MATH 6390.001 (25579) Syllabus
Numerical Linear Algebra
Spring 2014, MW 4:00–5:15 pm, GR 4.208

Instructor: Dr. Minkoff
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Note that I will maintain a web page for this course linked from my main web page. (I do not use eLearning.)

Office Hours: Monday and Wednesday 1:30–2:30 pm, or by appointment.

Prerequisite: Math 6313 or an equivalent Numerical Analysis course is recommended but not required. Students are expected to have a working knowledge of a high-level programming language such as C, Fortran, or Matlab. Note that we will be using Matlab exclusively in this course.

Course Description (from the catalog): Topics include direct and iterative methods for solving linear systems; vector and matrix norms; condition numbers; least squares problems; orthogonalization, singular value decomposition; computation of eigenvalues and eigenvectors; conjugate gradients; preconditioners for linear systems; computational cost of algorithms. Topics will be supplemented with programming assignments.

Texts — Required: *Fundamentals of Matrix Computations*, 3rd Edition, by Watkins. Publisher: Wiley-Interscience, 2010.

Additional References: (1) *Numerical Linear Algebra* by Trefethen and Bau. Publisher: SIAM. (2)*Matrix Computations* by Golub and Van Loan. Publisher: The Johns Hopkins University Press. (3)*Mastering MATLAB* by Hanselman and Littlefield. Publisher: Prentice Hall, Inc.

Grading Policy:

Homework	40%
Midterm Exam	30%
Final Exam	30%
Total	100%

Homework and computer assignments: There will be one homework (which may include paper and pencil and/or computer work) due every week on Wednesdays. Homework is to be turned in at the START of class on Wednesday or can be slipped under my office door *prior* to class on Wednesday if you must miss class for some reason. *Late homework will not be accepted.*

Please note that the homework constitutes a substantial portion of your overall grade. In order to learn the concepts and be able to apply them to solving problems on exams, etc., you are strongly encouraged to devote as much time as possible to working the homework

problems. It is possible that not all homework problems will be able to be graded, but most of your learning will come from devoting good chunks of time each week to the homework. I encourage you to discuss the homework assignments with other students in the class. However, I expect the homework you submit for grading to be written up by you alone (this includes computer programs which must not be duplicates of programs other students turn in).

Tests: No make-up exams will be given except *possibly* in the case of a serious emergency. In such a case I *must* be notified *in advance*. There will be no exceptions to taking the final exam at the date, time, and place specified by the University (TBD). The final exam will be comprehensive although material covered after the midterm will be emphasized.

Learning Goals and Course Motivation: Numerical Linear Algebra is a graduate subject intended to teach you how best to solve large linear systems and to find eigenvalues of those systems. One of the most important reasons we are interested in solving large matrix systems is that most physical systems are modeled by differential equations. These differential equations usually cannot be solved by hand, and hence must be discretized and solved approximately on a computer. This discrete pde approximation reduces the problem to solution of a linear system (often with millions or even billions of unknowns). The small matrix systems one studies in undergraduate linear algebra (which can be solved using paper and pencil) are rarely encountered by scientists working on real application or engineering problems. *Your goal in this course is to gain insight into why solution of linear systems is so fundamental in applied mathematics. You will learn about a variety of tools that exist for solving linear systems and finding eigenvalues of these systems. Further you will be able to evaluate when a problem should be solved using a direct or iterative method and what the advantages, disadvantages, and costs are for these methods. Moreover, you will gain fundamental insight into the way in which error in data can corrupt your solution and, therefore, how much confidence you can place in the solution you obtain.*

Academic Conduct: I take academic dishonesty *very seriously* and will not tolerate it in this class in any form. Academic misconduct includes willfully cheating on or giving aid during an exam or copying homework assignments (from the web, from each other, or from a solutions manual). Blatant copying on an exam, homework assignment, or computer assignment will result in a grade of zero for that work. Further information on the academic conduct policy can be found at http://www.utdallas.edu/deanofstudents/dishonesty/

UT Dallas Syllabus Policies and Procedures:
The information at http://go.utdallas.edu/syllabus-policies constitutes the University's policy and procedures segment of the course syllabus.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.

Class Attendance: I expect students to attend class and to turn up **on time**. Rarely do students do well in classes which they do not attend, and I will be less likely to give outside assistance to students who regularly miss class. Further, students arriving late for class disrupt the entire class. Students who consistently turn up more than a few minutes

late for class or who miss more than 3 classes may be docked points from their final grade. Students should also note that I do not allow cell phones, laptops or other electronic devices to be used in class and will ask that these items be turned off at the start of class.

Email: I am happy to answer questions about the class via email. However, I will not respond to email which does not include the name of the sender. Also, students should be aware that discussions of class concepts and involved homework questions are best asked in person during office hours. I reserve the right not to answer an email question if I feel the topic would best be discussed in person.

Tips for Succeeding in this Class:

1. Before you attempt the homework you should *read the sections in books if appropriate and study your notes.*

2. You will benefit greatly from working with others in the class so long as you use your peers as a way to hash over concepts and not a way to "get the answers". In other words, *start early* and use your fellow-classmates to discuss the best way to approach the problems. Then go off and try to work out the details yourself.

3. **Begin the new homework assignment the same day you turn in the previous assignment!** Do not wait 3–4 days to start the homework as then you will not have enough time to digest the material or understand the point of the problems. When computer assignments are given, starting early on the homework is essential. Debugging programs takes time and your grade and learning will suffer if you attempt the computer problems at the last minute.

4. Come to office hours and get help if you are stuck. It is much better to get help early than to wait. I may ask you to show me what you've come up with at the board so you should have at least attempted the homework problems before asking for help.

Important Dates:

Date	Notes
1/13/14	First day of class
1/21/14	Last day to register and last day to add/swap
3/5/14	Midterm Exam
4/3/14	**Absolute Last day to drop class**
5/3/14	Last day of classes
TBD	Final Exam

Tentative Schedule:

Date	Section/Topic
M 1/13/14	First Day Handout; §1.1, 1.2 – Matrix Multiplication, Systems of Linear Equations
W 1/15/14	§1.4 – Cholesky Decomposition
M 1/20/14	MLK Holiday (no class)
W 1/22/14	§1.7 – Gaussian Elimination and the LU Decomposition
M 1/27/14	§1.8 – Gaussian Elimination with Pivoting
W 1/29/14	§2.1 – Vector and Matrix Norms
M 2/3/14	§2.2 – Condition Numbers
W 2/5/14	§2.3, 2.5 – Perturbing the Coefficient Matrix, Backward Stability
M 2/10/14	§2.7 – Backward Error Analysis of Gaussian Elimination
W 2/12/14	§3.1 – Discrete Least Squares Problem
M 2/17/14	§3.2 – Orthogonal Matrices, Rotators, and Reflectors
W 2/19/14	§3.4 – Gram-Schmidt Process
M 2/24/14	§3.3 – Solution of the Least Squares Problem
W 2/26/14	§4.1, 4.2 – Applications of the Singular Value Decomposition
M 3/3/14	4.3 – The SVD and Least Squares Problem
W 3/5/14	**Midterm Exam (Chapters 1–4)**
M 3/10/14	**Spring Break**
W 3/12/14	**Spring Break**
M 3/17/14	§5.1 – Systems of Differential Equations

Date	Section/Topic
W 3/19/14	§5.3 – The Power Method
M 3/24/14	§5.5 – Reduction to Hessenberg and Tridiagonal Forms
W 3/26/14	§5.6 – The QR Algorithm
M 3/31/14	§5.7 – Use of QR Algorithm to Calculate Eigenvectors
W 4/2/14	§6.4 – Eigenvalues of Large, Sparse Matrices (Lanczos/ Arnoldi)
M 4/7/14	§8.2 – The Classical Iterative Methods
W 4/9/14	§8.3 – Convergence of Iterative Methods
M 4/14/14	§8.7 – The Conjugate Gradient Method
W 4/16/14	§8.8 – Derivation of the CG Algorithm
M 4/21/14	§8.9 – Convergence of the CG Algorithm
W 4/23/14	§8.6 – Preconditioners
M 4/28/14	Catch Up Day
W 4/30/14	Review
TBD	**Final Exam**