MATH3902

Nonlinear Dynamics and Chaos

Session 1, In person-scheduled-weekday, North Ryde 2025

School of Mathematical and Physical Sciences

Contents

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General Information

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Credit points
10

Prerequisites
MATH2020 or MATH2110

Corequisites

Co-badged status

Unit description
The remarkable fact that determinism does not guarantee regular or predictable behaviour is having a major impact on many fields of science and engineering, as well as mathematics. The discovery of chaos, or of chaotic motions, in simple dynamical systems changed our understanding of the foundations of physics and has found many practical applications. Dynamical systems involve the study of maps and systems of differential equations. In this unit, the diversity of nonlinear phenomena is explored through the study of second-order differential equations and second-order systems, in which nonlinearity is usually ignored in simpler treatments.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: Explain the principles and basic concepts of Nonlinear Dynamical Systems, both of discrete systems and continuous ones through Differential Equations. In particular, gain an appreciation of the characteristics of 'chaotic' behaviour.
ULO2: Competently use modern computing software to model a range of phenomena in science and engineering, displaying the complexity that can occur with nonlinear systems.
ULO3: Demonstrate an understanding of the breadth of the theory of Nonlinear Systems, and how the distinction between periodic and non-periodic orbits is related to the very numbers used to model or describe the state of a system.
ULO4: Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning especially in the context of the Dynamical Systems, and to produce appropriate computer graphics to aptly illustrate the phenomena involved.

General Assessment Information

Requirements to Pass this Unit

To pass this unit you need to:

- Achieve a total mark equal to or greater than 50% across all assessments

Attendance and participation

We strongly encourage all students to actively participate in all learning activities. Regular engagement is crucial for your success in this unit, as these activities provide opportunities to deepen your understanding of the material, collaborate with peers, and receive valuable feedback from instructors, to assist in completing the unit assessments. Your active participation not only enhances your own learning experience but also contributes to a vibrant and dynamic learning environment for everyone.

Late Assessment Submission Penalty

Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark of the task) will be applied for each day a written report or presentation assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of '0' will be awarded even if the assessment is submitted. The submission time for all uploaded assessments is 11:55 pm. A 1-hour grace period will be provided to students who experience a technical concern.

For any late submission of time-sensitive tasks, such as scheduled tests/exams, assign- ments, performance assessments/presentations, and/or scheduled practical assessments/labs, please

apply for Special Consideration: https://connect.mq.edu.au

Assessments where Late Submissions will be accepted:

- Assessment 1 – YES, Standard Late Penalty applies
- Assessment 2 – YES, Standard Late Penalty applies
- Assessment 3 – YES, Standard Late Penalty applies

Special Consideration

The Special Consideration Policy aims to support students who have been impacted by short-term circumstances or events that are serious, unavoidable and significantly disruptive, and which may affect their performance in assessment. If you experience circumstances or events that affect your ability to complete the assessments in this unit on time, please inform the convenor and submit a Special Consideration request through https://connect.mq.edu.au.

Written Assessments: If you experience circumstances or events that affect your ability to complete the written assessments in this unit on time, please inform the con- venor and submit a Special Consideration request through https://connect.mq.edu.au.

Assessment Tasks

Name	Weighting	Hurdle	Due
Assignment 1	15%	No	30/03/2025
Assignment 2	15%	No	11/05/2025
Assignment 3	15%	No	01/06/2025
Final examination	55%	No	Examination Period

Assignment 1

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 8 hours
Due: **30/03/2025**
Weighting: **15%**

The assignment will test the ability of the students to develop and analyse mathematical problems using concepts and techniques learnt in the unit.

On successful completion you will be able to:

- Explain the principles and basic concepts of Nonlinear Dynamical Systems, both of discrete systems and continuous ones through Differential Equations. In particular, gain

an appreciation of the characteristics of ‘chaotic’ behaviour.
- Competently use modern computing software to model a range of phenomena in science and engineering, displaying the complexity that can occur with nonlinear systems.
- Demonstrate an understanding of the breadth of the theory of Nonlinear Systems, and how the distinction between periodic and non-periodic orbits is related to the very numbers used to model or describe the state of a system.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning especially in the context of the Dynamical Systems, and to produce appropriate computer graphics to aptly illustrate the phenomena involved.

Assignment 2

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 8 hours
Due: **11/05/2025**
Weighting: **15%**

The assignment will test the ability of the students to develop and analyse mathematical problems using concepts and techniques learnt in the unit.

On successful completion you will be able to:
- Explain the principles and basic concepts of Nonlinear Dynamical Systems, both of discrete systems and continuous ones through Differential Equations. In particular, gain an appreciation of the characteristics of ‘chaotic’ behaviour.
- Competently use modern computing software to model a range of phenomena in science and engineering, displaying the complexity that can occur with nonlinear systems.
- Demonstrate an understanding of the breadth of the theory of Nonlinear Systems, and how the distinction between periodic and non-periodic orbits is related to the very numbers used to model or describe the state of a system.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning especially in the context of the Dynamical Systems, and to produce appropriate computer graphics to aptly illustrate the phenomena involved.

Assignment 3

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 8 hours
Due: **01/06/2025**

Weighting: **15%**

The assignment will test the ability of the students to develop and analyse mathematical problems using concepts and techniques learnt in the unit.

On successful completion you will be able to:

- Explain the principles and basic concepts of Nonlinear Dynamical Systems, both of discrete systems and continuous ones through Differential Equations. In particular, gain an appreciation of the characteristics of ‘chaotic’ behaviour.
- Competently use modern computing software to model a range of phenomena in science and engineering, displaying the complexity that can occur with nonlinear systems.
- Demonstrate an understanding of the breadth of the theory of Nonlinear Systems, and how the distinction between periodic and non-periodic orbits is related to the very numbers used to model or describe the state of a system.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning especially in the context of the Dynamical Systems, and to produce appropriate computer graphics to aptly illustrate the phenomena involved.

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 15 hours
Due: **Examination Period**
Weighting: **55%**

The exam will test the ability of students to utilise concepts and techniques learnt in the unit.

On successful completion you will be able to:

- Explain the principles and basic concepts of Nonlinear Dynamical Systems, both of discrete systems and continuous ones through Differential Equations. In particular, gain an appreciation of the characteristics of ‘chaotic’ behaviour.
- Competently use modern computing software to model a range of phenomena in science and engineering, displaying the complexity that can occur with nonlinear systems.
- Demonstrate an understanding of the breadth of the theory of Nonlinear Systems, and how the distinction between periodic and non-periodic orbits is related to the very

numbers used to model or describe the state of a system.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning especially in the context of the Dynamical Systems, and to produce appropriate computer graphics to aptly illustrate the phenomena involved.

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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

Classes

- Lectures (beginning in Week 1): There are two one-hour lectures each week.
- SGTA classes (beginning in Week 1): There is one two-hour SGTA each week.

The timetable for classes can be found on the University website at: https://publish.mq.edu.au/.

Enrolment can be managed using eStudent at: https://students.mq.edu.au/support/technology/systems/estudent

Suggested Textbooks

The following textbooks are useful as supplementary resources, for additional questions and explanations. They are available from the Macquarie University library:

- Hirsch, M.W., Smale S. & Devaney, R.L., *Differential Equations, Dynamical Systems & An Introduction to Chaos*, Elsevier Academic Press. (Available online via the library.)
- Drazin, P.G., *Nonlinear Systems*, Cambridge University Press.
- Strogatz. S. *Nonlinear dynamics with chaos.* Westview Press. (Available online via the library.)
- Salinelli, E. *Discrete dynamical models. Springer.* (Available online via the library.)

Technology Used and Required

This subject requires the use of several items of software. Each of these is available to you at no cost, either because the software is open source or otherwise freely available, or because Macquarie University has arranged access for students. You will need the following:

- Matlab: Macquarie University provides Matlab access on a wide range of computing platforms. You will be required to sign up with Mathworks using your student email

account.

– Access and installation instructions may be found at: https://au.mathworks.com/academia/tah-portal/macquarie-university-916052.html

– Students may also use the free online Matlab implementation using their university licence, found at https://au.mathworks.com/products/matlab-online.html

Methods of Communication

We will communicate with you via your university email or through announcements on iLearn. Queries to convenors can either be placed on the iLearn discussion board or sent to your lecturers from your university email address.

Unit Schedule

Week	Material	Assessment Due
1	*Continuous Dynamical Systems*: Introduction, Autonomous Systems	
2	*Continuous Dynamical Systems*: Autonomous Systems	
3	*Continuous Dynamical Systems*: Energy	
4	*Continuous Dynamical Systems*: Energy, Poincare-Bendixson Theorem	
5	*Continuous Dynamical Systems*: Poincare-Bendixson Theorem	Assignment 1 due
6	*Continuous Dynamical Systems*: Bifurcations	
7	*Discrete Dynamical Systems*: Introduction	
8	*Discrete Dynamical Systems*: Equilibrium points & Stability	
9	*Discrete Dynamical Systems*: Equilibrium points & Stability, continued	Assignment 2 due
10	*Discrete Dynamical Systems*: Periodic orbits, Sharkovskii's Theorem	
11	*Discrete Dynamical Systems*: Bifurcations, Period doubling, and Stability	
12	*Discrete Dynamical Systems*: Logistic map, Chaos	Assignment 3 due
13	Revision	

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://policie

s.mq.edu.au). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Assessment Procedure
- Complaints Resolution Procedure for Students and Members of the Public
- Special Consideration Policy

Students seeking more policy resources can visit Student Policies (https://students.mq.edu.au/support/study/policies). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

To find other policies relating to Teaching and Learning, visit Policy Central (https://policies.mq.edu.au) and use the search tool.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/admin/other-resources/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit connect.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Academic Integrity

At Macquarie, we believe academic integrity – honesty, respect, trust, responsibility, fairness and courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free online writing and maths support, academic skills development and wellbeing consultations.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

The Writing Centre

The Writing Centre provides resources to develop your English language proficiency, academic writing, and communication skills.

- Workshops
- Chat with a WriteWISE peer writing leader
- Access StudyWISE
- Upload an assignment to Studiosity
- Complete the Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

Student Services and Support

Macquarie University offers a range of Student Support Services including:

- IT Support
- Accessibility and disability support with study
- Mental health support
- Safety support to respond to bullying, harassment, sexual harassment and sexual assault
- Social support including information about finances, tenancy and legal issues
- Student Advocacy provides independent advice on MQ policies, procedures, and processes

Student Enquiries

Got a question? Ask us via the Service Connect Portal, or contact Service Connect.

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Changes from Previous Offering

We value student feedback to be able to continually improve the way we offer our units. As such we encourage students to provide constructive feedback via student surveys, to the teaching staff directly, or via the FSE Student Experience & Feedback link in the iLearn page.

Student feedback from the previous offering of this unit was very positive overall, with stu- dents pleased with the clarity around assessment requirements and the level of support from teaching staff. As such, no change to the delivery of the unit is planned, however we will continue to strive

to improve the level of support and the level of student engagement.

Unit information based on version 2025.03 of the Handbook