Math 504 (Fall 2010) - Numerical Methods I
Syllabus

Instructor
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Lecture Hours and Location
Monday, Wednesday between 12:30-13:45 at CAS Z25

Textbooks
(1) Numerical Linear Algebra by Lloyd N. Trefethen and David Bau
(2) Fundamentals of Matrix Computations, 2nd Ed by David S. Watkins

We will try to follow the textbook by Trefethen&Bau as closely as possible. This is a nicely written introductory book that presents an overview of fundamental algorithms in numerical linear algebra without a detailed analysis. On certain topics we will have to go deeper than Treftehen&Bau. We will depend on the book by Watkins on these occasions. Both of the textbooks will be available at the reserve desk in the library.

Supplementary Books
Brief notes on IEEE arithmetic by Overton is available on the course webpage. If you think you will be frequently involved in IEEE arithmetic, this book is relatively cheap when bought from the SIAM website (`http://www.siam.org`). The book by Golub and Van Loan (will be made available at the reserve desk in the library) is a classical reference book in numerical linear algebra.

- Numerical Computing with IEEE floating point arithmetic by Michael L. Overton
- Numerical Computing with Matlab by Cleve Moler
  (Available at `http://www.mathworks.com/moler/index_ncm.html`)
- Matrix Computations, 3rd Ed by Gene H. Golub and Charles F. Van Loan

Prerequisites
Knowledge of elementary linear algebra is required. Computations will be performed in Matlab. Familiarity with Matlab or any other programming language may help, but is not required. The course will be as self-contained as possible. The basic linear algebra concepts will be reminded whenever they are necessary.

For your convenience two elementary books on linear algebra are listed below.

- Linear Algebra and its Applications, 4th Ed by Gilbert Strang
- Linear Algebra and its Applications, 3rd Ed by David C. Lay

Course Webpage
`http://home.ku.edu.tr/~emengi/teaching/math504/math504.html`

Grading
Homeworks will be assigned once every two weeks. There will be one midterm and a final. Your overall grade will be determined based on following scheme.

$$\text{Total Score} = \%40\ (\text{Homework Score}) + \%20\ (\text{Midterm}) + \%40\ (\text{Final})$$

Midterm
The midterm will be held during the regular lecture hour on December 1st, Wednesday. The midterm will be a closed-book exam. Everything covered in class until the end of the previous week (up until and including the lecture on November 24th) is included.

Final
All of the topics covered in class throughout the semester are included. Date, time and location of the final will be announced later towards the end of the semester. Final will be a closed-book exam.

Homeworks
The homeworks will normally be assigned on Fridays once every two weeks. Your homework score will be the average of six homeworks. Half of the homework questions will be conceptual. The remaining half will be computational and require performing computations in Matlab. You can reach a freely available Matlab manual from the website `http://www.math.mtu.edu/~msgocken/intro/intro.html`

Description
The course covers various topics from numerical linear algebra. Most of the emphasis will be put on the numerical solutions of linear systems of equations, least squares problems (the best approximate solution for an inconsistent linear system), eigenvalue problems, and singular value problems. We will develop numerical algorithms for these four main-stream problems. The quality of a numerical algorithm is judged mainly based on two criteria namely efficiency (vaguely speaking number of arithmetic operations required) and accuracy. We will analyze the accuracy and efficiency of the numerical algorithms developed. The Krylov-subspace based Iterative algorithms will be studied as well as the direct algorithms.

Course Calendar

(Week 1) Fundamentals: IEEE Floating Point Arithmetic, Floating Point Operation Count, Orthogonality, Norms

(Week 2) The Singular Value Decomposition

(Week 3) Projectors, QR Factorizations

(Week 4) Gram-Schmidt Orthogonalization, Householder Orthogonalization

(Week 5) Least Squares Problem, Conditioning and Condition Numbers

(Week 6) Stability, Conditioning of Least Squares Problems, Stability of Least Squares Algorithms

(Week 7) Gaussian Elimination without and with Pivoting

(Week 8) *Kurban Bayrami - No Lectures*

(Week 9) Gaussian Elimination with Pivoting and its Stability

(Week 10) Cholesky Factorization
Midterm - December 1st, Wed (Covers weeks 1-9)

(Week 11) Cholesky Factorization, Eigenvalue Problems

(Week 12) Reduction to Hessenberg or Tridiagonal Form, Rayleigh Quotient, Inverse Iteration

(Week 13) QR Algorithm for Dense Eigenvalue Problems

(Week 14) Arnoldi Iteration (Iterative Solution of Eigenvalue Problems)

(Week 15) GMRES and Conjugate Gradient (Iterative Solution of Linear Systems)