EECE 7907/8907: Computational Science & Engineering (Syllabus)

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EECE 7907 / 8907
Computational Science and Engineering
Spring Semester 2014

Lectures: 218 Engineering Science Bldg; Tuesday and Thursday, 5.30 pm to 6.55 pm

Instructor: Madhu Balasubramanian
Office: 208D Engineering Science Building
Telephone: (901) 678-1199
Email: mblsbrmn@memphis.edu (more reliable)
Office hours: Tuesday 6.55 pm to 7.55 pm (right after class)
   Friday 9.30 am to 10.30 am
   Or by appointment (email for appointment)

Recommended Text
1. Lecture notes

Additional References

Website: https://elearn.memphis.edu

Prerequisites: Graduate standing or consent of the instructor

Grades
- Attendance and learning the materials
- Programming 1-D (one or two in-class programming exercise before spring break) and 2-D FEM in Matlab.
- Students are encouraged to work in small groups
- For 2-D FEM programming: PhD students “may” choose a problem of their interest or aligned with their dissertation topic (masters students are also encouraged)
- Any interested students “may” also present their 2-D FEM project (not necessary).

Course Objectives
1. Develop basic understanding of scientific computing techniques for solving engineering, scientific and biomedical problems
2. Learn the theoretical foundations of the finite element method, and
3. Lay foundation for research work using the finite element method such as in studying biomedical structures and biomedical fluid-structure interaction.
4. Lay foundation for my future courses in physics based modeling and visualization of a) fluid flow and b) fluid-structure interaction.
5. We will not cover commercial finite element software
Catalog Description

Scientific computing is a powerful approach to study and solve engineering, scientific, and interdisciplinary biomedical problems involving complex geometrical structure and function. The following topics are covered in this class to learn the theoretical foundation, to program and to use the finite element method to solve linear boundary value problems in 1-D and 2-D: 1) Review of tools and methods from ordinary differential equations, partial differential equations, and calculus of variation for solving boundary value problems; 2) Review of Hilbert and Banach spaces; 3) Overview of finite difference and finite element methods for solving boundary value problems; 4) Deriving strong and weak formulation, Galerkin approximation and matrix formulation; 5) Finite element formulation; 6) Conjugate gradient method and other numerical techniques for solving the finite element formulation; 7) Finite element formulation for solving 2-D boundary value problems; 8) Mesh generation; 9) Programming a finite element; 10) Convergence, exactness and error analysis of the finite element method; and 11) Student will complete a project work in their area of interest/research.

Course Outline

1. Course Introduction
2. Brief review of tools and methods from ordinary differential equations, partial differential equations, and calculus of variation for solving boundary value problems;
3. Brief review of Hilbert and Banach spaces;
4. Overview of finite difference and finite element methods for solving boundary value problems;
5. 1-D finite element:
   a. Deriving strong and weak formulation, Galerkin approximation and matrix formulation
   b. Finite element formulation by defining elements and finite element space using shape functions
   c. Assembling global stiffness matrix and force vector
   d. Conjugate gradient method for solving the finite element matrix formulation
6. 2-D Finite Element
   a. Deriving strong and weak formulation, Galerkin approximation and matrix formulation
   b. Finite element formulation
   c. Assembling global stiffness matrix and force vector
7. Mesh generation for the finite element method.
8. Programming a finite element method
   a. Bilinear quadrilateral element
   b. Linear triangular element
   c. Isoparametric elements
   d. Numerical integration; Gaussian quadrature