

# MA500-1 Advanced Linear Algebra

SEMESTER 1 2017-18

COURSE OUTLINE

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LECTURES: Monday 11.00, Tuesday 12.00, Wednesday 12.00, all in ADB-1020

COURSE WEBSITE: <http://www.maths.nuigalway.ie/~rquinlan/linearalgebra>

## Syllabus

This course is an exploration of some topics in linear algebra, from algebraic and algorithmic viewpoints. Linear algebra is a vast subject that pervades virtually all areas of mathematical work including (for example) algebra, analysis, geometry, coding theory, differential equations, numerical analysis, computational mathematics and mathematical modelling.

Mostly, we will investigate the spectrum (or list of eigenvalues) of a square matrix. We will consider such questions as *why we should care about the spectrum*, *how to calculate a spectrum*, and *what can be deduced about the spectrum from structural properties of a matrix or from inspection of its entries*. Both theoretical and computational considerations will be included, and we will discuss connections to graph theory and to other areas of mathematics and applied mathematics.

The course will include some classical highlights of matrix theory and some of their implications, for example

- The Cauchy Interlacing Theorem
- The Perron-Frobenius Theorem
- The Geršgorin Circle Theorem(s)
- The Jordan Canonical Form
- The Singular Value Decomposition
- The Schur form
- The Power method
- The QR factorisation algorithm.

## Background

Familiarity with the basic mechanisms of matrix algebra (matrix multiplication, determinants, inverses, eigenvalues, etc) is expected, as well as knowledge of the essential concepts of abstract linear algebra (vector space, linear independence, spanning set, basis, dimension, linear transformation). If you have any doubts about whether your background in these areas is sufficient, please consult the lecturers.

## Course Structure

The lecture “notes” for this module consist of notes posted (in instalments) on the module’s website and prescribed reading from text books; these constitute the “text” for the course. The lecture time will be used to discuss the central themes and important questions and not to read every detail of the notes. There will be a series of three or four homework assignments as the course proceeds. We can use some of the lecture time to talk about the homework problems.

## Assessment

The set of homework assignments will account for 30% of the marks.

The two-hour final exam in the Winter exam session will account for 70% - more details on that later.

## Essential and supplementary reading

You will find many books on linear algebra in the library, including the following which might be relevant to your work on this course. Wikipedia also has very good pages on many of the concepts of linear algebra that we will be discussing.

- *Basic Linear Algebra*, Blyth and Robertson (512.5)
- *Matrix Analysis*, Horn and Johnson (512.9434 HOR)
- *Numerical Linear Algebra*, Trefethen and Bau (512.5 TRE). The first five chapters are freely available.
- *Matrix Algorithms: Volume II: Eigensystems*, G.W. Stewart. The full text is freely available to NUI Galway students at <http://epubs.siam.org.libgate.library.nuigalway.ie/doi/book/10.1137/1.9780898718058>.
- *Applied Numerical Linear Algebra*, J.W. Demmel. The full text is freely available to NUI Galway students at <http://epubs.siam.org/doi/book/10.1137/1.9781611971446>