	Numerical problems on fatigue and reliability		✓	✓	
3	Reliability Block Diagram Modeling and Life Cycle Assessment (LCA)		✓	✓	
4	Optimization of a mechanical subsystem using MATLAB/Python			✓	
5	CAD–CAE Integrated Design and Validation Workflow	✓	✓		✓
6	Emerging Research Trends in Mechanical System Design	✓			✓

a. **Course Name:** Advanced Metrology and Inspection Techniques
b. **Course Code:** 03022101PE07
c. **Prerequisite:** Basics of Metrology
d. **Rationale:** To provide an insight into modern inspecting techniques along with the classical metrology so as to enhance the ability to apply knowledge of measurements and demonstrate excellent skills and techniques.

e. Course Learning Objective:

CLOBJ 1	Conceptualize the fundamentals, principles, and significance of metrology in precision engineering and manufacturing.
CLOBJ 2	Learn and analyze advanced measurement techniques and instruments used in modern metrology.
CLOBJ 3	Understand the principles, applications, and industrial importance of laser technology and holography.
CLOBJ 4	Understand the construction, working, and applications of Coordinate Measuring Machine (CMM) systems in dimensional inspection and quality control.

f. Course Learning Outcomes:

CLO 1	Conceptualize the fundamentals of metrology.
CLO 2	Learn advanced techniques used in metrology.
CLO 3	Understand the concept of Laser technology and holography.
CLO 4	Understand the concept of the CMM machine.

g. Mapping of Course Learning Outcomes and Bloom's Taxonomy:

Course Learning Outcomes		**Bloom's Level**
CLO 1	Conceptualize the fundamentals of metrology.	2
CLO 2	Learn advanced techniques used in metrology.	2
CLO 3	Understand the concept of Laser technology and holography.	2
CLO 4	Understand the concept of the CMM machine.	2

h. Teaching & Examination Scheme:

Teaching Scheme				**Evaluation Scheme**					
				Internal Evaluation			**ESE**		**Total**
L	**T**	**P**	**C**	**T**	**CE**	**P**	**Theory**	**P**	
2	**-**	**-**	**2**	**20**	**20**	**-**	**60**	**-**	**100**

L- Lectures; **T**- Tutorial; **P-** Practical; **C**- Credit; **MSE-** Mid-Semester Evaluation, **CE**- Continuous Evaluation, **ESE-** End Semester Examination

i. Course Content:

Sr. No.	**Content**	**Weightage**	**Teaching Hours**
1	**Fundamentals Of Metrology** Role of metrology in manufacturing; Classification of measurements; Calibration and traceability; Measurement errors; Accuracy, precision, uncertainty, repeatability & reproducibility, principles of dimensional and geometric measurements, surface finish measurement and evaluation, limits, fits, tolerances, and the ISO system of limits, fits, tolerances with applications.	**15%**	**5**
2	**Dimensional and Geometrical Metrology & CMM** Measurement of linear, angular, form, and geometric tolerances; Advanced gauges; GD&T; Surface roughness, waviness and profile measurement; Roundness, flatness, cylindricity, concentricity, Coordinate Measuring	**20%**	**6**

	Machines (CMM), Applications Types of CMMs (manual, DCC, portable); Probes (touch, scanning, optical, laser); CMM programming and operation; CAD integration and DMIS; Reverse engineering and part verification.		
3	**Holography** Principles of Optical and Digital Holography, Holographic Interferometry and NDT Applications, Vibration and Deformation Analysis, 3D Shape Measurement using Holography, Computational Holography and Advanced Applications.	**10%**	**3**
4	**Computer Aided Laser Metrology** Tool Makers Microscope, Principles and Types of Lasers in Metrology, Laser Interferometry and Dimensional Measurements, Laser Doppler Vibrometry (LDV), Laser	**20%**	**6**
	Triangulation and Displacement Sensors, 3D Laser Scanning and Reverse Engineering, Laser Scanning gauge, LASER micrometer, laser-based measurement integrated with CAD systems, laser interferometry for dimensional accuracy, use of laser trackers in adaptive machining, and real-time inspection, Optical - LASER interferometers-applications		
5	**Machine Vision and Intelligent Inspection** Machine vision systems, Illumination, Magnification, Vision system measurement multisensory systems. Overview of Image Processing; Pattern recognition and feature extraction; CNC and robotic system integration; AI/MLbased inspection, In-line and in-process inspection; CAD/CAM/CAE and PLM integration; Digital twin and real-time quality monitoring; Automation and robotic metrology.	**15%**	**4**
6	**Recent Research and Technological Advancements** Smart metrology systems; Real-time multi-axis metrology in CNC systems, Autonomous robotic metrology in smart factories Blockchain for traceability in inspection; Nano & quantum metrology; Latest research applications (aerospace, automotive, biomedical). AI and machine vision enable automated defect detection and adaptive inspection, smart factories now use real-time, in-process metrology integrated with IoT and digital twins, AR/VRbased inspection training.	**20%**	**6**

j. Text Book and Reference Book:

1. Metrology and Measurement by Anand Bewoor & Vinay Kulkarni | McGraw-Hill
2. Lasers – Principles, Types and Applications by Nambikar K | New Age International Limited Publishers
3. Co-ordinate Measuring Machines and Systems By Bosch J A | Giddings and Lewis Dayton; Marcel Dekker
4. Industrial Metrology by Smith G | Springer
5. Fundamentals of Dimensional Metrology by Dotson C. | Cengage. 2005

k. Mapping of Experiment List with Course Learning Outcomes:

Sr. NO.	Experiment List	CLO1	CLO2	CLO3	CLO4
1	Measurement of surface finish of polished components.	✓	✓		
2	Measurement of flatness of a surface plate	✓	✓		
3	Measurement of Geometric and Form features using CMM	✓	✓		✓
4	Creation of CAD data from a physical component using CMM		✓		✓
5	Generation of surface from point cloud using CMM		✓		✓
6	Depth measurement using vision system (stereoscopic image)		✓	✓	