

## ACMS 60790 Numerical Analysis II, Spring 2015

Instructor: Zhiliang Xu

Email: [zxu2@nd.edu](mailto:zxu2@nd.edu) Office: Hayes-Healy 242 Phone: 631-3423

**Class time and place:** MWF 2:00pm – 2:50pm, Hayes Healy Center 229

**Office hours:** W 4:00pm – 5:00pm, HH242

### 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. 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.

2. Elliptic problems –Laplace and Poisson equations. Finite difference. Finite element method basics: variational formulation, interpolation theory, quadrature, energy norm, a priori convergence, order of convergence.

Iterative methods for solving system of linear equations.

Parabolic PDE revisit. Finite element for solving parabolic PDE.

3. 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.

4. 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 and Project: 70%

Final project: 30%

**Honor Code:** As a member of the Notre Dame community, I will not tolerate academic dishonesty. All examinations, homework and computer projects are conducted under the Honor Code. You are encouraged to work together on the homework assignments and projects, but copying in any form or submitting work done by others as your own is a violation of the Honor Code.

**Attendance:** You are expected to attend every class including your assigned tutorials. Excessive absences may result in lowering your grade and even failing the course.

### 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.