

Course Outline for MATH 4652, Numerical Differential Equations

MATH 4652 Numerical Differential Equations (3 units)

Prerequisite: Graduate standing in Mathematics, MATH 451, or [MATH 3651](#). Recommended: MATH 344 or [MATH 3351](#).

Finite-difference methods for boundary-value problems described by ordinary and elliptic partial differential equations. Numerical methods for initial-value problems described by ordinary differential equations and systems thereof. Finite-difference methods for initial-boundary-value problems described by parabolic and hyperbolic partial differential equations. 3 lectures. Formerly MATH 452.

Course Learning Objectives	
1	Approximate differential operators for ordinary and partial differential equations using finite-difference discretization, and analyze their truncation errors and convergence.
2	Solve linear and nonlinear boundary-value-problems with various boundary conditions using direct and iterative linear solvers and Newton's method.
3	Implement one-step and multi-step methods for initial-value-problems and analyze their truncation errors and convergence.
4	Analyze zero stability and absolute stability of numerical methods for initial-value-problems in ordinary differential equations
5	Identify stiff initial-value-problems and apply appropriate numerical methods to approximate their solutions.
6	Implement and analyze numerical methods for partial differential equations of parabolic and hyperbolic types including Von Neumann analysis for these problems.

Expanded Course Content

Textbooks, materials, and/or other resources

Instructors can choose from a variety of textbooks and/or additional readings; possible textbooks include:

Randall LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations, Society of Industrial and Applied Mathematics, 2007.

Uri M. Ascher, Numerical Methods for Evolutionary Differential Equations, Society of Industrial and Applied Mathematics, 2008.

The outline below is based upon the LeVeque text.

Week	Readings	Topics of Discussion
1	Chapter 1 of LeVeque	Finite difference approximations
2	Sections 2.1-2.8 of LeVeque	Steady states and boundary value problems
3	Sections 2.9-2.16 of LeVeque	Steady states and boundary value problems
4	Sections 2.17-2.20 of LeVeque	Steady states and boundary value problems
5	Sections 3.1-3.4 of LeVeque	Elliptic equations
6	Sections 3.5-3.7, 4.3 of LeVeque	Elliptic equations; iterative methods for sparse linear systems
7	Sections 5.1-5.5 of LeVeque	The initial-value problem for ODEs
8	Sections 5.6-5.9 of LeVeque	The initial-value problem for ODEs
9	Sections 6.1-6.4 of LeVeque	Zero-stability and convergence for IVPs
10	Sections 7.1-7.6 of LeVeque	Absolute stability for ODEs
11	Sections 8.1-8.6 of LeVeque	Stiff ODEs
12	Sections 9.1-9.8 of LeVeque	Diffusion equations and parabolic problems
13	Sections 10.1-10.5 of LeVeque	Advection equations and hyperbolic systems
14	Sections 10.6-10.12 of LeVeque	Advection equations and hyperbolic systems
15	Sections 11.1-11.6 of LeVeque	Mixed equations

Method of Assessment

The possible methods of assessment are written individual examinations, quizzes, in-class worksheets and presentations, projects, and homework. One or more midterms and a cumulative final exam are required.

Instructional Mode

The instructional mode for this class is face-to-face. This designation means that the essential academic standards of the course require in-class student engagement, and thus remote instruction is not appropriate.