MAE 290A Numerical Linear Algebra and ODE Simulation
Fall 2020

Course Description: This course will cover the fundamental concepts in numerical linear algebra, i.e., fundamental matrix decompositions: LU, QR, Eigen, Schur, Jordan, SVD; how compute them, and how to use them to solve very large linear systems. Stability and conditioning of those solutions will be discussed. We will cover numerical differentiation (Finite differences) and integration.

Instructor: Prof. Boris Kramer (bmkramer@ucsd.edu)

Teaching Assistant: Mr. Li Tan (ltan@eng.ucsd.edu)

E-mail communication: In an e-mail to instructor or TA please put "MAE290A" **first** in the subject line.

Class schedule: Tu/Thu 8:00a – 9:20a PST (San Diego Time);
Start Thursday Oct 1, 2020; no class Thursday Nov 26 (Thanksgiving)

Final Exam: Tuesday 12/15/2020 8.00a – 11.00a PST

Zoom Class Info: Before the first class, you need to register at:
https://ucsd.zoom.us/meeting/register/tJIsfuigpzwiHdK4s3Si0lPuWkaZTiR5uzs8
Once registered, you can use https://ucsd.zoom.us/j/96191897876 every time to join class. **Password: 290A.** Class sessions will be also recorded and made available to students asynchronously (available in Canvas within 24h of recording)

Zoom office Hours: Thu 9:30a – 11:00a (Boris Kramer) https://ucsd.zoom.us/j/95112809985
Mo & Wed 10a – 11:30a (Li Tan) https://ucsd.zoom.us/j/92849342523

Prerequisites: Graduate standing or consent of instructor.

Software: MATLAB will be used as the standard computing environment and proficiency is required. You can get a Total Academic Headcount (TAH) license (free for students) from https://matlab.ucsd.edu/student.html and install MATLAB on your own computer.

Textbooks:

- Trefethen, L.N., and Bau, D. Numerical linear algebra. Vol. 50. SIAM, 1997. *(We will use this mostly for the numerical linear algebra portion of class)*
- Bewley, T.R. Numerical Renaissance: simulation, optimization, & control. Renaissance Press, 2012. (*free and great resource from our own Prof. Tom Bewley, MAE, UCSD*)
- Golub, G.H. and Van Loan, C.F; Matrix Computations, (3^{rd} or 4^{th} edition); (*An absolute classic, not written as a textbook, but rather a "handbook" that everyone who works in NLA should have, in my opinion).*
- Moin, P., Fundamentals of Engineering Numerical Analysis, Cambridge University Press, 2012.

Homework: This is a very important part of this course. There will be a homework assignment about every two weeks, for a total of 5-6. You can work together on homework problems, but your final write up must be your own work, done independently. Homework has to be turned in on-time. Late assignments within 24h of due date will be graded but the points reduced by 50%. Assignments past 24h of the deadline will get zero points.

Grading: Homework (25%), Midterm exam (25%), Final exam (50%)
A 90% will guarantee an A-, 80% a B-, 70% a C- and 60% a D. Re-grade requests need to be made within 48h of the return of the assignment. Appeals outside of this time frame will not be considered.

Missing a graded assignment: If **for a documented reason** you cannot turn in your homework, then the remaining N-1 homework results will determine your homework grade. If **for a documented reason** you cannot turn in your midterm, your final grade will replace your midterm. If **for a documented reason** you cannot participate in the final exam, the instructor reserves the right to assess your grade based on an oral exam.

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Topics

1. Fundamentals of linear algebra (matrix vector multiplications, orthogonality, norms, singular value decomposition)
2. QR Factorization and least squares
3. Conditioning and stability (possibly floating point arithmetic)
4. Solving systems of equations (LU, Cholesky, pivoting)
5. Eigendecomposition
6. Iterative methods (Arnoldi, GMRES, Steepest descent, CG, BCG, Preconditioning)
7. Special topics (1 lecture each)
    - Proper orthogonal decomposition
    - Randomized matrix methods for large data
8. Numerical differentiation: finite differences and error analysis
9. Numerical Integration: Trapezoidal/Simpson's Rule, Romberg integration, Richardson extrapolation, Gauss quadrature.

Last Updated: September 26, 2020. The instructor reserves the right to change the syllabus at any time.