Department of Mechanical Engineering

ME 425 - Finite Element Method in Mechanical Engineering

Elective

Catalog Description: ME 425 (3-0-3)

Introduction to central ideas underlying the finite element method in mechanical engineering and its computer implementation. Fundamental concepts such as interpolation functions for one- and two –dimensional elements, bar element method, Galerkin's method, disretization of a model, methods of assembling global matrices, and the final solution techniques for obtaining nodal values. Specific applications to mechanical engineering problems in trusses, beams, torsion, heat transfer, fluid flow, plane stress, and plane strain.

Prerequisites: CIS 101 – Computer Programming and Problem Solving
Math 222 – Differential Equations
MECH 237 Strength of Materials

Textbook(s) Materials Required:
FINITE ELEMENT ANALYSIS– Theory and Application with ANSYS
By SAEED MOAVENI, 2nd Ed. Prentice Hall, 2003
Reference(s) (Not Required):
ANSYS Manual
FEM Notebook (Class hand out)
Course Supervisor: Dr. R. Chen

Pre-requisite by topic:
1. Computer Programming – basic knowledge in one language
2. Calculus – Integration by parts
3. Ordinary differential equations – 2nd order ordinary differential equation
4. Strength of Materials – deformation, strain and stress
5. First Law and energy balance – conduction and convection heat transfer

Course Objectives[1]:
1. To provide the student with some knowledge and analysis skills in applying basic laws in mechanics and integration by parts to develop element equation for a spring element and steps used in solving the problem by finite element method. (A, B, C)
2. To develop the student's skills in applying the basic matrix operation to form a global matrix equation and enforce the concept of steps in obtaining solutions for a truss structures (A,B,C)
3. To develop the student's skills in applying the Hermite interpolation functions to solve beam problems. (A,B,C)
4. To provide the student with some knowledge and analysis skills in forming basic data required in a FEM computer program. (A,B,C)
5. To develop the student's skills in applying the Gaussian quadrature in computing integration in FEM. (A, B, C)
6. To provide the student with some knowledge in isoparametric transformation. (A,B,C)

7. To develop the student's skills in applying FEM solution steps by using ANSYS intelligently. (A,B,C,D,E,F)

Topics[2]:

1. Introduction, spring and bar elements, element and global matrix equations, solution (3 hrs)
2. Interpolation functions, potential energy, residual integral. (3 hrs)
3. Matrix algebra (1 hr)
4. Truss element formulation, element stiffness, assembled and condensed matrices (3 hrs)
5. ANSYS – truss structure (1 hr)
6. Heat transfer in a fin, axial deformation of a bar using 3-node element. (3 hrs)
7. Beam and Frame elements, Hermite interpolation functions (3 hrs)
8. ANSYS – frame strucrure (1 hr)
9. Gaussian quadrature (2 hrs)
10. 2-D elements, triangular and rectangular elements, isoparametric transformation. (3 hrs)
11. ANSYS – 2-D heat transfer (2 hr)
12. Potential flow and torsion of a solid bar. (2 hrs)
13. Plane elastic problems (6 hrs)
14. 1-D time dependent problems (2 hrs)
15. ANSYS – plane stress analysis (2 hrs)

Evaluation Method:

1. Quizzes
2. Exam
3. Homework
4. Projects

Schedule: Lecture Recitation: 3 hours

Professional Component: Engineering Science and Design

Program Objectives Addressed: A, B, C, D, E, F

Course Outcomes[3] :

Objective 1

Students will demonstrate an ability to derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts. (1,2,3) (a,d,e,k,l,n)

Objective 2

Students will demonstrate an ability to apply the steps required for FEM solution to variety of physical systems and obtain engineering design quantities. (1,2,3) (a,c,d,e,,k,o)

Objective 3

Students will use ANSYS to do projects. (4) (a,c,e,g,i,k,o)

Objective 4

4.1. Students will demonstrate an ability to determine engineering design quantities (deformation, force, strain, stress) for truss, beam and frame structures. (1,2,3) (a,c,e,h,k,o)

4.2. Students will demonstrate an ability to determine engineering design quantities (deformation, force, strain, stress, stress concentration factor) for plane stress problems. (1,3,4) (a,c,e,h,k,o)
4.3. Students will demonstrate an ability to determine engineering design quantities (temperature distribution, heat flux) for heat transfer problems. (1,2,3) (a,c,e,h,k,o)

Prepared by: R. Chen **Date: September 25, 2006**

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[1] Capital Letters in parenthesis refer to the Program Objectives of the Mechanical Engineering
Department. Listed in Sec 2 d Tables B-2-9, B-2-12. Table B-2-8 links Program Objectives with the ABET a-k Criterion.
[2] Topic numbers in parenthesis refer to lecture hours. (three hours is equivalent to 1 week)
[3] Outcome numbers in parenthesis refer to evaluation methods used to assess the student performance. Lower case letters in parenthesis refer to ABET a-k outcomes.