Mechanical Engineering and Mechanics

MEM 427 Introduction to Finite Element Methods

Fall 2006

Designation: Elective

Catalog Description: Introduction of the fundamental theory and formulations of finite element method and its application in areas of structural mechanics and thermal/fluid science. Topics include formulation of 1-D and 2-D elements, isoparametric elements, static and dynamic analysis of trusses, beams, and frames, 2-D plane problems, and heat transfer problems.

Prerequisites: MEM230 Mechanics of Materials I

Textbook(s) and other required material:
Required: Finite Element Analysis Theory and Applications with ANSYS, Second Edition, Saeed Moaveni, Prentice Hall, 2003

Course Objectives:
1. Formulate stiffness matrices for truss elements and beam elements using direct method, the Ritz method, and weighted residual methods.
2. Assemble global stiffness matrix using equilibrium and compatibility conditions.
3. Analyze 2-D trusses, beams, and frames using Castigliano's Theorems.
4. Perform 1-D and 2-D numerical integrations by Gaussian quadratures.
5. Perform static finite element analyses of trusses, beams, frames, plates, 2-D plane stress/strain problems, and heat transfer problems using ANSYS finite element program.
6. Determine natural frequencies and natural modes of structures using ANSYS finite element program.

Topics:
1. Matrix Methods of Structural Analysis – Direct Formulation of Truss Element
2. Review of Mechanics of Materials, with Emphasis on Energy Principles
3. Formulation of Truss Element Based on Energy Principles
4. One-dimensional Structural Elements (Axially Loaded Members, Beams, and Frames)
5. Formulation of 2-D Elements for Plane Problems
6. Isoparametric Elements and Numerical Integration
7. Convergences of Solutions, h-Method versus p-Method
8. Transient and Dynamic Analysis
9. Heat Transfer and Fluid Mechanics
10. Advanced Topics

Class Schedule: 2 hours/week lecture (2 credits); 2 hours of laboratory/week (1credit)

Contribution to Professional Component:
This course introduces to the Mechanical Engineering students the modern numerical analysis theories and techniques that are essential for them to be successful professionally in the 21st century. The principles and methodologies taught in this course are also very helpful for students in their capstone design projects.

Relationship to Program Outcomes:

Outcomes a - k	Conten	Explanation	Evidence
a. An ability to apply knowledge of mathematics, science and engineering	**2**	This course requires the students to develop an in-depth understanding of structural mechanics. The students learn how to apply and synthesize their knowledge of mathematics, science, and engineering.	Homework, Exams, Design Project
b. An ability to design and conduct experiments as well as to analyze and interpret data	**0**	NA	NA
c. An ability to design a system, component or process to meet desired needs	**2**	The assigned design problems are always required to meet societal or industrial needs.	Final report for the design project
d. An ability to function on multidisciplinary teams	**0**	NA	NA
e. An ability to identify, formulate and solve engineering problems	**2**	The problems and project require students to identify, formulate and solve engineering problems.	Homework, exams, design project
f. An understanding of professional and ethical responsibility	**1**	This is emphasized as part of the engineer's overall responsibility.	Classroom discussion; Final report for the design project
g. An ability to communicate effectively	**2**	Written presentation of the final design problem is required.	Final report for the design project
h. The broad education necessary to understand the impact of engineering solutions in a global/societal context	**1**	The impact of engineering design on the environment and society are discussed.	Classroom discussion; Final report for the design project
i. A recognition of the need for and an ability to engage in lifelong learning	**0**	NA	NA
j. A knowledge of contemporary issues	**0**	NA	NA
k. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice	**2**	Computer packages are used to explore the solution domain for homework and the design project	Homework; Final report for the design project

Prepared by: Dr. Tein-Min Tan, November 15, 2006