CS 680/780: Topics in Numerical Computing Fall 2006

Johnstone **Course outline**

Course Description

This course covers the classical topics in numerical computing: least squares, spectral analysis (the computation of eigenvectors and eigenvalues), singular value decomposition, and solution of linear systems. Both direct and iterative methods will be studied. Efficient and robust algorithms will be emphasized. A novel aspect of this course is its discussion of applications, including principal component analysis, subdivision surfaces, and computer vision. These applications motivate the numerical techniques developed in the course, and are often explored further in projects. Numerical computing relies on a firm foundation in linear algebra, which will be reviewed at the beginning of the course, although the student is also expected to enter the course with a good understanding of linear algebra at an undergraduate level.

Professor	Dr. John K. Johnstone, CH125
Time	MWF 10-10:50, CH132
Office Hours	MWTh 12-1
Prerequisites	Graduate standing, knowledge of linear algebra, C, and UNIX.
Textbook	*Matrix Computations* by Gene Golub and Charles Van Loan (1996), 3rd edition, Johns Hopkins University Press.
Website	www.cis.uab.edu/cs780
Equipment	Get a department computer account if you don't already have one (go to www.cis.uab.edu/it/accountApplication.php)

Additional References

- *Numerical Linear Algebra* by Lloyd Trefethen and David Bau (SIAM, 1997)..
- You should find a good undergraduate linear algebra text as a reference. Three good examples are *Introduction to Linear Algebra* by Gilbert Strang (Wellesley-Cambridge Press, 2003), *Linear Algebra* by Serge Lang (Springer, 2004), and *The Linear Algebra Problem Book* by Paul Halmos (MAA, 1996).
- *MATLAB Guide* by Desmond and Nicholas Higham (Cambridge University Press, 2005)
- LAPACK and CLAPACK documentation: www.netlib.org/lapack, www.netlib.org/clapack
- *An Introduction to the Conjugate Gradient without the Agonizing Pain* by Jonathan Shewchuk (CMU Tech Report, 1994), www.cs.cmu.edu/ jrs/jrspapers.html

Grading

	680	780
Homework and pop quizzes	20%	20%
Project	0%	20%
Midterm 1 (Wednesday, Sept. 27, in class)	20%	15%
Midterm 2 (Wednesday, Nov. 1, in class)	20%	15%
Final (Wednesday, December 13, 8am-10:30)	40%	30%

All exams are closed book. There will be differences between the 680 and 780 exams and homeworks, and only 780 students will do a project. There is no TA for this course. Homework is due in class, at the beginning of class. Please staple or paperclip your homeworks. Late penalty is 10% per day until a homework solution is handed back, which will be done within one or two lectures. No homeworks may be handed in once the solution set is available. Late homework must be handed in to the department office (Campbell 115), with a secretary's signature acknowledging time and date of receipt. If we get a TA, they will grade the homeworks. I will grade all of the exams. Last day to withdraw with 'W': December 6, 2006.

Tentative due dates for homeworks: 9/8, 9/29, 10/20, 11/10.

Curriculum

- Introduction
  - Motivating applications; (review of) linear algebra fundamentals; the problems of numerical computing; the patois of numerical computing
- Matrix-vector and matrix-matrix multiplication
- Least squares
  - including Householder matrices, QR decomposition
- Spectral analysis (the computation of eigenvectors and eigenvalues)
  - Tridiagonalization and QR iteration; Givens rotation algorithm; application 1: PCA; application 2: subdivision surfaces
- Robustness: conditioning and stability (least squares, LU)
- Solution of linear systems
  - direct methods (LU, Cholesky), iterative methods (CG), applications
- Singular value decomposition (including vision applications)
- Optional (based on time): solution of nonlinear systems; quadrature

Honour code

All of the following are strictly forbidden:

- Any form of cooperation on exams, whether take-home or in-class.
- Any form of cooperation on homework or projects, other than preliminary oral discussion at a high level (that is, definition of the problem). Homework is to be solved and written up alone and independently.
- Any coercion of other students to help on homework, exams, or projects (even if help is not forthcoming).

All references and/or websites used must be included in a bibliography. Care must be taken not to plagiarize.

Violations of any part of this honour code will result in a 0 on that exam/assignment/project, possible failure of the course, and possible forwarding of the case to the school ethics board, where a decision about expulsion from UAB is made.

Grading policy

In general, the marking scheme for this class will be as follows.

- A: 85-100
- B: 70-84
- C: 60-69
- F: below 60

These standards may be adjusted for certain exams or homeworks, but any adjustment will be announced in class.

Attendance policy

You are expected to attend every class. Please note that the beginning of each class is the most important part of each lecture. I often make important announcements and usually set up the lecture with review of

relevant issues and overarching motivation. Therefore, it is crucial that you arrive on time for class. If you must miss a class because of illness or some other unavoidable reason, you are responsible for getting the notes and any assignments from a fellow student. Large gaps in attendance are not acceptable (e.g., if you must work during class hours, please drop the course). If you miss (or are noticeably late) for 10 or more classes, you will receive a 10% penalty on your grade (e.g., 83% becomes 73%).

Makeup policy

Midterm exams can be made up if missed due to illness, upon receipt of a doctor's note. The final exam cannot be made up. The final exam cannot be offered to students early (e.g., for Christmas travel).