MATH2121
THEORY AND APPLICATIONS OF DIFFERENTIAL EQUATIONS
Semester 2, 2015
Course Staff

- The Course Convenor is Dr Anna Cai, Room 2083, The Red Centre.
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General Course Information

- MATH2121 is a Mathematics Level II course.
- Prerequisites: MATH1231 or MATH1241 or MATH1251
- Exclusions: MATH2019, MATH2029, MATH2059, MATH2130
- Units of credit: 6
- The higher version of this course, MATH2221 Higher Mathematical Methods for Differential Equations, is also taught in semester 2, 2015.

Course Schedule: Location and Times

- Lectures: There will be two lectures per week in Weeks 1-12, Webster Theatre A
  ➢ Wednesday 14-16 pm
  ➢ Friday 10-11 am
- Tutorials: There will be one tutorial every week after Week 1, i.e., Weeks 2–13.
  ➢ Tutorials will be based on the set of exercises in the course notes. All relevant materials will be made available on Moodle.
  
  It is important to attempt as many problems as you can before tutorials.
  ➢ No change of tutorial time will be permitted after the end of Week 3.

Course Description and Course Aims

- Differential Equations (DEs) were first introduced by Newton to describe the behaviour of dynamical systems such as the motions of the planets and the trajectories of cannon balls. DEs now have applications in biology (spread of epidemics), medicine (growth of tumours), sociology (emigration rates), psychology (learning theories), economics (option pricing), chemistry (reaction rates), physics (dynamics of a laser) and engineering (electric circuits). Methods for solving DEs are therefore of fundamental importance for understanding nature and technology.

- In first year you learnt how to solve first order ordinary differential equations and second order ordinary differential equations with constant coefficients. In this course we learn how to deal with second order ordinary differential equations with variable coefficients and give an introduction to partial differential equations. We also learn how to find solutions that obey prescribed boundary conditions. Not all DEs can be solved in terms of known functions such as polynomials, exponentials and the like. A major aim of this course is to teach you how to get information about the solution in these cases using power series methods and Frobenius' method. A second major aim is to learn how to find solutions to boundary value problems using Sturm-Liouville methods and Fourier series methods.
This course is a prerequisite for the third year courses MATH3121 Mathematical Methods and Partial Differential Equations, MATH3201 Dynamical Systems and Chaos, and MATH3261 Fluids, Oceans and Climates.

**Assessment**

- Assessment in this course will use problem-solving tasks of a similar form to those practised in tutorials, to encourage the development of the core skills underpinning this course and the development of analytical thinking.
- In tests and exams, marks will be awarded for correct working and appropriate explanations and *not just the final answer.*
  - A 45 minute class test in Week 5 worth 15%.
  - A 45 minute class test in Week 9 or 10 worth 15%.
  - The final exam (2 hours) is worth 70% of the final grade.

**Student Learning Outcomes**

- We believe that effective learning is best supported by a climate of inquiry, in which students are actively engaged in the learning process. Hence this course is structured with a strong emphasis on problem-solving tasks in lectures, in tutorials and in assessment tasks, and students are expected to devote the majority of their class and study time to the solving of such tasks.
- New ideas and skills are first introduced and demonstrated in lectures, and then students develop these skills by applying them to specific tasks in tutorials and assessments.
- This course has a major focus on training analytical and logical thinking and learning fundamental methods for solving ordinary and partial differential equations. Both the knowledge about differential equations as well as the training of analytical faculties will be useful for the students in the course of their further studies. The course also explores the capacity and motivation for intellectual development through the solution of both simple and more complex mathematical problems from the important field of differential equations.
- After attending the course students are expected to have adequate knowledge of the covered material and to be able to solve ordinary and partial differential equations similar to the examples discussed in the lecture with the learned mathematical tools. These goals will be assessed by the two class tests and the final exam.

**Teaching Strategies**

- Since the time in the lectures is limited the tutorials will be focussed on practising the methods for solving differential equations by solving problems similar to those discussed in the lectures. It is essential that students attend both the lectures and the tutorial and devote sufficient time to solving exercises from the problem sheets themselves. Students are encouraged to ask questions in the lecture, the tutorials and during consultation hours. Students should also consult resources such as textbooks in the library for more examples on topics and methods that they find difficult.
Course Evaluation and Development

- The School of Mathematics and Statistics evaluates each course each time it is run. Feedback on the course is gathered, using among other means, UNSW’s Course and Teaching Evaluation and Improvement (CATEI) Process. Student feedback is taken seriously, and continual improvements are made to the course based in part on such feedback.

Syllabus

The course content is ultimately defined by the material covered in lectures.

Topics that will be covered are as follows:

1. First order ordinary differential equations (ODEs): General terminology; review of first year material on ordinary differential equations: geometric interpretation of an ODE, classification, elementary methods for solving first order ODEs (direct integration and substitution), separable ODEs, method of integrating factors.
2. Systems of ODEs: eigenvalues, eigenvectors, phase plane, critical points, applications.
4. Second order ODEs - elementary methods: Classification, linear ODEs, reduction of order techniques, linear second order ODEs with constant coefficients, Cauchy-Euler equations, finding particular solutions.
5. Power series and Frobenius' method: Ordinary points, singular points, regular points, analytic functions, power series method, Frobenius' method, indicial equation, example: Bessel's equation.
6. Orthogonal functions and Fourier series: Orthogonal functions, generalised Fourier series, trigonometric Fourier series, convergence in the mean and pointwise convergence, odd and even expansions, half-range expansions.
7. Boundary value problems for homogeneous linear 2nd order ODEs: Boundary values, Sturm-Liouville problem, eigenfunctions and eigenvalues, Fourier Bessel series.
8. Partial differential equations (PDEs): Classification of PDEs, separation of variables, heat equation, wave equation, Laplace equation and its solution via separation of variables.

Course Resources List:

Copies of these are available in the Main Library. Also see for example call numbers P510.253, P517.38, P517.383 in the main library.

- References
➢ M. Spiegel: Advanced Mathematics for Engineers and Scientists. (Schaum Outline Series, 1983).

Library
● The library’s website has some past exam papers of MATH2120 that will be useful for practice.

Additional Assessment
● The School of Mathematics has a strict policy on additional assessment. It can be found at http://www.maths.unsw.edu.au/currentstudents/assessment-policies

Academic Misconduct
● The University of New South Wales has rules relating to Academic Misconduct. They can be found at http://www.maths.unsw.edu.au/currentstudents/assessment-policies

Rules for the Conduct of Examinations
● The University of New South Wales has rules for the conduct of examinations. They can be found at http://www.maths.unsw.edu.au/currentstudents/assessment-policies

Occupational Health and Safety

Equity and Diversity
● Equity and diversity: those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convenor prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit (9385 4734 or http://www.studentequity.unsw.edu.au/). Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made. Information on designing courses and course outlines that take into account the needs of students with disabilities can be found at: http://www.studentequity.unsw.edu.au/forms