IV B.Tech I Semester Regular/Supplementary Examinations, Oct/Nov - 2018 FINITE ELEMENT METHODS
(Common to Aeronautical Engineering, Automobile Engineering and Mechanical Engineering)

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

## PART-A (22 Marks)

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

## 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 $\mathrm{K}_{1}=100 \mathrm{~N} / \mathrm{mm}, \mathrm{K}_{2}=200 \mathrm{~N} / \mathrm{mm}, \mathrm{K}_{3}=100$ $\mathrm{N} / \mathrm{mm}, \mathrm{P}=500 \mathrm{~N}$.


Figure 2 (a)
b) Write the advantages, disadvantages and applications of FEM.

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

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)
b) Derive the shape functions for a beam element.

5 a) For the axisymmetric element shown in Figure 5 (a) determine the element stiffness matrix. Take $\mathrm{E}=200 \mathrm{GPa}$, and $\mathrm{v}=0.3$.


Figure 5 (a)
b) Discuss a few applications of axi-symmetric elements.

6 a) Using the gauss quadrature method evaluate the following integral and compare the results with the exact solute $\int_{-1}^{+1}(6 x+x 2)$.
b) Explain briefly about isoparametric elements.

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
$\mathrm{E}=200 \mathrm{GPa}$ and mass density $=7850 \mathrm{~kg} / \mathrm{m}^{3}, \mathrm{~L}_{1}=\mathrm{L}_{2}=0.3 \mathrm{~m}, \mathrm{~A}_{1}=350 \mathrm{~mm}^{2}$, $\mathrm{A}_{2}=600 \mathrm{~mm}^{2}$.


Figure 7 (a)
b) Derive angle of twist for a uniform shaft subjected to torsion.

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PART-A (22 Marks)
1 a) Explain the principle of finite element method.
b) Write the properties of global stiffness matrix.
c) State the significance of shape functions.
d) What is the size of the stiffness matrix for axisymmetric triangular element?
e) Describe the strain displacement matrix for 3-noded triangular element.
f) What is thermal conductivity matrix for 2D heat transfer problems?

PART-B (3x16 = 48 Marks)
2 a) Explain the potential energy formulation for obtaining element equations in Finite element methods.
b) The following stresses are developed in a plate under plane stress $\sigma_{x x}=120 \mathrm{Mpa}$, $\sigma_{\mathrm{yy}}=14 \mathrm{Mpa}$ and $\sigma_{\mathrm{xy}}=5 \mathrm{Mpa}$. Determine the strain induced in the plate, assuming that $\mathrm{E}=209 \mathrm{Gpa}$ and $v=0.3$.

3 a) Determine the nodal displacement for the stepped bar loaded as shown in Figure 3 (a), $\mathrm{P}_{1}=100 \mathrm{KN}$ and $\mathrm{P}_{2}=75 \mathrm{KN}$. The details of each section of the bar is shown in table:

| Portion | Material | E(GPa) | Area $\left(\mathrm{mm}^{2}\right)$ |
| :---: | :---: | :---: | :---: |
| A | Steel | 200 | 1200 |
| B | Aluminium | 70 | 800 |



Figure 3 (a)
b) Explain the requirements for the selection of interpolation function.

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


Figure 4 (a)
1 of 2

## Set No. 2

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

5 a) For point p located inside the triangle as shown in figure 5 (a), the shape functions $\mathrm{N}_{1}$ and $\mathrm{N}_{2}$ are 0.15 and 0.25 respectively. Determine the x -and y coordinates of point P .


Figure 5 (a)
b) Differentiate between CST and LST with respect to the triangular element.

6 a) Derive the stiffness matrix for the four noded quadrilateral element in terms of natural coordinate system.
b) Write a note on two point integration rule for 1-D and 2-D problems.

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 $\rho$. Estimate the natural frequencies of axial vibration of the bar using both consistent and lumped mass matrices.
b) Discuss Eigen value and Eigen vector analysis.

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## PART-A (22 Marks)

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

## PART-B (3x16 = 48 Marks)

2 a) Determine the displacements stress and support reactions in the structure shown in the figure 2 (a). Take $\mathrm{P}=62 \times 10^{3} \mathrm{~N}, \mathrm{E}=20 \times 10^{3} \mathrm{~N} / \mathrm{mm}^{2}$


Figure 2 (a)
b) Explain the various steps involved in solving a problem using finite element method.

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

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 $50 \mathrm{kN} / \mathrm{m}$ throughout the length. Take EI $=700 \mathrm{Nmm}^{2}$.
b) Derive the stiffness matrix of a truss element.

5 a) Evaluate the axisymmetric stiffness matrix $\boldsymbol{K}$ 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 $E=2.6 \mathrm{GPa}$ and $v=0.2$.


Figure 5 (a)
b) What are the properties of constant-strain triangular element? Explain.

6 a) Derive the shape functions of one dimensional cubic element.
b) Evaluate the following Gaussian guadrature $\mathrm{I}=\int_{1}^{3} \frac{d x}{x}$ by 3-point formula.

7 a) Derive stiffness matrix for 1-D heat conduction problem.
b) Explain the following (i) Consistent mass matrix (ii) Lumped mass matrix

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Time: 3 hours
Max. Marks: 70

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

## 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.
b) Consider the rod as shown in figure $2(b)$, where the strain at any point is given by $E=1+2 x^{2}$. Find the tip displacement $\delta$.


Figure 2 (b)
3 a) Determine the load nodal displacements for the bar shown in figure 3 (a) if axial $\operatorname{load} \mathrm{P}=200 \times 10^{3} \mathrm{~N}$ is applied.


Figure 3 (a)
b) Discuss the effect of element shape and size on the convergence of the finite element solution.

4 a) A concentrated load $\mathrm{P}=60 \mathrm{KN}$ 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 $E=2.1 \times 10^{5} \mathrm{~N} / \mathrm{mm}^{2}$ as shown in figure 4 (a)


Figure 4 (a)
b) Explain how temperature effects are taken into consideration for a truss element.

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

6 a) Derive the shape functions of two dimensional four noded iso-parametric element. Plot the shape functions.
b) Use Gaussian quadrature with two points to evaluate the integral $\int_{-1}^{+1} \cos x /\left(1-2 x^{2}\right) d x$. Compare the result with actual integral value.

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 $140^{\circ} \mathrm{C}$ and the free end is open to the atmosphere. Assume $\mathrm{T} \alpha=40^{\circ} \mathrm{C}, \mathrm{h}=10 \mathrm{~W} / \mathrm{cm}^{2} /{ }^{\circ} \mathrm{C}, \mathrm{k}=70$ $\mathrm{W} / \mathrm{cm}{ }^{0} \mathrm{C}$.
b) Explain the concept of Free vibration analysis using FEM.

