Code No: **RT41033** **R13** **Set No. 1**

IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018

FINITE ELEMENT METHODS

(Common to Aeronautical Engineering, Automobile Engineering and Mechanical Engineering)

Time: 3 hours **Max. Marks: 70**

Question paper consists of Part-A and Part-B
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A *(22 Marks)*

1 a) Write the stress strain relations for 2 D plane stress and plane strain conditions. [4]
b) What are the consistent nodal force vector for uniform load and varying load? [4]
c) Differentiate between truss and beam element based on degree of freedom. [3]
d) How axisymmetric element can be equalized to the CST element. [3]
e) How are triangular elements isoparametrically represented? [4]
f) Formulate the equation of one dimensional criteria of composite wall. [4]

PART–B *(3x16 = 48 Marks)*

2 a) For the spring system shown in the figure 2 (a) find the displacements at the nodes and the reactions. Given K_1=100 N/mm, K_2=200 N/mm, K_3= 100 N/mm, P=500 N.

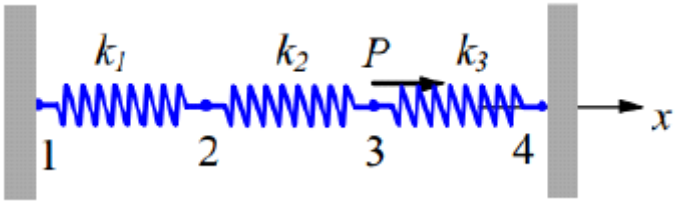

Figure 2 (a) [8]

b) Write the advantages, disadvantages and applications of FEM. [8]

3 a) Obtain the interpolation functions for a two noded axial element using local coordinate system, global coordinate system and natural coordinate system. [8]
b) Explain the importance of (i) Node numbering (ii) Mesh generation [8]

4 a) A three member truss is loaded as shown in Figure 4 (a), assume (AE/L) is same for all the members. Analyze the truss using finite element method and determine the Joint displacements.

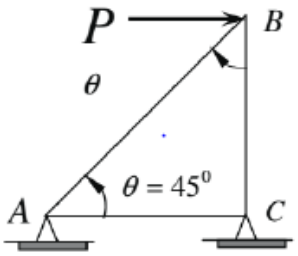

Figure 4 (a) [8]

b) Derive the shape functions for a beam element. [8]

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5 a) For the axisymmetric element shown in Figure 5 (a) determine the element stiffness matrix. Take E=200 GPa, and υ=0.3. [8]

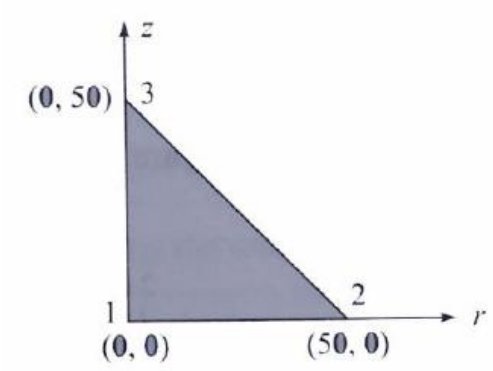

Figure 5 (a)

b) Discuss a few applications of axi-symmetric elements. [8]

6 a) Using the gauss quadrature method evaluate the following integral and compare the results with the exact solute $\int_{-1}^{+1}(6x + x2)$. [8]

b) Explain briefly about isoparametric elements. [8]

7 a) For the stepped bar shown in the figure 7 (a), develop the global stiffness and mass matrices and also determine the natural frequencies and mode shapes. Assume
E = 200 GPa and mass density = 7850 kg/m^3, $L_1 = L_2 = 0.3$ m, $A_1 = 350$ mm^2, $A_2 = 600$ mm^2. [8]

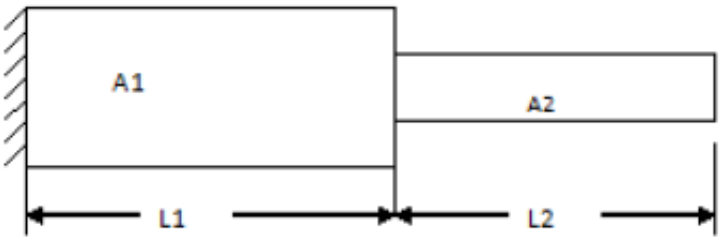

Figure 7 (a)

b) Derive angle of twist for a uniform shaft subjected to torsion. [8]

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Answer any THREE questions from Part-B
*****

PART–A *(22 Marks)*

1 a) Explain the principle of finite element method. [4]
b) Write the properties of global stiffness matrix. [4]
c) State the significance of shape functions. [3]
d) What is the size of the stiffness matrix for axisymmetric triangular element? [3]
e) Describe the strain displacement matrix for 3-noded triangular element. [4]
f) What is thermal conductivity matrix for 2D heat transfer problems? [4]

PART–B *(3x16 = 48 Marks)*

2 a) Explain the potential energy formulation for obtaining element equations in Finite element methods. [8]
b) The following stresses are developed in a plate under plane stress σ_{xx} = 120 Mpa, σ_{yy} = 14 Mpa and σ_{xy} = 5 Mpa. Determine the strain induced in the plate, assuming that E = 209 Gpa and ν = 0.3. [8]

3 a) Determine the nodal displacement for the stepped bar loaded as shown in Figure 3 (a), P_1=100 KN and P_2=75 KN. The details of each section of the bar is shown in table:

Portion	Material	E(GPa)	Area(mm^2)
A	Steel	200	1200
B	Aluminium	70	800

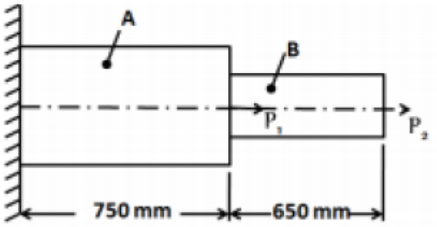
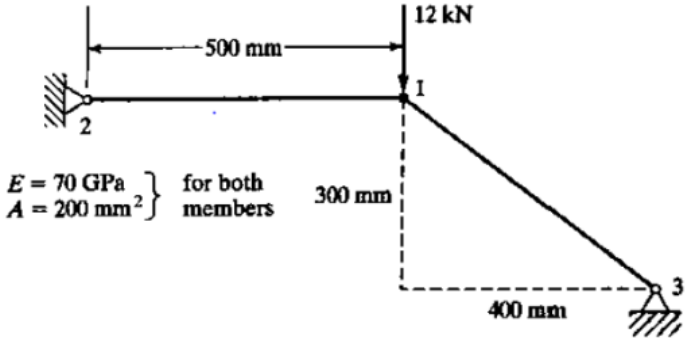


Figure 3 (a) [10]

b) Explain the requirements for the selection of interpolation function. [6]

4 a) For the two-bar truss shown in figure 4 (a), determine the displacements of node 1 and stress in element 1-3.



[10]

Figure 4 (a)

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b) What are essential and natural boundary conditions for a beam element? [6]

5 a) For point p located inside the triangle as shown in figure 5 (a), the shape functions N_1 and N_2 are 0.15 and 0.25 respectively. Determine the x-and y-coordinates of point P. [8]

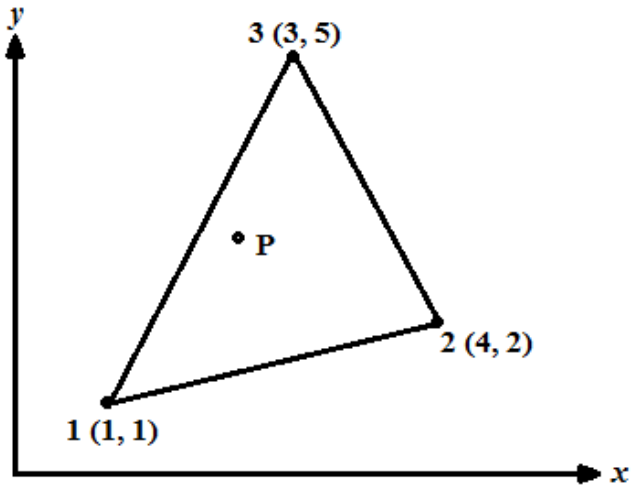

Figure 5 (a)

b) Differentiate between CST and LST with respect to the triangular element. [8]

6 a) Derive the stiffness matrix for the four noded quadrilateral element in terms of natural coordinate system. [10]

b) Write a note on two point integration rule for 1-D and 2-D problems. [6]

7 a) Consider a uniform cross section bar of length L made up of a material whose Young's modulus and density are given by E and ρ. Estimate the natural frequencies of axial vibration of the bar using both consistent and lumped mass matrices. [8]

b) Discuss Eigen value and Eigen vector analysis. [8]

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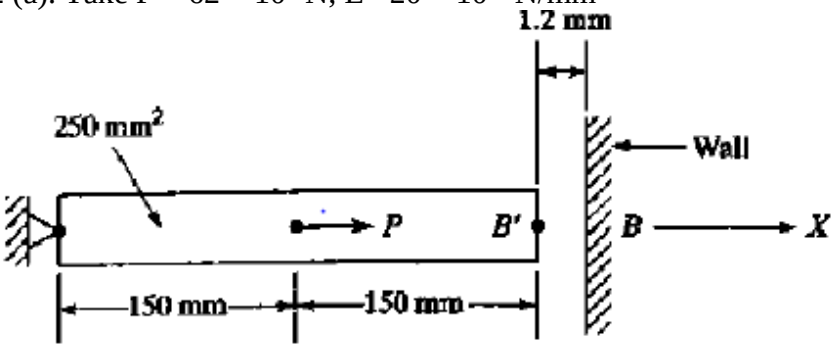
Answer ALL sub questions from Part-A
Answer any THREE questions from Part-B
*****

PART–A *(22 Marks)*

1 a) Explain the principle of minimum Potential energy. [4]
b) Differentiate between local and global coordinate systems. [4]
c) Represent the Hermite shape functions graphically. [3]
d) Specify the strain displacement matrix of CST element and comment on it. [3]
e) Differentiate among the Iso-parametric and Sub-parametric formulation. [4]
f) What is the difference between static and dynamic analysis with suitable examples? [4]

PART–B *(3x16 = 48 Marks)*

2 a) Determine the displacements stress and support reactions in the structure shown in the figure 2 (a). Take P = 62×10^3 N, E= 20×10^3 N/mm^2



[8]

Figure 2 (a)

b) Explain the various steps involved in solving a problem using finite element method. [8]

3 a) Explain assembly of stiffness matrix with example. [8]
b) Explain the following:
(i) Discretization of domain (ii) Boundary conditions. [8]

4 a) Calculate the deflection at the centre and slopes at the ends of a simply supported beam of 2 m length subjected to a Uniformly Distributed Load (UDL) of 50 kN/m throughout the length. Take EI = 700 Nmm^2. [8]
b) Derive the stiffness matrix of a truss element. [8]

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5 a) Evaluate the axisymmetric stiffness matrix ***K*** of the triangular element shown in the Figure 5 (a). Consider the coordinates of nodes as 1 (2, 1), 2 (4, 0), and 3 (3, 2). Also assume E = 2.6 GPa and ν = 0.2. [8]

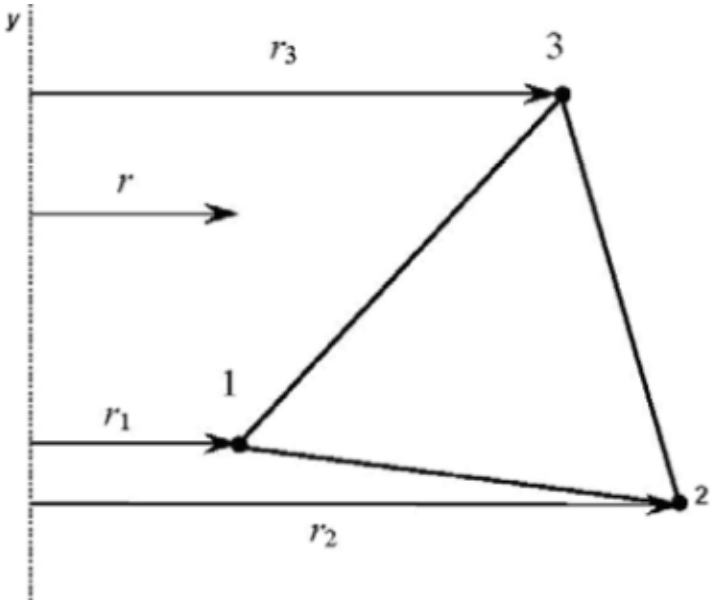

Figure 5 (a)

b) What are the properties of constant-strain triangular element? Explain. [8]

6 a) Derive the shape functions of one dimensional cubic element. [8]

b) Evaluate the following Gaussian guadrature $I = \int_1^3 \frac{dx}{x}$ by 3-point formula. [8]

7 a) Derive stiffness matrix for 1-D heat conduction problem. [8]

b) Explain the following (i) Consistent mass matrix (ii) Lumped mass matrix [8]

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Answer any THREE questions from Part-B

*****

PART – A

1 a) Write the D- Matrix for plane stress and plane strain conditions. [4]
b) Write the stiffness matrix for 2-noded beam element. [4]
c) What are the various functions considered under classical beam theory? [3]
d) What are the strain displacement relations for axisymmetric element? [3]
e) How do you define two dimensional elements? [4]
f) Differentiate between the transient dynamic analysis and Eigen value analysis. [4]

PART – B

2 a) Using the stress-equilibrium equations, derive the governing differential equation for a prismatic bar subjected to body load and traction force. [8]
b) Consider the rod as shown in figure 2 (b), where the strain at any point is given by $\in = 1+ 2x^2$. Find the tip displacement δ.

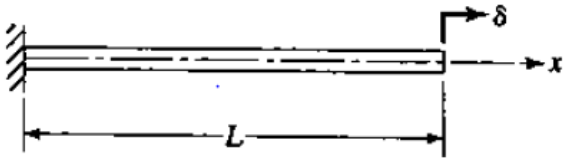

Figure 2 (b)

[8]

3 a) Determine the load nodal displacements for the bar shown in figure 3 (a) if axial load P = 200×10^3N is applied.

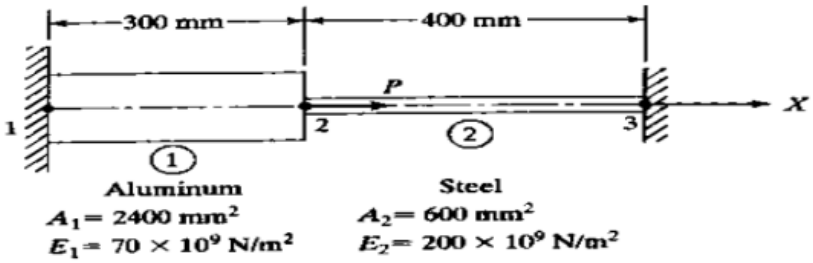

Figure 3 (a)

[8]

b) Discuss the effect of element shape and size on the convergence of the finite element solution. [8]

4 a) A concentrated load P = 60 KN is applied at the center of a fixed beam of length 3 m, depth 200 mm and width 120 mm. Calculate the deflection and slope at the midpoint. Also find reactions at the supports. Assume E = 2.1×10^5 N/mm^2 as shown in figure 4 (a)

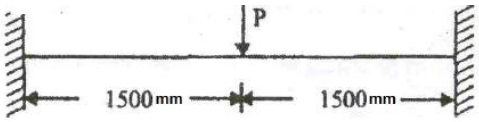

Figure 4 (a)

[8]

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b) Explain how temperature effects are taken into consideration for a truss element. [8]

5 Derive the expression for strain displacement matrix for a constant strain triangular element. Also derive the stiffness matrix. [16]

6 a) Derive the shape functions of two dimensional four noded iso-parametric element. Plot the shape functions. [8]

b) Use Gaussian quadrature with two points to evaluate the integral $\int_{-1}^{+1} \cos x / (1-2x^2)\, dx$. Compare the result with actual integral value. [8]

7 a) Determine the temperature distribution along a circular fin of length 5 cm and radius 1 cm. The fin is attached to boiler whose wall temperature 140^0C and the free end is open to the atmosphere. Assume $T\alpha = 40^0$C, h = 10 W/cm^2 / ^{0}C, k = 70 W/cm ^{0}C. [8]

b) Explain the concept of Free vibration analysis using FEM. [8]

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