MATH3201

DYNAMICAL SYSTEMS AND CHAOS

SEMESTER 2, 2018

FACULTY OF SCIENCE

SCHOOOL OF MATHEMATICS AND STATISTICS

Cricos Provider Code: 00098G

MATH3201 – Course Outline Information about the course

Course Authority: Adelle Coster
Lecturer: Adelle Coster RC-2086, email A.Coster@unsw.edu.au.
Consultation: Please use email to arrange an appointment.
Credit, Prerequisites: This course counts for 6 Units of Credit (6UOC).
Prerequisites: 12 units of credit in Level 2 Mathematics courses including MATH2120 or MATH2130, and MATH2501 or MATH2601, or both MATH2019(DN) and MATH2089, or both MATH2069(CR) and MATH2099.
Lectures: There will be three lectures per week:
Monday 12:00-14:00 Red Centre 4082
Thursday 14:00-15:00 Red Centre 4082
Tutorials: There will be one tutorial per week starting in Week 2 and continuing through to Week 13.
Thursday 15:00-16:00 Red Centre 4082
UNSW Moodle: Further information and other course material will be provided via Moodle.

Course Description

A dynamical system is any system whose state changes as a function of time. This course studies the regular and irregular behaviour of nonlinear dynamical systems, concentrating on ordinary differential equations (ODEs) and their solutions.

Topics from the theory of ODEs include: existence and uniqueness theorems; linear ODEs with constant and periodic coefficients and Floquet theory; linearization and stability analysis; perturbation methods; bifurcation theory; phase plane analysis for autonomous systems. The theory is illustrated with applications to physical, biological and ecological systems.

In addition, a selection from the dynamical concepts: Hamiltonian dynamics, resonant oscillations, chaotic systems, Lyapunov exponents, Poincare maps, homoclinic tangles.

Relation to other mathematics courses and other disciplines

Dynamical Systems is a subject that sits at the threshold of pure and applied mathematics and has links to many other areas of mathematics, including Analysis, Linear Algebra, Measure Theory, Ergodic Theory, Functional Analysis, Topology, Numerical Analysis, Stochastic Processes, Group Theory, and Mathematical Modelling.

This course will make use of many pure mathematical tools that you have learnt so far, and refine those parts of pure mathematics that are particularly useful for studying dynamical systems. You will make use of many applied mathematical methods you already know and develop more specialised methods.

This course is very useful for those majoring in Applied or Pure Mathematics, those interested in being able to model and understand dynamical phenomena (e.g. stock markets, the weather, biological populations) at a deeper level, and those planning to teach. Dynamical Systems has applications in Engineering, Physics, Chemistry, Space, Biology, and Computer Science and those majoring in these disciplines would also benefit from the course.

Student Learning Outcomes

Students taking this course will develop an appreciation of the usefulness of the mathematics that they have learned so far and the connection between dynamical systems and other mathematics subjects. An emphasis will be upon problem solving and students will develop and hone their problem solving skills via tutorial questions.

Through regularly attending lectures and applying themselves in tutorial exercises, students will develop competency in mathematical presentation, written and verbal skills.

Relation to graduate attributes

The above outcomes are related to the development of the Science Faculty Graduate Attributes, in particular: 1. Research, inquiry and analytical thinking abilities, 4. Communication, 6. Information literacy

Teaching strategies underpinning the course

New ideas and skills are introduced and demonstrated in lectures then students develop these skills by applying them to specific tasks in tutorials and assessments.

Assessment in this course will use problem-solving tasks of a similar form to those practiced in tutorials, to encourage the development of the core analytical and computing skills underpinning this course.

Rationale for learning and teaching strategies

We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class as outlined below.

We believe that effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes, in the case of lectures, and, in the case of tutorials, by having made a serious attempt at doing for themselves the tutorial problems prior to the tutorials.

Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes.

Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material.

The art of logically setting out mathematics is best learned by watching an expert and paying particular attention to detail. This skill is best learned by regularly attending classes.

Assessment

Assessment in this course will consist of two 45 minute mid-session tests (40% in total) and a final examination (60%).

Knowledge and abilities assessed: All assessment tasks will assess the learning outcomes outlined above in particular the understanding of dynamical systems concepts, the ability to prove theoretical results, the ability to solve problems via dynamical systems methods, both theoretically and numerically by computer.

Assessment criteria: The main criteria for marking all assessment tasks will be clear and logical presentation of correct solutions.

Task	Date and Time	Weighting
Test 1	Week 5, 30 August 2018, 15:00	20%
Test 2	Week 11, 18 October 2018, 15:00	20%

Examination

Duration: Two hours.

Rationale: The final examination will assess student mastery of the material covered in the lectures.

Weighting: 60% of your final mark.

Further details about the final examination will be available in class closer to the time.

Additional resources and support

Tutorial Exercises

A set of tutorial exercises will be given out. These problems are for you to do to enhance mastery of the course.

Some of the problems will be done in tutorials, but you will learn a lot more if you try to do them before the tutorial.

Textbooks

There is no set text for this course. The content of the course will be defined by the lectures and outline lecture notes will be made available on Moodle in instalments.

Any book on Dynamical Systems may prove useful and some will be mentioned at various points, including

R. Grimshaw "Nonlinear Ordinary Differential Equations", (CRC Press, Boca Raton, 1993)

D.W. Jordan and P. Smith "Nonlinear Ordinary Differential Equations", (Oxford University Press, Oxford, 1997)

Moodle

Further information, skeleton lecture notes, and other material will be provided via Moodle (http://moodle.telt.unsw.edu.au).

Course Evaluation and Development

The School of Mathematics and Statistics evaluates each course each time it is run. We carefully consider the student responses and their implications for course development. It is common practice to discuss informally with students how the course and their mastery of it are progressing.

Administrative matters

School Rules and Regulations

Students must read and understand the School of Mathematics and Statistics Policies as contained in the 'Important Information for Undergraduate Students' document. This can be found on the web at

http://www.maths.unsw.edu.au/currentstudents/assessment-policies

Note that the Additional Assessment Exams for Semester 2 are held in December (dates to be advised) and at no other times.

Plagiarism and academic honesty

Plagiarism is the presentation of the thoughts or work of another as one's own. Issues you must be aware of regarding plagiarism and the university's policies on academic honesty and plagiarism can be found at https://student.unsw.edu.au/plagiarism.

Lecture Outline

1. Introduction to Dynamical Systems
   Lipschitz condition, existence and uniqueness
2. Linear ODEs with constant coefficients
   Eigenvalues, eigenvectors and generalised eigenvectors
3. Linear ODEs with periodic coefficients
   Floquet theory, perturbation methods
4. Plane autonomous systems
   Phase plane analysis, critical points, linearised stability, limit cycles, limit cycle stability
5. Perturbation methods
   Poincaré-Lindstedt method, shifted frequencies
6. Forced Oscillations
   Resonant forcing, perturbation methods, response diagrams
7. Bifurcations in flows
   1D bifurcations, 2D bifurcations
8. Poincaré maps
   Bifurcations in 1D maps, period doubling, chaos