



**B.E/B.TECH DEGREE EXAMINATIONS: APRIL / MAY 2024**

(Regulation 2018)

Sixth Semester

**MECHANICAL ENGINEERING**

U18MEI6203: Finite Element Analysis

**COURSE OUTCOMES**

- CO1:** Solve problems by applying standard finite element techniques.
- CO2:** Analyze 1-D finite elements and to build the stiffness matrix.
- CO3:** Examine 2-D finite element continuum for structural applications.
- CO4:** Solve 1-D and 2-D heat transfer problems using finite element approach.
- CO5:** Apply axisymmetric formulation for specific applications.
- CO6:** Make use of finite element principles in iso-parametric applications.

**Time: Three Hours**

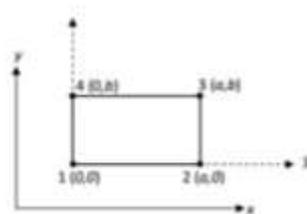
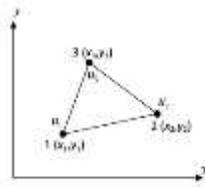
**Maximum Marks: 100**

**Answer all the Questions: -**

**PART A (10 x 2 = 20 Marks)**

**(Answer not more than 40 words)**

- 1 Why is the variational formulation referred to as weak formulations? What are the advantages of the weak form? CO1 [K<sub>2</sub>]
- 2 Differentiate material non linearity and geometric non linearity. CO1 [K<sub>2</sub>]
- 3 A 2D domain as shown in figure is discretized using 3 noded triangular elements and 4 noded rectangular elements. What is the size of the stiffness matrix and semi band width for each of the meshes? Assume that the mesh is for a scalar variable. CO2 [K<sub>3</sub>]



- 4 Distinguish between essential and natural boundary conditions with suitable examples. CO2 [K<sub>3</sub>]
- 5 Why should the sum of shape function be equal to unity? CO3 [K<sub>3</sub>]
- 6 Write the stress strain relationship for plane stress problems CO3 [K<sub>3</sub>]
- 7 Write the governing equation of heat transfer problem of composite wall CO4 [K<sub>2</sub>]

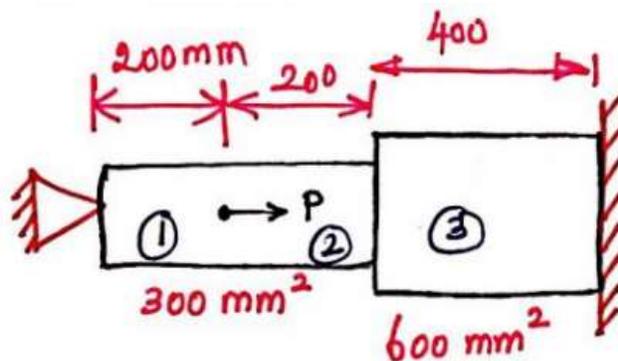
- 8 Illustrate the shape function of a CST element? CO5 [K<sub>2</sub>]
- 9 What is the purpose of iso parametric elements? CO6 [K<sub>2</sub>]
- 10 Write down the Jacobian matrix for four noded rectangular elements? CO6 [K<sub>2</sub>]

**Answer any FIVE Questions:-**  
**PART B (5 x 16 = 80 Marks)**  
**(Answer not more than 400 words)**

11. a) The following differential equation is available for a physical phenomenon, 10 CO1 [K<sub>2</sub>]  

$$d^2 y/dx^2 - 10x^2 = 5, 0 \leq x \leq 1$$
with boundary conditions as  $y(0) = 0$  and  $y(1) = 0$ .  
find the solution of the problem using above differential equation by using following method of weighted residuals and also compare with exact solution.
- (i) Point Collocation method  
(ii) Least square method
- 11 b) List out the applications of finite element analysis 6 CO1 [K<sub>2</sub>]
12. A structure is shown in figure, is subjected to a axial load ( $P=400$  kN). 16 CO2 [K<sub>3</sub>]  
Determine, (All Dimensions are in mm)  
(i) the nodal displacements,  
(ii) element stresses.

Take  $E = 2 \times 10^5$  N/mm<sup>2</sup>



13. For the plane strain triangular element shown in figure. The nodal displacements 16 CO3 [K<sub>3</sub>]  
are

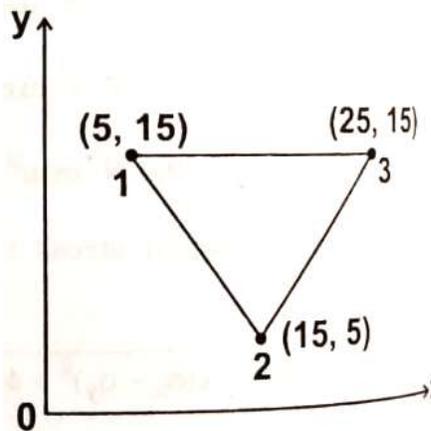
Nodal displacement in	Displacement in t (mm)	Nodal displacement in y-direction	Displacement (mm)
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x-direction			
$U_1$	0.005	$V_1$	0.002
$U_2$	0.0	$V_2$	0.0
$U_3$	0.005	$V_3$	0.0

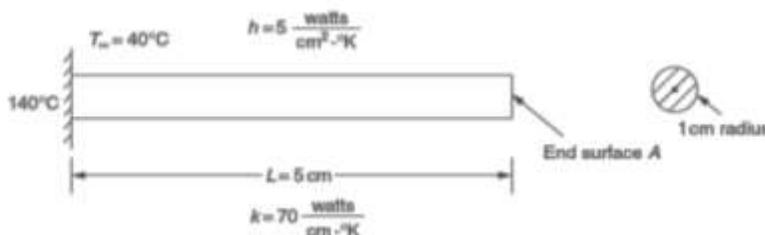
Assume  $E = 70 \text{ GPa}$  :  $\mu = 0.3$  use unit thickness for plane strain. All coordinates are in millimetres.

Determine the

- (i) Element stress, normal stress in x direction ( $\sigma_x$ ) , normal stress in y direction ( $\sigma_y$ ) ,Shear stress ( $\tau_{xy}$ )
- (ii) Maximum and minimum principal stress ( $\sigma_1$  &  $\sigma_2$ )



14. a) Find the temperature distribution in the one-dimensional fin shown in Figure 10 CO4 [K<sub>3</sub>] with the following physical properties:  
 Thermal conductivity ( $k$ ) =  $70 \text{ W/cm}^\circ\text{K}$   
 Heat transfer coefficient ( $h$ ) =  $5 \text{ W/cm}^2^\circ\text{K}$   
 Temperature at the root of the fin ( $T_0$ ) =  $140^\circ\text{C}$ .  
 Surrounding temperature ( $T_\infty$ ) =  $40^\circ\text{C}$   
 Assume the free end of the fin is insulated (Consider two elements)  
 Radius of the fin =  $1 \text{ cm}$



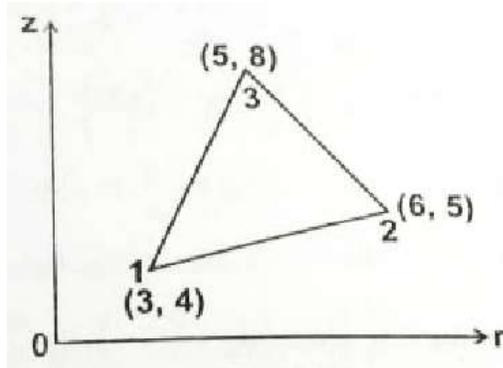
b) Enumerate the generalized procedure involved in Finite Element Method 6 CO4 [K<sub>2</sub>]

15. Compute the strain-displacement matrix for the axisymmetric triangular element shown in figure. 16 CO5 [K<sub>3</sub>]

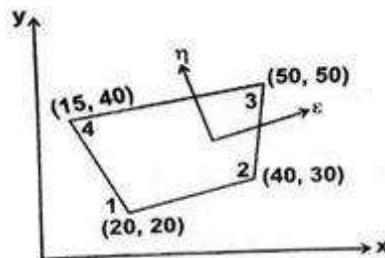
Also determine the element strain.

All dimensions are in centimetre. The nodal displacements are found out as

Nodal displacement in r-direction	Displacement (cm)	Nodal displacement in z-direction	Displacement (cm)
U <sub>1</sub>	0.002	W <sub>1</sub>	0.001
U <sub>2</sub>	0.001	W <sub>2</sub>	-0.004
U <sub>3</sub>	-0.003	W <sub>3</sub>	0.007



16. a) For the four noded quadrilateral element shown in figure. Determine the Jacobian and evaluate its value at the point (1/2, 1/2). 10 CO6 [K<sub>5</sub>]



b) Find the integral of  $I = \int_{-1}^1 (2x^3 + 5x^2 + 6)$  using gaussian quadrature method with 2 point scheme. The gauss points are + 0.5774 and - 0.5774 and the weights at the two points are equal to unity. 6 CO6 [K<sub>3</sub>]

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