CMSC/AMSC 661-0101 Monday 4pm-7pm, CSI 2107
SCIENTIFIC COMPUTING II, Spring, 2010
`http://www.cs.umd.edu/users/oleary/c661/`

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Office Hours: Monday 3-3:40, Tuesday 12:30-1:20, Friday 8:45-10, and by appointment, in AVW 3271.
Please restrict telephone inquiries to office hour times, except in "emergencies." E-mail is welcome anytime!

Prerequisite: Undergraduate-level knowledge of numerical analysis. Programming assignments will be in Matlab and will use the PDE Toolpack.

Text: QA 374.L337 2003: Stig Larsson and Vidar Thomée, Partial Differential Equations with Numerical Methods, 2003 (Springer Texts in Applied Mathematics Series) ISBN 3-540-01772-0

Topics: Numerical solution of elliptic, parabolic, and hyperbolic partial differential equations; solution of sparse linear systems; Fourier and wavelet techniques.

News: Assignments, course notes, answers to homeworks and quizzes, and announcements will be posted on the course's homepage. You are responsible for checking this site before each class.

Final Exam: None.

Grading: Grading will be on a *curve*, except that you will be guaranteed an A- if your average is 90% or better, a B- if your average is 80% or better, etc. Keep all of your work in case there is any question about recording of grades.

- **Homework**: 4 assignments, 160 points. To pass this course, you must make an honest effort at each homework. Partial credit will be given for partially-working programs. Assignments will be due **before class begins**. There will be a 15% penalty for assignments turned in up to 2 days late, 30% penalty for assignments turned in 2-4 days late, etc.

- **Quizzes**: 140 points. Quizzes will be 20 minutes long. Make-ups will not be permitted unless you have documented medical or other serious excuses for more than two quiz dates. If no classes are cancelled, there will be 9 quizzes. The lowest two scores will be dropped.
- **Project**: 100 points. Your task will be to write a summary of an article, implement the algorithm it discusses, and compare with techniques discussed in class.
- **Extra Credit**: 1/2 point of extra credit will be given to the first student to find each error in my course materials.

Note for Computer Science Department MS comp students: The MS Comp grade for this course is based on your best 7 quizzes.

Regrades: If you think a mistake has been made in grading your work, submit it for regrading within two weeks of the date on which the work was returned to the class. After that, the grade will be considered final.

Academic Integrity: Class accounts are to be used only for class assignments. All files within the accounts are subject to inspection, and the campus code of computer conduct must be followed. All work that you submit in this course must be your own; group efforts will be be considered academic dishonesty. See `http://www.inform.umd.edu/CampusInfo/-Departments/PRES/policies/iii100a.html` for definitions and sanctions. You may discuss homework in general way, but you may not consult any one else's written work, program drafts, computer files, etc. Any marked similarity in form or notation between submissions with different authors will be regarded as evidence of academic dishonesty – so protect your work. You are free to use reference material to help you with assignments, but you must cite any reference you use and clearly mark any quotation or close paraphrase that you include. Such citation will not lower your grade, although extensive quotation might.

CourseEvalUM: Please complete your evaluations for this course near the end of the semester at http://www.courseevalum.umd.edu.

COURSE OUTLINE

1. Introduction (approx. 1 lecture = 1/2 week)
    - survey of course material and organization
    - discussion of syllabus
    - classification of partial differential equations (PDEs)
2. Boundary value problems for ordinary differential equations (ODEs) (approx. 3 lectures) (2.1-2.4, 4.1, 5.1)
    - the problem and boundary conditions
    - the Maximum Principle
    - the Green's function
    - the variational formulation
    - solution and error estimates using finite differences
    - solution and error estimates using finite elements
3. Elliptic PDEs (approx. 5 lectures) (Chapters 3-5)
    - the problem and boundary conditions
    - the Maximum Principle
    - the Green's function
    - the variational formulation
    - solution and error estimates using finite differences
    - solution and error estimates using finite elements
4. The Elliptic Eigenvalue Problem (approx. 2 lectures) (Chapter 6)
    - eigenfunction expansions
    - numerical methods
5. Sparse Matrix Methods (approx. 4 lectures)
    - Direct methods for sparse linear systems
    - Iterative methods for sparse linear systems

- Multigrid methods
- Methods for sparse eigenproblems

6. Initial value problems for ODEs (approx. 1 lecture) (Chapter 7)
    - the problem
    - numerical solution
7. Parabolic PDEs (approx. 5 lectures) (Chapters 8-10)
    - the problem and initial/boundary conditions
    - the Maximum Principle
    - the eigenexpansion
    - the variational formulation
    - solution and error estimates using finite differences
    - solution and error estimates using finite elements
8. Hyperbolic PDEs (approx. 5 lectures) (Chapters 11-13)
    - the problem and initial/boundary conditions
    - the Maximum Principle
    - the eigenexpansion
    - the variational formulation
    - solution and error estimates using finite differences
    - solution and error estimates using finite elements
9. Fourier and Wavelet Methods (approx. 3 lectures)

REFERENCES

- **General:**

  Dianne P. O'Leary, Scientific Computing with Case Studies, SIAM Press, 2009.

  Michael T. Heath, Scientific Computing: An Introductory Survey, McGraw Hill, 2002.

  Cleve B. Moler, Numerical Computing with MATLAB, SIAM, 2004.

  Singiresu S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice Hall, 2002.

  Charles F. van Loan, Introduction to Scientific Computing, Prentice Hall, 2000.

- **Matlab information:**

  Desmond J. Higham and Nicholas J. Higham, MATLAB Guide, SIAM, 2005.

  van Loan, Chapter 1.

- **Machine arithmetic and error analysis:**

  O'Leary, Chapters 1, 2.

  Michael L. Overton, Numerical Computing with IEEE Floating Point Arithmetic, SIAM Press, Philadelphia, 2001.

- **Ordinary differential equations:**

  Background: van Loan, Chapter 9 or O'Leary, Unit V.

  Uri M. Ascher and Linda R. Petzold, Computer Methods for Ordinary Differential Equations and Differential-Algebraic Equations, SIAM Press, Philadelphia, 1998.

- **Fourier Transforms:**

  QA403.5 .K36 2000 David W, Kammler, A First Course in Fourier Analysis, Prentice-Hall, 2000. Chap 1,2,6

  van Loan, Section 5.4.

- **Wavelets:**

  QA403.5 .K36 2000 David W. Kammler, A First Course in Fourier Analysis, Prentice Hall, 2000, Chapter 10.

- **Partial Differential Equations:**

  O'Leary, Unit VII.

  QA805.S45 2000 VOL 1 A.P.S. Selvadurai, Partial Differential Equations in Mechanics, volume 1, Springer, 2000.

  QA377.M69 1994 K. W. W. Morton and D. F. Mayers Numerical Solution of Partial Differential Equations, 1993.

  QA377.E947 2000 G. A. Evans, P. D. Yardley, and J. M. Blackledge, Numerical Methods for Partial Differential Equations.

  Q172.L36 1982 Leon Lapidus, With George Francis Pinder, Numerical Solution of Partial Differential Equations in Science and Engineering.

  QA371.5.D37 C65 1996 K. Eriksson, Claes Johnson, Donald Estep, and Peter Hansbo, Computational differential equations.

- **Sparse Linear Systems:**

  O'Leary, Unit VII.

  QA188.S17 2003 Yousef Saad, Iterative Methods for Sparse Linear Systems, SIAM, 2003.

  QA188.D84 I. S. Duff, A. M. Erisman, and J. K. Reid, Direct Methods for Sparse Matrices, Oxford Press, 1986.