MNE4120: BIOINSPIRED COMPOSITES: DESIGN, MECHANICS AND MANUFACTURING

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Bioinspired Composites: Design, Mechanics and Manufacturing

Subject Code
MNE - Mechanical Engineering
Course Number
4120

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MNE2110 Engineering Materials

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

Modern industries such as aircraft/spacecraft, high-speed vessels, sport cars, and electronic devices depend on high-performance composite materials. These advanced composites call for innovations in structural designs that are achievable by learning from nature.

This course aims to introduce fascinating biological and bioinspired structural composites that encompass the design, mechanics, and manufacturing. This includes the ingenious biological materials and bioinspired designs, the classical micromechanical models used in engineering practice, and the manufacturing techniques of composites.

Students will be equipped with exciting, inter-disciplinary knowledge to understand the design tactics of natural materials for developing novel bioinspired composites, and to analyze the lightweight, high-specific strength and toughness composites for diverse technologies.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the basic concepts of biological and engineering composites, and explain the distinct features of the two.		x	x	
2	Identify how biological materials promote the innovation of engineering composites.		x	x	
3	Apply micromechanical theories to quantitatively analyse the overall mechanical properties of composites based on the constituents and structure.		x	x	x
4	Demonstrate abilities of critical thinking and problem solving by literature review, topics selection, and academic presentation.		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	The lectures will cover contents including structural design, micromechanics, and manufacturing of biological and engineering composites; the format of lectures will be in classroom teaching; with a sequence of pre-class quizzes/ preview, lecture, and homework problems, to enhance assimilation and application. Tutorials will be focusing on applying micromechanical analysis on composites led by the lecturer.	1, 2, 3, 4	3 hrs for 11 weeks
2	Classroom Presentation	Based on insightful and interesting topics from the learned knowledge, students will be guided to formulate important and specific problems and provide preliminary solution plans by giving an academic presentation.	1, 2, 3, 4	3 hrs for 2 weeks

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Quizzes and Assignments	1, 2, 3	30	Quizzes during each classroom teaching and assignments throughout the semester.	No
2	Classroom Presentation	1, 2, 3, 4	30	One individual classroom presentation.	Yes

Continuous Assessment (%)

60

Examination (%)

40

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

30

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Assessment Rubrics (AR)

Assessment Task

Quizzes and Assignments

Criterion

Understand and describe basic concepts, theories, and fabrication of biological and engineering composites. Explain the idea and methodology of developing bioinspired composites.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even reaching marginal levels

Assessment Task

Classroom Presentation

Criterion

Identify cases that create advanced engineering composites and systems with inspirations from biological materials and structures, explain design and manufacturing processes, and summarize the problem and solutions by a clear, logical academic presentation.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
Describe the key concepts, principles, and methodologies of biological and engineering composites. Understand key, classical theories for analyzing the overall mechanical behaviors of composites.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Additional Information for AR
Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus
- Composite material;
- Biological material;
- Heterogeneous material;
- Hierarchical structure;
- High designability;
- Micromechanics;
- Eshelby theory;
- Self-consistent scheme;
- Shear-lag theory;
- Tension-shear-chain model;
- Composite manufacturing;

Reading List

Compulsory Readings

	Title
1	Meyers MA and Chen P-Y. 2014. Biological Materials Science. Cambridge University Press.

Additional Readings

	Title
1	Chawla KK. 2019. Composite Materials: Science and Engineering. 4th edition. Springer.
2	Janine MB. 1997. Biomimicry: Innovation Inspired by Nature. William Morrow.
3	Fitzgerald RW. 1982. Mechanics of Materials. 2nd edition. Addison-Wesley Publishing Company.
4	Strong AB. 2008. Fundamentals of Composites Manufacturing: Materials, Methods and Applications, 2nd edition. Society of Manufacturing Engineers, Dearborn, Michigan.
5	Yin HM and Zhao YT. 2016. Introduction to the Micromechanics of Composite Materials. CRC Press.