ECI 212A: Finite Element Procedures in Applied Mechanics

Winter 2017, UC Davis

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Lectures

MW: **12:10pm–2:00pm** (Storer 1342)
Office Hours: MW (**10:00am – 11:30am**), and by appointment

Grader

Subhajit Banerjee (`jitbanerjee@ucdavis.edu`)

Textbook

J. Fish and T. Belytschko, "A First Course in Finite Elements," John Wiley & Sons, 2007.

Reference Textbooks

1. M. R. Gosz, "Finite Element Method: Applications in Solids, Structures, and Heat Transfer, CRC Press, Boca Raton, FL, 2006.
2. T. J. R. Hughes (1987), "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis," Prentice-Hall, Englewood Cliffs, NJ. (**also published by Dover**)

3. J. N. Reddy (2005), "An Introduction to the Finite Element Method," 3rd Ed., McGraw-Hill, NY.

4. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt (2002), "Concepts and Applications of Finite Element Analysis," 4th Ed., John Wiley and Sons, NY.

5. M. S. Gockenbach (2006), "Understanding and Implementing the Finite Element Method," SIAM Publications, Philadelphia, PA.

6. G. Strang and G. J. Fix (1973), "An Analysis of the Finite Element Method," Prentice-Hall, Englewood Cliffs, NJ.

Suggested Prerequisites (Topics and UCD Courses)

1. Vector calculus and linear algebra
2. Ability to program in Matlab or Fortran 77
3. Exposure to ordinary differential equations and numerical analysis (e.g., ECI 115)
4. Fundamentals of structural/solid mechanics (stress, strain, trusses, beams, etc.)

Course Outline

The course will be based on topics that are covered in class. Besides the textbook, a few reference textbooks on FEM are indicated, which can be consulted. The focus in this course is to provide students a sound understanding of the variational basis and tools required to develop Galerkin finite elements for linear boundary-value problems in applied mechanics. Students will be introduced to good programming practices for finite elements, and through computer assignments, they will program finite elements for the purpose of computer simulations in structural and solid mechanics. The main topics that will be covered in this course are the following:

1. Introduction: Mathematical modeling for physical phenomena (**1 lecture**)
2. Mathematical preliminaries (function spaces and variational calculus) (**1 lecture**)
3. Rayleigh Ritz Galerkin method and weak/variational form for one-dimensional elasticity (**2 lectures**)
4. Galerkin finite elements in one-dimension (basis/shape functions, trial and test approximations, discrete weak form, numerical integration, assembly of discrete equations, higher-order one-dimensional finite elements, error measure and convergence (**4 lectures**)

5. Variational/weak formulation for Euler-Bernoulli beam (**2 lectures**)
6. Linearized theory of elasticity – review from ECI 201 (**1 lecture**)
7. Continuum finite elements (3-node triangle and 4-node quadrilateral element). Numerical integration, evaluation of element matrices/vectors and their assembly. Solve problems such as bending of cantilever beam and plate with a hole using FEM (**5 lectures**)
8. Extension to 3D finite elements (8-node brick elements). Numerical integration, evaluation of element matrices/vectors and their assembly. (**2 lectures**)

Computer Usage: Use of 1D and 2D Matlab finite element programs to solve linear boundary-value problems in applied mechanics. Computer assignments will require the students to implement finite elements in 1D and 2D, and to also assess accuracy and convergence through numerical tests.

Evaluation

1. Homework (30%)
2. Mid-term (20%) on February 8, 2017
3. Final exam (50%)

A homework will be assigned every week on Wednesday and will be due by 5p.m. on the following Wednesday. *Homework drop-box for ECI 212A is located on the second floor of Ghausi Hall.* Please drop-off the homeworks in the drop box before the deadline; I won't pick them up in class. You are encouraged to discuss the homework with others, but must write-up the homework solutions on your own. If you have questions on the material covered in class or on the homeworks, the best time for clarifications is during office hours. Exams will be closed book and closed notes. A one-page crib sheet (can write on both sides) with formulas can be used. The mid-term and final exams will be held in Storer 1342.