U.S.N

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

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Mechanical Engineering

Semester End Examination; August - 2023

Finite Element Method

Time: 3 hrs *Max. Marks: 100*

Course Outcomes

The Students will be able to:

CO1: Understand the basic concepts and mathematical preliminaries of FEM required to solve basic field problems.

CO2: Develop interpolation models for 1D and 2D elements that satisfy convergence criteria and geometrical isotropy and used isoparametric concept in the finite element analysis.

CO3: Formulate element stiffness Matrices and load vectors for different elements using variational principle and analyze axially loaded bars.

CO4: Use finite element formulation in the determination of stresses, strains and reaction of trusses and transversely loaded beams.

CO5: Formulate finite element equation for heat transfer problems using variational and Galerkin techniques and apply these models to analyze conduction and convection heat transfer problems

Note: ***I) PART - A*** *is compulsory.* ***Two*** *marks for each question.*

II) PART - B*: Answer any* ***TWO*** *sub questions (from a, b, c) for Maximum of* ***18 marks*** *from each unit.*

Q. No.	Questions	Marks	BLs	COs	POs
	I : PART - A	**10**			
1 a.	During discretization mention the place where it is necessary to place the node.	2	L1	CO1	PO1
b.	State the reason for using polynomial type of interpolation function in FEM.	2	L1	CO2	PO1
c.	How do you calculate the size of the Global stiffness matrix?	2	L1	CO3	PO1
d.	State the assumption made for Truss analysis.	2	L1	CO4	PO1
e.	Write down the governing equation for one dimensional steady state heat conduction with convention at the end and subjected to internal heat generation.	2	L1	CO5	PO1
	II : PART - B	**90**			
	UNIT - I	**18**			
2 a.	Explain the discretization process of a given domain based on number of elements and size of the elements.	9	L1	CO1	PO1
b.	Evaluate the integral using Gauss quadrature three point formula $I=\int_0^1 \frac{dx}{(1+x)}$ and compare with exact value.	9	L1	CO2	PO2
c.	Solve the following system of simultaneous equation by Gauss elimination method. $2x + 4y + 2z = 15$ $2x + y + 2z = 5$ $4x + y - 2z = 0$	9	L1	CO3	PO3

		Marks			
	UNIT - II	**18**			
3 a.	For one dimensional two noded bar element, write the shape functions and their variation along the length of the element. What are its characteristics?	9	L2	CO1	PO1
b.	Show that interpolation function for linear triangular elements is given by $N_i = \frac{1}{2}A_e(a_i + b_{ix} + c_{iy})$ where i = 1, 2, 3	9	L2	CO2	PO2
c.	Nodal coordinates for triangular elements are (1, 2), (5, 3), and (4, 6). The pressure at nodal points are 30 bar, 40 bar and 50 bar. Determine the pressure at interior point *P* whose coordinates are (3.3, 3.3), also determine Jacobian matrix for the element.	9	L2	CO2	PO2
	UNIT - III	**18**			
4 a.	Compute the consistent load vector in quadratic bar element due to body force.	9	L2	CO3	PO2
b.	Compute the strain displacement matrix (B matrix) for linear triangular element with nodal coordinates (1, 2), (5, 3) and (4, 6).	9	L3	CO3	PO2
c.	A bar having uniform cross section area of 250 mm^2 and is subjected to load of P = 60 kN as shown in Fig.Q3 (c). Determine the displacement and support reaction forces of a bar. Take $E = 2\times10^4$ N/mm^2.	9	L2	CO3	PO3
	UNIT - IV	**18**			
5 a.	List the assumption made in the finite element analysis of a truss structure.	4	L1	CO4	PO1
b.	For the two bar truss as shown in Fig.Q4 (b). Take E = 200kN/mm^2 and A = 70.71mm^2 for each element, A force of P = 100 kN is applied at node 2. Determine; (i) Global stiffness Matrix and global force vector (ii) Displacement of the point where load is applied	14	L3	CO4	PO3
c.	For the beam shown Fig.Q4 (c), determine the deflection at mid-span of second element by taking the modulus of elasticity of material as 200 GPa and moment of inertia as 4×10^6 m^4.	14	L3	CO4	PO3
	UNIT - V	**18**			
6 a.	Derive element Conductivity Matrix for a 1D heat conduction problem.	6	L2	CO5	PO1
b.	A furnace wall consists of two materials, as shown in Fig.Q5 (b). The furnace temperature is 1500ºc and the outside air temperature is 20ºc with a convection coefficient of h_i = 12 W/m^2.K and h_o = 2 W/m^2.K. Find the temperature along the composite wall. Take k_1 = 1.2 *W/mK*, k_2 = 0.2 *W/mK.*	12	L2	CO5	PO3
c.	Calculate the temperature distribution of one dimensional fin with the physical properties given below in Fig.Q5 (c). Assume that the convection heat loss occurs from the end of the fin. Model the fin by four elements.	12	L3	CO5	PO3

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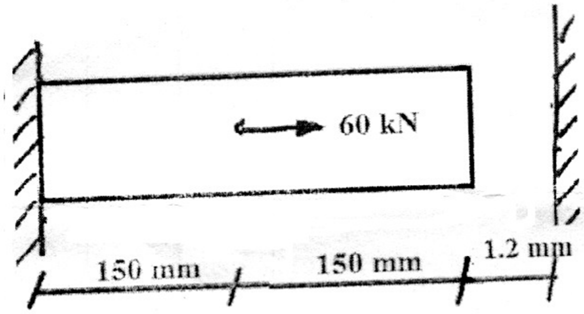

Fig. Q 3 (c)

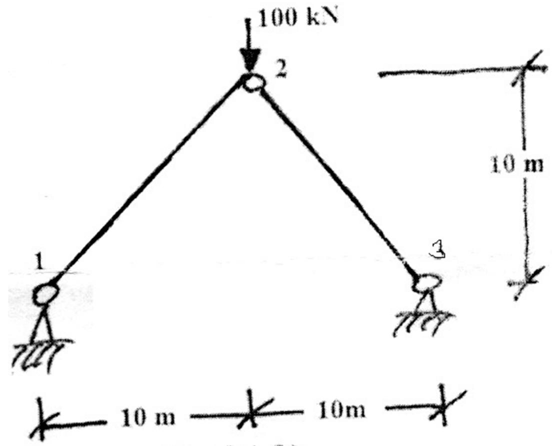

Fig. Q 4 (b)

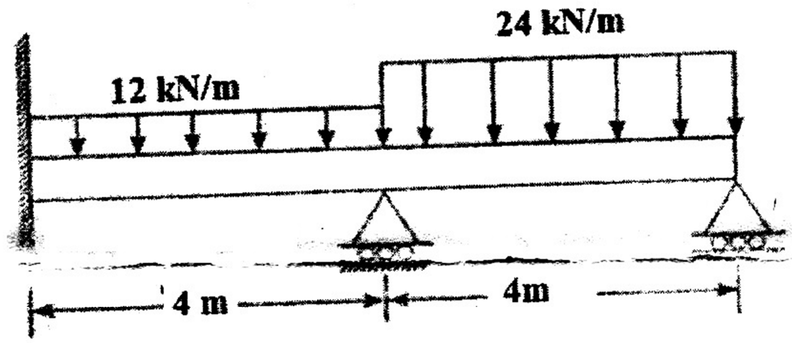

Fig. Q 4 (c)

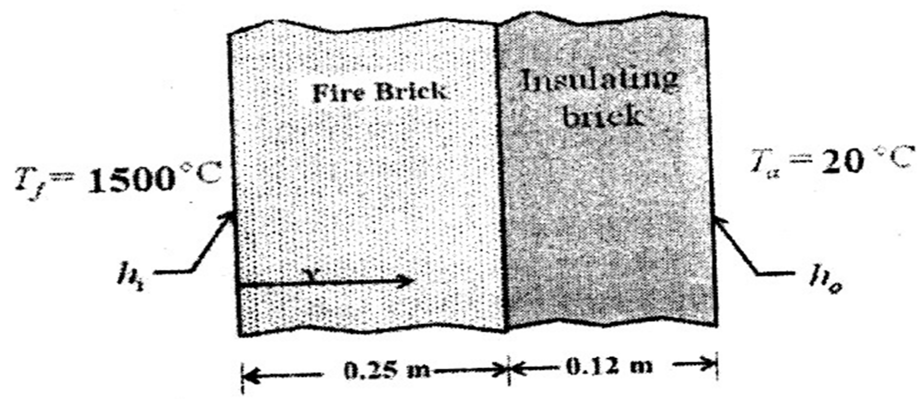

Fig. Q 5 (b)

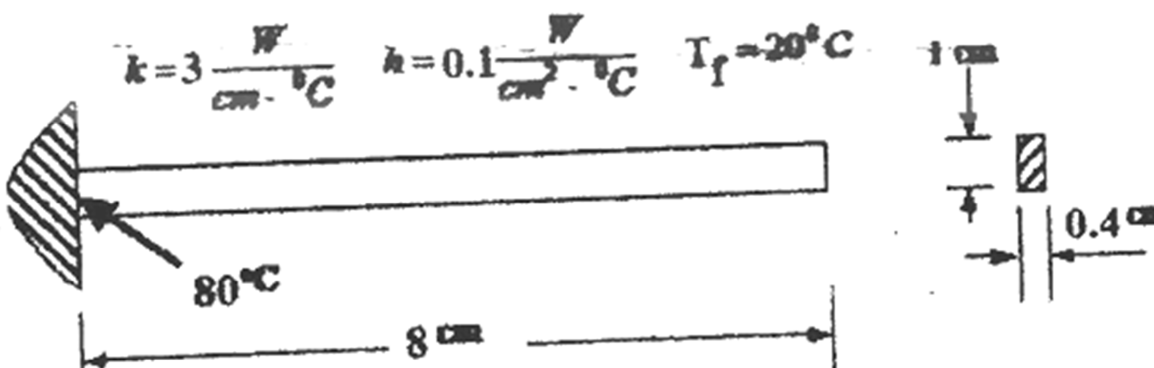

Fig. Q 5 (c)