ACMS 60790 Numerical Analysis II, Spring 2014

Instructor: Zhiliang Xu

Email: zxu2@nd.edu   Office: Hayes-Healy 226   Phone: 631-3423

Class time and place: MWF 2:00pm – 2:50pm, Pasquerilla Center 105
Office hours: W 4:00pm – 5:00pm, HH226

Course Description

This course is the second part of a two semester sequence of numerical analysis courses. It is an introductory graduate level course designed to introduce mathematics, engineering, and science students the fundamental concepts in numerical methods for solving partial differential equations and theoretical analysis. This is a three credit course.

Main Topics:

1. Introduction and classification of PDEs.
2. Parabolic problems – diffusion or convection-diffusion equations. Finite difference method basics: convergence, stability and consistency, von Neumann stability analysis and Fourier transforms. Methods of lines – time discretization schemes (explicit, implicit methods etc).

   Numerical methods for solving high order nonlinear equations.

3. Elliptic problems – two-point boundary value problems, Laplace and Poisson equations. Finite element method basics: variational formulation, interpolation theory, quadrature, energy norm, a priori convergence, order of convergence.

   Short review of iterative methods for solving system of linear equations.

   Parabolic PDE revisit. Finite element for solving parabolic PDE.

4. Hyperbolic problems – advection equation, nonlinear hyperbolic conservation laws, method of characteristics, stability, the CFL condition, convergence. Finite volume method basics: LF, LW, TVD, MUSCL, ENO/WENO.

   Discontinuous Galerkin finite element method for convection-dominant problems.

5. Miscellaneous topics as time permits - multigrid, spectral methods.

Prerequisites:

The course requires a moderate amount of programming. FORTRAN or C or C++ programming languages are preferred. However, students may also use software programs including Matlab, Mathematica.

Grades:

Course grades will be based on homework and projects.

Homework:	20%
4 Projects:	50%
Final project including project presentation:	30%

The Notre Dame Academic Code of Honor Pledge is observed in this course. "As a member of the Notre Dame community, I will not participate in or tolerate academic dishonesty."

Textbooks:

1. J.W. Thomas, Introduction to Numerical Methods for Partial Differential Equations, Springer, ISBN 0-387-97999-9
2. J.W. Thomas, Numerical Partial Differential Equations: conservation laws and elliptic equations, Spring. ISBN 0-387-98346-5
3. Zhangxin Chen, Finite element methods and their applications, Springer

Reference books and papers:

4. K. Eriksson, D. Estep, P. Hansbo, and C. Johnson, Computational Differential Equations, ISBN 0-521-56738-6
5. R.J. LeVeque, Numerical Methods for Conservation Laws, Birkhauser Verlag, 1992.
6. C.T. Kelley, Iterative methods for linear and nonlinear equations, Society of Industrial and Applied Mathematics
7. C.-W. Shu, Essentially non-oscillatory and weighted essentially non-oscillatory schemes for hyperbolic conservation laws, in Advanced Numerical Approximation of Nonlinear Hyperbolic Equations, B. Cockburn, C. Johnson, C.-W. Shu and E. Tadmor (Editor: A. Quarteroni), Lecture Notes in Mathematics, volume 1697, Springer, 1998, pp.325-432.