Math 950, Spring 2009

Course: Numerical Methods for Partial Differential Equations I

Time & Location: T/Th, 2:40-4:00pm, C308 WH

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Office hours: T/Th: 4:30pm-5:30pm, Th: 11:00am-12:00pm, and by appointment.

Class webpage: Homework assignments and supplemental materials will be given here. http://www.math.msu.edu/~richardl/teaching/math950

Course Description: This graduate level course is about the numerical solutions of Partial Differential Equations using Finite Difference methods. We will introduce techniques for analyzing the convergence of the schemes and evaluate their advantages and limitations. Emphasis will be also on the implementations.

Prerequisites: Programming skills with Fortran, C/C++, or Matlab are necessary. The students are expected to have taken ODE/PDE courses at the advanced undergraduate level. Previous knowledge on Numerical Analysis is also required.

Textbooks:
  This will be our primary reference for the course. Exercises for each chapter are available at the website of the book, where you can also find Matlab codes for some of the algorithms. http://www.amath.washington.edu/~rjl/fdmbook/index.html

Grading policy: 60% on homeworks; 40% on final project.

Homework: Home works will be assigned every other week from the second week. A due date will be denoted on each assignment and no late homework will be accepted except extreme situations. There will be approximately 6 homework assignments in total. Each homework set will consist of a few problems regarding proofs and a couple of other problems for code implementation. A sample homework can be found on the website of the LeVeque book. When collected,
• the homework must be prepared with LaTeX. LaTeX is a must skill for mathematicians. Here is a helpful link. http://www-h.eng.cam.ac.uk/help/tpl/textprocessing

• the numerical results must be illustrated with Tables and Figures in the format indicated in the problems. You can generate figures using Matlab or Gnuplot. A tutorial for Matlab can be found at http://www.math.mtu.edu/~msgocken/intro/intro.html

A free GNU software called Octave provides computational environment compatible with matlab. Details can be found at http://www.gnu.org/software/octave/

• the code must submitted together with the homework. In Unix, the following command produces a readable print of a program in a two-column landscape format:
enscript -G2r filename

**Final Project:** A final project will be given to make sure that things can be put together. Details will be announced later.

**Schedule:** We will try to follow the following schedule which is still subject to change.

**Week 1,2:** Introduction, Boundary Value Problems

1. Finite difference approximation
2. Consistency, stability and convergence
3. Neumann boundary condition
4. Linear and Non-linear equations
5. Singular perturbation, Non-uniform grid
6. Higher order and spectral methods

**Week 3,4:** Elliptic Equations

1. Analysis of elliptic equations
2. 5-point and 9-point Laplacian methods
3. Divergence form equations
4. Non-rectangle boundary
5. Coordinate change

**Week 5,6:** Iterative Methods for Sparse Linear Systems

1. Jacobi, Gaussian-Seidel, SOR
2. Conjugate Gradient
3. Arnoldi process and GMRES
4. Multigrid

**Week 7,8,9:** Parabolic Equations

1. Analysis of parabolic equations
2. MOL (Explicit, Implicit, Crank-Nicolson)
3. Stiffness, stability and convergence
4. Von-Neumann analysis, Maximum principle  
5. Neumann boundary conditions  
6. Variable coefficients and non-linear problems  
7. ADI, LOD for higher dimensions  
8. Polar coordinate and curved boundaries  

Week 10,11,12: Hyperbolic Equations  
1. Analysis of hyperbolic equations  
2. MOL (Lax-Wendroff, Upwind, ...)  
3. Von-Neumann analysis, CFL condition  
5. Dissipation and dispersion  
6. Hamiltonian systems  
7. Modified equation analysis  
8. Equations in higher dimensions  
9. Initial boundary value problems  

Week 13,14,15: Mixed Equations, Selected topics  
1. Second order equations  
2. MOL, Taylor series methods  
3. Time stepping  
4. Eno&Weno methods  

The University’s policy concerning academic integrity is covered in the Spartan Life booklet, General Student Regulations. According to the handbook, "No student shall claim or submit the work of another as one’s own."