SNS COLLEGE OF TECHNOLOGY
(An Autonomous Institution) Coimbatore – 35
Department of Automobile Engineering

Question Bank with Answers

2 Marks

UNIT -1

1. State the methods of engineering analysis.

There are three methods of engineering analysis. They are:
1. Experimental methods.
2. Analytical methods.
3. Numerical methods or approximate methods.

2. What is meant by finite element?

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

3. What is meant by finite element analysis?

Finite element method is a numerical method for solving problems of Engineering and Mathematical physics. In the finite element method, instead of solving the problem for the entire body in one operation, we formulate the equations for each finite element and combine them to obtain the solution of the whole body.

4. Give examples for the finite element.

1. One dimensional elements: (a) Truss elements.
(b) Bar, Beam elements.
2. Two dimensional elements: (a) Triangular elements.
(b) Rectangular elements.
3. Three dimensional elements: (a) Tetrahedral elements.
(b) Hexahedral elements.

5. What is meant by node or joint? (NOV/DEC2015)

Each kind of finite element has a specific structural shape and is interconnected with theadjacent elements by nodal points or nodes. At the nodes, degrees of freedom are located. The forces will act only at nodes and not at any other place in the element.

6. What is the basis of finite element method?

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

7. What are the types of boundary conditions?

There are two types of boundary conditions. They are:
1. Primary boundary condition.
2. Secondary boundary condition.

8. State the three phases of finite element method.

The three phases are:
1. Preprocessing.
2. Analysis.
3. Post processing.

9. What are structural and non-structural problems?

Structural problems: In structural problems, displacement at each nodal point is obtained. By using these displacement solutions, stress and strain in each element can be calculated.

Non-structural problems: In non-structural problems, temperatures or fluid pressure at each nodal point is obtained. By using these values, properties such as heat flow, fluid flow, etc., for each element can be calculated.

10. What are the methods are generally associated with the finite element analysis?

The following two methods are generally associated with the finite element analysis. They are:

(i) Force method.
(ii) Displacement or stiffness method.

11. Explain force method and stiffness method?

In force method, internal forces are considered as the unknowns of the problem. In displacement or stiffness method, displacements of the nodes are considered as the unknowns of the problem. Among them two approaches, displacement method is desirable.

12. Why polynomial types of interpolation functions are mostly used in FEM?

The polynomial type of interpolation functions are mostly used due to the following reasons:

1. It is easy to formulate and computerize the finite element equations.
2. It is easy to perform differentiation or integration.
3. The accuracy of the results can be improved by increasing the order of the Polynomial.

13. Name the variational methods.

1. Ritz method.
2. Rayleigh-Ritz method.

14. Name the weighted residual methods. (Nov/Dec-2014)(May/June 2016)

1. Point collocation method.
2. Sub domain collocation method.
3. Least squares method.
4. Galerkin's method.

15. What is meant by post processing? [M.Y., April 2001]

Analysis and evaluation of the solution results is referred to as post processing. Post processor computer programs help the user to interpret the results by displaying them in graphical form.

16. What is Rayleigh-Ritz method? (NOV/DEC 2015)

Rayleigh-Ritz method is a integral approach method which is useful for solving complex structural problems, encountered in finite element analysis. This method is possible only if a suitable functional is available.

17. What is meant by Discretization and assemblage?(Nov/Dec 2015)

The art of subdividing a structure into a 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.

18. What is meant by degrees of freedom?

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

19. What is "Aspect ratio"?

Aspect ratio is defined as the ratio of the largest dimension of the element to the smallest dimension. In many cases, as the aspect ratio increases, the inaccuracy of the solution increases. The conclusion of many researches is that the aspect ratio should be close to unity as possible.

20. What is truss element?

The truss elements are the part of a truss structure linked together by point joints, which transmit only axial force to the element,

21. List the two advantages of post-processing.

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

22. If a displacement field in x direction is given by u = 2 xl+4 yl+ 6 xy. Determine the strain in x direction.

$$u = 2x^2 + 4y^2 + 6xy$$

$$\text{Strain, } e = \frac{\partial u}{\partial x} = 4x + 6y$$

23. What are 'It' and 'p' versions of finite element method?

'h' versions and 'p' versions are used to improve the accuracy of the finite element method.

In 'h' versions, 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.

24. During Discretization, mention the places where it is necessary to place a node?

The following places are necessary to place a node during Discretization process.

(i) Concentrated load acting point.
(ii) Cross-section changing point.
(iii) Different material inter junction point.
(iv) Sudden change in load point.

25. 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 problems.

26. Name any four FEA software's.

1. NASTRAN, 2. NISA, 3.ANSYS, 4.COSMOS.

27. 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.

28. Distinguish between potential energyfunction and potential energy functional.

If a system has finite number of degrees of freedom (ql q2 and q3)' then the potential energy is 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,

$$\pi = \int f \cdot \left(x, y, \frac{dy}{dx}, \frac{d^2y}{dx^2}, \dots \right) dx$$

It is known as functional.

29. What do you mean by constitutive law?

For a finite element, the stress-strain relations are expressed as follows:

$$\{\sigma\} = [D]\{e\}$$

where $\{\sigma\}$ = Stress

$\{e\}$ = Strain

$[D]$ = Stress-Strain relationship matrix or Constitutive matrix.

This equation is known as constitutive law.

30. Compare the Ritz technique with nodal approximation method (Nov/Dec-2014)

- Rayleigh Ritz method is an approximate method of finding displacements that is based on the theorem of minimum potential energy.
- The method is restricted to conservative systems that may be linear or non-linear.

31. State the principle of potential energy theorem. (May/June2016)

The deformed **state** a structure attains upon the application of forces is the equilibrium **state** of a structural system. The **Potential energy** (PE) of a structural system is defined as the sum of the strain **energy** (SE) and the work **potential** (WP). The strain **energy** is the elastic **energy** stored in deformed structure.

32. What are the methods generally associated with finite element Analysis?(May/June2016)

- Numerical methods for approximating
- variational formulation for galerkin method
- Weak formulation

UNIT - 2

1. What are the types of loading acting on the structure?

There are three types of loading acting on the body. They are:

(i) Body force (f).
(ii) Traction force (T).
(iii) Point load (P).

2. Define body force (f).

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.

3. Define Traction force (T).

Traction force is defined as distributed force acting on the surface of the body.
Unit: Force per unit area.
Examples: Frictional resistance, viscous drag, surface shear etc.

4. What is Point Load (P).

Point load is force acting at a particular point which causes displacement.

5. What are the basic steps involved in the finite element modelling.

Finite element modelling consists of the following:
(i) Discretization of structure.
(ii) Numbering of nodes.

6. What is Discretization? (NOV/DEC 2015)

The art of subdividing a structure into a convenient number of smaller components is known as Discretization.

7. What are the classifications of co-ordinates?

The co-ordinates are generally classified as follows:
(i) Global co-ordinates.
(ii) Local co-ordinates.
(iii) Natural co-ordinates.

8. What is Global co-ordinates? [Anna University, June 2005], [Nov 2013]

The points in the entire structure are defined using co-ordinate system is known as global co-ordinate system.
Example:

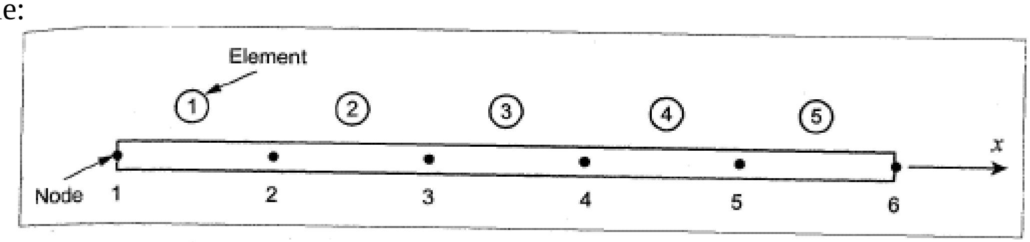


Fig. One dimensional bar

9. What is natural co-ordinates? [Nov 2013]

A natural co-ordinate system is used to define any point inside the element by a set of dimensionless numbers, whose magnitude never exceeds unity. This system is very useful in assembling of stiffness matrices.

10. Define shape function. [Anna University, Dec 2007]

In finite element method, field variables within an element are generally expressed by the following approximate relation:

$$\phi(x, y) = N_1(x, y)\,\phi_1 + N_2(x, y)\,\phi_2 + N_3(x, y)\,\phi_3$$

where ϕ_1, ϕ_2 and ϕ_3 are the values of the field variable at the nodes and 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.

11. What are the characteristics of shape function? (Apr/May 2015)

The characteristics of shape function are as follows:

1.'The shape function has unit value at one nodal point and zero value at other nodal points.

2, The sum of shape function is equal to one.

12. Why polynomials are generally used as shape/unction?

Polynomials are generally used as shape function due to the following reasons.

1. Differentiation and integration of polynomials are quite easy.
2. The accuracy of the results can be improved by increasing the order of the polynomial.
3. It is easy to formulate and computerize the finite element equations.

13. How do you calculate the size of the global stiffness matrix?

$$\text{Global stiffness matrix size} = \text{Number of nodes} \times \begin{Bmatrix} \text{Degrees of freedom} \\ \text{per node} \end{Bmatrix}$$

14. Give the general expression for element stiffness matrix.(Nov/Dec 2015)

$$\text{Stiffness matrix, } [K] = \int_v [B]^T [D][B]\, dv$$

where, $[B] \rightarrow$ Strain displacement matrix [Row matrix].

$[D] \rightarrow$ Stress, strain relationship matrix [Row matrix].

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

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

where, $A \rightarrow$ Area of the bar element.

$E \rightarrow$ Young's modulus of the bar element.

$l \rightarrow$ Length of the bar element.

16. State the properties of a stiffness matrix. [Anna University, Jan 2006]

The properties of a stiffness matrix [K] are:

1. It is symmetric matrix.
2. The sum of elements in any column must be equal to zero.
3. It is an unstable element. So, the determinant is equal to zero.

17. Write down the general finite element equation.

General finite element equation is,

$$\{F\} = [K]\{u\}$$

where, $\{F\}$ → Force vector [Column matrix].

$[K]$ → Stiffness matrix [Row matrix].

$\{u\}$ → Degrees of freedom [Column matrix].

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

The finite element equation for one dimensional two noded bar element is,

$$\begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix} = \frac{AE}{l}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} u_1 \\ u_2 \end{Bmatrix}$$

19. What is truss?

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

20. State the assumptions are made while finding the forces in a truss.

The following assumptions are made while finding the forces in a truss.

(i) All the members are pin jointed.

(ii) The truss is loaded only at the joints.

(iii) The self-weight of the members are neglected unless stated.

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

$$\text{Stiffness matrix, } [K] = \frac{A_e E_e}{l_e}\begin{bmatrix} l^2 & lm & -l^2 & -lm \\ lm & m^2 & -lm & -m^2 \\ -l^2 & -lm & l^2 & lm \\ -lm & -m^2 & lm & m^2 \end{bmatrix}$$

where, A → Area

E → Young's modulus

l_e → Length of the element

l, m → Direction cosines

22. Write down the expression of shape function N and displacement u for one Dimensional bar element. [Anna University, Jan 2005](Nov/Dec 2015)

For one dimensional bar element,

Displacement function, $u = N_1 u_1 + N_2 u_2$

where, Shape function, $N_1 = \frac{l - x}{l}$

Shape function, $N_2 = \frac{x}{l}$

23. Define total potential energy.

The total potential energy 1t of an elastic body is defined as the sum of total strain energy U and the potential energy of the external forces, (W).

$$\text{Total potential energy, } \pi = \text{Strain energy (U)} + \left\{ \begin{matrix} \text{Potential energy of} \\ \text{the external forces (W)} \end{matrix} \right\}$$

24. State the principle of minimum potential energy. [Anna University, Dec 2007]

The principle of minimum potential energy states: Among all the displacement equations that satisfy internal compatibility and the boundary conditions, those that also satisfy the equations of equilibrium make the potential energy a minimum in a stable system.

25. What is the stationary property of total potential energy? (May/June 2016)

If a body is in equilibrium, its total potential energy π is stationary.

For stable equilibrium, $\delta^2\pi > 0$, otherwise π is minimum for stable equilibrium.

For neutral equilibrium, $\delta^2\pi = 0$. In this case π is unchanging.

For unstable equilibrium, $\delta^2\pi < 0$, otherwise π is maximum.

26. State the principles of virtual work. [Anna University, Dec 2006]

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

27. Distinguish between essential boundary conditions and natural boundary conditions.

There are two types of boundary conditions. They are:

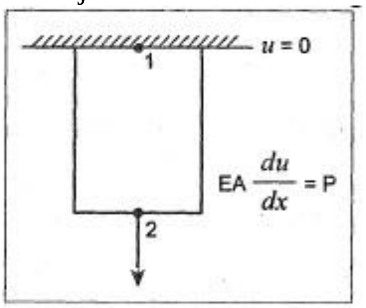
1. Primary boundary condition (or) Essential boundary)' condition:

The boundary condition which in terms of field variable is known as primary boundary condition.

2. Secondary boundary condition or Natural boundary condition:

The boundary conditions which are in the differential form of field variables are known as secondary boundary condition.

Example: A bar is subjected to axial load. It's shown in Fig.



In this problem, Displacement u at node 1 =0, that is primary boundary condition.

$EA\frac{du}{dx} = P$, that is secondary boundary condition.

28. What are/he differences between boundary value problem and initial value problem.[Anna University, June 2005J

The solution of differential equation is obtained for physical problems which satisfies some specified conditions known as boundary conditions.

The differential equation together with these boundary conditions, subjected to aboundary value problem. The differential equation together with initial conditions subjected to an initial value problem.

Examples: Boundary value problem.

$$\frac{d^2y}{dx^2} - a(x)\frac{dy}{dx} - b(x)y - c(x) = 0$$

With boundary conditions, $y(m) = \alpha$ and

$y(n) = \beta$

Initial value problem, $a x^2 + bx + c = 0$

Boundary conditions: $x(0) = 0$

$x(0) = 7$

UNIT - 3

PART - A

1. How do you define two dimensional elements?

Two dimensional elements are defined by three or more nodes in a two-dimensional plane (i.e., x, y plane). The basic element useful for two-dimensional analysis is the triangular element.

2. What is CST element? [Dee. 2007, (Nov/Dec 2015)

Merit:

1. Calculation of stiffness matrix is easier.

Demerit:

1. The strain variation within the element is considered as constant. So, the results will be poor.

3. What is LST element?

Six noded triangular elements is known as Linear Strain Triangle (LST), which is shown In Fig. It has twelve unknown displacement degrees of freedom. The displacement Functions for the element are quadratic instead of linear as in the CST.

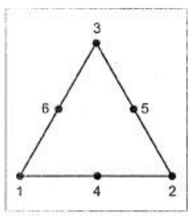


Fig. 3.26. Linear strain triangular element

4. What is QST element?

Ten noded triangular elements is known as Quadratic Strain Triangle (QST) which is shown in Fig.3.27. It is also called cubic displacement triangle.

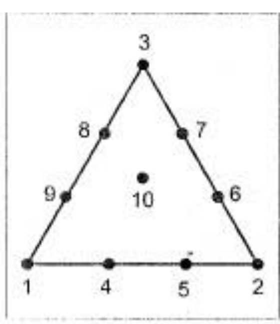


Fig. 3.27. Quadratic strain triangle element

5. What is meant by plane stress analysis?

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

6. Define plane strain analysis.(Nov/Dec 2015).

Plane strain is defined to be a state of strain in which the strain normal to the xy plane and the shear strains are assumed to be zero.

7. Write a displacement function equation for CST element.

$$\text{Displacement function } u = \begin{Bmatrix} u(x,y) \\ v(x,y) \end{Bmatrix} = \begin{bmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 \\ 0 & N_1 & 0 & N_2 & 0 & N_3 \end{bmatrix} \begin{Bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{Bmatrix}$$

where, N_1, N_2, N_3 are shape functions.

8. Write a strain-displacement matrixfor CST element.(May/June 2016)

Strain-Displacement matrix for CST element is,

$$[B] = \frac{1}{2A} \begin{bmatrix} q_1 & 0 & q_2 & 0 & q_3 & 0 \\ 0 & r_1 & 0 & r_2 & 0 & r_3 \\ r_1 & q_1 & r_2 & q_2 & r_3 & q_3 \end{bmatrix}$$

where, A = Area of the element

$q_1 = y_2 - y_3; \quad q_2 = y_3 - y_1; \quad q_3 = y_1 - y_2$

$r_1 = x_3 - x_2; \quad r_2 = x_1 - x_3; \quad r_3 = x_2 - x_1$

9. Write down the stress-strain relationship matrix for plane stress condition.

For plane stress problems. Stress-strain relationship matrix is,

$$[D] = \frac{E}{1-\nu^2} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix}$$

where, E = Young's modulus

ν = Poisson's ratio

10. Write down the stress-strain relationship matrix for plane strain condition.

For plane strain problems. Stress-strain relationship matrix is.

$$[D] = \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} (1-\nu) & \nu & 0 \\ \nu & (1-\nu) & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$$

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

Stiffness matrix, $[K] = [B]^T [D] [B] A\, t$

where, $[B] \rightarrow$ Strain-displacement matrix

$[D] \rightarrow$ Stress-strain matrix

$A \rightarrow$ Area of the element

$t \rightarrow$ Thickness of the element

12. Write down the expressionfor the shape functions for a constant ...uruin triangular element.

For CST element,

Shape function, $N_1 = \frac{p_1 + q_1 x + r_1 y}{2A}$

$$N_2 = \frac{p_2 + q_2 x + r_2 y}{2A}$$

$$N_3 = \frac{p_3 + q_3 x + r_3 y}{2A}$$

where, $p_1 = x_2 y_3 - x_3 y_2$

$p_2 = x_3 y_1 - x_1 y_3$

$p_3 = x_1 y_2 - x_2 y_1$

$q_1 = y_2 - y_3; \quad q_2 = y_3 - y_1; \quad q_3 = y_1 - y_2$

$r_1 = x_3 - x_2; \quad r_2 = x_1 - x_3; \quad r_3 = x_2 - x_1$

13. What is axisymmetric element? idée. 2007, Anna University]

Many three dimensional problems in engineering exhibit symmetry about an axis of rotation. Such types of problems are solved by a special two dimensional element called as axisymmetric element.

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

1. The problem domain must he symmetric about the axis of revolution.
2. AU boundary conditions must be symmetric about the axis of revolution.
3. All loading conditions must be symmetric about the axis ofrevolution.

15. Write down the displacement equation for an axisymmetric triangular element.

$$\text{Displacement function, } u(r,z) = \begin{Bmatrix} u(r,z) \\ w(r,z) \end{Bmatrix} = \begin{bmatrix} N_1 & 0 & N_2 & 0 & N_3 & 0 \\ 0 & N_1 & 0 & N_2 & 0 & N_3 \end{bmatrix} \begin{Bmatrix} u_1 \\ w_1 \\ u_2 \\ w_2 \\ u_3 \\ w_3 \end{Bmatrix}$$

16. Write down the shapefunctions for an axisymmetric triangular element.

$$\text{Shape function, } N_1 = \frac{\alpha_1 + \beta_1 r + \gamma_1 z}{2A}$$

$$N_2 = \frac{\alpha_2 + \beta_2 r + \gamma_2 z}{2A}$$

$$N_3 = \frac{\alpha_3 + \beta_3 r + \gamma_3 z}{2A}$$

where,

$$\alpha_1 = r_2 z_3 - r_3 z_2$$
$$\alpha_2 = r_3 z_1 - r_1 z_3$$
$$\alpha_3 = r_1 z_2 - r_2 z_1$$
$$\beta_1 = z_2 - z_3$$
$$\beta_2 = z_3 - z_1$$
$$\beta_3 = z_1 - z_2$$
$$\gamma_1 = r_3 - r_2$$
$$\gamma_2 = r_1 - r_3$$
$$\gamma_3 = r_2 - r_1$$

17. Give the Strain-Displacement matrix equation for an axisymmetric triangular element.

Strain-Displacement matrix,

$$[B] = \frac{1}{2A} \begin{bmatrix} \beta_1 & 0 & \beta_2 & 0 & \beta_3 & 0 \\ \frac{\alpha_1}{r} + \beta_1 + \frac{\gamma_1 z}{r} & 0 & \frac{\alpha_2}{r} + \beta_2 + \frac{\gamma_2 z}{r} & 0 & \frac{\alpha_3}{r} + \beta_3 + \frac{\gamma_3 z}{r} & 0 \\ 0 & \gamma_1 & 0 & \gamma_2 & 0 & \gamma_3 \\ \gamma_1 & \beta_1 & \gamma_2 & \beta_2 & \gamma_3 & \beta_3 \end{bmatrix}$$

where,

$$\text{Co-ordinate, } r = \frac{r_1 + r_2 + r_3}{3}$$

$$\text{Co-ordinate, } z = \frac{z_1 + z_2 + z_3}{3}$$

18. **18. Write down the Stress-Strain relationship matrix for an axisymmetric triangular element.(May/June 2016)**

$$\text{Stress-Strain relationship matrix, } [D] = \frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix} 1-\nu & \nu & \nu & 0 \\ \nu & 1-\nu & \nu & 0 \\ \nu & \nu & 1-\nu & 0 \\ 0 & 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix}$$

where, $E \rightarrow$ Young's modulus

$\nu \rightarrow$ Poisson's ratio

19. Give the stiffness matrix equation for an axisymmetric triangular element.

$$\text{Stiffness matrix, } [K] = 2\pi r A \; [B]^T [D] [B]$$

where, co-ordinate $r \rightarrow \frac{r_1 + r_2 + r_3}{3}$

$A \rightarrow$ Area of the triangular element matrix

20. What are the ways in .which a three "dimensional problem can be reduced to a two dimensional approach.

1. Plane stress: One dimension is too small when compared to other two dimensions. Example: Gear - Thickness is small.
2. Plane strain: One dimension is too large when compared to other two dimensions. Example: Long pipe [Length is long compared to diameter]
3. Axisymmetric: Geometry is symmetric about the axis.
Example: Cooling tower

21. Calculate the Jacobian of the transformation J for the triangular" element shown Fig. (i).

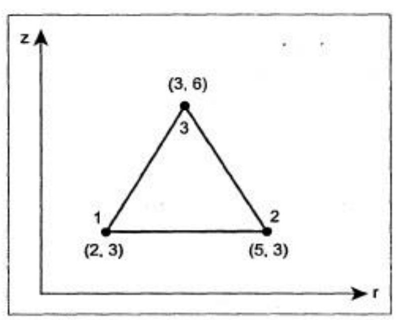


Fig. (i)

Solution: Co-ordinates: $r_1 = 2;\quad z_1 = 3$

$r_2 = 5;\quad z_2 = 3$

$r_3 = 3;\quad z_3 = 6$

$$J = \begin{bmatrix} r_1 - r_3 & z_1 - z_3 \\ r_2 - r_3 & z_2 - z_3 \end{bmatrix} = \begin{bmatrix} -1 & -3 \\ 2 & -3 \end{bmatrix}$$

$$|J| = 3 + 6 = 9 \text{ units}$$

22. What is the purpose of Isoparametric elements? [Jan 2006, Anna University]

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. In order to overcome this drawback, Isoparametric elements are used i.e., for problems involving curved boundaries, a family of elements known as "Isoparametric elements" are used.

23. Write down tile shape functions for 4 noded rectangular elements using natural coordinate system.

Shape functions:

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

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

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

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

where, ε and η are natural co-ordinates.

24.

Write down the Jacobian matrix for four noded quadrilateral element.

$$\text{Jacobian matrix, } [J] = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix}$$

where,

$$J_{11} = \frac{1}{4}[-(1-\eta)x_1 + (1-\eta)x_2 + (1+\eta)x_3 - (1+\eta)x_4]$$

$$J_{12} = \frac{1}{4}[-(1-\eta)y_1 + (1-\eta)y_2 + (1+\eta)y_3 - (1+\eta)y_4]$$

$$J_{21} = \frac{1}{4}[-(1-\varepsilon)x_1 - (1+\varepsilon)x_2 + (1+\varepsilon)x_3 + (1-\varepsilon)x_4]$$

$$J_{22} = \frac{1}{4}[-(1-\varepsilon)y_1 - (1+\varepsilon)y_2 + (1+\varepsilon)y_3 + (1-\varepsilon)y_4]$$

vhere, η and ε are local co-ordinates.

$x_1, x_2, x_3, x_4, y_1, y_2, y_3$ and y_4 are cartesian co-ordinates.

25.

Write down the stiffness matrix equation for four noded isoparametric quadrilateral element.

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

where, t = Thickness of the element

$|J|$ = Determinant of the Jacobian

ε, η = Natural co-ordinates

$[B]$ = Strain-Displacement matrix

$[D]$ = Stress-Strain relationship matrix

26.

Write down the element force vector equation for four noded quadrilateral element.

$$\text{Force vector, } \{F\}_e = [N]^T \begin{Bmatrix} F_x \\ F_y \end{Bmatrix}$$

where, N is the shape function.

F_x is a load or force on x direction.

F_y is a force on y direction.

27.

Write down the Gaussian quadrature expression for numerical integration.

Gaussian quadrature expression,

$$\int_{-1}^{1} f(x)\,dx = \sum_{i=1}^{n} w_i\, f(x_i)$$

where, w_i → Weight function

$f(x_i)$ → Values of the function at pre-determined sampling points.

28. Define super parametric element. [Dec. 2006, Anna University]

If the number of nodes used for defining the "geometry is more than number of nodes used for defining the displacements, then, it is known as super parametric element.

29. What is meant by sub parametric element? [Dec. 2006, Anna University]

If the number of nodes used for defining the geometry is less than number of nodes used for defining the displacements, then, it is known as sub parametric element.

30. 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 displacements, then, it is known as Isoparametric element.

31. Is beam element an Isoparametric element?

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

32. What is the difference between natural co-ordinate and simple natural co-ordinate?

A natural co-ordinate is one whose value lies between zero and one.

Examples: $L_2 = \frac{x}{l}$; $L_1 = \left(1 - \frac{x}{l}\right)$

Area co-ordinates: $L_1 = \frac{A_1}{A}$; $L_2 = \frac{A_2}{A}$; $L_3 = \frac{A_3}{A}$

A simple natural co-ordinate is one whose value lies between -1 and +1.

33. Give examples for essential (forced or geometric) and non-essential (natural) Boundary conditions.

The geometric boundary conditions are displacement, slope, etc. The natural boundary conditions are bending moment, shear force, etc.

34. What are the types of non-linearity? [Dec. 2007, Anna University]

Types of non-linearity:

(a) Non-linearity in material behavior from point to point.
(b) Non-linearity in loading-deformation relation.
(c) Geometric non-linearity.
(d) Change in boundary condition for different loading.

35. Define path line and stream line.(May/ June 2016)

Streamlines are a family of curves that are instantaneously tangent to the velocity vector of the flow. These show the direction in which a massless fluid element will travel at any point in time.

Path **lines** are the trajectories that individual fluid particles follow. These can be thought of as "recording" the path of a fluid element in the flow over a certain period. The direction the path takes will be determined by the streamlines of the fluid at each moment in time.