MATH 614 Numerical Linear Algebra

Fall 2021, UAF

Instructor:
Ed Bueler
Chapman 306C
office hours: bueler.github.io/OffHrs.htm
elbueler@alaska.edu

Class info:
MWF 10:30am -- 11:30am
Chapman **206** ~~107~~ and online
CRN: 74997 (F01) and 75737 (FXA)

Textbook:

Trefethen & Bau, *Numerical Linear Algebra*, SIAM Press 1997

Course Websites:

There are *two* websites:

- *public* materials and schedule: bueler.github.io/M614F21/
- enrolled students: Canvas course website at https://canvas.alaska.edu/courses/2362

The public site has a daily schedule of topics, due dates, links to assignments, links to Matlab examples and solutions, and other helpful content. It will be updated on an ongoing basis to reflect what topics were actually covered.

The Canvas site has password-protected stuff like your grades and exam/homework solutions. It also has the links for the Zoom lecture and recorded Zoom sessions for each day. However, *most information is at the public site*.

Course Content:

This course covers how actual matrices and vectors of any (finite) dimension are handled in a fast and accurate manner on computers. This is essential technology for scientific and engineering computation.

Numerical linear algebra will be placed in the correct mathematical framework, emphasizing the geometry of the matrix action. We will cover famous matrix decompositions, theorems, and algorithms: singular value decomposition (SVD), Householder reflections, LU decomposition, spectral theorem, Schur decomposition, the QR method for eigenvalues, and Krylov methods. Additionally, the conditioning of problems and the stability of algorithms are central themes.

Applications of these ideas include solving large linear systems, solving systems of ordinary differential equations, statistical methods, inverse methods in geophysics, and Markov processes. Furthermore, numerical linear algebra is key for solving partial differential equations, network problems, and optimization problems, and it is an underlying theory in machine learning.

Student competence with scientific computing languages is a goal of the course. Examples in class and homework problems will routinely use Matlab. Student work can be done in Matlab, Octave, Python, or Julia, all of which are well-suited to numerical linear algebra. Students already comfortable with Python or Julia are free to use them, but I will support use of Matlab and Octave in particular.

Ordered Major Topics:

- matrix/vector mechanics
- geometric view of linear algebra
- singular value decomposition
- QR factorization and least squares
- conditioning and stability
- operation count and algorithmic complexity
- systems of equations and Gaussian elimination
- computing eigenvalues
- iterative methods

Outcomes:

At the end of this course you will be able to understand and apply the ideas and algorithms of numerical linear algebra. You will be very comfortable with Matlab or a similar scientific computing language.

The Hybrid Classroom:

There are two sections of the class, in-person (F01) and online (FXA), but they are treated as one course and they occur simultaneously.

In this "hybrid" set-up, each lecture will be a recorded (and recurring) Zoom session generated from Chapman **206** ~~107~~. The link for the Zoom session is inside Canvas; go to https://canvas.alaska.edu/courses/2362. The Zoom recordings will be linked from inside Canvas, and thus not be public.

My intention is to treat all students the same, regarding proctored assessments (see below) and participation during class time. Students in each sections have some obligations to help make the hybrid mode work:

- *F01 in-person students:* To allow in-class play with Matlab, and to help classroom

communication for e.g. group work, please bring a laptop if you can, and join the Zoom session so you see the online students.
- *FXA online students:* Please sign into the Zoom session (link at https://canvas.alaska.edu/courses/2362) before class and participate as energetically as you can. Keep your camera on if possible. For in-class group work you will want to get the PDF of worksheets etc. from bueler.github.io/M614F21/ *before class starts* if possible. Note that you must turn in homework and take-home assessments electronically, namely as clear and combined PDFs, which may require scanning documents. You will need to schedule proctoring for the in-class assessments (see below).

Evaluation and Grading:

Weekly homework dominates your grade. The homework will include by-hand computations, proofs, and Matlab computations.

There will also be a **1/2 hour proctored quarterterm quiz** and a **one hour proctored midterm exam**. These occur during class time for the F01 students, and during the same day for the FXA students. These assessments will emphasize definitions, basic manipulations, short pseudocodes, and short proofs.

FXA online students: The two in-class assessments, namely the Quarterterm Quiz and the Midterm Exam, will be on paper at a testing center with an in-person proctor. By Friday 10 September you will need to go to

- https://ecampus.uaf.edu/exam-services/

and schedule proctoring for these two assessments; see dates below.

At the end of the course there will be a **take-home final exam** emphasizing proofs, less trivial calculations, applications, and less trivial Matlab calculations.

Work	**Percent of Grade**	**Dates**
Homework	55%	nearly weekly
Quarterterm Quiz	5%	Friday, 1 October, *proctored in class or at a testing center*
Midterm Exam	15%	Friday, 15 October, *proctored in class or at a testing center*
Take-home Final Exam	25%	Due in my box or by email, 5:00 pm Wednesday 8 December

Based on your raw homework and exam scores, weighted according to the above percentages, I *guarantee* grades according to the following schedule:

90 – 100 % = **A**, 79 – 89 % = **B**, 68 – 78 % = **C**, 57 – 67 % = **D**, 0 – 56 % = **F**

I reserve the right to *increase* your grade above this schedule based on the actual

difficulty of the work and on average class performance. However, any increases will preserve the ordering of students by weighted total score.

Prerequisites:

In summary, the prerequisites are undergraduate linear algebra and mathematical maturity. Officially: *MATH 314 Linear Algebra or equivalent. Recommended: MATH 421 Applied Analysis OR MATH 401 Introduction to Real Analysis OR equivalent post-calculus course in analysis.*

Policies:

The Dept of Mathematics and Statistics has reasonable policies on incompletes, late withdrawals, early final examinations, etc.; see www.uaf.edu/dms/policies. You are covered by the UAF Student Code of Conduct. UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: alaska.edu/nondiscrimination. I will work with the Office of Disabilities Services (208 WHIT, 474-5655) to provide reasonable accommodation to students with disabilities.

Student Protections Statement. UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: catalog.uaf.edu/academics-regulations/students-rights-responsibilities.

COVID-19 Statement. Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website: sites.google.com/alaska.edu/coronavirus/uaf Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.