UNSW SCIENCE

SCHOOL OF MATHS AND STATISTICS

MATH3041
MATHEMATICAL MODELLING
FOR REAL WORLD SYSTEMS

Term 2, 2019

Cricos Provider Code: 00098G

MATH3041 – Course Outline Information about the course

Course Authority: A/Prof Adelle Coster

Lecturer: A/Prof 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.

Exclusions: MATH2140

Lectures: 4 hours per week (except Week 6 – no lectures)

Tutorials/Labs: 1 hour per week

UNSW Moodle: Further information and other course material will be provided via Moodle.

Course Description

Why are no two snowfakes alike? When will the next major stock market collapse occur? Which is the greatest sporting nation on earth? Addressing real world problems involves the steps of formulating a mathematical description of the problem, solving the mathematical model, interpreting the mathematical solution and critically evaluating the model. Motivated by real world problems, the course will survey mathematical techniques for achieving the best possible outcomes, predicting future events and dealing with uncertainties. The course will provide introductions to popular mathematical resources for algebraic manipulation, numerical simulation and presentation. As part of the course requirements, students will be expected to work in groups on mathematical modelling projects and they will be expected to prepare a group report, both written and oral, describing the project. The course aims to equip students with the modelling skills and presentation skills for dealing with real world problems.

This six unit of credit course is recommended for all students undertaking study plans or majors in mathematics. The course is also useful for other students who are likely to use quantitative methods in their future careers.

The fundamental aim of this course is to help students to acquire the skills that major employers of science/mathematics graduates have expressed most interest in.

These skills include:

- formulating, modelling and solving problems from diverse and challenging areas,
- flexibility in applying mathematics and problem solving across different applications,
- computational skills,
- written and spoken communication skills
- teamwork skills

Some methods in statistics and stochastic modelling may also be employed.

Specialist skills in dynamical systems will be taught with emphasis on how to take a real world problem and set the problem up using mathematics, how to solve the mathematical problem efficiently, how to interpret and relate the mathematical results to the real world problem, and how to prepare reports on the problem.

Much of the time in lectures will be devoted to working through examples. Students will be encouraged to contribute to the formulation of problems and their solutions in class.

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

Individual Literature Search Project

Rationale: The first assessment activity for this course will be a literature search project. The aims of this activity are: to familiarize students with some of the history of mathematical modelling, to help students to develop information technology skills through independent research of a topic, to help students gain communication skills through preparing written reports using mathematical typesetting. Guidelines for the style and length of the report will be provided when the assessment activity is issued.

This activity will also provide students with early feedback on their research, organizational and written skills.

The literature search project is due at the end of Week 3, via MOODLE.

Weighting: 10% of your final mark.

Group Project I & II

Rationale: A major part of the assessment for this course will be based on two group projects. Each project will be dealing mathematically with a real world problem. Each team will consist of four or five individuals. Each member of the team will be expected to participate in all aspects of the project including; background research, setting up the model, mathematical analysis of the model, writing computer code, and preparation of final reports and presentations.

Each member of the team will complete and submit responses to questions relating to their individual understanding of and contribution to the project. The team will collectively submit a group written report. The Group Report should include an executive summary, an introduction, details of calculations, summary and discussion, references, and computer programs (as appendices). These reports must not exceed fifteen pages (doubled spaced, 12pt font) excluding figures, tables and appendices. Each member of the team will be awarded the same group mark for the project.

Weighting:

Group Project I (20%): Individual Questionnaire (8%). Group report (12%). The first group reports as well as the individual questionnaires are due shortly after week 5 (to be advised).

Group Project II (20%): Individual Questionnaire (5%). Group Report (10%). Group Oral/Video Presentation (5%). The second group reports as well as the individual questionnaires for this Group Project are due at the end of Week 9. The presentations and peer assessment for the group project will be held during lecture times in Week 9 and 10. The due dates stated here may be subjected to change (and the date stated on MOODLE is the definitive timing) and all submissions are to be made on the MOODLE website for this course.

Class Participation

Rationale: Developing peer review and constructive criticism skills is an important outcome of the course, and students will be assessed on the feedback they give and participation in class activities.

Weighting: 5% of your final mark.

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

Examination

Duration: Two hours.

Rationale: The final examination will assess student mastery of the material covered in the lectures and may include questions relating to the projects.

Weighting: 45% 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 these will be computational in nature.

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.

Some books which may be useful references include

Mathematical Modeling
M.M. Meerschaert
Academic Press
2nd edition
This is an excellent reference book for this course. The level of treatment in this book is the same as this course, as is the range of topics. Some of the examples treated are taken from this reference.

A First Course in Mathematical Modeling
F.R. Giordano, M.D. Weir and W.P. Fox
Brooks/Cole Publishing
1997
2nd Edition
The level of mathematics is slightly below that in the book by Meerschaert. The range of topics is excellent.

The Nature of Mathematical Modeling
N. Gershenfeld
Cambridge University Press
1999
This is much more of a reference work. It contains algorithms for many of the mathematical methods used in real world modelling. The level is advanced undergraduate and graduate. A good book to have on your shelves in future years.

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

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

The course will include material taken from some of the following topics. This is not an extensive list of the material to be covered and should only serve as a guide. The course content is ultimately defined by the material covered in lectures.

- Introduction to Modelling
- Fitting Real World Data
- Discrete Time Systems
- Simulation Modelling
- Dimensional Analysis and Similitude
- Population Modelling
- Compartmental Models
- Interacting Populations
- Epidemics
- Case Studies