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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VII SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: FINITE ELEMENT METHODS [MME 4102]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. A Howe scissors roof truss shown in Fig 1a is used to support a roof. The loading and support configurations are given. Explain the following steps involved in solving this problem using FEM. **04**

i) Selection of element type
ii) Discretization
iii) Applying various boundary conditions –loads and supports
iv) Stiffness matrices

Justify all your answers.

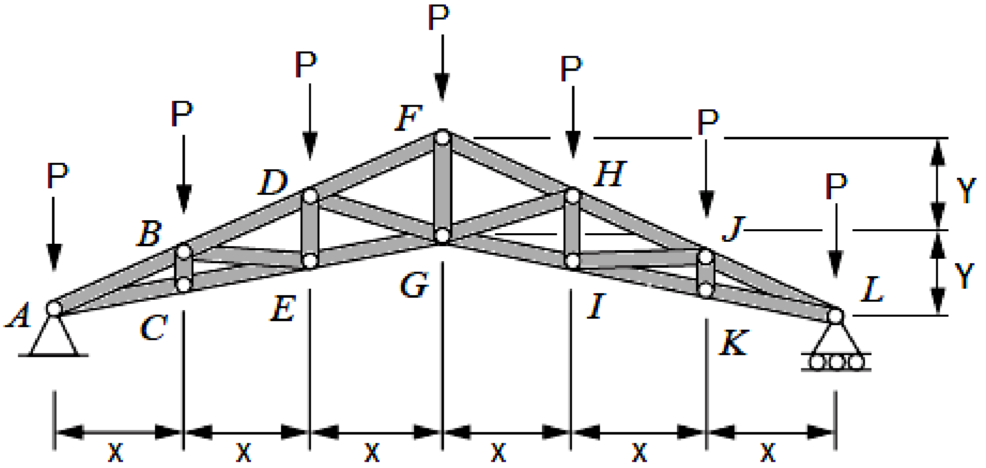


Fig 1a

1B. Explain the following in brief **04**

i) Plane Stress- Plane Strain Conditions
ii) Displacement function
iii) Weighted residual method
iv) Convergence of a solution

1C. Derive the shape functions for 3 noded 1D vertical element using Lagrange polynomial. **02**

2A. For the spring assemblage shown in Fig 2a obtain the global stiffness relation using principle of minimum potential energy. **02**

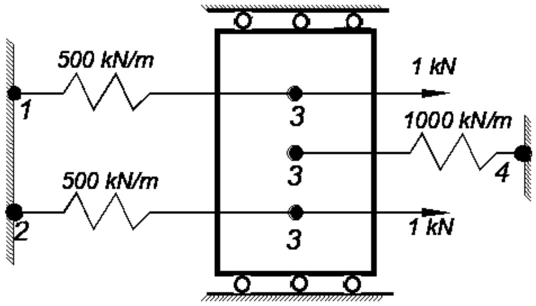


Fig 2a

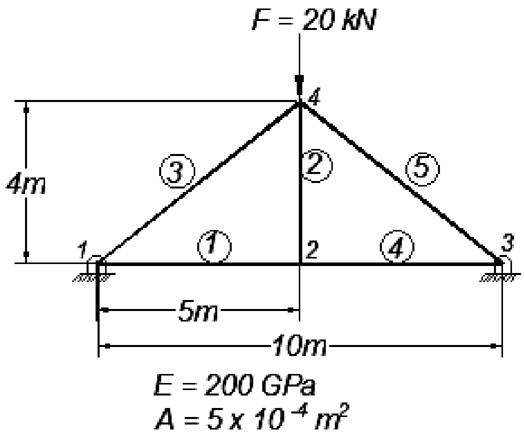


Fig 2b

2B. For the structure shown in Fig 2b evaluate the unknown displacements by using 1D truss/link element. Use direct stiffness method with symmetric boundary conditions. **05**

2C. A compound bar is subjected to point loads, body force and traction force as shown in Fig 2c. Determine the global force vector through finite element method using minimum number of elements. Use the data given in Table 1. **03**

Table 1

	Steel	**Aluminum**	**Brass**
Modulus of Elasticity (GPa)	200	70	105
Area (mm^2)	2400	600	1200
Coefficient of Thermal Expansion (/^oC)	12×10^{-6}	24×10^{-6}	20×10^{-6}
Temperature Change (^oC)	30	60	50
Body Force (kN/mm^3)	0.4	0.6	0.5
Traction Force (N/mm)	Nil	Nil	6

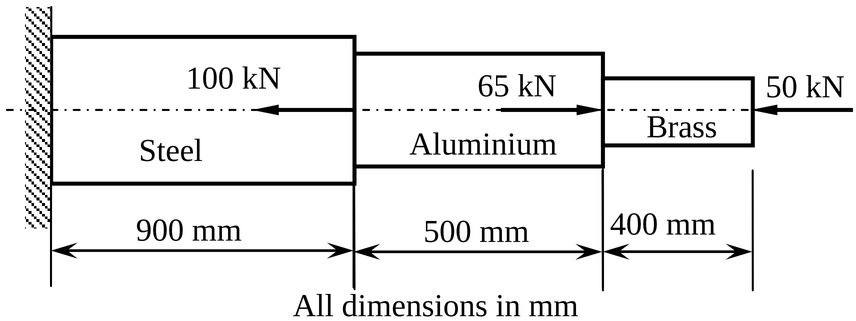
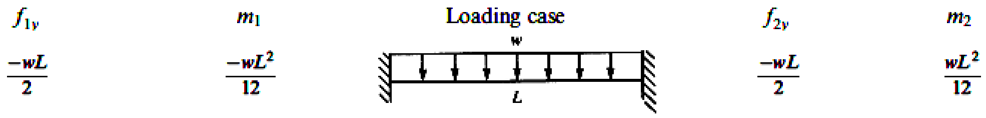


Fig 2c

3A. Derive the element body force vector and element traction force vector of a 1D linear element using strain energy method. **04**

3B. A uniform rectangular cross section beam subjected to a point load and a uniformly distributed load as shown in Fig 3b. Young's Modulus = 200 GPa. Using FEM, obtain the global stiffness relation with minimum number of elements. **03**



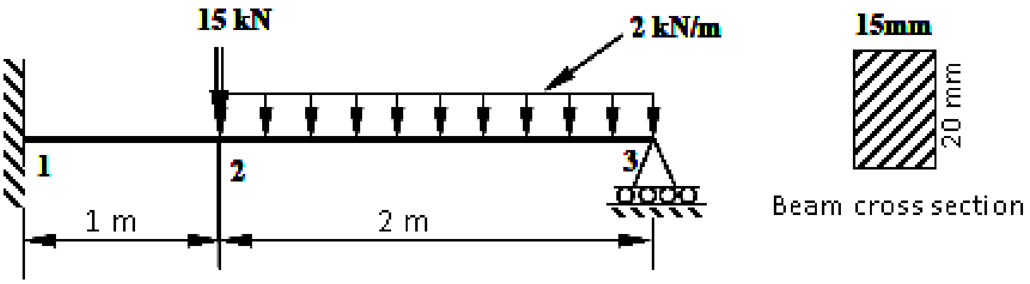


Fig 3b

3C. For the global stiffness equation obtained in Question 3B, apply the boundary conditions as shown in Fig 3b and determine the deflections and slopes at all nodes. Also evaluate the support reaction forces and reaction moments. **03**

4A. Formulate an expression for displacement of a vertical bar whose ends are fixed, using Rayleigh Ritz method. Also determine the displacement and strain values at half of the length of the bar. A point load of 4 N acts halfway down the length as shown in Fig 4a. Traction force of 6 N/mm acts on bar. **05**

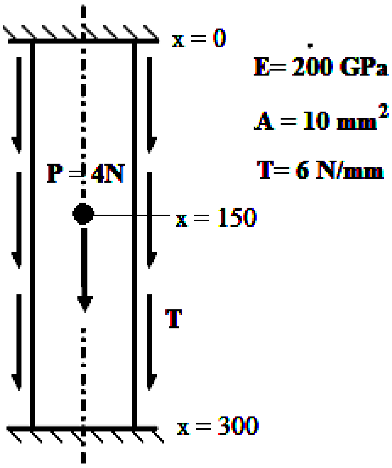


Fig 4a

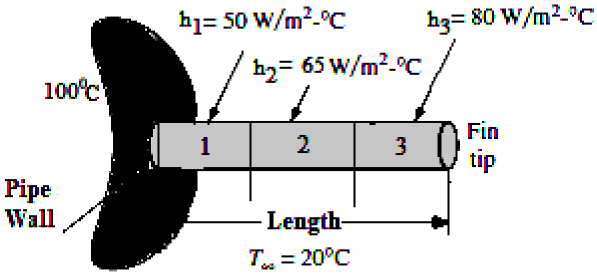


Fig 4b

4B. Condensing steam is used to maintain a room at 20°C. The steam flows through pipes that keep the pipe surface at 100°C. To increase heat transfer from the pipes, stainless steel fins (k = 15 W/m°C), 15 cm long and 0.5 cm in diameter, are welded to the pipe surface as shown in Fig 4b. A fan forces the room air over the pipe and fins, resulting in a convective heat transfer coefficient of 50W/m^2°C at the base surface of the fin where it is welded. However, the air flow distribution increases the convective heat transfer coefficient to 65 W/m^2°C at half of the length of the fin and 80 W/m^2°C at the fin tip. Discretize the fin into minimum 3 elements as shown and determine the temperature distribution along the length of the fin. **05**

5A. Explain in brief with an example i) Isoparametric Element ii) Subparamteric Element **02**

5B. A 2 mm thick steel constant strain triangular element with nodes 1, 2 and 3 is shown in Fig 5b. Node 1 is at the origin of the global coordinate system. Traction force (0.15 N/mm^2 acting normal to surface of edge 2-3 and directed outward) and point loads (28 N & 15 N) are acting on the element as shown. The density of steel is ρ = 7850 kg/m^3. Consider self-weight (ρg acting vertically downwards) of the element as body force contribution. Evaluate the global force vector. **04**

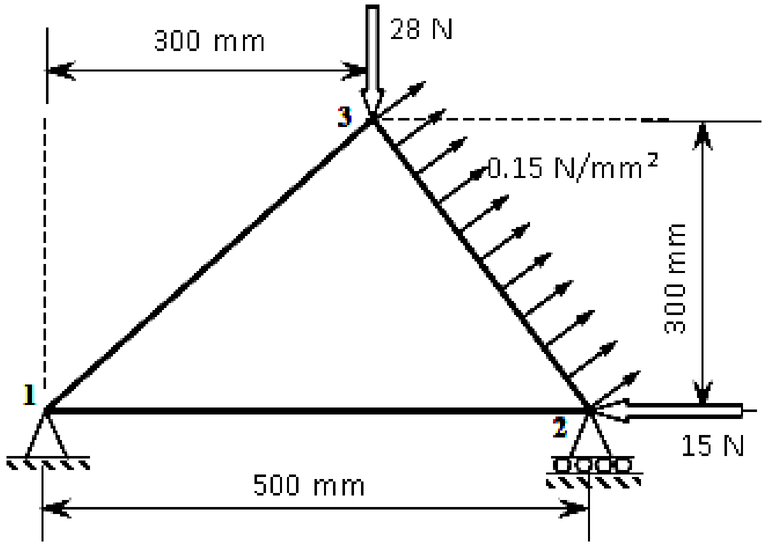


Fig.5b

5C. A CST element ABC made of steel is shown in Fig 5c. Node A is at the origin of the global coordinate system. The displacement components for the corners A, B and C in the 'x' directions are -2 mm, 1 mm, and 1.5 mm respectively and in 'y' directions -0.8 mm, 2.3 mm and -0.65 mm respectively. Assuming plane stress condition, Young's modulus = 200 GPa and Poisson's ratio = 0.3, evaluate the element stress components using {σ}=[D][B]{q} relation **04**

$$[D]=\frac{E}{1-\nu^2}\begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix}$$

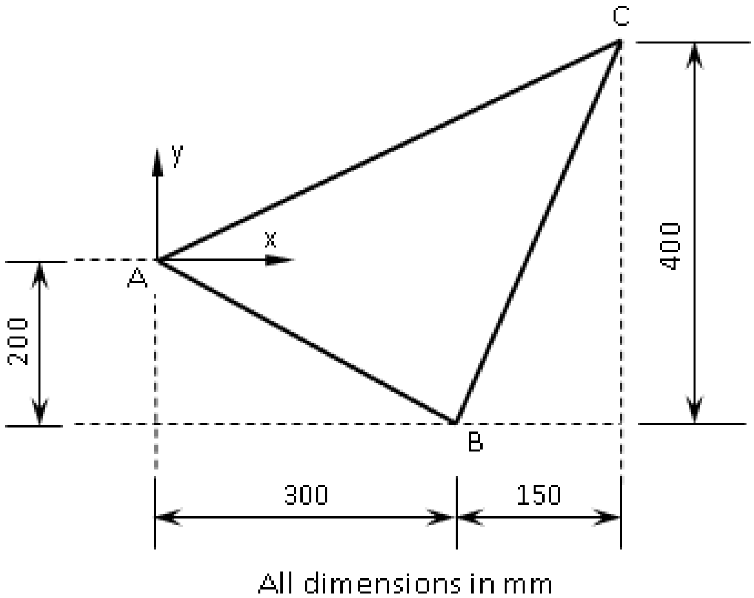


Fig 5c

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