

MNE4120: BIOINSPIRED COMPOSITES: DESIGN, MECHANICS AND MANUFACTURING

Effective Term

Semester A 2024/25

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 DEC-A1 DEC-A2 DEC-A3 app.)			
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 (e.g. Parameter for GenAI use)
1	Quizzes and Assignments	1, 2, 3	30	Quizzes during each classroom teaching and assignments throughout the semester.
2	Classroom Presentation	1, 2, 3, 4	30	One individual classroom presentation.

Continuous Assessment (%)

60

Examination (%)

40

Examination Duration (Hours)

2

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.