Code No: RR410104 **Set No.1**

IV B.Tech. I Semester Regular Examinations, November -2005
FINITE ELEMENT METHODS
(Civil Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What is a boundary value problem ? [4]
   (b) Explain an initial value problem. [4]
   (c) Explain the difference between homogeneous and non homogeneous initial conditions. [4]
   (d) What is an eigen functions. [4]

2. (a) What do you understand by functional approximation Explain giving engineering parameters. [6]
   (b) Explain how Rayleigh's method can be used to approximate the first natural frequency of a beam. [10]

3. The potential energy of a torsion menton is given by the expression
   $\pi = \frac{1}{2}\int_0^1 EI_W \left[\frac{d^2\phi}{dx^2}\right]^2 + GJ\left[\frac{d^2\phi}{dx}\right]^2 dx - \int_0^1 \bar{M}\phi\, dx$
   Where J and Iw are the torsion and warping constants respectively. G is the shear modulus. θ is the angle of twist and M is the applied twisting moment/unit length of the member. Develop Euler equation and boundary conditions for the functional.

   [16]

4. A helical spring of made of a 2 mm rod of material having E=2.38 x 10^7 N/m^2. The spring is having a length of 22 mm having 10 coils. Model the spring and determine the location and magnitude of maximum stress induced for an axial load of 60 kN applied at one end, where as the other end is fixed. [16]

5. (a) Discuss the continuity requirement of for shape function (C_1 continuity) [8]
   (b) Explain the compatibility condition for polynomial expressions to be used for shape functions. [8]

6. Determine the first two longitudinal natural frequencies of a rod (A,E,L,m) , fixed at one end and with an attached mass m^2 at the other. Use two linear elements. Boundary conditions for the beam are u(0) = 0 and $EA\,\frac{\partial u}{\partial x} + m_2\,\partial^2 u/\partial(L)|_{x=L} = 0$. [16]

7. A Uniform cantilever beam of length L, moment of Inersial I, modulus of elasticity E and mass m begins to vibrate with initial displacement, $w(x,0)= w_0 x^2/L^2$and zero initial velocity. Find its displacement at a subsequent time using Euler-Bernouli beam element.

[16]

8. (a) Define Isoparametric elements? [3]
   (b) Give two reasons for Isoparametric elements to have become popular. [4]
   (c) Write a detailed notes on curved sided elements. [9]

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1. (a) Give a detailed historic background of Finite elements. [10]
   (b) What are the areas of general application of Finite element method? [6]

2. Solve the poison equation governing heat conduction in a square region -K ∇^2 T = q0 T=0 on side x=1 and y=1, $\frac{\partial T}{\partial n} = 0$ (insulated) on sides x=0 and y=0 using a one parameter Rayleigh-Ritz approximation of for a .

   $$T_1(x,y) = C_1 (1\text{-}x^2) (1 - y^2)$$ [16]

3. A bar of length L has a cross-sectional area, which varied linearly from value 2A at end 1 to A at end 2. End 1 is held against any moment while the bar is stretched by an axial force F applied at end Z. Obtain solutions for axial displacements and axial stress distributions and the value of the potential energy based on the following displacement field in turns.

   (a) $U = C_1X$
   (b) $U = C_1X + C_2X^2$ [8+8]

   Compare the results obtained with exact solution.

4. A boiler drum holds the steam at a presume of 60 bar. The internal diameter of the drum is 50 mm and the outer diameter is 80 mm. The E=2.8 x 10^7 N/m^2. Model the drum for the given load condition considering its axis symmetric shape.

   [16]

5. (a) Discuss the continuity requirement of for shape function (C_1 continuity) [8]
   (b) Explain the compatibility condition for polynomial expressions to be used for shape functions. [8]

6. (a) What do you understand by pascal triangle and its relevance in geometric isotropy.

   [6]

   (b) Derive volume integral of a tetrahedron element . Considering it in a system of natural co-ordinates. [10]

7. The flow of liquid in a pipe subjected to a surge of pressure wave (live a water hammer) experiences a surge of pressure P, which is given by the governing equation.

$\frac{\partial^2 p}{\partial t^2} - c^2 \frac{\partial^2 p}{\partial x^2} = 0, \quad C^2 = \frac{1}{m} \left[\frac{1}{k} \frac{D}{bE}\right]^{-1}, \ where$

M is the mass density, K is the bulk modulus of the fluid, D is modulus of elasticity of the material. Determine the pressure P(x,t) using one linear finite element, for the following boundary conditions.
P(O,t) = P_0, P(L,$_t$)= 0, P(x,0) = P_0 [16]

8. Derive the shape functions and the element stiffness matrix for an axisymmetric annular ring element as shown in the figure1 . [16]

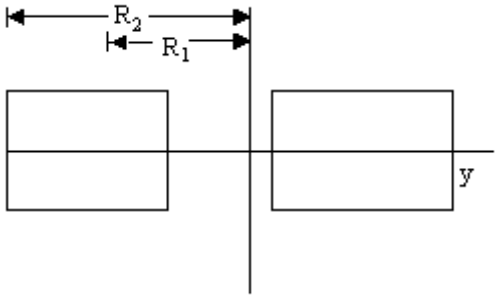

Figure 1:

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Code No: RR410104 **Set No.3**

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1. (a) Explain how a standard problems treatment can lead to Finite element method of approximation to continuum problems. [10]
   (b) Give some examples to eigen value problems in solid mechanics and Fluid Mechanics. [6]
2. (a) Compare the Rayleigh's method of functional approximation with Gale rkin's functional approximation. [6]
   (b) Find the fundamental natural frequency of the cantilever beam shown in figure2 using Rayleigh's method. [10]

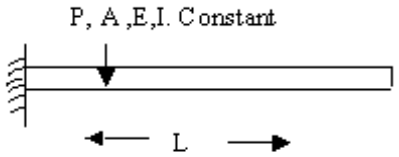

Figure 2:

3. A rectangular plane 1m length and 0.4m width and 10mm thickness has a central hole of 160mm. The plane is subjected to a tensile force 15N/mm in y-direction. Using constant strain triangles, obtain the displacements. Also find the maximum and minimum principle stressed. [16]
4. A helical spring of made of a 2 mm rod of material having E=2.38 x 10^7 N/m^2. The spring is having a length of 22 mm having 10 coils. Model the spring and determine the location and magnitude of maximum stress induced for an axial load of 60 kN applied at one end, where as the other end is fixed. [16]
5. (a) Discuss the continuity requirement of for shape function (C_1 continuity) [8]
   (b) Explain the compatibility condition for polynomial expressions to be used for shape functions. [8]
6. (a) What do you understand by pascal triangle and its relevance in geometric isotropy.

   [6]

(b) Derive volume integral of a tetrahedron element . Considering it in a system of natural co-ordinates. [10]

7. A bar of length L and mass n is fixed at x=0 and loaded with mass u at x=L. Determine the motion u(x,t) of the system when the mass u is subjected to a load P_0. Use one linear finite element. [16]

8. Find the interpolation function corresponding to node 3 of a quadratic triangular element using . [16]

$$-N_i = f^i_{(L1)} f^i_{(L2)} f^i_{(L3)} - (E_1) \qquad where$$

$$F^i_{(Lj)} = \begin{cases} p & 1/k(m1_j - k + 1) \quad if\ P \geq 1 - (E_2) \\ \Pi & K = 1 \quad if\ P = 0 \\ 1 & \end{cases}$$

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Code No: RR410104 **Set No.4**

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1. (a) What do you understand by Transformation of Co-ordinates and why it is resorted to. [4]
   (b) Explain the discontinuity of displacement functions between elements. [8]
   (c) What do you understand by patch test and explain its relevance in convergence. [4]

2. For a Cantilever beam of under uniformly distributed load of intensity P_o per unit length and end mount No, find the transverse defection using Rayleigh-Ritz functional evaluation and compare the results with exact analytical solution . [16]

3. A bar of length L has a cross-sectional area, which varied linearly from value 2A at end 1 to A at end 2. End 1 is held against any moment while the bar is stretched by an axial force F applied at end Z. Obtain solutions for axial displacements and axial stress distributions and the value of the potential energy based on the following displacement field in turns.
   (a) $U = C_1X$
   (b) $U = C_1X + C_2X^2$ [8+8]

   Compare the results obtained with exact solution.

4. A compressed air receiver is made of a mild. Steel (E=2.3 x 10^7 N/m^2) is subjected to internal presume of 2.8 bar air presume. Model the receiver vessel cylindrical in shape, if its internal diameter is 750 mm and external diameter is 1200 mm. [16]

5. The cubic interpolation function for the displacement of a beam element is expressed as

   $\phi(x) = \alpha_1 = \alpha_2\, x + \alpha_3\, x^2 + \alpha_4\, x^3$ with the degrees of freedom defined asϕ_1=ϕ(x,x_1), ϕ_2 = dϕ/dx (x = x1) ϕ_3 =ϕ(x-x_2) and ϕ_4 = (dϕ/dx) (x=x_2) where x_1 and x_2 are x- co-ordinate of node 1 and 2 of the element. If x_1 = 1.0 inch and X_2 = 6 inches, determine matrices $[\eta]$, $[\eta]^{-1}$ and [N] - [16]

6. For a triangular element in a stage of plane stress, it is proposed to consider three corner and three inside nodes. Suggest a suitable displacement model and discuss its convergence and other properties. [16]

7. A bar of length L and mass n is fixed at x=0 and loaded with mass u at x=L. Determine the motion u(x,t) of the system when the mass u is subjected to a load P_0. Use one linear finite element. [16]

8. Assume the quadratic serendipity element shown Figure3is to be used to solve a field problem with one dependent variable Q (x,y). [16]

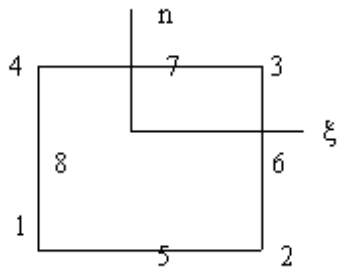

Figure 3:

(a) Derive shape functions

(b) Write $|N|$ [Q]

(c) Write [B] matrix such that
$$\begin{bmatrix} Q_{1x} \\ Q_{1y} \end{bmatrix} = [B]\,[Q]$$

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