BAKER COLLEGE
STUDENT LEARNING OUTCOMES

ME4730 INTERMEDIATE FEA

3 Semester Hours

Program Outcomes

1. Explore the potential energy approach and residual methods to derive the stiffness matrix for spring, beam, truss elements
    a. Apply theorem of minimum potential energy
    b. Describe Galerkin's method
    c. Examine other residual methods - collocation, least squares, and the subdomain
2. Analyze structures using axisymmetric elements
    a. Review the basic concepts and theory of elasticity equations for axisymmetric behavior.
    b. Derive the axisymmetric element stiffness matrix, body force, and surface traction equations.
    c. Demonstrate the solution of an axisymmetric pressure vessel using the stiffness method.
    d. Compare the finite element solution to an exact solution for a cylindrical pressure vessel.
    e. Illustrate some practical applications of axisymmetric elements
3. Formulate isoparametric formulation
    a. Derive the isoparametric formulation of stiffness matrix for bar and plane four-noded quadrilateral (Q4) elements
    b. Describe two methods for numerical integration—Newton-Cotes and Gaussian Quadrature—used for numerical evaluation of definite integrals and to demonstrate their application to specific examples
    c. Construct a flowchart describing how to evaluate the stiffness matrix for the plane quadrilateral element by a four-point Gaussian quadrature rule
    d. Solve an explicit example showing the evaluation of the stiffness matrix for the plane quadrilateral element by the four-point Gaussian quadrature rule
    e. Illustrate by example how to evaluate the stresses at a given point in a plane quadrilateral element using Gaussian quadrature
    f. Evaluate the stiffness matrix of the three-noded bar using Gaussian quadrature and compare the result to that found by explicit evaluation of the stiffness matrix for the bar.
4. Apply three-dimensional stress analysis
    a. Examine concepts of three-dimensional stress and strain
    b. Derive the tetrahedral solid-element stiffness matrix
    c. Describe how body and surface tractions are treated
    d. Illustrate a numerical example of the tetrahedral element stiffness matrix

    e. Examine some commercial computer program examples of three-dimensional solid models and results for real-world applications
    f. Compare four-noded tetrahedral, the ten-noded tetrahedral, the eight-noded brick, and the twenty-noded brick elements
5. Explore structural dynamics, time-dependent heat transfer
    a. Discuss the dynamics of a single-degree-of-freedom spring-mass system
    b. Derive the finite element equations for the time-dependent stress analysis of the one-dimensional bar, including derivation of the lumped-and consistent-mass matrices
    c. Introduce procedures for numerical integration in time, including the central difference method, Newmark's method, and Wilson's method
    d. Describe how determine the natural frequencies of bars by the finite element method
    e. Illustrate the finite element solution of a time-dependent bar problem
    f. Develop the beam element lumped-and consistent-mass matrices
    g. Illustrate the determination of natural frequencies for beams by the finite element method
    h. Develop the mass matrices for truss and plane frame elements
    i. Derive the time-dependent heat transfer equations, including the consistent-and lumped-mass matrices in one dimension
6. Evaluate 2D structural and thermal problems using the commercial FEA software, ANSYS
    a. Construct finite element models using ANSYS
    b. Solve problems and postprocess results
    c. Compare FEA results with available theoretical and experimental results

---

These SLOs are not approved for experiential credit.
Effective: Summer 2020