EX/PG/ME/T/129A/2019

M.E. MECHANICAL ENGINEERING FIRST YEAR

SECOND SEMESTER EXAM., 2019

FINITE ELEMENT ANALYSIS IN ENGINEERING

Time: Three hours Full Marks: 100

Answer any *five* questions. All questions carry equal marks.

1. Consider a beam element having two degrees of freedom comprising deflection and rotation. The elements of the element stiffness matrix are given as $(EI/l^3)\ K_{ij}$ where $K_{11} = 12$, $K_{22} = 4$, $K_{33} = 12$, $K_{44} = 4$, $K_{21} = K_{41} = 6$, $K_{31} = -12$, $K_{32} = K_{43} = -6$ and $K_{42} = 2$. The notations have their usual meanings. Using FEM determine the deflection at the mid-span of a fixed-fixed beam subjected to a uniformly distributed load of intensity p. The kinematically consistent element load vector is given as
$\{Q\} = (pl/12)\ [6 \quad 1 \quad 6 \quad -1]^T$

2. For a constant strain triangle (CST) finite element express the shape functions in terms of natural coordinates. Show that elements of the strain-displacement matrix of a CST finite element with isoparametric formulation are constants.

3. (a) For a four-node isoparametric quadrilateral element derive the Jacobian matrix [J]. The element is having two degrees of freedom per node and the shape functions in terms of natural coordinates ξ, η are expressed as
$N_i = 1/4\ (1+\xi\,\xi_i)(1+\eta\,\eta_i)$.

(b) For a nine-node quadrilateral element determine the shape functions using the product rule.

4. Discuss the assumptions adopted in Kirchhoff Theory for bending of flat plates. Express the strain-displacement and moment curvature relations according to Kirchhoff Theory. Discuss the procedure for deriving the element stiffness matrix of a Mindlin plate element.

5. Determine the weight factor and the location of the sampling points for two-point Gauss quadrature. With suitable diagrams show the relevant parameters of an axially symmetric finite element of rectangular cross-section. Also derive the strain-displacement matrix [B] for this element.

6. (a) Express the displacements and nodal coordinates of an eight-node isoparametric degenerated solid shell element with suitable diagrams and reasons. What should be the orders of Jacobian matrix [J] and strain-displacement matrix [B] for this element?

   (b) Discuss about the skyline storage scheme, mesh convergence, standard eigen value problem and generalized eigen value problem. Distinguish between lumped mass and consistent mass matrix formulations.