Unit study package code: MATH3000

Mode of study: Internal

Tuition pattern summary: Note: For any specific variations to this tuition pattern and for precise information refer to the Learning Activities section.
Lecture: 3 x 1 Hours Weekly
Computer Laboratory: 1 x 1 Hours Weekly
This unit does not have a fieldwork component.

Credit Value: 25.0

Pre-requisite units: 8127 (v.0) Advanced Calculus 201 or any previous version
OR
8648 (v.0) Mathematical Methods 201 or any previous version
OR
MATH2009 (v.1) Advanced Calculus

Co-requisite units: Nil

Anti-requisite units: Nil

Result type: Grade/Mark

Approved incidental fees: Information about approved incidental fees can be obtained from our website. Visit fees.curtin.edu.au/incidental_fees.cfm for details.

Unit coordinator:
Title: Dr
Name: Greg Gamble
Phone: +618 9266 3482
Email: G.Gamble@curtin.edu.au
Location: Building: 314 - Room: 353

Teaching Staff:

Administrative contact:
Name: Greg Gamble
Phone: +618 9266 3482
Email: G.Gamble@curtin.edu.au
Location: Building: 314 - Room: 353

Learning Management System: Blackboard (lms.curtin.edu.au)
Acknowledgement of Country

We respectfully acknowledge the Indigenous Elders, custodians, their descendants and kin of this land past and present.

Syllabus

This unit broadly covers topics in Complex Analysis, Laplace Transforms, Special and Generalised Functions, and Second order ordinary differential equations with symmetry properties. In Complex Analysis we discover that the Complex Number Field is in some sense a natural completion of the Real Number Field, with Laurent Series the natural extension of Taylor Series, and Residue Theory giving us exciting new methods of integration. Laplace Transforms give us a method of reducing a differential equation to an algebraic problem. Special functions are functions that are written in terms of integrals. The ones considered, the Gamma function and Error function, turn up in statistics. Generalised functions, only really make sense under an integral sign. The ones we consider, including the Dirac delta, Unit step and signum functions arise naturally in work with Laplace Transforms. Second order differential equations with certain symmetry properties, namely homogeneous Sturm-Liouville systems, have properties analogous to eigenvalue problems involving symmetric matrices. Their study gives rise to orthogonal complete sets of functions on an interval, such as Fourier Series (seen in Advanced Calculus), Legendre Polynomials, and Bessel Functions. Finally we see how to construct Green's Functions that are used to solve non-homogeneous Sturm-Liouville systems.

Introduction

We explore some beautiful mathematics in Complex Analysis culminating in Residue Theory which provides some new methods for solving real integrals; we see how Laplace Transforms can be used to reduce a Differential Equations problem to an algebraic problem, and we discover eigenvalue problems (Sturm-Liouville Theory) in a homogeneous linear Differential Equations setting which provide families of functions with properties similar to Fourier Series. Finally, we see how to determine Green's functions that deal with corresponding non-homogeneous Sturm-Liouville problems.

More specifically we cover the following topics:

- **Complex Analysis:** "Functions" of a complex variable. Analytic functions. Cauchy's Theorem and Cauchy's Integral Formula. Taylor and Laurent series. Residue theory.
- **Special Functions:** Gamma function. Error function. (These arise, for example, in statistics.)
- **Generalised functions:** Dirac delta, Unit step and signum functions. (These arise naturally with Laplace Transforms.)
- **Green's Functions.**

While not listed as pre-requisites, it’s eminently preferred that students have taken Linear Algebra MATH2010 (previously Linear Algebra 202) and the Advanced Topics unit that has run as Analysis 202, Mathematics Topics 401 or Advanced Topics in Applied and Computational Mathematics 400 or Advanced Topics in Applied and Computational Mathematics MATH4001. MATH3000 is a difficult unit; students with an inadequate background are ill-advised to take this unit.

Disclaimer

While this document endeavours to be 100% accurate, inevitably, there are errors, and problems arise as the semester progresses which need to be dealt with in a manner different to what is stated in this outline, e.g. you will notice some typos. in the syllabus which the lecturer has no control over, and which this introduction tries to correct. Also, the "computer laboratory" is, in fact, a tutorial/lecture.
Unit Learning Outcomes

All graduates of Curtin University achieve a set of nine graduate attributes during their course of study. These tell an employer that, through your studies, you have acquired discipline knowledge and a range of other skills and attributes which employers say would be useful in a professional setting. Each unit in your course addresses the graduate attributes through a clearly identified set of learning outcomes. They form a vital part in the process referred to as assurance of learning. The learning outcomes tell you what you are expected to know, understand or be able to do in order to be successful in this unit. Each assessment for this unit is carefully designed to test your achievement of one or more of the unit learning outcomes. On successfully completing all of the assessments you will have achieved all of these learning outcomes.

Your course has been designed so that on graduating we can say you will have achieved all of Curtin’s Graduate Attributes through the assurance of learning process in each unit.

<table>
<thead>
<tr>
<th>On successful completion of this unit students can:</th>
<th>Graduate Attributes addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Apply complex analysis in various applications</td>
<td></td>
</tr>
<tr>
<td>2 Apply residue calculus to evaluate integrals (complex and real)</td>
<td></td>
</tr>
<tr>
<td>3 Apply Laplace Transforms to solve differential equations with discontinuous, impulse and periodic forcing functions, and some integral and integro-differential equations</td>
<td></td>
</tr>
<tr>
<td>4 Apply special functions in various applications</td>
<td></td>
</tr>
<tr>
<td>5 Approximate functions using a generalised Fourier series in a homogeneous Sturm-Liouville setting, and construct Green’s functions for solving a non-homogeneous Sturm-Liouville system</td>
<td></td>
</tr>
</tbody>
</table>

Curtin’s Graduate Attributes

- Apply discipline knowledge
- Thinking skills (use analytical skills to solve problems)
- Information skills (confidence to investigate new ideas)
- Communication skills
- Technology skills
- Learning how to learn (apply principles learnt to new situations) (confidence to tackle unfamiliar problems)
- Professional Skills (work independently and as a team) (plan own work)
- International perspective (value the perspectives of others)
- Cultural understanding (value the perspectives of others)
- Professional Skills (work independently and as a team) (plan own work)

Find out more about Curtin’s Graduate attributes at the Office of Teaching & Learning website: ctl.curtin.edu.au
Learning Activities
Lectures, some mini i-lectures and tutorials.

Written Assignments
The assignments will be available in the Blackboard site for Mathematical Methods. As the assignment questions are used for assessment purposes no assistance will be given by the staff. Assistance will be given on any other questions. The assignment must be neatly written in ink, but computer printout will be accepted where this is appropriate. Assignments must have the official cover sheet that can be found as the last page on the assignment questions. Assignments without the completed cover sheet will not be accepted. All pages must be stapled together on the top left hand corner. Assignments should be put in your lecturer/tutor's assignment box situated opposite the Department of Mathematics Office in Building 314. The solutions to the assignment will be available on Blackboard after the evaluated assignments have been returned. The due date for each assignment will be stated in Blackboard and on the top of the sheet containing the assignment's problems.

Online Quizzes
There are some online quizzes, for the particularly algorithmic aspects of the unit. You can access the quiz(izes) through the Mathematical Methods section of Blackboard (see above). Once you are in Blackboard, click on Online Quizzes. This is a link to the (AiM) web server that hosts the quizzes. Alternatively, if Blackboard is down, you may access the quiz(izes) directly on http://aim03.curtin.edu.au. Note that your AiM Online quiz password is not the same as your OASIS/Blackboard password; it will be the same as what it was for the unit in which you had AiM Quizzes in first year, and if you have forgotten it, just use Send password reminder and it will be sent to your student.curtin.edu.au email address. If this happens to be your first acquaintance with AiM, read Online quiz Info. Queries can be sent to maths-aim@lists.curtin.edu.au but such queries must have subject including the unit, quiz and question number, e.g.: MM Quiz 4 Question 3. The administrator (who is also your lecturer) will endeavour to encapsulate responses to queries in a blog, a link to which is available in the quiz environment. You should visit the blog before posing a query, just in case a response to another student already sufficiently answers the query you were about to pose. The quiz questions in this unit have more parts and more feedback than for AiM on-line quizzes than you have encountered in early year units. This is to help you learn the ideas involved as you do the quizzes. In general, students who complete the quizzes without leaving any questions or parts out will earn 100% of the marks available for the quizzes. If you leave parts out, the mark shown by the quiz will stand.

In-class tests
As much as possible the in-class tests will be on one key idea covered in the week’s on-line quiz.

Examination
There is one final examination. This will be held during the examination period at the end of the semester. The final examination will be closed book: notes and books will not be allowed. You will also not be allowed to use a calculator (but the questions will be of a nature that there would be little need for one, anyway).
Learning Resources
Library Reserve
There are resources for this unit in the library Reserve collection. To access these resources, please click on the following link:
http://link.library.curtin.edu.au/primo/course?MATH3000

Recommended texts
You do not have to purchase the following textbooks but you may like to refer to them.


Other resources
Except for Fisher, at least one edition of the above texts is available from the Robertson Library; Fisher can be bought from the Publisher or through Curtin Bookshop. Note that older editions are generally just as good as newer editions, and often better because they tend to be shorter and more concise. If you happen upon a second hand copy of Churchill, buy it; it’s a gem.

You will need the following "text" in order to complete this unit. A soft copy is available on-line in Blackboard. A bound copy will be given to you in the first lecture.

- Mathematical Methods MATH3000 Lecture Notes 2016

These notes have a table of contents, an index, and exercises at the end of each chapter.
Assessment

Assessment schedule

<table>
<thead>
<tr>
<th>Task</th>
<th>Value %</th>
<th>Date Due</th>
<th>Unit Learning Outcome(s) Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment 1</td>
<td>16 percent</td>
<td>Week: 1,2,3,4,5,6,7,8,9,10,11,12</td>
<td>1,2,3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Day: TBA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time: As advised at login</td>
<td></td>
</tr>
<tr>
<td>Assignment 2</td>
<td>10 percent</td>
<td>TBA</td>
<td>1,3,5</td>
</tr>
<tr>
<td>In-Class Test</td>
<td>24 percent</td>
<td>TBA</td>
<td>1,3,4</td>
</tr>
<tr>
<td>Final Examination</td>
<td>50 percent</td>
<td>Week: In Exam Period</td>
<td>2,3,5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Day: TBA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time: TBA</td>
<td></td>
</tr>
</tbody>
</table>

Detailed information on assessment tasks

1. These are the AiM On-line quizzes. See the Learning Activities section for more information. Other details, including closing dates are provided on login to the quizzes.
2. Written assignments (up to 4, or fewer but longer). A true mathematician must learn to be precise in writing proofs/solutions to problems.
3. Generally, there will be a single question, but sometimes a bonus follow-up question. These will be at regular intervals, either weekly or fortnightly.
4. Either 2 hours or 2 1/2 hours. See further details under Learning Activities.

Pass requirements
To pass this unit you must:

- Achieve a grade/mark overall greater than or equal to 5/50.
- Obtain at least 50% in the final examination.

Fair assessment through moderation
Moderation describes a quality assurance process to ensure that assessments are appropriate to the learning outcomes, and that student work is evaluated consistently by assessors. Minimum standards for the moderation of assessment are described in the Assessment and Student Progression Manual, available from policies.curtin.edu.au/policies/teachingandlearning.cfm

Late assessment policy
This ensures that the requirements for submission of assignments and other work to be assessed are fair, transparent, equitable, and that penalties are consistently applied.

1. All assessments students are required to submit will have a due date and time specified on this Unit Outline.
2. Students will be penalised by a deduction of ten percent per calendar day for a late assessment submission (eg a mark equivalent to 10% of the total allocated for the assessment will be deducted from the marked value for every day that the assessment is late). This means that an assessment worth 20 marks will have two marks deducted per calendar day late. Hence if it was handed in three calendar days late and given a mark of 16/20, the student would receive 10/20. An assessment more than seven calendar days overdue will not be marked and will receive a mark of 0.

Assessment extension
A student unable to complete an assessment task by/on the original published date/time (eg examinations, tests) or due date/time (eg assignments) must apply for an assessment extension using the Assessment Extension form (available from the Forms page at students.curtin.edu.au/administration/) as prescribed by the Academic Registrar. It is the responsibility of the student to demonstrate and provide evidence for exceptional circumstances beyond the student's control that prevent them from completing/submitting the assessment task.

The student will be expected to lodge the form and supporting documentation with the unit coordinator before the assessment date/time or due date/time. An application may be accepted up to five working days after the date or due date of the assessment task where the student is able to provide an acceptable explanation as to why he or she was not able to submit the application prior to the assessment date. An application for an assessment extension will not be accepted after the date of the Board of Examiners' meeting.

According to Samuel Johnson (famous writer), "What is written without effort, is often read without pleasure".

It happens (but hopefully not too often) that the submission of an assignment by a due date, will mean the work is less than complete and not so legible. If by asking for an extension, you can make your work more pleasurable for the lecturer to mark, please do ask!

Generally, the smaller numbers of students engaged in this unit allow for a little more flexibility. It is good discipline for students to try to keep to deadlines, and not procrastinate. However, if an assessment is not completed within 2 weeks of the date assigned, this is a signal that the student has fallen 2 weeks behind. A student who falls 3 weeks behind has negligible chance of passing the unit. So after 2 weeks, sadly the only mark that can be awarded is 0.

Deferred assessments
If your results show that you have been granted a deferred assessment you should immediately check your OASIS email for details.

Deferred examinations/tests will be held from 18/07/2016 to 22/07/2016. Notification to students will be made after the Board of Examiners’ meeting via the Official Communications Channel (OCC) in OASIS.

Supplementary assessments
Supplementary assessments, if granted by the Board of Examiners, will have a due date or be held between 18/07/2016 and 22/07/2016. Notification to students will be made after the Board of Examiners’ meeting via the Official Communications Channel (OCC) in OASIS.

It is the responsibility of students to be available to complete the requirements of a supplementary assessment. If your results show that you have been granted a supplementary assessment you should immediately check your OASIS email for details.

Referencing style
The referencing style for this unit is Chicago.

More information can be found on this style from the Library web site: http://libguides.library.curtin.edu.au/referencing.

Copyright
© Curtin University. The course material for this unit is provided to you for your own research and study only. It is subject to copyright. It is a copyright infringement to make this material available on third party websites.

Academic Integrity (including plagiarism and cheating)
Any conduct by a student that is dishonest or unfair in connection with any academic work is considered to be academic misconduct. Plagiarism and cheating are serious offences that will be investigated and may result in penalties such as reduced or zero grades, annulled units or even termination from the course.

Plagiarism occurs when work or property of another person is presented as one's own, without appropriate acknowledgement or referencing. Submitting work which has been produced by someone else (e.g. allowing or contracting another person to do the work for which you claim authorship) is also plagiarism. Submitted work is subjected to a plagiarism detection process, which may include the use of text matching systems or interviews with
students to determine authorship.

Cheating includes (but is not limited to) asking or paying someone to complete an assessment task for you or any use of unauthorised materials or assistance during an examination or test.

From Semester 1, 2016, all incoming coursework students are required to complete Curtin’s Academic Integrity Program (AIP). If a student does not pass the program by the end of their first study period of enrolment at Curtin, their marks will be withheld until they pass. More information about the AIP can be found at: https://academicintegrity.curtin.edu.au/students/AIP.cfm

Refer to the Academic Integrity tab in Blackboard or academicintegrity.curtin.edu.au for more information, including student guidelines for avoiding plagiarism.

Information and Communications Technology (ICT) Expectations

Curtin students are expected to have reliable internet access in order to connect to OASIS email and learning systems such as Blackboard and Library Services.

You may also require a computer or mobile device for preparing and submitting your work.

For general ICT assistance, in the first instance please contact OASIS Student Support: oasisapps.curtin.edu.au/help/general/support.cfm

For specific assistance with any of the items listed below, please contact The Learning Centre: life.curtin.edu.au/learning-support/learning_centre.htm

- Using Blackboard, the I Drive and Back-Up files
- Introduction to PowerPoint, Word and Excel

Additional information

Hints on how to pass this unit

Attend all the lectures and tutorials. Much of the material is quite abstract and there’s a lot of it – you really need to hear the lecture to get the idea. By missing lectures and trying to catch up by reading the notes, you will miss too much. If you keep up, and apply yourself diligently to the assignments, you will have no trouble passing the final exam. If you have “work commitments” and can only attend half the lectures, you would be well-advised to either re-organise your work arrangements to attend all the lectures, or to re-schedule to take the unit at some later time. This is a difficult unit requiring a strong commitment.

Enrolment

It is your responsibility to ensure that your enrolment is correct - you can check your enrolment through the eStudent option on OASIS, where you can also print an Enrolment Advice.

Student Rights and Responsibilities

It is the responsibility of every student to be aware of all relevant legislation, policies and procedures relating to their rights and responsibilities as a student. These include:

- the Student Charter
- the University’s Guiding Ethical Principles
- the University’s policy and statements on plagiarism and academic integrity
- copyright principles and responsibilities
- the University’s policies on appropriate use of software and computer facilities

Information on all these things is available through the University’s "Student Rights and Responsibilities" website at: students.curtin.edu.au/rights.
Student Equity

There are a number of factors that might disadvantage some students from participating in their studies or assessments to the best of their ability, under standard conditions. These factors may include a disability or medical condition (e.g. mental illness, chronic illness, physical or sensory disability, learning disability), significant family responsibilities, pregnancy, religious practices, living in a remote location or another reason. If you believe you may be unfairly disadvantaged on these or other grounds please contact Student Equity at eesi@curtin.edu.au or go to http://eesi.curtin.edu.au/student_equity/index.cfm for more information.

You can also contact Counselling and Disability services: http://www.disability.curtin.edu.au or the Multi-faith services: http://life.curtin.edu.au/health-and-wellbeing/about_multifaith_services.htm for further information.

It is important to note that the staff of the university may not be able to meet your needs if they are not informed of your individual circumstances so please get in touch with the appropriate service if you require assistance. For general wellbeing concerns or advice please contact Curtin's Student Wellbeing Advisory Service at: http://life.curtin.edu.au/health-and-wellbeing/student_wellbeing_service.htm

Recent unit changes

Students are encouraged to provide unit feedback through eVALUate, Curtin's online student feedback system. For more information about eVALUate, please refer to evaluate.curtin.edu.au/info/.

To view previous student feedback about this unit, search for the Unit Summary Report at https://evaluate.curtin.edu.au/student/unit_search.cfm. See https://evaluate.curtin.edu.au/info/dates.cfm to find out when you can eVALUate this unit.

Recent changes to this unit include:

Apart from a name change from Mathematical Methods 301 (its name in 2014) and cleaning away of some typos. in the Lecture Notes, the unit's content has been stable since 2008, and its assessment structure was altered when the final exam was reduced to 50%. Progressively, some quizzes have been added to help students learn some of the algorithmic components of the unit, with a mini i-lecture added in front of the Green's function quiz in 2014.
**Program calendar**

Note, the schedule below is a guide only. The pace may vary, and some topics, such as "Hermite polynomials" will only be covered if time permits.

<table>
<thead>
<tr>
<th>WK (starting)</th>
<th>Lecture Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (29 Feb)</td>
<td><strong>Complex analysis:</strong> Review of complex number properties. <em>Functions of a complex variable:</em> definition, z-plane and w-plane, regions in the complex plane, limits, continuity, derivatives.</td>
</tr>
<tr>
<td>2. (7 Mar)</td>
<td><strong>Analytic functions:</strong> Cauchy-Riemann equations, harmonic functions. <em>Elementary functions:</em> polynomial, exponential, hyperbolic, logarithmic, trigonometric, complex powers, inverse trigonometric. Conformal mappings.</td>
</tr>
<tr>
<td>3. (14 Mar)</td>
<td><strong>Integration in the complex plane:</strong> contour integrals, Cauchy's Theorem, path independence, deformation of contours, Cauchy integral formula, derivatives of analytic functions, Maximum Modulus Theorem.</td>
</tr>
<tr>
<td>4. (21 Mar)</td>
<td><strong>Taylor's Theorem,</strong> zeros of analytic functions, <strong>Laurent Theorem and singularities of complex functions.</strong> Good Friday lecture made up on 28 March, usual time, usual place.</td>
</tr>
<tr>
<td>5. (28 Mar)</td>
<td>Tuition Free (includes Easter), except catch-up lecture for Good Friday scheduled on 28 March.</td>
</tr>
<tr>
<td>6. (4 Apr)</td>
<td><strong>Residue Theory:</strong> Cauchy's Residue Theorem, residues of simple and higher order poles, evaluation of complex and real integrals.</td>
</tr>
<tr>
<td>7. (11 Apr)</td>
<td>Residue Theory (continued).</td>
</tr>
<tr>
<td>8. (18 Apr)</td>
<td>Tuition Free.</td>
</tr>
<tr>
<td>9. (25 Apr)</td>
<td><strong>The Laplace Transform:</strong> definition and operational properties. <strong>The Inverse Laplace Transform:</strong> definition and operational properties. Application of Laplace Transform to solution of DEs partial fractions method; complex inversion formula.</td>
</tr>
<tr>
<td>10. (2 May)</td>
<td><strong>Special Functions:</strong> gamma, beta, error and hypergeometric functions. <strong>Generalised functions:</strong> Dirac delta, Unit step and signum functions. <strong>Partial Differential Equations (PDEs):</strong> Laplace’s equation in Different Coordinate Systems.</td>
</tr>
<tr>
<td>11. (9 May)</td>
<td><strong>Sturm-Liouville Systems.</strong> Complete sets of orthogonal functions on an interval.</td>
</tr>
<tr>
<td>12. (16 May)</td>
<td>Sturm-Liouville System for Legendre Polynomials; for Hermite Polynomials.</td>
</tr>
<tr>
<td>13. (23 May)</td>
<td>Sturm-Liouville System for Bessel Functions. <strong>Green’s Functions.</strong></td>
</tr>
<tr>
<td>14. (30 May)</td>
<td>Green’s Functions (continued).</td>
</tr>
</tbody>
</table>