Group – D

6. Evaluate the given integral analytically and using Gauss-Legendre formula.
$\int_1^5 \int_0^6 (5y^3 + 2x^2 + 5)\,dx\,dy$

4 + 8= 12

7. (a) What do you understand by CST element? Present a brief but to-the-point discussion on your understanding.

(b) Consider the isoparametric quadrilateral element in Figure 4 below. Map the point P(ξ = 0.3, η = 0.7) in the parent element to the corresponding physical point in the quadrilateral element

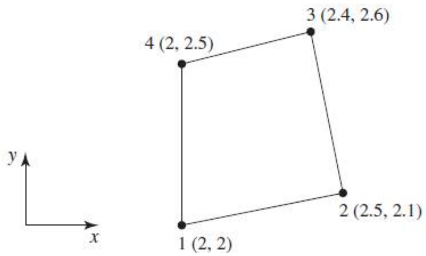

Figure 4

3 + 9=12

Group – E

8. Discuss in detail about the methodology to evaluate stress in a beam using Finite Element Method. **12**

9. Discuss about the detailed classification of different elements used in a FEA process. **12**

B.TECH/ME /5TH SEM/MECH 3142/2019

FINITE ELEMENT METHOD

(MECH 3142)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and <u>any 5 (five)</u> from Group B to E, taking <u>at least one</u> from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The eminent personality who left remarkable contribution in setting up Finite Element Method to solve any physical problem.
(a) Boris Galerkin (b) Claude-Louis Navier
(c) Sir Gorge Stokes (d) Heisenberg.

(ii) Stiffness matrix of a BEAM element is a:
(a) 3 × 3 matrix (b) 4 × 4 Matrix
(c) 2 × 2 matrix (d) Single column matrix.

(iii) Stiffness of a bar under axial loading having length ‘L’, cross-sectional area ‘A’ and Modulus of rigidity ‘E’ is
(a) $\frac{AE}{3L}$ (b) $\frac{AE}{L}$ (c) $\frac{E}{AL}$ (d) $\frac{AE}{L^2}$.

(iv) Linear strain ε_x for a beam is expressed as:
(a) $\varepsilon_x = -y\frac{d^2v}{dx^2}$ (b) $\varepsilon_x = -y\frac{dv}{dx}$
(c) $\varepsilon_x = -y\frac{d^3v}{dx^3}$ (d) $\varepsilon_x = -\frac{d^2v}{dx^2}$.

(vi) CST element possesses
(a) constant field variable throughout the element.
(b) derivative of the field variable is constant throughout the element.
(c) variation of the field variable is quadratic throughout the element.
(d) variation of the field variable is cubic throughout the element.

(vi) The coefficient in stress-strain relation for a linear, elastic, isotropic material under plane strain condition is given by-

(a) $\frac{E}{(1+\nu)}\begin{bmatrix} 1-\nu & 0 & 0 \\ \nu & 1-\nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$

(b) $\frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix} 1-\nu & \nu & 0 \\ \nu & 1-\nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$

(c) $\frac{E}{(1-2\nu)}\begin{bmatrix} 1-\nu & 0 & 0 \\ \nu & 1-\nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$

(d) $\frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix} \nu & 0 & 0 \\ \nu & \nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$.

(vii) For a Four-Noded Rectangular element if one of the shape functions in user-coordinate (x, y) is expressed as $N_1 = \left(1-\frac{x}{l}\right)\left(1-\frac{y}{w}\right)$ then the corresponding shape function in normalized coordinate (ξ, η) will be?

(a) $\frac{1}{4}(1-\xi)(1+\eta)$ (b) $\frac{1}{4}(1-\xi)(1-\eta)$

(c) $\frac{1}{2}(1-\xi)(1-\eta)$ (d) $\frac{1}{4}(1-\xi)$.

(viii) The weight factor W_i for a single point integration by Gauss Quadrature formula is

(a) 4 (b) 3 (c) 1 (d) 2.

(ix) The sequence of the numerical simulation in any FEA software is

(a) Pre-processing→Solution→Post-processing

(b) Post-processing→Solution→Pre-processing

(c) Pre-processing→Post-processing→Solution

(d) Solution→ Pre-processing→Post-processing.

(x) Which one of the following software is a FEA dedicated software

(a) CATIA (b) CRO Parametric

(c) ANSYS (d) UG NX

Group – B

2. For the following differential equation and stated boundary conditions, obtain a one-term solution using Galerkin's method of weighted residuals and the specified trial function. Compare the one-term solution to the exact solution.

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

y(0) = 0 and y(1) = 0 (Boundary conditions)

$N_1(x) = x(1-x^2)$ (Shape Function)

6 + 6 = 12

3. A simply supported beam is imposed with a distributed load of 'q' as shown in Figure 1. Write down the expression for total potential energy for this beam under this loading and boundary condition and then determine the solution function for beam deflection 'v' with respect to the domain variable 'x' considering the approximate solution $[v(x) \approx c_1 \sin(\pi x/L)]$ using Rayleigh-Ritz method. Here c1 is a constant.

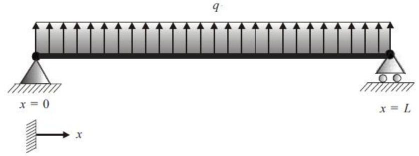

Figure 1

2 + 10 = 12

Group – C

4. Consider the spring assembly system shown in Figure 2 below. Using finite element method (FEM) find out is global stiffness matrix and then find out deflections at node 2, 3 and 4.

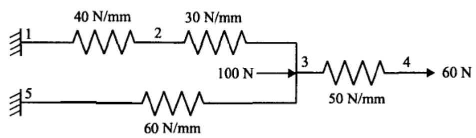

Figure 2

3 + 9 = 12

5. Find out the transverse displacement and angle of rotation of the beam at point B of the beam shown in Figure 3 below. Here ℓ = 1000 mm, w = 5 N/mm, the beam has a square cross section of dimension 15mm × 15mm and Modulus of Elasticity of the beam material is 189 GPa. Take two finite elements. First find out the nodal equivalent forces & moments for triangular load.

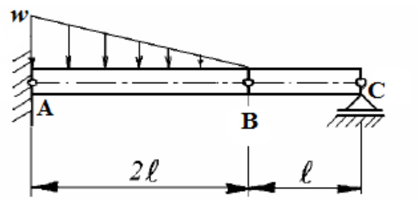

Figure 3

12