

Numerical Linear Algebra with Applications
MATH-4840
Spring 2025

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Tentative Outline

- I.** LU Method: review (0.5 week)
 - a) Factorization
 - b) Error and condition number
 - c) Software (LAPACK, BLAS, MKL, MATLAB, etc) and hardware (multicore, multiprocessor, and cluster computing systems)
- II.** Computing an Eigenvalue (1 week)
 - a) Review and applications
 - b) Power method
 - c) Inverse and Rayleigh quotient iteration
- III.** Computing Multiple Eigenvalues (1 week)
 - a) Orthogonal iteration
 - b) QR method
- IV.** Applications (1 week)
 - a) Natural frequencies
 - b) Markov chains
- V.** Computational Optimization: Regression (2 weeks)
 - a) Least squares (normal equations and QR, pseudoinverse, regularization, over-fitting)
 - b) QR Factorization (Householder method)
- Exam 1 (about February 24)
- VI.** Computational Optimization: $\mathbf{Ax} = \mathbf{b}$ (2 weeks)
 - a) Descent methods
 - b) Conjugate gradient method (sparse systems and preconditioning methods)
- VII.** Singular Value Decomposition (2 weeks)
 - a) Derivation and computational algorithm(s)
 - b) Application: low-rank approximations and image compression
- VIII.** Data Analysis (3 weeks)
 - a) Principal Component Analysis
 - b) Independent Component Analysis
 - c) Data Based Modeling

Exam 2 (about April 21)

Piazza Course Page: [Here](#)

Textbook: *Introduction to Scientific Computing and Data Analysis, 2nd ed* by Mark H. Holmes
Book Web-Page: [Here](#)

Grading

Homework: 25%, Exams 75% (no final exam)

Comments: 1) No homework score will be dropped. 2) Grade modifiers are not used.

References

Numerical Linear Algebra and Applications by Datta

Applied Numerical Linear Algebra by Demmel

Matrix Computations by Golub and Van Loan (this is the bible but not a good textbook)

Numerical Linear Algebra by Trefethen and Bau (this is often the textbook for the grad level course)

Difficulty Level and Prerequisites

This course requires mathematical maturity and familiarity with the basic concepts from matrix algebra and numerical computing (MATH-4800 is a prerequisite for the course). Very little time, if any, will be spent reviewing these background skills and concepts. It is expected that you are familiar with a computing language, and the one used by the instructor is MATLAB. If you have a strong preference for another language, such as Python, you can use it but you are responsible for making it work.

Piazza: This is a discussion forum where you can ask questions about the homework, course, etc. For questions that others might be interested in, the post will be made readable by everyone in the class (the default setting is that the post is to the Instructor). Also, all pdf's and MATLAB files will be posted on our Piazza page (under Resources).

Homework: There will be regularly assigned homework, with all involving one or more coding/computational problems. These are to be turned in during class (emailed pdf files will not be accepted). For the computational problems you are free to use Python, MATLAB, or even FORTRAN.

Attendance, Course Material and Exams

Lecture attendance is very strongly recommended as you will be responsible for any information given out in class. Exam attendance is mandatory.

Grade Appeals

Appeals must be made within one week of the date the item is returned in class. It is important that you keep all the returned material for the entire semester as they will be your only method for correcting any recording errors that may accidentally occur on my part.

Late Policies

Late homework is usually not accepted without a legitimate excuse. Missing an exam without a legitimate excuse results in a grade of zero and cannot be made up. If you are too ill to come to class, you must email Prof. Holmes before the class begins and explain the situation.

Academic Integrity

With respect to homework, you are free to seek assistance or advice from any person, book, or computer. However, what you hand in must be your own work. You are free to use the MATLAB codes provided by the instructor on Piazza, but other computer files must not be shared or exchanged. Violating this policy will result in a score of zero for the assignment. For exams you are to only consult with the instructor. Also, all the rules and policies in the Rensselaer handbook should be followed (<https://rpi.app.box.com/s/bfzzwdsrqzrm3j1kr2uv6gn7zu6dh1t>).