Math 951, Spring 2010

Course: Numerical Methods for Partial Differential Equations II

Time & Location: T/Th, 10:20-11:40am, A204 WH

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Office hours: T/Th: 9:10-10:10am, 1:00pm-1:30pm, and by appointment.

Class webpage: Homework assignments and supplemental materials will be given here. http://www.math.msu.edu/~richardl/teaching/math951

Course Description: This graduate level course is about the numerical solutions of Partial Differential Equations using Finite Element 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. Prior knowledge on Numerical Analysis is also required.

Textbooks:

- Numerical Solution of Partial Differential Equations by the Finite Element Method, Claes Johnson. This will be our primary reference for the course. I have reserved it at the math library.


- Understanding and Implementing the Finite Element Method, by Mark S. Gockenbach. An very good reference on details of the implementation.

Grading policy: 60% on homeworks; 40% on midterm and final projects.

Homework: Homeworks will be assigned every week on Tu. and will be due the next Th. There will be approximately 12 homework assignments in total. Each homework set will consist of a couple of problems regarding proofs and code implementation. When collected,

- 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

Midterm and Final Projects: A midterm project and a final project will be given to make sure that things can be put together. Details will be announced later. The projects 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

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

Week 1-6: Introduction to Elliptic Problems
1. Variational Formulation
2. FEM with piecewise linear functions
3. Error Estimate
4. Sobolev Spaces
5. Neumann boundary condition
6. Construction of FEM spaces
7. Multigrid methods
8. Preconditioning
9. Adaptive meshes
10. Boundary Elements and Curved Elements

Week 7-9: Nonconforming Methods
1. Variational Crimes
2. Isoparametric Elements
3. Saddle Point Problems
4. Mixed methods
5. Stokes Problem

Week 10-11: Applications in Solid Mechanics
1. Elasticity Theory, Hyperelastic Materials
2. Membranes, Beams and Plates

Week 12-15: Parabolic and Hyperbolic Equations
1. Backward Euler and Crank-Nicolson
2. Discontinuous Galerkin
3. Convection-Diffusion Problem, Artificial Diffusion
4. Streamline diffusion method
5. Non-linear Problems

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.”