ME 259 August 3:0

Nonlinear Finite Element Methods

Instructor

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Email:

Department: Mechanical Engineering

Course Time:

Lecture venue: Mechanical Engineering Lecture Hall

Detailed Course Page:

Announcements

Brief description of the course

This course is intended for students who have already taken a linear finite element methods course (such as ME257) and wish to learn about applications of finite element procedures to nonlinear Structural / Solid Mechanics problems. Different types of structural nonlinearities such as material, geometric and contact will be discussed. The formulation of finite element procedure to solve boundary value problems involving above nonlinearities will be presented. Stress update procedures in elasto-plasticity, consistent linearization and solution of discrete equilibrium equations by the iterative Newton-Raphson method will be emphasized. An important aspect of the course is to expose the student to implementing algorithms in finite element codes and debugging them through example problems.

Prerequisites

ME257 Linear Finite Element Methods or equivalent

Syllabus

1. Introduction to structural nonlinearities.

2. One-Dimensional plasticity and viscoplasticity.

3. Continuum theories of plasticity.

4. Finite element procedures for small strain plasticity.

5. Introduction to continuum mechanics.

6. Finite element formulations for finite deformation elasticity - Total Lagrangian and Updated Lagrangian formulations.

7. Finite element procedures for contact problems - gap element formulation and penalty method.

Course outcomes

Nonlinear finite element procedures are extensively used by structural engineers to design components for applications where large deformations or material nonlinearities are encountered. Also, manufacturing engineers require knowledge of these procedures to design dies and fixtures for various forming processes like sheet metal forming, rolling and extrusion. This course will provide the necessary fundamentals to students to undertake these tasks. In addition to exposure to algorithmic aspects, the course will provide the student with hands-on experience in implementing them in finite element codes and debugging them through carefully designed example problems. Thus, the student will acquire the skill to implement the algorithms via user-defined subroutines in general purpose finite element codes like ANSYS and ABAQUS. Moreover, a quick but thorough exposure will be given to Continuum Mechanics concepts which are crucial to understanding nonlinear finite element procedures.

Grading policy

Mid-term and assignments: 50%

Final exam: 50%

Assignments

Many computer assignments will be given to help the student learn and implement the algorithms discussed in class in a general purpose Finite Element Code and debug them through example problems.

Resources

1. O.C.Zienkiewicz and R.L.Taylor, Finite Element Method, Vol2: Solid and Structural Mechanics, 6th edition, Elsevier Butterworth-Heinemann publishers.

2. J.C.Simo and T.J.R.Hughes, Computational Inelasticity, Springer.

3.J.Bonet and R.D.Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge publishers, 2nd edition.