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NONLINEAR FINITE ELEMENT ANALYSIS with applications to solid and structural mechanics

INSTRUCTOR:
Professor J. N. Reddy
College Station, Texas USA

ABOUT THE COURSE

Background

The Finite Element Method (FEM) is a numerical and computer-based technique of solving a variety of practical engineering problems that arise in different fields. It is recognized by developers and users as one of the most powerful numerical analysis tools ever devised to analyze complex problems of engineering. As applied to solid and structural problems, the finite element method is the leading technique for analyzing the behavior of structures when subjected to a variety of loads. The loads may be static or dynamic, and the structural responses can be linear or non-linear, with varying degrees of complexity. The underlying theory of the method is now well established, with many books and courses providing adequate explanations of the theory.

Course Objectives

The two-day course is designed to bridge the gap between the theoretical finite element knowledge and its industrial applications by providing physical insights into the theory of the method and relationship between the physical data (e.g., loads, boundary conditions, constitutive behavior, etc.) and the finite element model of a physical problem. The instructor will share his knowledge and experience to address some of the issues such as physical characteristics of elements, element selection, boundary conditions, load representation, and response characteristics.

This course is intended to provide engineers working in aerospace, automotive, civil, and mechanical engineering industries as well as numerical analysts and materials scientists with the theory and applications of the nonlinear finite element analysis of problems from solid and structural mechanics. At the end of the course one would have acquired knowledge of finite-element analysis linear and nonlinear analysis of structural problems as well as other field problems. Every attempt will be made to make the course as self-contained as possible overview as applied to linear problems will be included in the course.

ABOUT THE COURSE

Profile of Participants

The course is aimed at engineers/scientists who are involved with modeling of structures and who intend using commercially available finite element packages to analyze engineering problems of the aeronautical, automobile, mechanical, civil and other engineering industries. The course will also enable participants to be able to write their own FEM software. Participants are assumed to have knowledge of the basic principles of structural mechanics. Some knowledge of the finite element method is an advantage, but not essential, as an overview as applied to linear problems will be included in the course.

Benefits of Attending the Course

Persons who have attended the course and followed the material should benefit in strengthening their background in the following areas:

An understanding of the formulative steps involved in nonlinear finite element model development of the equations of solid mechanics.

Generation of finite element data (e.g., selection of elements and mesh, computation of nodal forces, imposition of boundary conditions, etc.) and proper imposition of boundary conditions, exploitation of problem symmetries, and interpretation and evaluation of the results.

The ability to write a finite element computer module for a physical problem (e.g., user-specified subroutine for a commercial program).

The ability to read and evaluate technical proposals/reports/papers on the finite element analysis of structural problems in engineering.

The knowledge to teach the finite element analysis procedures to others.

Course Materials

A copy of the overheads used in the presentation of the course will be provided as a part of the course material. The material used in the power point slides is largely taken from the authors following two books:

J. N. Reddy, An Introduction to the Finite Element Method, 3rd ed., McGraw-Hill, New York, 2006.

J. N. Reddy, An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, Oxford, UK (2004) - 2nd edition (2015) / available -

COURSE CONTENTS
(actual coverage and sequence may differ depending on the participants background)

Background: Introduction to Numerical Methods
Overview – basic ingredients of the FEM
Comparison with alternative numerical methods

Basic Concepts of FEM – One-Dimensional Problems
Strong and weak forms (variational and virtual work statements)
Primary and secondary variables of the formulation
Essential vs. natural boundary conditions
Methods of approximations (weak-form Galerkin method)
Finite element approximation functions (linear, quadratic, and cubic elements)
Assembly of element equations
Illustrative examples and discussion of results in light of physical response

Introduction to Non-Linear Problems
Geometric and material non-linearity
Nonlinear formulation of a 2-D Model problem
Solution algorithms for the solution of non-linear algebraic equations
Derivation of tangent stiffness coefficients
Convergence criteria

Nonlinear Bending of Beams
Euler-Bernoulli beam theory
Nonlinear finite element formulation of Euler-Bernoulli beam theory
Tangent stiffness calculations
Membrane locking
Timsohenko beam theory and its finite element model
Shear locking
Numerical examples

Nonlinear Bending of Plates
Nonlinear finite element formulation of the first-order shear deformation (Mindlin) plate theory
Tangent matrix coefficients
Shear and membrane locking
Numerical examples

Continuum Formulations
Continuum equations
Measures of stress and strain
Total and Updated Lagrangian descriptions
Degenerated thick shell element
Applications

About the Course Instructor: J. N. Reddy

http://isihighlycited.com/ and http://www.tamu.edu/acml

Dr. JN Reddy is a Distinguished Professor and inaugural holder of the Oscar S. Wyatt Endowed Chair in Mechanical Engineering at Texas A&M University, College Station, Texas. He is the author of numerous journal papers and text books on theoretical formulations and finite-element analysis of problems in solid and structural mechanics (plates and shells), composite materials, computational fluid dynamics, numerical heat transfer, and applied mathematics. Dr. Reddy's research centers on theoretical formulations and numerical simulations of problems in solid and structural mechanics, composite materials, computational fluid dynamics, numerical heat transfer, geology and geophysics, and computational biology. Dr. Reddy's research provides the cutting edge advances that enable others to adapt his accomplishments into sophisticated computer software used by design engineers world-wide. His novel theories and finite element models have been implemented into commercial finite element commercial softwares like ABAQUS, NISA and HyperForm. Such an eminent record of research has earned Dr. Reddy numerous national and international awards, including the 1998 Nathan M. Newmark Medal from the American Society of Civil Engineers; Award for Excellence in the Field of Composites and Distinguished Research Award from the American Society for Composites; and the 2003 Computational Solid Mechanics award from US Association for Computational Mechanics. He also won the AFS Award for Distinguished Achievement in Research, the Texas A&M Bush Excellence Award for Faculty in International Research, and Distinguished Research Award of the Sigma Xi. Dr. Reddy is one of the few researchers in engineering around the world (only one at TAMU) who is recognized by ISI Highly Cited Researchers with over 10,000 citations and H-index of over 50.