CS 680/780: Topics in Numerical Computing Fall 2007

Johnstone **Course outline**

Course Description

This course covers the classical topics in numerical computing: solution of linear systems, least squares, spectral analysis, and singular value decomposition. 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 computer vision, principal component analysis, and subdivision surfaces. 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	John K. Johnstone; office: CH125
Time	MWF 10-10:50, EB236 (but soon to change)
Office Hours	MWTh 2-3pm
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 IT section of website or directly to www.cis.uab.edu/cisweb/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, or LAPACK Users' Guide, 3rd edition, SIAM Press, E. Anderson et. al., 1999.
- *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. 26, in class)	20%	15%
Midterm 2 (Wednesday, Oct. 31, in class)	20%	15%
Final (Wednesday, December 12, 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. Last day to withdraw with 'W': December 5, 2007.

Tentative due dates for homeworks: 9/10, 10/1, 10/22, 11/19.

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.

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)

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.

Attendance policy

Arrive on time!! The most important minutes of the class are the first 5 minutes. 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. Tardiness also disrupts the class. If late arrival becomes an issue, we will meet to try and resolve it.

You are expected to attend every 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.

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).