Scheme & Syllabus

As per

(CBCS Scheme)

for

M.Tech (Composite Science and Engineering)

w.e.f 2025-26

UNIVERSITY INSTITUTE OF ENGINEERING AND TECHNOLOGY
FACULTY OF ENGINEERING AND TECHNOLOGY
MAHARSHI DAYANAND UNIVERSITY
ROHTAK -124001(HARYANA)

Program Specific Outcomes (PSOs) of Composite Science and Engineering

At the end of the program, the student will:

PSO1: Should be able to demonstrate a comprehensive understanding of composite materials, including fibers, matrices, and processing techniques, with a clear ability to apply this knowledge in engineering applications.

PSO2: Should be able to integrate learning from core courses such as Mechanics of Composite Materials, Polymer Technology, and Preform Engineering to effectively solve practical engineering problems related to design and manufacturing of composites.

PSO3: Should possess proficiency in using modern tools and techniques including CAD, finite element methods, and composite characterization tools to model, simulate, and analyze composite structures.

PSO4: Should be capable of conducting research in areas such as additive manufacturing, nanocomposites, and sustainability, and present findings clearly through technical reports, seminars, and dissertation work, while upholding ethical and environmental standards.

PSO5: Should be able to undertake industry-relevant projects and internships, showcasing an ability to translate academic knowledge into real-world solutions, and pursue innovation in advanced composite applications for sectors like aerospace, construction, and defense.

M.D. UNIVERSITY
SCHEME OF STUDIES AND EXAMINATION (CBCS Scheme effective from 2025-26)
M.TECH 1st YEAR (COMPOSITE SCIENCE AND ENGINEERING)
FIRST SEMESTER
CBCS Scheme effective from 2025-26

Sr. No	Course No.	Subject	Teaching Schedule				Examination Schedule (Marks)				Duration of Exam (Hours)	No of hours/ week
			L	T	P	Total Credits	Marks of Class works	Theory	Practical	Total		
1	25CST21C1	Fibres for Composites	4	0	0	4	50	100	0	150	3	4
2	25CST21C2	Preform Engineering	4	0	0	4	50	100	0	150	3	4
3	25CST21C3	Composite Process Engineering	4	0	0	4	50	100	0	150	3	4
4	25CST21C4	Mechanics of Composite Material	3	1	0	4	50	100	0	150	3	4
5	25CST21C5	Polymer Technology	4	0	0	4	50	100	0	150	3	4
6	25CST21CL1	Composite Processing Lab.	0	0	4	2	50	0	50	100	3	4
		TOTAL	**Credits: 22**									

Note: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

Fibres for Composites

Course code	**25CST21C1**				
Category	Professional Core Course				
Course Title	Fibres for Composites				
Scheme and Credits	L	T	P	Credits	Semester–I
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):
By the end of the course, the students will be able to:
CO1: Understand the fundamental concepts of fibre architectures and reinforcement forms used in composite materials.
CO2: Identify various types of fibres used in composites, including their structures, properties, and thermal stability.
CO3: Explain the role of fibre-matrix interface and different adhesion mechanisms in composite materials.
CO4: Differentiate between natural and synthetic fibres used in composites and evaluate their advantages and limitations.
CO5: Examine advanced and emerging fibre technologies such as hybrid fibres, nano-fibres, and smart/functional fibres used in next-generation composites.
NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Fiber Architecture and Processing in Composites, Reinforcement forms: roving, tows, yarns, chopped fibers, nonwovens, other textile structures suitable for composites, Introduction to composite materials: classification. Matrix-fibre synergy, Role of Fibres in composites, load transfer, anisotropy, failure modes, Fiber-matrix interface: adhesion mechanisms (mechanical, chemical, physical),

UNIT-II

Types of fibres used in Composites, Natural and Manufactured fibres. Glass fibres: Types (E-glass, S-glass), Carbon fibres: PAN-based, pitch-based, graphitization, Manufacturing processes, Structure, Properties & morphology, Thermal stability,

UNIT-III

Aramid and UHMWPE fibres: Kevlar, Twaron, Dyneema, Basalt and Ceramic fibres, Raw materials, Manufacturing processes, Structure & Properties, morphology, thermal stability, Natural fibres: Jute, flax, hemp, coir, banana, sisal, Structure- properties, advantages and limitations, Fiber sizing and surface treatments: plasma, silane, nano-coatings

UNIT-IV

Hybrid fibers and hybrid architectures, Effect of architecture on mechanical properties and failure modes, Advanced Fibres and Emerging Trends: Nano-fibers and electrospun mats for composites, Smart and functional fibers: sensing, self-healing, thermochromic, Bio-based and recyclable fibers.

Reference Books:

1. Chawla, K. K. (2012). *Composite materials: Science and engineering* (3rd ed.). Springer.
2. Peters, S. T. (Ed.). (1998). *Handbook of composites* (2nd ed.). Springer.
3. Triantafillou, T. (Ed.). (2016). *Textile fibre composites in civil engineering*. Woodhead Publishing.
4. Bhat, G. (Ed.). (2016). *Structure and properties of high-performance fibers*. Woodhead Publishing.
5. Zhang, X. (Ed.). (2016). *Advanced fibrous composite materials for ballistic protection*. Woodhead Publishing.

Preform Engineering

Course code	**25CST21C2**				
Category	Professional Core Course				
Course Title	Preform Engineering				
Scheme and Credits	L	T	P	Credits	Semester–I
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Explain the fundamental concepts of textile structural composites, their classifications, and material components.
CO2: Identify and distinguish various textile preform structures such as 2D, 3D woven, braided, stitched, and embroidered forms.
CO3: Analyze the geometry, arrangement, and anisotropic behavior of reinforcements in composite materials.
CO4: Evaluate manufacturing techniques and design approaches for specialized textile structures like honeycomb, aerodynamic, and auxetic forms.
CO5: Understand the principles and processes of composite preforming, including prepreg production, filament winding, and sandwich structures.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Definition of composites, textile composites and textile structural composites, Materials for composites, Matrix and Reinforcements, Classification of Textile Reinforced Structures based on axis and dimension; non-axial, mono-axial, biaxial, triaxial and multiaxial structures, UD, 2D,3D structures, Structural anisotropy, parallel arrangement and series arrangement of components, Chopped strand, flakes and Milled fibres, Hybrid fabrics, Non-crimp fabrics, Laminates, Stitched structure, Embroidery structures, Composite Rope

UNIT-II

Design, manufacture and applications of reinforcements, Manufacture and characterization of ultra-light 3D hollow textile structures for composites, 2D and 3D woven structures, Spacer fabrics by weaving, 3D woven Honeycomb structures, Profile structures, Aerodynamic structures, Radome structure

UNIT-III

Warp Knitted structures for composite preform, Single and Double Leno structures, Nonwoven structures for composite preform, Braided structure, Embroidery structures

UNIT-IV

Preform for acoustic composite materials, 2D and 3D woven auxetic structures for structural composites, Geometry of reinforcement, Particular, granular, fibrillar, lamellar, Properties of components, properties of interface, Preform and prepreg, Prepreg manufacturing, Filament winding process, Sandwich structure.

Reference Books:

1. Ko, F. K., & Tan, P. S. (Eds.). (2014). *Textile preforms for advanced composites: Materials, manufacturing, and applications*. Woodhead Publishing.
2. Long, A. C. (Ed.). (2005). *Design and manufacture of textile composites*. Woodhead Publishing.
3. Miravete, A. (Ed.). (1999). *3D textile reinforcements in composite materials*. Woodhead Publishing.
4. Hu, J. (Ed.). (2008). *Structure and mechanics of woven fabrics*. Woodhead Publishing.
5. Mallick, P. K. (2007). *Fiber-reinforced composites: Materials, manufacturing, and design* (3rd ed.). CRC Press.

Composite Process Engineering

Course code	**25CST21C3**				
Category	Professional Core Course				
Course Title	Composite Process Engineering				
Scheme and Credits	L	T	P	Credits	Semester–I
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Understand the classification of composite materials and identify various matrix and reinforcement options including thermosets, thermoplastics, and nano-reinforcements.
CO2: Describe and differentiate among various composite preforms and molding compounds used in composite manufacturing.
CO3: Analyze material selection methods and apply property-based and cost-performance criteria for selecting materials in composite applications.
CO4: Explain the fundamental steps and techniques involved in composite manufacturing processes including lay-up, filament winding, pultrusion, RTM, and autoclave processing.
CO5: Evaluate different manufacturing processes for thermoset and thermoplastic composites, their tooling requirements, and applications.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Definition of composites, Polymer composites, Fibre reinforced composites and Structural composites, Materials for composites, Matrix and Reinforcements, matrix materials - polymers, metals and ceramics. Thermoset resins, Epoxy, Phenolics, Polyesters ,Vinylesters , Cyanate Esters, Bismaleimide (BMI) and Polyimide, Polyurethane, Thermoplastic resins: Nylons, Polypropylene (PP), Polyetheretherketone (PEEK), Polyphenylene Sulfide (PPS), Reinforcements: Filaments, fibers, flakes, particulates: macro, micro and nano. Tows, Fabrics, Woven Fabrics, Noncrimp Fabrics

UNIT-II

Prepregs ,Thermoset Prepregs , Thermoplastic Prepregs , Preforms, Molding Compound, Sheet Molding Compound, Thick Molding Compound (TMC) , Bulk Molding Compound (BMC) , Injection Moldable Compounds, Honeycomb and Other Core Materials, Additives, Fillers and other functional materials, Material Selection Guidelines, Steps in the Material Selection Process, Material Selection Methods, Cost vs. Property Analysis, Weighted Property Comparison Method , Scaling for Maximum Property Requirement , Scaling for Minimum Property Requirement , Scaling for Nonquantitative Property, Expert System for Material Selection, Manufacturing Techniques, Manufacturing Process Selection Criteria, Production Rate/Speed , Cost and Performance, Mold and Tool Making , Basic Steps in a Composites Manufacturing Process : Impregnation, Lay-up, Consolidation , Solidification .

UNIT-III

Thermoset and Thermoplastic Composites Processing, Manufacturing Processes for Thermoset Composites, Prepreg Lay-Up Process, Major Applications , Basic Raw Materials ,Tooling Requirements, Making of the Parts , Methods of Applying Heat and Pressure ,Basic Processing Steps ,Wet Lay-Up Process , Major Applications ,Basic Raw Materials ,Tooling Requirements, Basic Processing Steps , Spray-Up Process Applications ,Basic Raw Materials ,Tooling Requirements Basic Processing , Filament Winding Process Major Applications ; Basic Raw Materials ,Tooling , Making of the Part ,Methods of Applying Heat and Pressure ,Methods of Generating the Desired Winding Angle ,Basic Processing Steps , Pultrusion Process , Major Applications , Basic Raw Materials , Basic Processing Steps ,Advantages and Limitations of the Pultrusion Process

UNIT-IV

Resin Transfer Molding Process ,Major Applications , Basic Processing Steps , Limitations of the Resin Transfer Molding Process ,Variations of the RTM Process , VARTM , SCRIMP , Structural Reaction Injection Molding (SRIM) Process ,Major Applications , Compression Molding Process , Major Applications , Roll Wrapping Process and Major , Manufacturing Processes for Thermoplastic Composites , Thermoplastic Tape Winding ,Thermoplastic Pultrusion Process, Sandwich composite processing, Core materials, Hot Press Technique , Autoclave Processing. Process Models, Importance of Models in Composites Manufacturing, Production Planning and Manufacturing Instructions, Objectives of Production Planning , Capacity Planning ,

Reference Books:

1. Mallick, P. K. (2007). *Fiber-reinforced composites: Materials, manufacturing, and design* (3rd ed.). CRC Press.
2. Strong, A. B. (2008). *Fundamentals of composites manufacturing: Materials, methods and applications* (2nd ed.). SME.

3. Carlsson, L. A., & Pipes, R. B. (2014). *Experimental characterization of advanced composite materials* (4th ed.). CRC Press.

4. Mazumdar, S. (2001). *Composites manufacturing: Materials, product, and process engineering*. CRC Press.

5. Campbell, F. C. (2010). *Structural composite materials*. ASM International.

Mechanics of Composite Materials

Course code	**25CST21C4**				
Category	Professional Core Course				
Course Title	Mechanics of Composite Material				
Scheme and Credits	L	T	P	Credits	Semester–I
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Understand the basic terminology of mechanics and perform stress-strain analysis of composite materials.
CO2: Analyze the macromechanical and micromechanical behavior of a lamina including strength and failure theories.
CO3: Evaluate the mechanical properties such as tensile, compressive, and shear strengths in longitudinal and transverse directions
CO4: Perform macromechanical analysis of laminates and analyze failure mechanisms in symmetric and non-symmetric composite beams.
CO5. Understand design considerations including fatigue, impact, and fracture resistance, and apply statistical and fracture mechanics principles.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Mechanics Terminology, stress-strain analysis, specific strength and specific modulus, fibre dimension, Macromechanical analysis of a lamina, strength failure theory of an angle lamina, Micromechanical analysis of a lamina, Volume and mass fraction, density and void content, ultimate strength of a unidirectional lamina

UNIT-II

Longitudinal and transverse tensile strength, Longitudinal and transverse compressive strength, In-plane shear strength, coefficient of thermal expansion, coefficient of moisture expansion

UNIT-III

Macromechanical analysis of laminates, Inplane and flexural modulus of laminate, Bending of beam, symmetric and non-symmetric beams, effect of fiber volume fraction on properties, failure theories of a lamina. Laminate analysis, failure of a laminate, design principles of tailor-made material systems.

UNIT-IV

Impact resistance, Fatigue resistance, Fracture resistance and fracture mechanics, statistical aspects of fracture, Griffin's theory.

Reference Books:

1. Jones, R. M. (1999). *Mechanics of composite materials* (2nd ed.). Taylor & Francis.
2. Daniel, I. M., & Ishai, O. (2006). *Engineering mechanics of composite materials* (2nd ed.). Oxford University Press.
3. Kaw, A. K. (2005). *Mechanics of composite materials* (2nd ed.). CRC Press.
4. Agarwal, B. D., & Broutman, L. J. (2006). *Analysis and performance of fiber composites* (3rd ed.). Wiley-Interscience.
5. Christensen, R. M. (2005). *Mechanics of composite materials*. Dover Publications.

Polymer Technology

Course code	**25CST21C5**				
Category	Professional Core Course				
Course Title	Polymer Technology				
Scheme and Credits	L	T	P	Credits	Semester–I
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):
By the end of the course, the students will be able to:
CO1: Understand the classification, nomenclature, and polymerization mechanisms including chain-growth and step-growth polymerization.
CO2: Analyze polymer structure, molecular weight, architecture, and behavior using configuration, conformation, and statistical models.
CO3: Evaluate polymer morphology, phase transitions, and viscoelastic properties in both solid and solution states.
CO4: Examine the processing techniques of polymers including extrusion, molding, and nanocomposite processing.
CO5: Identify and describe the roles of specialty polymers, additives, rheology principles, and nanofillers in advanced polymer applications.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction to Polymers; Introduction to polymers, Nomenclature of polymers, Classification of polymers, Polymer composition and general characteristics. Methods and Mechanisms of Polymerization: Methods of polymerization: Addition, Condensation, Chain growth, Step growth, Kinetics of polymerization, Polymerization techniques, Copolymerization and reactivity ratios, Atom Transfer Radical Polymerization (ATRP) . Polymer Structure and Molecular Characteristics: Molecular weight of polymers, General structure and characteristics of polymers, Molecular architecture: linear, branched, crosslinked, dendritic, Configuration and conformation of ideal and real polymer chains, Random Walk models of polymer conformations, Gaussian chain, Self-avoiding walks and excluded-volume interaction.

UNIT-II

Polymer Morphology and Phase Transitions: The amorphous phase and its chemical-physical aspects, The glass transition phenomenon, The WLF (Williams-Landel-Ferry) equation, The crystalline state and its chemical-physical aspect, Cross-linked polymers and rubber elasticity. Polymer Solution Behavior and Properties: Behavior of polymers in solutions and mixtures, Viscoelasticity and rheology of polymers, Mechanical properties of polymers, Polymer Processing Technologies: Extruders, Film blowing, Moulding and forming: Injection moulding, Thermoforming, Processing of biopolymer nanocomposites, Directional anisotropy.

UNIT-III

Polymer Resins and Specialty Polymers: Resins: Thermoset, Thermoplastic, Elastomer, Thermoplastic elastomers (TPE): Resin characteristics, Molecular weight, Viscosity, Degradability, Engineering polymers: ABS, Polycarbonate, Polyamides, Polyesters, Polyacetal, Polyimides, Liquid Crystalline Polymers (LCPs): Thermotropic, Lyotropic, Structural and functional properties, Viscosity, Dendritic polymers, Vitrimers – thermoset-like materials with dynamic covalent networks enabling reprocessability

UNIT-IV

Rheology and Fluid Behavior in Polymers: Principles of rheology: Stresses, strains, rate of strain, Equations of fluid motion, Constitutive equations, Fluid types: Newtonian and non-Newtonian, Shear thinning/thickening, Viscoelastic/time-dependent, Linear viscoelasticity: Kelvin and Maxwell models, Relaxation spectrum, Oscillatory shear, Generalized Maxwell model, Effect of temperature, concentration, molecular weight on polymer rheology. Additives and Nanofillers in Polymers,Additive types and roles: Fillers (particulate and non-particulate), Reinforcing agents, Plasticizers (primary and secondary), Processing aids, Colouring agents, Antioxidants, Nanofillers: nanoclays, graphene, CNTs, nanosilica, nanocellulose.

Reference Books:

1. Fried, J. R. (2014). *Polymer science and technology* (3rd ed.). Prentice Hall.
2. Billmeyer, F. W. (1984). *Textbook of polymer science* (3rd ed.). Wiley-Interscience.
3. Rudin, A., & Choi, P. (2012). *The elements of polymer science and engineering* (3rd ed.). Academic Press.
4. Sperling, L. H. (2005). *Introduction to physical polymer science* (4th ed.). Wiley.
5. Odian, G. (2004). *Principles of polymerization* (4th ed.). Wiley-Interscience.

Composite Processing Lab

Course code	**25CST21CL1**				
Category	Professional Core Course				
Course Title	Composite Processing Lab.				
Scheme and Credits	L	T	P	Credits	Semester–I
	0	0	4	2	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	50 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Course Objectives:

CO1: Understand and apply various textile techniques such as weaving, knitting, nonwoven, and braiding for fabricating composite preforms.
CO2: Demonstrate knowledge of different composite manufacturing processes including hand lay-up, spray lay-up, compression molding, and VARTM.
CO3: Operate and evaluate filament winding techniques for the preparation of fiber-reinforced composites.
CO4: Analyze the role of additives, fillers, and surface treatments in enhancing the performance of composite materials.
CO5: Perform and assess machining operations such as drilling, cutting, pinning, and joining, including adhesive bonding, in composite components.

Fabrication of composite preforms by weaving, knitting, nonwoven and braiding, Preparation of composite material by hand lay, spray lay, compression molding and VART process, Preparation of composite by filament winding, Preparation of composites using additives and fillers, surface treatment of composite, Machining of composites, drilling, pinning, cutting, joining of composites, adhesive bonding

M.D. UNIVERSITY
SCHEME OF STUDIES AND E9XAMINATION
M.TECH 1st YEAR (COMPOSITE SCIENCE AND ENGINEERING)
SECOND SEMESTER
CBCS Scheme effective from 2025-26

Sr. No	Course No.	Subject	Teaching Schedule				Examination Schedule (Marks)				Duration of Exam (Hours)	No of hours/ week
			L	T	P	Total Credits	Marks of Class Works	Theory	Practical	Total		
1	25CST22C1	Design of Experiment and Research Methodology	3	1	0	4	50	100	0	150	3	4
2	25CST22C2	Composite Characterization	4	0	0	4	50	100	0	150	3	4
3	25CST22CL1	Composite Characterization Lab.	0	0	4	2	50	0	50	100	3	4
4	25CST22CL2	CAD for Composites Lab.	0	0	4	2	50	0	50	100	3	4
5	25CST22D1/ 25CST22D2/ 25CST22D3/ 25CST22D4	Elective-I	4	0	0	4	50	100	0	150	3	4
6		Open Elective	3	0	0	3					3	3
7		Foundation Elective	2	0	0	2					2	2
		TOTAL	**Credits: 21**									

Note: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

Elective-I: Choose any one of the following papers

25CST22D1: Composites for Defence Applications
25CST22D2: Lightweight Materials and Structures
25CST22D3: Multifunctional Composite
25CST22D4: Project Appraisal and Finance

Open Elective: Choose any one of the following papers

A candidate has to select this paper from the pool of Open Electives provided by the University

Foundation Elective: Choose any one of the following papers

A candidate has to select this paper from the pool of Foundation Electives provided by the University

Design of Experiment and Research Methodology

Course code	**25CST22C1**				
Category	Professional Core Course				
Course Title	Design of Experiment and Research Methodology				
Scheme and Credits	L	T	P	Credits	Semester–II
	3	1		4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO):

By the end of this course, students will be able to:

CO1: Formulate research problems and perform effective literature review and data evaluation.
CO2: Apply statistical tools (mean, median, mode, standard deviation, etc.) for interpreting experimental data.
CO3: Understand different types of errors and apply methods like least squares and regression for data analysis.
CO4: Design and analyze experiments using various experimental designs including factorial, robust, and response surface methods.
CO5: Perform hypothesis testing, ANOVA, and regression analysis using statistical software tools for engineering applications.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Research Methodology: Problem formulation, Literature search, Data evaluation, Analysis and interpretation, Various statistical methodologies (viz. Mean, Median, Mode, Std Dev. etc) to get the optimum output from the dday-to-dayEngineering life experiment

UNIT-II

Experimental Analysis: Types of measurements and errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Method of least squares, the curve fitting, General linear regression, Theory of errors, Binomial and Gaussian distribution, Chi-square test.

UNIT-III

Design of Experiments and Statistical Techniques: objectives, principles, terminologies, guidelines, and applications of design of experiments. Completely randomized design. Randomized block design. Latin square design. Two level and three level full factorial designs. Fractional factorial designs. Robust design. Mixture experiments. Central composite and Box-Behnken designs. Response surface methodology. Multi-response optimization.

UNIT-IV

Analysis of variance. Statistical test of hypothesis. Analysis of multiple linear regression. use of statistical software packages

Reference Books:

1. **Montgomery, D.C.** – *Design and Analysis of Experiments*, Wiley.
2. **Ranjit Kumar** – *Research Methodology: A Step-by-Step Guide for Beginners*, Sage Publications.
3. **Jiju Antony** – *Design of Experiments for Engineers and Scientists*, Elsevier.
4. **Douglas C. Montgomery and George C. Runger** – *Applied Statistics and Probability for Engineers*, Wiley.
5. **Kothari, C.R.** – *Research Methodology: Methods and Techniques*, New Age International Publishers.

Composite Characterization

Course code	**25CST22C2**				
Category	Professional Core Course				
Course Title	Composite Characterization				
Scheme and Credits	L	T	P	Credits	Semester–II
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Understand and perform mechanical characterization tests such as tensile, compressive, flexural, and impact testing on composite materials.
CO2: Evaluate physical, chemical, and microstructural properties of composites using advanced characterization techniques.
CO3: Apply non-destructive evaluation (NDE) methods like ultrasonic, radiographic, and thermographic inspection for defect detection.
CO4: Analyze the environmental effects on composite materials, including moisture, UV radiation, erosion, and heat damage.
CO5: Implement quality control, material selection, and failure analysis methods to ensure optimal composite performance and reliability.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT- I

Mechanical Characterization: testing the material's strength, stiffness, toughness, and fatigue resistance under different loading conditions. Techniques include tensile, compressive, flexural, shear and impact tests, open hole tension and Compression test, Bolt bearing Strength, Flat wise tension test, Compression strength after Impact, Fracture toughness testing, Adhesive Shear testing, Adhesive peel testing, Honeycomb flatwise tension, Fatigue, Delamination and Impact resistance, Effect of defects, voids and porosity, Fiber distortion, Fastener Hole Defects.

UNIT- II

Physical Characterization: evaluating properties like density, thermal expansion, and electrical conductivity. Chemical Characterization: chemical composition and stability of the composite materials, including the matrix and reinforcement phases. Microstructural Characterization: examining the microstructure of the composite, including the size, shape, and distribution of the reinforcement phase within the matrix. Techniques like microscopy (optical, electron) and spectroscopy

UNIT- III

Non-Destructive Evaluation (NDE): Techniques like ultrasonic testing, X-ray tomography, and thermography to assess the internal structure and detect defects without damaging the material. Visual Inspection, Ultrasonic Inspection, Radiographic Inspection, Thermographic Inspection, Environmental degradation, Moisture Absorption, Fluids, ultraviolet radiation and erosion, lightning Strikes, Thermo oxidative Stability, Heat damage, Flammability.

UNIT- IV

Quality Control: Ensuring that composite materials meet specific performance standards during manufacturing. Performance Optimization: Understanding how different factors affect the material's properties, allowing for optimization for specific applications. Material Selection: Providing data for selecting the most suitable composite material for a given application. Failure Analysis: Helping to understand the causes of composite material failure and prevent future occurrences.

Reference Books:

1. Mallick, P. K. (2007). *Fiber-reinforced composites: Materials, manufacturing, and design* (3rd ed.). CRC Press.
2. Agarwal, B. D., & Broutman, L. J. (2006). *Analysis and performance of fiber composites* (3rd ed.). Wiley-Interscience.
3. Carlsson, L. A., & Pipes, R. B. (2014). *Experimental characterization of advanced composite materials* (4th ed.). CRC Press.
4. Matthews, F. L., & Rawlings, R. D. (1999). *Composite materials: Engineering and science* (2nd ed.). Woodhead Publishing.
5. Daniel, I. M., & Ishai, O. (2006). *Engineering mechanics of composite materials* (2nd ed.). Oxford University Press.

Composites for Defence Applications

Course code	**25CST22D1**				
Category	Professional Elective Course				
Course Title	Composites for Building Material				
Scheme and Credits	L	T	P	Credits	Semester–II
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Identify and classify different types of composites used in defence, including FRPs, PMCs, MMCs, and CMCs.
CO2: Explain the advantages of using composites in defence systems such as weight reduction, impact resistance, and corrosion resistance.
CO3: Analyze the role of composites in land, air, naval, and missile systems for performance enhancement and structural efficiency.
CO4: Examine specialized composite applications in weaponry, armor systems, stealth technology, and personal protection.
CO5: Understand the development and applications of advanced materials like nanocomposites, multifunctional, and auxetic composites in modern defence.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Types of composites used in defense: Fiber Reinforced Polymers (FRPs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) used in applications like hypersonic missiles and aero engines, Polymer Matrix Composites (PMCs), Advantages of using composites in defense: Lightweight, High Strength and Stiffness, Corrosion Resistance, Design Flexibility, Impact Resistance. Lightweight Armor: composites for lightweight body armor and vehicle armor, protection against ballistic threats and blasts.

UNIT-II

Aerospace: Composites in aircraft construction, including fighter jets, drones, and transport aircraft, to reduce weight, improve fuel efficiency, and enhance performance. Land Systems: Composites in armored vehicles, enhancing protection and reducing weight, other components like wheels and structural elements.

UNIT-III

Naval Vessels: Composites used in the construction of naval ships and submarines, offering benefits like corrosion resistance and reduced weight. Missiles and Rockets: Composites employed in missile and rocket components due to their ability to withstand high temperatures and stresses.

UNIT-IV

Weaponry: Composites incorporated into weapon systems to reduce weight, enhance durability, and mitigate recoil issues. Other Applications: Composites in various other Défense applications, including protective clothing, helmets, stealth, and other equipment. Nanocomposites for defence applications, Multifunctional composites, Auxetic composites,

Reference Books:

1. Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K. (2017). *Analysis and performance of fiber composites* (4th ed.). Wiley.
2. Chung, D. D. L. (2010). *Composite materials: Science and applications* (2nd ed.). Springer.
3. Mallick, P. K. (2007). *Fiber-reinforced composites: Materials, manufacturing, and design* (3rd ed.). CRC Press.
4. Gohil, T. P. (2021). *Advanced composite materials for aerospace engineering*. Elsevier.
5. Fink, J. K. (2021). *Defense and aerospace applications of materials: A reference guide*. William Andrew Publishing.

Light Weight Materials and Structures

Course code	**25CST22D2**				
Category	Professional Elective Course				
Course Title	Lightweight Materials and Structures				
Scheme and Credits	L	T	P	Credits	Semester–II
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Understand the fundamentals and design principles of lightweight materials and structures, including isotropic and anisotropic components.
CO2: Evaluate manufacturing techniques for composite structures using thermoset and thermoplastic matrices, including automation technologies.
CO3: Apply adaptive and integrative structural design methods for functionally optimized lightweight systems.
CO4: Analyze simulation models and the nonlinear deformation behavior of materials in lightweight structural design.
CO5: Investigate advanced applications of lightweight construction in industries such as robotics, medical technology, and bio-inspired engineering.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Fundamentals of Lightweight Materials and structures, Development of Lightweight Structures, Manufacturing of Composite Structures, Basics of Plastics Engineering, Designing with Plastics, Construction Materials and Surface Engineering, Industry-Specific Lightweight Structures and Technologies, Quality Assurance Management, and Special Problems of Lightweight Construction. Calculation of lightweight structures made from isotropic and anisotropic materials, Adaptive Structures for Lightweight Construction

UNIT-II

Design of Lightweight Structures, Structures and Technologies of Selected Industries, for example, in material properties, as well as solution concepts for vibroacoustic and optimization of lightweight structures. Manufacturing processes in relation to the constructive requirements of the component, both fundamentally and application-oriented, particularly manufacturing processes for components with thermoset and thermoplastic matrices using newer technologies for the automated production of composite components.

UNIT-III

Adaptive Structures for Lightweight Construction, fundamentals of designing and investigating active structural elements and lightweight structures and systems, particularly functionally integrative lightweight structures and active compliant mechanisms, methods for material-appropriate design, configuration, processing, and signal processing, as well as their application in functionally integrative lightweight structures, functionally integrative designs of compliant motion structures in active compliant mechanisms, assembly and play-free solid joints with preferred deformation direction in composite construction

UNIT-IV

Design and simulation models, material behavior under geometrically nonlinear deformation, and integrable actuators (drives), positioning mechanisms, robot structures, as well as handling and tool kinematics, Special Issues in Lightweight Construction : Transferring biological principles into technical applications for lightweight construction, Integration of enhanced functions into lightweight structures, Lightweight construction for applications in medical technology, or Numerical methods for the calculation of hybrid lightweight structures.

Reference Books:

1. Ashby, M. F., Shercliff, H., & Cebon, D. (2013). *Materials: Engineering, science, processing and design* (3rd ed.). Butterworth-Heinemann.
2. Lightweight Innovations for Tomorrow (LIFT). (2018). *Introduction to lightweight materials*. SME.
3. Chawla, K. K. (2012). *Composite materials: Science and engineering* (3rd ed.). Springer.
4. Altenbach, H., & Öchsner, A. (Eds.). (2011). *Lightweight design in structural engineering*. Springer.
5. Friedrich, K., & Almajid, A. A. (2013). *Manufacturing aspects of advanced composite materials and structures*. Springer.

Multifunctional Composites

<table>
<tr><td>Course code</td><td colspan="5">25CST22D3</td></tr>
<tr><td>Category</td><td colspan="5">Professional Elective Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Multifunctional Composite</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–II</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">100 Marks</td></tr>
<tr><td>Total</td><td colspan="5">150 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Course Outcome (CO):

By the end of this course, students will be able to:

CO1: Define and classify multifunctional composite materials (MFCMs) and describe their structural and non-structural characteristics.
CO2: Analyze the properties and fabrication methods of energy-storing and supercapacitive multifunctional composites.
CO3: Evaluate the performance of carbon fiber composites with multifunctional capabilities like sensing, self-healing, and thermal management.
CO4: Understand the principles of metamaterials and specialty composites such as auxetic, ductile, and acoustic composites.
CO5: Apply the knowledge of multifunctional magnetic soft composites and smart composites in advanced engineering applications including aerospace.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Multifunctional composite: definition, classification, Structural and non-structural properties of MFCMs, Electrical energy storage and Supercapacitance: design, fabrication method, and characterization, applications, Multifunctional Carbon Fiber Composites: Structural, Energy Harvesting, Strain-Sensing Material, Thermal conductivity/insulation composites, Adsorption, Self-healing functions.

UNIT-II

Fire-retardant properties of MFCMs, Biodegradability of MFCMs, Micro and nano filler-based hybrid MFCMs, Nanomaterial based MFCMs, Micro and nano filler-based hybrid MFCMs, Properties of multifunctional composite materials based on nanomaterials, Multiple structural properties of MFCM, Applications,

UNIT-III

Multifunctional composites: a metamaterial perspective, Electrodynamic metamaterials, Acoustic metamaterials, Mechanical metamaterials, fabrication technics and applications, Specialty composites: Acoustic composites, Ductile composites, Auxetic composites.

UNIT-IV

Multifunctional magnetic soft composites: material composition, fabrication method, characterization, applications, Mechanics of multifunctional composite materials and structures, Smart composites and applications, multifunctional structure for aerospace applications,

Reference Books:

1. **Gibson, R.F.** – *Principles of Composite Material Mechanics*, CRC Press.
2. **Ashok B. Dey** – *Smart Materials and Structures*, Narosa Publishing House.
3. **Friedrich, Klaus** – *Multifunctionality of Polymer Composites: Challenges and New Solutions*, William Andrew Publishing.
4. **Nalwa, H.S.** – *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*, American Scientific Publishers.
5. **Chandrakant Patel, R. & Desai, F.** – *Multifunctional Composites: Design, Fabrication and Characterization*, Springer.

Project Appraisal and Finance

Course code	**25CST22D4**				
Category	Professional Elective Course				
Course Title	Project Appraisal and Finance				
Scheme and Credits	L	T	P	Credits	Semester–II
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO):

By the end of this course, students will be able to:

CO1: Differentiate between project finance and corporate finance and understand the structure of the Indian financial system.
CO2: Analyze and interpret financial statements, working capital, and inventory management in the context of project evaluation.
CO3: Apply techniques like NPV, IRR, MIRR, and real options for valuing and appraising projects financially and economically.
CO4: Evaluate the technical, market, demand, and environmental aspects of project formulation using standard appraisal techniques.
CO5: Conduct risk analysis and financial forecasting using tools such as sensitivity analysis, decision trees, and Monte Carlo simulations.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction to Project Finance - Description of Project Finance Transaction, difference between corporate finance and project finance, Indian Financial system, Structuring the Project, Limited Resource Structures, Capital Investments: Importance & Difficulties, CPV analysis.

UNIT-II

Financial statements, financial statement analysis, Working capital management, Inventory management.

UNIT-III

Project cycle, Project Formulation, Project Appraisal, Financial appraisal, Economic Appraisal, Social Cost Benefit Analysis- Shadow Prices and Economic rate of return, Financing Projects, Sources of funding, Valuing Projects, NPV, IRR, MIRR, Real options, Decision Trees and Monte Carlo Simulations.

UNIT-IV

Financial Estimates & projections, Technical Analysis, Market & Demand Analysis, Investment Criteria, Cost of capital, Project Risk analysis, Sensitivity Analysis, Leverage analysis, Environment Appraisal of the project and Detailed Project Report, Case studies on Textile and composite projects.

Reference Books:

1. **Prasanna Chandra** – *Projects: Planning, Analysis, Selection, Financing, Implementation, and Review*, McGraw Hill Education.
2. **Yescombe, E.R.** – *Principles of Project Finance*, Academic Press.
3. **Benjamin C. Esty** – *Modern Project Finance: A Casebook*, Wiley.
4. **Brealey, Myers, Allen** – *Principles of Corporate Finance*, McGraw Hill Education.
5. **Machiraju, H.R.** – *Introduction to Project Finance*, Vikas Publishing House.

Composite Characterization Lab

<table>
<tr><td>Course code</td><td colspan="5">26CST22CL1</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Composite Characterisation Lab.</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–II</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">50 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Corse Outcomes:

CO1: Perform and interpret results from tensile, compression, flexural, and shear tests to evaluate mechanical behavior of composite materials.
CO2: Assess the impact strength, fatigue resistance, and hardness of composites using standardized testing methods.
CO3: Analyze machinability characteristics of composites through cutting, drilling, and related performance evaluations.
CO4: Evaluate the environmental degradation and thermal conductivity of composites under various exposure conditions.
CO5: Apply non-destructive testing (NDT) techniques to detect internal defects and ensure structural integrity of composite components.

Mechanical Testing of composites, Tensile, compression, flexural, shear test, Impact properties, Fatigue analysis, Hardness testing, machinability test, Environmental degradation test, thermal conductivity , nondestructive test.

CAD for Composite Lab.

<table>
<tr><td>Course code</td><td colspan="5">26CST22CL2</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Composite Characterisation Lab.</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–II</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">50 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Corse Outcomes:

CO1: Develop textile-structure-based composite preforms using 3D modeling tools like SolidWorks.
CO2: Understand and apply modeling and simulation techniques for structural composite analysis.
CO3: Gain hands-on experience with FEA software such as ANSYS or Abaqus for composite structure evaluation.
CO4: Execute practical exercises and mini projects related to the design and analysis of composite materials.
CO5: Interpret FEA results effectively to support design decisions and structural performance improvements in composites.

Software Applications: Hands-on experience to develop textile structure based preforms with SolidWorks. Understanding the concept of modelling and simulation for structural composites. Hands-on experience with FEA software packages (e.g., ANSYS or Abaqus,), Practical exercises and projects focusing on composite structures, learning to interpret and utilize FEA results for design and analysis.

M.D. UNIVERSITY
SCHEME OF STUDIES AND EXAMINATION
M.TECH 2nd YEAR (COMPOSITE SCIENCE AND ENGINEERING)
THIRD SEMESTER
CBCS Scheme effective from 2025-26

Sr. No	Course No.	Subject	Teaching Schedule				Examination Schedule (Marks)				Duration of Exam (Hours)	No of hours/ week
			L	T	P	Total Credits	Marks of Class Works	Theory	Practical	Total		
1	26CST23C1	Additive Manufacturing	4	0	0	4	50	100	0	150	3	4
2	26CST23C2	Bio and Nano composites	4	0	0	4	50	100	0	150	3	4
3	26CST23C3	Dissertation Stage-I	0	0	2	2	100	0	0	100		4
4	26CST23C4	Seminar	0	0	2	2	50	0	0	50		2
5	26CST23D1/ 26CST23D2/ 26CST23D3/ 26CST23D4	Elective-II	4	0	0	4	50	100	0	150	3	4
6		Open Elective	3	0	0	3					3	3
		TOTAL	**Credits: 19**									

Note: Choose any one of the following papers

26CST27E1: Sustainability and Environment
26CST27E2: Machinability and Damage Analysis of composite material
26CST27E3: Vibration, Fatigue and Fracture
26CST27E4: Fundamentals of Aerodynamics and Aerospace Vehicles

Open Elective: Choose any one of the following papers

A candidate has to select this paper from the pool of Open Electives provided by the University

Additive Manufacturing

Course code	**26CST23C1**				
Category	Professional Core Course				
Course Title	Additive manufacturing				
Scheme and Credits	L	T	P	Credits	Semester–III
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO):

By the end of this course, students will be able to:

CO1: Understand the evolution, classification, and foundational principles of additive manufacturing (AM) technologies.
CO2: Analyze the role of different composites and matrix materials in AM processes and their influence on final properties.
CO3: Apply additive manufacturing techniques to fabricate polymer matrix and continuous fiber composites with design considerations.
CO4: Evaluate AM methods for metal and ceramic matrix composites, understanding microstructural evolution and mechanical behavior.
CO5: Assess post-processing techniques, quality control measures, and explore industrial applications and emerging trends in AM including AI integration.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction to Additive Manufacturing, History, evolution, and classification of AM processes, Advantages and limitations of AM, Design for Additive Manufacturing, Materials used in AM, Basics of Composite Materials, Types of composites: particulate, short fiber, continuous fiber, Matrix materials: thermoplastics vs thermosets, Interfacial adhesion and fiber-matrix interaction, Composites relevance to AM.

UNIT-II

Additive Manufacturing of Polymer Matrix Composites, Fused Deposition Modeling (FDM) for composites, Direct Ink Writing, Stereolithography (SLA) with filled resins Material Extrusion and filament fabrication techniques, Influence of process parameters on print quality and mechanical properties, Case studies with thermoplastics and thermosets reinforced with fibers. Additive Manufacturing of Continuous Fiber Composites, In-situ and off-line fiber embedding techniques, Robotic-assisted AM with continuous fibers, Hybrid techniques, Limitations and design considerations.

UNIT-III

AM of Metal and Ceramic Matrix Composite, Overview of powder bed fusion, binder jetting for metal/ceramic composites, Challenges with reinforcement dispersion, residual stresses, and defects. Process–Structure–Property Relationships: Microstructure development during AM, Porosity, fiber orientation, interfacial bonding, Mechanical properties: tensile, flexural, impact, fatigue behavior, Thermal and morphological characterization.

UNIT-IV

Post-Processing and Quality Control, Heat treatment, infiltration, and surface finishing, Non-destructive testing techniques (CT, microscopy), Standards and certifications (ASTM, ISO). Applications, Challenges, and Future Trends, Aerospace, biomedical, automotive applications, Environmental and sustainability aspects, Recent research directions and industrial trends, AI and digital twins in composite AM.

Reference Books:

1. **Ian Gibson, David Rosen, Brent Stucker** – *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, Springer.
2. **Andreas Gebhardt** – *Understanding Additive Manufacturing*, Hanser Publishers.
3. **Lijie Grace Zhang, John P. Fisher** – *3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine*, Academic Press.
4. **Yong He and Jiayin Wang** – *Additive Manufacturing of Polymer-Matrix Composites*, Elsevier.
5. **Kun Zhou (Ed.)** – *Additive Manufacturing of Structural Materials*, Springer.

Bio and Nano Composites

<table>
<tr><td>Course code</td><td colspan="5">26CST23C2</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Bio and Nano Composites</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–III</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">100 Marks</td></tr>
<tr><td>Total</td><td colspan="5">150 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Course Outcomes (COs):

By the end of the course, the students will be able to:

CO1: Understand the classification, properties, and testing methods of biomaterials and their biocompatibility.
CO2: Describe the structure–property relationships and fabrication techniques for bio-composites.
CO3: Analyze the principles and significance of nanoscience and nanotechnology in relation to composite materials.
CO4: Explain the synthesis and characteristics of nanomaterials like carbon nanotubes, fullerenes, and metal/metal oxide nanoparticles.
CO5: Evaluate the mechanical, thermal, optical, and rheological properties of nanocomposites and their advanced applications.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Definition of biomaterials (history & background), Classification of biomaterials (based on response, materials & applications), Biocompatible materials, Biocompatibility, Cytotoxicity and Testing (In vitro/ In vivo), Structure-property correlation, Processing of biocompatible materials including various fabrication techniques. Raw materials used in bio-composites, Basic design principles, Properties and applications, Life cycle assessment

UNIT-II

Introduction to Nanoscience and Nanotechnology; Size and surface dependence of their physical and chemical properties such as mechanical, thermodynamical, electronic, catalysis etc; Introduction to Nanomaterials and Nanocomposites, Classification of Nanomaterials and Nanocomposites.

UNIT-III

Synthesis of Nanomaterials, carbon nanotube, fullerenes, metal and metal oxide nanoparticles i.e. nano silver, nano silica, nano titania, nano zinc oxide, nano magnesium oxide etc.; Preparation of Nanocomposites

UNIT-IV

Mechanical Properties of Nanocomposites, Thermal Properties of Novel Polymer Nanocomposites , Optical Properties of Nanocomposites, Rheological Behavior of Nanocomposites, Applications of nanocomposites.

Reference Books:

1. Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. (2004). *Biomaterials science: An introduction to materials in medicine* (2nd ed.). Academic Press.
2. Bhushan, B. (Ed.). (2017). *Springer handbook of nanotechnology* (4th ed.). Springer.
3. Tiwari, A., & Boukherroub, R. (Eds.). (2013). *Materials and devices for biomolecular detection* (Vol. 2). Wiley.
4. Nalwa, H. S. (Ed.). (2002). *Handbook of nanostructured biomaterials and their applications in nanobiotechnology* (Vols. 1–2). American Scientific Publishers.
5. Gaharwar, A. K., Sant, S., Hancock, M. J., & Hacking, S. A. (Eds.). (2020). *Nanomaterials in tissue engineering: Fabrication and applications*. Woodhead Publishing.

Sustainability and Environment

Course code	**26CST23D1**				
Category	Professional Elective Course				
Course Title	Sustainability and environment				
Scheme and Credits	L	T	P	Credits	Semester–III
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO)

By the end of this course, students will be able to:

CO1: Understand the principles of sustainability and evaluate the environmental impact of materials, energy, and resource consumption.
CO2: Apply life cycle assessment (LCA) tools to analyze the environmental footprint of products and processes.
CO3: Examine green chemistry principles, sustainable technologies, and renewable energy materials and policies.
CO4: Analyze industrial waste management practices and relevant environmental laws and policies for pollution control.
CO5: Evaluate compliance standards, eco-labeling, certifications (e.g., ISO 14024:2018), and ethical sustainability practices in engineering and manufacturing.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Overview of Sustainability, Design for Sustainability, Sustainable Technology Development, Life Cycle Assessment, Materials Extraction and Resource Implications, Environmental Impacts During Processing, Waste Management and Materials Recycling.

UNIT-II

Green Chemistry, Environmental Protection, Environmentally Friendly Materials, Materials for Green and Renewable Energy, Renewable Energy Policy, Environmental Justice, legislation, Various Policies for Sustainability, etc

UNIT-III

Green processing technologies – low liquor technologies, ozone, super critical carbon dioxide and ultrasound technologies. Technologies using organic and natural fibers, process technologies using new enzymes and foam technology, lowsalt reactive dyes, combined dyeing and finishing.

UNIT-IV

Industrial hazardous waste management, in-plant management, reduction, recycling and disposal of waste. Hazards involved in chemical processing and laws related to environmental protection. Life cycle analysis with case studies, compliance, certification, social accountability and ethical practices. Concept of eco-labels, ISo 14024:2018

Reference Books

1. **Anil Markandya & M.A. Pedroso-Galinato** – *Sustainability: Principles and Practice*, Routledge.
2. **Paul Hawken, Amory Lovins, L. Hunter Lovins** – *Natural Capitalism: Creating the Next Industrial Revolution*, Little, Brown and Company.
3. **Tibor Krajnc & Mojca T. Jerman** – *Life Cycle Assessment and Green Chemistry for Sustainable Engineering*, Elsevier.
4. **Stanley E. Manahan** – *Environmental Chemistry*, CRC Press.
5. **M. Asif and T. Muneer** – *Sustainable Buildings and Infrastructure: Principles and Practice*, Wiley.

Machinability and Damage Analysis of Composite Material

Course code	**26CST23D2**				
Category	Professional Elective Course				
Course Title	Machinability and Damage Analysis of Composite Material				
Scheme and Credits	L	T	P	Credits	Semester–III
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO)
By the end of this course, students will be able to:
CO1: Understand various traditional and non-traditional machining methods used for composite materials.
CO2: Analyze the machinability of composite materials considering anisotropy, tool wear, delamination, and heat generation.
CO3: Evaluate different joining techniques for composites, including adhesive and mechanical joints, and their failure modes.
CO4: Identify damage mechanisms in composites such as matrix cracking, delamination, and fiber breakage, and their effects on structural performance.
CO5: Apply experimental and numerical techniques for damage analysis, including multiscale and damage tolerance analysis, to ensure design safety and longevity.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Importance of Machinability, Machining Methods: Traditional Machining Methods, Drilling, Turning, Milling, Grinding. Non-Traditional Machining Methods: Laser Machining, Waterjet Machining, Ultrasonic Machining, Electro-Discharge Machining (EDM). Factors Influencing Machinability: Composite Type, Reinforcement Material, Matrix Material, Cutting Parameters, Tool Geometry and Material: Specific Considerations for Composites during: Anisotropy, Abrasiveness, Delamination, Fiber Pull-Out, Heat Generation.

UNIT-II

Joining of Composite Materials ,Adhesive Bonding ,Failure Modes in Adhesive Bonding , Basic Science of Adhesive Bonding , Adsorption Theory ,Mechanical Theory , Electrostatic and Diffusion Theories , Mechanical Joints ,Failure Modes in a Bolted Joint , Machining and Cutting of Composites ,Failure Mode during Machining of Composites ,Cutting Tools ,Types of Machining Operations ,Cutting Operation ,Waterjet Cutting ,Laser Cutting ,Drilling Operation ,Recycling of Composites.

UNIT-III

Challenges in Machining Composites: Anisotropy and Non-Homogeneity, Abrasiveness of Reinforcements, Damage to Workpiece, Tool Wear. Factors Affecting Machinability, Tool Material and Geometry, Cutting Parameters, Reinforcement Type and Volume Fraction, Matrix Material,

UNIT-IV

Damage in composites, importance, causes, impact, Damage Mechanisms in Composites: Matrix Cracking, Delamination, Fiber Breakage, Other Defects: Porosity, fiber-matrix debonding, and other manufacturing flaws can also contribute to damage. Analysis Techniques of composite damage: Experimental Testing, Overview of damage modeling, Multiscale Analysis, Damage Tolerance Analysis: Importance of Damage Analysis: Ensuring Safety, Optimizing Design, Extending Service Life, Examples of Damage Analysis in Practice: Impact Damage, Fatigue Damage, Delamination Analysis.

Reference Books

1. Davim, J. Paulo – Machining of Composite Materials, Springer.
2. K. Friedrich & U. Breuer – Composite Materials: Functional Materials for Modern Technologies, Wiley-VCH.
3. Peter Beaumont, A. Kelly, and Nicholas P. Suvorov – Structural Integrity and Durability of Advanced Composites, Woodhead Publishing.
4. D. Hull and T.W. Clyne – An Introduction to Composite Materials, Cambridge University Press.
5. Mallick, P.K. – Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press.

Vibration, Fatigue and Fracture Mechanics

Course code	**26CST23D3**				
Category	Professional Elective Course				
Course Title	Vibration, Fatigue and Fracture Mechanics				
Scheme and Credits	L	T	P	Credits	Semester–III
	4	0	0	4	
Branch	Composite Science and Engineering				
Class work	50 Marks				
Exam	100 Marks				
Total	150 Marks				
Duration of Exam	03 Hours				

Course Outcome (CO):

By the end of this course, students will be able to:

CO1: Understand and model mechanical vibrations in single and multi-degree of freedom systems and apply vibration control strategies.
CO2: Analyze fatigue behavior in composite materials, including fatigue testing methods and life prediction models.
CO3: Classify and interpret fracture mechanisms, including ductile, brittle, and fatigue fracture across materials.
CO4: Evaluate stress intensity factors, fracture toughness, and the influence of fiber–matrix interactions in composite failure.
CO5: Apply micro- and macro-mechanical modeling approaches for analyzing crack propagation, delamination, and interfacial fracture in composites**.**

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction to Vibration, basics of mechanical vibrations, single and multi-degree of freedom systems, Fundamentals of Oscillation, Sources of Vibration, Modeling Mechanical Systems, free and forced vibrations, damping, Undamped Free Vibration, Damped Free Vibration, Resonance, vibration isolation, Vibration Absorbers, and vibration control methods, and measurement

UNIT-II

Fundamentals of fatigue, Importance of fatigue in the composite structure, Classification of fatigue, Mechanics of Fatigue damage, Different fatigue test Methods: Tension fatigue, Bending fatigue, Residual strength models, Residual stiffness models, Progressive damage models, Prediction of fatigue life, Modeling fatigue in composites: Damage accumulation, Crack Nucleation Approaches, Crack Growth Approaches,

UNIT-III

Introduction to Fracture Mechanics, Definition and Importance of Fracture Mechanics, Historical Development and Key Milestones, Types of Fracture: Ductile, brittle, intergranular, and fatigue fracture. Modes of Fracture: Mode I (opening), Mode II (shearing), and Mode III (tearing), Overview of Fracture Mechanics in Different Materials, Stress Intensity Factor and Fracture Toughness.

UNIT-IV

Crack Propagation and Failure Modes in Composites: Material Properties: Influence of fiber, matrix, and interface properties on fracture behavior, Delamination: Analysis of delamination cracks in layered composites, Toughening Mechanisms: Methods to enhance fracture resistance in composites, Micro- and Macro-mechanical Models: Approaches to modeling fracture processes in composites, Interfacial Fracture: Fracture behavior at the interface between fiber and matrix.

Reference Books

1. **S.S. Rao** – Mechanical Vibrations, Pearson.
2. **T.L. Anderson** – Fracture Mechanics: Fundamentals and Applications, CRC Press.
3. **J. Schijve** – Fatigue of Structures and Materials, Springer.
4. **D.R. Henshall & W.D. Pilkey** – Peterson's Stress Concentration Factors, Wiley.
5. **P. Paris & F. Erdogan** – Fatigue and Fracture Mechanics of Composites, ASTM STP Series.

Fundamentals of Aerodynamics and Aerospace Vehicles

<table>
<tr><td>Course code</td><td colspan="5">26CST23D4</td></tr>
<tr><td>Category</td><td colspan="5">Professional Elective Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Fundamentals of Aerodynamics and Aerospace Vehicles</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–III</td></tr>
<tr><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">100 Marks</td></tr>
<tr><td>Total</td><td colspan="5">150 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Course Outcomes:

By the end of the course, the students will be able to:

CO1: Understand and explain fundamental aerodynamic variables and principles, including aerodynamic forces, moments, and center of pressure.
CO2: Apply dimensional analysis and the Buckingham Pi theorem to evaluate fluid flow similarities and related aerodynamic problems.
CO3: Analyze inviscid and incompressible flows over airfoils and wings using potential flow and profile theory.
CO4: Evaluate aircraft motion and flight performance by applying equations of motion, including analysis of stability and controllability.
CO5: Demonstrate foundational knowledge in conceptual aircraft design, including configuration, aerodynamic design, propulsion systems, materials, and economic assessment.
NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.
\UNIT-I

Introduction and Importance of aerodynamics, some fundamental Aerodynamics variables, Aerodynamic forces and moments, centre of pressure, Dimensional Analysis, The Buckingham Pi theorem, Flow similarity, Fluid statics, Buoyancy force.

UNIT-II

Types of flow, Fundamentals of Inviscid, Incompressible flow, Incompressible flow over Air foils, Incompressible flow over finite wings, Calculation of inviscid flows using potential theory and the profile theory using skeleton and droplet theory, Wing theory covering induced drag and circulation distribution, Analysis of friction effects using boundary layer theory.

UNIT-III

Equations of motion for aircraft, the forces and moments acting on aircraft, determination of flight performance in all major flight phases and manoeuvres, Controllability and stability about the lateral axis in flight mechanics.

UNIT-IV

Basics in aircraft design during the conceptual phase, certification regulations, design methodology, configurations, methods for mass estimation, cabin layout, aerodynamic design aspects, flight performance, tail design, propulsion concepts, and economic evaluation criteria, Typical materials used in aerospace applications such as aluminium, titanium, magnesium, and nickel alloys, as well as composite materials, properties, microstructures, and stresses.

Reference Books

1 **John D. Anderson, Jr.** – Fundamentals of Aerodynamics, McGraw-Hill Education

2 **John D. Anderson, Jr.** – Introduction to Flight, McGraw-Hill Education

3 **Eugene A. Avallone, Theodore Baumeister** – Marks' Standard Handbook for Mechanical Engineers

4 **Michael J. Kroes, Thomas Wild** – Aircraft Powerplants, McGraw-Hill Education

5 **Daniel P. Raymer –** Aircraft Design: A Conceptual Approach, AIAA Education Series

DISSERTATION STAGE- I

<table>
<tr><td>Course code</td><td colspan="5">26CST23C3</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">DISSERTATION STAGE- I</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–III</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>4</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">100 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">0 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

COURSE OUTCOMES:

By the end of this course every student is expected to be able to

CO1: Understand the process of research.
CO2 To do the literature survey to identify a research problem.
CO3: Communicate and discuss research ideas.
CO4: To find out the research gaps
CO5: Plan and write dissertation synopsis.

A candidate has to prepare a report covering identification of research topic, literature review, planning of research scheme and systematic documentation. The marks will be given on the basis of a report prepared covering the above said contents, contents of the presentation, communication and presentation skills.

Seminar

<table>
<tr><td>Course code</td><td colspan="5">26CST23C4</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Seminar</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–III</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">50 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">0 Marks</td></tr>
<tr><td>Total</td><td colspan="5">50 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Course Objectives:

At the end of this course the student shall be able to

CO1: Identify and prepare relevant content on a recent technical topic or research advancement.
CO2: Organize and structure a technical seminar presentation effectively.
CO3: Deliver a technical presentation confidently with clarity and coherence.
CO4: Demonstrate improved verbal and non-verbal communication skills in a professional setting.
CO5: Compile and submit a well-structured seminar report reflecting technical understanding and documentation skills.

A candidate has to present a seminar on a recent topic/ technology/ research advancement and has to submit a seminar report. The marks will be given on the basis of seminar report, contents of the presentation, communication and presentation skills.

M.D. UNIVERSITY
SCHEME OF STUDIES AND EXAMINATION
M.TECH 2nd YEAR (COMPOSITE SCIENCE AND ENGINEERING)
FOURTH SEMESTER
CBCS Scheme effective from 2025-26

Sl. No	Course No.	Subject	Teaching Schedule				Examination Schedule (Marks)				No of Credits
			L	T	P	Total	Marks of Class works	Theory	Practical	Total	
1.	27CSE24C1	Dissertation and viva (Dissertation Stage 2)	-	-	-	-	250	-	500	750	**20**
		TOTAL	**Credits: 20**				**Marks: 750**				

Note:

Students have to publish a research paper in a journal / conference of the research work done in the semester.

DISSERTATION and VIVA (Stage-II)

<table>
<tr><td>Course code</td><td colspan="5">27CSE24C1</td></tr>
<tr><td>Category</td><td colspan="5">Professional Core Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Dissertation and Viva (Sage-II)</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–IV</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>20</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
<tr><td>Class work</td><td colspan="5">250 Marks</td></tr>
<tr><td>Exam</td><td colspan="5">500 Marks</td></tr>
<tr><td>Total</td><td colspan="5">750 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

COURSE OUTCOMES:

By the end of this course every student is expected to be able to

CO1: Identify and formulate research problems using appropriate modern tools, techniques, and methodologies.
CO2: Critically review and analyze existing literature to establish the research context and identify gaps.
CO3: Design, plan, and execute experimental investigations to address specific research objectives.
CO4: Prepare well-structured dissertations and technical reports adhering to academic and professional standards.
CO5: Communicate research findings effectively through scholarly publications and presentations.

Students undertake independent research on a selected topic under faculty guidance. In Phase I, they identify a problem, conduct literature review, and define methodology. Phase II involves implementation, analysis, and thesis submission. Continuous evaluation through progress reviews, presentations, and viva-voce. Emphasis on originality, technical depth, and quality documentation. Outcome includes a comprehensive dissertation report and potential publication.

OPEN ELECTIVE
&
FOUNDATION ELECTIVE CORSES

Finite Element Methods and Applications

Course code	**25CST22O1**				
Category	Open Elective Course				
Course Title	Finite Element Methods and Applications				
Scheme and Credits	L	T	P	Credits	Semester–II
	3	0	0	3	
Branch	Composite Science and Engineering				

Course Outcome (COs):
By the end of this course, students will be able to:
CO1: Understand the principles of Finite Element Analysis (FEA) and the basic behavior and types of composite materials.
CO2: Develop finite element formulations for various element types applicable to composites and apply appropriate boundary conditions.
CO3: Model anisotropic composite structures using Classical Lamination Theory (CLT) and incorporate hygrothermal effects.
CO4: Analyze advanced behaviors such as interlaminar stresses, delamination, buckling, and fatigue in composite structures using FEA.
CO5: Execute and interpret FEA simulations using commercial software tools for composite applications and validate the results through case studies.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction to FEA and Composite Materials: Overview of FEA principles and its applications in engineering, Introduction to composite materials, including their types, properties, and manufacturing methods (e.g., Resin Transfer Molding, lamination), Basic concepts of elasticity, stress-strain relationships, and material behavior.

UNIT-II

Finite Element Formulation for Composites: Element types suitable for composite structures (e.g., 1D bar, 2D plane stress/strain, shell elements, solid elements), Shape functions and their role in element formulation, Derivation of stiffness matrices for different element types, Assembly of global stiffness matrix and handling boundary conditions, Numerical integration techniques (e.g., Gauss quadrature).

UNIT-III

Modeling Composite Materials: Modeling anisotropic material properties, Classical lamination theory (CLT) and its application to laminate analysis, Modeling layered composite structures (e.g., stacking sequences, layup definition), Modeling different types of composite structures (e.g., beams, plates, shells), Consideration of hygrothermal effects on composite behavior. Advanced FEA Techniques for Composites: Interlaminar stress analysis, Failure analysis of composite laminates (e.g., Tsai-Wu, Hashin criteria), Delamination analysis and modelling, Buckling analysis of composite structures, Fatigue analysis of composite materials.

UNIT-IV

Practical Aspects of FEA for Composites: Pre-processing: Model creation, mesh generation, material definition, Solution: Solving the FEA problem using commercial software,Post-processing: Interpretation of results, visualization of stresses, strains, and failure parameters, Verification and validation of FEA results. Case studies of FEA applications in composite structures.

Reference Books:

1. **J.N. Reddy** – *An Introduction to the Finite Element Method*, McGraw-Hill.
2. **Robert D. Cook, David S. Malkus, Michael E. Plesha** – *Concepts and Applications of Finite Element Analysis*, Wiley.
3. **Barbero, E.J.** – *Finite Element Analysis of Composite Materials*, CRC Press.
4. **Daniel, I.M. and Ishai, O.** – *Engineering Mechanics of Composite Materials*, Oxford University Press.
5. **Zienkiewicz, O.C., Taylor, R.L.** – *The Finite Element Method*, Butterworth-Heinemann.

Composites for Building Materials

Course code	**25CST22F1**				
Category	Foundation Elective Course				
Course Title	Composites for Building Material				
Scheme and Credits	L	T	P	Credits	Semester–II
	2	0	0	2	
Branch	Composite Science and Engineering				

Course Outcome (COs):

By the end of this course, students will be able to:

CO1: Classify and compare traditional and modern building materials, including clay, stone, wood, glass, and metal-based materials.
CO2: Understand the properties and applications of various composite materials used in construction such as FRPs, WPCs, MMCs, and CMCs.
CO3: Analyze the structural benefits and limitations of using composites in architectural and civil engineering applications.
CO4: Explain the design and performance characteristics of Textile Reinforced Concrete (TRC) and fibre-reinforced rebars in modern construction.
CO5: Evaluate the environmental, mechanical, and functional advantages of advanced composites including nanotechnology integration in building materials.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Introduction and classification of building materials: Clay products and alternatives like Fly-ash, CEB, CSEB, Stone, stone tiles and stone dust blocks Wood and engineered wood, Glass and glazing systems, ceramic tiles, vitrified tiles, insulation, Fine aggregate, Coarse aggregate, Cement, Concrete, Precast items – flooring, roofing, walling system, HBC, AAB, Ferrous and non-ferrous metals, Bitumen as damp proofing materials, Paints, plastics, Polycarbonate roofing material, Fibre reinforced sheet materials, Composites.

UNIT-II

Types of Composite Materials in Construction: Fiber-Reinforced Polymers (FRPs), High performance fibers (glass, carbon, etc.) reinforced polymer matrix composites for various applications like structural reinforcement, cladding, and bridge construction, Wood-Plastic Composites (WPCs), WPCs for decking, siding, and fencing, Reinforced Concrete, Combination of concrete and steel reinforcement (rebar) for high tensile strength and ductility, Metal Matrix Composites (MMCs), Combination of metal matrix with other materials (like ceramic particles) for improved strength, wear resistance, and high-temperature performance.

UNIT-III

Ceramic Matrix Composites (CMCs), Combination of ceramic materials with other phases to enhance fracture toughness and thermal shock resistance suitable for high-temperature applications, Advantages of Using Composites in Building Materials: Increased Strength and Durability, Reduced Weight, Corrosion Resistance, Design Flexibility, Sustainability, In-situ Repair and Strengthening, Nanotechnology applications in construction industry.

UNIT-IV

Textile Reinforced concrete (TRC): Chopped fibre reinforced concrete, Textile structure reinforced concrete, 3D fabric reinforced concrete, Advantages of TRC, Applications of TRC: Retrofitting, Non-structural elements like facade panels, window frames, and other architectural elements, Structural elements in load-bearing structures like walls, slabs, and beams, Thin-walled structures for creating thin, lightweight structures with complex shapes. Fibre reinforced rebar, properties, applications, advantages.

Reference Books

1. **Mallick, P.K.** – *Fiber-Reinforced Composites: Materials, Manufacturing, and Design*, CRC Press.
2. **Chung, D.D.L.** – *Composite Materials: Science and Applications*, Springer.
3. **Agarwal, B.D. and Broutman, L.J.** – *Analysis and Performance of Fiber Composites*, Wiley.
4. **Mehta, P.K., Monteiro, P.J.M.** – *Concrete: Microstructure, Properties, and Materials*, McGraw-Hill Education.
5. **Krosse, P. and Krause, D.** – *Textile Reinforced Concrete*, CRC Press.

Fundamentals of Plastics Engineering

<table>
<tr><td>Course code</td><td colspan="5">26CST23O1</td></tr>
<tr><td>Category</td><td colspan="5">Open Elective Course</td></tr>
<tr><td>Course Title</td><td colspan="5">Fundamentals of Plastics Engineering</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester–III</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Branch</td><td colspan="5">Composite Science and Engineering</td></tr>
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Course Outcome (CO)
By the end of this course, students will be able to:

CO1: Identify various types of plastics and understand global trends and production methods.
CO2: Analyze plastic manufacturing processes such as injection molding, extrusion, thermoforming, and additive manufacturing.
CO3: Evaluate the environmental challenges associated with plastic waste and explore conventional and advanced recycling methods.
CO4: Explain the physical and chemical properties of plastics and their relevance to engineering and industrial applications.
CO5: Assess sustainability approaches including bioplastics, microplastic mitigation, and circular economy principles in plastic engineering.

NOTE: Examiner will set nine questions in total. Question One will be compulsory and will comprise of all section and remaining eight questions to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each Unit.

UNIT-I

Overview of plastic production: global plastic production, types of polymers commonly used, such as polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), and polyethylene terephthalate (PET). Classification of Plastics: classification based on chemical composition, biodegradability and recyclability. Plastics processes and technologies: additive manufacturing, blow molding, compounding, robotic automation, injection molding, pressing and extrusion, feeding and blending, heating and cooling, drying, thermoforming and resin conveying, process phenomenology and process control in plastics technologies.

UNIT-II

Plastic Waste Management: Conventional methods, landfilling and incineration, limitations and environmental impact. Recycling Technologies: mechanical recycling (collection, sorting, shredding, washing, and extrusion) and chemical recycling (pyrolysis, gasification, etc.). Upcycling and Valorisation: use of microbial or enzymatic degradation to create valuable chemical intermediates. Bioplastics: development and applications of bioplastics (biodegradable and bio-based plastics) as alternatives to traditional plastics. Environmental Impact of Plastic

Pollution: Sources of plastic pollution: land-based sources (litter, landfills), marine sources (ocean currents, fishing nets). Impacts on ecosystems: Examining the effects of plastic pollution on marine life, human health, and ecosystems.

UNIT-III

Microplastics: formation and impacts of microplastics on the environment and human health. Circular Economy and Sustainable Solutions: Circular economy principles to minimize waste and maximize resource utilization. Policy and regulations: role of government policies, regulations, and initiatives in promoting sustainable plastic management. Design for recycling: importance of designing plastics that are easier to recycle and reduce the complexity of waste management, Advanced recycling technologies, Physical Properties of plastic: Lightweight, Strength and Durability, Flexibility and Malleability, Low Thermal Conductivity, Low Electrical Conductivity, Resistant to Corrosion and Chemicals, Varying Density, Tensile Strength, Glass Transition Temperature, Transparency or Opacity, Wear Resistance.

UNIT-IV

Chemical Properties: Chemical Stability, Reactivity, Biodegradability, Recyclability, Mechanics of plastics: Concepts in Plasticity, Elastic Deformation, Plastic Deformation, Yielding, Strain Hardening, Flow Stress, Factors Influencing Plastic Behavior: Intermolecular Forces, Temperature, Time Under Load, Crystallinity, Molecular Weight. Mechanisms of Plastic Deformation: Slip, Twinning, Viscous Flow. Machining of plastics: weldability, machinability, formability, castability, high strength, wear resistance), Practical Applications: Manufacturing, Engineering Design. Constructions, packaging, construction, automotive, and medical fields.

Reference Books

1. **A. Brent Strong** – *Plastics: Materials and Processing*, Pearson.
2. **Tim A. Osswald** – *Polymer Processing Fundamentals*, Hanser Publishers.
3. **Myer Kutz** – *Applied Plastics Engineering Handbook*, William Andrew Publishing.
4. **Rosato, D.V. and Rosato, D.V.** – *Injection Molding Handbook*, Springer.
5. **Elsner, P. & Henning, F.** – *Plastics in Automotive Engineering*, Hanser Publishers.