MATH838 – Finite Elements and Boundary Element Methods

Catalog description

Finite element methods for elliptic problems including: weak solutions, multidimensional interpolation, Bramble-Hilbert lemma and error analysis, multidimensional quadrature, multigrid and domain decomposition methods, preconditioning, saddle point problems, LBB condition and mixed methods. Boundary element methods for elliptic problems including: jump conditions, error analysis, quadrature methods for singular integrals and Fast Multipole Method for Laplace's equation. Coupling between boundary elements and finite element methods. Discontinuous Galerkin methods for elliptic and hyperbolic problems. Applications selected by the instructor.

Essential information

- Instructor: Francisco-Javier "Pancho" Sayas
- Lecture times: MW 2:00-3:15 in EWG207
- Office hours: By appointment. Or simply show at my office door
- Website: www.math.udel.edu/~fjsayas/math838
- Support book: The FEniCS Book, edited by Anders Logg, Kent-Andre Mardal, and Garth Wells, and published as Volume 84 of Lecture Notes in Computational Science and Engineering by Springer, 2012. (Check in http://fenicsproject.org/book/)
- Class-notes for most of the topics will be posted online in the website.

Course contents

- A gentle introduction to the Finite Element Method
  - Linear triangular elements
  - Theoretical and practical notions (assembly, higher order finite elements)
  - [A basic MATLAB code]
  - New classes of elements (elements on parallelograms, three dimensional elements)
  - More advanced questions (isoparametric elements, quadrilaterals, mass lumping, discrete eigenvalues)
  - Evolution problems (heat and wave equations)
- Getting to know FEniCS
- Advanced topics in finite elements
  - Polynomial bases for high order elements
  - Hermite elements
  - C1 elements
  - Non-conforming elements
  - Mixed formulations

- o   Divergence-preserving finite elements
- o   Some discontinuous Galerkin methods
- o   A posteriori error estimation
- A taste of the theory of the finite element method
  - o   Lax-Milgram's and Cea's lemmas
  - o   Scaling arguments and the Bramble-Hilbert lemma
  - o   Non-homogeneous Dirichlet conditions
- Introduction to the boundary element method
  - o   The single layer potential for the Laplacian
  - o   Green's representation theorem
  - o   The Calderon Calculus
  - o   The Helmholtz equation

Evaluation
- Homework 20% of the grade
- One take-home exam 30% of the grade
- One long project 50% of the grade

Attendance policy
Attendance to lectures is mandatory.

Academic honesty
As worded by the University of Delaware, All students must be honest and forthright in their academic studies. To falsify the results of one's research, to steal the words or ideas of another, to cheat on an assignment, or to allow or assist another to commit these acts corrupts the educational process. Students are expected to do their own work and neither give nor receive unauthorized assistance. Any violation of this standard must be reported to the Office of Student Conduct. For more details, check (www.udel.edu/stuguide/14-15/code.html#honesty). Cheating of any kind (even if the student does not take any advantage from it) will be grounds for an F grade.