MNE6115: BIO-INSPIRED ROBOTS

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Bio-Inspired Robots

Subject Code
MNE - Mechanical Engineering

Course Number
6115

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
BME6115 Biorobotics

Exclusive Courses
Nil

Part II Course Details

Abstract
This course aims to expose students to the robotic systems developed by applying concepts from nature to the design of real world engineered systems. The objective is for students to learn the principles behind the bio-inspired robots from

biological examples and how they are implemented in robotic systems. Dynamics and locomotion will be discussed. The course intends to enhance students' skills for understanding of dynamics, physics of scaling, and locomotion, taking inspiration from nature.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	To compare and give account of the engineering, bio-inspired, and biomimetic systems.		x	x	
2	To derive the dynamics and governing laws for flying, walking, and different locomotion seen in creatures and robots.			x	
3	To examine the basics of multi-agent and decentralised systems in biology and demonstrate their applications and potential in robotic systems.			x	
4	To analyse and identify additional underlying principles of biological systems of interest and illustrate how to critically apply them to engineering systems.			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 main teaching activity.	1, 2, 3	2 hrs/week
2	Discussion	Seminar-style interactive discussion between students themselves and the instructor based on given topics and readings.	4	1 hr/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Mid-term test	1, 2, 3	60	
2	Group report and presentation	4	40	Maximum group size of four students. 10% for the presentation and 30% for the written report.

Continuous Assessment (%)

100

Assessment Rubrics (AR)

Assessment Task

Mid-term exam (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1. ABILITY to IDENTITY/CONTRAST similarities and differences between engineering, bio-inspired, and bio-mimetic systems.
2. ABILITY to EMPLOY robotic principles to ANALYSE different locomotion seen in creatures and robots.
3. ABILITY to EXPLAIN and INTEPRETE the significance of decentralised systems.

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

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

Criterion

1. CAPACITY for SELF-DIRECTED LEARNING to study biological and robotic systems.
2. ABILITY to COMMUNICATE and PRESENT the finding in robotic framework.
3. ABILITY to critically APPLY biological and physic principles to engineering systems.

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

Mid-term exam (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. ABILITY to IDENTITY/CONTRAST similarities and differences between engineering, bio-inspired, and bio-mimetic systems.
2. ABILITY to EMPLOY robotic principles to ANALYSE different locomotion seen in creatures and robots.
3. ABILITY to EXPLAIN and INTEPRETE the significance of decentralised systems.

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Failure

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Assessment Task

Group report and presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. CAPACITY for SELF-DIRECTED LEARNING to study biological and robotic systems.
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Part III Other Information

Keyword Syllabus

Bio-inspired and bio-mimetic, Flying, Aerial robots, Flapping-wing robots, Terrestrial robots, Walking, Limit cycle, Dynamics, Stability, Physics of scaling, Decentralised systems, Multi-agent systems. Synchronisation.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Tennekes, Hendrik. The simple science of flight: from insects to jumbo jets. MIT press, 2009.
2	Russ Tedrake. Underactuated Robotics: Algorithms for Walking, Running, Swimming, Flying, and Manipulation (Course Notes for MIT 6.832). Downloaded on June 2016 from http://underactuated.mit.edu/
3	Haberland, M., and S. Kim. "On extracting design principles from biology: I. Method? General answers to high-level design questions for bioinspired robots." Bioinspiration & biomimetics 10.1 (2015): 016010.
4	Ma, Kevin Y., et al. "Controlled flight of a biologically inspired, insect-scale robot." Science 340.6132 (2013): 603-607.
5	Werfel, Justin, Kirstin Petersen, and Radhika Nagpal. "Designing collective behavior in a termite-inspired robot construction team." Science 343.6172 (2014): 754-758.
6	Koh, Je-Sung, et al. "Jumping on water: Surface tension–dominated jumping of water striders and robotic insects." Science 349.6247 (2015): 517-521.
7	Cully, Antoine, et al. "Robots that can adapt like animals." Nature 521.7553 (2015): 503-507.