UNSW Course Outline

MATH5361 Stochastic Differential Equations: Theory, Applications, and Numerical Methods - 2024

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General Course Information

Course Code : MATH5361
Year : 2024
Term : Term 3
Teaching Period : T3
Is a multi-term course? : No
Faculty : Faculty of Science
Academic Unit : School of Mathematics & Statistics
Delivery Mode : Multimodal
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Stochastic differential equation models play a prominent role in a range of application areas,

including biology, chemistry, epidemiology, mechanics, microelectronics, economics, and finance. This course covers the theory and applications of stochastic differential equations, the design and implementation on computers of numerical methods for solving these practical mathematical equations. The course will start with a background knowledge of random variables, Brownian motion, and Ornstein-Uhlenbeck process. Other topics studied include: stochastic integrals, the Euler-Maruyama method, Milstein, higher order method, stability and convergence. In addition to lectures, the distinct tutorial and lab classes will give students the opportunity to work on both mathematical exercises and computing problems.

Course Aims

The aim of this course is to introduce the basic theory of stochastic differential equations (SDEs), explain real-life applications, and introduce numerical methods to solve these equations. Stochastic differential equation models play a prominent role in a range of application areas, including biology, chemistry, epidemiology, mechanics, microelectronics, economics, and finance. With the ongoing development of powerful computers, there is a real need to solve these stochastic models. The corresponding SDEs generalise the ordinary deterministic differential equations (ODEs).

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Distinguish different types of stochastic differential equations and different types of solutions (Ito vs Stratonovich, strong solution vs weak solution).
CLO2 : Identify applications in modelling for each equation.
CLO3 : Describe, identify the strengths and weaknesses, and explain the differences in the numerical solutions learnt (Euler-Maruyama, Milstein, high order schemes, implicit schemes).
CLO4 : Implement methods learnt by writing computer code or using available software.
CLO5 : Appraise the confidence in computer solutions and predict uncertainties associated with a given computational problem.
CLO6 : Explain the convergence, consistency, and stability of each method.

Course Learning Outcomes	Assessment Item
CLO1 : Distinguish different types of stochastic differential equations and different types of solutions (Ito vs Stratonovich, strong solution vs weak solution).	• Assignment • Lab test • Final exam • Written Test
CLO2 : Identify applications in modelling for each equation.	• Assignment • Written Test
CLO3 : Describe, identify the strengths and weaknesses, and explain the differences in the numerical solutions learnt (Euler-Maruyama, Milstein, high order schemes, implicit schemes).	• Lab test • Final exam • Assignment • Written Test
CLO4 : Implement methods learnt by writing computer code or using available software.	• Lab test • Assignment
CLO5 : Appraise the confidence in computer solutions and predict uncertainties associated with a given computational problem.	• Final exam • Lab test • Assignment
CLO6 : Explain the convergence, consistency, and stability of each method.	• Final exam • Assignment

Learning and Teaching Technologies

Moodle - Learning Management System

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Assignment Assessment Format: Individual	20%	Start Date: 13/10/2023 12:00 AM Due Date: 10/11/2023 11:59 PM Post Date: 13/10/2023 12:00 AM
Lab test Assessment Format: Individual	15%	Start Date: 21/10/2024 02:00 PM Due Date: Not Applicable
Final exam Assessment Format: Individual	50%	Due Date: Exam Period
Written Test Assessment Format: Individual	15%	Due Date: Part one is taken in week 4; part two is taken in week 8

Assessment Details

Assignment

Assessment Overview

In the assignment that you will submit by the end of Week 9, you will apply the theory and code that you have learnt to solve a practical problem. Some harder questions requiring a comprehensive understanding of the course will be asked. Feedback will be given in the form of marks and comments from academic staff.

Course Learning Outcomes

- CLO1 : Distinguish different types of stochastic differential equations and different types of solutions (Ito vs Stratonovich, strong solution vs weak solution).
- CLO2 : Identify applications in modelling for each equation.
- CLO3 : Describe, identify the strengths and weaknesses, and explain the differences in the numerical solutions learnt (Euler-Maruyama, Milstein, high order schemes, implicit schemes).
- CLO4 : Implement methods learnt by writing computer code or using available software.
- CLO5 : Appraise the confidence in computer solutions and predict uncertainties associated with a given computational problem.
- CLO6 : Explain the convergence, consistency, and stability of each method.

Submission notes

Submission instructions on Moodle

Assessment information

Standard late submission panelties apply to this assignment.

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Lab test

Assessment Overview

In the Lab test in Week 7, you will be required to write some short programs under exam conditions.

The lab test will assess your ability to write and modify short MATLAB programs, test your knowledge of the language syntax and your understanding of standard programming constructs. You will need to demonstrate within an hour lab test that you have the necessary skills to write code to apply the methods learnt in lectures. Feedback will be given in the form of marks and comments from academic staff.

Course Learning Outcomes

- CLO1 : Distinguish different types of stochastic differential equations and different types of solutions (Ito vs Stratonovich, strong solution vs weak solution).
- CLO3 : Describe, identify the strengths and weaknesses, and explain the differences in the numerical solutions learnt (Euler-Maruyama, Milstein, high order schemes, implicit schemes).
- CLO4 : Implement methods learnt by writing computer code or using available software.
- CLO5 : Appraise the confidence in computer solutions and predict uncertainties associated with a given computational problem.

Assessment Length

1hr

Submission notes

Exam in Tutorial

Generative AI Permission Level

No Assistance

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Final exam

Assessment Overview

The final exam is designed to summarise your learning and problem-solving skills on all topics delivered across all weeks of the term, including material from lectures, tutorials and workshops. The exam is typically 2hrs 10 minutes and consists of questions that require short and long answers - details will be confirmed during the course. The examination will occur during the official university examination period. Feedback is available through inquiry with the course convenor.

Course Learning Outcomes

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- CLO5 : Appraise the confidence in computer solutions and predict uncertainties associated with a given computational problem.
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Written Test

Assessment Overview

In the class test, you are expected to demonstrate that you understand the theory and know how to apply it. Feedback will be given in the form of marks and comments from academic staff.

Course Learning Outcomes

- CLO1 : Distinguish different types of stochastic differential equations and different types of solutions (Ito vs Stratonovich, strong solution vs weak solution).

- CLO2 : Identify applications in modelling for each equation.
- CLO3 : Describe, identify the strengths and weaknesses, and explain the differences in the numerical solutions learnt (Euler-Maruyama, Milstein, high order schemes, implicit schemes).

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General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 September	Lecture	Probability spaces, sigma algebras, Lebesgue measure, random variables
Week 2 : 16 September - 22 September	Lecture	distributions, expectations, filtrations, independence, stochastic process, variance, correlation, conditional expectation, martingale, Markov process
Week 3 : 23 September - 29 September	Lecture	Brownian motion
Week 4 : 30 September - 6 October	Lecture	stochastic integrals
Week 5 : 7 October - 13 October	Lecture	stochastic differential equations
Week 7 : 21 October - 27 October	Lecture	multivariable stochastic differential equations
Week 8 : 28 October - 3 November	Lecture	numerical solutions of stochastic differential equations, Euler-Maruyama method, Milstein method
Week 9 : 4 November - 10 November	Lecture	Brownian bridge, connection between stochastic differential equations and partial differential equations
Week 10 : 11 November - 17 November	Lecture	parameter estimation in stochastic differential equation models

Attendance Requirements

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

General Schedule Information

Weeks 1-5: Theory of SDEs and their solutions

Weeks 7-10: Numerical Methods

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Lecturer	Daniel Han		Rm. 4074, Anita B Lawrence Building			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.**