City University of Hong Kong
Course Syllabus

offered by
Department of Mechanical Engineering
with effect from Semester A 2024 / 25

Part I Course Overview

Course Title:	Advanced Topics in Nonlinear Dynamics, Vibration & Control
Course Code:	MNE8122
Course Duration:	1 semester
Credit Units:	3 credits
Level:	R8
Medium of Instruction:	English
Medium of Assessment:	English
Prerequisites: *(Course Code and Title)*	Nil
Precursors: *(Course Code and Title)*	Bachelor level of Dynamics; Vibration; Control; Fundamental of Robots
Equivalent Courses: *(Course Code and Title)*	Nil
Exclusive Courses: *(Course Code and Title)*	Nil

Part II Course Details

1. 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.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Understand some nonlinear signal processing methods.			✓	
2.	Understand nonlinear vibration and control methods.			✓	
3.	Understand nonlinear benefits in engineering and some advanced control methods in robots.			✓	
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.		✓		✓
		N.A.			

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.

3. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.				Hours/week (if applicable)
		1	2	3	4	
Lecture	This includes a combination of lectures and tutorial classes accompanied by in-class problem solving sessions and case studies.	✓	✓	✓	✓	2 hrs/week
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 hr/week

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.				Weighting	Remarks
	1	2	3	4		
Continuous Assessment: 60%						
Assignments	✓	✓			20%	2 assignments
Projects	✓	✓	✓	✓	40%	1 comprehensive project and report
Examination: 40% (duration: 2 hours)						
Examination	✓	✓	✓		40%	
					100%	

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

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignments	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.	75%-100%	60%-74%	45%-59%	40%-44%	<40%
2. Projects	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.	Strong evidence of critical thinking; good capacity to analyze; superior grasp of subject matter; evidence of extensive knowledge of the project concerned.	Evidence of grasp of subject matter, some evidence of critical thinking and analysis; reasonable understanding of concepts; ability to develop the project.	Student who is profiting from the project; understanding of the subject matter; evidence of familiarity with the project.	Basic familiarity with the subject matter to enable the student to use knowledge in the project.	Little evidence of familiarity with the subject matter to accomplish the project.
3. Examination	Ability to understand the key concepts, principles, methods, and applications of microfluidic systems used in both scientific research and real-world products.	75%-100%	60%-74%	45%-59%	40%-44%	<40%

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignments	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.	75%-100%	65%-74%	50%-64%	<50%
2. Projects	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.	Strong evidence of critical thinking; good capacity to analyse problem; superior grasp of subject matter; evidence of extensive knowledge of the project concerned.	Evidence of grasp of subject matter, some evidence of critical thinking and analysis; reasonable understanding of concepts; ability to develop the project.	Student who is fairly profiting from the project; mediocre understanding of the subject matter; fair evidence of familiarity with the project.	Little evidence of familiarity with the subject matter to accomplish the project.
3. Examination	Ability to understand the key concepts, principles, methods, and applications of microfluidic systems used in both scientific research and real-world products.	75%-100%	65%-74%	50%-64%	<50%

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

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.

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

N.A.

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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.