

MTPE3008 COMPOSITE MATERIALS (3-0-0)

Objectives of the Course:

This course aims to introduce students to the principles, fabrication methods, properties, and applications of composite materials used in advanced engineering systems. It focuses on the structure–property relationships, reinforcement mechanisms, and processing techniques of fiber-reinforced, particle-reinforced, and laminated composites. Emphasis is given to metal, polymer, and ceramic matrix composites, their mechanical behavior, testing, and industrial relevance in aerospace, automotive, marine, and defense sectors.

Module – I: (06 hours)

Introduction and Fundamentals

Definition and classification of composite materials. Historical development and importance of composites in modern engineering. Comparison between composites and conventional engineering materials (metals, ceramics, polymers). Components of a composite: matrix, reinforcement, and interface. Role of reinforcement and matrix — load transfer, stiffness, and toughness improvement. Advantages, limitations, and areas of application.

Module – II: (06 hours)

Reinforcements and Matrices

Types of reinforcements: fibers, whiskers, and particles. Fiber materials — glass, carbon, aramid, boron, silicon carbide, alumina fibers. Fiber properties, orientation, and aspect ratio effects. Matrices: polymer, metal, and ceramic matrices — properties and selection criteria. Interface characteristics — bonding, wettability, and chemical stability.

Module – III: (06 hours)

Processing and Fabrication Techniques

Polymer Matrix Composites (PMCs): hand lay-up, spray-up, filament winding, pultrusion, resin transfer molding (RTM), and compression molding. Metal Matrix Composites (MMCs): powder metallurgy route, stir casting, squeeze casting, diffusion bonding, and infiltration methods. Ceramic Matrix Composites (CMCs): sol-gel, slurry infiltration, hot pressing, and chemical vapor infiltration (CVI). Fabrication of laminated composites. Processing parameters, defects, and quality control.

Module – IV: (06 hours)

Mechanical Behavior and Testing

Stress–strain behavior and failure modes of composites. Rule of mixtures and micromechanical analysis. Longitudinal and transverse modulus and strength of unidirectional composites. Mechanical testing — tensile, flexural, impact, hardness, and interlaminar shear strength tests. Environmental effects — temperature, humidity, and radiation.

Module – V: (06 hours)

Applications and Recent Developments

Hybrid composites and sandwich panels. Tribological behavior and wear resistance. Applications in aerospace, marine, automotive, defense, and biomedical fields. Nanocomposites and smart composites — concept and future trends.

Course Outcomes:

After completing this course, the student will be able to:

- CO1: Explain the structure, classification, and roles of various components in composite materials.
- CO2: Analyze the mechanical behavior of composites using micromechanical and macromechanical models.
- CO3: Evaluate different fabrication methods for polymer-, metal-, and ceramic-matrix composites.
- CO4: Perform testing and analysis to determine the strength, stiffness, and durability of composites.

Books:

1. K. K. Chawla. Composite Materials: Science and Engineering, Springer.
2. M. F. Ashby & D. R. H. Jones. Engineering Materials Vol. II: An Introduction to Microstructures, Processing and Design, Elsevier.
3. D. Hull & T. W. Clyne. An Introduction to Composite Materials, Cambridge University Press.

Reference Books:

1. R. M. Jones. Mechanics of Composite Materials, Taylor & Francis.
2. A. Kelly & C. Zweben. Comprehensive Composite Materials, Elsevier.
3. Bhattacharya, S. K. Metal Matrix Composites, Narosa Publishing House.
4. Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K. Analysis and Performance of Fiber Composites, Wiley.

Digital Learning Resources:

Course Name: Introduction to Composite Materials

Course Link: <https://nptel.ac.in/courses/112/104/112104319>

Course Instructor: Prof. K. Gopalakrishnan, IIT Madras

Course Name: Composite Materials

Course Link: <https://nptel.ac.in/courses/112/107/112107292>

Course Instructor: Prof. S. Suwas, IISc Bangalore