Math 350 – Introduction to Computational Mathematics

Time and Location: 11:25-12:40 TR, Location LS 240
Instructor: Greg Fasshauer
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Office hours: TR: 1:30-3:00, also by appointment
TA: Allen Flavell (aflavell@iit.edu)

Textbook(s): Cleve Moler, *Numerical Computing with* MATLAB, SIAM (revised reprint)
Also available for FREE at http://www.mathworks.com/moler/chapters.html).
S. C. Chapra & R. P. Canale, Numerical Methods for Engineers, 5th Edition, McGraw Hill, 2006 (online optional supplementary material).

Other required material: MATLAB, some examples in Maple or Mathematica

Prerequisites: Calculus, Differential Equations, basic Linear Algebra as acquired in MATH251, MATH 252, MATH 332 or MATH 333, and CS 105 or CS 115, or consent of instructor

Objectives:

1. Students should gain an appreciation for the role of computers in mathematics, science and engineering as a complement to analytical and experimental approaches.
2. Students should have a basic knowledge of numerical approximation techniques, know how, why, and when these techniques can be expected to work, and have ability to program simple numerical algorithms in MATLAB or other programming environments.
3. Students should have learned what computational mathematics is about: designing algorithms to solve scientific problems that cannot be solved exactly; investigating the robustness and the accuracy of the algorithms and/or how fast the numerical results from the algorithms converge to the true solutions. This includes a basic understanding of computer arithmetic and round-off errors and how to avoid loss of significance in numerical computations.
4. Students should be able to use and evaluate alternative numerical methods for the solution of linear and nonlinear systems, basic data fitting problems, and ordinary differential equations.
5. Students should be able to make appropriate assumptions to come up with a mathematical model that accurately reflects an appropriate scientific theory, and that is amenable to solution with a computer.
6. Students should appreciate the importance of written and graphical communication.

Course Outline: Hours

1. Introduction to Computational Mathematics 10
   - mathematical modeling

- review of Taylor series
- numerical error (floating-point representation, computer arithmetic, round-off errors, and loss of significance in numerical computations)
- programming in MATLAB

2. Solving Systems of Linear Equations 6
   - direct methods (LU factorization)
   - basic iterative methods (Jacobi, Gauss-Seidel and SOR)
3. Interpolation 6
   - polynomial interpolation
   - piecewise polynomial and spline interpolation
4. Locating Roots of Equations 6
   - bisection method
   - Newton's method
   - secant method
   - introduction to the solution of systems of nonlinear equations
     - Newton's method for systems
5. Least Squares Problems 5
   - Motivation and applications
   - Least squares fitting with polynomials
   - The QR decomposition
   - The SVD
6. Numerical Integration 4
   - Newton-Cotes methods
   - adaptive quadrature
7. Numerical differentiation and solution of ordinary differential equations 5
   - finite differences
   - Runge-Kutta methods
   - multistep methods and stiff equations (comparison of various MATLAB stiff solvers)
   - FFT and spectral methods

Assessment:	Homework	15%
	Computer Programs/Project	15%
	2 Midterms (February 17, April 7)	40%
	Final Exam (Monday, May 2, 10:30am-12:30pm)	30%

Weekly homework sets will alternate between written problems taken mostly from the textbook and computer assignments. All problems are to be performed **individually** and turned in for grading. Midterm exams are tentatively scheduled as listed above. The final will be comprehensive, and approximately 75-80% of the problems will be taken from the material covered in the midterms. Make-ups for tests will be given only **when authorized in advance** by the instructor. Only 90% of the make-up score will count. **Late homework will not be accepted**.

Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources and make an appointment to speak with me as soon as possible. The Center for Disability Resources is located in the Life Sciences Building, room 218, 312-567-5744 or disabilities@iit.edu.