

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) $4 \times 4$
b) $2 \times 4$
c) $8 \times 8$
d) $3 \times 3$.
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) $U=a_{0}+b x+c y$ 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 the Finite Element Analysis of a triangular element is
a) Four
b) Three
c) $\quad \mathrm{Six}$
d) Any of these.
x) The strain energy per unit volume is given by
a) $\frac{1}{2} \times$ Stress $\times$ Strain
b) Stress $\times$ 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? $3+2$
3. 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.
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 :

$$
\begin{aligned}
& 4 x_{1}+2 x_{2}+3 x_{3}=4 \\
& 2 x_{1}+3 x_{2}-5 x_{3}=2 \\
& 2 x_{1}+7 x_{2}=4
\end{aligned}
$$


( Long Answer Type Questions )
Answer any three of the following. $\quad 3 \times 15=45$
7. 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 ( $\mathrm{A}=$ Cross-sectional Area, $\mathrm{E}=$ Young's Modulus, $\mathrm{L}=$ 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 $P$.


$$
10+5
$$

9. 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 $\sigma_{x}=100 \mathrm{MPa}$, $\sigma_{y}=-150 \mathrm{MPa}, \mathrm{E}=200 \mathrm{GPa}, \mathrm{G}=100 \mathrm{GPa}$, and $v=0.3$. Determine the values of the strains $\varepsilon_{x}, \varepsilon_{y}$ and $\gamma_{x y} .10+5$
10. 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 :

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


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


