Reg. No. :

Question Paper Code : 91850

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019

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. Distinguish between essential and natural boundary conditions with suitable examples.
2. How will you mathematically model a long thin bar of varying cross section fixed at the upper end and subjected to its own self weight and a point load at the lower free end ?
3. List all the differences between two noded and linear and three noded Quadratic bar element.
4. Give the primary and secondary variables associated with the one dimensional beam element and their values at the boundary for a fixed – fixed beam and a simply supported beam.
5. A four noded quadrilateral element gives a better approximation than a three noded triangular element. Explain why.
6. Write down the shape functions for a linear strain triangular (LST) element used for a scalar variable problem.
7. Write the Constitutive Matrix for axisymmetric analysis.
8. Give one practical example each for Plane stress analysis and Plane strain analysis indicating the primary variables.
9. What are the advantages of Natural coordinates ?
10. What are serendipity elements ? Sketch a few such 2D and 3D elements ?

PART – B **(5×13=65 Marks)**

11. a) Determine using any weighted residual technique, the variation of displacement along a bar of constant cross section and length 10 cm. The bar is attached to a wall and suspended vertically. The bar is subjected to only self-weight. E = 200 GPa, $\gamma = 0.0785$ N/cm^3. The cross sectional area of the bar is 1 cm^2. What is the Governing Equation for this system ? What are the associated boundary conditions ? Give the displacement at the tip of the bar (1+1+2+9 for displacement function).

(OR)

b) A circular pin made of metal is attached to a hot wall and receives a heat influx of 0.1 k cal/sq. cm. The length of the fin is 1m and it has constant thermal conductivity of 0.12 k cal/cm° C. Heat is dissipated by convection to the surrounding air at an ambient temperature of 20°C. The convection coefficient is 1.5×10^{-4} k cal/cm² °C. The free end of the fin is maintained at 0°C. The pin diameter is 1 cm. Determine the temperature distribution in the pin using Ritz technique.

12. a) A composite wall consists of three materials as shown in Fig. 12 (a). The inside wall temperature is 100°C and the outside air temperature is 50°C with a convection coefficient h of 10 W/cm² °C. Determine the temperature along the composite wall if the conduction coefficients of the three materials are as given in the figure.

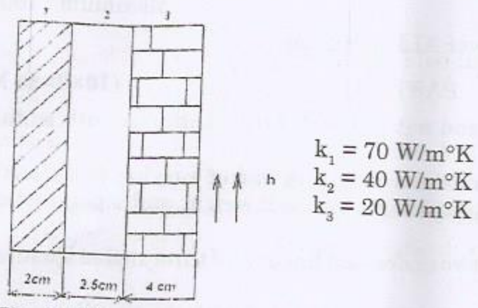

Fig. 12 (a)

(OR)

b) Determine the maximum deflection and slope for the simply supported beam subjected to concentrated transverse load of 25000 N as shown in Fig. 12 (b). Flexural rigidity EI = $2(10^{10})$ N cm².

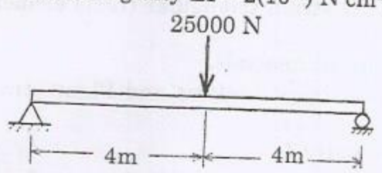

Fig. 12 (b)

13. a) The Governing equation for the torsion of non-circular section is given below along with the boundary condition. Derive the weak form of this equation and hence the stiffness matrix assuming three noded linear triangular elements are used to discretize the section. Also derive the load vector.

$$\frac{1}{G}\frac{\partial^2 \phi}{\partial x^2} + \frac{1}{G}\frac{\partial^2 \phi}{\partial y^2} + 2\theta = 0$$

B.C. On the free boundary $\phi = 0$.

(OR)

b) i) For the element shown in Fig. 13 (b) determine the temperature at the point whose coordinates are (12, 15) and also three points on the 200° C contour line. (10)

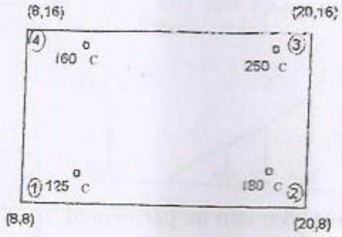

Fig. 13 (b)

ii) Explain how convection is accounted for in 2D heat transfer problems with an example. (3)

14. a) i) A thin plate shown in Fig. 14 (a) is subjected to an in plane load as shown. What type of analysis will be used for this problem ? (2)

ii) If a two-element idealization is used as shown determine the constitutive matrix and the strain displacement matrix. Assume E = 200 GPa, μ = 0.33 and t = 10 mm. (6)

iii) What are the unknown variables at each node and the boundary conditions ? How will you determine the stiffness matrix (derivation not needed) ? Give the load vector. (5)

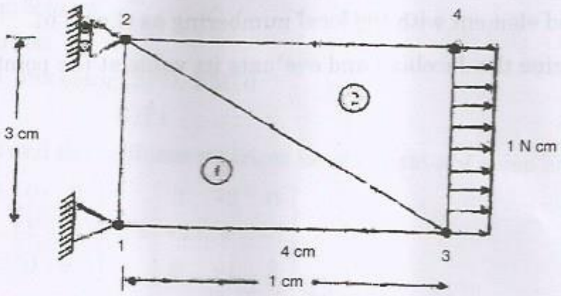

Fig. 14 (a)

(OR)

b) i) Give the shape functions for a 4 noded bilinear rectangular element in Cartesian coordinates and hence derive the strain displacement matrix assuming plane stress conditions. (5)

ii) Calculate the nodal forces corresponding to a uniform radial pressure $p_r = 100 \text{ N/cm}^2$ acting as shown on the axisymmetric element in figure 14 (b). **(5)**

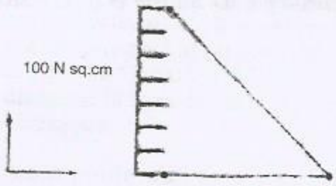

Fig. 14 (b)

iii) Give two examples where axisymmetric analysis can be performed. **(3)**

15. a) i) Using Gauss Quadrature evaluate the following integral. **(7)**

$$I = \int_{-1}^{+1}\int_{-1}^{1} \frac{12 + 2\xi^2 + \eta}{1 + \eta^2} d\xi \, d\eta$$

ii) Evaluate the shape functions for a corner node and mid side node of a quadratic triangular serendipity element and plot its variation. **(6)**

(OR)

b) i) Explain the concept behind coordinate transformation. Discuss about isoparametric elements with suitable examples. **(5)**

ii) For the four noded element with the local numbering as shown in Fig. 15 (b) determine the Jacobian and evaluate its value at the point. **(8)**

$$\left(-\frac{1}{\sqrt{3}}, -\frac{1}{\sqrt{3}}\right).$$

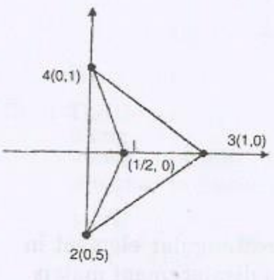

Fig. 15 (b)

PART – C (1×15=15 Marks)

16. a) With the help of any one FEA software discuss the following problem while solving for the figure 16 (a).

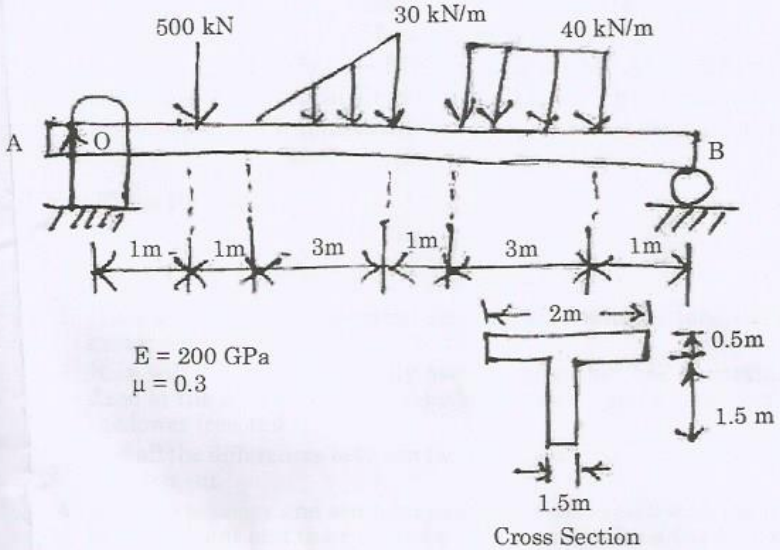

Fig. 16 (a)

i) Preprocessor.
ii) Solution
iii) Post processor (SFD, BMD)

(OR)

b) The mass and the stiffness matrices for a system are given below :

$$[m]=\begin{bmatrix}0.5 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 0.5\end{bmatrix} \quad k=\begin{bmatrix}3 & -2 & 0\\ -2 & 4 & -1\\ 0 & -1 & 2\end{bmatrix}$$

The initial displacement and velocity vectors are given by [0.4, 0.3, 0.3] and [0, 7, 0] respectively. Determine the Natural frequency and Mode shapes.