Linear Algebra, Math 215, Spring 2008

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Text:	L.N. Stout, **Linear Algebra** , manuscript 1998, revised Summer 2007

Course Description

Linear Algebra is the study of vector spaces and linear transformations. This is rather different from your study of calculus or previous algebra experience because we are studying a whole class of spaces, not just the properties of one particular number system. Vectors in Euclidean 2-space and 3-space are studied in Calculus 3 and in the analysis sequence, so some of the properties of a vector space may be familiar: vectors can be added to get another vector and vectors can be multipied by a scalar to get another vector. A vector space over a field is a set equipped with a two operations, one which behaves like addition of vectors, and one that behaves like multiplication by a scalar. Linear transformations are functions which respect the operations of addition and scalar multiplication. Differentiation is a good example of a linear transformation.

Properties of vector spaces and linear transformations are often most easily proved in the abstract. Once we have the notion of a basis, however, we can make the finite dimensional part of the subject quite concrete by representing vectors as n-tuples of numbers and linear transformations as matrices. Another side of the subject then involves manipulating matrices and interpreting the results you get. This linking of the abstract with the concrete makes the subject a good bridge from the concrete mathematics of the lower division to the abstract mathematics at the 300 and 400 levels. Concepts from linear algebra are used in nearly every upper level mathematics course and have become quite important in physics, engineering, economics, and statistics.

This course approaches the subject by first limiting the computational difficulty and considering all of the notions of Linear Algebra in the very simple setting of Euclidean 2 space where geometric intuition works nicely and there is little difficulty in solving any systems of equations which may come up. We then move to the level of full abstraction. This necessitates a more systematic approach to solving systems of equations, so we take up Gaussian elimination as a computationally efficient means of systematic solution. The problem of solution of a system of equations can be rather sensitive to round off error, so we will avoid using approximate arithmetic and leave analysis of error propigation and other algorithms which control error to a course in numerical analysis or numerical linear algebra.

One particular algorithm gets quite a workout in this course: row reduction. We will use it first to solve systems of equations, then to answer questions about independence (which reduce to systems of equations, but we'll use the algorithm more directly), then to find inverses for linear transformations, then to find determinants. We will use observations about the progress of the algorithm in proofs.

Once we have a good method for solving systems of equations we can turn to the problems of finding bases and representing linear transformations with matrices, given choices of basis for domain and codomain. Good choices entail finding eigenvalues, so we'll develop some algorithms for that problem.

Eigenvalues for linear transformations are extremely important in applications and as a theoretical tool. In particular, they tell us a lot about the dynamics of iteration of linear transformations. We will first gain an understanding of the kind of information they give by looking at small examples and then see how they can be found and used in more general situations. Addition of an inner product to our structure will allow us to consider length and angle (or at least orthogonality) in our spaces. This leads to the notion of best approximation through orthogonal projection, the basis for Fourier series and wavelet analysis and several other important notions in numerical analysis.

We will use *Mathematica* to illustrate the concepts and take the drudgery out of some of the computations. Some time will need to be spent outside of the schedulded class time to complete the lab problems.

Exams and Grading

There will be three in exams in the course. See the course calendar for tentative dates. The third is at the time scheduled for the final. Each of these will count 150 points (typically 100 points in class, 50 in a takehome using the lab). I will assign regular homework to help you keep up with the class.

My exams always include definitions, examples of how those definitions apply, proofs of theorems, and problems of varying difficulty. Competence in the mechanics of the subject will earn you a C; mastery of the technique and the definitions and reasonable facility with the applications is B work; I expect facility with the theory, mastery of the technique and applications, and clear expression of mathematical ideas for an A.

I will use a straight scale for determining grade. To allow flexibility at boundaries, I reserve the right to change the boundaries, but will draw them no higher than:

A :	90% or over
A-:	[87,90)
B+:	[83,87)
B :	[78,83)
B-:	[75,78)
C+:	[70,75)
C :	[65,70)
C-:	[60,65)
D :	[50,60)
F :	below 50%

Note: The line for passing will not move, the others *may* move downward.

Attendance Policy

Classes and office hours are what you pay tuition for, so take advantage of them. If you don't come to class you will not learn the material with the same emphasis that I put on it. That will hurt your exam scores and detract from what you learn. I do not deduct points for classes missed.

Policy on Academic Integrity

Work handed in for a grade is expected to be your own work. **On Take Home exams there should be no collaboration.** On daily homework there is something to be gained by talking and working with your fellow students: if homework is done in a group each student should write it up but include the names of all of the students who worked together in the group. If you use outside sources, cite them. If you get help from an individual, give credit. It is not wise for you to neglect learning how to do the work on your own, since exams will all require all work to be done individually. Any cheating on exams or collaboration on assignments where it has been explicitly prohibited will be treated as a violation of the policy on academic dishonesty in the student handbook and will be reported to the Associate Provost.