FACULTY OF SCIENCE

SCHOOL OF MATHEMATICS AND STATISTICS

MATH2601
HIGHER LINEAR ALGEBRA

Term 2, 2019

MATH2601 – Course Outline

Course Authority and lecturer: John Steele, Red Centre 5103, phone 9385 7060, email `j.steele@unsw.edu.au`.

Consultation hours: TBA.

Credit: 6 Units of Credit (6UOC).

Prerequisites: MATH1231 or MATH1241 or MATH1251, each with a mark of at least 70.

Exclusions: MATH2501, MATH2099.

Lectures: There will be five lectures per week:

Monday 10am-12noon-2pm	Mathews-B
Wednesday 11am	Law G04
Friday 12noon-2pm	Chemical Sci M18

NOTE: These theatres are correct at time of printing, however they may change. Please check your online timetable for the most up–to–date information.

Tutorials. There will be one tutorial per week, from week 1 to week 10. Please check your online timetable for the most up-to-date information on which classes have space.

About this course

This 6UOC course is the Higher version of the core second year mathematics topic MATH2501 Linear Algebra. Either this course or MATH2501 is required for completion of a mathematics or statistics major. MATH2501 and MATH2601 are also compulsory or recommended for several other programs. MATH2601 is required for all maths or stats majors in advanced science and is required by all students an advanced mathematics degree.

Higher or Ordinary?

Formally, entry to MATH2601 requires a mark of 70 in first year. Past experience indicates that students who have not achieved this grade struggle with the course. MATH2601 contains a large amount of extra, theoretical material compared to MATH2501, and less emphasis on calculation. Apart from the deeper understanding that this brings, its reward is that the marks of both classes are moderated to make sure that the grades reflect the greater difficulty of MATH2601. Many more distinctions and high distinctions are awarded in MATH2601 than in MATH2501. The pass rate in MATH2601 is usually very high (as it should be with the quality of students in the course). However, **do not** believe the rumours that say "nobody ever fails higher" – you will have to work hard to get any benefit from studying this course.

Course aims

The principal aim of this subject is for students to develop a working knowledge of the central ideas of linear algebra: vector spaces, linear transformations, orthogonality, eigenvalues and eigenvectors, canonical forms and applications of these ideas in science and engineering.

In particular, the course introduces one of the major themes of modern mathematics: classification of structures and objects. Using linear algebra as a model, we will look at techniques that allow us to tell when two apparently different objects can be treated as if they were the same. Our secondary aim is to understand how certain calculations in linear algebra can be thought of as algorithms, that is, as fixed methods which will lead in finite time to solutions of whole classes of problems.

Additionally, there will be a focus on writing clear mathematical proofs.

Student learning outcomes

After completing this course, you should be able to

- demonstrate a deep understanding of the theory of the structure and properties of finite dimensional vector spaces over the real, complex and simple finite fields;
- apply the key ideas of linear algebra to a range of theoretical and applied problems;
- provide clear and logically written mathematical calculations and proofs.

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.

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. Students should attend all classes, prepare for lectures by reading through previous lecture notes, and work through practice problems prior to the tutorial. Tutorials will be run on the "flipped classroom" model, where students will work in groups of two or three on problem sets. The tutor will offer help or feedback when needed, and will also discuss the problems with groups in order to ensure that every student understands his/her group's solution.

Rationale for learning and teaching strategies

The course is structured to create a climate of enquiry in which students are actively engaged in the learning process. The emphasis is on problem-solving in tutorials and in the assessment; students are expected to devote the majority of their study time to this.

Assessment

UNSW assesses students under a "standards based" assessment policy. For more information on how this policy is applied in the School of Mathematics and Statistics, see
www.maths.unsw.edu.au/currentstudents/assessment-policies
In particular, please note carefully the following excerpt from this page.

> *The School of Mathematics and Statistics expects students to give solutions to problems and questions in tests, assignments and exams with the steps and arguments explained clearly and logically. You should attempt as far as possible to present your work to the same standard of exposition as given in lectures, notes and text books.*

The timetable for the summative assessment is given below.

Task	Details	Weight
Class test 1	Week 3	15%
Short assignment	due Friday 5p.m. week 6	10%
Class test 2	Week 9	15%
Final examination	scheduled by the University	60%

You should keep all marked assessment tasks until the end of semester in case an error has been made in recording the marks. Your marks will be available online, and you should check these well before the end of semester.

In addition, I will try to provide some formative assessment quizzes on moodle — some of these I may run in the lecture classes too

Mathematical writing and the short assignment

In all the assessment tasks, marks will be awarded for correct working, logical setting out, appropriate explanations and presentation, not just on the final answer. The aim of this is to develop your ability to present your mathematics in a professional way. Students should pay attention to neatness, grammar, clarity of argument, use of notation and so forth.

The short assignment will give students an opportunity to gain feedback on their mathematical writing. The assignment may be prepared in the mathematical typesetting language LaTeX, but this is not compulsory.

Class tests

The class tests will be held in the final lecture hour in weeks 3 and 9, and will last about 45 minutes. They are designed to give you a chance to assess your mastery of the course material, including both the theoretical and computational aspects of the course. Marks will be awarded for correct working, logical setting out and appropriate explanations and not just the final answer. Announcements will be made in lectures about the topics that are examinable.

Normal exam conditions apply in tests. In particular, you must bring writing paper, pens, a stapler and your student card to each test, you must not consult any kind of written material during the test, and you must not try to get assistance from or give assistance to any other person. You will not be allowed to use a calculator in class tests.

If you are absent from the test for illness or other reason, you must apply for special consideration using the UNSW Special Consideration online service. For details, and all other MathsStats policies of assessment, see

https://student.unsw.edu.au/special-consideration

https://www.maths.unsw.edu.au/currentstudents/assessment-policies

Resit of class test:

If you miss a class test and provide valid documentation, you will be permitted to take a resit version of the test. This resit will be offered a week or two after the original test, at a time outside the usual class times, probably at either 8am or 6pm on a day to be agreed (and depending on availability of a room).

If you are absent without a medical certificate you will receive a mark equivalent to zero for that task.

Final exam

The final two hour exam is the major assessment task; its purpose is to determine the level of student mastery of both the theoretical and computational course material.

You may bring a UNSW approved calculator to the exam, so long as it carries a UNSW sticker which shows that the calculator has been checked. These stickers may be obtained from the School of Mathematics and Statistics Office, and other Faculty Student Centres or Schools. See https://student.unsw.edu.au/exam-approved-calculators-and-computers for a link to the list of approved calculators.

For final exams for which a special consideration is granted, the Exams Unit will email the rescheduled supplementary exam date, time and location to your student zID email account directly. Please ensure you regularly check your student email account (zID account) for the information on new date for your final supplementary exam if your application is successful.

The supplementary exam period for the final exam can be found at this web site:
https://student.unsw.edu.au/exam-dates
Please ensure you are aware of these dates and that you are available during this time.

Lecture Notes

Lecture notes will be made available through Moodle. Normally I will provide, before each section begins, skeleton lecture notes. The lectures will be based on those and I will discus some matters further, write further details and solve problems. It is probably best to print the lectures notes (maybe 2 to a page) and bring them to lectures, where you can write on them the solutions to problems etc. (The notes have some colour but a black-and-white printout is fine.)

For some of the more important problems whose solutions are omitted from the notes, I may provide short videos on YouTube to supplement the lecture recordings.

Other Resources for Students

There is no set textbook and no one book covers all the course. The lectures, available through Moodle, will comprehensively cover the material and the lectures will define the course.

Practice problems will also be available on Moodle.

There are many texts on Linear Algebra in the library; you may want to look at:

- *Linear algebra done right* by S. Axler (P512.5/235)
- *Elementary linear algebra* by H. Anton (P512.897/153J)
- *Finite–dimensional vector spaces* by P.R. Halmos (P512.86/27)
- *Linear algebra* by J.B Fraleigh and R.A. Beauregard (P512.897/184)
- *Linear algebra* by M. O'Nan and H. Enderton (P512.5/239)

Syllabus and Rough Course Schedule

The syllabus consists of 8 chapters as listed below.

Note that topics in this syllabus have significant overlap with first year linear algebra will be treated very briefly. We expect you already to be proficient in all aspects of MATH1241 Algebra (or equivalent); if you are not, you should probably be taking MATH2501 instead of MATH2601.

1. Introduction and abstract algebra: groups, fields, subgroups, isomorphism.
2. Vector spaces, subspaces, bases, dimension, coordinates, sums and direct sums.

3. Linear transformations and matrices, kernels and images, isomorphisms, change of basis, similarity.

4. Orthogonality, inner product spaces, norms, projections, Gram–Schmidt algorithm, adjoints, QR factorisation, least squares, Householder algorithm.

5. Permutations, cycles and determinants.

6. Eigenvalues and eigenvectors, diagonalisability, spectral theorems, complexification. Applications: quadratic forms, rotations and reflections, singular value decomposition.

7. Triangularisation, Cayley–Hamilton Theorem, minimal and characteristic polynomials, decomposable linear maps, generalised eigenspaces, Jordan forms.

8. Exponentials of matrices, applications to differential equations.

The last lecture hour in weeks 5 and 8 (and maybe some others, depending on how we are progressing) will be used as a Problem Class where no new material is introduced but we will go through worked examples, typically from the tutorial problem set or old tests and exams.

The topics will be covered in the given order.

Rough Schedule

Lectures may fall behind or get slightly ahead of this timetable – with the new calendar I am largely guessing at how the lectures will pan out.

Weeks	content
1.	Chapter 1; Chapter 2;
2.	Chapter 2;
3.	Chapter 3; Test 1
4.	Chapter 3
5.	Chapter 4;
6.	Chapter 4; assignment due
7.	Chapter 5; Chapter 6;
8.	Chapter 6
9.	Chapter 7 ; test 2
10.	Chapter 8

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. Feedback is very important to us, so please don't leave it to the end of the course to pass on any ideas.

- As a result of feedback from 2006 we have increased the in-session assessment component, which was previously 20%.
- As a result of feedback from 2009 we have added some examples of true/false questions to the Problem Sheets.
- As a result of feedback from 2014 we have adopted the standard convention of using boldface symbols for vectors.

Administrative matters

Additional assessment.

For the School of Mathematics and Statistics policies on additional assessment, go to
www.maths.unsw.edu.au/currentstudents/special-consideration-illness-misadventure.

School rules and regulations.

Fuller details of the rules regarding attendance, release of marks, special consideration etc. are available via the School of Mathematics and Statistics web page at
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 are at
student.unsw.edu.au/plagiarism
and
my.unsw.edu.au/student/academiclife/Plagiarism.pdf.