UNSW Course Outline

# MATH5371 Numerical Linear Algebra - 2024

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## General Course Information

**Course Code :** MATH5371
**Year :** 2024
**Term :** Term 1
**Teaching Period :** T1
**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 :** Postgraduate
**Units of Credit :** 6

**Useful Links**

Handbook Class Timetable

## Course Details & Outcomes

### Course Description

The course is intended for students from Science and Engineering programs with interests in mathematics, statistics, data science or numerical simulation.

Algorithms from numerical linear algebra are ubiquitous in scientific and statistical software. The

theoretical component of the course aims to impart an understanding of how these algorithms work as well as an appreciation of their potential limitations. To illustrate the applications of numerical linear algebra, a variety of examples from statistics, data science and applied mathematics are described. The course includes a substantial computing component providing practical experience with widely used software libraries.

## Course Aims

The primary aim of the course is to introduce the fundamental algorithms used to solve the three key problems in linear algebra: solving a square system of linear equations; finding the least-squares solution to an overdetermined linear system; and computing the eigenvalues and eigenfunctions of a square matrix. A recurring theme is that the computational cost of a solution can often be greatly reduced by exploiting any special structure present in a matrix. The course also discusses a few of the wide range of applications of numerical linear algebra.

# Course Learning Outcomes

| Course Learning Outcomes |
|---|
| CLO1 : Estimate how the computational cost of an algorithm scales with the problem size for simple and complex problems in linear algebra. |
| CLO2 : Identify relevant structure in a matrix and select and analyse a specialised algorithm that exploits this structure for improved efficiency. |
| CLO3 : Use standard matrix factorisations to construct solution procedures in numerical linear algebra. |
| CLO4 : Identify matrix properties that can compromise the accuracy and reliability of numerical computations. |
| CLO5 : Quantify the relative merits of direct and iterative methods for problems in linear algebra. |
| CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions. |
| CLO7 : Describe the role of numerical linear algebra in a variety of scientific and statistical applications. |

| Course Learning Outcomes | Assessment Item |
|---|---|
| CLO1 : Estimate how the computational cost of an algorithm scales with the problem size for simple and complex problems in linear algebra. | • Online quizzes<br>• Exam<br>• Test |
| CLO2 : Identify relevant structure in a matrix and select and analyse a specialised algorithm that exploits this structure for improved efficiency. | • Online quizzes<br>• Exam<br>• Test |
| CLO3 : Use standard matrix factorisations to construct solution procedures in numerical linear algebra. | • Online quizzes<br>• Exam<br>• Test |
| CLO4 : Identify matrix properties that can compromise the accuracy and reliability of numerical computations. | • Assignment<br>• Exam |
| CLO5 : Quantify the relative merits of direct and iterative methods for problems in linear algebra. | • Assignment<br>• Exam |
| CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions. | • Assignment<br>• Online quizzes<br>• Test<br>• Exam |
| CLO7 : Describe the role of numerical linear algebra in a variety of scientific and statistical applications. | • Assignment<br>• Exam |

# Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360 | Blackboard Collaborate

## Learning and Teaching in this course

The lectures and the tutorial will be delivered in person and recorded on Echo360. The weekly computer lab class will not be recorded.

# Assessments

## Assessment Structure

| Assessment Item | Weight | Relevant Dates |
|---|---|---|
| Assignment<br>Assessment Format: Group | 15% | Start Date: 26/03/2024 12:00 AM<br>Due Date: 21/04/2024 12:00 AM<br>Post Date: 21/04/2024 12:00 AM |
| Online quizzes<br>Assessment<br>Format: Individual | 15% | Start Date: Monday in weeks 1, 3, 5<br>Due Date: Sunday following weeks 2, 4, 6 |
| Exam<br>Assessment<br>Format: Individual | 50% | Start Date: Check exam timetable when available<br>Due Date: Not Applicable |
| Test<br>Assessment<br>Format: Individual | 20% | Start Date: 25/03/2024 05:00 PM<br>Due Date: Not Applicable |

## Assessment Details

### Assignment

**Assessment Overview**

You will receive the assignment details shortly after the class test, with a submission date at the end of week 10.

The assignment will focus on a specific problem in linear algebra. By providing written answers to a series of short questions, you will develop the theory needed to solve the problem. Subsequent questions will guide you in writing a computer program to implement the solution for a concrete example. You will upload a zip archive containing your source files together with a pdf of your written answers.

As a rough guide, the written part of the assignment will be about 2 pages (typed), and the computing part about 100 lines of code.

Within 10 days of the due date, worked solutions and individual feedback will be provided via Moodle.

Course Learning Outcomes

- CLO4 : Identify matrix properties that can compromise the accuracy and reliability of numerical computations.
- CLO5 : Quantify the relative merits of direct and iterative methods for problems in linear algebra.
- CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions.
- CLO7 : Describe the role of numerical linear algebra in a variety of scientific and statistical applications.

Submission notes

See the assignment handout

Assessment information

Standard late submission rules apply (5% per day, up to a maximum of 5 days).

Assignment submission Turnitin type

This is not a Turnitin assignment

## Online quizzes

Assessment Overview

These three online quizzes will help reinforce your understanding of key concepts from lectures, as well as provide some revision of linear algebra topics. You will have two weeks to complete each quiz, with deadlines at the end of weeks 2, 4 and 6.

Immediate feedback is provided following the completion of the tasks.

Course Learning Outcomes

- CLO1 : Estimate how the computational cost of an algorithm scales with the problem size for simple and complex problems in linear algebra.
- CLO2 : Identify relevant structure in a matrix and select and analyse a specialised algorithm that exploits this structure for improved efficiency.
- CLO3 : Use standard matrix factorisations to construct solution procedures in numerical linear algebra.
- CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions.

Assignment submission Turnitin type

Not Applicable

## Exam

### Assessment Overview

The final exam is designed to assess your learning and problem-solving skills on all topics delivered across the term. The exam is 2 hours long and consists of 4 questions, with most question parts similar in style to problems discussed in the tutorials. The examination will occur during the official university examination period.
Feedback is available through inquiry with the course convenor.

### Course Learning Outcomes

- CLO1 : Estimate how the computational cost of an algorithm scales with the problem size for simple and complex problems in linear algebra.
- CLO2 : Identify relevant structure in a matrix and select and analyse a specialised algorithm that exploits this structure for improved efficiency.
- CLO3 : Use standard matrix factorisations to construct solution procedures in numerical linear algebra.
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- CLO5 : Quantify the relative merits of direct and iterative methods for problems in linear algebra.
- CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions.
- CLO7 : Describe the role of numerical linear algebra in a variety of scientific and statistical applications.

### Assignment submission Turnitin type

Not Applicable

## Test

### Assessment Overview

The Class Test assesses your knowledge of topics from weeks 1-5 using questions similar to those in the tutorials. This test will typically be held in Week 7 and be of 45 minutes duration. Solutions will be provided following the test, as well as individual feedback.

### Course Learning Outcomes

- CLO1 : Estimate how the computational cost of an algorithm scales with the problem size for simple and complex problems in linear algebra.
- CLO2 : Identify relevant structure in a matrix and select and analyse a specialised algorithm that exploits this structure for improved efficiency.
- CLO3 : Use standard matrix factorisations to construct solution procedures in numerical

linear algebra.
- CLO6 : Use a suitable programming language to solve simple and complex problems in linear algebra via calls to numerical library functions.

**Assignment submission Turnitin type**

Not Applicable

## General Assessment Information

**Grading Basis**

Standard

# Course Schedule

| Teaching Week/Module | Activity Type | Content |
|---|---|---|
| Week 1 : 12 February - 18 February | Lecture | Matrix and Vector Operations |
| Week 2 : 19 February - 25 February | Lecture | LU-Factorisation |
| | Assessment | Online Quiz 1 |
| Week 3 : 26 February - 3 March | Lecture | QR-Factorisation |
| Week 4 : 4 March - 10 March | Lecture | Exploiting Matrix Structure |
| | Assessment | Online Quiz 2 |
| Week 5 : 11 March - 17 March | Lecture | Eigenproblems |
| Week 6 : 18 March - 24 March | Other | No classes |
| | Assessment | Online Quiz 3 |
| Week 7 : 25 March - 31 March | Lecture | Singular Value Decomposition |
| | Assessment | Class Test |
| Week 8 : 1 April - 7 April | Lecture | Accuracy and Reliability |
| Week 9 : 8 April - 14 April | Lecture | Iterative Solution of Linear Systems |
| Week 10 : 15 April - 21 April | Lecture | Artificial Neural Networks |
| | Assessment | Assignment |

## Attendance Requirements

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

# Course Resources

## Prescribed Resources

Students can download all prescribed resources from Moodle.  These resources include the lecture slides, a detailed set of course notes that includes the tutorial exercises, and weekly exercises for the computer labs.

## Recommended Resources

The following are suitable reference books for the course.

- Peter J. Olver and Chehrzad Shakiban, Applied Linear Algebra, Second Edition, Springer 2018. (Digital copy P 512.5/244)
- Lloyd N. Trefethen and David Bau, Numerical Linear Algebra, SIAM Publications, 1997. (Hard copy, Library Level 4, P512.5/128 A)

# Staff Details

| Position | Name | Email | Location | Phone | Availability | Equitable Learning Services Contact | Primary Contact |
|---|---|---|---|---|---|---|---|
| Convenor | William McLean | | Anita B. Lawrence Centre (H13), Room 2085 | | | Yes | 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

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.**