

## ME 6603 –FINITE ELEMENT ANALYSIS

### PART A QUESTIONS WITH ANSWERS

#### UNIT 1

1. What is meant by finite element?

A small units having definite shape of geometry and nodes is called finite element.

2. What is meant by node or joint?

Each kind of finite element has a specific structural shape and is inter- connected with the adjacent element by nodal point or nodes. At the nodes, degrees of freedom are located. The forces will act only at nodes at any others place in the element.

3. What is the basic of finite element method?

Discretization is the basis of finite element method. The art of subdividing a structure in to convenient number of smaller components is known as discretization.

4. What are the types of boundary conditions?

Primary boundary conditions

Secondary boundary conditions

5. State the methods of engineering analysis?

Experimental methods

Analytical methods

Numerical methods or approximate

methods

6. What are the types of element?

7. 1D element

2D element

3D element

8. State the three phases of finite element method.

Preprocessing

Analysis

Post Processing

9. What is structural problem?

Displacement at each nodal point is obtained. By these displacements solution stress and strain in each element can be calculated.

10. What is non structural problem?  
Temperature or fluid pressure at each nodal point is obtained. By using these values properties such as heat flow fluid flow for each element can be calculated.
10. What are the methods are generally associated with the finite element analysis?  
Force method  
Displacement or stiffness method.
11. Explain stiffness method.  
Displacement or stiffness method, displacement of the nodes is considered as the unknown of the problem. Among them two approaches, displacement method is desirable.
12. What is meant by post processing?  
Analysis and evaluation of the solution result is referred to as post processing. Postprocessor computer program help the user to interpret the result by displaying them in graphical form.
13. Name the variation methods. Ritz method.  
Ray-Leigh Ritz method.
14. What is meant by degrees of freedom?  
When the force or reaction act at nodal point node is subjected to deformation. The deformation includes displacement rotation, and or strains. These are collectively known as degrees of freedom
15. What is meant by discretization and assemblage?  
The art of subdividing a structure in to convenient number of smaller components is known as discretization. These smaller components are then put together. The process of uniting the various elements together is called assemblage.
16. What is Rayleigh-Ritz method?  
It is integral approach method which is useful for solving complex structural problem, encountered in finite element analysis. This method is possible only if a suitable function is available.
17. What is Aspect ratio?  
It is defined as the ratio of the largest dimension of the element to the smallest
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dimension. In many cases, as the aspect ratio increases the in accuracy of the solution increases. The conclusion of many researches is that the aspect ratio

18. What is truss element?

The truss elements are the part of a truss structure linked together by point joint which transmits only axial force to the element.

19. What are the h and p versions of finite element method?

It is used to improve the accuracy of the finite element method. In h version, the order of polynomial approximation for all elements is kept constant and the numbers of elements are increased. In p version, the numbers of elements are maintained constant and the order of polynomial approximation of element is increased.

20. Name the weighted method

Point collocation method

Sub domain collocation  
method

Least squares method

Galerkins method.

## UNIT 2

21. List the two advantages of post processing.

Required result can be obtained in graphical form. Contour diagrams can be used to understand the solution easily and quickly.

22. During discretization, mention the places where it is necessary to place a node?

Concentrated load acting point

Cross-section changing point

Different material interjections

Sudden change in point load

23. What is the difference between static and dynamic analysis?

Static analysis: The solution of the problem does not vary with time is known as static analysis

Example: stress analysis on a beam

Dynamic analysis: The solution of the problem varies with time is known as dynamic analysis

24. Name any four FEA softwares.

ANSYS

NASTRAN

COSMOS

25. Differentiate between global and local axes.

Local axes are established in an element. Since it is in the element level, they change with the change in orientation of the element. The direction differs from element to element.

Global axes are defined for the entire system. They are same in direction for all the elements even though the elements are differently oriented.

26. Distinguish between potential energy function and potential energy functional

If a system has finite number of degree of freedom ( $q_1, q_2, \text{and } q_3$ ), then the potential energy expressed as,

$$\pi = f(q_1, q_2, \text{and } q_3)$$

It is known as function. If a system has infinite degrees of freedom then the potential energy is expressed as

27. What are the types of loading acting on the structure?  
Body force (f)  
Traction force (T)  
Point load (P)
28. Define the body force  
A body force is distributed force acting on every elemental volume of the body  
Unit: Force per unit volume.  
Example: Self weight due to gravity
29. Define traction force  
Traction force is defined as distributed force acting on the surface of the body.  
Unit: Force per unit area.  
Example: Frictional resistance, viscous drag, surface shear
30. What is point load?  
Point load is force acting at a particular point which causes displacement.
31. What are the basic steps involved in the finite element modeling.  
Discretization of structure.  
Numbering of nodes.
32. Write down the general finite element equation.  
$$\{F\} = [K] \{u\}$$
33. What is discretization?  
The art of subdividing a structure into a convenient number of smaller components is known as discretization.
34. What are the classifications of coordinates?  
Global coordinates  
Local coordinates  
Natural coordinates
35. What is Global coordinates?  
The points in the entire structure are defined using coordinate system is known as global coordinate system.

36. What is natural coordinates?  
A natural coordinate system is used to define any point inside the element by a set of dimensionless number whose magnitude never exceeds unity. This system is very useful in assembling of stiffness matrices.
37. Define shape function.  
Approximate relation  $\phi(x,y) = N_1(x,y) \phi_1 + N_2(x,y) \phi_2 + N_3(x,y) \phi_3$   
Where  $\phi_1$ ,  $\phi_2$ , and  $\phi_3$  are the values of the field variable at the nodes  $N_1$ ,  $N_2$ , and  $N_3$  are the interpolation functions.  
 $N_1$ ,  $N_2$ , and  $N_3$  are also called shape functions because they are used to express the geometry or shape of the element.
38. What are the characteristic of shape function?  
It has unit value at one nodal point and zero value at other nodal points. The sum of shape function is equal to one.
39. Why polynomials are generally used as shape function?  
Differentiation and integration of polynomial are quit easy.  
The accuracy of the result can be improved by increasing the order of the polynomial.  
It is easy to formulate and computerize the finite element equations
40. How do you calculate the size of the global stiffness matrix?

Global stiffness matrix size = Number of nodes X Degrees of freedom per node

### UNIT 3

41. Write down the expression of stiffness matrix for one dimensional bar element.

$$[K] = \frac{AE}{l} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

42. State the properties of stiffness matrix. It is a symmetric matrix.

The sum of elements in any column must be equal to zero.  
It is an unstable element. So the determinant is equal to zero.

43. Write down the expression of stiffness matrix for a truss element.

$$[K] = \frac{EA}{l} \begin{bmatrix} \cos^2 \theta & \cos \theta \sin \theta & -\cos \theta & 0 \\ \cos \theta \sin \theta & \sin^2 \theta & \sin \theta & 0 \\ -\cos \theta & \sin \theta & \cos \theta & -\sin \theta \\ 0 & 0 & -\sin \theta & -\cos \theta \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{Bmatrix}$$

44. Write down the expression of shape function N and displacement u for one dimensional bar element.

$$U = N_1 u_1 + N_2 u_2$$

$$N_1 = 1 - X/l$$

$$N_2 = X/l$$

45. Define total potential energy.

Total potential energy,  $\pi =$  Strain energy (U) + potential energy of the external forces (W)

46. State the principle of minimum potential energy.

Among all the displacement equations that satisfied internal compatibility and the boundary condition those that also satisfy the equation of equilibrium make the potential energy a minimum is a stable system.

47. Write down the finite element equation for one dimensional two noded bar element.

$$[K] = \frac{AE}{l} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

48. What is truss?

A truss is defined as a structure made up of several bars, riveted or welded together.

49. States the assumption are made while finding the forces in a truss. All the members are pin jointed.  
The truss is loaded only at the joint  
The self weight of the members is neglected unless stated.
50. State the principles of virtual energy?  
A body is in equilibrium if the internal virtual work equals the external virtual work for the every kinematically admissible displacement field
51. What is essential boundary condition?  
Primary boundary condition or EBC Boundary condition which in terms of field variable is known as Primary boundary condition.
52. Natural boundary conditions?  
Secondary boundary natural boundary conditions which are in the differential form of field variable is known as secondary boundary condition
53. How do you define two dimensional elements?  
Two dimensional elements are define by three or more nodes in a two dimensional plane. The basic element useful for two dimensional analysis is the triangular element.
54. What is CST element?  
Three noded triangular elements are known as CST. It has six unknown displacement degrees of freedom ( $u_1, v_1, u_2, v_2, u_3, v_3$ ). The element is called CST because it has a constant strain throughout it.
55. What is LST element?  
Six noded triangular elements are known as LST. It has twelve unknown displacement degrees of freedom. The displacement function for the elements are quadratic instead of linear as in the CST.
56. What is QST element?  
Ten noded triangular elements are known as Quadratic strain triangle. It is also called as cubic displacement triangle.
58. What meant by plane stress analysis?  
Plane stress is defined to be a state of stress in which the normal stress and shear stress directed perpendicular to the plane are assumed to be zero.



## UNIT 4

61. Write down the stiffness matrix equation for two dimensional CST elements.

$$\text{Stiffness matrix } [K] = [B]^T [D] [B] A t$$

$[B]^T$  - Strain displacement  $[D]$  - Stress strain matrix  $[B]$  - Strain displacement matrix

62. Write down the stress strain relationship matrix for plane stress conditions.

$$\frac{E}{1+\nu} \frac{1-2\nu}{2} \begin{pmatrix} 1-\nu & \nu & 0 \\ 0 & 1-\nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{pmatrix}$$

63. What is axisymmetric element?

Many three dimensional problem in engineering exhibit symmetry about an axis of rotation such type of problem are solved by special two dimensional element called the axisymmetric element

64. What are the conditions for a problem to be axisymmetric?

The problem domain must be symmetric about the axis of revolution

All boundary condition must be symmetric about the axis of revolution

All loading condition must be symmetric about the axis of revolution

65. Give the stiffness matrix equation for an axisymmetric triangular

element. Stiffness matrix  $[K] = [B]^T [D] [B] 2\pi r A$

66. What is the purpose of Isoparametric element?

It is difficult to represent the curved boundaries by straight edges finite elements. A large number of finite elements may be used to obtain reasonable resemblance between original body and the assemblage.

67. Write down the shape functions for 4 noded rectangular elements using natural coordinate system.

$$N_1 = \frac{1}{4} (1-\varepsilon)(1-\eta) \quad N_2 = \frac{1}{4} (1+\varepsilon)(1-\eta)$$

$$N_3 = \frac{1}{4} (1+\varepsilon)(1+\eta) \quad N_4 = \frac{1}{4} (1-\varepsilon)(1+\eta)$$

68. Write down Jacobian matrix for 4 noded quadrilateral elements.

$$[J] = \begin{pmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{pmatrix}$$

69. Write down stiffness matrix equation for 4 noded isoparametric quadrilateral elements.

$$\text{Stiffness matrix } [K] = t \int_{-1}^1 \int_{-1}^1 [B]^T [D] [B] J \delta\varepsilon \delta\eta$$

70. Define super parametric element.

If the number of nodes used for defining the geometry is more than of nodes used for defining the displacement is known as super parametric element

71. Define sub parametric element.

If the number of nodes used for defining the geometry is less than number of nodes used for defining the displacement is known as sub parametric element.

72. What is meant by Isoparametric element?

If the number of nodes used for defining the geometry is same as number of nodes used for defining the displacement is known as Isoparametric element.

73. Is beam element an Isoparametric element?

Beam element is not an Isoparametric element since the geometry and displacement are defined by different order interpretation functions.

74. What is the difference between natural coordinate and simple natural coordinate?

$$L1 = 1-x/l$$

$$L2 = x/l$$

75. What is Area coordinates?

$$L1 = A1/A \quad L2 = A2/A \quad L3 = A3/A$$

76. What is simple natural coordinate?

A simple natural coordinate is one whose value between -1 and 1.

77. Give example for essential boundary conditions.

The geometry boundary condition are displacement, slope.

78. Give example for non essential boundary conditions.

The natural boundary conditions are bending moment, shear force

79. What is meant by degrees of freedom?

When the force or reaction act at nodal point node is subjected to deformation. The deformation includes displacement rotation, and or strains. These are collectively known as degrees of freedom.

80. What is QST element?

Ten noded triangular elements are known as Quadratic strain triangle. It is also called as cubic displacement triangle.

## UNIT 5

81. What meant by plane stress analysis?

Plane stress is defined to be a state of stress in which the normal stress and shear stress directed perpendicular to the plane are assumed to be zero.

82. Define plane strain analysis.

Plane strain is defined to be state of strain normal to the x,y plane and the shear strains are assumed to be zero.

83. What is truss element?

The truss elements are the part of a truss structure linked together by point joint which transmits only axial force to the element.

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86. During discretization, mention the places where it is necessary to place a node?

Concentrated load acting point

Cross-section changing point

Different material inter junction point

Sudden change in point load

87. What is the difference between static and dynamic analysis?

Static analysis: The solution of the problem does not vary with time is known as static analysis

Example: stress analysis on a beam  
Dynamic analysis: The solution of the problem varies with time is known as

dynamic analysis

Example: vibration analysis problem.

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94. State the principles of virtual energy?

A body is in equilibrium if the internal virtual work equals the external virtual work for the every kinematically admissible displacement field.

95. Define Eigen value problem.

The problem of determining the constant is called eigen value problem.

$$\frac{d}{dx} \left( \frac{du}{dx} \right) = \lambda u$$

96. What is non-homogeneous form?

When the specified values of dependent variables are non-zero, the boundary condition is said to be non-homogeneous.

97. What is homogeneous form?

When the specified values of dependent variables is zero, the boundary condition are said to be homogeneous.

98. Define initial value problem.

An initial value problem is one in which the dependent variable and possibly is derivatives are specified initially.

99. Define boundary value problem.

A differential equation is said to describe a boundary value problem if the dependent variable and its derivatives are required to take specified values on the boundary.