Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

ME Semester –II Examination Dec. - 2011

Subject code: 1720801 **Date: 09/12/2011**
Subject Name: Finite Element Method
Time: 02.30 pm – 05.00 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)** Explain Rayleigh-Ritz and Galerkin method used in FEM. **05**

(b) Giving examples of plane stress and plane strain problems, write only the stress-strain relationships. For the plane strain case, determine σ_z, if $\sigma_x = 200MPa$ and $\sigma_y = -100MPa$ for a component made up of steel having E=2x10^5 MPa and $\nu = 0.3$. **09**

Q.2 **(a)** Make a finite element model for a uniform cross section fixed-free bar with a diameter of 30 mm and length 1 m made up of steel having a modulus of elasticity 210 GPa and density of 7850 kg/m^3. Estimate the first two natural frequencies of axial vibration of the bar using consistent and lumped mass matrices. Comment on the results obtained. **07**

(b) Consider heat transfer in a plane wall of total thickness 0.1 m. the left surface is maintained at temperature T_o=50^0 C and the right surface is exposed to ambient temperature T_∞=5^0 C with heat transfer coefficient of 25 W/ (m^2 ^{0}C). Taking thermal conductivity k=0.01 W/ (m ^{0}C), determine the temperature distribution in the wall and heat input at the left surface of the wall by using (a) two linear finite elements and (b) one quadratic element. **07**

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(b) A steel shaft (having a modulus of rigidity of 77 GPa) and an aluminum tube (having a modulus of rigidity of 27 GPa) are connected to a fixed support and to a rigid disc as shown in figure 1. Determine the shear stresses in the steel shaft and aluminum tube, if 6.325 kN-m torque is applied at the disc end. **07**

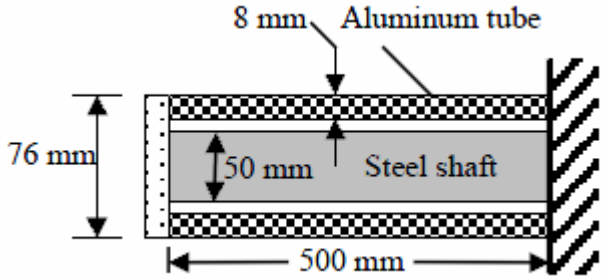

Figure 1 [Question No. 2 (b)]

Q.3 **(a)** What is the importance of isoparametric representation? Explain. **05**

(b) Model a composite bar which is subjected to 200 kN at the junction of aluminum and steel parts using finite elements. To handle boundary conditions, apply penalty approach. Find nodal displacements, stresses in each material and the reaction forces. The length of an aluminum is 0.3 m with a c/s area of is 2400 mm^2 and the length of steel is 0.4 m whereas the area is one fourth of aluminum. Take a modulus of elasticity for aluminum as $70x10^9$ N/m^2 and that of steel as $200x10^9$ N/m^2. **09**

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Q.3 **(a)** Describe Gauss quadrature for numerical integration. **05**

(b) For a truss shown in figure 2, find the deflections, reaction forces and stresses in each element if the cross section area 400 mm^2 is same for all and E= 200 GPa. Distances AB and BC are 800 mm each. **09**

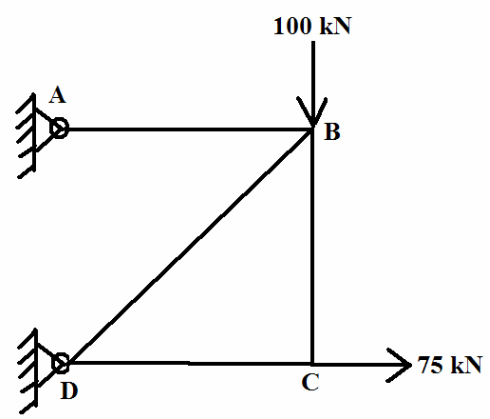

Figure 2. [Question No. 3(b) above]

Q.4 **(a)** Derive the element stiffness matrix for plane truss in global coordinate system. **05**

(b) In a problem of composite bar of Q.3 (b), if the load is applied at 30^0 C and then the temperature is raised to 90^0 C. What would be the nodal displacements and element stresses? Take $\alpha_{Al} = 23\times10^{-6}\ per^0C$ and $\alpha_{steel} = 11.7\times10^{-6}\ per^0C$. **09**

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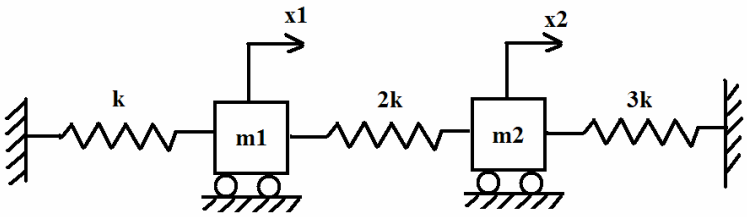
Q.4 **(a)** Using Lagrange's approach, obtain equations of motion for a three degree of freedom spring mass system. **07**

(b) Give the significance of interpolating functions in the FEM. **07**

Q.5 **(a)** Find the response of the system shown in figure 3 below, when the first mass alone is given an initial displacement of 2 units and released from rest. Get orthonormalised modeshapes, write modal equations and convert the initial conditions in real physical coordinates, x_1 and x_2, into those on modal coordinates p_1 and p_2. **07**



Take m_1 and m_2 both 1 kg each and k=1 kN/m.

(b) Explain HRZ lumping scheme for the dynamic analysis using FEM. **07**

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Q.5 **(a)** What is the basic difference between mode superposition method and direct integration based method to solve damped vibration equations. Explain central difference method. **07**

(b) Enlist the methods for solving eigen value problems. Explain any one in detail. **07**