

MSE6182: POLYMERS AND COMPOSITES AND NANO-APPLICATIONS

Effective Term

Semester A 2025/26

Part I Course Overview

Course Title

Polymers and Composites and Nano-applications

Subject Code

MSE - Materials Science and Engineering

Course Number

6182

Academic Unit

Materials Science and Engineering (MSE)

College/School

College of Engineering (EG)

Course Duration

One Semester

Credit Units

3

Level

P5, P6 - Postgraduate Degree

R8 - Research Degree

Medium of Instruction

English

Medium of Assessment

English

Prerequisites

Nil

Precursors

Nil

Equivalent Courses

AP6182 Polymers and Composites-with an Introduction to Their Nano-applications (From the old curriculum)

Exclusive Courses

AP8182 Polymer and Composites-with an introduction to their Nano-applications (From the old curriculum)

Part II Course Details

Abstract

This course aims to develop basic research skills and introduce recent research developments in polymer science and engineering. This course covers basic knowledge on molecular structure of polymers, physical & chemical properties of polymers and their composites, micromechanic theories of polymer composites, as well as polymer composites with various functions. In addition, up-to-date applications of polymers and composites, as well as advanced nanocomposites including self-healing materials, thermally conductive materials and biomimetic composites will be discussed.

Course Intended Learning Outcomes (CILOs)

| CILOs | | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|-------|---|---------------------|--------|--------|--------|
| 1 | Describe the molecular nature, polymerization approaches and properties of polymers. | 25 | x | x | |
| 2 | Apply experimental techniques to characterize the behavior of polymers and composites. | 25 | x | x | x |
| 3 | The innovative design of polymer matrix composites targeting mechanical reinforcement and thermal conductivity improvement etc. | 30 | x | x | x |
| 4 | Identify various functional polymers & their composites, including self-healing materials and biomimetic composites etc. | 20 | x | x | x |

A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

| LTAs | Brief Description | CILO No. | Hours/week (if applicable) | |
|------|-------------------|---|----------------------------|---|
| 1 | Lecture | Students will engage in formal lectures to gain knowledge about key concepts; chain structure of polymer molecules, thermal properties of polymers, processing methods, performances, structures and functions of polymer composites. | 1, 2, 3, 4 | 2 |

| | | | | |
|---|--------------|---|------------|--|
| 2 | Tutorials | Students will engage in tutorial activities to identify strengths and weaknesses and increase their knowledge and skills. | 1, 2, 3, 4 | 1 |
| 3 | Assignments | Students will engage in completing the assignments at home to check and consolidate their learnings. | 1, 2, 3 | 1 |
| 4 | Presentation | Students will participate in groups to present a topic related to science and engineering of polymer or polymer composites. | 1, 2, 3, 4 | 3 hrs/wk for 1 or 1.5 weeks (Depending on the size of class) |

Assessment Tasks / Activities (ATs)

| | ATs | CILO No. | Weighting (%) | Remarks ("- " for nil entry) | Allow Use of GenAI? |
|---|------------------|------------|---------------|------------------------------|---------------------|
| 1 | Assignments | 1, 2, 3, 4 | 10 | - | No |
| 2 | Presentation | 1, 2, 3, 4 | 10 | - | Yes |
| 3 | Middle Term Exam | 1, 2, 3, 4 | 20 | - | No |

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Assessment Rubrics (AR)**Assessment Task**

Assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

CAPABILITY for SELF-DIRECTED learning and problem solving

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

ABILITY to explain a topic related to polymer or their composites, including their background, current problems and potential solutions.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Middle Term Exam (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

ABILITY to understand structure, properties, performances and functions of polymers.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

ABILITY to understand structure, properties, performances and functions of polymers and composite materials as a whole.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

CAPABILITY for SELF-DIRECTED learning and problem solving

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

ABILITY to explain a topic related to polymer or their composites, including their background, current problems and potential solutions.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Middle Term Exam (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

ABILITY to understand structure, properties, performances and functions of polymers.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

ABILITY to understand structure, properties, performances and functions of polymers and composite materials as a whole.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not even reaching marginal level

Part III Other Information

Keyword Syllabus

- Macromolecules.
- Copolymers.
- Physical characterization techniques in polymer science.
- Viscoelasticity and rubber elasticity.
- Micromechanics for polymer matrix composites.
- Natural and synthetic fibre reinforced polymer composites. Thermosetting and thermoplastic matrices. Fibre properties
- Fibre-polymer interface
- Roles of the interface. Types of interfaces. Characterization of interfaces.

- Behaviour of composite laminae. Density and fibre content. Iso-strain and iso-stress models. Halpin-Tsai equation. Longitudinal tensile strength prediction. Transverse tensile strength prediction. Compression behaviour. Hygrothermal behaviour.
- Mechanics of laminae
- Transformation of stress and strain. Constitutive equations for orthotropic lamina.
- Failure criteria
- Maximum stress theory. Maximum strain theory. Tsai-Wu failure criterion.
- Processing of polymer composites
- Hand lay-up. Vacuum bag and autoclaving. Pultrusion. Filament winding.
- Short fibre composites
- Load-transfer length and critical fibre length. Tensile, fracture and toughness properties.
- Metal matrix and ceramic matrix composites.
- Biomimetic polymer composites
- Polymer nanocomposites
- Carbon nanotube/graphene nanocomposites. Clay-polymer nanocomposites. Intercalation and exfoliation. Potential applications.

Reading List

Compulsory Readings

| Title | |
|-------|-----|
| 1 | N/A |

Additional Readings

| Title | |
|-------|--|
| 1 | R J Young and P A Lovell, "Introduction to polymers", CRC press, 2011. (QD381 .Y68 2011)F L Matthews and R D Rawlings, "Composite materials: engineering and science", Chapman and Hall (1994). TA418.9.C6 M33 1999 |
| 2 | F L Matthews and R D Rawlings, "Composite materials: engineering and science", Chapman and Hall (1994). TA418.9.C6 M33 1999B D Agarwal and L J Broutman, "Analysis and performance of fibre composites, 2nd ed", John Wiley and Sons (1990). TA418.9.C6 A34 2006 |
| 3 | B D Agarwal and L J Broutman, "Analysis and performance of fibre composites, 2nd ed", John Wiley and Sons (1990). TA418.9.C6 A34 2006L H Sperling, Introduction to Physical Polymer Science, 4th Edition, Wiley, 2006. (QD381.S635 2006) |
| 4 | L H Sperling, Introduction to Physical Polymer Science, 4th Edition, Wiley, 2006. (QD381.S635 2006)I M Ward and J Sweeney, An Introduction to The Mechanical Properties of Solid Polymers, 2nd Edition, Wiley, 2004. (TA455.P58 W36 2004) |
| 5 | I M Ward and J Sweeney, An Introduction to The Mechanical Properties of Solid Polymers, 2nd Edition, Wiley, 2004. (TA455.P58 W36 2004) |