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GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII (NEW) - EXAMINATION – SUMMER 2018

Subject Code: 2181911 **Date: 30/04/2018**

Subject Name: Finite Elements Method(Department Elective II)

Time: 10:30 AM to 01:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Can the FEM handle a wide range of problems, i.e., solve general PDEs? Enlist two advantages of FEM. **03**

(b) List four applications of FEM and computer programs used for the FEM. **04**

(c) List and briefly describe the process of the Finite Element Method. **07**

Q.2 **(a)** What are the characteristics of shape function? Why polynomials are generally used as shape function? **03**

(b) Draw three 2D and 3D types of finite element. **04**

(c) Derive the Stiffness Matrix for a Spring Element. **07**

OR

(c) (a) Formulate the global stiffness matrix and equations for solution of the unknown global displacement and forces. The spring constants for the elements are k_1; k_2, and k_3; P is an applied force at node 2. **07**

(b) Using the direct stiffness method, formulate the same global stiffness matrix and equation as in part (a).

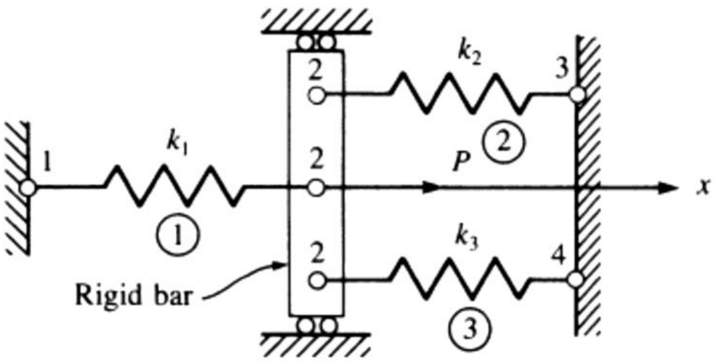

Figure 1

Q.3 **(a)** Distinguish between essential boundary conditions and natural boundary conditions. Give their examples. **03**

(b) Discuss the penalty approach for FEM. **04**

(c) A tapered bar 1200 mm long, having cross-sectional area 450 mm^2 at one end and 150 mm^2 at other end is fixed at the larger end. It is subjected to an axial load of 35 kN. Calculate the stress on a model bar having three finite elements 400 mm long. Assume modulus of elasticity, E = 2 x 105 N/mm^2 circular cross section at both end. **07**

OR

Q.3 **(a)** For the loading system as shown in Figure 2, determine the element stiffness matrix and globle stiffness matrix. Assume modulus of elasticity as 80×10^3 N/mm^2 **03**

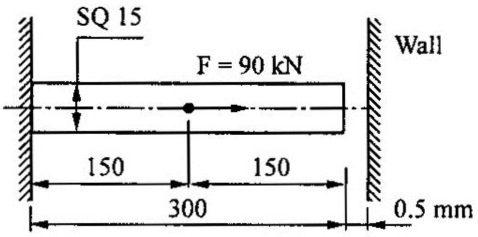

Figure 2

(b) For above Q. 3 (a) determine the displacements, stresses and support reaction using penalty approach. **04**

(c) Axial load P = 300 KN is applied at 20° C to the rod as shown in Figure 3. The temperature is then raised to 60° C. The coefficient of thermal expansion for Aluminium is 23×10^{-6} per °C and Steel is 11.7×10^{-6} per °C. A_{Al} = 900 mm^2, A_{Steel} = 1200 mm^2, $E_{Al} = 70 \times 10^9$ N/m^2, $E_{Steel} = 200 \times 10^9$ N/m^2. Using FEM, Determine the nodal displacement and element stresses and the reaction forces at the supports. **07**

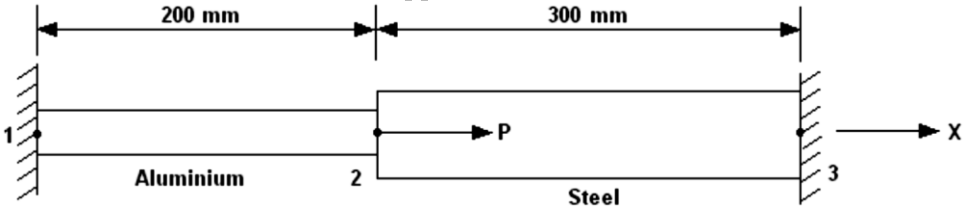

Figure 3

Q.4 **(a)** Write the shape function and stiffness matrix for one-dimensional finite element formulation of the fluid-flow problem. **03**

(b) Derive the element stiffness matrix of truss element and write the stress calculation formula for truss. **04**

(c) A three bar truss is shown in Figure 4. The modulus of elasticity of the material is 300×10^3 N/mm^2. The area of the bar used for the truss is 60 mm^2 for all the elements. The length L_1 = 750 mm and L_2 = 100 mm. The load P = 20 kN and P_2 = 25 kN. Determine the element stiffness matrix for each element and the global stiffness matrix. **07**

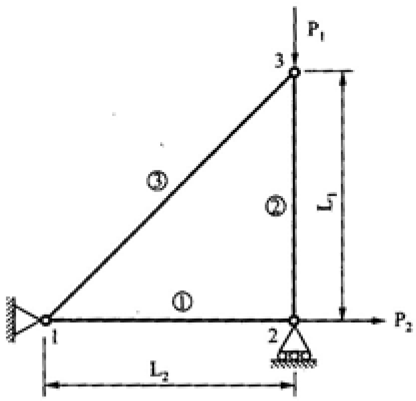

Figure 4

OR

Q.4 **(a)** List out the application of axisymmetric elements. **03**

(b) Discuss the terms "plain stress" and "plain strain" problems. **04**

(c) Evaluate the stiffness matrix for the element shown in Figure 5. The coordinates are shown in units of inches. Assume plane stress conditions. Let E = 30 x 10^6 psi, ν = 0.25, and thickness t =1 in. Assume the element nodal displacements have been determined to be u_1= 0, v_1 = 0.0025 in., u_2 = 0.0012 in., v_2 = 0, u_3 = 0, and v_3 = 0.0025 in. Determine the element stresses. **07**

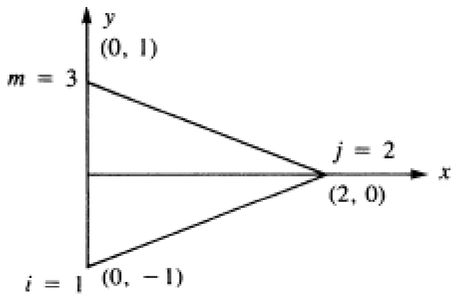

Figure 5 Plane stress element for stiffness matrix evaluation

Q.5 **(a)** Write the point force, body force and surface traction force using natural coordinate system. **03**

(b) Write the four shape function equations for a beam element. **04**

(c) Using the direct stiffness method, solve the problem of the propped cantilever beam subjected to end load P in Figure 6. The beam is assumed to have constant EI and length 2L. It is supported by a roller at mid length and is built in at the right end. Propped cantilever beam shown in below Figure 6 **07**

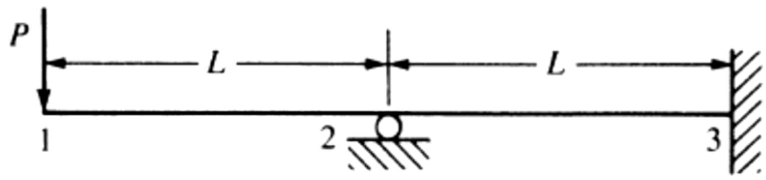

Figure 6

OR

Q.5 **(a)** Write the consistent and lumped mass matrices for 1D element. **03**

(b) List out applications of the axisymmetric elements. **04**

(c) For the smooth pipe shown discretized in Figure 7 with uniform cross section of 1 in^2, determine the flow velocities at the center and right end, knowing the velocity at the left end is v_x = 2 in./s. **07**

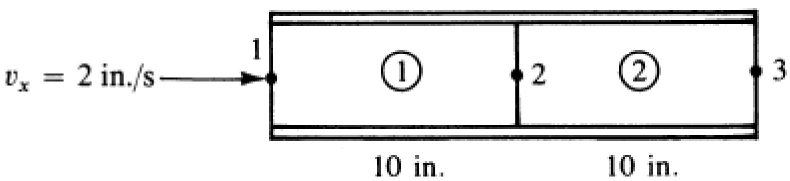

Figure 7 Discretized pipe for fluid-flow problem

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