Reg. No. :

Question Paper Code : 91069

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

Sixth Semester

Aeronautical Engineering

AE 6601 – FINITE ELEMENT METHODS

(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A (10×2=20 Marks)

1. What is Rayleigh-Ritz method ?
2. What are the h and p versions of finite element method ?
3. What is discretization ?
4. State the properties of stiffness matrix.
5. What is CST element ?
6. What is meant by plane stress analysis ?
7. What is the purpose of Isoparametric element ?
8. Write down stiffness matrix equation for 4 noded isoparametric quadrilateral elements.
9. Name any four FEA softwares.
10. What are the various sources of errors in FEA ?

PART – B (5×13=65 Marks)

11. a) Consider a bar of uniform cross-section shown in Fig. 1. The distributed force acting on the bar is varying linearly with x. Calculate the displacement in the bar using Ritz method and compare with exact solution.

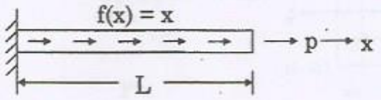


Fig. 1

(OR)

b) For the spring system shown in Fig. 2. k_1 = 100 N/mm, k_2 = 200 N/mm, k_3 = 100 N/mm, P = 500 N, $u_1 = u_4 = 0$. Calculate :

i) The global stiffness matrix. (6)

ii) The nodal displacements at 2 and 3. (4)

iii) The reaction forces at node 1 and 4. (3)

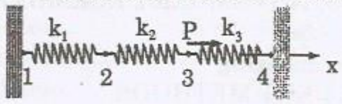


Fig. 2

12. a) Derive the stiffness matrix for a two noded bar element using a linear displacement function.

(OR)

b) Derive stiffness matrix for a beam element using formal approach.

13. a) Evaluate the stiffness matrix for the plate element shown in Fig. 3. Take t = 0.5 cm, E = 2×10^7 N/cm², μ = 0.27 using plane stress formulation.

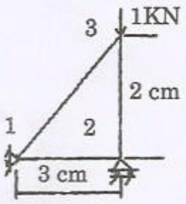
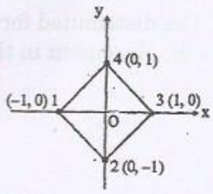


Fig. 3

(OR)

b) For the plane strain element the nodal displacements are u_1 = 0.005 mm, v_1 = 0.002 mm, u_2 = 0 mm, v_2 = 0.0 mm, u_3 = 0.005 mm, v_3 = 0 mm. Determine the element stresses σ_x, σ_y, τ_{xy}. Given E = 70 GPa and μ = 0.3. Use unit thickness for plane strain.

14. a) For the 4 nodded quadrilateral element shown in Fig. 4, calculate the Jacobian. The parent element is shown in Fig. 5.



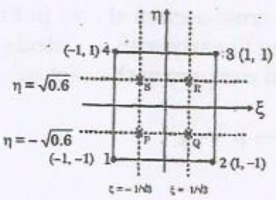


Fig. 4 Quad. 4 element Fig. 5 Parent element in ξ-η plane

(OR)

b) Evaluate the following integral using Gauss quadrature (two point) method.

$$I=\int_{-1}^{1}(2+x+x^2)dx$$ **(6)**

$$I=\int_{-1}^{1}\cos\frac{\pi x}{2}\,dx$$ **(7)**

15. a) Solve the following system of equation using Naive Gauss Elimination method.

$$\begin{aligned} 6x_1 - 2x_2 + 2x_3 + 4x_4 &= 16 \\ 12x_1 - 8x_2 + 6x_3 + 10x_4 &= 26 \\ 3x_1 - 13x_2 + 9x_3 + 3x_4 &= -19 \\ -6x_1 + 4x_2 + x_3 - 18x_4 &= -34 \end{aligned}$$

(OR)

b) A tapered plate of 30 cm length has a width of 10 cm at the top fixed end and 6 cm at the bottom free end. The plate is of uniform thickness of 2 mm. Find the displacement at the nodes by forming into two element model. The plate has a mass density $\rho = 7800$ kg/m^3 and Young's modulus $E = 2 \times 10^5$ MN/m^2. In addition to self-weight, the plate is subjected to the point load P = 10 kN at its centre acting along its length.

PART – C **(1×15=15 Marks)**

16. a) For the 2-D body shown in Figure 6, determine the temperature distribution. The temperature at the left side of the body is maintained at 100°F. The edges on the top and bottom of the body are insulated. There is heat convection from the right side with convective coefficient h = 20 Btu/h-ft^2-°F. The free stream temperature is $T_\infty = 50$°F. The coefficients of thermal conductivity are $K_{xx} = K_{yy} = 25$ Btu/h-ft-°F. The dimensions are shown in the figure. Assume the thickness to be 1 ft.

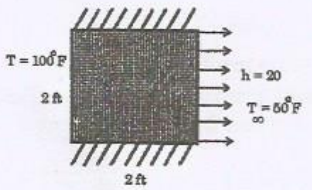


Fig. 6

(OR)

b) Use finite element method to determine the temperature variation across the thickness of longitudinal fins of a tubular heat exchanger as shown in the figure 7. The heat exchanger is designed to heat up the cold fluid outside the tube by the hot fluid circulating inside the tube. The cross-section of a single fin is illustrated in the right side of the figure. The fin is made of aluminium with the properties : Mass density $\rho = 2.7$ g/cm^3, specific heat $c = 0.942$ J/g-°C and thermal conductivity $k = 2.36$ W/cm-°C. The discretized FE model of the fin cross-section is also shown in the figure.

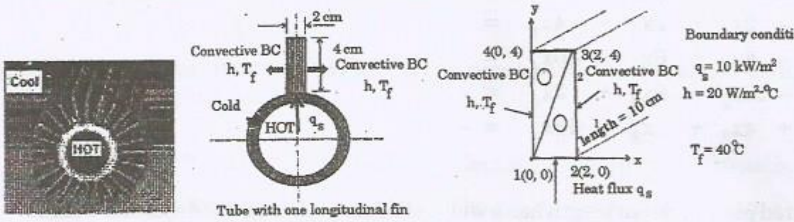


Fig. 7