



Two-Year Postgraduate Programme

Master of Technology

Material Engineering (Nanotechnology)

Faculty of Engineering & Technology

Parul University

Vadodara, Gujarat, India

Program Curriculum

Semester 1						
Sr. No.	Subject Code	Subject Name	Credit	Lect	Lab	Tut
		Professional Core Courses (PCC-I)				
1	03023701PC01	Advanced Materials and Processing	2	2	0	0
2	03023701PC02	Advanced Materials and Processing Lab	1	0	2	0
		Professional Core Courses (PCC-II)				
3	03023701PC03	Computational Material Science	3	3	0	0
4	03023701PC04	Computational Material Science lab	1	0	2	0
		Professional Core Courses (PCC-III)				
5	03023701PC05	Introduction to Nanomaterials and Nanotechnology	3	2	0	1
		Professional Elective Courses (PEC-I)				
6	03023701PE01	Nanotribology	3	2	0	1
7	03023701PE02	Quantum Mechanics	3	2	0	1
8	03023701PE03	Physical Metallurgy	3	2	0	1
		Professional Elective Courses (PEC-II)				
9	03023701PE04	Nanoscience and Nanocatalysis for Sustainable Future	3	2	0	1
10	03023701PE05	Nanotoxicology	3	2	0	1
11	03023701PE06	Spectroscopy Technique for Nanomaterials	3	2	0	1
		"Humanities and Social Science, including Management Courses (HSMC-I)"				
12	03020201HM01	Research Methodology and IPR	4	4	0	0
		Mandatory courses (MC-I)				
13	03023701MC01	Environmental Nanotechnology	0	2	0	0
14	03023701MC01	Industrial Safety	0	2	0	0
15	03020001MC02	Value Education	0	2	0	0
Total			20	17	06	02

Semester 2						
Sr. No.	Subject Code	Subject Name	Credit	Lect	Lab	Tut
		Professional Core Courses (PCC-IV)				
16	03023702PC01	Surface Engineering for Nanotechnology	2	2	0	0
17	03023702PC02	Surface Engineering for Nanotechnology Lab	1	0	2	0
		Professional Core Courses (PCC-V)				
18	03023702PC03	Materials Characterization Techniques	3	3	0	0
19	03023702PC04	Materials Characterization Techniques Lab	1	0	2	0
		Professional Core Courses (PCC-VI)				
20	03023702PC05	Nanocomposites	3	2	0	1
		Professional Elective Courses (PEC-III)				
21	03023702PE01	Nanosensors and Devices	3	2	0	1
22	03023702PE02	Carbon Nanotechnology	3	2	0	1
23	03023702PE03	Interfaces and Adhesion in Materials	3	2	0	1
		Professional Elective Courses (PEC-IV)				
24	03023702PE04	MEMS and NEMS	3	2	0	1
25	03023702PE05	Metals, Alloys and Composite Materials	3	2	0	1
26	03023702PE06	Energy Materials	3	2	0	1
		Multidisciplinary Open Professional Electives Courses (MOPEC-I)				
27	03022102UE01	Operations Research	4	4	0	0
28	03023702UE01	Design of Experiments	4	4	0	0
29	03022002UE01	Waste to Energy	4	4	0	0
		Mandatory courses (MC-II)				
30	03020002MC01	Pedagogy Studies	0	2	0	0
31	03023702MC01	Disaster Management	0	2	0	0
32	03023702MC02	Cost Management of Engineering Projects	0	2	0	0
Total			20	17	06	02
Semester 3						
		Dissertation				
33	03023703IN02	Dissertation Phase - I	20	0	40	0

Semester 4						
		Dissertation				
34	03023704IN02	Dissertation Phase - II	20	0	40	0
Total			80			

Semester 1

- a. **Course Name:** Advanced Materials and Processing
- b. **Course Code:** 03023701PC01
- c. **Prerequisite:** Fundamental knowledge of materials science, phase diagrams, thermodynamics, and basic manufacturing and processing techniques.
- d. **Rationale:** This course aims to provide advanced understanding of modern engineering materials and their processing techniques with special emphasis on nanomaterials, advanced composites, functional materials, and surface engineering. The course focuses on structure–property–processing relationships, emerging processing routes, and applications in high-performance and nano-enabled systems.
- e. **Course Learning Objective:**

CLOBJ 1	To develop fundamental understanding of advanced engineering materials including metallic, ceramic, polymeric, composite, and nano-engineered materials.
CLOBJ 2	To study structure–property–processing relationships governing the performance of advanced materials under different service conditions.
CLOBJ 3	To introduce advanced processing and manufacturing techniques for tailoring microstructure, mechanical behaviour, and functional properties of materials.
CLOBJ 4	To familiarize students with selection criteria and application potential of advanced materials for high-performance engineering and nanotechnology applications.
CLOBJ 5	To understand surface engineering, coating technologies, and material modification techniques for enhancing durability, wear resistance, corrosion resistance, and functional performance.

f. Course Learning Outcomes:

CLO 1	Explain classification, structure, and properties of advanced and nano-engineered materials.
CLO 2	Analyze structure–property–processing relationships for metallic, ceramic, composite, and nanomaterials.
CLO 3	Apply advanced processing techniques to tailor microstructure and functional performance.
CLO 4	Evaluate suitability of advanced materials for high-performance and nanotechnology applications.
CLO 5	Integrate surface engineering and coating technologies to enhance durability and functional behaviour.

g. 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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF ADVANCED MATERIALS Classification of advanced materials, structure-property relationships, crystallography and defects, thermodynamics and kinetics, phase transformations, diffusion mechanisms, nanoscale size effects, mechanical, thermal, electrical, and magnetic properties of advanced materials	12%	4
2	ADVANCED METALLIC MATERIALS AND ALLOYS High-strength low-alloy steels, superalloys and intermetallic compounds, shape memory alloys, bulk metallic glasses, nanocrystalline metals, strengthening mechanisms, heat treatment and thermomechanical processing, aerospace and automotive applications	17%	5
3	ADVANCED CERAMICS AND COMPOSITES Structural and functional ceramics, oxide and non-oxide ceramics, fiber and particle reinforced composites, metal, ceramic and polymer matrix composites, processing techniques, interfacial bonding, damage and failure mechanisms	17%	5
4	NANOMATERIALS AND NANO-ENABLED SYSTEMS Classification of nanomaterials, top-down and bottom-up synthesis, carbon nanomaterials, nanoparticles and hybrid structures, size-dependent properties, self-assembly, applications in electronics, energy, catalysis and biomedical fields	20%	6
5	ADVANCED MATERIAL PROCESSING TECHNIQUES Synthesis of Polymer Composites, Synthesis of Metal Composites, CVD and PVD, and additive manufacturing	17%	5
6	SURFACE ENGINEERING AND FUNCTIONAL COATINGS Surface modification techniques, thermal spraying, laser and electron beam processing, ion implantation,	17%	5

	thin films and nanocoatings, corrosion and oxidation protection, tribological performance, industrial case studies		
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i. Text Book and Reference Book:

1. "Callister & Rethwisch", Materials Science and Engineering: An Introduction, Wiley
2. "Edelstein & Cammarata", Nanomaterials: Synthesis, Properties and Applications, CRC Press
3. "Krishan Kumar Chawla", Composite Materials: Science and Engineering, Springer
4. "Peter Martin", Introduction to Surface Engineering and Functionally Engineered Materials, Wiley
5. "Ian Gibson", David Rosen, Brent Stucker, Additive Manufacturing Technologies, Springer

0	-	2	1	-	-	20	-	30	50
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L- Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

h. Text Book and Reference Book:

1. "Callister & Rethwisch", Materials Science and Engineering: An Introduction, Wiley
2. "Edelstein & Cammarata", Nanomaterials: Synthesis, Properties and Applications, CRC Press
3. "Cullity & Stock", Elements of X-Ray Diffraction, Pearson
4. "Goldstein et al.", Scanning Electron Microscopy and X-Ray Microanalysis, Springer
5. "Gibson, Rosen, Stucker", Additive Manufacturing Technologies, Springer

- a. **Course Name:** Computational Material Science
- b. **Course Code:** 03023701PC03
- c. **Prerequisite:** Basic knowledge of materials science, crystallography, thermodynamics, numerical methods, and programming fundamentals.
- d. **Rationale:** This course aims to provide in-depth knowledge of computational approaches used in materials science to model, simulate, and predict structure–property relationships. The course focuses on atomistic, mesoscopic, and continuum-scale modeling techniques and their applications in design and optimization of advanced and nanomaterials.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts and mathematical foundations of computational materials science and atomistic modeling.
CLOBJ 2	To develop understanding of computational techniques used for analyzing structure, properties, and behavior of materials at atomic, molecular, and microstructural scales.
CLOBJ 3	To familiarize students with simulation methods such as molecular dynamics, Monte Carlo methods, density functional theory, and finite element analysis for materials applications.
CLOBJ 4	To enable students to predict material performance and optimize processing–structure–property relationships using computational approaches.
CLOBJ 5	To develop the ability to apply computational tools and simulation software for solving advanced materials and nanotechnology-related engineering problems.

f. Course Learning Outcomes:

CLO 1	Explain fundamental principles and multiscale nature of computational materials modeling.
CLO 2	Apply atomistic and electronic structure simulation techniques to study materials behavior.
CLO 3	Analyze microstructure evolution using mesoscopic and phase field models.
CLO 4	Use continuum and finite element methods for mechanical and thermal simulations.
CLO 5	Integrate data-driven and AI-based approaches for computational materials design.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF COMPUTATIONAL MATERIAL SCIENCE Role of computation in materials science, length and time scales in materials modeling, overview of multiscale modeling, numerical methods in materials simulations, interatomic potentials and force fields, energy minimization and relaxation techniques	40%	18
2	CONTINUUM AND FINITE ELEMENT MODELING Elasticity and plasticity models, finite element formulation, meshing strategies, boundary conditions, coupled thermo-mechanical simulations, fracture and damage modeling, applications in structural materials	33%	15
3	DATA-DRIVEN AND AI-BASED MATERIALS DESIGN Materials informatics, databases and descriptors, machine learning algorithms in materials science, high-throughput computations, computational screening, digital twins, integration with experimental data	12%	12

i. Text Book and Reference Book:

1. "Leslie E. Frenkel & B. Smit", Understanding Molecular Simulation, Academic Press
2. "Martin", Electronic Structure: Basic Theory and Practical Methods, Cambridge University Press
3. "G. Gottstein", Physical Foundations of Materials Science, Springer
4. "Raabe et al.", Computational Materials Science: An Introduction, Wiley-VCH
5. "Curtarolo et al.", Materials Informatics, Springer

- a. **Course Name:** Computational Material Science Lab
- b. **Course Code:** 03023701PC04
- c. **Prerequisite:** Basic knowledge of materials science, numerical methods, programming (Python/Matlab), crystallography, and thermodynamics.
- d. **Rationale:** This laboratory course aims to provide practical exposure to computational tools and simulation techniques used in materials science. The course emphasizes hands-on training in atomistic modeling, electronic structure calculations, microstructure simulations, and data-driven materials analysis for understanding structure–property relationships in advanced and nanomaterials.
- e. **Course Learning Objective:**

CLOBJ 1	To provide hands-on experience in computational modeling and simulation of materials using modern software tools and numerical techniques.
CLOBJ 2	To develop practical understanding of atomistic, molecular, and continuum-scale simulations for analyzing material structure and properties.
CLOBJ 3	To familiarize students with computational methods such as molecular dynamics, Monte Carlo simulations, density functional theory, and finite element analysis.
CLOBJ 4	To enable students to interpret simulation results for predicting material behavior, microstructural evolution, and functional performance.
CLOBJ 5	To develop skills in computational data analysis, visualization, technical reporting, and problem-solving for advanced materials and nanotechnology applications.

f. Course Learning Outcomes:

CLO 1	Use computational tools to model and visualize crystal structures and nanomaterials.
CLO 2	Perform atomistic and electronic structure simulations to predict materials behavior.
CLO 3	Analyze microstructure evolution using phase field and mesoscale models.
CLO 4	Apply finite element and continuum methods for thermo-mechanical simulations.
CLO 5	Integrate machine learning and data-driven approaches for materials design and optimization.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Text Book and Reference Book:

1. "Frenkel & Smit", Understanding Molecular Simulation, Academic Press
2. "Allen & Tildesley", Computer Simulation of Liquids, Oxford University Press
3. "Martin", Electronic Structure: Basic Theory and Practical Methods, Cambridge University Press
4. "Raabe et al.", Computational Materials Science: An Introduction, Wiley-VCH
5. "Curtarolo et al.", Materials Informatics, Springer

- a. Course Name:** Introduction to Nanomaterials and Nanotechnology
- b. Course Code:** 03023701PC05
- c. Prerequisite:** Basic knowledge of materials science, solid state physics, chemistry, and engineering mathematics.
- d. Rationale:** This course aims to introduce fundamental concepts of nanoscience, nanomaterials, and nanotechnology with emphasis on structure, properties, synthesis, characterization, and applications. The course provides a foundation for understanding nanoscale phenomena and prepares students for advanced research and technological applications in nanotechnology.
- e. Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts, principles, and scope of nanoscience and nanotechnology.
CLOBJ 2	To develop understanding of structure, properties, and size-dependent behavior of nanomaterials.
CLOBJ 3	To familiarize students with synthesis, processing, and characterization techniques used for nanomaterials.
CLOBJ 4	To enable students to analyze applications of nanotechnology in engineering, energy, electronics, biomedical, and environmental fields.
CLOBJ 5	To develop awareness regarding challenges, safety aspects, ethical issues, and future prospects of nanotechnology.

f. Course Learning Outcomes:

CLO 1	Explain fundamental concepts of nanoscience and nanotechnology.
CLO 2	Analyze structure and size-dependent properties of nanomaterials.
CLO 3	Describe synthesis and fabrication techniques for nanomaterials.
CLO 4	Apply characterization methods to analyze nanoscale materials.
CLO 5	Evaluate applications, challenges, and societal implications of nanotechnology.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY Definition and scope of nanoscience and nanotechnology, historical development, length scales and dimensionality, classification of nanomaterials, surface to volume ratio, quantum size effects, and overview of applications	13%	4
2	STRUCTURE AND PROPERTIES OF NANOMATERIALS Crystal structures at nanoscale, defects and interfaces, electronic, optical, magnetic, mechanical, and thermal properties, size-dependent phenomena, surface energy and stability	20%	6
3	SYNTHESIS AND FABRICATION TECHNIQUES Top-down and bottom-up approaches, physical and chemical vapor deposition, sol-gel processing, chemical precipitation, hydrothermal synthesis, self-assembly, lithography and patterning techniques	20%	6
4	CHARACTERIZATION OF NANOMATERIALS X-ray diffraction, scanning and transmission electron microscopy, atomic force microscopy, scanning tunneling microscopy, spectroscopy techniques, particle size and surface area analysis	17%	5
5	CARBON AND INORGANIC NANOMATERIALS Fullerenes, carbon nanotubes, graphene, metal and oxide nanoparticles, quantum dots, nanowires and nanorods, synthesis, properties, and applications	17%	5
6	APPLICATIONS AND SOCIETAL ASPECTS OF NANOTECHNOLOGY Nanoelectronics, energy and environmental applications,	13%	4

	nanobiotechnology and medicine, sensors and coatings, safety, toxicity, ethical issues, and future prospects		
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i. Text Book and Reference Book:

1. "Poole & Owens", Introduction to Nanotechnology, Wiley
2. "Cao & Wang", Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific
3. "Roduner", Nanoscopic Materials: Size-Dependent Phenomena, RSC
4. "Kelsall, Hamley, Geoghegan", Nanoscale Science and Technology, Wiley
5. "Bhushan", Springer Handbook of Nanotechnology, Springer

- a. **Course Name:** Nanotribology
- b. **Course Code:** 03023701PE01
- c. **Prerequisite:** Basic tribology, materials science, surface engineering, and solid mechanics.
- d. **Rationale:** This course introduces friction, wear, and lubrication phenomena at the nanoscale with emphasis on surface interactions, contact mechanics, characterization techniques, and applications in MEMS, coatings, and nano-devices.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts of friction, wear, lubrication, and surface interactions at the nanoscale.
CLOBJ 2	To develop understanding of contact mechanics, adhesion, and interfacial phenomena governing tribological behavior of nano-engineered surfaces and materials.
CLOBJ 3	To familiarize students with advanced characterization and testing techniques used in nanotribology, including AFM-based measurements and nanoscale surface analysis.
CLOBJ 4	To enable students to analyze wear mechanisms, lubrication strategies, and surface modification methods for improving tribological performance.
CLOBJ 5	To develop the ability to apply nanotribology principles in MEMS/NEMS, coatings, biomedical devices, and advanced engineering applications.

f. Course Learning Outcomes:

CLO 1	Explain nanoscale friction and wear mechanisms.
CLO 2	Analyze surface interactions and contact mechanics.
CLO 3	Apply nanotribology concepts to coatings and devices.
CLO 4	Evaluate tribological performance of nano-surfaces.
CLO 5	Integrate nanotribology in MEMS and nano-systems.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF TRIBOLOGY AND NANOTRIBOLOGY Tribology basics, friction and wear mechanisms, surface roughness, contact mechanics, transition from macro to nano scale, adhesion and surface forces	17%	5
2	SURFACE INTERACTIONS AND CONTACT MECHANICS Van der Waals forces, capillary forces, adhesion hysteresis	20%	6
3	CHARACTERIZATION TECHNIQUES Microscopy, surface profilometry, spectroscopy methods	17%	5
4	WEAR AND LUBRICATION AT NANOSCALE Atomic wear mechanisms, boundary lubrication, solid lubricants, tribofilms	20%	6
5	COATINGS AND SURFACE MODIFICATION Hard coatings, DLC, nanocomposite coatings, surface texturing	13%	4
6	APPLICATIONS OF NANOTRIBOLOGY Aerospace and automotive components, biomedical implants, nano-manufacturing	13%	4

i. Text Book and Reference Book:

1. "Bhushan", Introduction to Tribology, Wiley
2. "Persson, B. N. J.", Sliding Friction: Physical Principles and Applications, Springer.
3. "Stachowiak & Batchelor", Engineering Tribology, Butterworth
4. "Persson, B. N. J.", Sliding Friction: Physical Principles and Applications, Springer.
5. "Bowden, F. P. & Tabor, D.", The Friction and Lubrication of Solids, Oxford University Press.

- a. **Course Name:** Quantum Mechanics
- b. **Course Code:** 03023701PE02
- c. **Prerequisite:** Engineering mathematics, linear algebra, classical mechanics, and basic physics.
- d. **Rationale:** This course provides fundamental understanding of quantum theory and its applications in materials science, nanotechnology, and modern devices.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental principles and postulates of quantum mechanics governing microscopic systems.
CLOBJ 2	To develop understanding of wave mechanics, Schrödinger equation, operators, and quantum states for analyzing atomic and subatomic phenomena.
CLOBJ 3	To familiarize students with quantum mechanical models for particles, atoms, and electronic structures relevant to materials science and nanotechnology.
CLOBJ 4	To enable students to apply quantum concepts for understanding electronic, optical, and magnetic behavior of advanced materials and nanostructures.
CLOBJ 5	To develop analytical and problem-solving skills for solving quantum mechanical problems related to modern engineering and nanotechnology applications.

f. Course Learning Outcomes:

CLO 1	Explain principles of quantum mechanics.
CLO 2	Solve basic quantum mechanical problems.
CLO 3	Apply quantum concepts to nanomaterials.
CLO 4	Analyze electronic structure of materials.
CLO 5	Relate quantum effects to device behavior.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF QUANTUM THEORY Wave-particle duality, operators, observables, postulates of quantum mechanics	17%	5
2	SCHRÖDINGER EQUATION Time-dependent and independent equations, boundary conditions, normalization	20%	6
3	QUANTUM SYSTEMS Particle in a box, harmonic oscillator, tunneling, potential barriers	20%	6
4	ATOMIC STRUCTURE Hydrogen atom, angular momentum, spin, Pauli principle	17%	5
5	SOLID STATE APPLICATIONS Energy bands, density of states, quantum wells, wires, and dots	13%	4
6	NANOTECHNOLOGY APPLICATIONS Quantum confinement, nano-electronics, optoelectronic devices	13%	4

i. Text Book and Reference Book:

1. "Griffiths, D. J. & Schroeter, D. F.", Introduction to Quantum Mechanics, Cambridge University Press.
2. "Eisberg, R. & Resnick, R.", Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley.
3. "Sakurai, J. J. & Napolitano, J.", Modern Quantum Mechanics, Cambridge University Press.
4. "Cohen-Tannoudji, C., Diu, B., & Laloë, F.", Quantum Mechanics (Vol. I & II), Wiley.
5. "Dirac, P. A. M.", The Principles of Quantum Mechanics, Oxford University Press.

- a. **Course Name:** Physical Metallurgy
- b. **Course Code:** 03023701PE03
- c. **Prerequisite:** Basic knowledge of materials science, crystallography, thermodynamics, and mechanical metallurgy.
- d. **Rationale:** This course aims to provide in-depth understanding of the physical principles governing the structure, properties, and behavior of metallic materials. The course focuses on crystal structures, defects, diffusion, phase transformations, strengthening mechanisms, and microstructural control for advanced engineering and nanotechnology applications.
- e. **Course Learning Objective:**

CLOBJ 1	To develop fundamental understanding of crystal structures, defects, and phase transformations in metallic materials.
CLOBJ 2	To study diffusion mechanisms, phase equilibria, and microstructural evolution governing the behavior of metals and alloys.
CLOBJ 3	To familiarize students with strengthening mechanisms, heat treatment processes, and microstructural control techniques for enhancing material performance.
CLOBJ 4	To enable students to analyze structure–property relationships influencing mechanical and functional behavior of engineering alloys.
CLOBJ 5	To develop the ability to apply principles of physical metallurgy for material selection, processing, and advanced engineering applications.

f. Course Learning Outcomes:

CLO 1	Explain crystal structures and defects in metallic materials.
CLO 2	Analyze diffusion and phase transformation phenomena.
CLO 3	Interpret phase diagrams and microstructural evolution.
CLO 4	Apply strengthening mechanisms for property enhancement.
CLO 5	Evaluate mechanical behavior and microstructural control strategies.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	CRYSTAL STRUCTURE AND IMPERFECTIONS Crystal systems, unit cells, atomic packing factor, crystal structures of metals, point defects, line defects (dislocations), surface defects, grain boundaries, defect energetics	20%	6
2	DIFFUSION IN SOLIDS Fick's laws of diffusion, diffusion mechanisms, vacancy and interstitial diffusion, temperature dependence of diffusion, applications of diffusion	13%	4
3	PHASE DIAGRAMS AND SOLID SOLUTIONS Unary and binary phase diagrams, lever rule, solid solutions, Hume-Rothery rules, eutectic and peritectic reactions	20%	6
4	PHASE TRANSFORMATIONS Nucleation and growth, solid-state transformations, time-temperature-transformation (TTT) diagrams, continuous cooling transformation (CCT) diagrams	17%	5
5	STRENGTHENING MECHANISMS Grain size strengthening, solid solution strengthening, precipitation hardening, work hardening, dispersion strengthening	13%	4
6	MECHANICAL BEHAVIOR AND MICROSTRUCTURAL CONTROL Elastic and plastic deformation, fracture, fatigue, creep, heat treatment processes, microstructural engineering	17%	5

i. Text Book and Reference Book:

1. "Callister & Rethwisch ", Materials Science and Engineering: An Introduction, Wiley
2. "Dieter", Mechanical Metallurgy, McGraw-Hill
3. "Porter, Easterling & Sherif", Phase Transformations in Metals and Alloys, CRC Press
4. "Reed-Hill & Abbaschian", Physical Metallurgy Principles, Cengage
5. "Hillert", Phase Equilibria, Phase Diagrams and Phase Transformations, Cambridge

- a. Course Name:** Nanoscience and Nanocatalysis for Sustainable Future
- b. Course Code:** 03023701PE04
- c. Prerequisite:** Basic knowledge of materials science, physical chemistry, thermodynamics, and nanotechnology fundamentals.
- d. Rationale:** This course aims to provide fundamental and applied knowledge of nanoscience and nanocatalysis with emphasis on sustainable energy, environmental remediation, and green chemical processes. The course focuses on structure–property–activity relationships of nanocatalysts, synthesis methods, characterization techniques, and applications toward a sustainable future.
- e. Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts of nanoscience, catalysis, and sustainability in advanced material systems.
CLOBJ 2	To develop understanding of structure–property–activity relationships governing the performance of nanocatalysts.
CLOBJ 3	To familiarize students with synthesis, processing, and characterization techniques used for catalytic nanomaterials.
CLOBJ 4	To enable students to analyze applications of nanocatalysis in energy conversion, environmental remediation, green chemistry, and sustainable technologies.
CLOBJ 5	To develop the ability to evaluate emerging nanocatalytic systems and sustainable approaches for future energy and environmental challenges.

f. Course Learning Outcomes:

CLO 1	Explain fundamental concepts of nanoscience and sustainable catalysis.
CLO 2	Analyze structure–property–activity relationships of nanocatalysts.
CLO 3	Describe synthesis and characterization techniques for nanocatalysts.
CLO 4	Apply nanocatalysis concepts to energy and environmental applications.
CLO 5	Evaluate emerging trends and sustainability aspects of nanotechnology.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				T	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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF NANOSCIENCE AND SUSTAINABILITY Introduction to nanoscience, nanoscale phenomena, classification of nanomaterials, surface energy and size effects, concepts of sustainability, green chemistry principles, role of nanotechnology in sustainable development	17%	5
2	PRINCIPLES OF HETEROGENEOUS AND HOMOGENEOUS CATALYSIS Catalysis fundamentals, adsorption and desorption, reaction kinetics, catalytic cycles, active sites, turnover frequency and selectivity, structure–activity relationships	23%	7
3	NANOCATALYSTS: TYPES AND SYNTHESIS METHODS Metal and metal oxide nanoparticles, bimetallic and core–shell nanocatalysts, supported catalysts, top-down and bottom-up synthesis routes, green synthesis approaches	20%	6
4	APPLICATIONS IN ENERGY AND ENVIRONMENT Photocatalysis and electrocatalysis, hydrogen production and storage, CO ₂ reduction, fuel cells, biomass conversion, wastewater treatment and air purification	23%	7
5	EMERGING TRENDS AND SUSTAINABLE NANOCATALYSIS Single-atom catalysis, plasmonic catalysis, enzyme-mimetic nanomaterials, circular economy, life-cycle assessment, techno-economic analysis, future prospects	17%	5

i. Text Book and Reference Book:

1. “Roduner”, Nanoscopic Materials: Size-Dependent Phenomena, RSC
2. “Somorjai & Li”, Introduction to Surface Chemistry and Catalysis, Wiley
3. “Zhang et al.”, Nanocatalysis: Synthesis and Applications, Springer
4. “Anastas & Warner”, Green Chemistry: Theory and Practice, Oxford University Press
5. “Klabunde”, Nanoscale Materials in Chemistry, Wiley

- a. **Course Name:** Nanotoxicology
- b. **Course Code:** 03023701PE05
- 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	To introduce fundamental concepts, principles, and scope of nanotoxicology related to nanomaterials and human health.
CLOBJ 2	To develop understanding of nanoparticle–biological interactions, cellular uptake mechanisms, and toxicity pathways of nanomaterials.
CLOBJ 3	To familiarize students with methods for toxicity assessment, risk evaluation, and safety analysis of nanomaterials.
CLOBJ 4	To enable students to analyze environmental, ecological, and occupational impacts associated with nanotechnology and engineered nanomaterials.
CLOBJ 5	To develop awareness regarding regulatory frameworks, ethical considerations, and safe-by-design approaches for sustainable and responsible nanotechnology development.

f. **Course Learning Outcomes:**

CLO 1	Explain principles and scope of nanotoxicology.
CLO 2	Analyze nanoparticle–biological interactions and toxicity mechanisms.
CLO 3	Apply toxicity assessment methods for nanomaterials.
CLO 4	Evaluate environmental and ecological impacts of nanomaterials.
CLO 5	Interpret regulatory frameworks and safe-by-design strategies.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO NANOTOXICOLOGY Definition and scope of nanotoxicology, classification of nanomaterials, sources and exposure routes, physicochemical properties influencing toxicity, dose metrics and biodistribution	13%	4
2	NANOPARTICLE-BIOLOGICAL INTERACTIONS Protein corona formation, cellular uptake mechanisms, membrane interactions, intracellular trafficking, oxidative stress and inflammation	17%	5
3	MECHANISMS OF NANOTOXICITY Genotoxicity, cytotoxicity, immunotoxicity, neurotoxicity, reproductive toxicity, mechanisms of cell death, oxidative damage	20%	6
4	TOXICITY ASSESSMENT METHODS In-vitro and in-vivo testing models, cytotoxicity assays, imaging techniques, omics approaches, high-throughput screening	20%	6
5	ENVIRONMENTAL AND ECOTOXICOLOGY Fate and transport of nanomaterials, bioaccumulation and biomagnification, impact on aquatic and terrestrial ecosystems	17%	5
6	RISK ASSESSMENT AND REGULATION Risk assessment framework, exposure assessment, dose-response relationships, regulatory guidelines, ethical and societal aspects, safe-by-design approaches	13%	4

i. Text Book and Reference Book:

1. "Oberdörster et al.", Nanotoxicology: An Emerging Discipline, Academic Press
2. "Fadeel et al.", Handbook of Safety Assessment of Nanomaterials, CRC Press
3. "Nel et al.", Understanding Biophysicochemical Interactions at the Nano-Bio Interface, Springer
4. "Klaassen", Casarett and Doull's Toxicology, McGraw-Hill
5. "Ju-Nam & Lead", Manufactured Nanomaterials: An Overview of Their Chemistry, Interactions and Potential Environmental Impacts, Wiley

- a. **Course Name:** Spectroscopy Techniques for Nanomaterials
 b. **Course Code:** 03023701PE06
 c. **Prerequisite:** Basic knowledge of physics, chemistry, materials science, and nanotechnology fundamentals.
 d. **Rationale:** This course aims to provide fundamental and practical knowledge of spectroscopic techniques used for characterization of nanomaterials. The course focuses on principles, instrumentation, data interpretation, and applications of various spectroscopic methods to analyze structural, electronic, optical, and chemical properties of nanomaterials.

e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental principles of spectroscopy and interaction of electromagnetic radiation with nanomaterials.
CLOBJ 2	To develop understanding of spectroscopic techniques used for structural, electronic, vibrational, and chemical characterization of nanomaterials.
CLOBJ 3	To familiarize students with instrumentation, working principles, and data interpretation of major spectroscopic methods such as UV-Vis, FTIR, etc.
CLOBJ 4	To enable students to analyze spectroscopic data for evaluating composition, bonding, defects, and functional properties of nanomaterials.
CLOBJ 5	To develop the ability to select and apply appropriate spectroscopic techniques for advanced materials research and nanotechnology applications.

f. **Course Learning Outcomes:**

CLO 1	Explain fundamental principles of various spectroscopic techniques.
CLO 2	Analyze spectroscopic data for nanomaterial characterization.
CLO 3	Interpret electronic, vibrational, and chemical information from spectra.
CLO 4	Apply advanced spectroscopic methods for nanotechnology research.
CLO 5	Evaluate suitability of spectroscopic techniques for specific nanomaterials.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO SPECTROSCOPY AND NANOMATERIAL CHARACTERIZATION Electromagnetic radiation, interaction of radiation with matter, basic principles of spectroscopy, energy levels, selection rules, importance of spectroscopy in nanomaterials research	13%	4
2	UV-VISIBLE AND PHOTOLUMINESCENCE SPECTROSCOPY Principles of UV-Vis spectroscopy, electronic transitions, Beer-Lambert law, instrumentation, band gap estimation, photoluminescence spectroscopy, recombination mechanisms, applications to quantum dots and nanoparticles	20%	6
3	INFRARED AND RAMAN SPECTROSCOPY Vibrational spectroscopy principles, FTIR spectroscopy, molecular vibrations, group frequencies, Raman scattering, surface-enhanced Raman spectroscopy (SERS), applications to nanomaterials and functional groups	20%	6
4	X-RAY AND PHOTOELECTRON SPECTROSCOPY X-ray absorption and emission, X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), core-level binding energies, chemical state analysis	20%	6
5	NUCLEAR MAGNETIC RESONANCE AND ELECTRON PARAMAGNETIC RESONANCE Basic principles of NMR, chemical shift, spin-spin coupling, solid-state NMR, EPR spectroscopy, paramagnetic centers in nanomaterials	13%	4
6	ADVANCED AND EMERGING SPECTROSCOPIC TECHNIQUES Time-resolved spectroscopy, in-situ and operando spectroscopy, terahertz spectroscopy, synchrotron radiation techniques, applications in energy, catalysis, and biomedical nanomaterials	14%	4

i. Text Book and Reference Book:

1. "Hollas", Modern Spectroscopy, Wiley
2. "Banwell & McCash", Fundamentals of Molecular Spectroscopy, McGraw-Hill
3. "Skoog et al.", Principles of Instrumental Analysis, Cengage
4. "Brundle et al.", Surface Analysis by Auger and X-ray Photoelectron Spectroscopy, Wiley
5. "Ferraro et al.", Introductory Raman Spectroscopy, Academic Press

- a. **Course Name:** Research Methodology and 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. 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

h. 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, Research Questions, Research Methods vs. Research Methodology.	10%	4
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

i. Text Book and Reference Book:

1. "Kothari", Research Methodology: Methods and Techniques, New Age
2. "Montgomery", Design and Analysis of Experiments, Wiley
3. "Day & Gastel", How to Write and Publish a Scientific Paper, Cambridge
4. "Halbert", Intellectual Property in the New Technological Age, Aspen
5. "Government of India", The Patents Act, 1970 (as amended)
6. "WIPO", Intellectual Property Handbook

- a. **Course Name:** Environmental Nanotechnology
- b. **Course Code:** 03023701MC01
- c. **Prerequisite:** Basic knowledge of nanomaterials, environmental science, chemistry, and materials science.
- d. **Rationale:** This course aims to provide fundamental and applied knowledge of nanotechnology for environmental protection and sustainability. The course focuses on nanomaterials for water and air purification, pollution remediation, sensing, waste management, and sustainable development. It emphasizes structure–property–function relationships and environmental impact assessment of nanomaterials.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts and principles of environmental nanotechnology and sustainable development.
CLOBJ 2	To develop understanding of nanomaterials and nanostructures used for pollution control, environmental remediation, and resource recovery.
CLOBJ 3	To familiarize students with nanotechnology-based approaches for water treatment, air purification, soil remediation, and environmental monitoring.
CLOBJ 4	To enable students to analyze environmental impacts, ecotoxicity, and risk assessment associated with engineered nanomaterials.
CLOBJ 5	To develop the ability to apply nanotechnology solutions for sustainable environmental management and green engineering applications.

f. Course Learning Outcomes:

CLO 1	Explain principles of environmental nanotechnology.
CLO 2	Analyze nanomaterials for pollution control.
CLO 3	Apply nanotechnology for water and air purification.
CLO 4	Evaluate environmental impacts of nanomaterials.
CLO 5	Integrate sustainability and risk assessment concepts.

g. Teaching & Examination Scheme:

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

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	INTRODUCTION TO ENVIRONMENTAL NANOTECHNOLOGY Concept and scope of environmental nanotechnology, classification of nanomaterials, nanoscale phenomena, environmental challenges, sustainability and green nanotechnology	13%	4
2	NANOMATERIALS FOR WATER TREATMENT Nanoadsorbents, carbon nanomaterials, metal oxide nanoparticles, membranes and nanofiltration, desalination, removal of heavy metals and organic pollutants	20%	6
3	NANOTECHNOLOGY FOR AIR AND SOIL REMEDIATION Nanocatalysts for air purification, photocatalysis, soil remediation, magnetic nanoparticles, nanobioremediation	17%	5
4	NANOSENSORS FOR ENVIRONMENTAL MONITORING Principles of nanosensors, gas and chemical sensors, biosensors, real-time monitoring, IoT integration	13%	4
5	WASTE MANAGEMENT AND RESOURCE RECOVERY Nanomaterials for waste treatment, recycling, recovery of valuable resources, circular economy	17%	5
6	ENVIRONMENTAL IMPACT AND RISK ASSESSMENT Fate and transport of nanomaterials, ecotoxicity, life-cycle assessment, regulatory frameworks, ethical and societal aspects	20%	6

i. Text Book and Reference Book:

1. "Diallo et al.", Nanotechnology for Sustainable Development, Springer
2. "Sharma et al.", Nanotechnology for Water Treatment, Elsevier
3. "Bhushan", Springer Handbook of Nanotechnology, Springer
4. "Quina", Nanotechnology in Environmental Science, Wiley
5. "Oberdörster et al.", Nanotoxicology, Academic Press

- a. **Course Name:** Industrial Safety
- b. **Course Code:** 03023701MC01
- c. **Prerequisite:** Basic knowledge of engineering operations, materials handling, and workplace practices.
- d. **Rationale:** This course aims to impart knowledge of industrial safety principles, hazard identification, risk assessment, and accident prevention techniques. The course focuses on safety management systems, statutory regulations, occupational health, and safe operation of industrial equipment to ensure a safe and healthy working environment.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, principles, and importance of industrial safety in engineering environments.
CLOBJ 2	To develop understanding of hazard identification, risk assessment, and accident prevention techniques for industrial operations.
CLOBJ 3	To familiarize students with occupational health practices, safety regulations, emergency preparedness, and safety management systems.
CLOBJ 4	To enable students to analyze mechanical, electrical, chemical, and environmental hazards associated with industrial processes.
CLOBJ 5	To develop awareness regarding legal, ethical, and sustainable safety practices for maintaining safe and healthy workplaces.

f. Course Learning Outcomes:

CLO 1	Explain the principles and importance of industrial safety.
CLO 2	Identify workplace hazards and assess risks.
CLO 3	Apply hazard control and accident prevention methods.
CLO 4	Implement safety management systems.
CLO 5	Comply with legal and environmental safety regulations.

g. Teaching & Examination Scheme:

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

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	INTRODUCTION TO INDUSTRIAL SAFETY Need for safety, accident causation theories, safety organization, safety culture, role of safety officer, statutory provisions	13%	4
2	HAZARD IDENTIFICATION AND RISK ASSESSMENT Types of hazards, HIRA, job safety analysis, hazard control methods, safety audits	20%	6
3	INDUSTRIAL HAZARDS AND CONTROL Mechanical hazards, electrical hazards, chemical hazards, fire and explosion hazards, radiation hazards	23%	7
4	OCCUPATIONAL HEALTH AND HYGIENE Industrial diseases, ergonomics, ventilation, noise and vibration, thermal environment	17%	5
5	SAFETY MANAGEMENT SYSTEMS Safety policy, safety training, permit to work system, emergency preparedness, disaster management	17%	5
6	ENVIRONMENTAL AND LEGAL ASPECTS OF SAFETY Factories Act, environmental regulations, safety standards, ethics and social responsibility	10%	3

i. Text Book and Reference Book:

1. "L.M. Deshmukh", Industrial Safety Management, Tata McGraw-Hill
2. "Grimaldi & Simonds", Safety Management, AITBS
3. "Goetsch", Occupational Safety and Health, Pearson
4. "Brauer", Safety and Health for Engineers, Wiley
5. Factories Act, 1948 (as amended)

- a. **Course Name:** Value Education
- b. **Course Code:** 03020001MC02
- c. **Prerequisite:** No specific prerequisite.
- d. **Rationale:** This course aims to inculcate moral, ethical, and social values among students to develop responsible professionals and citizens. The course focuses on personal integrity, social responsibility, professional ethics, human values, and sustainable development to prepare students for ethical decision-making in personal and professional life.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental human values, ethical principles, and moral responsibilities essential for personal and professional development.
CLOBJ 2	To develop understanding of social responsibility, integrity, empathy, and respect for diversity in individual and societal contexts.
CLOBJ 3	To familiarize students with professional ethics, leadership qualities, teamwork, and decision-making practices.
CLOBJ 4	To enable students to apply value-based approaches for resolving ethical dilemmas and promoting sustainable and responsible behavior.
CLOBJ 5	To develop life skills, emotional well-being, and positive attitudes for becoming responsible professionals and citizens.

f. Course Learning Outcomes:

CLO 1	Understand the importance of human values.
CLO 2	Apply ethical principles in decision making.
CLO 3	Demonstrate social responsibility.
CLO 4	Develop leadership and teamwork skills.
CLO 5	Practice life skills for personal well-being.

g. Teaching & Examination Scheme:

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

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	INTRODUCTION TO HUMAN VALUES Meaning and importance of values, types of values, value education and its relevance, self-awareness and personal development	17%	5
2	ETHICS AND MORAL DEVELOPMENT Ethics and morality, moral reasoning, ethical theories, professional ethics	20%	6
3	SOCIAL RESPONSIBILITY Social justice, equality, gender sensitivity, environmental ethics, sustainability	20%	6
4	LEADERSHIP AND TEAMWORK Leadership qualities, emotional intelligence, teamwork, conflict resolution	17%	5
5	CITIZENSHIP AND NATIONAL INTEGRATION Rights and duties, national values, cultural heritage, unity in diversity	13%	4
6	LIFE SKILLS AND PERSONAL WELL-BEING Stress management, time management, decision making, work-life balance	13%	4

i. Text Book and Reference Book:

1. "Chakraborty", Values and Ethics for Organizations, Oxford
2. "Gandhi", My Experiments with Truth
3. "Radhakrishnan", Indian Philosophy
4. "Velasquez", Business Ethics, Pearson
5. "UNESCO", Learning to Be

Semester 2

- a. **Course Name:** Surface Engineering for Nanotechnology
- b. **Course Code:** 03023702PC01
- c. **Prerequisite:** Basic knowledge of materials science, surface chemistry, and nanotechnology fundamentals.
- d. **Rationale:** This course aims to provide comprehensive understanding of surface engineering principles and techniques with emphasis on nanoscale surface modification and functionalization. The course focuses on thin films, coatings, surface treatments, characterization methods, and applications of engineered surfaces in nanotechnology, electronics, energy, and biomedical fields.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts of surface engineering, surface phenomena, and nanoscale interfacial behavior of materials.
CLOBJ 2	To develop understanding of thin film deposition, coating technologies, and surface modification techniques used in nanotechnology applications.
CLOBJ 3	To familiarize students with nanostructured coatings, surface functionalization methods, and advanced characterization techniques for engineered surfaces.
CLOBJ 4	To enable students to analyze structure–property relationships governing wear resistance, corrosion resistance, adhesion, and functional performance of surfaces.
CLOBJ 5	To develop the ability to apply surface engineering principles for advanced applications in nanoelectronics, energy systems, biomedical devices, and protective coatings.

f. Course Learning Outcomes:

CLO 1	Explain principles of surface engineering and nanoscale surface phenomena.
CLO 2	Analyze thin film and coating deposition techniques.
CLO 3	Apply surface modification methods for functional enhancement.
CLO 4	Characterize engineered surfaces using modern tools.
CLO 5	Evaluate applications of surface engineering in nanotechnology.

g. 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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO SURFACE ENGINEERING Surface properties, surface energy, adhesion, wettability, tribology basics, role of surfaces in materials performance, nanoscale surface phenomena	17%	5
2	THIN FILMS AND COATING TECHNOLOGIES Physical vapor deposition (PVD), chemical vapor deposition (CVD), atomic layer deposition (ALD), sputtering, evaporation, sol-gel coatings	23%	7
3	SURFACE MODIFICATION TECHNIQUES Ion implantation, plasma treatment, laser surface engineering, electron beam processing, surface alloying	17%	5
4	NANOSTRUCTURED AND FUNCTIONAL COATINGS Nanocomposite coatings, hard coatings, DLC, hydrophobic and superhydrophobic surfaces, bioactive coatings	17%	5
5	SURFACE CHARACTERIZATION TECHNIQUES AFM, SEM, XPS, FTIR, Raman spectroscopy, contact angle measurements, nanoindentation	13%	4
	APPLICATIONS IN NANOTECHNOLOGY Nanoelectronics, energy devices, sensors, biomedical implants, corrosion and wear protection	13%	4

i. Text Book and Reference Book:

1. "Peter Martin", Introduction to Surface Engineering and Functionally Engineered Materials, Wiley
2. "Mattox", Handbook of Physical Vapor Deposition, Elsevier
3. "Ohring", Materials Science of Thin Films, Academic Press
4. "Bhushan", Springer Handbook of Nanotechnology, Springer
5. "Poole & Owens", Introduction to Nanotechnology, Wiley

- a. **Course Name:** Surface Engineering for Nanotechnology Lab
- b. **Course Code:** 03023702PC02
- c. **Prerequisite:** Basic knowledge of materials science, thin films, surface chemistry, and laboratory safety.
- d. **Rationale:** This laboratory course aims to provide hands-on training in surface engineering techniques and nanoscale surface modification methods. The course focuses on thin film deposition, surface treatments, characterization techniques, and performance evaluation of engineered surfaces for applications in nanotechnology, electronics, energy, and biomedical fields.

e. Course Learning Objective:

CLOBJ 1	To provide hands-on experience in thin film deposition, surface modification, and coating techniques used in nanotechnology applications.
CLOBJ 2	To develop practical understanding of processing–structure–property relationships of engineered surfaces and nanostructured coatings.
CLOBJ 3	To familiarize students with modern surface characterization techniques such as SEM, AFM, FTIR, etc.
CLOBJ 4	To enable students to evaluate mechanical, tribological, corrosion, and functional performance of coated and surface-engineered materials.
CLOBJ 5	To develop skills in experimental analysis, interpretation of surface characterization data, and technical reporting for advanced surface engineering applications.

f. Course Learning Outcomes:

CLO 1	Perform thin film deposition and surface modification using standard techniques.
CLO 2	Characterize engineered surfaces using modern analytical tools.
CLO 3	Evaluate mechanical, tribological, and corrosion performance of coatings.
CLO 4	Analyze processing–structure–property relationships for surfaces.
CLO 5	Prepare technical reports and interpret experimental results.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Text Book and Reference Book:

1. "Peter Martin", Introduction to Surface Engineering and Functionally Engineered Materials, Wiley
2. "Mattox", Handbook of Physical Vapor Deposition, Elsevier
3. "Ohring", Materials Science of Thin Films, Academic Press
4. "Bhushan", Springer Handbook of Nanotechnology, Springer
5. "Goldstein et al.", Scanning Electron Microscopy and X-Ray Microanalysis, Springer

- a. **Course Name:** Materials Characterization Techniques
- b. **Course Code:** 03023702PC03
- c. **Prerequisite:** Basic knowledge of materials science, crystallography, and solid-state physics.
- d. **Rationale:** This course aims to provide comprehensive understanding of modern characterization techniques used for analyzing structure, microstructure, composition, and properties of materials and nanomaterials. The course focuses on principles, instrumentation, data interpretation, and applications of major characterization tools in research and industry.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental principles and significance of materials characterization in advanced engineering and nanotechnology applications.
CLOBJ 2	To develop understanding of diffraction, microscopy, spectroscopy, thermal, and mechanical characterization techniques used for material analysis.
CLOBJ 3	To familiarize students with instrumentation, working principles, sample preparation, and data interpretation of modern characterization tools.
CLOBJ 4	To enable students to analyze structure, microstructure, composition, defects, and properties of materials and nanomaterials using characterization techniques.
CLOBJ 5	To develop the ability to select appropriate characterization methods for evaluating processing–structure–property relationships in advanced materials research.

f. **Course Learning Outcomes:**

CLO 1	Explain principles of major materials characterization techniques.
CLO 2	Analyze microstructure and phase composition of materials.
CLO 3	Interpret diffraction, microscopy, and spectroscopy data.
CLO 4	Apply characterization tools for nanomaterials research.
CLO 5	Evaluate suitability of techniques for specific material systems.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO MATERIALS CHARACTERIZATION Need and scope of characterization, length scales in materials, overview of characterization techniques, resolution and contrast, sample preparation methods	11%	5
2	X-RAY DIFFRACTION TECHNIQUES Bragg's law, crystal structures, powder XRD, phase identification, lattice parameter determination, crystallite size and strain, Rietveld refinement	22%	10
3	ELECTRON MICROSCOPY SEM principles, electron-matter interactions, imaging modes, EDS analysis, TEM principles, diffraction, high-resolution TEM, sample preparation for TEM	22%	10
4	SCANNING PROBE MICROSCOPY AFM and STM principles, imaging modes, force-distance curves, surface roughness, nanomechanical properties	13%	6
5	SPECTROSCOPIC TECHNIQUES FTIR, Raman spectroscopy, UV-Vis spectroscopy, XPS, AES, elemental and chemical state analysis	18%	8
6	THERMAL, MECHANICAL AND MAGNETIC CHARACTERIZATION DSC, TGA, DMA, hardness and nanoindentation, tensile testing, magnetic measurements (VSM, SQUID)	14%	6

i. Text Book and Reference Book:

1. "Cullity & Stock", Elements of X-Ray Diffraction, Pearson
2. "Goldstein et al.", Scanning Electron Microscopy and X-Ray Microanalysis, Springer
3. "Ohring", Materials Science of Thin Films, Academic Press
4. "Bhushan", Springer Handbook of Nanotechnology, Springer
5. "Smith", Scanning Electron Microscopy, McGraw-Hill

- a. **Course Name:** Materials Characterization Techniques Lab
 b. **Course Code:** 03023702PC04
 c. **Prerequisite:** Basic knowledge of materials science, crystallography, and laboratory safety.
 d. **Rationale:** This laboratory course aims to provide hands-on training in modern materials characterization techniques used to analyze structure, microstructure, composition, and properties of materials and nanomaterials. The course focuses on practical operation of instruments, data acquisition, interpretation, and report preparation.

e. **Course Learning Objective:**

CLOBJ 1	To provide hands-on experience in operating modern materials characterization instruments for analysis of materials and nanomaterials.
CLOBJ 2	To develop practical understanding of diffraction, microscopy, spectroscopy, thermal, and mechanical characterization techniques.
CLOBJ 3	To familiarize students with sample preparation methods, experimental procedures, data acquisition, and interpretation of characterization results.
CLOBJ 4	To enable students to evaluate microstructure, phase composition, surface morphology, thermal behavior, and functional properties of materials.
CLOBJ 5	To develop skills in experimental analysis, technical reporting, and selection of appropriate characterization techniques for advanced materials research and engineering applications.

f. **Course Learning Outcomes:**

CLO 1	Operate major materials characterization instruments.
CLO 2	Analyze microstructure, phase, and composition of materials.
CLO 3	Interpret microscopy, diffraction, and spectroscopy data.
CLO 4	Evaluate properties of nanomaterials using characterization tools.
CLO 5	Prepare technical reports and experimental documentation.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Text Book and Reference Book:

1. "Cullity & Stock", Elements of X-Ray Diffraction, Pearson
2. "Goldstein et al.", Scanning Electron Microscopy and X-Ray Microanalysis, Springer
3. "Bhushan", Springer Handbook of Nanotechnology, Springer
4. "Smith", Scanning Electron Microscopy, McGraw-Hill
5. "Stuart", Infrared Spectroscopy: Fundamentals and Applications, Wiley

- a. **Course Name:** Nanocomposites
- b. **Course Code:** 03023702PC05
- c. **Prerequisite:** Basic knowledge of materials science, polymers, ceramics, and nanotechnology fundamentals.
- d. **Rationale:** This course aims to provide comprehensive understanding of nanocomposite materials, including their synthesis, structure, properties, characterization, and applications. The course focuses on polymer, metal, and ceramic matrix nanocomposites, interfacial phenomena, processing techniques, and performance enhancement for advanced engineering and nanotechnology applications.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, classification, and significance of nanocomposite materials in advanced engineering applications.
CLOBJ 2	To develop understanding of structure–property relationships and interfacial phenomena governing the behavior of nanocomposites.
CLOBJ 3	To familiarize students with synthesis, processing, fabrication, and characterization techniques used for polymer, metal, and ceramic matrix nanocomposites.
CLOBJ 4	To enable students to analyze mechanical, thermal, electrical, tribological, and functional performance of nanocomposite materials.
CLOBJ 5	To develop the ability to evaluate and apply nanocomposites for aerospace, energy, biomedical, electronic, and sustainable engineering applications.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals and classification of nanocomposites.
CLO 2	Analyze role of nanofillers and interfaces in property enhancement.
CLO 3	Apply processing techniques for nanocomposite fabrication.
CLO 4	Characterize structure and properties of nanocomposites.
CLO 5	Evaluate applications and emerging trends in nanocomposites.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO NANOCOMPOSITES Definition and classification of nanocomposites, advantages over conventional composites, role of nanoscale reinforcements, structure–property relationships, applications	13%	4
2	TYPES OF NANOCOMPOSITES Polymer matrix nanocomposites, metal matrix nanocomposites, ceramic matrix nanocomposites, carbon-based nanocomposites	20%	6
3	NANOFILLERS AND INTERFACES Carbon nanotubes, graphene, nanoclays, metal and oxide nanoparticles, dispersion techniques, interfacial bonding, surface functionalization	23%	7
4	PROCESSING TECHNIQUES Solution mixing, melt blending, in-situ polymerization, powder metallurgy routes, sol–gel processing, additive manufacturing of nanocomposites	17%	5
5	CHARACTERIZATION OF NANOCOMPOSITES XRD, SEM, TEM, AFM, FTIR, Raman spectroscopy, thermal and mechanical testing, electrical and barrier properties	13%	4
6	APPLICATIONS AND EMERGING TRENDS Structural and functional applications, energy storage, sensors, biomedical devices, sustainable nanocomposites, future prospects	14%	4

i. Text Book and Reference Book:

1. “Ajayan, Schadler, Braun”, Nanocomposite Science and Technology, Wiley
2. “Paul & Robeson”, Polymer Nanocomposites, Polymer
3. “Chung”, Carbon Fiber Composites, Butterworth-Heinemann
4. “Boudenne”, Polymer Nanocomposites for Industrial Applications, CRC Press
5. “Bhushan”, Springer Handbook of Nanotechnology, Springer

- a. **Course Name:** Nanosensors and Devices
- b. **Course Code:** 03023702PE01
- c. **Prerequisite:** Basic electronics, materials science, nanotechnology fundamentals.
- d. **Rationale:** This course introduces principles, fabrication, characterization, and applications of nanosensors and nano-devices for sensing, electronics, biomedical, and environmental systems.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts and operating principles of nanosensors and nano-enabled devices.
CLOBJ 2	To develop understanding of nanoscale phenomena, transduction mechanisms, and material properties governing sensor performance.
CLOBJ 3	To familiarize students with fabrication, characterization, and integration techniques used in nanosensors and nanoelectronic devices.
CLOBJ 4	To enable students to analyze applications of nanosensors in biomedical, environmental, energy, industrial, and communication systems.
CLOBJ 5	To develop the ability to design and evaluate advanced nanosensor systems and nano-devices for emerging technological applications.

f. Course Learning Outcomes:

CLO 1	Explain working principles of nanosensors.
CLO 2	Analyze nanomaterials for sensing applications.
CLO 3	Design nano-device architectures.
CLO 4	Evaluate sensor performance parameters.
CLO 5	Apply nanosensors in real-world systems.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	FUNDAMENTALS OF NANOSENSORS Sensor basics, transduction mechanisms, scaling effects, sensitivity and selectivity	13%	4
2	NANOMATERIALS FOR SENSING CNTs, graphene, nanoparticles, nanowires, functionalization	17%	5
3	FABRICATION TECHNIQUES Lithography, thin film deposition, self-assembly, micro/nano-fabrication	17%	5
4	ELECTRICAL AND OPTICAL NANOSENSORS Gas sensors, biosensors, optical sensors, plasmonic sensors	23%	7
5	INTEGRATION AND DEVICE DESIGN MEMS/NEMS, packaging, signal conditioning, reliability	17%	5

i. Text Book and Reference Book:

1. "Bhushan", Springer Handbook of Nanotechnology, Springer
2. "Rogers et al.", Nanoscale Sensors, Wiley
3. "Cui", Nanowire Biosensors, Springer
4. "Wilson & Hawkes", Biosensors: An Introduction, Oxford University Press.
5. "Campbell, S. A.", Fabrication Engineering at the Micro- and Nanoscale, Oxford University Press.

- a. **Course Name:** Carbon Nanotechnology
- b. **Course Code:** 03023702PE02
- c. **Prerequisite:** Basic knowledge of materials science, solid state physics, and nanotechnology fundamentals.
- d. **Rationale:** This course aims to provide comprehensive understanding of carbon-based nanomaterials including their synthesis, structure, properties, characterization, and applications. The course focuses on fullerenes, carbon nanotubes, graphene, and other emerging carbon nanostructures for advanced engineering and nanotechnology applications.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts, classification, and unique properties of carbon-based nanomaterials.
CLOBJ 2	To develop understanding of the structure–property relationships of fullerenes, carbon nanotubes, graphene, and other carbon nanostructures.
CLOBJ 3	To familiarize students with synthesis, processing, functionalization, and characterization techniques used for carbon nanomaterials.
CLOBJ 4	To enable students to analyze mechanical, electrical, thermal, optical, and tribological behavior of carbon nanomaterials for advanced applications.
CLOBJ 5	To develop the ability to apply carbon nanotechnology in nanoelectronics, energy storage, sensors, composites, biomedical systems, and sustainable technologies.

f. **Course Learning Outcomes:**

CLO 1	Explain fundamentals and classification of carbon nanomaterials.
CLO 2	Analyze synthesis and processing techniques.
CLO 3	Characterize structure and properties of carbon nanomaterials.
CLO 4	Apply carbon nanomaterials in advanced technologies.
CLO 5	Evaluate emerging trends in carbon nanotechnology.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO CARBON NANOMATERIALS Allotropes of carbon, historical development, classification of carbon nanomaterials, nanoscale phenomena, structure–property relationships	13%	4
2	FULLERENES AND CARBON NANOTUBES Structure and properties of fullerenes, synthesis methods, single-walled and multi-walled carbon nanotubes, growth mechanisms	23%	7
3	GRAPHENE AND 2D CARBON MATERIALS Structure and properties of graphene, synthesis methods, electronic and mechanical properties, graphene derivatives	20%	6
4	SYNTHESIS AND PROCESSING TECHNIQUES Arc discharge, laser ablation, chemical vapor deposition (CVD), exfoliation methods, purification and functionalization	17%	5
5	CHARACTERIZATION TECHNIQUES SEM, TEM, AFM, Raman spectroscopy, XRD, XPS, optical spectroscopy	13%	4
6	APPLICATIONS AND EMERGING TRENDS Nanoelectronics, energy storage, sensors, composites, biomedical applications, future prospects	14%	4

i. Text Book and Reference Book:

1. “Dresselhaus et al.”, Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Springer
2. “Saito et al.”, Physical Properties of Carbon Nanotubes, Imperial College Press
3. “Geim & Novoselov”, Graphene, Nature
4. “Bhushan”, Springer Handbook of Nanotechnology, Springer
5. “Poole & Owens”, Introduction to Nanotechnology, Wiley

- a. **Course Name:** Interfaces and Adhesion in Materials
- b. **Course Code:** 03023702PE03
- c. **Prerequisite:** Basic knowledge of materials science, surface chemistry, and solid mechanics.
- d. **Rationale:** This course aims to provide in-depth understanding of interfaces and adhesion phenomena in materials. The course focuses on surface and interfacial thermodynamics, adhesion mechanisms, interfacial characterization, and applications of adhesion science in coatings, composites, microelectronics, and nanotechnology.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts of interfaces, surface phenomena, and adhesion in engineering materials.
CLOBJ 2	To develop understanding of surface and interfacial thermodynamics, wetting behavior, and mechanisms governing adhesion between materials.
CLOBJ 3	To familiarize students with interfacial characterization techniques, adhesion testing methods, and failure analysis approaches.
CLOBJ 4	To enable students to analyze the role of interfaces and adhesion in coatings, composites, thin films, microelectronics, and nanotechnology applications.
CLOBJ 5	To develop the ability to apply surface engineering and adhesion principles for improving durability, reliability, and functional performance of material systems.

f. Course Learning Outcomes:

CLO 1	Explain principles of interfaces and adhesion.
CLO 2	Analyze surface and interfacial thermodynamics.
CLO 3	Apply adhesion mechanisms in materials systems.
CLO 4	Characterize and test adhesion strength.
CLO 5	Evaluate applications of adhesion science in nanotechnology.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No	Content	Weightage	Teaching Hours
1	INTRODUCTION TO INTERFACES AND ADHESION Definition and importance of interfaces, types of interfaces, surface energy, work of adhesion, wetting and contact angle, relevance in materials engineering and nanotechnology	17%	5
2	SURFACE AND INTERFACIAL THERMODYNAMICS Gibbs free energy, surface tension, adsorption, Young's equation, Dupré equation, capillarity	20%	6
3	MECHANISMS OF ADHESION Mechanical interlocking, adsorption theory, diffusion theory, electrostatic theory, chemical bonding	17%	5
4	INTERFACIAL STRUCTURE AND CHARACTERIZATION Grain boundaries, phase boundaries, interfacial defects, AFM, SEM, TEM, XPS, contact angle measurement	17%	5
5	ADHESION TESTING AND FAILURE MECHANISMS Peel test, lap shear test, scratch test, fracture mechanics of interfaces, cohesive and adhesive failure	17%	5
6	APPLICATIONS AND EMERGING TRENDS Coatings and thin films, composites, microelectronics packaging, biomedical adhesives, nano-interfaces	12%	4

i. Text Book and Reference Book:

1. "Kinloch", Adhesion and Adhesives: Science and Technology, Springer
2. "Mittal", Adhesion Measurement of Films and Coatings, CRC Press
3. "Israelachvili", Intermolecular and Surface Forces, Academic Press
4. "Bhushan", Springer Handbook of Nanotechnology, Springer
5. "Mattox", Handbook of Physical Vapor Deposition, Elsevier

- a. **Course Name:** MEMS and NEMS
- b. **Course Code:** 03023702PE04
- c. **Prerequisite:** Basic knowledge of solid state physics, electronics, materials science, and nanotechnology fundamentals.
- d. **Rationale:** This course aims to provide comprehensive understanding of microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS). The course focuses on design principles, fabrication techniques, materials, characterization, and applications of MEMS and NEMS in sensors, actuators, biomedical devices, and nanoelectronics.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, principles, and applications of Microelectromechanical Systems (MEMS) and Nanoelectromechanical Systems (NEMS).
CLOBJ 2	To develop understanding of materials, fabrication techniques, and scaling effects involved in MEMS and NEMS device manufacturing.
CLOBJ 3	To familiarize students with design, modeling, characterization, and packaging of microscale and nanoscale devices.
CLOBJ 4	To enable students to analyze the operation and performance of MEMS/NEMS-based sensors, actuators, resonators, and biomedical devices.
CLOBJ 5	To develop the ability to apply MEMS and NEMS technologies in nanoelectronics, healthcare, energy systems, communication, and smart sensing applications.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals of MEMS and NEMS.
CLO 2	Analyze fabrication and modeling techniques.
CLO 3	Design basic MEMS/NEMS devices.
CLO 4	Characterize and package MEMS/NEMS systems.
CLO 5	Evaluate applications and emerging trends.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No	Content	Weightage	Teaching Hours
1	INTRODUCTION TO MEMS AND NEMS Overview and historical development, scaling laws, differences between MEMS and NEMS, applications and market trends	13%	4
2	MATERIALS FOR MEMS/NEMS Silicon and compound semiconductors, polymers, metals, piezoelectric materials, smart materials	17%	5
3	MICRO/NANO FABRICATION TECHNIQUES Photolithography, etching, thin film deposition, bulk and surface micromachining, nanofabrication techniques	20%	6
4	DESIGN AND MODELING OF MEMS/NEMS Mechanical and electrical modeling, resonators, sensors and actuators, CAD tools	23%	7
5	CHARACTERIZATION AND PACKAGING Mechanical testing, electrical characterization, reliability, packaging techniques	13%	4
6	APPLICATIONS AND EMERGING TRENDS Biomedical MEMS, RF MEMS, energy harvesting, lab-on-chip, quantum NEMS	14%	4

i. Text Book and Reference Book:

1. "Madou", Fundamentals of Microfabrication and Nanotechnology, CRC Press
2. "Gad-el-Hak", MEMS: Design and Fabrication, CRC Press
3. "Senturia", Microsystem Design, Kluwer
4. "Bhushan", Springer Handbook of Nanotechnology, Springer
5. "Maluf", An Introduction to Microelectromechanical Systems Engineering, Artech House

- a. **Course Name:** Metals, Alloys and Composite Materials
- b. **Course Code:** 03023702PE05
- c. **Prerequisite:** Basic knowledge of materials science, physical metallurgy, and mechanical behavior of materials.
- d. **Rationale:** This course aims to provide comprehensive understanding of metallic materials, alloys, and composite materials. The course focuses on structure–property–processing relationships, phase diagrams, strengthening mechanisms, fabrication techniques, characterization, and applications of metals, alloys, and composites in advanced engineering and nanotechnology.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, classification, and properties of metals, alloys, and composite materials used in engineering applications.
CLOBJ 2	To develop understanding of structure–property–processing relationships governing the behavior and performance of metallic and composite material systems.
CLOBJ 3	To familiarize students with fabrication techniques for metals and composites.
CLOBJ 4	To enable students to analyze mechanical, thermal, and functional properties of alloys and composite materials for advanced engineering applications.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals of metals and alloys.
CLO 2	Interpret phase diagrams and heat treatment processes.
CLO 3	Analyze mechanical behavior and strengthening mechanisms.
CLO 4	Describe composite materials and fabrication techniques.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO METALS AND ALLOYS Crystal structures of metals, metallic bonding, defects, solid solutions, alloying principles, classification of alloys	17%	5
2	PHASE DIAGRAMS AND HEAT TREATMENT Unary and binary phase diagrams, lever rule, eutectic and peritectic systems, iron-carbon diagram, heat treatment processes	23%	7
3	MECHANICAL BEHAVIOR AND STRENGTHENING MECHANISMS Elastic and plastic deformation, dislocations, work hardening, solid solution strengthening, precipitation hardening	20%	6
4	INTRODUCTION TO COMPOSITE MATERIALS Definition and classification of composites, matrix and reinforcement materials, load transfer mechanisms	13%	4
5	TYPES AND FABRICATION OF COMPOSITES Polymer matrix, metal matrix and ceramic matrix composites, fabrication techniques, processing challenges	13%	4
6	CHARACTERIZATION AND APPLICATIONS Mechanical testing, microstructural analysis, NDT techniques, applications in aerospace, automotive, energy, and nanotechnology	14%	4

i. Text Book and Reference Book:

1. "Callister & Rethwisch", Materials Science and Engineering: An Introduction, Wiley
2. "Dieter ", Mechanical Metallurgy, McGraw-Hill
3. "Hull & Clyne", An Introduction to Composite Materials, Cambridge
4. "Chung", Composite Materials: Science and Engineering, Springer
5. "Reed-Hill & Abbaschian", Physical Metallurgy Principles, Cengage

- a. **Course Name:** Energy Materials
- b. **Course Code:** 03023702PE06
- c. **Prerequisite:** Basic knowledge of materials science, solid state physics, and electrochemistry.
- d. **Rationale:** This course aims to provide comprehensive understanding of materials used for energy generation, storage, and conversion. The course focuses on photovoltaic materials, battery materials, fuel cell materials, supercapacitors, thermoelectric materials, and hydrogen storage materials with emphasis on structure–property–performance relationships and sustainability.
- e. **Course Learning Objective:**

CLOBJ 1	To introduce fundamental concepts and significance of materials used for energy generation, storage, and conversion systems.
CLOBJ 2	To develop understanding of structure–property–performance relationships of photovoltaic, battery, fuel cell, supercapacitor, thermoelectric, and hydrogen storage materials.
CLOBJ 3	To familiarize students with synthesis, processing, characterization, and performance evaluation techniques for advanced energy materials.
CLOBJ 4	To enable students to analyze efficiency, durability, sustainability, and environmental aspects of energy material systems.
CLOBJ 5	To develop the ability to select and apply suitable energy materials for renewable energy technologies, energy storage devices, and sustainable engineering applications.

f. **Course Learning Outcomes:**

CLO 1	Explain fundamentals of energy materials.
CLO 2	Analyze photovoltaic and battery materials.
CLO 3	Apply materials selection for energy storage and conversion.
CLO 4	Evaluate performance and sustainability of energy materials.
CLO 5	Assess emerging trends in energy technologies.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				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

h. Course Content:

Sr. No	Content	Weightage	Teaching Hours
1	INTRODUCTION TO ENERGY MATERIALS Energy scenario, renewable and non-renewable energy sources, role of materials in energy technologies, sustainability and life-cycle assessment	13%	4
2	PHOTOVOLTAIC MATERIALS Silicon solar cells, thin film photovoltaics, perovskite solar cells, organic photovoltaics, efficiency limits	23%	7
3	ELECTROCHEMICAL ENERGY STORAGE MATERIALS Lithium-ion batteries, sodium-ion batteries, solid-state batteries, electrode and electrolyte materials	27%	8
4	FUEL CELL AND HYDROGEN STORAGE MATERIALS Proton exchange membrane fuel cells, solid oxide fuel cells, catalysts, hydrogen storage materials	20%	6
5	EMERGING ENERGY MATERIALS AND APPLICATIONS Wearable energy devices, recycling of energy materials, future trends	17%	5

i. Text Book and Reference Book:

1. "Linden & Reddy", Handbook of Batteries, McGraw-Hill
2. "Green", Solar Cells: Operating Principles, Technology, and System Applications, Prentice Hall
3. "Winter & Brodd", What Are Batteries, Chem. Rev.
4. "Zhang", Thermoelectrics Handbook, CRC Press
5. "Bruce et al.", Energy Storage Materials, Springer

- a. **Course Name:** Operations Research
- b. **Course Code:** 03022102UE01
- c. **Prerequisite:** Basic knowledge of engineering mathematics, linear algebra, probability, and statistics.
- d. **Rationale:** This course aims to provide students with fundamental concepts and techniques of Operations Research (OR) for effective decision-making in engineering and management. The course focuses on mathematical modeling, optimization techniques, and analytical methods for solving real-world problems in production, logistics, resource allocation, and systems planning.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, principles, and applications of Operations Research for engineering and managerial decision-making.
CLOBJ 2	To develop understanding of mathematical modeling and optimization techniques for solving complex engineering and resource allocation problems.
CLOBJ 3	To familiarize students with linear programming, transportation, assignment, network, inventory, and queuing models.
CLOBJ 4	To enable students to analyze and optimize production, logistics, scheduling, and project management systems using Operations Research techniques.
CLOBJ 5	To develop analytical and problem-solving skills for applying Operations Research methods in industrial, engineering, and management applications.

f. Course Learning Outcomes:

CLO 1	Explain fundamental concepts of Operations Research.
CLO 2	Formulate and solve linear programming problems.
CLO 3	Apply transportation, assignment, and network models.
CLO 4	Analyze inventory and queuing systems.
CLO 5	Use OR techniques for engineering decision-making.

g. 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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO OPERATIONS RESEARCH Definition, scope and applications of OR, OR methodology, modeling and problem formulation, engineering and management decision-making	10%	6
2	LINEAR PROGRAMMING Formulation of linear programming problems, graphical method, simplex method, dual simplex method, sensitivity analysis	27%	16
3	TRANSPORTATION AND ASSIGNMENT MODELS Transportation problem, initial feasible solutions, optimality tests, assignment problem, Hungarian method	17%	10
4	NETWORK MODELS Shortest path problem, minimum spanning tree, maximum flow problem, project scheduling using CPM and PERT	17%	10
5	INVENTORY MODELS Deterministic and probabilistic inventory models, EOQ, quantity discount models, production inventory models	15%	9
6	QUEUING THEORY AND DECISION MODELS Elements of queuing systems, M/M/1 and M/M/s models, decision theory, replacement models, game theory (basics)	14%	9

i. Text Book and Reference Book:

1. "Hillier & Lieberman", Introduction to Operations Research, McGraw-Hill
2. "Taha", Operations Research: An Introduction, Pearson
3. "Kanti Swarup et al.", Operations Research, Sultan Chand
4. "Sharma", Operations Research: Theory and Applications, Macmillan
5. "Hamdy Taha", Operations Research: An Introduction, Pearson

- a. **Course Name:** Design of Experiments
- b. **Course Code:** 03023702UE01
- c. **Prerequisite:** Students should have a basic understanding of statistics and probability, along with fundamental knowledge of engineering design and manufacturing processes. Familiarity with CAD/CAM systems and data analysis tools like Excel or MATLAB will be helpful to grasp the course concepts effectively.
- d. **Rationale:** Design of Experiments (DOE) provides a systematic approach to planning and analyzing experiments, enabling engineers to optimize manufacturing processes and improve product quality. In the context of CAD/CAM, DOE helps in identifying critical process parameters and achieving robust designs with fewer trials. This course prepares students to apply statistical methods for data-driven decision-making, fostering innovation and aligning with modern interdisciplinary and sustainable engineering practices as emphasized by NEP 2020.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts and statistical principles of experimental design for engineering and scientific investigations.
CLOBJ 2	To develop understanding of planning, conducting, and analyzing experiments for process optimization and performance evaluation.
CLOBJ 3	To familiarize students with factorial designs, ANOVA, response surface methodology, Taguchi methods, and regression analysis.
CLOBJ 4	To enable students to identify significant process parameters and optimize engineering systems using statistical tools and experimental techniques.
CLOBJ 5	To develop analytical and decision-making skills for designing efficient experiments and interpreting experimental data in research and industrial applications.

f. Course Learning Outcomes:

CLO 1	Explain the basic principles and strategies used in the design of experiments.
CLO 2	Design single-factor and full factorial experiments for manufacturing systems.
CLO 3	Analyze experimental results using ANOVA considering statistical assumptions.
CLO 4	Apply Taguchi and fractional factorial methods for robust design optimization.
CLO 5	Develop second-order models using Response Surface Methodology (RSM) for manufacturing processes.
CLO 6	Demonstrate the application of DOE in interdisciplinary case studies with focus on ethics and sustainability.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
4	1	-	4	20	20	-	60	-	100

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	Unit 1: Introduction to Design of Experiments Importance and role of DOE in CAD/CAM and manufacturing engineering, Terminology: factors, levels, responses, interactions, blocks, Fundamental principles: randomization, replication, blocking, Types of experimental designs: observational vs experimental, Guidelines for planning an effective experiment	18%	8
2	Unit 2: Single-Factor and Full Factorial Designs Completely Randomized Design (CRD) and Randomized Block Design (RBD), Single-factor experiments: one-way layout, two-way layout, Full factorial designs (2^2 , 2^3 , and 3^2), Estimation of main and interaction effects, Use of Minitab for design matrix creation and data input	18%	8
3	Unit 3: Analysis of Variance (ANOVA) Introduction to hypothesis testing in DOE, One-way and two-way ANOVA, F-test, p-values, confidence intervals, Model adequacy checks: residual analysis, normality, homoscedasticity, Application in real/simulated CAD/CAM case studies	18%	8
4	Unit 4: Taguchi Methods and Fractional Factorial Designs Need for fractional designs; alias structure and confounding, Design resolution (III, IV, V), Taguchi's philosophy: signal-to-noise ratios, loss functions, Orthogonal arrays (L4, L8, L9, L18, L27), Application in process and product optimization	15%	7

5	Unit 5: Response Surface Methodology (RSM) Introduction to second-order polynomial models, Central Composite Design (CCD) and Box-Behnken Design (BBD), Contour and surface plots, Path of steepest ascent and optimization, Case study: Tool wear vs. cutting parameters	18%	8
6	Unit 6: Case Studies, Project-Based Learning, and Ethical Practices in DOE Execution of a mini-project applying DOE techniques to real-world or simulated CAD/CAM problems, Case studies from manufacturing, robotics, thermal systems, and additive manufacturing, Ethical considerations in experiment planning, data integrity, and responsible reporting, Alignment of project themes with Sustainable Development Goals (SDGs) and societal impact	13%	6

i. Text Book and Reference Book:

1. Montgomery, D. C., Design and Analysis of Experiments, Wiley India, 9th Edition.
2. Myers, R. H., Montgomery, D. C., & Anderson-Cook, C. M., Response Surface Methodology: Process and Product Optimization Using Designed Experiments, Wiley, 4th Edition.
3. Antony, J., Design of Experiments for Engineers and Scientists, Elsevier/Butterworth-Heinemann.
4. Phillip J. Ross, Taguchi Techniques for Quality Engineering, McGraw-Hill Education.
5. S. R. Schmidt and R. G. Launsby, Understanding Industrial Designed Experiments, Air Academy Press.
6. Box, G. E. P., Hunter, W. G., & Hunter, J. S., Statistics for Experimenters: Design, Innovation, and Discovery, Wiley.

- a. **Course Name:** Waste to Energy
- b. **Course Code:** 03022002UE01
- c. **Prerequisite:** Basic knowledge of environmental science, thermodynamics, and energy systems.
- d. **Rationale:** This course aims to provide comprehensive understanding of waste-to-energy (WtE) technologies for sustainable energy generation and waste management. The course focuses on classification of wastes, conversion technologies, system design, environmental impacts, and techno-economic assessment of WtE systems.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts and significance of waste-to-energy technologies for sustainable waste management and energy generation.
CLOBJ 2	To develop understanding of different types of wastes, waste characterization, and energy recovery potential from waste materials.
CLOBJ 3	To familiarize students with thermal, biological, and advanced waste conversion technologies such as incineration, gasification, pyrolysis, and anaerobic digestion.
CLOBJ 4	To enable students to analyze environmental, economic, and operational aspects of waste-to-energy systems and pollution control measures.
CLOBJ 5	To develop the ability to evaluate and design sustainable waste-to-energy solutions for industrial, municipal, and environmental applications.

f. Course Learning Outcomes:

CLO 1	Explain principles of waste-to-energy technologies.
CLO 2	Analyze different waste conversion methods.
CLO 3	Design basic WtE systems.
CLO 4	Evaluate environmental and economic impacts.
CLO 5	Assess feasibility of WtE projects.

g. 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

h. Course Content:

Sr. No.	Content	Weightage	Teaching Hours
1	INTRODUCTION TO WASTE TO ENERGY Concept and scope of WtE, global and Indian scenario, waste generation and characterization, energy potential of wastes	13%	8
2	TYPES OF WASTES AND PRE-TREATMENT Municipal solid waste, industrial waste, agricultural waste, hazardous waste, segregation, size reduction, drying, RDF preparation	17%	10
3	THERMAL CONVERSION TECHNOLOGIES Incineration, pyrolysis, gasification, plasma gasification, process parameters, energy recovery	23%	14
4	BIOLOGICAL CONVERSION TECHNOLOGIES Anaerobic digestion, biogas production, landfill gas recovery, fermentation, composting	17%	10
5	WtE SYSTEM DESIGN AND ENVIRONMENTAL IMPACTS Plant layout, emission control, ash handling, environmental regulations, life-cycle assessment	17%	10
6	ECONOMICS AND CASE STUDIES Techno-economic analysis, project financing, policy frameworks, case studies, future prospects	13%	8

i. Text Book and Reference Book:

1. "Themelis", Waste-to-Energy Technologies and Project Implementation, Columbia University
2. "Kreith", Handbook of Solid Waste Management, McGraw-Hill
3. "Tabasaran ", Thermal Conversion of Solid Wastes, Oldenbourg
4. "Tchobanoglous", Integrated Solid Waste Management, McGraw-Hill
5. "World Bank", Waste to Energy Guidance Report

- a. **Course Name:** Pedagogy Studies
- b. **Course Code:** 03020002MC01
- c. **Prerequisite:** No specific prerequisite.
- d. **Rationale:** This course aims to introduce students to the principles and practices of effective teaching and learning in higher education. The course focuses on pedagogy theories, instructional design, assessment strategies, use of educational technologies, and outcome-based education to prepare students for academic and professional teaching roles.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, theories, and principles of teaching and learning in higher education.
CLOBJ 2	To develop understanding of learner-centered approaches, instructional design, and outcome-based education practices.
CLOBJ 3	To familiarize students with lesson planning, assessment methods, educational technologies, and classroom management techniques.
CLOBJ 4	To enable students to analyze and apply effective pedagogical strategies for improving teaching-learning processes and student engagement.
CLOBJ 5	To develop professional ethics, communication skills, and reflective teaching practices for academic and lifelong learning environments.

f. Course Learning Outcomes:

CLO 1	Understand fundamental principles of pedagogy.
CLO 2	Apply learning theories in instructional design.
CLO 3	Design effective lesson plans and assessments.
CLO 4	Use educational technologies in teaching.
CLO 5	Demonstrate professional ethics in education.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	-	20	30	-	-	-	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	INTRODUCTION TO PEDAGOGY Meaning and scope of pedagogy, teaching and learning processes, roles of a teacher, learner-centered education	13%	4
2	LEARNING THEORIES Behaviorism, cognitivism, constructivism, experiential learning, multiple intelligences	20%	6
3	INSTRUCTIONAL DESIGN Bloom's taxonomy, learning outcomes, lesson planning, curriculum design, teaching methods	23%	7
4	ASSESSMENT AND EVALUATION Formative and summative assessment, rubrics, feedback, outcome-based education	17%	5
5	EDUCATIONAL TECHNOLOGY E-learning platforms, blended learning, MOOCs, use of ICT in education	13%	4
6	PROFESSIONAL ETHICS AND DEVELOPMENT Teaching ethics, academic integrity, inclusive education, lifelong learning	14%	4

i. Text Book and Reference Book:

1. "Biggs & Tang", Teaching for Quality Learning at University, McGraw-Hill
2. "Bloom", Taxonomy of Educational Objectives, Pearson
3. "Joyce, Weil & Calhoun", Models of Teaching, Pearson
4. "Fink", Creating Significant Learning Experiences, Jossey-Bass
5. "UNESCO", Teaching and Learning for a Sustainable Future

- a. **Course Name:** Disaster Management
- b. **Course Code:** 03023702MC01
- 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. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	-	-	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	INTRODUCTION TO DISASTER MANAGEMENT Concept and scope of disaster management, disaster cycle, vulnerability and risk, disaster management framework, national and international perspective	20%	6
2	TYPES OF DISASTERS AND MITIGATION Natural disasters: earthquakes, floods, cyclones, droughts, landslides; man-made disasters: industrial accidents, fires, nuclear disasters; structural and non-structural mitigation measures	30%	9
3	DISASTER PREPAREDNESS AND RESPONSE Preparedness planning, early warning systems, hazard mapping, emergency operations, search and rescue, relief operations, medical response, coordination among agencies	27%	8
4	RECOVERY, GOVERNANCE AND TECHNOLOGY Reconstruction and rehabilitation, livelihood restoration, disaster management policies, legal framework, role of NGOs, community participation, use of GIS, remote sensing and ICT	23%	7

i. Text Book and Reference Book:

1. "Goel", Disaster Management, Deep & Deep Publications
2. "Coppola", Introduction to International Disaster Management, Butterworth-Heinemann
3. "NDMA", National Disaster Management Guidelines, Government of India
4. "Alexander", Principles of Emergency Planning and Management, Oxford
5. "UNESCO", Disaster Preparedness and Mitigation

- a. **Course Name:** Cost Management of Engineering Projects
- b. **Course Code:** 03023702MC02
- c. **Prerequisite:** Basic knowledge of engineering economics, project management principles, mathematics, and accounting fundamentals.
- d. **Rationale:** This course aims to provide students with knowledge and skills required for effective cost management of engineering projects. The course focuses on cost estimation, budgeting, cost control, project appraisal, financial analysis, and risk management to ensure timely and economical completion of engineering projects.

e. Course Learning Objective:

CLOBJ 1	To introduce fundamental concepts, principles, and importance of cost management in engineering projects.
CLOBJ 2	To develop understanding of cost estimation, budgeting, financial planning, and resource allocation techniques for project execution.
CLOBJ 3	To familiarize students with project appraisal methods, cost control strategies, earned value management, and risk assessment techniques.
CLOBJ 4	To enable students to analyze financial performance, economic feasibility, and cost optimization of engineering projects.
CLOBJ 5	To develop managerial and analytical skills for effective planning, monitoring, and successful completion of engineering projects within budget and time constraints.

f. Course Learning Outcomes:

CLO 1	Explain fundamentals of cost management in engineering projects.
CLO 2	Apply cost estimation and budgeting techniques.
CLO 3	Analyze project costs using financial tools.
CLO 4	Implement cost control and risk management strategies.
CLO 5	Evaluate real-world engineering project case studies.

g. Teaching & Examination Scheme:

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	-	-	-	20	30	-	-	-	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	INTRODUCTION TO COST MANAGEMENT Concept of cost, elements of cost, types of costs, cost management framework, project life cycle, role of cost engineer	17%	5
2	COST ESTIMATION TECHNIQUES Cost estimation methods, analogous and parametric estimation, detailed estimation, learning curves, cost indices	23%	7
3	BUDGETING AND COST CONTROL Project budgeting, cash flow analysis, earned value management (EVM), variance analysis, cost reporting	23%	7
4	PROJECT APPRAISAL AND FINANCIAL ANALYSIS Time value of money, NPV, IRR, payback period, break-even analysis, depreciation	20%	6
5	RISK MANAGEMENT AND CONTRACTS Risk identification and assessment, contingency planning, contract types, tendering and procurement	17%	5

i. Text Book and Reference Book:

1. "K.K. Chitkara", Construction Project Management, Tata McGraw-Hill
2. "Ahuja, Dozzi & Abourizk", Project Management: Techniques in Planning and Controlling Construction Projects, Wiley
3. "Kerzner", Project Management: A Systems Approach, Wiley
4. "Humphreys", Project and Cost Engineers' Handbook, CRC Press
5. "PMI", PMBOK Guide, Project Management Institute