Mathematics 614: Numerical Linear Algebra

Fall 2019

Instructor: John Rhodes

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Office Hours: M 11:45-12:45, Tu 9:15-10:15, F 9:15-10:15, and by appointment

Web page: `https://jarhodesuaf.github.io/M614.html`

Prerequisites: undergraduate Linear Algebra

Credit Hours: 3.0

Textbook: Numerical Linear Algebra, by Trefethen and Bau, SIAM 1997

Class Meetings: MWF 10:30-11:30, Chapman 204

Exams: Midterm: Monday, October 14, in class;
Final: 10:15 a.m.-12:15 p.m., Wednesday, December 11

Catalog Description: Algorithms and theory for stable and accurate computation using matrices and vectors on computers. Matrix factorizations, direct and iterative methods for solving linear systems, least squares, eigenvalue and singular value decompositions. Practical implementation and application of algorithms.

Course overview and goals:

Linear Algebra is arguably the most important mathematical framework for modern scientific computation. Even problems that appear to be based firmly on calculus (e.g., the solution of partial differential equations) are generally translated into linear algebra problems through discretization. However, computers are incapable of working with exact real (or complex) numbers, and large computations can be very time consuming even with the best available hardware.

This course covers how linear algebra computations are performed in practice, in order to be both efficient (giving answers in a reasonable amount of time) and accurate (so that the inevitable errors in computer calculations are kept small). As you will quickly learn, some of the approaches emphasized in an undergraduate linear algebra course are computational disasters, and must be replaced with new algorithms. Building on your conceptual understanding from an undergraduate linear algebra course, you should gain a much more comprehensive understanding of how linear algebra should be used on the large-scale problems typical of real applications.

Specific topics include: the Singular Value Decomposition, QR factorization and least squares, conditioning and stability, operation count and problem size, systems of equations and Gaussian elimination, computing eigenvalues, and iterative methods.

While the emphasis will be on the mathematical ideas, understanding them fully requires implementation and experimentation. Students will therefore gain facility with MATLAB (or Octave).

Mechanics of the course:

Lectures The course will be delivered as a lecture, but I prefer to keep it informal. I am happy to be interrupted with questions and comments at any point. It is particularly important to speak up if you do not understand some background material, and also see me outside of class if you find you have some large gap. Asking question during lectures will benefit everyone.

Textbook and Software The textbook is required. It is widely recognized as excellent, and worth owning. You should read sections relevant to the lectures thoroughly.

If your undergraduate linear algebra is rusty, you may want to refer to a text for that as well. Whatever textbook you used is likely to be good enough, but if you need other suggestions, I especially recommend those by Gilbert Strang and David Lay.

You will need regular access to MATLAB (licensed for computers of UAF affiliates, installable on OSX through OIT Self Service, or on Windows through detailed instructions on the OIT Software webpage, or, if you prefer, Octave (free, but you are on your own for support).

Homework Homework problems will be assigned at most class meetings, but only collected each Monday (due in class – hard copy only – but accepted at my office or mailbox until 2pm).

Homework will be posted on the course web page soon after it is assigned. If you miss class, that is where you should look.

Late homework that has not been approved ahead of time will not be accepted. *There will be no exceptions to this* other than for a genuine emergency (e.g., a death in the family, documented illness, etc.).

I encourage you to work with others on the homework, but to *write up the solutions independently.* In writing up your work, you should present your arguments in such a way that an intelligent, but ignorant, person can understand them. In particular complete sentences and a logical presentation are expected.

All homework must be typed, using LaTeX. A recommended homework template is available on the course web page. If you have not used LaTeXbefore, you should install your choice of the many free implementations on your computer, and ask either the instructor or another student for a quick introduction. Google searches and the Detexify website will then provide answers to most questions that you have.

Examinations Both the midterm and final examinations will be in-class, closed-book exams. For missed examinations that are not approved in advance, no make-up exams will be given, except in case of emergencies.

Grades Your performance will be evaluated based on 55% homework, 20% midterm exam, 25% final exam. Course grades will be determined according to the following cutoffs:

$$A \geq 90\%, \quad B \geq 80\%, \quad C \geq 70\%, \quad D \geq 60\%,$$

with $+/-$ assigned for the ends of these ranges. I reserve the right to move the cutoff points downward if necessary to ensure fairness. Note that you are not in competition with your peers – everyone in the class may get an A, or everyone may get an F.

University and Department Policies Your work in this course is governed by the UAF Honor Code. The Department of Mathematics and Statistics has specific policies on incompletes, late withdrawals, and early final exams which can be found at

`http://www.dms.uaf.edu/dms/Policies.html`.

If you have any disabilities that affect your work in this class, bring them to the attention of the instructor as soon as possible, so that we can work with the Office of Disability Services to set up any necessary accommodations.

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Tentative Schedule

Week	Dates	Topics
1	Aug 26-Aug 30	Fundamentals
	Sept 2	LABOR DAY
2	Sept 4-6	
3	Sept 9-13	QR and Least Squares
4	Sept 16-20	
5	Sept 23-27	Conditioning and Stability
6	Sept 30-Oct 4	
7	Oct 7-11	
8	Oct 14-18	MIDTERM EXAM (Monday) , Systems of Equations
9	Oct 21-25	
10	Oct 28-Nov 1	Eigenvalues
11	Nov 4-8	
12	Nov 11-15	
13	Nov 18-22	Iterative Methods
14	Nov 25	
	Nov 27-29	THANKSGIVING
15	Dec 2-6	
	Dec 11	FINAL EXAM