Hall Ticket No Question Paper Code: AAE009

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Four Year B.Tech V Semester End Examinations (Regular) - November, 2018

Regulation: IARE – R16

FINITE ELEMENT METHODS

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. (a) Discuss the finite element methodology to solve the structural problems. **[7M]**

   (b) Consider a bar as shown in Figure 1. An axial load of 200 kN is applied at a point p. Take $A_1 = 2400\ mm^2$, $E_1 = 70 \text{ x } 10^9\ N/m^2$, $A_2 = 600\ mm^2$, $E_2 = 200 \text{ x } 10^9\ N/m^2$. Calculate the following: (i) Nodal displacement at point P (ii) Stresses in each material. **[7M]**

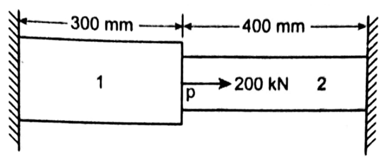

Figure 1

2. (a) Derive the stiffness matrix k' for Quadratic shape functions **[7M]**

   (b) A two-step bar subjected to loading condition as shown in Figure 2 is fixed at one end and the free end is at a distance of 3.5mm from the support. Determine stresses in the element. Take E=200X10^9 N/mm^2. **[7M]**

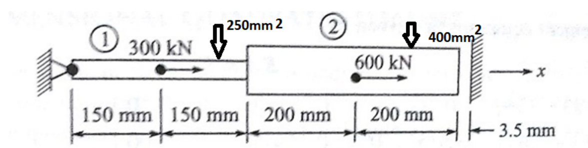

Figure 2

UNIT – II

3. (a) Derive the transformation Matrix 'L' for a plane truss element. **[7M]**

   (b) For the truss in Figure 3 . a horizontal load of P = 4000 lb is applied in the x direction at node 2.Write down the element stiffness matrix [k]. **[7M]**

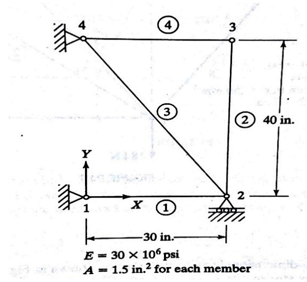

Figure 3

4. (a) Derive shape function and stiffness matrix for 2D truss element. **[7M]**

   (b) For the cantilever beam subjected to the uniform load w as shown in Figure 4, determine the vertical displacement and rotation at the free end. Assume the beam to have constant EI throughout its length. **[7M]**

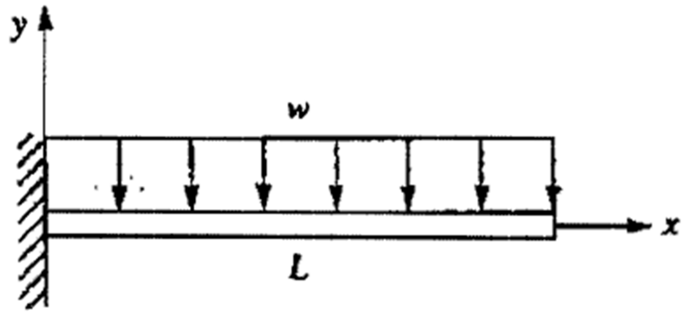

Figure 4

UNIT – III

5. (a) Derive the stiffness matrix for beam element using potential energy approach. **[7M]**

   (b) For a thin plate subjected to in-plane loading a shown in Figure 5 determine the Global Stiffness matrix. The plate thickness t=1cm, E = 20 X 10^6 N/cm^2 and moment of inertia I=2500cm^4. Consider it as a two elemental beam problem. **[7M]**

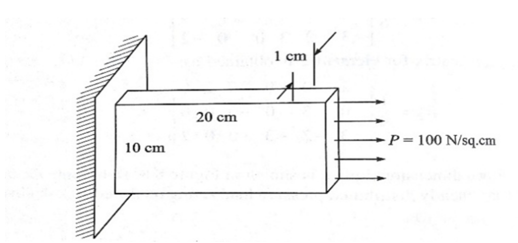

Figure 5

6. (a) For the triangular element shown in Figure 6. Obtain the strain-displacement relationship matrix [B] and determine the strains $\varepsilon_x, \varepsilon_y$ and γ_{xy}. **[7M]**

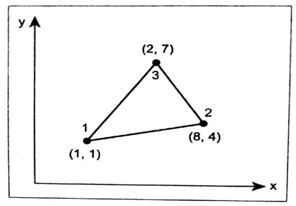

Figure 6

(b) The nodal coordinates for an axisymmetric triangular element are given Table 1. Evaluate [B] matrix for that element. **[7M]**

Table 1

$r_1 = 10$ mm	$z_1 = 10$ mm
$r_2 = 30$ mm	$z_2 = 10$ mm
$r_3 = 30$ mm	$z_3 = 40$ mm

UNIT – IV

7. (a) Derive the shape function and stiffness matrix for 1D heat conduction element. **[7M]**

(b) Compute element matrices and vectors for the element shown in Figure 7, when the edge kj experiences convection heat loss. **[7M]**

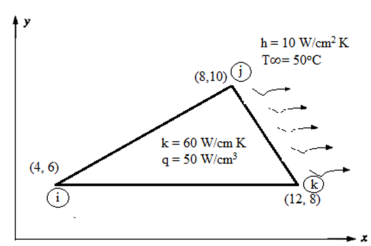

Figure 7

8. (a) Calculate the temperature distribution in a one dimension fin with physical properties given in Figure 8. The fin is rectangular in shape and is 120 mm long. 40 mm wide and 10 mm thick. Assume that convection heat loss occurs from the end of the fin. Use two elements. Take k = 0.3 W/mm^oC; h = 1 x 10^{-3}W/$mm^{2o}c$, $T\infty = 20^o$C. Assume unit area. **[7M]**

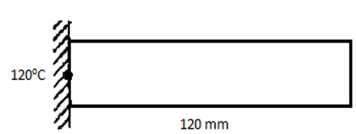

Figure 8

(b) Find the temperature distribution in a square region with uniform heat generation as shown in Figure 9. Assume that there is no temperature variation in the z-direction. Take k= 30W/cm^0c, h=10 watts/cm^{20}k, l = 10cm, $T\infty = 50^oC$, Q= 100 W/cm^3. Consider it a two elemental problem. **[7M]**

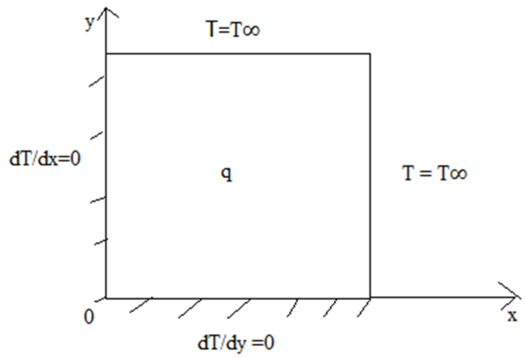

Figure 9

UNIT – V

9. (a) Consider a uniform cross-section bar as shown in Figure 10 of length L made up of material whose Young's modulus and density is given by E and ρ. Estimate the natural frequencies of axial vibration of the bar using lumped mass matrix. Consider the bar as one element. **[7M]**

   (b) For the one dimensional bar shown in Figure 10, determine natural frequencies of longitudinal vibration using two elements of equal length. Take E = 2 x 10^5 N/mm^2, ρ = 0.8 x 10^{-4} N/mm^3, and L= 400 mm. **[7M]**

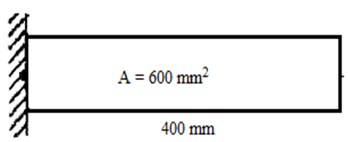

Figure 10

10. (a) Determine the natural frequencies of transverse vibration for a beam fixed at both ends. The beam may be modeled by two elements, each of length L, density ρ, modulus of elasticity E, cross sectional area A and moment of inertia I. Consider lumped mass approach. **[7M]**

    (b) Consider the simply supported beam shown in Figure 11. Let the length L = 1 m, E = 2 x 10^{11} N/m^2, area of cross section A = 30 cm^2, moment of inertia I = 100 mm^4, density ρ = 7800 kg/m^3. Determine the natural frequency using lumped mass matrix approach. **[7M]**

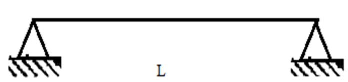

Figure 11

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INSTITUTE OF AERONAUTICAL ENGINEERING

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Four Year B.Tech V Semester End Examinations (Supplementary) - January, 2019

Regulation: IARE – R16

FINITE ELEMENT METHODS

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. (a) Name the different methods used for solving problems in FEM. Write the expressions for stress strain relationship for 2D elastic problems. **[7M]**
   (b) List and briefly describe the general procedures followed in FEA to solve the structural engineering problems. **[7M]**
2. (a) Define principle of virtual work. Describe the FEM formulation for 1D bar element. **[7M]**
   (b) A bar is subjected to an axial force is divided into a number of quadratic elements. For a particular element the nodes 1, 3, 2 are located at 15mm, 18mm and 21mm respectively from origin. If the axial displacements of the three nodes are given by u_1=0.00015mm, u_3=0.0033 and u_2=0.00024mm. **[7M]**
   Determine the following
   i) Shape function
   ii) Variation of the displacement u(x) in the element
   iii) Axial strain in the element

UNIT – II

3. (a) What is the stress equation for truss elements and write the transformation matrix of a truss. Write the expression for strain energy in a truss element. **[7M]**
   (b) Determine the stiffness matrix, nodal displacements and stresses in the truss structure shown in Figure 1 **[7M]**

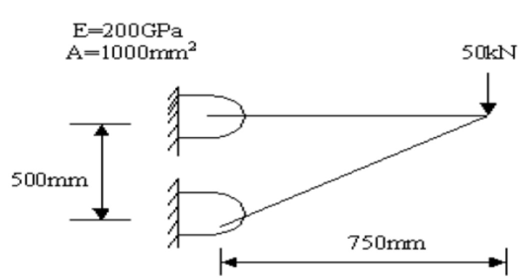

Figure 1

4. (a) Draw Hermite shape functions. Write the stiffness matrix for a beam. **[7M]**

   (b) Determine the displacement and rotation under the force and moment located at the center of the beam shown in Figure 2. The beam has been discretized into the two elements and the beam is fixed at each end. A downward force of 10 KN and an applied moment of 20 kN-m act at the center of the beam. Let E = 210GPa and I = 4 x 10^{-4} m^4 throughout the beam length. **[7M]**

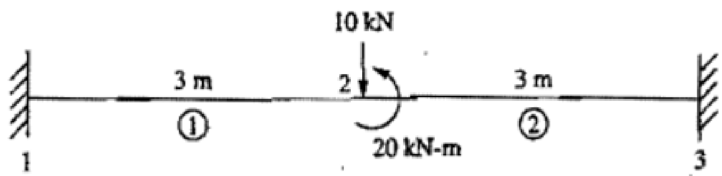

Figure 2

UNIT – III

5. (a) Explain plane stress and plane strain problem with assumptions. **[7M]**

   (b) Calculate the element stresses σ_x, σ_y, and τ_{xy}, for the element shown in Figure 3. The nodal displacements are u_1= 2 mm, u_2= 0.5 mm, u_3= 3 mm, v_1= 1 mm, v_2 = 0 mm v_3 =1 mm. Take E = 2.1x10^5 N/mm^2 and υ =0.25. Assume plain stress condition. **[7M]**

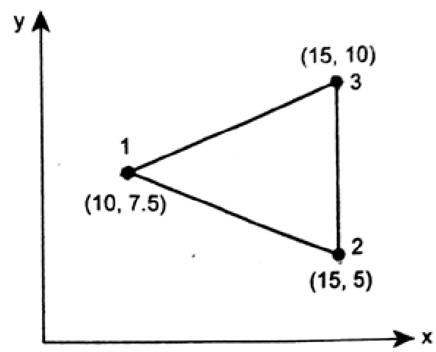

Figure 3

6. (a) Obtain the stiffness matrix of an axisymmetric element using potential energy approach. **[7M]**

   (b) The Cartesian global coordinates of the corner nodes of an isoparametric quadrilateral element are given by (1,0), (2,0), (2.5, 1.5) and (1.5,1). Find its Jacobian matrix. **[7M]**

UNIT – IV

7. (a) Specify the applications of heat transfer problems. Describe heat transfer analysis for composite wall. **[7M]**

   (b) Consider the shaft with a rectangular cross section shown in Figure 4. Determine in terms of M and G, the angle of Twist per unit length. **[7M]**

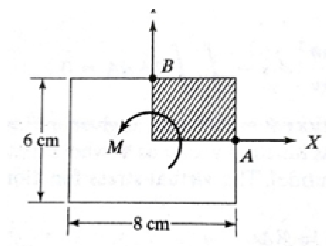

Figure 4

8. (a) What are different types of boundary conditions for 1D heat conduction problems? **[7M]**

   (b) For the two dimensional body as shown in Figure 5, determine the temperature distribution. The edges on the top and bottom of the body are insulated. Assume kx and ky. Use three element model. **[7M]**

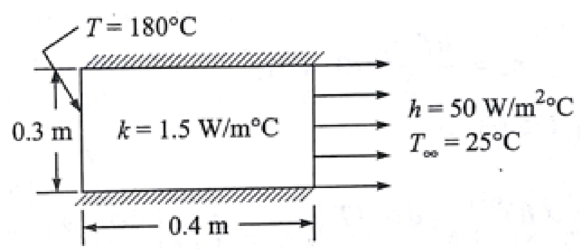

Figure 5

UNIT – V

9. (a) Derive element mass matrix for one dimensional bar element. **[7M]**
   (b) Evaluate the lowest eigen value and the corresponding eigenmode for the bar shown in Figure 6. **[7M]**

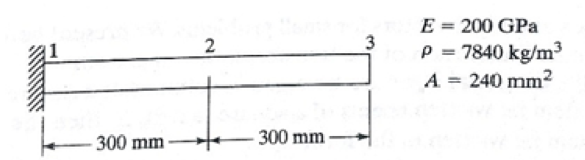

Figure 6

10. (a) State the advantages and disadvantages of ANSYS and compare it with NASTRAN **[7M]**
    (b) Evaluate eigen vectors and eigen values or the stepped bar shown in Figure 7. Take E = 200 Gpa and Specific weight 7850kg/m^3, $A_1 = 400\ mm^2$, $A_2 = 200\ mm^2$. **[7M]**

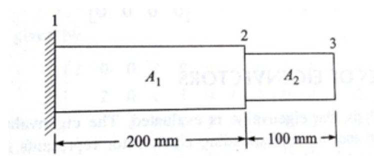

Figure 7

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INSTITUTE OF AERONAUTICAL ENGINEERING

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Four Year B.Tech V Semester End Examinations (Supplementary) - July, 2019

Regulation: IARE – R16

FINITE ELEMENT METHODS

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
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UNIT – I

1. (a) List out the properties of 'K' Matrix. Explain finite element methods. **[7M]**

   (b) Solve the given Figure 1 using a finite element solution with two noded elements. Show all work such as element matrices, assembly, boundary conditions, and solution. **[7M]**

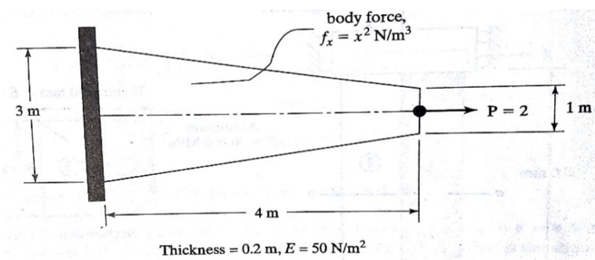


Figure 1

2. (a) What is the element stiffness matrix for a quadratic element? Derive shape function and stiffness matrix for 1D linear bar element. **[7M]**

   (b) A thin steel plate of uniform thickness 25mm is subjected to a point load of 420 N at mid depth as shown in Figure 2. Take E = 2x10^5 N/mm^2. Calculate the following: (i) Displacement at each nodal point (ii) Stresses in each element. **[7M]**

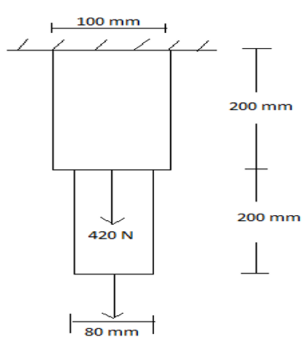


Figure 2

UNIT – II

3. (a) Represent the truss in local and global coordinate system. Write the stress equation and expression for strain energy for truss elements. **[7M]**

   (b) For the truss given in Figure 3, a horizontal load of P = 4000 lb is applied in the x-direction at node 2.

   i) Write down the element stiffness matrix k for each element.

   ii) Assemble the K matrix

   iii) Using elimination approach, Understand for Q **[7M]**

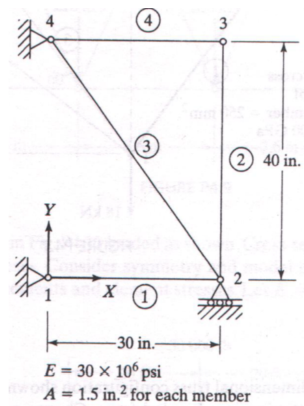


Figure 3

4. (a) Draw Hermite shape functions. For a beam element obtain the expression for shear force and bending moments. **[7M]**

   (b) A beam fixed at one end and supported by a roller at the other end, has a 20kN concentrated load applied at the center of the span as shown in Figure 4. Calculate the deflection under the load. **[7M]**

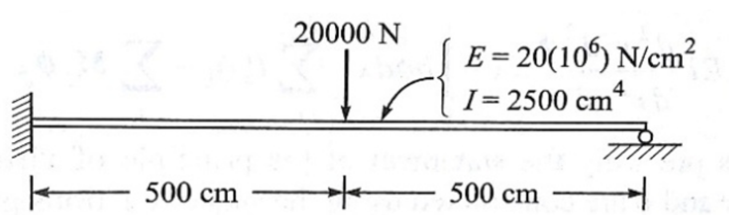


Figure 4

UNIT – III

5. (a) Define plane stress and plane strain. Formulate the shape function for a constant strain triangle (CST) element. **[7M]**

   (b) For element shown in Figure 5, determine the stiffness matrix. Assume axisymmetry condition. Take E = 200 GPa and $\nu = 0.25$. **[7M]**

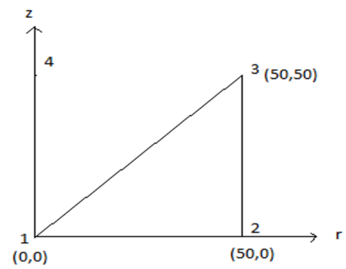


Figure 5

6. (a) Write short notes on: (i) Sub parametric (ii) Isoparametric and (iii) Super parametric element **[7M]**

   (b) The (x,y) co-ordinates of nodes i, j and k of an triangular element are given by (3.4), (6,5) and (5,8) cm respectively. The element displacement (in cm) vector is given as q= $[0.002, 0.001, 0.004, -0.003, 0.007]^T$. Determine the element strains **[7M]**

UNIT – IV

7. (a) Derive the stiffness matrix for composite wall and consider the boundary conditions such as specified temperature, insulation and convection. **[7M]**

   (b) A composite wall consists of three materials, as shown in Figure 6. The outer temperature is T_o= 20°C. Convection heat transfer takes place on the inner surface of the wall with $T_\alpha = 800^o$C and h = 25 W $/m^2.\ ^oC$. Determine the temperature distribution in the wall. **[7M]**

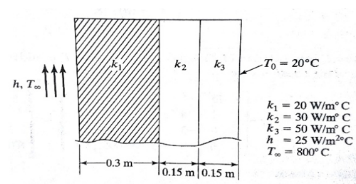


Figure 6

8. (a) What is the purpose of the Fin? Derive the governing equation for one dimensional thin fins. **[7M]**

   (b) A metallic fin, with thermal conductivity k = 360 W /m.°C, 0.1 cm thick, and 10 cm long, extends from a plane wall whose temperature is 235^0C Determine the temperature distribution and amount of heat transferred from the fin to the air at 20^0C with h = 9 $W/m^{2o}c$. Take the width of fin to be 1 m. **[7M]**

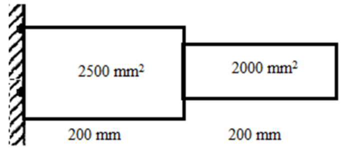
UNIT – V

9. (a) What is lumped mass matrix and consistent mass matrix. Obtain the expression for element mass matrix for truss element. **[7M]**

   (b) State the properties of Eigen Values. Determine the Eigen values and the associated Eigen vectors of the matrix [A] given by $\begin{pmatrix} 5 & 6 \\ 6 & -5 \end{pmatrix}$ **[7M]**

10. (a) Define the terms vibration and natural frequency. Explain lumped parameter model and continuous system model with examples. **[7M]**

(b) Determine the Eigen values and frequencies for the stepped bar as shown in Figure 7. **[7M]**



Take $E = 2 \times 10^5$ N/mm², $\rho = 0.8 \times 10^{-4}$ N/mm³

Figure 7

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