

Numerical Linear Algebra with Applications
MATH-4840
Spring 2023

Instructor: Mark H. Holmes
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Office Hours: W 4-5, Th 2-3

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
- Exam 1 (about Feb 13)
- V.** Computational Optimization: Regression (2 weeks)
 - a) Least squares (normal equations and QR, pseudoinverse, regularization, over-fitting)
 - b) QR Factorization (Householder method)
- VI.** Computational Optimization: $\mathbf{Ax} = \mathbf{b}$ (2 weeks)
 - a) Descent methods
 - b) Conjugate gradient method (sparse systems and preconditioning methods)
- Exam 2 (about March 23)
- 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 3 (about April 24)

Piazza Course Page: <https://piazza.com/class/lcnkjg8dc1au1>

Textbook: *Introduction to Scientific Computing and Data Analysis* by Mark H. Holmes

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).

Attendance, Course Material and Exams

In the course outline, where possible, the relevant sections of the text are indicated. Attendance is very strongly recommended as you will be responsible for any information given out in class.

Academic Integrity

Do not copy or cheat during exams. 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. Also, all the rules and policies in the Rensselaer handbook should be followed (<https://rpi.app.box.com/s/bfzzwdsrqxzm3jkr2uv6gn7zu6dhlt>).

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. For example, if you are too ill to come to class, you will need a doctor's, or an Office of Student Experience (<https://success.studentlife.rpi.edu/current-students/academic-and-personal-support/requesting-excused-absence>) note to be excused.

COVID Complications: Anyone who must quarantine will still be required to submit any HW, or take any missed exam(s), but on a modified schedule (which will be worked out on an individual basis).