

MA4528: INTRODUCTION TO DYNAMICAL SYSTEMS AND CHAOS

Effective Term

Semester A 2022/23

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.

Teaching and Learning Activities (TLAs)

TLAs	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
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Assessment Tasks / Activities (ATs)

ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)	
1	Test	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. Test

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, Poincare-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