AMSC 614

NUMERICAL METHODS FOR STATIONARY PDE

Tu-Th 5-6:15, MTH 1313

Instructor

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Description. This course deals with finite element and finite difference methods for elliptic partial differential equations (PDE) arising in science and engineering (solid and fluid mechanics, electromagnetism, thermodynamics, etc). Each topic starts with a review of basic PDE theory (maximum principle and variational methods). The emphasis is on stability, interpolation and error estimates (a priori and a posteriori).

Syllabus

- • Maximum principle, finite difference method, upwinding, error analysis.
- • Variational formulation of elliptic problems and examples: the inf-sup theory.
- • The finite element method and its implementation.
- • Piecewise polynomial interpolation theory in Sobolev spaces.
- • A priori error estimates and applications: quasi-uniform and graded meshes.
- • A posteriori error estimates and adaptivity: contraction property and optimality.
- ⋆ Fast solvers: multigrid methods, multilevel preconditioners, domain decomposition.
- ⋆ Variational crimes: nonconformity, quadrature, isoparametric finite elements.
- ⋆ Mixed FEM: inf-sup condition and stable spaces, applications to Stokes Flow.

Prerequisities. Functional analysis and PDE theory (variational method, maximum principle) will be reviewed. Prior exposure to graduate level PDE and MATLAB is useful but not mandatory. This course is an excellent complement to MATH 674 and AMSC 667, which cover Sobolev spaces, modern PDE theory and FEM in 1d.

Books (suggested)

D. Braess, Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics, Cambridge Univ. Press, (2007), 3rd edition, ISBN 978-0-521-70518-9.

Ph. G. Ciarlet, *The Finite Element Methods for Elliptic Problems*, North-Holland (1987), 2nd edition, ISBN 0-444-89016-9.

S.C. Brenner and L.R. Scott, *The Mathematical Theory of Finite Element Methods*, Springer (2002), 2nd edition, ISBN0-387-95451-1.

Stig Larsson and Vidar Thomée, *Partial Differential Equations with Numerical Methods*, Springer (2003).

Evaluation. Homeworks, both theoretical (80%) and computational (20%). Basic MATLAB programs will be distributed and will have to be modified appropriately