

ACMS 60-790-01, Spring 2011

**Numerical Analysis II**

**Instructor: Zhiliang Xu**

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**Class time and place:** MW 1:30pm – 2:45pm, Edward J. DeBartolo Hall 140.

**Office hours:** W 4:30pm – 5:30pm or by appointment and drop-in (when available)

**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 partial differential equations and theoretical analysis. This is a three credit course.

**Main Topics:**

1. Introduction and classification of PDEs.
2. Parabolic Problems and the 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 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 parabolic PDE.

4. Hyperbolic Problems – advection equation, method of characteristics, stability, the CFL condition, convergence.

Nonlinear hyperbolic conservation laws – consistency, conservation, numerical schemes (TVD, MUSCL, ENO/WENO, discontinuous Galerkin).

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.

40% homework

60% projects

**Reference books and papers:**

J.W. Thomas, Introduction to Numerical Methods for Partial Differential Equations, Springer, ISBN 0-387-97999-9

Claes, Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, ISBN 0521 345 146.

R.J. LeVeque, Numerical Methods for Conservation Laws, Birkhauser Verlag, 1992. C.T. Kelley, Iterative methods for linear and nonlinear equations, Society of Industrial and Applied Mathematics

C. T. Kelley, *Iterative Methods for Linear and Nonlinear Equations*, SIAM 1995

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.