GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Aeronautical Engineering
Subject Code: BE05001051
Subject Name: Composite Materials

w.e.f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 1

Prerequisite:	Mechanics of Solids
Rationale:	Composite materials play a vital role in modern aviation, being widely used in the production of various aircraft components. Their exceptional strength-to-weight ratio makes them highly suitable for aerospace applications, as they contribute to improved fuel efficiency, performance, and structural integrity. In addition to weight reduction, composites offer advantages such as corrosion resistance, design flexibility, and enhanced durability. This subject is designed to provide students with a comprehensive understanding of the mechanical behavior of composite materials, along with fundamental design principles and practical considerations for their effective application in engineering structures.

Course Outcomes:

Sr. No.	CO statement	RBT Level
CO1	Develop an understanding of fundamental terminologies, key concepts, and mechanical behavior of composite materials, along with their applications in the aerospace industry.	Remember, Understand, Application
CO2	Explain and apply the principles of micromechanics and lamination theory to analyze composite material systems.	Remember, Understand
CO3	Select appropriate constituent materials and identify suitable combinations for designing composite structures based on required performance.	Remember, Understand
CO4	Evaluate the elastic properties of composite laminates and perform basic simulations to predict their mechanical behavior.	Evaluate Application
CO5	Analyze and establish stress–strain relationships in different types of composite laminates under various loading conditions.	Understand, Analyze

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	TW/SL (I)	ESE (V)	
45	0	02	15	90	03	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Content:

Module No.	Detailed Contents	Hours	% Weightage
1	**Fundamentals of Composite Materials** Basic definitions and concepts of composite materials, Types and properties of fibers and matrix materials, Introduction to prepregs, fillers, lamina, and laminates. Basic micromechanics and mechanical behavior of composites. Overview of composite material properties and applications.	**4**	15%
2	**Aerospace Materials and Applications** Introduction to aerospace materials and their requirements. Study of aluminum alloys, FRP, glass and carbon composites. Overview of fibers, resins, and super alloys. Emerging trends and applications of composite materials in the aerospace industry.	**8**	20%
3	**Micromechanical Analysis of Composite Materials** Study of properties of typical composite materials. Concepts of volume fraction and weight fraction. Evaluation of longitudinal strength and stiffness. Determination of transverse modulus and in-plane shear modulus. Analysis of Poisson's ratio and its significance in composite behavior.	**13**	20%
4	**Elastic Properties of Unidirectional Lamina** Introduction to elastic behavior of unidirectional lamina. Stress–strain relationships for different material systems including Anisotropic, monoclinic, specially orthotropic, transversely isotropic, and isotropic materials. Definition and evaluation of engineering constants. Formulation of stress–strain relations for a thin lamina under different loading conditions.	**9**	20%
5	**Analysis of Laminated Composites** Introduction to laminated composites and their basic assumptions. Strain–displacement and stress–strain relationships in laminates. Formulation of equilibrium equations and evaluation of laminate stiffness. Classification of laminate configurations including symmetric, balanced, anti-symmetric, quasi-isotropic, and unsymmetrical laminates.	**11**	25%

Total		**Hours**	**100%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
35	**35**	**10**	**10**	**10**	**-**

R: Remembrance; U: Understanding; A: Application; N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guide line for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of *Composite Material* directly contributes to

Sr. No.	SDG No.	Relevance to Syllabus
1	**SDG 7**	**Affordable and Clean Energy** – Lightweight composite materials reduce aircraft weight, resulting in lower fuel consumption and improved energy efficiency.
2	**SDG 9**	**Industry, Innovation and Infrastructure** – Advanced composite materials encourage innovation in aerospace manufacturing and improve aircraft strength and performance.
3	**SDG 11**	**Sustainable Cities and Communities** – Composite-based lightweight aircraft support sustainable transportation with reduced environmental impact.
4	**SDG 12**	**Responsible Consumption and Production** – Recycling and development of eco-friendly composite materials promote sustainable production practices in the aviation sector.
5	**SDG 13**	**Climate Action** – Use of composite materials helps reduce carbon emissions by decreasing aircraft mass and fuel usage.

Reference Books:

1. Mechanics of Composite Materials and Structures – Madhujit Mukhopadhyay, University Press.
2. Mechanics of Composite Materials – R. M. Jones, CRC Press.
3. Aerospace Materials and Material Technologies Volume 1 – Edited by N. Eswara Prasad and Russell Wanhill.
4. Introduction to Metal Matrix Composites – T. W. Clyne and P. J. Withers, Cambridge University Press, 1993.

List of Experiments:

1. Study and evaluate the properties of different composite materials using standard data and literature.
2. Analyze isotropic, anisotropic, and orthotropic material behavior with suitable examples.
3. Compare symmetric and unsymmetric laminate configurations based on their structural performance.
4. Study the design concept and working of sandwich composite plates with honeycomb core.
5. Analyze stress distribution around discontinuities (such as holes or cut-outs) in composite plates.
6. Evaluate and interpret the stiffness matrix of composite laminates.
7. Perform mathematical analysis of strain–displacement and stress–strain relationships in composite materials.
8. Conduct analysis of composite materials using ANSYS software.

List of Open Source Software/learning website:
https://nptel.ac.in/

List of suggested activities for Problem-based Learning (PBL):

Sr.No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power converters/electronics/drives company)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing /	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.

	Research Writing	Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solvingtargeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluation critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	MicroProject	Working/non-working model on technical topics	Working = 10hrs Non-working = 10hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technicaltopics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth,knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10hrs	Based on quiz scores and reflection report after each quiz.
9	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject *Composite Materials*;

   These activities are incorporated as integral Project-Based Learning (PBL) components.

These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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