Code No: M0122 **R07** **Set No. 1**

IV B.Tech. I Semester Regular Examinations, November, 2012
FINITE ELEMENT METHODS IN CIVIL ENGINEERING
(Civil Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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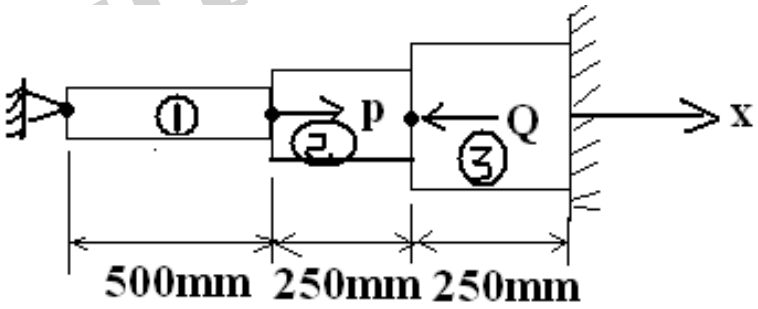
1. a) Describe the basic steps involved in the Finite Element Method of analysis.
   b) Define the stiffness matrix for axial members using Raleigh Ritz method.

2. If a displacement field is described by
   $u = (-x^2 + 2y^2 + 6xyz + 2z^2 + 4yz)\ 10^{-4}$
   $v = (3x + 6y - y^2 + 6yz + 3z)\ 10^{-4}$
   $w = (x^2 + 2y^2 + z^2 - 2z + 2xyz)\ 10^{-4}$
   Determine the strain field at the point x = 1 and y =0.

3. For the stepped bar shown in figure, determine the nodal displacements, element stress and Support reactions. Take P=300 kN, Q=500 kN, $E=2\times10^{11}$ N/m^2. A_1=250mm^2, A_2 =500mm^2, A_3=1000 mm^2.



4. a) What are the convergence conditions that should satisfy the assumed displacement function?
   b) Derive the shape functions to four node bilinear element.

5. Determine the strain displacement matrix for a right angled triangle with nodal coordinates 1 (0, 0), 2 (a, b) and 3 (0, b). Assume displacement field as $u=a_1+ a_2x+ a_3y$ *and* $v=a_4+ a_5x+ a_6y$.

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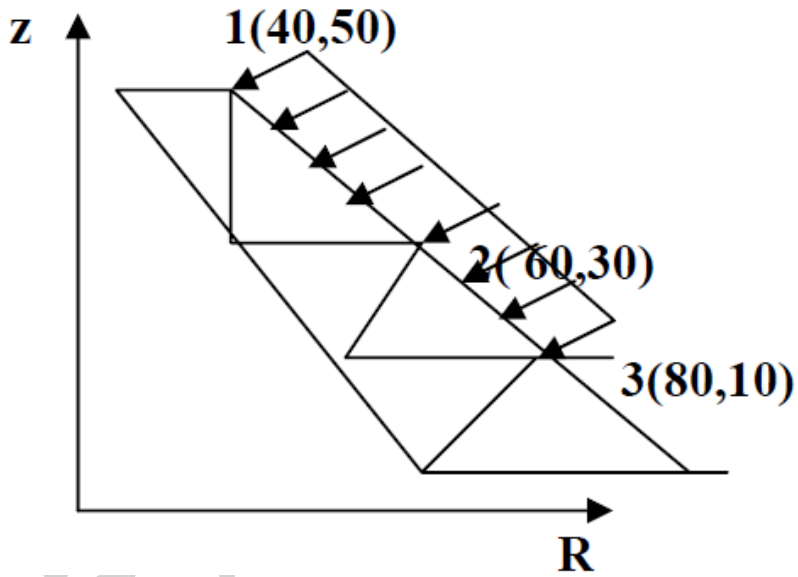
6. a) Describe isoparametric mapping procedure with an example.
   b) Derive the Jacobian matrix for a bilinear isoparametric element to solve static problems.

7. An axi-symmetric body with a uniformly distributed load of 0.3 MPa on the conical surface shown in figure below. Calculate the equivalent loads at nodes 1, 2 and 3.



8. a) Solve the following integral equation using one point, two point and three point Gaussian quadrature method and compare with exact solution
   $\int \frac{1}{1+x^3} + 3e^x \, dx$ with the limits from -1 to 1.
   b) Write about static condensation.

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1. a) State and explain the principle of minimum potential energy by considering suitable example.
   b) Finite element method is known to be an approximate method, explain.

2. Describe different stresses and equilibrium conditions for the structural problems.

3. a) Derive the shape functions to 1D finite element in which the displacement assumes a linear and quadratic degree polynomials.
   b) Derive the element characteristic matrix for the elastic bar element using force displacement relations.

4. a) Derive the shape functions for a CST element by assuming displacement function as a polynomial.
   b) What are the convergence and compatibility requirements for a finite element displacement model?

5. Compute the strain displacement matrix for a plane strain problem in terms of the ratio $r=a/b$ for the rectangular element of sides a and b, using $\upsilon=0.25$ and r=1. Assume displacement model as $u=a_1+ a_2x+ a_3 y+ a_4 xy$ *and* $v=a_5+ a_6 x+ a_7 y+a_8 xy$.

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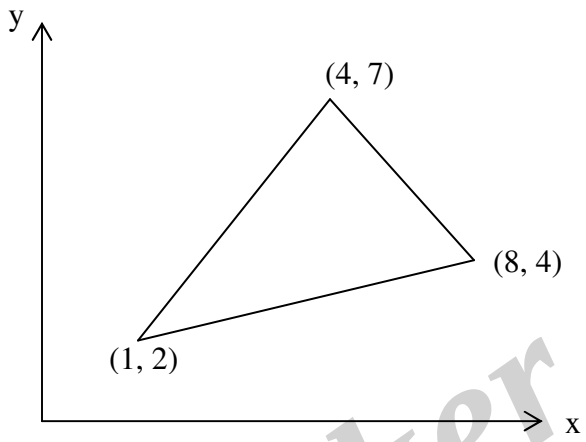
6. Obtain the strain-displacement matrix for the triangular element shown in Figure using the isoparametric transformation.



7. In an axi-symmetric problem, the element coordinates and displacements in r and z directions are given below :

Node No.	Coordinates	Displacements
1	(1,1)	(0,0)
2	(10,4)	(-0.2,-0.1)
3	(6,7)	(0.6,0.8)

Calculate the strains and stresses developed in the element.

8. Explain in detail the following:
   a) Full integration
   b) Under integration and spurious modes.

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(Civil Engineering)

Time: 3 Hours **Max Marks: 80**

Answer any FIVE Questions
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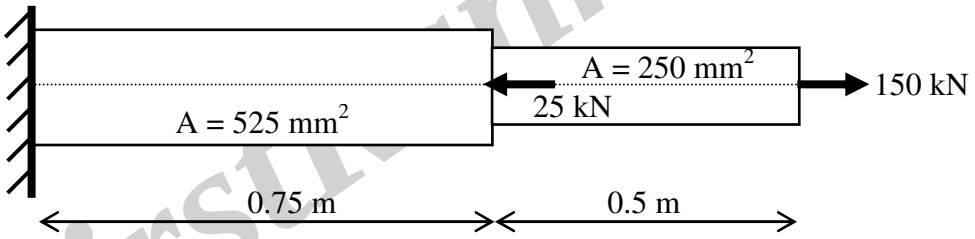
****

1. a) Define finite Element method and its applications in structural Engineering.
   b) Define principle of virtual work and state the theorem of virtual forces.

2. Develop the stress-strain relations and strain-displacement relations for two dimensional elasticity problems.

3. a) Determine the nodal displacements and element stresses for the stepped bar shown in figure. Assume E =210 GPa.



4. a) Derive the shape functions to linear triangular element using natural coordinates.
   b) What is geometric invariance? Explain how do you achieve this property with an example.

5. a) Describe the procedure for generation of stiffness matrix to a four node rectangular element to solve the plane strain problem.
   b) Derive the finite element load vector to a triangular element of constant body force.

6. Describe the concept of isoparametric formulation and sketch different elements used in isoparametric formulation with Cartesian and curvilinear coordinates.

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7. Compute the strain displacement matrix and also the strains of a axi-symmetric triangular element with the coordinates r_1= 3 cm, z_1= 4 cm, r_2 = 6 cm, z_2 = 5 cm, r_3 = 5 cm, z_3 = 8 cm. The nodal displacement values are u_1 = 0.01 mm, w_1 = 0.01 mm, u_2 = 0.01 mm, w_2 = -0.04 mm, u_3 = -0.03 mm, w_3 = 0.07 mm.

8. a) Evaluate the integral $\iint (x^2 + y^2)\, dx\, dy$ by Gaussian quadrature over the area of quadrilateral with the co-ordinates 1(1,1), 2(5,1), 3(6,6) and 4(1,4).
   b) Discuss various solution techniques for static loads.

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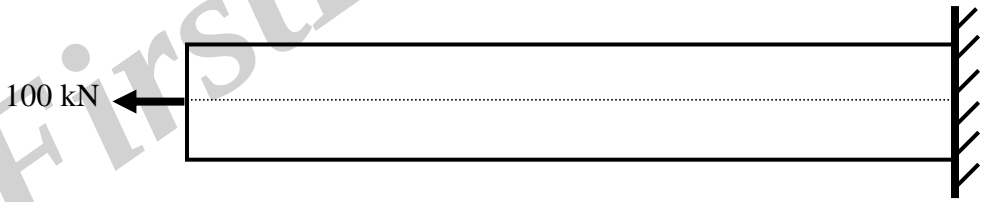
1. a) Describe the Rayleigh-Ritz method with an example.
   b) What do you mean by zero slope condition with respect to energy function?

2. a) Explain the strain-displacement matrix and derive the constitutive matrix for a plane stress condition.
   b) What is meant by an Axi-symmetric problem? How do you carry finite element analysis of such problems?

3. a) Derive the shape functions to one dimensional element with one degree of freedom per node.
   b) Determine the elongation and the support reaction of a steel bar, shown in figure of length 1.25 m long and having cross-sectional area 625 mm^2. Assume E= 210 GPa and μ=0.3.



4. a) State different finite elements which are suitable for the analysis of plane stress and plane strain problems.
   b) Derive the shape functions to four node bilinear element using natural coordinates.

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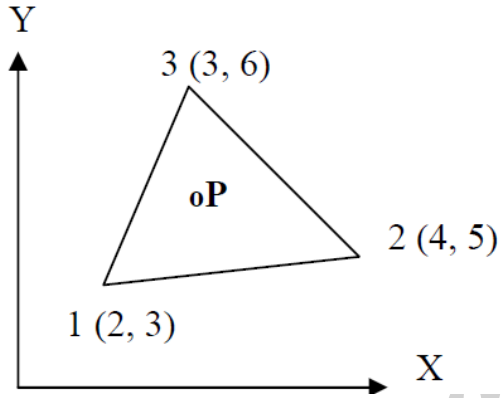
5. a) What is a constant strain triangular element? State its properties and applications.
   b) The nodal coordinates of the triangular element are shown in Figure below. At the interior point P, the X co-ordinate is 2.6 and N_1 =0.4. Find N_2, N_3 and the Y coordinate at point P.



6. a) What is isoparametric formulation? What type of shape functions are usually used in the isoparametric formulation?
   b) Prove that determinant of Jacobian matrix of a triangular element is twice the area of that element.

7. Derive the strain displacement matrix for an axially symmetric ring of rectangular cross-section.

8. a) Explain in detail selective integration method.
   b) Using a 2 x 2 rule, evaluate the integral over the given area by Gaussian quadrature.