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Invigilator's Signature :	

CS/B.TECH/AUE/SEM-8/AUE-819/2013

2013 FINITE ELEMENT METHOD AND ITS APPLICATION

Time Allotted : 3 Hours

Full Marks: 70

The figures in the margin indicate full marks. Candidates are required to give their answers in their own words as far as practicable.

GROUP - A

(Multiple Choice Type Questions)

- 1. Choose the correct alternatives for the following : $10 \times 1 = 10$
 - i) For a 4-noded quadrilateral element having one degree of freedom at each node, the dimension of element stiffness matrix is

a)	4 × 4	b)	2×4
c)	8 × 8	d)	3 × 3.

ii) The sum of the shape functions for an element should be equal to

- a) 1
- b) 0
- c) equal to the number of nodes
- d) none of these.

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- iii) $U = a_0 + bx + cy$ is the deformation field in the case of a
 - a) constant strain field
 - b) linearly varying strain field
 - c) parabolic variation of strain field
 - d) cubic variation of strain field.

iv) $f(\xi) = \xi^2 + 2\xi + 1$. The value of $\int_{-1}^{1} f(\xi) d\xi$ by two-point

method is

- a) 2.0 b) 1.667
- c) 2.667 d) none of these.
- v) Finite element formulations can be extended for
 - a) structural problems
 - b) mechanical vibration analysis
 - c) fluid flow problems
 - d) all of these.
- vi) A short ring fitted on a shaft may be treated for 2-D case as
 - a) Plane stress
 - b) Plane strain
 - c) Either plane stress or plane strain
 - d) None of these.



vii) The element stiffness matrix leads to the global stiffness matrix using the process of

- a) Assembly b) Addition
- c) Selection d) None of these.
- viii) The process of dividing a physical domain with finite elements is referred to in FEM as
 - a) Meshing b) Normalizing
 - c) Minimizing d) None of these.
- ix) The number of interpolation functions to be used in theFinite Element Analysis of a triangular element is
 - a) Four b) Three
 - c) Six d) Any of these.
- x) The strain energy per unit volume is given by
 - a) $\frac{1}{2} \times \text{Stress} \times \text{Strain}$
 - b) Stress × Strain
 - c) Stress + Strain
 - d) None of these.

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GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

- 2. a) What is meant by interpolation/shape functions ? Explain with an example.
 - b) What are the properties that the shape functions should satisfy ? 3 + 2
- a) Discuss the roles of Preprocessor, Model Solution and Post-processor in FEM.
 - b) Write in detail, about some of the computer packages available for FEM.
 2 + 3
- 4. a) Explain the meaning of numerical integration in FEM.
 - b) How do you compare finite element method with finite difference method ? 3 + 2
- 5. a) Enumerate the advantages of FEM.
 - b) What is the application of boundary conditions in FEM ? Illustrate with proper examples. 2 + 3
- 6. Solve the following system of simultaneous equations by the Gaussian Elimination Method :

$$4x_1 + 2x_2 + 3x_3 = 4$$
$$2x_1 + 3x_2 - 5x_3 = 2$$
$$2x_1 + 7x_2 = 4$$

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(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

- a) Explain briefly the weighted residual method for obtaining approximate solutions of finite element equations.
 - b) Explain the Galerkin's method of weighted residuals.
 - c) Determine the global stiffness matrix for the bar elements as shown in the figure using the assembly approach (A = Cross-sectional Area, E = Young's Modulus, L = Length of a bar element).



4 + 3 + 8

- 8. a) Using isoparametric formulation, determine the expressions for strain in a constant strain triangle (CST).
 - b) For point P located inside the triangle shown in the figure, the shape functions N_1 and N_2 are 0.15 and 0.25,

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respectively. Assuming isoparametric formulation, determine the *x*- and *y*-coordinates of point *P*.



10 + 5

- a) Derive the relations between the stresses and strains for both plane stress and plane strain problems.
 - b) In a plane stress problem, given that $\sigma_x = 100$ MPa, $\sigma_y = -150$ MPa, E = 200GPa, G = 100GPa, and v = 0.3. Determine the values of the strains ε_x , ε_y and γ_{xy} . 10 + 5
- a) Determine the Gaussian weighting factors and sampling points for one-dimensional integration using the twopoint method.
 - b) Evaluate the integral using Gaussian integration with one and two-point Gauss Quadrature and compare them with the exact integration value :

$$I = \int_{-1}^{1} \left[\frac{r^2 - 1}{(r+3)^2} \right] dr \qquad 6 + 9$$

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11. For the two-element truss configuration as shown in the figure, determine the global stiffness matrix. Given, E = 200 GPa, $A = 1.5 \text{m}^2$ (for both the elements).



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