THE UNIVERSITY OF SYDNEY
MATH2061 LINEAR MATHEMATICS and VECTOR CALCULUS
Unit of Study Information, Summer School 2019

MATH2061 consists of two separate modules – Linear Mathematics and Vector Calculus. Linear mathematics will be taught in the first half of the Summer School, and vector calculus in the second half.

In each module, you attend 7 lectures and 2 tutorials for every three days of classes. There will be three or four days of classes each week.

The **lectures** will present the material covered in this unit. Examples and applications of the theory will also be discussed.

During the **tutorials** you will be expected to work on the supplied problem sets. Your tutor will give you help where needed. You are strongly encouraged to work in a small group in the tutorial, and to discuss the problems with fellow students. Practice sheets contain questions similar to tutorial questions.

Web Site

The MATH2061 home page:

`http://www.maths.usyd.edu.au/u/UG/SS/SS2061`

You should check the page regularly, since important announcements relating to the unit will often be posted there. You should obtain the practice session questions, tutorial exercise sheets and assignment questions from this page, as they become available.

You should also check the School of Mathematics and Statistics Summer School web page

`http://www.maths.usyd.edu.au/u/UG/SS`

regularly, for any announcements relating to Summer School mathematics in general.
Email enquiries specific to this unit should be sent to `MATH2061@sydney.edu.au`.
General enquiries relating to Summer School mathematics should be sent to
`nathan.brownlowe@sydney.edu.au`.

Lectures and consultation times

Lectures run for 5 weeks, with the first lecture on Tuesday 8 January and the last lecture on Friday 8 February. You should attend all lectures, and the tutorial stream assigned to you at the beginning of Summer School.

	Monday	Tuesday	Thursday	Friday
Week 1		10am Lecture 11am Lecture 12pm Lecture	10am Lecture 11am Lecture 12pm Tutorial 2pm Consultation	10am Lecture 11am Lecture 12pm Tutorial
Week 2	10am Lecture 11am Lecture 12pm Lecture	10am Lecture 11am Lecture 12pm Tutorial	10am Lecture 11am Lecture 12pm Tutorial 2pm Consultation	10am Lecture 11am Lecture 12pm Lecture
Week 3	10am Lecture 11am Lecture 12pm Tutorial	10am Lecture 11am Lecture 12pm Tutorial	10am Lecture 11am Lecture 12pm Lecture 2pm Consultation	10am Lecture 11am Lecture 12pm Tutorial
Week 4		10am Lecture 11am Lecture 12pm Tutorial	10am Lecture 11am Lecture 12pm Lecture 2pm Consultation	10am Lecture 11am Lecture 12pm Tutorial
Week 5	10am Lecture 11am Lecture 12pm Tutorial	10am Lecture 11am Lecture 12pm Lecture	10am Lecture 11am Lecture 12pm Tutorial 2pm Consultation	10am Lecture 11am Lecture 12pm Tutorial

Note: All lectures are held in Chemistry Lecture Theatre 1. All consultations are held in Carslaw 605. Tutorials are held in various rooms throughout Summer School. Please see your timetable on Canvas for details.

Note: If you are unable to make those consultation times, I will be happy to make an alternative arrangement with you.

Tutorials

Tutorials start in week 1, and run for 5 weeks. The final tutorial for this unit will be on Friday 8 February. Tutorial sheets will be available from the Summer School MATH2061 website. You must take each tutorial sheet with you to your class. Solutions to tutorial questions will be posted on the web after each tutorial.

Course Notes

Course Notes for Linear Mathematics by J. Henderson, are available from Kopystop, 55 Mountain Street, Broadway. Please note that Chapter 6 on Linear Transformations is no longer in the course.

Course Notes for MATH2061/2067 Vector Calculus by S Britton and K-G Choo, are available from Kopystop, 55 Mountain Street, Broadway.

It is also recommended that you have *"the little blue book"*, which is a compact reference book containing a summary of information from first year mathematics that is essential for many second year mathematics courses. This is available from the Co-op Bookshop on campus.

Reference books for Linear Mathematics

Anton and Busby, *Contemporary Linear Algebra*. Wiley.
Anton, H., and Rorres, C. *Elementary Linear Algebra; applications version* , Wiley.
Lay, David C. *Linear Algebra and its Applications*, 2^{nd} Edition. Addison Wesley.
Leon, Steven J. *Linear Algebra with Applications*, 6^{th} Edition. Prentice Hall.
Noble, B. and Daniel, J. *Applied Linear Algebra*, 3^{rd} Edition. Prentice-Hall.
Strang, G., *Linear Algebra and its Applications*, 3^{rd} Edition. Harcourt Brace Jovanovich.

Reference books for Vector Calculus

Hughes-Hallett et al, *Single and Multivariable Calculus*, 3^{rd} edition, Wiley.
Kreyszig, E., *Advanced Engineering Mathematics*, 7^{th} or 8^{th} edition, Wiley.
Stewart, J., *Calculus*, 4^{th} or 5^{th} edition, Brooks/Cole.

Assessment

Each module will be assessed separately. Your final mark for the unit will be the sum of the marks for each module divided by two. Your final mark for each module will be calculated as the sum of your marks for the examination (65%), the quiz (30%, using the better mark principle) and the assignment (5%).

The *better mark principle* means the quiz counts if and only if it is better than or equal to your exam mark for that module. If your quiz mark is less than your exam mark, the exam mark will be used for that portion of your assessment instead. For example, if your quiz mark is worse than your exam mark, then the exam will count for 95%, and the assignment will count for 5% of your mark for that module. The assignment mark counts for 5% regardless of whether it is better than your exam mark or not.

Examination – worth 65%.

There will be an examination at the end of Summer School. More information relating to the exam will be provided later in the semester.

Two quizzes – worth 30%.

The quizzes will be held during your tutorial on **Monday 21 January** (for Linear Mathematics) and **Thursday 7 February** (for Vector Calculus).

Two assignments – worth 5%

The assignments will be due on **Thursday 17 January** (for Linear Mathematics) and **Monday 4 February** (for Vector Calculus). Please note that the maximum possible **extension for the assignment is 7 days** (including the weekend). The handwritten assignment **must be scanned/imaged and submitted** in PDF format online via LMS (https://canvas.sydney.edu.au/) with **Turnitin**. Please ensure your submitted pdf is legible and keep your original handwritten version.

Late penalties: All assignments must be submitted by the due date. Students are expected to manage their time and to prioritise tasks to meet deadlines. Assessment items

submitted after the due date without an approved extension using a special consideration or special arrangement form or request will incur penalties.
If you encounter a problem submitting your work on time, you may be able to arrange a simple extension. A simple extension is an informal arrangement between you and your unit of study coordinator. You may be able to receive an extension of up to two working days for non-examination tasks, as outlined in clause 66A of the Coursework Policy 2014. If you need an extension for a longer period, you may be eligible to apply for special consideration. `sydney.edu.au/students/simple-extensions`

Special consideration: A special consideration application can be made for short-term circumstances beyond your control, such as illness, injury or misadventure, which affect your preparation or performance in an assessment.
`sydney.edu.au/special-consideration-and-arrangements`.

Graduate qualities: The graduate qualities are the qualities and skills that all University of Sydney graduates must demonstrate on successful completion of an award course. As a future Sydney graduate, the set of qualities have been designed to equip you for the contemporary world. For more information go to `sydney.edu.au/students/graduate-qualities`.

GQ1 Depth of disciplinary expertise

GQ2 Critical thinking and problem solving

GQ3 Communication (oral and written)

GQ4 Information & digital literacy

GQ5 Inventiveness

GQ6 Cultural competence

GQ7 Interdisciplinary effectiveness

GQ8 Integrated professional, ethical and personal identity

GQ9 Influence

WHAT IS LINEAR MATHEMATICS ABOUT?

Linear mathematics is one of the foundations of modern mathematics. It is important theoretically because so many apparently different processes in the natural world have the same *linear structure* – they are *vector spaces*. In addition, many non–linear processes are often so complicated that they are modelled by linear approximations as a first step towards their understanding. Numerical solutions to many linear problems can be found quickly and accurately, using the theory that is at the heart of this course. We will study the beginnings of vector space theory and discuss some of the applications.

Assumed Knowledge

The prerequisite for this module is any one of the first year linear algebra units of study (MATH1002, MATH1902 or MATH1014). You should revise the following topics from that unit: equations of lines and planes in space, the solution of systems of linear equations, reduced row echelon form of a matrix, elementary matrices, the calculation of eigenvectors and eigenvalues for 2×2 and 3×3 matrices.

Objectives

∗ To introduce the basic concepts of vector spaces.
∗ To demonstrate how abstract theory can be applied to concrete problems in science and engineering.
∗ To develop logical thinking and the ability to analyse mathematical arguments.
∗ To enhance your problem-solving abilities.

Outcomes

At the end of this unit of study, students should be able to:
∗ solve a system of linear equations,
∗ apply the subspace test in several different vector spaces,
∗ calculate the span of a given set of vectors in various vector spaces,
∗ test sets of vectors for linear independence and dependence,
∗ find bases of vector spaces and subspaces,
∗ find a polynomial of minimum degree that fits a set of points exactly,
∗ find bases of the fundamental subspaces of a matrix,
∗ test whether an $n \times n$ matrix is diagonalisable, and if it is find its diagonal form,
∗ apply diagonalisation to solve recurrence relations and systems of DEs.

Intended weekly outline

- Week 1: Linear systems, Gaussian elimination, vector spaces, subspaces, linear combinations, span.
- Week 2: Linear dependence and independence, basis, dimension, Lagrange interpolation, column space, null space, rank, nullity, eigenvalues and eigenvectors, Diagonalisation theorem, recurrence relations.
- Week 3: Leslie population model, systems of linear differential equations.

WHAT IS VECTOR CALCULUS ABOUT?

Vector calculus is a powerful mathematical instrument for the study of various physical phenomena, and is indispensable as a tool in applied mathematics, engineering and science, and fundamental to many other areas of mathematics. We study the calculus of vector fields, which are functions that assign vectors to points in space.

A substantial part of the module will deal with integration in the plane and in space using vector methods. The module begins with a discussion of line integrals, which, for example, can be used to find work done by a force field in moving an object along a curve. Next, we will discuss double and triple integrals, which can be used to evaluate area, volume, centroids, mass of a variable-density solid, and many other quantities. These ideas are then extended to surface integrals, which can be used to find the rate of fluid flow across a surface or flux of an electric field across a surface. Connections between these types of integrals are given by the three important theorems of vector calculus, namely, Green's Theorem, Gauss' Theorem and Stokes' Theorem.

Assumed knowledge

The prequisites for this module are (MATH1021/1921 or MATH1001/1901) and (MATH1002/1902) and (MATH1023/1923 or MATH1003/1903). The vectors section of MATH1002/1902 is particularly important, as are the curve sketching, 3D surfaces and the integration techniques from the Calculus units.

Objectives

∗ To introduce the basic concepts of vector calculus.
∗ To demonstrate how abstract theory can be applied to concrete problems in science and engineering.
∗ To develop logical thinking and the ability to analyse mathematical arguments.

Outcomes

Students who successfully complete this course should:
∗ have extended (from first year) their knowledge of vectors in two and three dimensions, and of functions of several variables;
∗ be able to evaluate certain line integrals, double integrals, surface integrals and triple integrals;
∗ understand the physical and geometrical significance of these integrals;
∗ know how to use the important theorems of Green, Gauss and Stokes.

Intended weekly outline

- Week 3: Vector equations of lines and curves (revision). Arc length. Two types of line integrals. Work done by a force. Vector fields. Grad and curl. Normals to surfaces. Conservative fields and potential functions.
- Week 4: Conservative fields and potential functions. Double integrals. Area, volume and mass. Green's theorem. Div (divergence of a vector field). Surface integrals.
- Week 5: Flux across a curve. Surface area. Flux across a surface. Polar, cylindrical and spherical coordinates. Triple integrals. Volume and mass revisited. Gauss' divergence theorem. Triple integrals in cylindrical/spherical coordinates. Stokes' theorem. Connections between different types of integrals.

For best results and maximum enjoyment in this unit of study, you should make every effort to attend all the lectures, practice sessions and tutorials. Do as many problems as you can, and make sure you work through the solutions to the tutorial exercises each week. Read over your own notes as well as the printed lecture notes, think deeply about the new definitions and ideas, and come with your questions to consultation times. I will be pleased to help you.

Educational integrity: While the University is aware that the vast majority of students and staff act ethically and honestly, it is opposed to and will not tolerate academic dishonesty or plagiarism and will treat all allegations of dishonesty seriously.
All written assignments submitted in this unit of study will be submitted to the similarity detecting software program known as Turnitin. Turnitin searches for matches between text in your written assessment task and text sourced from the Internet, published works and assignments that have previously been submitted to Turnitin. If such matches indicate evidence of plagiarism to your teacher, they are required to report your work for further investigation.
Plagiarism is defined as presenting another persons work as ones own by presenting, copying or reproducing it without appropriate acknowledgement of the source.
Plagiarism includes presenting work for assessment, publication, or otherwise, that includes:

a. phrases, clauses, sentences, paragraphs or longer extracts from published or unpublished work (including from the internet) without appropriate acknowledgement of the source; or

b. the work of another person, without appropriate acknowledgement of the source and in a way that exceeds the boundaries of legitimate co-operation.

Further information on academic honesty and the resources available to all students can be found on the Academic Integrity page of the current students website: `sydney.edu.au/educational-integrity`.