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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; July / Aug. - 2022

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 iso parametric 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 a Maximum of* ***18 marks*** *from each unit.*

Q. No.	Questions	Marks	BLs	COs
	I : PART - A	**10**		
I a.	Define FEM. Write the application of FEM.	2	L1	CO1
b.	Explain ISO-parametric, Sub-parametric and super-parametric elements.	2	L1	CO2
c.	Write the load vector for uniformly distributed loan on a beam.	2	L1	CO3
d.	Explain principle of minimum potential energy.	2	L1	CO4
e.	Write the stiffness Matrix for Truss element.	2	L1	CO5
	II : PART - B	**90**		
	UNIT - I	**18**		
1 a.	Explain the steps involved in FEM.	9	L1	CO1
b.	Derive the equilibrium equation for 3D elastic body subjected to body force.	9	L2	CO1
c.	Explain plane stress and plane strain condition.	9	L1	CO1
	UNIT - II	**18**		
2 a.	Derive shape function for 1D linear element on Cartesian coordinate system.	9	L2	CO2
b.	Derive the shape function of CST element in neutral coordinate system.	9	L1	CO2
c.	State the properties of Shape functions and prove them.	9	L2	CO2
	UNIT - III	**18**		
3 a.	Derive the stiffness Matrix for 1D bar element.	9	L2	CO3
b.	Determine the nodal displacement for a bar which is subjected load shown in Fig.Q3 (b), by elimination method.	9	L3	CO3

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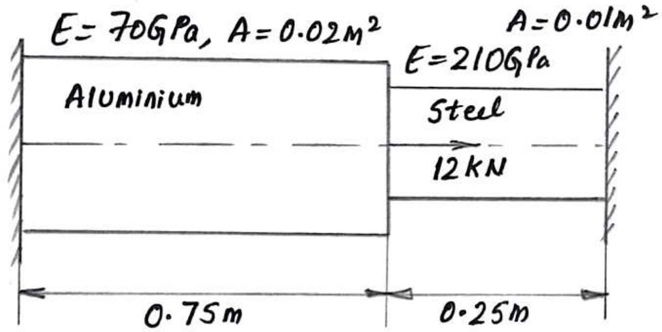

Fig. 3(b)

c. For the bar shown in Fig.Q3 (c). Determine Nodal displacements use penalty approach to handle the boundary conditions take E = 200 GPa. 9 L2 CO3

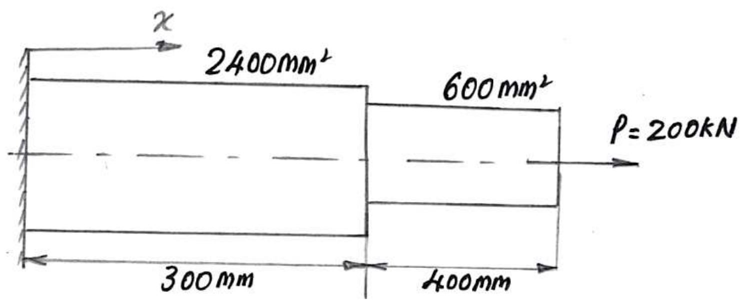

Fig. 3(c)

UNIT - IV **18**

4 a. Derive the stiffness Matrix for a truss element. 4 L3 CO4

b. A truss shown in Fig.Q4 (b). Made of 2 bars, determine nodal displacement stress in each element. Take A_1 = 1200 mm^2, E_1 = E_2 = $2*10^5 N/mm^2$, A_2 = $1000mm^2$. 14 L3 CO4

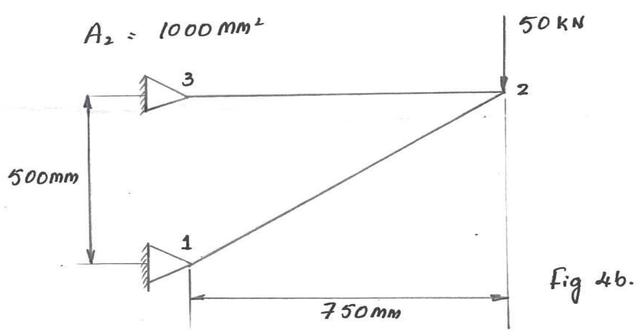

Fig. 4(b)

c. A beam fixed at one end and supported by a roller at the other end has a 20 kN concentrated load applied at the center of the span as shown in Fig.Q4 (c). Calculate the deflection and slopes. 14 L1 CO4

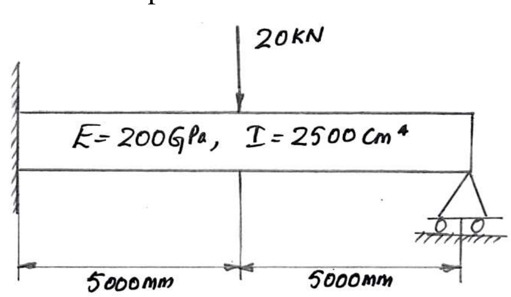

Fig. 4(c)

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UNIT - V **18**

5 a. Derive the convective Matrix for a one dimensional fin. 4 L3 CO5

b. Determine the temperature distribution through the composite wall shown in Fig.Q5 (b). When convection heat it loss occurs on the left surface. Assume unit area, wall thickness t = 4 cm, K_1 = 0.5 W/cm°C, K_2 = 0.05 W/cm°C, h = 0.1 W/cm^2 °C and $T_\infty = -5$°C. 14 L3 CO5

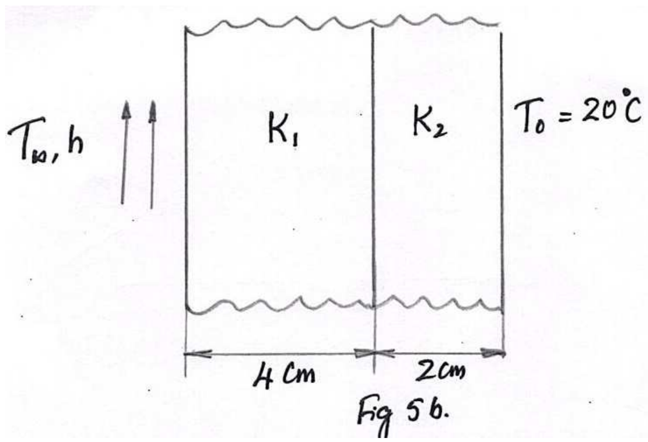

Fig. 5(b)

c. A metallic fan with thermal and conductivity of 70 W/cm°C of 0.5 cm radius and 5cm long extends from a plate whose temperature is 140°C. Determine the temperature distribution along the fin of heat transferred to ambient air at 20°C with convection coefficient of 5 W/cm^{2}°C shown in Fig.Q5 (c). Take two elements along the fin. Element one is insulated. 14 L1 CO5

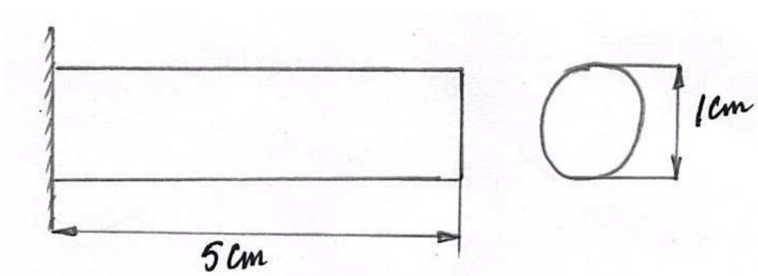

Fig. 5(c)

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