CEE-576 NONLINEAR FINITE ELEMENTS
(Same as CSE-552)

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

10:00 – 11:20 am Mon, Wed; 1311 Newmark CE Bldg; Units: 4 hours

Instructor: Professor Arif Masud, Ph.D.
Department of Civil and Environmental Engineering
3129-E Newmark Civil Engineering Laboratory,
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Website: http://amasud.web.engr.illinois.edu/
Office Hours: To be announced

Teaching Assistant: To be Announced

Text Books:

1. The class lectures will be supplemented with handouts and typed notes that will be provided regularly.
2. Nonlinear Finite Elements for Continua and Structures, 2nd Edition by T. Belytschko, W.K. Liu, B. Moran, and Khalil Elkhodary. John Wiley and Sons 2014. ISBN 0-471-98774-3.
3. The Finite Element Method: Linear static and dynamic finite element analysis by Thomas J.R. Hughes, 2000. Dover.

References:

1. Nonlinear Continuum Mechanics for Finite Element Analysis, by J. Bonet and R.D. Wood. Cambridge University Press 2008. ISBN-13 978-0-511-39468-3.
2. Bathe, K. J. Finite Element Procedures. 2nd ed. Klaus-Jürgen Bathe, 2014. ISBN: 9780979004957.

Required Background:

Students should have completed a first-year graduate course on linear finite element analysis, have exposure to partial differential equations, and possess a working knowledge of one programming language. Graduate standing is required.

TOPICAL OUTLINE

1. Nonlinear Statics:

1. Small deformation nonlinear elasticity
2. Nonlinear heat equation
3. Linearized operators
4. Finite element formulation
5. One dimensional examples: Nonlinear elasticity, Nonlinear heat
6. Finite element programming (Code Development)

2. Methods of Solving Nonlinear Algebraic Systems:

1. Newton and Modified-Newton Methods
2. Consistent linearization
3. Line search techniques
4. Arc-length strategies
5. Convergence criterion
6. Some features of quasi-static drivers

3. Finite Deformation (Hyperelasticity):

1. Continuum mechanics background
2. Variational/weighted residual type formulations
3. Linearized approximations
4. Total and Updated Lagrangian formulations
5. Finite element discretizations
6. Comparison with linear formulations and methods
7. Finite element programming (Code Development)

4. Finite Deformation Elastodynamics:

1. Continuum mechanics background
2. Semi-discrete weighted residual formulations
3. Classical time-stepping algorithms
4. Stability, Consistency and Convergence
5. Formulation of Algorithms for Nonlinear Problems
6. Finite element programming (Code Development)

5. Theory of Mixed Finite Element Methods:

1. Introduction to the theory of Mixed Finite Element Methods
2. Incompressibility Constraint and Volumetric locking
3. Babuska-Brezzi (BB) stability condition
4. Strain Projection Methods (Linear and Nonlinear cases)
5. Stabilized and Multiscale Finite Element Methods for Nonlinear Field Theories

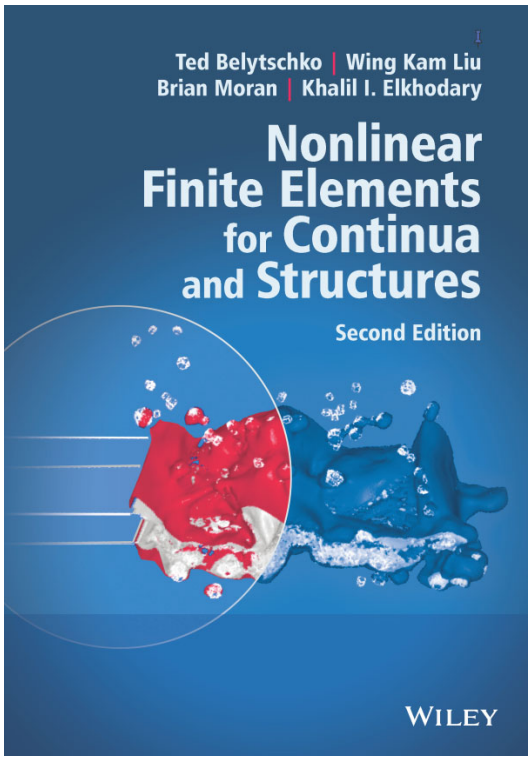
6. Mixed-Methods for Nonlinear Coupled-Field Problems:

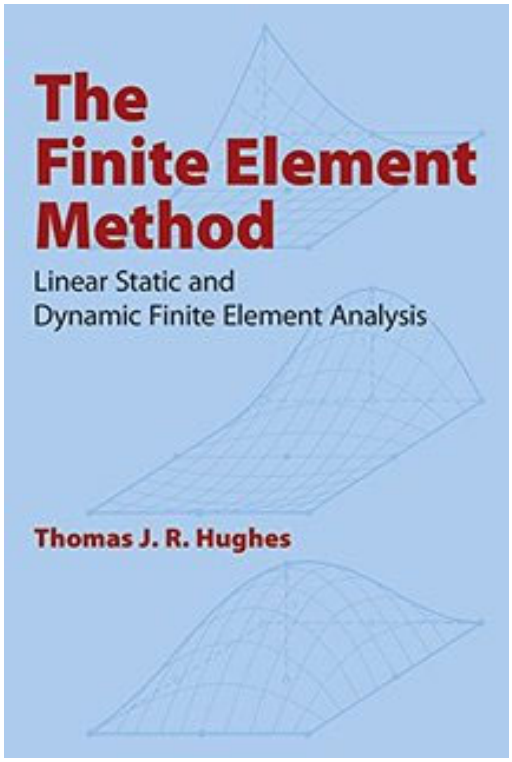
1. Introduction to the General Classes of Coupled-Field Problems
2. Theory of Stress-assisted Diffusion in Solids
3. Theory and formulation for small-strain Thermoelasticity
4. Stability of the continuum and discrete formulations
5. Operator splitting methodology and solution algorithms
6. Stability and accuracy of solution algorithms
7. Introduction to the Theory and Formulation of Finite-strain Thermoelasticity

GRADING

- Homework 40%
- Programming Assignments 15%
- Midterm Exam 15%
- Final Exam 30%

Text Books:





Recommended Reference Books