MNE8122: ADVANCED TOPICS IN NONLINEAR DYNAMICS, VIBRATION & CONTROL

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Topics in Nonlinear Dynamics, Vibration & Control

Subject Code
MNE - Mechanical Engineering
Course Number
8122

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Bachelor level of Dynamics; Vibration; Control; Fundamental of Robots

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course includes some selected advanced topics related to nonlinear dynamics, vibration, control and associated application case studies. The course is delivered partially in a traditional lecturing mode and partially in a guided study mode, and students are required to complete a comprehensive project. The topics may include (varying with time): nonlinear modelling and analysis, nonlinear systems identification, nonlinear signal processing, nonlinear vibrations, nonlinear benefits in engineering, bio-inspired structures/mechanisms, nonlinear control by employing nonlinear benefits, advanced control methods (with examples in vehicle suspensions, UAVs, and robots), and so on. Students will also be guided to have some self-studying topics and reports/presentation or even prototypes will be produced eventually to get more in-depth understanding of engineering nonlinearities, control, and applications.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand some nonlinear signal processing methods.			x	
2	Understand nonlinear vibration and control methods.			x	
3	Understand nonlinear benefits in engineering and some advanced control methods in robots.			x	
4	Present results, analyses and conclusions from experiments or simulations in a written report such that a technically qualified person can obtain a clear understanding of the findings.		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	This includes a combination of lectures and tutorial classes accompanied by in-class problem solving sessions and case studies.	1, 2, 3, 4	2 hrs/week

2	Project work	Students will carry out projects to design identification algorithm data processing methods, nonlinear modelling, vibration control or robotic control systems. These will be reported in the form of a detailed project report.	1, 2, 3, 4	1 hr/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignments	1, 2	20	2 assignments	Yes
2	Projects	1, 2, 3, 4	40	1 comprehensive project and report	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

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

Criterion

To be able to design and model nonlinear systems, develop identification algorithms, assess the performance of nonlinear response of a system, and/or handle some advanced control issues.

Excellent

(A+, A, A-) 75%-100%

Good

(B+, B, B-) 60%-74%

Fair

(C+, C, C-) 45%-59%

Marginal
(D) 40%-44%

Failure
(F) <40%

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

Criterion
Ability to explain the methodology and procedures used and analyse the data, discuss the findings with concise conclusions; Identify engineering issues and formulate into academic problems with feasible solutions.

Excellent
(A+, A, A-) Strong evidence of critical thinking; good capacity to analyze; superior grasp of subject matter; evidence of extensive knowledge of the project concerned.

Good
(B+, B, B-) Evidence of grasp of subject matter, some evidence of critical thinking and analysis; reasonable understanding of concepts; ability to develop the project.

Fair
(C+, C, C-) Student who is profiting from the project; understanding of the subject matter; evidence of familiarity with the project.

Marginal
(D) Basic familiarity with the subject matter to enable the student to use knowledge in the project.

Failure
(F) Little evidence of familiarity with the subject matter to accomplish the project.

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

Criterion
Ability to understand the key concepts, principles, methods, and applications of microfluidic systems used in both scientific research and real-world products.

Excellent
(A+, A, A-) 75%-100%

Good
(B+, B, B-) 60%-74%

Fair
(C+, C, C-) 45%-59%

Marginal
(D) 40%-44%

Failure
(F) <40%

Assessment Task

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

Criterion

To be able to design and model nonlinear systems, develop identification algorithms, assess the performance of nonlinear response of a system, and/or handle some advanced control issues.

Excellent

(A+, A, A-) 75%-100%

Good

(B+, B) 65%-74%

Marginal

(B-, C+, C) 50%-64%

Failure

(F) <50%

Assessment Task

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

Criterion

Ability to explain the methodology and procedures used and analyse the data, discuss the findings with concise conclusions; Identify engineering issues and formulate into academic problems with feasible solutions.

Excellent

(A+, A, A-) Strong evidence of critical thinking; good capacity to analyse problem; superior grasp of subject matter; evidence of extensive knowledge of the project concerned.

Good

(B+, B) Evidence of grasp of subject matter, some evidence of critical thinking and analysis; reasonable understanding of concepts; ability to develop the project.

Marginal

(B-, C+, C) Student who is fairly profiting from the project; mediocre understanding of the subject matter; fair evidence of familiarity with the project.

Failure

(F) Little evidence of familiarity with the subject matter to accomplish the project.

Assessment Task

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

Criterion

Ability to understand the key concepts, principles, methods, and applications of microfluidic systems used in both scientific research and real-world products.

Excellent

(A+, A, A-) 75%-100%

Good

(B+, B) 65%-74%

Marginal

(B-, C+, C) 50%-64%

Failure

(F) <50%

Part III Other Information

Keyword Syllabus

Nonlinear systems: Modelling & Analysis; Frequency domain methods of Nonlinear systems; Nonlinear system identification; Nonlinear vibration and control; Bio-inspired methods for vibration control; Bio-inspired robotic design; Discrete control systems; Optimal Control; Case studies.

In addition to several assignments, students are required to learn through a project to improve their understanding on strategic thinking, problem solving, team working processes, the relationships and interactions between the fields of knowledge that they have learnt in this and other courses.

Reading List

Compulsory Readings

	Title
1	N.A.

Additional Readings

	Title
1	Stephen A Billings, Nonlinear System Identification NARMAX Methods in the Time, Frequency, and Spatio -Temporal Domain, John Wiley & Sons, Ltd, 2013.
2	Xingjian Jing, Z. Lang, Frequency domain analysis and design of nonlinear systems based on Volterra series expansion: a parametric characteristic approach, Springer, 2015.
3	Ivana Kovacic, Nonlinear Oscillations- Exact Solutions and their Approximations, Springer, 2020.
4	A.H. Nayfeh, D.T. Mook, Nonlinear Oscillations, Wiley-Interscience, New York (1979).
5	Optimal control theory / L.D. Berkovitz. Berkovitz, Leonard David, 1924.; New York: Springer-Verlag, 1974.
6	Discrete Control Systems [electronic resource] / by Yoshifumi Okuyama. Okuyama, Yoshifumi. author.; London: Springer London: Imprint: Springer, 2014.
7	Ryaboy, Vyacheslav M., Title: Vibration control for optomechanical systems / Vyacheslav M Ryaboy, MKS Instruments, USA.