Reg.No. | | | | | | | | | | |

CONTROLLER OF EXAMINATIONS ADDITIONAL AU CHENNAI 600 025

**ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)**
**B.E. END SEMESTER EXAMINATIONS, April / May 2024**

DEPARTMENT OF MECHANICAL ENGINEERING
VII
**ME 5751 FINITE ELEMENT ANALYSIS**
(Regulation2019)

Time: 3 hrs Max.Marks: 100

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|---|---|
| CO1 | Developing mathematical models for Boundary Value Problems and their numerical solution. |
| CO2 | Applying concepts of Finite Element Analysis to solve one dimensional problem. |
| CO3 | Determining field variables for two dimensional scalar variable problems. |
| CO4 | Determining field variables for two dimensional vector variable problems |
| CO5 | Applying the need for Isoparametric transformation and the use of numerical integration. |

**BL – Bloom's Taxonomy Levels**
(L1-Remembering, L2-Understanding, L3-Applying, L4-Analysing, L5-Evaluating, L6-Creating)

## PART- A(10x2=20Marks)
(Answer all Questions)

| Q.No | Questions | Marks | CO | BL |
|---|---|---|---|---|
| 1 | Give the governing equation for 1D solid mechanics problem | 2 | 1 | L1 |
| 2 | State the advantages of weak form | 2 | 1 | L1 |
| 3 | Write and plot the shape functions for 1D quadratic element | 2 | 2 | L1 |
| 4 | List the properties of stiffness matrix | 2 | 2 | L1 |
| 5 | Why a CST element so called ? | 2 | 3 | L2 |
| 6 | Write the governing equation for the torsion of non-circular sections and give the associated boundary conditions | 2 | 3 | L1 |
| 7 | Give the strain displacement matrix for CST element | 2 | 4 | L1 |
| 8 | Write the constitutive matrix for plane stress problem | 2 | 4 | L1 |
| 9 | What is meant by iso parametric element | 2 | 5 | L2 |
| 10 | Write down the expression for the jacobian for a 1 D linear element. | 2 | 5 | L1 |

## PART- B(5x 13= 65 Marks)

| Q.No | Questions | Marks | CO | BL |
|---|---|---|---|---|
| 11 (a) | Using Ritz technique , determine the temperature distribution in the fin shown in Fig.11(a). $T\alpha = 20°C$, $h = 0.2$ W/ $cm^2$ °C, $k = 4$W /cm °C . Assume the free end is open to the atmosphere. | 13 | 1 | L4 |

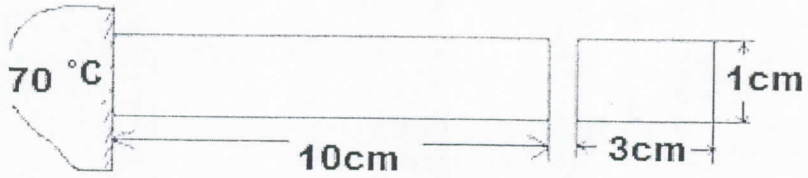



Fig.11(a)

OR

| | | | | |
|---|---|---|---|---|
| 11 (b) | Using collocation method, find the displacement of given governing equation<br>$\frac{d}{dx}\left[x\frac{du}{dx}\right]-2x^2=0$ , $1 < x < 5$<br>at $x = 1, u = 3$, at $x = 5$, $x\frac{du}{dx} = -\frac{1}{6}$ | 13 | 1 | L4 |
| 12 (a) | Determine the first two natural frequencies of longitudinal vibration of the stepped steel bar shown in Fig.12 (a) and plot the mode shapes. Take E = 200GPa and density 7800kg/m$^3$. Cross sectional area of section A and B is 300 mm$^2$ and 150 mm$^2$ respectively. | 13 | 2 | L4 |

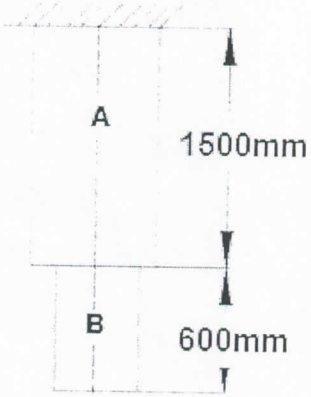
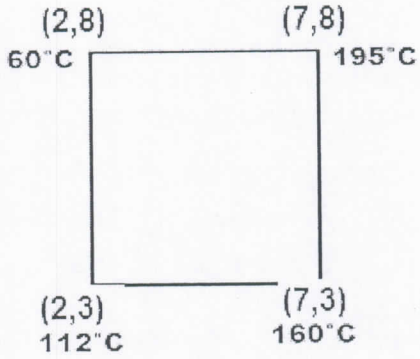
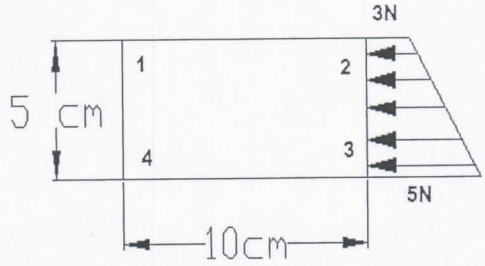



Fig.12(a)



OR

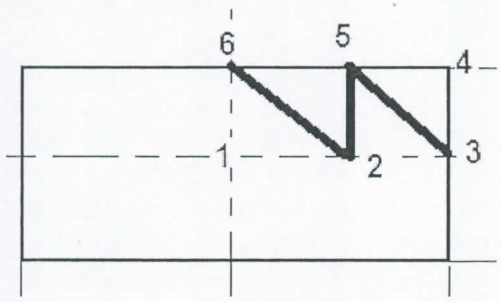
| | | | | |
|---|---|---|---|---|
| 12 (b) | A shaft of length 2000 mm and diameter 8 mm carries a pulley weighing 100 N at the center. If the shaft is mounted on both ends in ball bearings, determine the first two natural frequencies. E = 200 GPa and density 7800 kg/ m$^3$. | 13 | 2 | L4 |

| | | | | |
|---|---|---|---|---|
| 13 (a) | Determine the temperature at the location (5,6) in a square plate with the data shown in Fig.13 (a). Also draw the 125°C isotherm using at least three points.<br>  <br><br>Fig.13(a) | **13** | 3 | L4 |
| | **OR** | | | |
| 13 (b) | Determine the nodal load vector for the given element shown in Fig. 13(b).<br>  <br><br>Fig.13(b) | **13** | 3 | L4 |
| 14 (a) | The nodal co-ordinates of a plane stress element are 1(2,6),2(12,9) and 3 (6,5). The nodal displacements are u1 = 0.002 mm, v1 = 0.003 mm, u2 = 0.0 mm, v2 =0.0 mm and u3 =0.004 mm, v3 =0.0mm. Find the element stresses. Assume E = 70GPa and μ = 0.3. Use unit thickness for plane stress. All the coordinates are in milli metres. | **13** | 4 | L4 |
| | **OR** | | | |
| 14 (b) | The nodal co-ordinates for an axi-symmetric triangular element are given below. r1 = 35 mm, r2=85 mm, r3=85mm,z1=40 mm, z2=40 mm, z3= 80 mm. Evaluate strain displacement matrix. Also determine the element strains. The nodal displacements are found out as u1= 0.002 mm, v1 = 0.001 mm, u2 = 0.004 mm, v2 = - 0.003 mm and u3 = -0.004 mm, v3 =0.006 mm. | **13** | 4 | L4 |

| | | | | |
|---|---|---|---|---|
| 15 (a) (i) | Using Gauss Quadrature, evaluate the following integral $$I=\int_{-1}^{+1}\int_{-1}^{+1}\frac{\left(9-8\xi+3\xi^2\right)}{\left(2+6\eta+5\eta^2\right)}d\xi\,d\eta$$ | **8** | 5 | L4 |
| (ii) | Evaluate the shape functions for one corner node and mid side node of a nine-noded quadratic quadrilateral iso-parametric element. | **5** | 5 | L4 |
| | **OR** | | | |
| 15 (b) (i) | For a four-noded element with coordinates (1, 1),(3, 0), (3.5, 2.5) and (2,3) ,determine the Jacobian matrix at (1/6, 1/6). | **8** | 5 | L4 |
| (ii) | Evaluate the shape functions for one corner node and mid side node of a iso-parametric linear strain triangular element | **5** | 5 | L4 |

## PART- C(1x 15=15Marks)

(Q.No.16 is compulsory)

| Q.No | Questions | Marks | CO | BL |
|---|---|---|---|---|
| 16. | A member of rectangular cross section 6 cm x 2 cm as shown in Fig.16. is to be analysed for determining the stress distribution. Considering geometric and boundary condition symmetry, 1/4th of the cross section was modeled using equisized triangular elements. Carry out the assembly and solve for the unknown stress function values. $2G\Theta = 3450$   Fig.16 | **15** | 2 | L5 |