Reg. No. :

Question Paper Code : X20848

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2020

Sixth/Seventh Semester

Mechanical Engineering

ME 6603 – FINITE ELEMENT ANALYSIS

(Common to : Mechanical Engineering (Sandwich)/Automobile Engineering/ Manufacturing Engineering/Mechanical and Automation Engineering)

(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. What are h and p versions of finite element method ?
2. Why is variational formulation referred to as weak formulation ?
3. Write down the expression of longitudinal vibration of bar element.
4. What are the difference between boundary value problem and initial value problem ?
5. Distinguish between CST and LST elements.
6. Write the stiffness matrix used for the torsion problem of a square shaft assuming three noded triangular elements of area A.
7. What is meant by plane stress analysis ?
8. Write the strain-displacement matrix for a CST element.
9. What is the purpose of isoparametric elements ?
10. What is the difference between natural coordinates and local coordinates ?

PART – B **(5×13=65 Marks)**

11. a) A 50 mm long Aluminium pin fin of diameter 1 mm is attached to a wall that is maintained at 300°C. It is subjected to both conduction and convection heat transfer. The thermal conductivity k of Aluminium is 200 W/m°C and the convective heat transfer coefficient h is 20 $W/m^2°C$. The free end of the fin is insulated. Determine using any weighted Residual technique or the Ritz technique the temperature distribution along the fin and hence the temperature at the tip. The Governing differential equation for the fin is given by

$$\frac{d}{dx}\left(-kA\frac{dT}{dx}\right) + hp(T - T_\infty) = 0$$

Boundary Conditions :

i) T(0) = 300°C

ii) $\left(\frac{dT}{dx}\right)_{x=50} = 0$

(OR)

b) Determine the variation of displacement along a bar of varying cross section of length 90 cm. The bar is attached to a wall and suspended vertically. It carries a load of 20 kN at the tip. E = 210 GPa, $\gamma = 0.0785\ N/cm^3$. The bar is of rectangular cross section of side 5 cm × 3 cm at the fixed end and 3 cm × 3 cm at the free end. The displacement at the tip of the bar due to the point load and its own self weight is to be determined.

i) How will you mathematically model this problem ? **(2)**

ii) What is the difference between the use of weighted residual technique, Ritz technique and the finite element technique for solving the above problem. **(2)**

iii) Take at least 2 elements of equal length and solve for the displacement. What is the displacement at the tip of the bar ? **(9)**

12. a) The beam is loaded as shown in Fig. 1; determine :

i) The slopes at 2 and 3 and

ii) The vertical deflection at the midpoint of the distributed load.

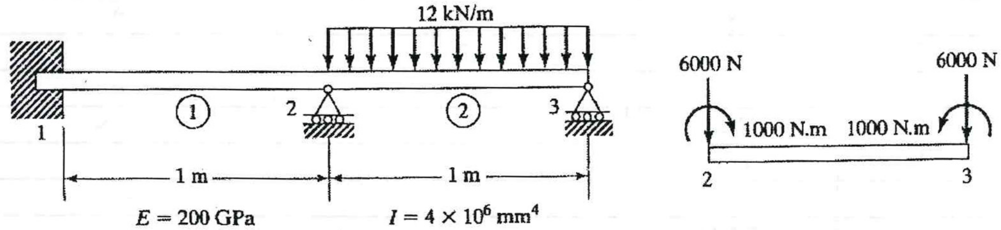

Fig.1

(OR)

b) Determine the natural frequencies of transverse vibration for a beam fixed at both ends. The beam may be modeled by two elements, each of length L and cross sectional area A. The use of symmetry boundary condition is optional.

13. a) Calculate the element stiffness matrix and the temperature force vector for the plane stress element shown in fig 3. The element experiences a 20°C increase in temperature. Assume coefficient of thermal expansion is 6×10^{-6}C. Take $E = 2 \times 10^5$ N/mm^2, v = 0.25, t = 5 mm.

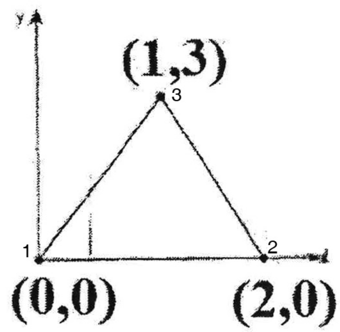

Fig. 3

(OR)

b) Derive the shape function for the constant strain triangular element.

14. a) For the triangular element as shown in the Fig. 14 (a) determine the strain-displacement matrix [B] and constitutive matrix = [D]. Assume plane stress conditions. Take $\mu = 0.3$, $E = 30 \times 10^6$ N/m^2 and thickness t = 0.1m. Also calculate the element stiffness matrix for the triangular element.

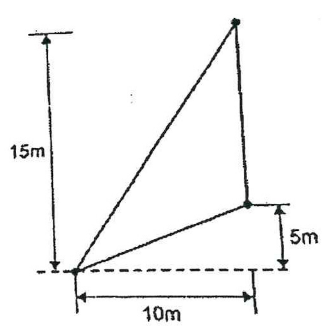

Fig. 14 (a)

(OR)

b) For the axisymmetric element shown in the Fig. 14 (b), determine the stiffness matrix. Let $E = 2.1 \times 10^5$ N/mm^2 and $\mu = 0.25$. The coordinates are in mm.

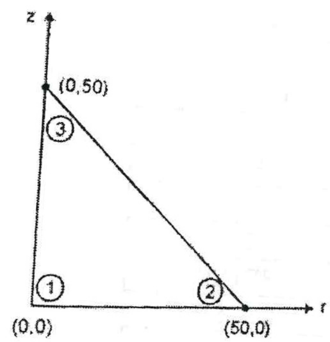

Fig.14 (b)

15. a) For the isoparametric quadrilateral element shown in Fig. 15 (a), the Cartesian coordinates of point 'P' are (6, 4). The loads 10 kN and 12 kN are acting in x and y direction on that point P. Evaluate the nodal forces.

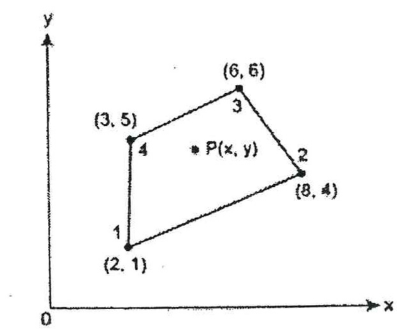

Fig. 15 (a)

(OR)

b) Evaluate the Jacobian matrix for the isoparametric quadrilateral element shown in Fig. 15 (b).

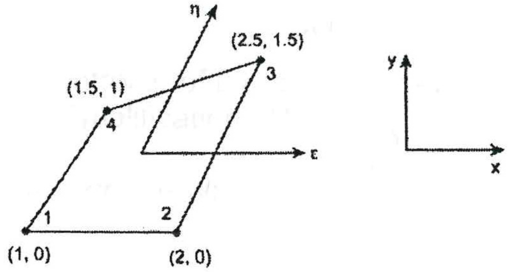

Fig. 15 (b)

PART – C **(1×15=15 Marks)**

16. a) For the two bar truss as shown in Fig. 5 determine the displacements at node 2 and the stresses in both elements.

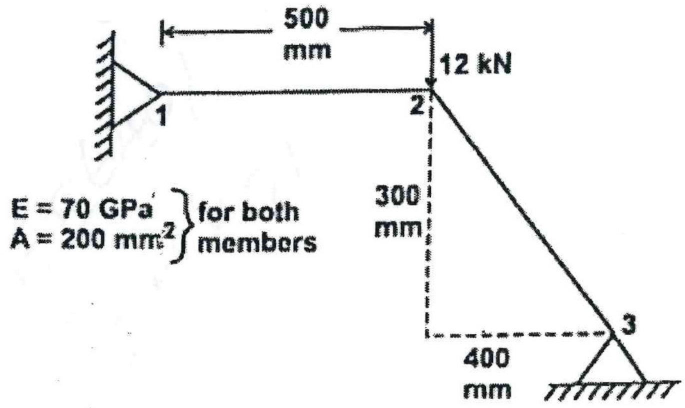

Fig.5

(OR)

b) Solve the following simultaneous equations using Gaussian elimination method.

$2a + b + 2c - 3d = -2$

$2a - 2b + c - 4d = -15$

$1a + 2c - 3d = -5$

$4a + 4b - 4c + d = 4$