UNSW
THE UNIVERSITY OF NEW SOUTH WALES

FACULTY OF SCIENCE
SCHOOL OF MATHEMATICS AND STATISTICS

MATH2601

HIGHER LINEAR ALGEBRA

Semester 2, 2013

MATH2601 – Course Outline

Course Authority and lecturer: Dr Daniel Chan, Room RC-4104, phone 9385 7084, email danielc@unsw.edu.au, webpage: web.maths.unsw.edu.au/∼ danielch.

Consultation hours: will be announced when my timetable is firm.

Credit: 6 Units of Credit (6UOC).

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

Exclusions: MATH2501.

Lectures: Lectures are scheduled as follows:

Wednesday	9:00–11:00	RC-Theatre
Thursday	11:00–1:00	OMB 112

Lectures run Weeks 1 - 12.

Tutorials: There will be one tutorial per week: choose one of

Wednesday	13:00–14:00	RC-2061, RC-2063
Friday	9:00-10:00	RC-1042, RC-1043

Tutorials run Weeks 2 - 13.

About this course. This 6UOC course is the Higher version of the core second year mathematics topic, Linear Algebra MATH2501. 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 highly recommended for students intending to proceed to Honours.

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 significant amount of extra, theoretical material compared to MATH2501. Apart from the extra understanding that this brings, the reward for this is that the marks of both classes are scaled 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 traditionally very high (as it should be with the quality of students in the course).

Course aims. The aim of this course is to give you a solid grounding in the theory and practice of linear algebra. Linear phenomena can be found everywhere in mathematics and more generally in nature. The modern language for describing this is via the notion of vector spaces and linear maps. In first year mathematics whether it be MATH1241 or MATH1251, we are only able to give you a quick crash course in the theory. Though we will revise material from these courses, beware that we will require you to know the material in much greater depth so don't rely on your first year knowledge to get you by. A quick look at the tutorial questions should convince you of this.

This course in particular will be quite heavy on theory compared to previous courses you will have taken. Firstly, almost all results will be proved, including many from first year. Secondly, this course is fairly abstract in nature and indeed, serves as a nice introduction to many of the basic notions of modern abstract algebra. Abstraction is a fundamental methodology in mathematics that identifies common principles from diverse sources and hence underlies the wide applicability of mathematics. You all would have seen a glimpse of abstract algebra in the definition of a vector space. Though you could have gotten away in MATH1241,MATH1251 without fully understanding such abstract notions, this will no longer be possible in MATH2601. An important aim of this course is for you to understand and appreciate some basic notions of abstract algebra. This will be easy for a very small number of you, and will require dedicated study from the rest. Improving your mathematical writing will be another important goal of this course.

There are many applications of linear algebra not only to other parts of mathematics, but also to science and engineering more generally. This course will also study many of these applications.

Student learning outcomes. By regularly attending lectures, applying yourself in tutorials and working through the tutorial exercises prior to the tutorial, you will

- develop an understanding of the main ideas of linear algbera,
- apply these ideas to a range of theoretical and applied problems,
- gain experience in communicating mathematics in a precise and rigorous way.

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. Students should attend all classes, and work through the tutorial problems prior to the tutorial. Skeleton lecture notes will be put up on the web (see my webpage above) and should be printed off before lectures. As the notions introduced are somewhat abstract, some of you may find it prudent to skim through these skeleton lecture notes before the lecture. Certainly, we strongly recommend that you read through previous lecture notes before class.

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; students are expected to devote the majority of their study time to this.

Assessment.

Task	Details	Weight
Class test 1	Week 6, Thursday lecture	15%
Class test 2	Week 11, Thursday lecture	15%
Exam	scheduled by the University	70%

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.

Mathematical writing. In this course, we expect that you will develop your mathematical writing skills. This is not something traditionally taught in high school where you need only "show correct working" to obtain full marks. As a result, for many of you, this will require careful study on your part. Mathematics is written in a particular way, especially with regards to proofs, to make sure the reader is convinced of the veracity of the argument. A well written proof is one where it is easy to check the validity of the argument. In particular, the logic should be clear and faultless, and there should be no possibility of ambiguity. For example, one should not introduce notation without comment unless it is standard. To encourage good writing style, for all your proofs, a portion of the mark will be allocated to writing style.

Class tests. The class tests 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. The tests will last about 40 minutes. Again, 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 your student card to each test, you must not bring any kind of written material into 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 illness (or some other circumstance beyond your control) affects your attendance at or performance in the class test do not make an official application for Special Consideration, just show a medical certificate (or other appropriate documentation) to your lecturer or tutor. Your final mark will be calculated from your other assessment tasks.

Final exam. The final three-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. A link to the list of approved calculators can be found at
`http://www.maths.unsw.edu.au/currentstudents/exam-information-and-timetables`

Resources for students.

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

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 (P 512.86/27)
- *Linear algebra* by J.B Fraleigh. and R.A. Beauregard (P 512.897/184)
- *Linear algebra* by M. O'Nan and H. Enderton (P512.5/239)

Lecture notes. The lecture slides will be available via my webpage.

Problem sets and past exams. Tutorial problem sheets will be available via Moodle.

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. In response to last year's student feedback, we will be including answers and hints to all problem sheets.

Administrative matters.

Additional assessment. See additional handout or

`http://www.maths.unsw.edu.au/currentstudents/additional-assessment`

School rules and regulations. Fuller details of the general rules regarding attendance, release of marks, special consideration etc. are available via the School of Mathematics and Statistics web page at

`http://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 can be found at

`http://www.lc.unsw.edu.au/plagiarism`

and

`http://www.lc.unsw.edu.au/plagiarism/plagiarism_STUDENTBOOK.pdf`

Syllabus.

(1) Permutations, groups, fields.
(2) Vector spaces, linear maps, isomorphisms.
(3) Direct sums and linear maps between direct sums.
(4) Image and kernel of linear maps. Linear independence.
(5) Co-ordinates, basis, dimension theory, vector space complements, change of co-ordinates.
(6) Invariant subspaces, invariant direct sums and diagonalisation theory.
(7) Applications to discrete and continuous dynamical systems.
(8) Jordan canonical forms.
(9) Inner product spaces, orthogonal complements and bases.
(10) Duals, adjoints, applications to least-squares.
(11) Spectral theory for self-adjoint and normal operators. Applications to quadrics and rotations.