MA4528: INTRODUCTION TO DYNAMICAL SYSTEMS AND CHAOS

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Introduction to Dynamical Systems and Chaos

Subject Code
MA - Mathematics
Course Number
4528

Academic Unit
Mathematics (MA)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

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

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
MA3511 Ordinary Differential Equations

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course introduces fundamental concepts of dynamical systems and chaos with the help of computer experimentations. It helps students understand how the nonlinear property may give rise to rich complex phenomena.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	explain clearly basic ideas of dynamical systems and nature of chaotic behavior.		x		
2	analyze parametric families of mappings and their applications in modeling dynamical systems.			x	
3	describe properties of solutions of (non-linear) differential equations and their applications in modeling continuous-time dynamical systems.			x	
4	apply mathematical techniques of dynamical systems and chaos in modeling real-life phenomena/systems.				x
5	the combination of CILOs 1-4		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	Lectures	Learning through teaching is primarily based on lectures.	1, 2, 3, 4, 5	39 hours in total
2	Assignments	Learning through take-home assignments helps students understand concepts and techniques of dynamical systems and chaos, as well as their applications in sciences.	1, 2, 3, 4	after-class

3	Project	Learning through project helps students implement mathematical and computational methods of dynamical systems/chaos to model and analyze more sophisticated physical phenomena. It also helps students to communicate and collaborate effectively in the team.	4	after-class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Quizzes/Test/Midterm	1, 2	15	Questions are designed for the first part of the course to see how well students have learned basic concepts of dynamical systems and analyzed such systems with appropriate mappings.
2	Hand-in assignments	1, 2, 3, 4	10	These are skills based assessment which enables students to design and implement methods of dynamical systems and chaos in a range of application problems.
3	Project	4	5	Students are assessed on their ability in applying concepts and techniques of dynamical systems and chaos to model physical phenomena, as well as on its presentation with analysis.
4	Formative take-home assignments	1, 2, 3, 4	0	The assignments provide students chances to demonstrate their achievements on dynamical systems and chaos learned in this course.

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)
3

Additional Information for ATs
30% Coursework
70% Examination (Duration: 3 hours, at the end of the semester)
For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task
1. Quizzes/Test/Midterm

Criterion
Understanding of course materials

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
2. Hand-in assignments

Criterion
Problem solving skills

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
3. Project

Criterion
Research skills, problem solving skills

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
4. Formative take-home assignments

Criterion
Problem solving skills

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
5. Examination

Criterion
Understanding of course materials, problem solving skills

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

Part III Other Information

Keyword Syllabus

Examples of chaotic dynamical systems. Fixed points, periodic points, Poincaré–Bendixson theorem. Bifurcation theory, Hopf bifurcation, period doubling cascade. Hyperbolic invariant sets, attractors. Chaos, Liapunov exponents, fractal dimensions, topological entropy.

Reading List

Compulsory Readings

	Title
1	Lecture notes provided by the instructor

Additional Readings

	Title
1	Alligood, Sauer, and Yorke, Chaos: an introduction to dynamical systems, Springer, 1997.
2	S. Smale, Find a horseshoe on the beach of Rio, The Mathematical Intelligencer, Vol. 20, No. 1, pp. 39-44, 1998.
3	E. Lorenz, Deterministic nonperiodic flow, Journal of the Atmospheric Sciences, Vol. 20, pp. 130-141, 1963.
4	Nonlinear dynamics and chaos, Steven Strogatz, 1994, Taylor & Francis