MATH 6340.001 (27988) Syllabus Revised 3/23/20 Due to Transition to Remote Learning
Numerical Linear Algebra
Spring 2020, TuTh 1:00–2:15pm, CB3 1.308

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Note that I will maintain a web page for this course linked from my main web page.

Office Hours: Tuesdays 2:30–3:15 pm or by appointment.

Prerequisite: Math 6313 or an equivalent numerical analysis course is recommended but not required. Undergraduate linear algebra is 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.

Grading Policy:

Homework	40%
Midterm Exam	30%
Participation	10%
Final Exam	20%
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 Thursdays. **Homework is to be turned in via eLearning (an assignment requesting the homework will be set up each week). It must be submitted by 1pm on the date the homework is due.** *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). Note that the UTD Media Use policy states that "Students may not use any digital platform to seek or provide unauthorized assistance for any assignment done for academic credit."

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 Outcomes: 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 goals in this course are to:*

1. *gain insight into why solution of linear systems is so fundamental in applied mathematics.*

2. *be able to distinguish and analyze a variety of tools that exist for solving linear systems and finding eigenvalues of these systems.*

3. *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.*

4. *understand 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 other students, or from a solutions manual). Blatant copying on an exam, homework assignment, or computer assignment will result in disciplinary action as per the UTD academic dishonesty policy. Further information on the academic conduct policy can be found at https://www.utdallas.edu/conduct/dishonesty/.

UT Dallas Syllabus Policies and Procedures:

The information at https://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 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 the textbook 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.

Changes in Syllabus due to Transition to Online Instruction:

- After 3/30/2020 the course will be taught using Blackboard Collaborate from within eLearning. You should use a *Chrome or Firefox browser* for the course sessions. Please view the short video tutorials on Blackboard Collaborate Ultra prior to the first day of class (March 31).

- I will hold a virtual office hour each week right after class on Tuesdays (2:30-3:15pm) using the Blackboard Collaborate video/audio conference system in eLearning.

- Before each class I will scan notes that I will walk through and discuss during the class period. As this activity will be slightly quicker than writing on the board, we might also do some problems during the class for practice as an active learning exercise, and we might have time for students to present previous homework problems to the class. I can make students "presenters" within Blackboard Collaborate.

- I have reduced the percentage of the overall grade allocated to the final exam from 30% to 20%. Participation now constitutes 10% of your final grade (participation in the online classes from 3/30/20 through to the end of the semester). Participation includes being in attendance remotely at the normal class time for the lectures and asking/answering questions (as you always did in class). It may also include presenting problems the class works on during lecture or presenting previous homework solutions if time allows.
- The grading percentages for the homework and the midterm exam remain the same as listed originally in the syllabus.
- Homework is to be turned in via eLearning (an assignment requesting the homework will be set up each week). It must be submitted by 1pm on the date the homework is due.
- You will submit your homework by scanning it and uploading it from within eLearning. Please use a good quality scanner on your phone if you can such as camscanner, or abobe scan. (These phone scanners are free to download.) You may also use a regular scanner if you have one.
- The format of your final exam will be communicated to you at a later date.

Important Dates:

Date	Notes
1/13/20	First day of class
1/21/20	Last day to register and last day to add/swap
3/10/20	Midterm Exam
3/26/20	**Absolute Last day to drop class**
4/30/20	Last day of classes
5/7/20	Final Exam

Tentative Schedule:

Date	Section/Topic
Tu 1/14/20	First Day Handout; §1.1, 1.2 – Matrix Multiplication, Systems of Linear Equations
Th 1/16/20	Brief Linear Algebra Review and §1.4 – Cholesky Decomposition
Tu 1/21/20	§1.4 – Cholesky Decomposition
Th 1/23/20	§1.7 – Gaussian Elimination and the LU Decomposition
Tu 1/28/20	§1.8 – Gaussian Elimination with Pivoting
Th 1/30/20	§2.1 – Vector and Matrix Norms
Tu 2/4/20	§2.2 – Condition Numbers
Th 2/6/20	§2.3, 2.5 – Perturbing the Coefficient Matrix, Backward Stability
Tu 2/11/20	§2.7 – Backward Error Analysis of Gaussian Elimination
Th 2/13/20	§3.1 – Discrete Least Squares Problem
Tu 2/18/20	§3.2 – Orthogonal Matrices, Rotators, and Reflectors
Th 2/20/20	§3.4 – Gram-Schmidt Process
Tu 2/25/20	§3.3 – Solution of the Least Squares Problem
Th 2/27/20	§4.1, 4.2 – Applications of the Singular Value Decomposition
Tu 3/3/20	4.3 – The SVD and Least Squares Problem
Th 3/5/20	§5.1 – Systems of Differential Equations
Tu 3/10/20	**Midterm Exam (Chapters 1–4)**
Th 3/12/20	§5.2 Basic Facts about Eigenvalues and Eigenvectors
Tu 3/17/20	**Spring Break**
Th 3/19/20	**Spring Break**

Date	Section/Topic
Tu 3/24/20	**Extended Spring Break**
Th 3/26/20	**Extended Spring Break**
Tu 3/31/20	§5.2 Basic Facts about Eigenvalues and Eigenvectors §5.3 – The Power Method
Th 4/2/20	§5.5 – Reduction to Hessenberg and Tridiagonal Forms
Tu 4/7/20	§5.6 – The QR Algorithm
Th 4/9/20	§5.7 – Use of QR Algorithm to Calculate Eigenvectors
Tu 4/14/20	§6.4 – Eigenvalues of Large, Sparse Matrices (Lanczos/Arnoldi)
Th 4/16/20	§8.2 – The Classical Iterative Methods
Tu 4/21/20	§8.3 – Convergence of Iterative Methods
Th 4/23/20	§8.7 – The Conjugate Gradient Method
Tu 4/28/20	§8.8 – Derivation of the CG Algorithm
Th 4/30/20	§8.9 – Convergence of the CG Algorithm §8.6 – Preconditioners & Review
Th 5/7/20	**Final Exam**