UNSW Course Outline

MATH3101 Computational Mathematics for Science and Engineering - 2024

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General Course Information

Course Code : MATH3101
Year : 2024
Term : Term 2
Teaching Period : T2
Is a multi-term course? : No
Faculty : Faculty of Science
Academic Unit : School of Mathematics & Statistics
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Partial differential equations (PDEs) provide a natural mathematical description for many phenomena of interest in science and engineering. Such equations are often difficult or impossible to solve using purely analytical (pencil and paper) methods, especially for realistic industrial problems. This course introduces finite difference and finite element methods for elliptic and parabolic PDEs, and discusses key concepts such as stability, convergence and computational cost. Relevant techniques in numerical linear algebra are also discussed.

The course includes a substantial practical component dealing with the computer implementation of the algorithms used for solving partial differential equations. This component of the course is supported by a weekly computer lab. In addition, a weekly tutorial class provides exercises on the mathematical content covered in lectures.

The course is intended for students in mathematics programs, or students in science and engineering programs who have a strong mathematical background and an interest in computer modelling.

Note: Students must have prior experience with computer programming using Python, Matlab or Julia. For example, successful completion of an introductory programming course involving one of these three languages should be sufficient.

Course Aims

MATH3101 is designed to provide students with a solid mathematical foundation for employment or further study in a wide range of scientific and engineering fields that rely on numerical modeling based on partial differential equations. The practical component of the course provides students with the opportunity to develop their programming skills.

Relationship to Other Courses

Prerequisite: 12 units of credit in Level 2 Math courses including (MATH2011 or MATH2111) and (MATH2121 or MATH2221) or (both MATH2019(DN) and MATH2089) or (both MATH2069(CR) and MATH2099)

The school offers two related level 3 courses: Math3311 Computational Mathematics for Finance; and Math3371 Numerical Linear Algebra.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Formulate a finite difference approximation to a partial differential equation.
CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.
CLO3 : Employ Taylor expansions to estimate the local truncation error and the order of consistency of a finite difference scheme.
CLO4 : Determine the stability properties of a few simple time integration schemes for parabolic PDEs.
CLO5 : Solve a system of linear equations efficiently by exploiting sparsity and other matrix structures.
CLO6 : Use an appropriate programming language to implement numerical methods for solving partial differential equations, and to visualise and interpret features of the solution.

Course Learning Outcomes	Assessment Item
CLO1 : Formulate a finite difference approximation to a partial differential equation.	• Class test • Computing test • Assignment • Final Exam
CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.	• Class test • Computing test • Assignment • Final Exam
CLO3 : Employ Taylor expansions to estimate the local truncation error and the order of consistency of a finite difference scheme.	• Computing test • Assignment • Final Exam
CLO4 : Determine the stability properties of a few simple time integration schemes for parabolic PDEs.	• Computing test • Assignment • Final Exam
CLO5 : Solve a system of linear equations efficiently by exploiting sparsity and other matrix structures.	• Computing test • Assignment • Final Exam
CLO6 : Use an appropriate programming language to implement numerical methods for solving partial differential equations, and to visualise and interpret features of the solution.	• Computing test • Assignment

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Learning and Teaching in this course

The mathematical content of the course will be presented during the lectures (3 per week), and consolidated during the weekly tutorial. You will learn the computing component during the weekly lab class.

Additional Course Information

At the time of writing, the computing component of the course has three "offical languages": Matlab, Python and Julia. Students are free to choose any one of these.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Class test Assessment Format: Individual	15%	Start Date: Not Applicable Due Date: Not Applicable
Computing test Assessment Format: Individual	15%	Start Date: Not Applicable Due Date: Not Applicable
Assignment Assessment Format: Individual	20%	Start Date: Not Applicable Due Date: Week 10: 29 July - 04 August Post Date: 02/08/2024 12:00 AM
Final Exam Assessment Format: Individual	50%	Start Date: Not Applicable Due Date: Not Applicable

Assessment Details

Class test

Assessment Overview

The 45-minute class test will typically be scheduled for week 4. You will be expected to answer questions similar to those from the tutorials in weeks 1-3, and possibly some short questions about definitions and results from the lectures in weeks 1-3. Following the test, model solutions will be provided, and your script will be returned with feedback comments.

Course Learning Outcomes

- CLO1 : Formulate a finite difference approximation to a partial differential equation.
- CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.

Detailed Assessment Description

The 45-minute in-person class test will typically be scheduled for week 4. You will be expected to answer questions similar to those from the tutorials in weeks 1-3, and possibly some short questions about definitions and results from the lectures in weeks 1-3. Following the test, model solutions will be provided, and your script will be returned with feedback comments.

Assessment Length

A 45 minute written test.

Assignment submission Turnitin type

Not Applicable

Computing test

Assessment Overview

The computing test will typically be scheduled for week 7 and have a duration of 90 minutes. In the computer lab, you will be required to write a program using techniques covered during the lab classes in weeks 1-5. For example, you may be asked to use a given finite difference scheme to solve a partial differential equation and produce some appropriate graphical output. Following the test, model solutions will be provided, and you will receive feedback on your task.

Course Learning Outcomes

- CLO1 : Formulate a finite difference approximation to a partial differential equation.
- CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.
- CLO3 : Employ Taylor expansions to estimate the local truncation error and the order of consistency of a finite difference scheme.
- CLO4 : Determine the stability properties of a few simple time integration schemes for parabolic PDEs.
- CLO5 : Solve a system of linear equations efficiently by exploiting sparsity and other matrix structures.
- CLO6 : Use an appropriate programming language to implement numerical methods for solving partial differential equations, and to visualise and interpret features of the solution.

Detailed Assessment Description

The computing test will typically be scheduled for week 7 and have a duration of 90 minutes. In the computer lab, you will be required to write a program using techniques covered during the lab classes in weeks 1-5. For example, you may be asked to use a given finite difference scheme to solve a partial differential equation and produce some appropriate graphical output. Following the test, model solutions will be provided, and you will receive feedback on your task.

Assessment Length

Typically about 80 lines of code.

Assignment submission Turnitin type

Not Applicable

Assignment

Assessment Overview

The assignment will typically be available following the computing test and will be due at the end of the term. You will be provided with a description of a PDE model of some application, and a numerical method for computing the solution. You can expect some theory questions about the problem, but the programming component will account for most of the marks. Feedback on your assignment will be provided.

Course Learning Outcomes

- CLO1 : Formulate a finite difference approximation to a partial differential equation.
- CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.
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- CLO6 : Use an appropriate programming language to implement numerical methods for solving partial differential equations, and to visualise and interpret features of the solution.

Detailed Assessment Description

The assignment will typically be available following the computing test and will be due at the end of the term. You will be provided with a description of a PDE model of some application, and a numerical method for computing the solution. You can expect some theory questions about the problem, but the programming component will account for most of the marks. Feedback on your assignment will be provided.

Assessment Length

The written component will be one to three pages, and the programming part will be about 400 lines.

Submission notes

Submission will be via upload to Moodle

Assessment information

UNSW standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline,
- after which a student cannot submit an assessment, and
- no permitted variation.

Assignment submission Turnitin type

Not Applicable

Final Exam

Assessment Overview

The final exam will typically be a 2-hour written paper consisting of four multi-part questions on any topic from the course. The exam will emphasize the mathematical content, but you might be asked to write some pseudo-code.

The examination will take place during the official university examination period. Feedback is available through inquiry with the course convenor.

Course Learning Outcomes

- CLO1 : Formulate a finite difference approximation to a partial differential equation.
- CLO2 : Derive the weak form of an elliptic boundary-value problem and hence formulate an appropriate finite element method to compute an approximate solution.
- CLO3 : Employ Taylor expansions to estimate the local truncation error and the order of consistency of a finite difference scheme.
- CLO4 : Determine the stability properties of a few simple time integration schemes for parabolic PDEs.
- CLO5 : Solve a system of linear equations efficiently by exploiting sparsity and other matrix structures.

Detailed Assessment Description

The final exam will typically be a 2-hour written paper consisting of four multi-part questions on any topic from the course. The exam will emphasize the mathematical content, but you might be asked to write some pseudo-code.

The examination will take place during the official university examination period. Feedback is available through inquiry with the course convenor.

Assessment Length

A two-hour paper with four questions.

Assignment submission Turnitin type

Not Applicable

General Assessment Information

Check on Moodle for more information about each assessment.

Grading Basis

Standard

Requirements to pass course

There are no special requirements. You simply need a final mark of 50 or higher out of 100.

Course Schedule

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

The course is organised into six topics, arranged

1. Finite differences in 1D (Week 1)
2. Finite elements in 1D (Weeks 2-3)
3. Finite differences for parabolic problems (Week 4)
4. Finite elements for parabolic problems (Week 5)
5. Finite differences in 2D (Week 7)
6. Finite elements in 2D (Weeks 8-10)

Course Resources

Prescribed Resources

There are no prescribed resources apart from a personal computer and the course materials provided via Moodle. The latter include lecture slides, a set of course notes with tutorial exercises is provided, and a set of computer lab exercises.

Recommended Resources

The course notes should suffice, but as a supplement you might find the following text useful: Claes Johnson, *Numerical Solution of Partial Differential Equations* by the Finite Element Method, Dover Publications. The library has both hard copy and electronic versions of the book (518.64/4).

Course Evaluation and Development

At the start of term, students complete a short questionnaire about their computing background. This information is used to help with running the lab classes.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	William McL ean		H13 Anita Lawrence Building 2085	93857045	Monday-Friday	No	Yes

Other Useful Information

Academic Information

Upon your enrolment at UNSW, you share responsibility with us for maintaining a safe, harmonious and tolerant University environment.

You are required to:

- Comply with the University's conditions of enrolment.
- Act responsibly, ethically, safely and with integrity.
- Observe standards of equity and respect in dealing with every member of the UNSW community.
- Engage in lawful behaviour.
- Use and care for University resources in a responsible and appropriate manner.
- Maintain the University's reputation and good standing.

For more information, visit the UNSW Student Code of Conduct Website.

Academic Honesty and Plagarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words,

ideas or research. Not referencing other people's work can constitute plagiarism.
Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage. At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.
Further information about academic integrity, plagiarism and the use of AI in assessments can be located at:

- The Current Students site,
- The ELISE training site, and
- The Use of AI for assessments site.

The Student Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct

Submission of Assessment Tasks

Penalty for Late Submissions

UNSW has a standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

Any variations to the above will be explicitly stated in the Course Outline for a given course or assessment task.

Students are expected to manage their time to meet deadlines and to request extensions as early as possible before the deadline.

Special Consideration

If circumstances prevent you from attending/completing an assessment task, you must officially apply for special consideration, usually within 3 days of the sitting date/due date. You can apply by logging onto myUNSW and following the link in the My Student Profile Tab. Medical documentation or other documentation explaining your absence must be submitted with your application. Once your application has been assessed, you will be contacted via your student email address to be advised of the official outcome and any actions that need to be taken from there. For more information about special consideration, please visit: https://student.unsw.edu.au/special-consideration

Important note: UNSW has a "fit to sit/submit" rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so and cannot later apply for Special Consideration. This is to ensure that if you feel unwell or are faced with significant circumstances beyond your control that affect your ability to study, you do not sit an examination or submit an assessment that does not reflect your best performance. Instead, you should apply for Special Consideration as soon as you realise you are not well enough or are otherwise unable to sit or submit an assessment.

Faculty-specific Information

Additional support for students

- The Current Students Gateway
- Student Support
- Academic Skills and Support
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- UNSW IT Service Centre
- Science EDI Student Initiatives, Offerings and Guidelines

School-specific Information

School of Mathematics and Statistics and UNSW Policies

The School of Mathematics and Statistics has adopted a number of policies relating to enrolment, attendance, assessment, plagiarism, cheating, special consideration etc. These are in addition to the Policies of The University of New South Wales. Individual courses may also adopt other policies in addition to or replacing some of the School ones. These will be clearly notified in the Course Initial Handout and on the Course Home Pages on the Maths Stats web site. Students in courses run by the School of Mathematics and Statistics should be aware of the School and Course policies by reading the appropriate pages on the web site starting at: The School of Mathematics and Statistics assessment policies

The School of Mathematics and Statistics will assume that all its students have read and understood the School policies on the above pages and any individual course policies on the Course Initial Handout and Course Home Page. Lack of knowledge about a policy will not be an excuse for failing to follow the procedure in it.

Special Consideration - Short Extension Policy

The School of Mathematics and Statistics has carefully reviewed its range of assignments and projects to determine their suitability for automatic short extensions as set out by the UNSW Short Extension Policy. Upon comprehensive examination of our course offerings that incorporate these types of assessments, we have concluded that our current deadline structures already accommodate the possibility of unexpected circumstances that may lead students to require additional days for submission. Consequently, the School of Mathematics and Statistics has decided to universally opt out of the Short Extension provision for all its courses, having pre-emptively integrated flexibility into our assessment deadlines. The decision is subject to revision in response to the introduction of new course offerings. Students may still apply for Special Consideration via the usual procedures.

Computing Lab

The main computing laboratory is room G012 of the Anita B.Lawrence Centre (formerly Red Centre). You can get to this lab by entering the building through the main entrance to the School of Mathematics (on the Mezzanine Level) and then going down the stairs to the Ground Level. A second smaller lab is Room M020, located on the mezzanine level through the glass door (and along the corridor) opposite the School's entrance.

For more information, including opening hours, see the computing facilities webpage. Remember that there will always be unscheduled periods when the computers are not working because of equipment problems and that this is not a valid excuse for not completing assessments on time.

School Contact Information

Please visit the School of Mathematics and Statistics website for a range of information.

For information on Courses, please go to “Student life & resources” and either Undergraduate and/or Postgraduate and respective "Undergraduate courses" and "Postgraduate courses" for information on all course offerings.

All school policies, forms and help for students can be located by going to the "Student Services" within “Student life & resources” page. We also post notices in "Student noticeboard" for your information. Please familiarise yourself with the information found in these locations. If you cannot find the answer to your queries on the web you are welcome to contact the Student Services Office directly.

Undergraduate

E: ug.mathsstats@unsw.edu.au

P: 9385 7011 or 9385 7053

Postgraduate

E: pg.mathsstats@unsw.edu.au

P: 9385 7053

Should we need to contact you, we will use your official UNSW email address of in the first instance. **It is your responsibility to regularly check your university email account. Please use your UNSW student email and state your student number in all emails to us.**