CS 680/780: Topics in Numerical Computing Fall 2009

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, especially in computer graphics and computer vision, such as 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	Dr. J.K. Johnstone, CH125
Time	MWF 10-10:50 (TBD), CH145
TA	Lin Yang
Office Hours	Johnstone: MW 2-3, CH125; Yang: Tu 9-10, Th 3-4, CH142; or by appointment
Prerequisites	Graduate standing and 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).
- 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%	
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Midterm 1 (Wednesday, Sept. 23, 2009, in class)	20%	15%
Midterm 2 (Wednesday, Oct. 28, 2009, in class)	20%	15%
Final (1C slot, Friday, December 11, 2009, 8am-10:30)	35%	25%
Classroom participation	5%	5%

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. 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. No homeworks may be handed in once the solution set is available. Late homework should be handed in to the department office (Campbell 115, not to me), with a secretary's signature acknowledging time and date of receipt. Last day to withdraw with 'W': December 3, 2009.

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. 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).

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
- Solution of linear systems
  - direct methods (LU, Cholesky), iterative methods (CG), applications
- 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
- Singular value decomposition (including graphics/vision applications)
- Robustness: conditioning and stability (least squares, LU)

Honour code

All of the following are strictly forbidden:

- 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 form of cooperation on exams, whether take-home or in-class.
- 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: if you use a solution or a passage, even a sentence, from another source, you must put the passage in quotations and cite the work.

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

You are expected to attend every class, since it will be difficult to pass the course otherwise. If you must miss a class because of illness or 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 more than 10 classes, you will receive a 10% penalty on your final grade.

When you are in class, you are expected to be paying attention and actively participating. That is, attending class means actively attending class. No cell phones and, please, no use of computers.

Please arrive on time. Often the first 5 minutes of class is the most important 5 minutes as the lecture material is introduced and important administrative issues are discussed. If you arrive late and the door is closed, please wait until a break in the discussion before knocking. A particularly late arrival (more than 5 minutes) will be treated as an absence under the above 10-class-absence policy.