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# P.E.S. College of Engineering, Mandya - 571 401

*(An Autonomous Institution affiliated to VTU, Belagavi)*

**First Semester, M.Tech. - Mechanical Engineering (MMDN)**

**Semester End Examination; April / May - 2021**

**Finite Element Analysis**

*Time: 3 hrs* *Max. Marks: 100*

***Course Outcomes***

*The Students will be able to:*

*CO1: Explain the concept of finite element method, finite element discretization process and methods of deriving finite element equations and Solve one-dimensional structural problems..*

*CO2: Construct finite element equations for two-dimensional and three-dimensional elements and Analyze two-dimensional plane stress and strain problems.*

*CO3: Construct finite element equations for axi-symmetric and plane truss elements and Solve axi-symmetric and plane truss problems.*

*CO4: Develop finite element equations for beams and dynamic problems and estimate bending moment, shear force and stress in beam and natural frequencies and mode shape of one-dimensional structural problem.*

*CO5: Develop finite element equations for three-dimensional heat transfer problems and estimate temperature distribution and heat flow in composite walls and fins.*

***Note:*** ***I)*** *Answer any* ***FIVE*** *full questions, selecting* ***ONE*** *full question from each unit.*

***II)*** *Any* ***THREE*** *units will have internal choice and remaining* ***TWO*** *unit questions are compulsory.*

***III)*** *Each unit carries 20 marks.*

| Q. No. | UNIT - I | Marks | BL | COs | POs |
|---|---|---|---|---|---|
| 1 a. | Briefly explain the concepts of simplex, complex and multiplex elements. | 6 | L1 | CO1 | PO1 |
| b. | List the characteristics of shape function. | 4 | L1 | CO1 | PO1 |
| c. | A compound bar is loaded as shown in Fig. Q. 1(c). Initial temperature of the bar is 30°C. The temperature is then raised to 60°C. Take $P = 4\times10^5$ N. Determine; i) Nodal displacements ii) Stresses in each element iii) Reaction at the support | 10 | L3 | CO1 | PO1,2 |
| | **OR** | | | | |
| 1 d. | List the steps involved in finite element method. | 6 | L1 | CO1 | PO1 |
| e. | List the points to be considered while placement of nodes during discretization process. | 4 | L1 | CO1 | PO1 |
| f. | A steel bar of length 800 mm is subjected to an axial load of 3 kN as shown in Fig. Q. 1(f). Determine the nodal displacements by treating bar as quadratic bar element. | 10 | L3 | CO1 | PO1,2 |
| | **UNIT - II** | | | | |
| 2 a. | Show that interpolation function for linear triangular elements is given by $N_i = ½ A_e (a_i + b_i x + c_i y)$ where $i$ = 1, 2, 3. | 10 | L2 | CO2 | PO1 |
| b. | For linear triangular element, $N_1 = \frac{1}{16}(40-3x-4y)$ $N_2 = \frac{1}{16}(-16+4x)$ $N_3 = \frac{1}{16}(-8-x+4y)$ Determine the strain displacement matrix. | 10 | L3 | CO2 | PO1,2 |

Contd... 2

## UNIT - III

| | | | | | |
|---|---|---|---|---|---|
| 3 a. | Obtain [B] matrix in case of axi-symmetric triangular element. | 8 | L2 | CO3 | PO1 |
| b. | For the two bar truss shown in Fig. Q. 3(b). A force of 1000 kN is applied at node 1, while node 1settles an amount δ = 50 mm in the negative direction. Take $E$ = 210 GPa and $A = 66 \times 10^{-4}$ $m^2$ for each element. Determine the nodal displacements. | 12 | L3 | CO3 | PO1,2 |

## UNIT - IV

| | | | | | |
|---|---|---|---|---|---|
| 4 a. | For a beam element, write down the shape function in terms of global coordinates. Sketch their variation across the elemental length. | 6 | L1 | CO4 | PO1 |
| b. | For the beam shown in Fig. Q. 4(b), determine the rotation at *B* and *C*. | 14 | L3 | CO4 | PO1,2 |

**OR**

| | | | | | |
|---|---|---|---|---|---|
| 4 d. | What is the difference between static and dynamic analysis. Give example. | 6 | L1 | CO4 | PO1 |
| e. | Consider the axial vibration of steel bar shown in Fig. Q. 4(d). Develop the global stiffness and mass matrix. $E$ = 200 GPa and $\rho = 7830$ kg/$m^3$. | 14 | L3 | CO4 | PO1,2 |

## UNIT - V

| | | | | | |
|---|---|---|---|---|---|
| 5 a. | Derive element conductivity matrix for a 1D heat conduction problem. | 6 | L2 | CO5 | PO1 |
| b. | A composite wall consists of three materials, as shown in the Fig. Q 5(b). The inside wall temperature is 200°C and the outside air temperature is 50°C with a convection coefficient of $h$ = 10 W ($m^2$.K). Find the temperature along the composite wall<br>$\kappa_1 = 70W/(m\cdot K),\quad \kappa_2 = 40W/(m\cdot K),\quad \kappa_3 = 20W/(m\cdot K)$<br>$t_1 = 2cm,\quad t_2 = 2.5cm,\quad t_3 = 4cm$ | 14 | L3 | CO5 | PO1,2 |

**OR**

| | | | | | |
|---|---|---|---|---|---|
| d. | Explain the types of boundary conditions in heat transfer problem. | 6 | L1 | CO5 | PO1 |
| e. | Calculate the temperature distribution of one dimensional fin with the physical properties given below in Fig.Q.5 (d). Assume that convection heat loss occurs from the end of the fin. Model the fin by two elements. | 14 | L3 | CO5 | PO1,2 |

Contd... 3

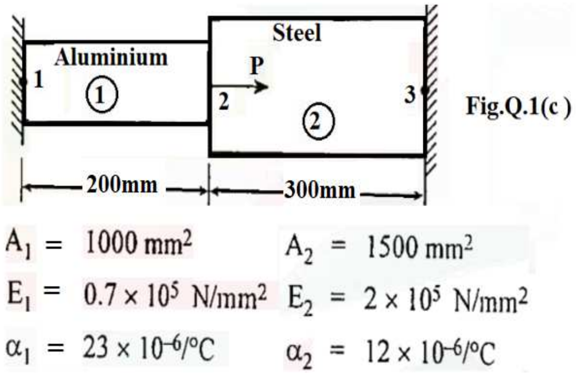



Fig.Q.1(c )

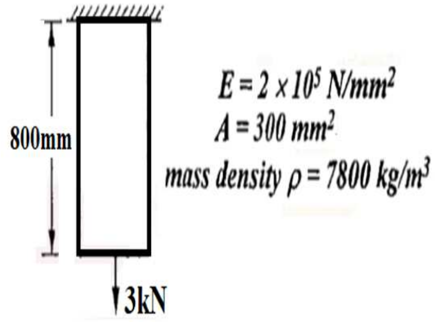



Fig.Q.1 (f)

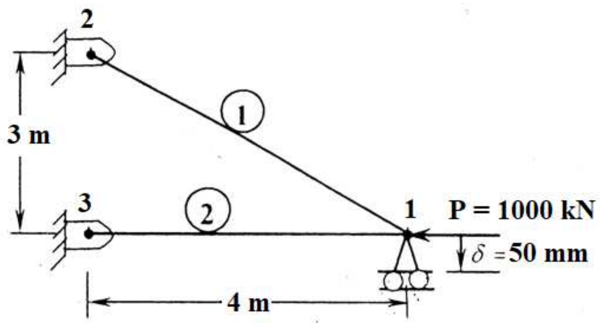
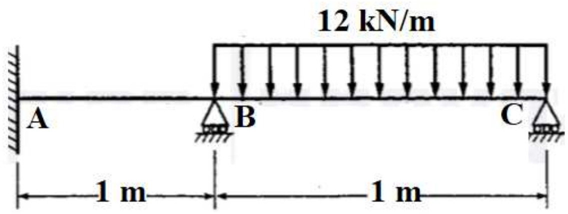



**Fig. Q. 3(b)**




*E = 210 GPa; I = 6 × 10$^6$ mm$^4$*

**Fig. Q. 4. (b)**

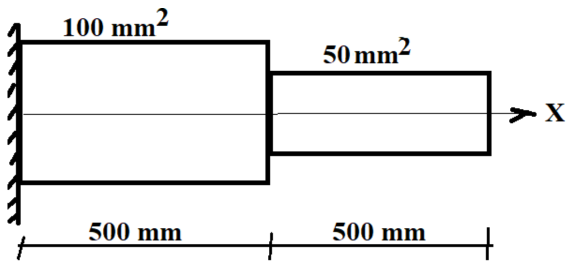



**Fig. Q. 4. (d)**

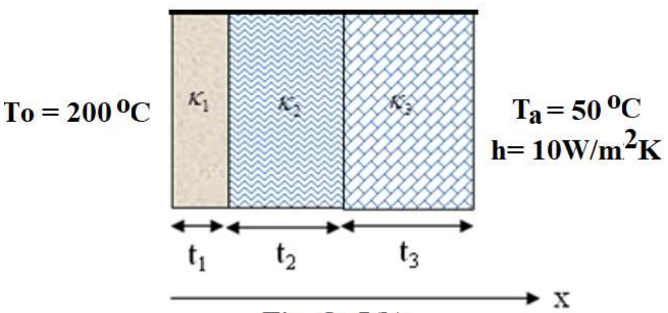



**Fig. Q. 5(b)**

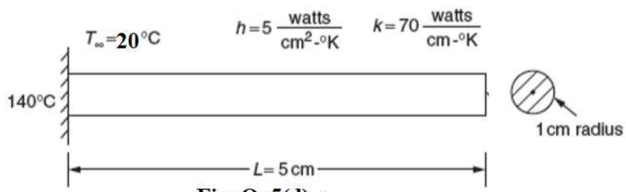



**Fig. Q. 5(d)**

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