

***A Two-Day\* Short Course on***  
**NONLINEAR FINITE ELEMENT ANALYSIS**  
***(with Applications to Solid Mechanics, Fluid Mechanics and Heat Transfer)***

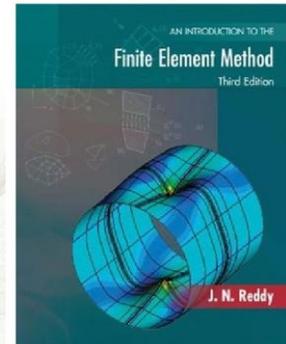
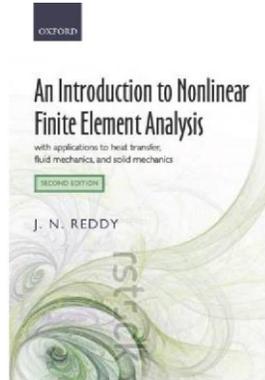
**Course Instructor/Lecturer**

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**ABOUT THE COURSE**

**BACKGROUND**

This course is intended to provide engineers/scientists working in academia as well as in engineering industries with the theory of the finite element method and its use in the solution of linear and nonlinear problems from solid and structural mechanics, fluid mechanics and heat transfer. The present course is designed to bridge the gap between the theoretical finite element knowledge and its industrial applications by providing sufficient insights into the relationship between the physical data (e.g., loads, boundary conditions, constitutive behavior, etc) and the finite element model. The course will also enable participants to be able to write their own finite element software. Participants are assumed to have knowledge of the basic principles of solid mechanics, heat transfer, and fluid mechanics.

**PROFILE OF PARTICIPANTS**

The course is aimed at engineers/scientists who are involved with modeling of problems involving structural elements, fluid flow, and heat transfer in commercial environment and who intend to use commercially available finite element packages to analyze their engineering problems. 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, fluid mechanics and heat transfer. Some knowledge of the finite element method is an advantage, but not essential.

**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:

- A *clear* understanding of the formulative steps involved in the finite element model development of problems of solid and structural mechanics, and certain heat transfer and fluid flow problems.
- Generation of finite element data (e.g., selection of elements and mesh, computation of nodal forces), imposition of boundary conditions, post-computation of stresses and strains, etc.), 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 problems in engineering.
- The knowledge to teach the finite element analysis procedures to others.

### **COURSE MATERIAL AND REFERENCE BOOK**

A copy of the overheads used in the presentation of the course will be provided as a part of the course material. The following finite element books are suggested as references:

1. J. N. Reddy, *An Introduction to the Finite Element Method*, 3<sup>rd</sup> ed., McGraw-Hill, New York, 2006.
2. J. N. Reddy, *An Introduction to Nonlinear Finite Element Analysis*, 2<sup>nd</sup> ed., Oxford University Press, Oxford, UK, 2015.

### **COURSE CONTENTS<sup>‡</sup>**

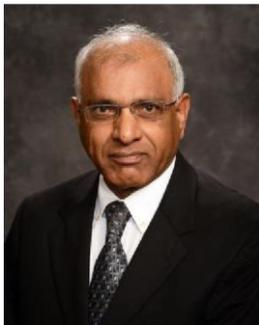
#### **DAY 1**

- **Background: Introduction to Numerical Methods**
  - Overview – basic features of the FEM
  - Membrane and heat transfer-like problems in 2D
  - Elements types (triangular and quadrilateral elements)
  - Convection heat transfer
- **Plate Bending Problems**
  - Theories of plates
  - Classical plate bending elements
  - Shear deformation plate elements
  - Shear locking
- **Introduction to Non-linear Problems**
  - Geometric and material non-linearity
  - 1-D Nonlinear problems (including beams)
  - Solution algorithms for non-linear equations
  - Tangent stiffness calculations
- **2-D Nonlinear Problems and Computer Implementation**
  - Finite element models of 2-D nonlinear problems
  - Computation of tangent coefficient matrices
  - Nonlinear code development and error criteria
  - Time integration procedures

## DAY 2

- **Nonlinear Formulations of Plate Bending Problems**
    - Shear deformation plate elements
    - Membrane locking
    - Tangent stiffness calculations
    - Post-computation of strains and stresses
  
  - **Continuum shell finite elements**
    - Review of continuum mechanics
    - Total and updated Lagrangian descriptions
    - Computer implementations
    - Degenerated thick shell element
  
  - **Finite Element Models of Viscous Flow Problems**
    - Governing equations (Navier-Stokes Equations)
    - Mixed finite element model (2D)
    - Penalty finite element model (2D)
    - Numerical examples
  
  - **Coupled Problems and Closure**
    - Coupled fluid flow and heat transfer formulations
    - Applications
    - Coupled fluid flow and solid mechanics
    - Summary of the course
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Vitae of Professor J.N. REDDY <http://www.tamu.edu/acml>.



Dr. Reddy is a Distinguished Professor, Regents' Professor, and inaugural holder of the Oscar S. Wyatt Endowed Chair in Mechanical Engineering at Texas A&M University, College Station, Texas. Dr. Reddy earned a Ph.D. in Engineering Mechanics in 1974 from University of Alabama in Huntsville and worked as a Post-Doctoral Fellow in Texas Institute for Computational Mechanics at the University of Texas at Austin, Research Scientist for Lockheed Missiles and Space Company, Huntsville, during 1974-75, and taught at the University of Oklahoma from 1975 to 1980, Virginia Tech from 1980 to 1992, and Texas A&M University from 1992 till now.

Dr. Reddy's research is concerned with the development of higher-order theories of plates and shells and extensions and applications of the finite element method to a broad range encompassing composite structures, numerical heat transfer, computational fluid dynamics, and more recently to biology and medicine. His shear deformation plate and shell theories and their finite element models and penalty finite element models of fluid flows have been implemented into commercial finite element computer programs like ABAQUS, NISA, and HyperForm. He has delivered over 130 plenary, keynote, or general invited lectures at international conferences and institutions; taught over 90 short courses on finite elements, composite materials, and nonlocal structural theories. Professor Reddy advised 32 postdoctoral fellows and research visitors and over 105 graduate theses. Dr. Reddy is one of the original top 100 ISI Highly Cited Researchers in Engineering around world with over 17,000 citations with h-index (h-index is the largest number h such that h publications have at least h citations) of over 62 as per Web of Science; as per Google Scholar the number of citations is nearly 40,000 with h-index of 82 and i10-index of 366. This year the US National Academy of Engineering (NAE) has named Dr. Reddy among its 2015 class of new members. He was recognized for his contributions to composite structures and engineering education and practice.