UNSW SCIENCE

SCHOOL OF MATHS AND STATISTICS

MATH3121

MATHEMATICAL METHODS
AND PARTIAL DIFFERENTIAL EQUATIONS

Term 1, 2019

Cricos Provider Code: 00098G

MATH 3121 - Course outline

Information about the course

Course Authority: Dr. Christopher Angstmann

Lecturer: Dr Christopher Angstmann
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Tutor: Dr Christopher Angstmann

Consultation times: Please use email to arrange an appointment

Credit: This course counts for 6 Units of Credit (6UOC)
Pre-requisites: 12 units of credit in Level 2 Math courses including (MATH2011 or MATH2111) and (MATH2120 or MATH2130 or MATH2121 or MATH2221), or (both MATH2019 (DN) and MATH2089), or (both MATH2069 (DN) and MATH2099).

Location and times: There are four lectures and one tutorial per week in all weeks apart from week six in which there will be no lectures and one tutorial.

Lectures:
Mondays 10:00-12:00 Old Main Building G31
Thursdays 12:00-14:00 Red Centre M032

Tutorials (you should be enrolled in one):
Tuesday: 13:00-14:00 Red Centre M010
Wednesday: 13:00-14:00 Webster 256

Due to public holidays some classes will be scheduled in week 11.

Moodle

Further information and other course materials will be provided via Moodle.

Course Description

This course builds on MATH2121 Theory and Applications of Differential Equations in that it is concerned with ways of solving the (usually partial) differential equations that arise mainly in physical, biological and engineering applications.

Analytical methods have considerable intrinsic interest, but their importance for applications is the driving motive behind this course. The main analytical tools developed in this course can be thought of as generalisations of the Fourier and power series representations of functions studied in MATH2121. This leads to new types of functions and to practical methods for solving differential equations. We will pay special attention to functions defined on infinite domains.

The course begins by characterising different partial differential equations (PDEs) and exploring similarity solutions and the method of characteristics to solve them. The Fourier transform, the natural extension of a Fourier series expansion is then investigated. For functions of time, the Fourier transform corresponds to the “spectrum” of the function or signal in the problem in the frequency domain. Closely related to the Fourier transform is the Laplace transform which is particularly useful for solving the initial value PDEs that arise in many physical applications. Although contour integration is an intrinsic part of using these transforms, only brief references to complex variable methods will be made.

Transforms give a wide insight into the behaviour of a function and suggests other possibilities for the integral representation of solutions of PDEs. By exploiting certain special solutions of a given linear PDE we eventually obtain the idea of a Green's function for the PDE and a corresponding integral form for the solution. The power of Green's functions can be observed in their use as the inverses of differential operators on both infinite and bounded domains.

Frequently it is not possible to evaluate in closed form the Fourier, Laplace or Green’s function integrals appearing in the solution of the given PDE. All is not lost as we can still explore the asymptotic behaviour of these integrals at large parameter values and obtain physically useful information on the solution of the underlying problem.

Relation to other mathematics course

Mathematics may be divided into the broad categories of analysis (calculus), algebra, geometry and logic.

This subject fits largely into the calculus category and follows on from material you will have learned in first year and from other related courses you may have taken, although algebra and areas will also be involved.

This course is very useful for those majoring in Applied Mathematics, those planning to teach, or those students of Mathematics who are interested in the application of mathematical techniques to real-world problem solving.

Student Learning Outcomes

Students taking this course will develop an appreciation of various techniques, transforms and mathematical methods related to the solution of differential equations. The ability to provide logical and coherent derivations of results, and the ability to solve differential problems via the methods will be paramount.

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.

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

The assessment tasks for this course comprise of an assignment (in two parts) 20%, an in-class test 20%, and the final exam 60%.

Knowledge and abilities assessed: All assessment tasks will assess the learning outcomes outlined above, specifically, the ability to provide logical and coherent mathematical derivations, and the ability to solve boundary and initial value problems using the methods presented.

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

Assignments

Rationale: Assignments will give an opportunity for students to try their hand at more difficult problems requiring more than one line of argument and also introduce them to aspects of the subject which are not explicitly covered in lectures. Assignments must be YOUR OWN WORK, or severe penalties will be incurred.

Task	Date and Time	Weighting
Assignment, Part 1	Due 5pm Friday 8th March	10%
Assignment, Part 2	Due 5 pm Thursday 18th April	10%
Class Test	In Class Thursday Week 5 (21st March)	20%
Final Exam	Exam Period	60%

Additional resources and support

Tutorial Exercises

A set of tutorial exercises will be given out. These problems are for YOU to do to enhance your 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 prescribed textbook for this course, but there are a large number of good textbooks that cover the material from this course.

This is a small selection of books that have FREE electronic copies available through the library:

- “Introduction to Partial Differential Equations", Peter J. Olver
- “Applied Partial Differential Equations", J. David Logan
- “Essential Partial Differential Equations", David Griffiths, John Dold, David Silvester
- “Mathematical Methods for Engineers and Scientists 3", K. T. Tang

Outline of Syllabus

The course will include material from the following. Outline lecture notes for this course will be made available via the Moodle site. They are not a substitute for attendance at lectures and tutorials. The course content is ultimately defined by the material covered in lectures.

Properties of and fundamental methods for the solution of partial differential equations (PDEs); classification of first and second order PDEs; Dirichlet and Neumann problems including the Wave, Heat and Laplace Equations;

Dimensionless Similarity Solutions; Method of Characteristics; Fourier and Laplace Transforms; Asymptotic Solutions for Integrals and Green's Functions.

Brief Outline of Lecture Topics

1. **Introduction and Revision**
2. **The Method of Characteristics**
3. **The Sturm-Liouville equations**
4. **Generalised Fourier series and their applications to PDEs**
5. **Laplace transforms**
6. **Fourier transforms**
7. **Green's functions**
8. **Asymptotic methods for integrals**

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.