UNIVERSITY OF Cincinnati

Mathematical Sciences
P.O. Box 210025
Cincinnati, OH 45221-0025

Advanced Numerical Analysis (Autumn 2008-9)

Time and Place: MW 3:00-4:15 PM, 807 Old Chem, 15-MATH-710-001
Instructor: Donald A. French (820D Old Chemistry)
Phone and Email: 556-4039 (Messages 556-4050), french@math.uc.edu
Office Hours: MW 4:15-5:15 PM and by appointment.

Prerequisites: Calculus I–IV, Differential Equations, Linear Algebra, programming (MATLAB is best here), PDE & FA, Advanced Calculus, and graduate mathematics courses including partial differential equations and numerical analysis (Numerical Analysis (15-MATH-514, 515, 516) and Partial Differential Equations (15-MATH-627,628, 629) would be best here).

Description: Partial differential equations (PDEs) model a wide range of physical phenomena including heat conduction, wave propagation, and fluid flow. Computer approximations to the solutions of the PDE problems that arise in these applications are usually required. A knowledge of the accuracy, stability and robustness of computational methods is beneficial in understanding the schemes and developing both new discretization procedures and enhancing existing ones.

We will focus on the finite element method (FEM) in this course which is intended for graduate students in Engineering, Physics, Chemistry and Mathematics who are interested in the analysis and development of error estimates. We shall study the use of energy (Hilbert space) techniques.

Initially, we will discuss the mathematical foundations of the FEM in Sobolev spaces and develop a basic approximation theory. Once this background is established, we will survey related topics. These may include applications of the FEM to first order hyperbolic equations or nonlinear time-dependent parabolic problems including the Cahn-Hilliard (phase transitions) or the Navier-Stokes (fluid flow) equations. We may also look at discontinuous Galerkin discretizations in time *and space*. Nonconforming methods are also of interest as well as the development of *a posteriori* error estimates and how they are used to design adaptive schemes.

Grading: There will be two exams;

Midterm: Wednesday, November 5 (In Class)
Final: Wednesday, December 10, 4:00-6:00 PM.

They will count toward most of the course grade. Homework assignments will also count and will be given every 1-2 weeks. Late homework may not be accepted or be subject to point reductions.

Relevant References:

1. Computational Differential Equations by K. Eriksson, D. Estep, P. Hansbo, and C. Johnson, Cambridge University Press (1996).

2. Numerical Solutions of Partial Differential Equations by the Finite Element Method by Claus Johnson, Cambridge University Press (1987).

3. Finite Element Methods for Viscous Incompressible Flows by M. D. Gunzburger, Academic Press (1989).
4. Theoretical Numerical Analysis – A Functional Analysis Framework by K. Atkinson and W. Han, Springer (2005).
5. The Mathematical Theory of Finite Element Methods (3rd Ed) by S.C. Brenner and L. R. Scott, Springer (2008).

The class notes are your primary resource for this course.