ECI 212A: Finite Element Procedures in Applied Mechanics

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Lectures

MW: **8:00am–9:50am** (1070 Bainer)
Office Hours: MW **10:30am–noon** or by appointment

Textbook

M. R. Gosz, "Finite Element Method: Applications in Solids, Structures, and Heat Transfer, CRC Press, Boca Raton, FL, 2006.

Further Reading

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

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. 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.

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

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

Prerequisites (Topics and UCD Courses)

1. Vector calculus and linear algebra
2. Exposure to ordinary differential equations and numerical analysis (e.g., EAD 115)
3. Ability to program in Matlab or Fortran 77.
4. A senior-level undergraduate course in linear elasticity or continuum mechanics.

Course Outline

The course will be based on topics that are covered in class. The textbook of Gosz will be followed in the course; additional reference text on finite elements are also indicated, which can be consulted for further reading. 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 (matrix algebra, tensors, and vector 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 of theory, principle of virtual work/variational formulation) (**3 lectures**)

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**)

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%)

3. Final exam (50%)