| Reg. No. | | | | | | | | | | | | | | | | |
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| Question Paper Code | 14353 |
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**B.E. / B.Tech. - DEGREE EXAMINATIONS, APRIL / MAY 2026**

Seventh Semester

**Mechanical Engineering**

**20MEPC701 - FINITE ELEMENT ANALYSIS**

Regulations - 2020

Duration: 3 Hours Max. Marks: 100

**PART – A (i) (MCQ)**
**(16 × 1 = 16 Marks)**
Answer ALL Questions

| | | Marks | K – Level | CO |
|---|---|---|---|---|
| 1. | Total potential energy =<br>a) Strain energy x work potential b) Strain energy / work potential<br>c) Strain energy + work potential d) Strain energy - work potential | 1 | K1 | CO1 |
| 2. | Interpret the relationship between the number of shape functions and the number of _____ in a finite element.<br>a) Nodes of element b) Elements of the structure<br>c) Size of the structure d) Co ordinates | 1 | K2 | CO1 |
| 3. | Identify the essential boundary condition used in finite element analysis.<br>a) Bending Moment b) Shear Force<br>c) Stress d) Displacement | 1 | K3 | CO1 |
| 4. | Stiffness matrix is<br>a) Non symmetric and square b) Non symmetric and rectangular<br>c) Symmetric and square d) Symmetric and rectangular | 1 | K1 | CO2 |
| 5. | Classify the number of shape functions used in a two-noded beam element.<br>a) 2 b) 3<br>c) 4 d) 5 | 1 | K2 | CO2 |
| 6. | Apply the concept of finite element modeling to identify what every element is connected to.<br>a) 2 Nodes b) 3 Nodes<br>c) 4 Nodes d) Infinite Node | 1 | K3 | CO2 |
| 7. | Identify the correct property of shape function<br>a) Summation of all shape function inside the body is +1 b) Summation of all shape function inside the body is -1<br>c) Summation of all shape function inside the body is zero d) Summation of all shape function inside the body is infinity | 1 | K1 | CO3 |
| 8. | Explain the condition of plane stress in which the normal stress and shear stress acting perpendicular to the plane are assumed to be<br>a) Zero b) Unity<br>c) Infinity d) Twice | 1 | K2 | CO3 |
| 9. | Choose the correct condition associated with an axisymmetric element.<br>a) Symmetric about axis b) Boundary conditions are symmetric about an axis<br>c) Loading conditions are symmetric about an axis d) All of the mentioned | 1 | K3 | CO3 |
| 10. | In Thermal analysis, the unknown at each node is<br>a) Temperature b) Power<br>c) Heat Sources d) All of the above | 1 | K1 | CO4 |

11. Illustrate the process by which energy is transmitted from one region to another due to a temperature difference. *1 K2 CO4*
    a) Heat Transfer b) Force Transfer
    c) Both (a) and (b) d) None of the above
12. Select the correct expression for convective heat flux. *1 K3 CO4*
    a) $q = (T - T_a)$ b) $q = h(T + T_a)$
    c) $q = h(T - T_a)$ d) $q = h(T * T_a)$
13. For a higher-order iso-parametric quadrilateral element, such as a 9-node quadratic element, how many integration points are needed for exact integration using Gaussian Quadrature? *1 K1 CO5*
    a) 4 b) 9
    c) 16 d) 25
14. Utilize the principle of Gaussian quadrature to determine the order of polynomial that can be integrated exactly using $n$Gaussian points. *1 K3 CO5*
    a) n-1 b) 2n-1
    c) n d) 3n-1
15. Interpret the type of equation used in finite element analysis to obtain the natural frequencies of a system. *1 K2 CO6*
    a) Stiffness Equation b) Mass Equation
    c) Eigen Value Equation d) Force Equation
16. Identify the characteristic of the damping matrix commonly used in vibration analysis. *1 K3 CO6*
    a) Proportional to the mass matrix b) Proportional to the stiffness matrix
    c) A combination of mass and stiffness matrices d) Independent of both mass and stiffness matrices

**PART – A (ii) (Short Answer Questions)**
**(6 × 3 = 18 Marks)**
Answer ALL Questions

17. Develop the concept of discretization in finite element analysis. *3 K3 CO1*
18. Examine the shape functions of a two-node bar element and illustrate their relationships. *3 K4 CO2*
19. Utilize the concepts of finite elements to compare the differences between CST and LST elements. *3 K3 CO3*
20. Write the stiffness matrix for a one-dimensional heat conduction element and analyze its components. *3 K4 CO4*
21. Illustrate the concept of longitudinal vibration. *3 K3 CO5*
22. Discuss the significance of Jacobian transformation in finite element analysis and list its important applications. *3 K4 CO6*

**PART - B (Descriptive Answer Questions)**
**(6 × 11 = 66 Marks)**
Answer ALL Questions

23. a) The differential equation of a physical phenomenon is given by, *11 K3 CO1*

$$\frac{d^2y}{dx^2} + 500x^2 = 0, 0 \le x \le 1$$

By using the trial function, $y = a_1(x - x^3) + a_2(x - x^5)$. Apply the Galerkin method to determine the values of the parameters $a_1$ and $a_2$. The boundary conditions are, $y(0) = 0; y(1) = 0$.

**OR**

b) Consider the differential equation for a problem such as, *11 K3 CO1*

$$\frac{d^2y}{dx^2} + 300x^2 = 0, 0 \le x \le 1$$

with the boundary conditions, $y(0) = y(1) = 0$. The functional corresponding to this problem to be extremized is given by,

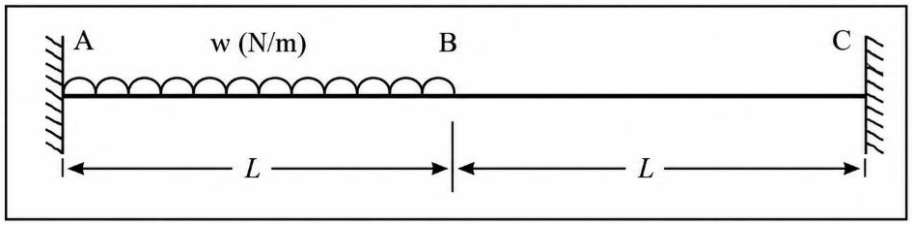
$$I = \int_0^1 \left[ -\frac{1}{2}\left(\frac{dy}{dx}\right)^2 + 300x^2 y \right] dx$$

Utilize the Rayleigh–Ritz method to obtain the solution of the differential equation $y = ax(1 - x^3)$

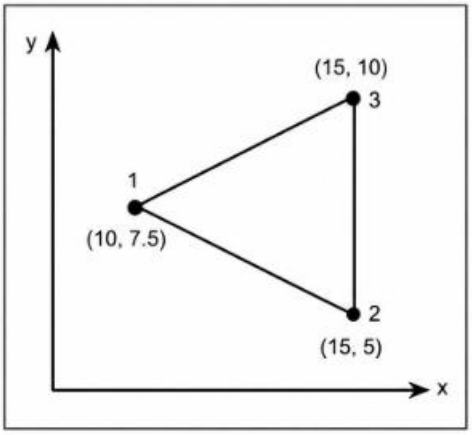
24. a) Develop the displacement function $u$ and shape function $N$ for a one-dimensional linear bar element. *11 K3 CO2*

**OR**

b) A fixed beam of length 2 L m carries a uniformly distributed load of $w$ (N/m) which run over a length of $L$ m from the fixed end, as shown in Fig. Apply the beam deflection relations to determine the rotation at point $B$. *11 K3 CO2*

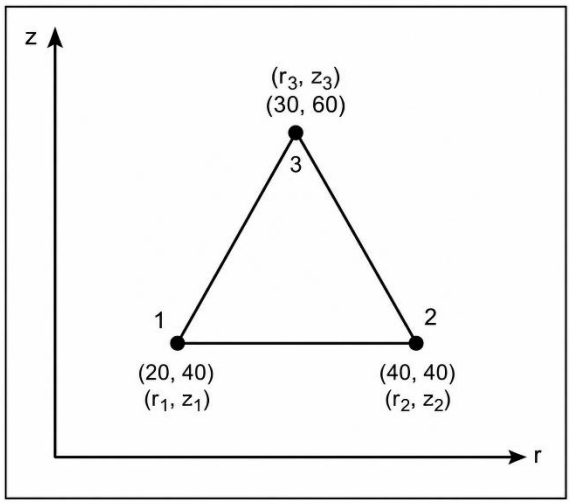



25. a) Build the stress state of the triangular element by evaluating the stresses $\sigma_x$, $\sigma_y$, $\tau_{xy}$, $\sigma_1$, $\sigma_2$ and principal angle $\theta_p$ shown in Fig. The nodal displacements are: $u_1 = 2.0$ mm, $v_1 = 1.0$ mm; $u_2 = 0.5$ mm, $v_2 = 0.0$ mm; $u_3 = 3.0$ mm, $v_3 = 1.0$ mm. Take $E = 2.1 \times 10^5$ N/mm$^2$ and $\nu = 0.25$. Assume plane stress condition. *11 K3 CO3*

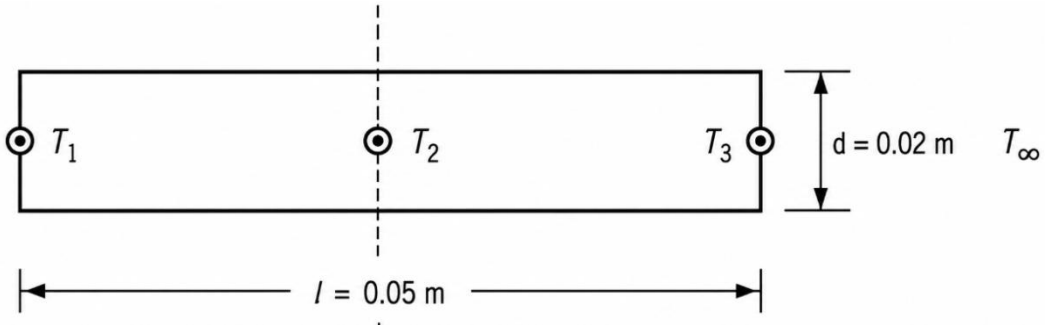



**OR**

b) The nodal co-ordinates for an axisymmetric triangular element are given below. $r_1 = 20$ mm, $z_1 = 40$ mm; $r_2 = 40$ mm, $z_2 = 40$ mm; $r_3 = 30$ mm, $z_3 = 60$ mm. Make use of the axisymmetric finite element relations to evaluate the [B] matrix. *11 K3 CO3*

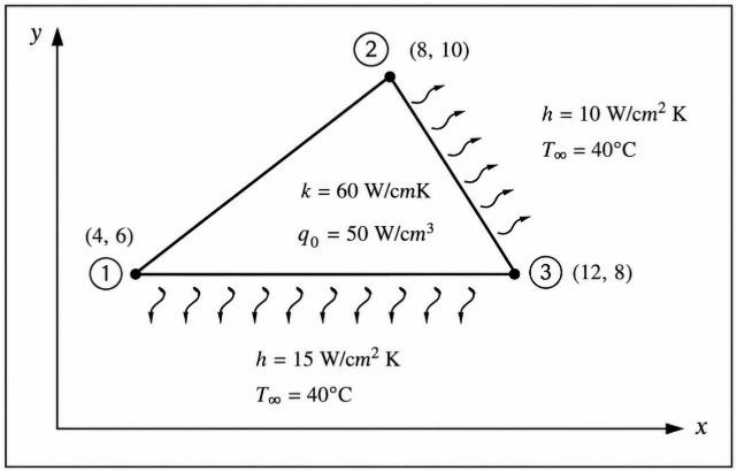



26. a) A steel rod of diameter $d = 2$ cm Length $L = 5$ cmand thermal conductivity $k = 50$ W/m˚C is exposed at one end to a constant temperature of 320°C. The other end is in ambient air of temperature 20°C with a convection coefficient of $h = 100$ W/m$^{2}$°C. Solve for the temperature at the midpoint of the rod using the given data. *11 K3 CO4*

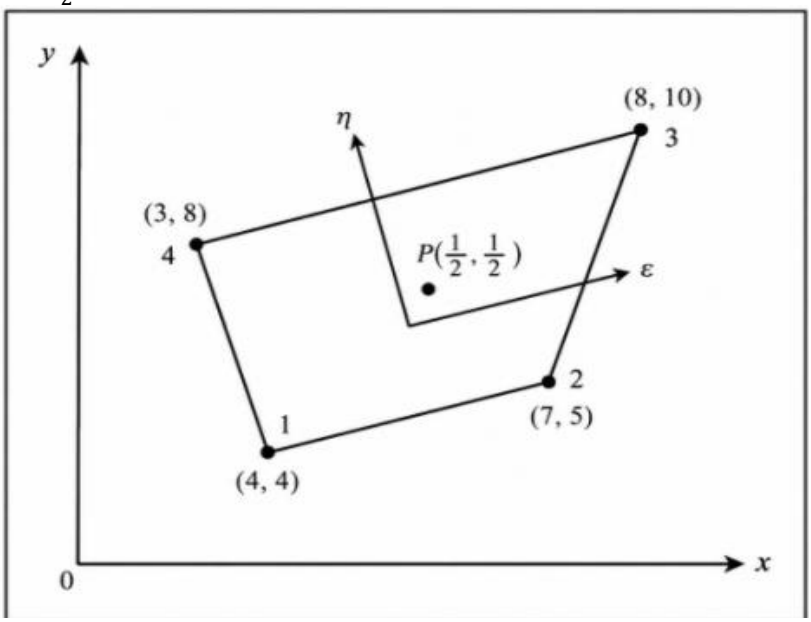



**OR**

b) Apply the finite element heat transfer formulation to compute the element matrix and vectors for the given element with convection heat loss along edges $2-3$ and $3-1$. *11 K3 CO4*



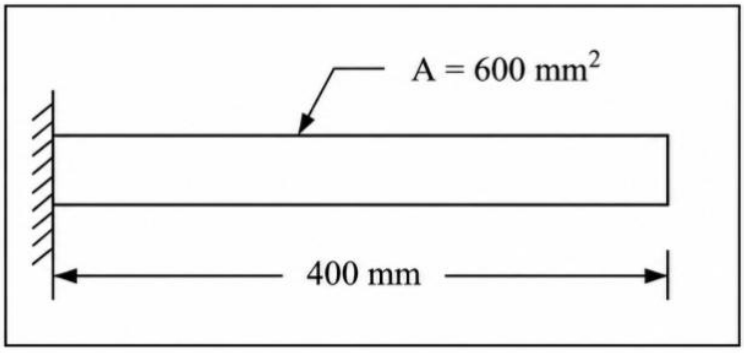
27. a) Examine the isoparametric element relations to evaluate the Jacobian matrix $[J]$ at $\varepsilon = \eta = \frac{1}{2}$ for the linear quadrilateral element shown in Fig. *11 K4 CO5*

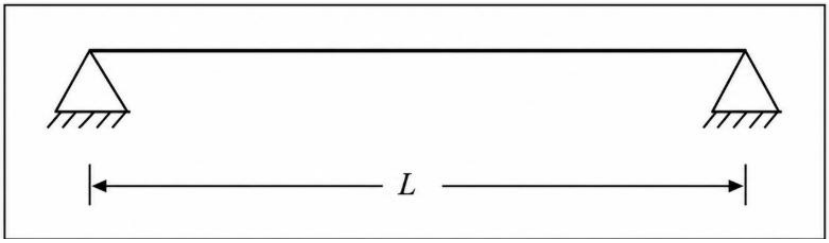



**OR**

b) Examine the integral $\int_{-1}^{1} \cos\left(\frac{x}{2}\right) dx$ by applying 3-point Gaussian quadrature. *11 K4 CO5*

28. a) Analyze the one-dimensional bar shown in Fig, determine the natural frequencies of longitudinal vibration using two elements of equal length. Take $E = 2 \times 10^5$ N/mm$^2$, $\rho = 0.8 \times 10^{-4}$ N/mm$^3$ and $L = 400$ mm. *11 K4 CO6*




**OR**

b) Consider the simply supported beam shown in Fig. Let the length $L =$ 1 m Young's modulus $E = 2 \times 10^{11}$ N/m$^2$ Area of cross-section $A = 30$ cm$^2$ Moment of inertia $I = 100$ mm$^4$ Density $\rho = 7800$ kg/m$^3$. Inspect the consistent mass matrix formulation to evaluate the natural frequency of the system. *11 K4 CO6*