Department of Aeronautical &Aerospace Engineering

U20AE601 Finite Element Methods

Part – A

Year/Sem: III/VI

Unit – I Introduction

1. State the methods of Engineering Analysis?

   There are three methods of engineering analysis. They are

   - Experimental methods
   - Analytical method
   - 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 node or joint?

   Each kind of finite element has a specific structural shape and is interconnected with the adjacent 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.

4. What is the basis of finite element method?

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

5. State the three phases of finite element method?

   The three phases are:

   - Preprocessing
   - Analysis
   - Post Processing

6. What is 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 problem:

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.

7. What are the methods are generally associated with the finite element Analysis?
   - Force method
   - Displacement or stiffness method.

8. Why polynomial type of interpolation functions are mostly used in FEM?

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

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

9. Name the variational methods.
   - Ritz method.
   - Rayleigh-Ritz method.

10. Name the weighted residual methods.
   - Point collocation method.
   - Sub-domain collocation method.
   - Least squares method
   - Galerkins’s method.

11. What is meant by post processing?

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.

12. What is Rayleigh-Ritz method?

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

13. What is meant by degrees of freedom?

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

14. What is “Aspect ratio”?

Aspect ratio is defined as the ratio of the largest dimensions 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 unity as possible.

15. 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.

16. What are ‘h’ and ‘p’ versions of finite element method?

In ‘h’ versions and ‘p’ versions are used to improve the accuracy of the finite element methods.In ‘h’ versions, the order of polynomial approximation for all elements is kept constant and the number of elements are increased.In ‘p’ versions, the number of elements are maintained constant and the order of polynomial approximation of element is increased.

17. 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.

- Concentrated load acting point
- Cross-section changing point
- Different material inter-junction point
- Sudden change in load point.

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

Static Analysis: The solution of the problem does not vary with time is known as dynamic 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.

19. Differentiate between global and local axes?

Local axes are established in an element. Since it is 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.

20. Distinguish between potential energy function and potential energy functional?

If a system has finite number of degrees of freedom (q1 q1 and q1), 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,

$\pi = \int f\left(x, y, \frac{dy}{dz}, \frac{d^2y}{dx^2}, \ldots\right) dx$ it is known as functional.

Unit – II Discrete Elements

21. What are the classification of co-ordinates?

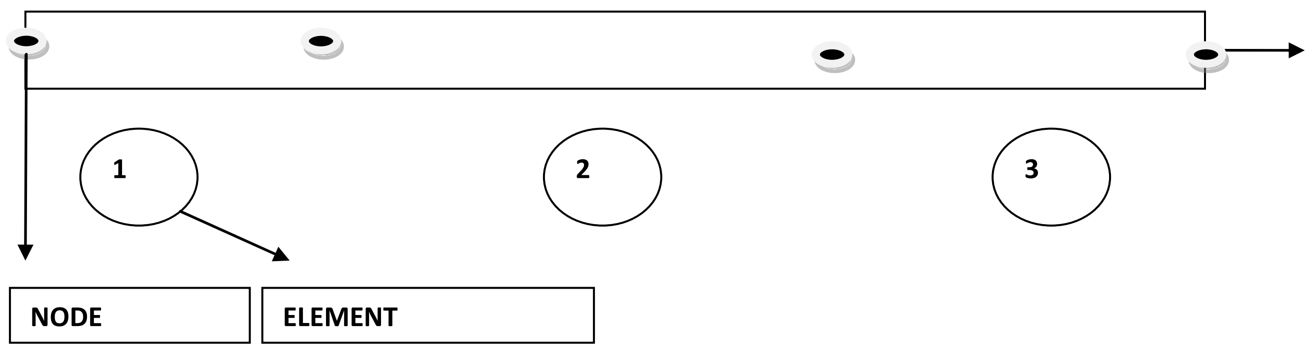
The co-ordinates are generally classified as follows:

- Global co-ordinates
- Local co-ordinates
- Natural co-ordinates

22. What is Global co-ordinates?

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

Example:



23. What is natural co-ordinates?

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.

24. Define shape function?

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

$\Phi(x,y) = N1(x,y)\phi_1 + N2(x,y)\phi_2 + N3(x,y)\phi_3$

Where ϕ_1, ϕ_2 and ϕ_3 are the values of the fields variables at the nodes and N1, N2 and N3 are the interpolation functions.

N1, N2 and N3 are also called shape function because they are used to express the geometry or shape of the element.

25. What are the characteristics of shape function?

- The shape function has unit value at one nodal point and zero value at other nodal points.
- The sum of shape function is equal to one.

26. Why polynomials are generally used as shape function?

- Polynomials are generally used as shape function due to the following reasons:
- Differentiation and integration of polynomials are quite easy.
- The accuracy of the results can be improved by increasing the order of the polynomial.
- It is easy to formulate and computerize the finite element equations.

27. Give the General expression for element stiffness matrix?

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

Where, [B]- strain displacement matrix [Row matrix]

[D]- stress, strain relationship matrix

28. State the properties of stiffness matrix?

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

29. 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)

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

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

- All the members are pin jointed
- The truss is loaded only at the nodes
- The self-weight of the members are neglected unless stated.

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

$$[K] = \frac{AE}{l}\begin{bmatrix} l^2 & lm & -l^2 & -lm \\ lm & m^2 & -lm & -m^2 \\ -l^2 & -lm & l^2 & lm \\ -lm & -m^2 & lm & m^2 \end{bmatrix}$$

Where,

A-Area

E- young's modulus

l- length of the element

l, m- direction cosines.

32. State the principle of minimum potential energy?

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.

33. State the principles of virtual wok.

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

34. Distinguish between essential boundary conditions and natural boundary conditions?

There are two types of boundary conditions. They are:

- Primary boundary condition (or) essential boundary conditions:

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

- Secondary boundary condition (or) natural boundary conditions:

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

35. Define Frequency of vibration?

It is the number of cycles described in one second. Unit is Hz.

36. Define damping ratio?

It is defined as the ratio of actual damping coefficient (C) to the critical damping coefficient (Cc).Damping ratio $e = \frac{C}{Cc} = \frac{C}{2mw_n}$

37. What is meant by longitudinal vibration?

When the particles of the shaft or disc moves parallel to the axis of the shaft, then the vibrations are known as longitudinal vibrations.

38. What is meant by transverse vibration?

When the particles of the shaft or disc move approximately perpendicular to the axis of shaft, then the vibrations are known as transverse vibrations.

39. Define magnification factor?

The ratio of the maximum displacement of the forced vibration to the static deflection under the static force is known as magnification factor.

40. Define resonance

When the frequency of external force is equal to the natural frequency of a vibrating body, the amplitude of vibration becomes excessively large is known as resonance.

Unit – III Continuum Elements

41. How do you define 2D elements?

Two dimensional elements are defined by three or more nodes in a 2D plane (i.e., x, y plane). The basic element useful for 2D analysis is triangular element.

42. What is mean by CST element?

Three noded triangular element is known as Constant Strain Triangular (CST). It has six unknown displacement degrees of freedom and value of strain is constant throughout the element.

43. What is mean by LST?

Six noded triangular element is known as Linear Strain Triangular (LST) element. It has 12 unknown displacement degrees of freedom.

44. What is mean by QST?

Ten noded triangular element is known as Quadratic Strain Triangle (QST). It is alaso called displacement triangle.

45. What is mean 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.

46. What is mean by plane strain analysis?

State of strain in which the strain normal to the xy plane and shear strain are assumed to be zero is known as plane strain analysis.

47. What is axisymmetric element?

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 an axisymmetric element.

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

- The problem domain must be symmetric about the axis of revolution
- All boundary conditions must be symmetric about the axis of revolution
- All loading conditions must be symmetric about the axis of revolution

49. Write down the expression for shape function for a CST element.

$$N_1 = \frac{a_1 + b_1 x + c_1 y}{2A}$$
$$N_2 = \frac{a_2 + b_2 x + c_2 y}{2A}$$
$$N_3 = \frac{a_3 + b_3 x + c_3 y}{2A}$$

$$A = \text{area of triangle} = \frac{1}{2}\det\begin{bmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ 1 & x_3 & y_3 \end{bmatrix}$$

$$a_1 = x_2 y_3 - x_3 y_2 \quad b_1 = y_2 - y_3 \quad c_1 = x_3 - x_2$$
$$a_2 = x_3 y_1 - x_1 y_3 \quad b_2 = y_3 - y_1 \quad c_2 = x_1 - x_3$$
$$a_3 = x_1 y_2 - x_2 y_1 \quad b_3 = y_1 - y_2 \quad c_3 = x_2 - x_1$$

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

$$[D] = \frac{E}{1-v^2} \cdot \begin{Bmatrix} 1 & v & 0 \\ v & 1 & 0 \\ 0 & 0 & \frac{1-v}{2} \end{Bmatrix}$$

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

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

52. Write a strain-displacement matrix for CST element?

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

Where, $q_1 = y_2 - y_3$ $r_1 = x_3 - x_2$

$q_2 = y_3 - y_1$ $r_2 = x_1 - x_3$

$q_3 = y_1 - y_2$ $r_3 = x_2 - x_1$

53. Define LST element

A six noded triangular element is a linear strain triangular element, a type of finite element with a triangular shape and linear interpolation functions used to approximate the strains (deformations) within the element

54. What are the ways in which a three-dimensional problem can be reduced to a two-dimensional approach?

- Plane stress
- Plane strain
- Axisymmetric

55. Write down the stress-strain relationship matrix for an axisymmetric triangular element

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

56. Write the strain displacement matrix for axisymmetric triangular element

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

$\beta_1 = z_2 - z_3$ $\beta_2 = z_3 - z_1$ $\beta_3 = z_1 - z_2$

$\gamma_1 = r_3 - r_2$ $\gamma_2 = r_1 - r_3$ $\gamma_3 = r_2 - r_1$

$\alpha_1 = r_2 z_3 - r_3 z_2$ $\alpha_2 = r_3 z_1 - r_1 z_3$ $\alpha_3 = r_1 z_2 - r_2 z_1$

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

$$[K]=[B]^T[D][B]\ 2\pi r\ A$$

58. What are the applications of axisymmetric elements?

- Pressure vessels
- Rotating machinery
- Bush and bearings
- Composite pressure vessels

59. Write the advantages of axisymmetric elements?

- Simplified modelling
- Reduced computational costs
- Efficient design optimization
- More accuracy

60. Write the advantages of axisymmetric elements?

- Limited applicability
- Incorrect representation of stress concentrations
- Increased computational effort for non-axisymmetric features:
- Limited insight into three-dimensional effects

Unit – IV Isoparametric Elements

61. What is mean by isoparametric element?

If the number nodes used for defining the geometry is same as number of nodes used for defining the displacements known as isoparametric elements.

62. What is mean by subparametric element?

If the number nodes used for defining the geometry is less than number of nodes used for defining the displacements known as subparametric elements.

63. What is mean by superparametric element?

If the number nodes used for defining the geometry is less than number of nodes used for defining the displacements known as superparametric elements.

64. Is beam element an isoparametric element?

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

65. Write down the shape functions for 4 noded rectangular element using natural coordinates

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

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

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

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

66. Write down the stiffness matrix for 4 nodedisoparametric quadrilateral element

$$[k] = \int_{-1}^{1}\int_{-1}^{1} [B]^T [D][B]\, t\, |J|\, d\xi\, d\eta$$

67. Write down the Jacobian matrix for 4 nodedisoparametric quadrilateral element

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

$$[J] = \begin{bmatrix} \frac{\partial x}{\partial \xi} & \frac{\partial y}{\partial \xi} \\ \frac{\partial x}{\partial \eta} & \frac{\partial y}{\partial \eta} \end{bmatrix}$$

68. Write down the Guassian quadrature expression for numerical integration

$$I = \int_{-1}^{1} f(\xi)\, d\xi \approx \sum_{i=1}^{n} W_i\, f(\xi_i)$$

Weight (W_i) — Integration point (ξ_i)

69. Write the significances of Guassian quadrature technique

Guassian quadrature implements the strategy of positioning any two points on a curve to define a straight line that would balance the negative and positive errors. Hence, the area evaluated under this straight line provides an improved estimate of the integral.

70. Write the applications of applications of Guassian quadrature techniques in Aeronautical engineering

- Wing design and optimization
- Control surface analysis
- Vortex lattice methods
- Evaluate integrals related to structural stiffness, deflection, and stress calculations, aiding in the design and optimization of aircraft structures for strength and weight considerations.

71. Write the advantages of guassian quadrature techniques

- High accuracy
- Flexible integration points
- Integration of higher-order polynomials
- Numerical stability

72. Write the disadvantages of guassian quadrature techniques

- Limited Applicability
- Gaussian quadrature techniques can be more complex compared to other numerical integration methods
- Lack of Adaptive Capability
- Numerical instability

73. Write the applications of isoparametric elements

- Isoparametric elements are extensively used in structural analysis to model and analyze the behavior of various structures under different loading conditions.
- The analysis of solid mechanics problems, including linear and nonlinear elasticity, plasticity, and viscoelasticity
- Simulate heat transfer phenomena, such as conduction, convection, and radiation. They enable the analysis of temperature distributions, heat fluxes, and thermal gradients in systems subjected to different thermal loads.
- Predict the behavior of materials under various loading conditions, such as aerodynamic forces and structural vibrations.

74. Write the advantages of isoparametric elements

- Higher Accuracy
- Reduced Element Count
- Enhanced Interpolation
- Flexible Element Shape
- Smooth Interpolation along Element Boundaries
- Compatibility with Higher-Order Integration

75. Write the disadvantages of isoparametric elements

- Mesh Generation is very complex
- Sensitivity to Element Distortion
- Reduced Accuracy with High Aspect Ratio
- Difficulty in Handling Singularities
- More expensive

76. What is mean by Serendipity elements?

Higher-order finite elements that have nodes only at the corners or edges of the element, without any additional interior nodes. They are used to accurately represent complex geometries and behaviors in structural and solid mechanics simulations.

77. Write the advantages of serendipity elements of FEA

- Enhanced Solution Accuracy
- Reduced Degrees of Freedom
- Lower Stiffness Matrix Bandwidth
- Enhanced Mesh Generation
- Consistent and Conforming Displacements
- Compatibility with Quadrilateral Domains

78. Write the disadvantages of serendipity elements of FEA

- Limited Shape Flexibility
- Higher Mesh Density Required
- Limited Stress Recovery
- Difficult to Handle the Singularities

79. Write the applications of Jacobian matrix in finite element methods

- Coordinate Transformations
- Element Shape Functions
- Mapping Element Deformation
- Element Jacobian Matrix

80. Write the applications of serendipity elements of FEA in Aerospace Engineering

- Structural Analysis
- Composite Materials
- Aerodynamic Analysis
- Heat Transfer Analysis
- Fatigue Analysis
- Multi physics Simulations

Unit V - Field Problem

81. Define heat transfer

Heat transfer can be defined as the transmission of energy from one region to another region due to temperature difference.

82. State the assumptions in the theory of pure torsion

- The material of the shaft is homogeneous, perfectly elastic and obeys Hooke's law.
- Twist is uniform along the length of the shaft
- The stress does not exceed the limit of proportionality
- Strain and deformation are small.

83. Write the three modes of heat transfer

- Conduction
- Convection
- Radiation

84. What is mean by conduction?

The transfer of heat through a material or between materials in direct contact, primarily by molecular or atomic interactions.

85. What is mean by convection?

Convection is a mode of heat transfer that involves the movement of a fluid (liquid or gas) due to temperature differences within the fluid. It is characterized by the bulk motion of the fluid itself, which carries heat energy from one place to another.

86. What is mean by radiation?

The transfer of heat through electromagnetic waves, without the need for a medium. It can occur in a vacuum as well as in the presence of matter.

87. What is mean by free convection?

Free convection or Natural convection arises when a fluid, such as air or water, experiences density variations due to temperature differences. When a portion of the fluid is heated, it becomes less dense and tends to rise, while the cooler, denser portion sinks. This movement creates a circulating flow known as a convection current. Examples of natural convection include the upward movement of hot air near a heat source or the circulation of water in a pot that is being heated.

88. What is mean by forced convection?

Forced convection occurs when an external force, such as a fan or a pump, is used to propel the fluid and enhance heat transfer. The forced motion of the fluid increases the rate of convective heat transfer compared to natural convection. Common examples of forced convection include the use of fans to cool electronic components or the circulation of coolant in a car's radiator.

89. What is mean by thermal conductivity

A property of materials that quantifies their ability to conduct heat. It represents the rate of heat transfer through a unit area of a material for a unit temperature gradient.

90. What is mean by thermal resistance

The opposition offered by a material or a combination of materials to the flow of heat. It is the reciprocal of thermal conductivity and is used to calculate the overall heat transfer rate in a system.

91. What is heat transfer co-efficient?

A measure of the rate of heat transfer per unit area between a solid surface and a fluid (liquid or gas). It depends on the properties of the fluid and the surface, as well as the flow conditions.

92. State the Fourier’s law in heat transfer analysis

A fundamental equation in heat conduction that states that the heat flux (rate of heat transfer per unit area) is proportional to the temperature gradient (change in temperature per unit distance) in a material.

93. What is mean by torsion?

Torsion refers to the twisting or rotational deformation experienced by an object under the action of a torque. It occurs when a force is applied tangentially to an object, causing it to rotate around its longitudinal axis.

94. What is mean by torsional stiffness?

Torsional stiffness, often represented by the symbol "k," measures the resistance of a component or structure to twisting or rotational deformation. It indicates how much torque is required to produce a certain amount of twist in the element.

95. What is mean by torsional rigidity?

Torsional rigidity is the ability of an element to resist twisting under the influence of an applied torque. It is a measure of how effectively an element can transmit torque without excessive deformation.

96. What is mean by torsional moment?

Torsional moment, denoted by the symbol "M," refers to the twisting moment or torque applied to a structural member or component. It is the product of the applied force and the lever arm (distance from the axis of rotation).

97. What is mean by torsional deformation?

Torsional deformation is the angular displacement or twist experienced by a structural element under the action of a torque. It is measured in degrees or radians and represents the change in orientation of the element's cross-section.

98. Define Polar moment of inertia

The polar moment of inertia, denoted by the symbol "J," is a geometric property of a cross-section that describes its resistance to torsional deformation. It is related to the distribution of mass around the axis of rotation.

99. What is torsional resonance

Torsional resonance occurs when the natural frequency of torsional vibrations in a system matches the frequency of an external excitation or forcing function. It can lead to significant amplification of torsional vibrations and potential failure of the system.

100. What is mean by torsional damping?

Torsional damping refers to the dissipation of energy in a torsional system, reducing the amplitude of vibrations. It is crucial in controlling torsional resonance and ensuring stable operation of rotating machinery.

Department of Aeronautical & Aerospace Engineering

Question Bank (Part-B)

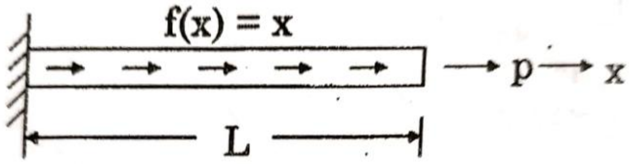
U20AE601Finite Element Methods

Year/Sem: III/VI **Academic Year: 2023-2024**

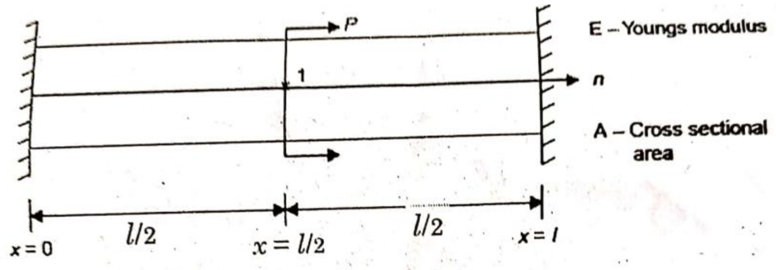
UNIT – I

INTRODUCTION

1. Consider a bar of uniform cross section shown in fig. the distributed force acting on the bar is varying linearly with x. Calculate the displacement in the bar using Ritz method and compare with exact solutions (Nov Dec'19)



2. Using Rayleigh Ritz method, determine the expressions for displacement and stress in a fixed bar subject to axial force P as shown in fig. Draw the displacement and stress variation diagram. Take 3 terms in displacement function (April May 19)



3. The differential equation of physical phenomenon is given by $\frac{d^2y}{dx^2}$-10x^2 = 5. Obtain two terms Galerkin solution by using the trial functions: $N_1(x)=x(x-1)$; $N_2(x) = x^2(x-1)$; $0 \leq x \leq 1$ boundary conditions are y(0)=0, y(1)=0 (April May 19)
4. For the differential equation $-\frac{d}{dx}[(1+x)\frac{dy}{dx}] = 0$ for $0 < x < 1$ with the boundary conditions y(0)=0 and y(1)=1, obtain an approximate solution using Rayleigh-Ritz method (Nov Dec 18)

5. Consider the differential equation $\frac{d^2y}{dx^2} + 300x^2 = 0$, $0 \le x \le 1$ with boundary conditions y(0)=0 and Y(1)=0. Find the solution of the using one co-efficient trial function $y=a_1x(1-x^3)$. Use point collocation , least square method and Galerkin's method(Nov Dec'18)

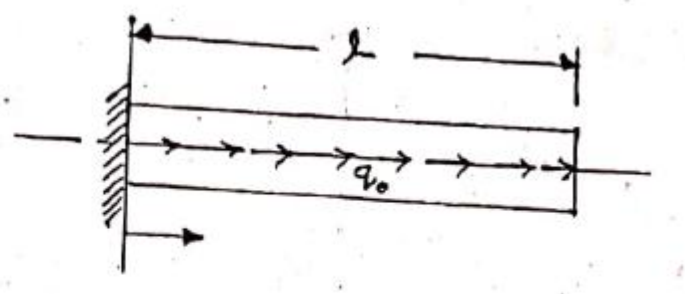
6. Determine the deflection under the point load of a simply supported beam of length 5m which is carrying a point load of 5kN, acting 3m from the left end. Take $E = 2x10^5$ N/mm^2 and $I = 1x10^8$ mm^4, use Rayleigh ritz method and compare with exact solutions (April May 18)

7. A simply supported beam of span length l subjected to uniform distributed load of w/unit length, throughout its length. Find the deflection at the center of the beam by using Sub domain collocation method, least square method and Galerkins Method (April May 18)

8. A beam of length L and uniform section is simply supported at its ends and subjected to uniform distributed load over its entire length. Using Rayleigh-Ritz method with two term approximation for displacement in the form of trigonometric function obtain the expression for maximum deflection and maximum bending moment (Nov dec17)

9. Explain the various steps involved in Finite Element Analysis (May June 16)

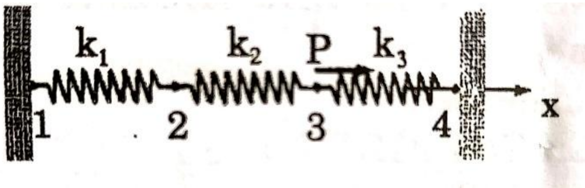
10. An uniform rod subjected into an axial load as shown in fig the deformation of the bar is governed by the differential equation EA $\frac{d^2u}{dx^2} + q_0 = 0$. The boundary conditions are $u(x=0)=0$ and $\frac{du}{dx} = 0$ where x = l, Find an approximation solution by using Galerkins method (Nov Dec 16)



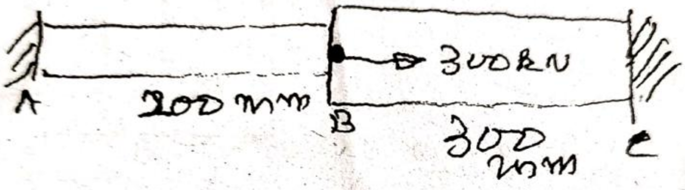
Unit 2

Discrete Elements

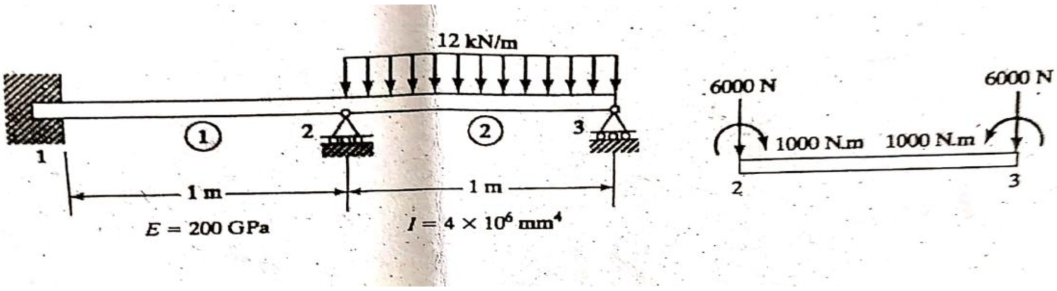
1. For the spring system shown in the fig (ii) k_1 = 100N/mm, k_2 = 200N/mm, k_3 = 100N/mm, P=500 N, $u_1 = u_4 = 0$. Calculate (i) the global stiffness matrix, the nodal displacements at 2 and 3 and (iii) the reaction forces at node 1 and 4 (Nov Dec'19)



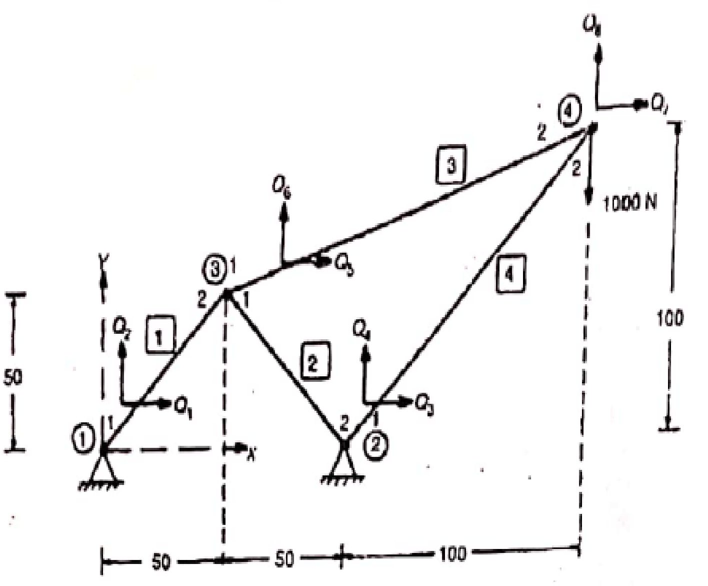
2. A stepped bar ABC is subjected to an axial load of 300 kN as shown in fig. it is also subjected to an increase in temperature of 40° C. The cross section area of AB, made of steel is 900 mm^2 and that of BC, made of aluminium is 1200mm^2. Modulus of elasticity of aluminium and steel are respectively 70 GPa and 200 GPa. Coefficients of thermal expansion of aluminium and steel are respectively $23x10^{-6}$/°C and $11x10^{-6}$/°C. Determine the stresses developed in AB and BC by considering the bar ABC into two elements (April May 19)



3. Using two finite elements, find the stress distribution in a uniformly tapering bar of cross sectional area 300 mm^2 and 200 mm^2 at their ends, length 100 mm, subjected to an axial tensile load of 50 N at the smaller end and fixed at the larger end. Take E = $2x10^5$ N/mm^2 and also it is subject to self-weight , unit weight ρ = 0.8 x 10^{-4} N/mm^3(Nov Dec18)
4. The beam is loaded as shown in fig, determine the slopes at 2 and 3 and the vertical deflection at the midpoint of the distributed load. (Nov Dec 18)



5. Find the nodal displacements developed in the planar truss shown in the fig when a vertically downward load of 1000 N is applied at node 4, the applicable data are given in the table (Apr May 18)

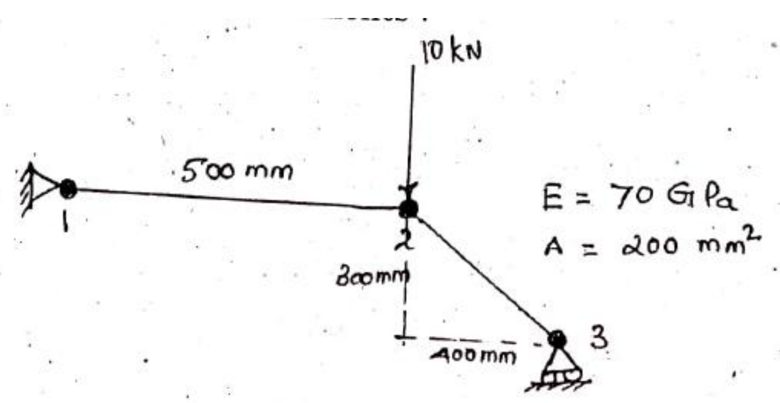


dimensions are in cm

Member number "e"	Cross-sectional area $A^{(e)}$ cm^2	Length $l^{(e)}$ cm	Young's modulus $E^{(e)}$ N/cm^2
1	2.0	$\sqrt{2}\ 50$	2×10^6
2	2.0	$\sqrt{2}\ 50$	2×10^6
3	1.0	$\sqrt{2.5}\ 100$	2×10^6
4	1.0	$\sqrt{2}\ 100$	2×10^6

6. Determine the natural frequencies of transverse vibrations for a fixed beam at both ends. The beam may be modelled by two elements, each of length L and cross sectional area A. The use of symmetry boundary condition is optional (Apr May 18)

7. For the two plane truss shown in the fig find the nodal displacements and stresses in each element (Nov Dec 16)



8. A stepped bar ABCDE is rigidly fixed at its ends, segment ABC is made of steel and its length and area are 300 mm and 250 mm^2 respectively. Modulus of elasticity is 200 GPa. CDE is made of aluminium and its length and area are 300mm and 400 mm^2 respectively. Modulus of elasticity is 70 GPa. A load of 20kN is applied at B, the mid point of AC, in the direction of BC. A load of 10kN is applied at D, mid point of CE, in the direction of DE. Determine the stresses developed in AB,BC, CD and DE.(Apr May 17)

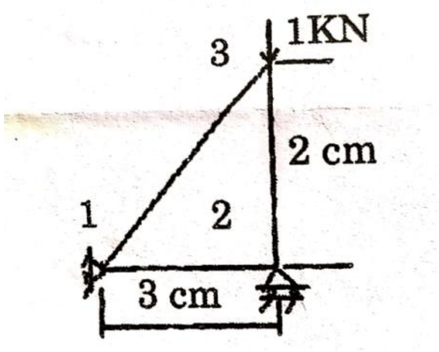
9. Derive the stiffness matrix for a two noded bar element using a linear displacement function (Nov Dec 19)

10. Derive stiffness matrix for a beam element using formal approach (Nov Dec 19)

Unit 3

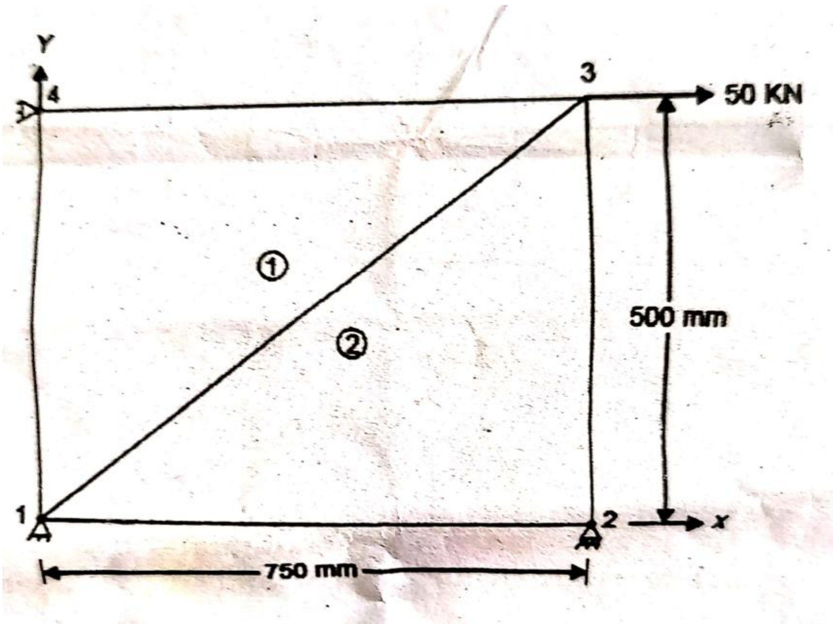
Continuum Elements

1. Evaluate the stiffness matrix for the plate element shown in the fig, take t = 0.5 cm, $E=2x10^7$ N/cm^2, μ = 0.27, using plane stress formulation (Nov Dec 19)

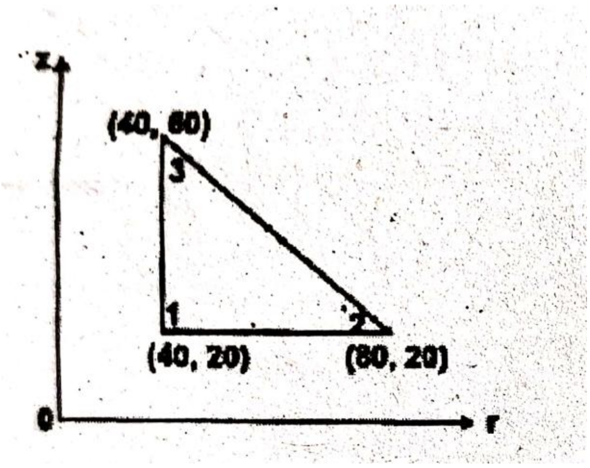


2. For the plane strain element the nodal displacements are u_1 = 0.005 mm, v_1 = 0.002mm u_2 = 0, v_2 = 0 , u_3 = 0.005 mm, v_3 = 0. Determine the element stresses σ_x,$\sigma_y$and τ_{xy}. Given E = 70 GPa, μ =0 .3. Use unit thickness for plane strain. (Nov Dec 19)

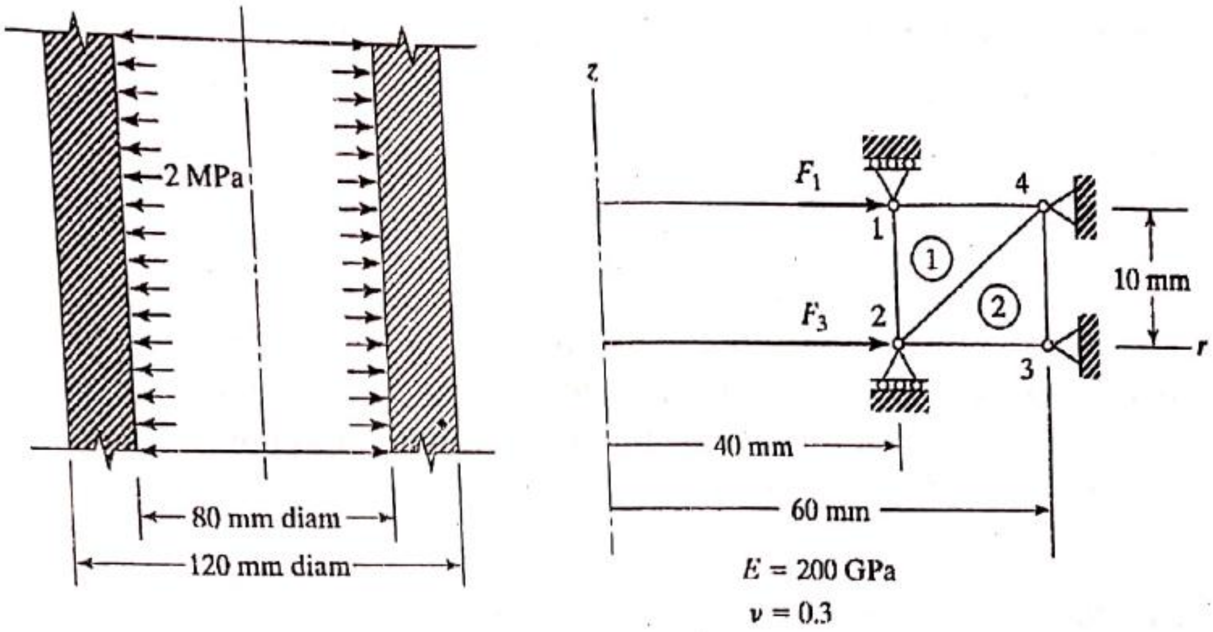
3. Determine the strain displacement matrix [B] of two CST elements of the propped beam shown in the fig, idealize the beam into two CST element as shown in the fig. Assume plane stress conditions (Apr May 19)



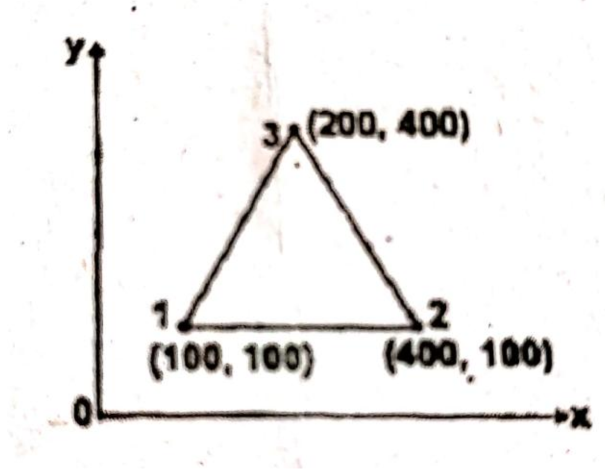
4. Calculate the element stresses for the axisymmetric element shown in fig, the nodal displacements are u_1 = 0.02 mm, w_1 = 0.03mm, u_2 = 0.01, w_2 = 0.06 , u_3 = 0.04 mm, w_3 = 0.01 mm, take E = 210 GPa, μ =0 .25 (Nov Dec 18)



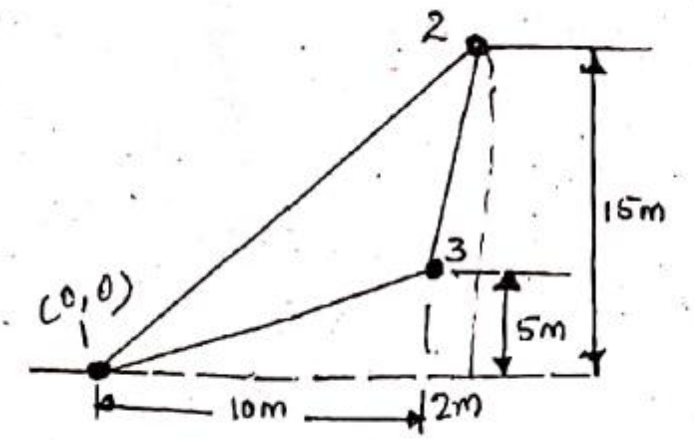
5. Establish the shape functions and derive the strain displacement matrix for an Axisymmetric element. (May June 16)
6. Derive the shape functions for constant strain triangular element and obtain the strain displacement matrix for it (Nov Dec 17)
7. A long cylinder of inside diameter 80 mm and outside diameter 120 mm tightly fix in a hole over its full length, the cylinder is then subjected to an internal pressure of 2 MPa. Using two elements on the 10 mm length, find the displacements at the inner radius (Apr May 18)



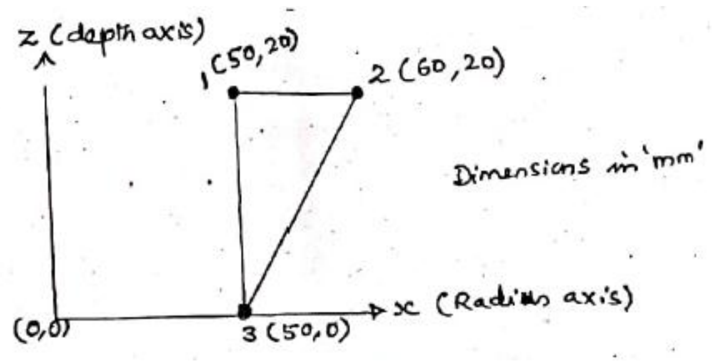
8. For a plane stress element shown in fig, the displacements (u_1, v_1), (u_2, v_2), (u_3, v_3) are (2, 1), (1,1.5) and (2.5, 0.5) respectively. Determine the element stress. Assume E = 200GN/m^2, μ = 0.3 and t= 10 mm, all co-ordinates are in mm. (Nov Dec 18)



9. For the triangular element shown in the fig, assuming plane stress condition obtain strain-displacement matrix take poisson's ratio is 0.3, young's modulus is $30x10^6$N/mm^2 and thickness is 0.1 mm. (Nov Dec 16)



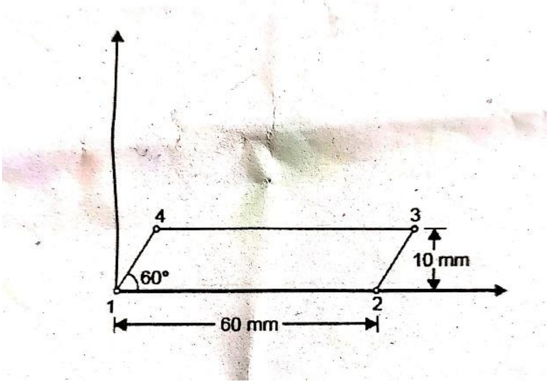
10. Compute strain displacement and stress, strain matrices for axisymmetric triangular element as shown in the fig, take poisson's ratio is 0.25, young's modulus is $2.1x10^5$N/mm^2 (Nov Dec 16)



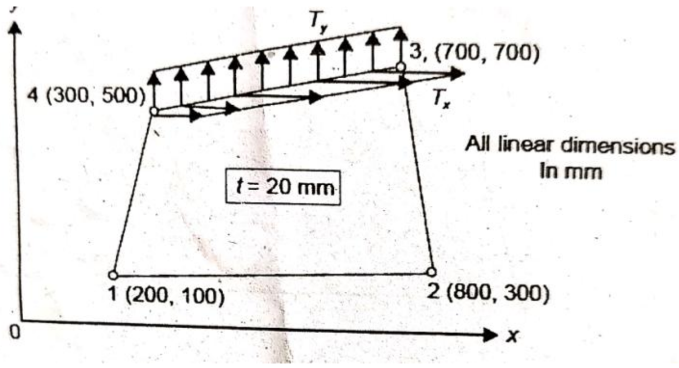
Unit 4

Isoparametric Elements

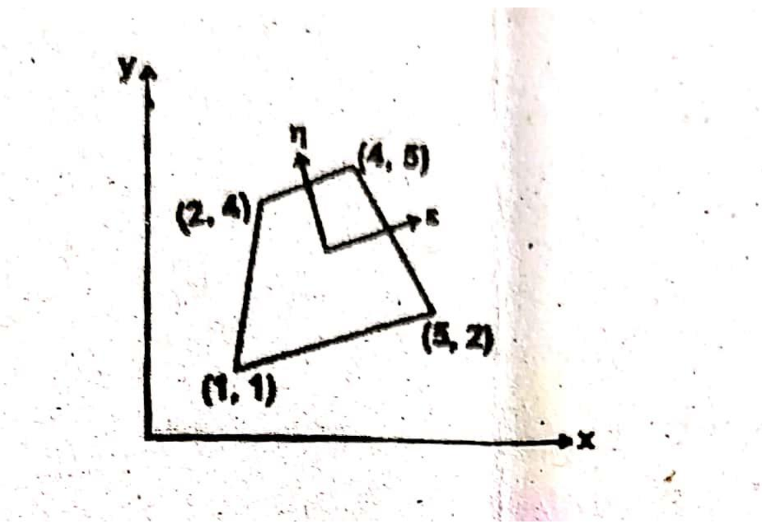
1. Determine the Jacobian matrix and strain displacement matrix corresponding to Gauss point (0.5775, 0.5775) for the element show in fig (Apr May 19)



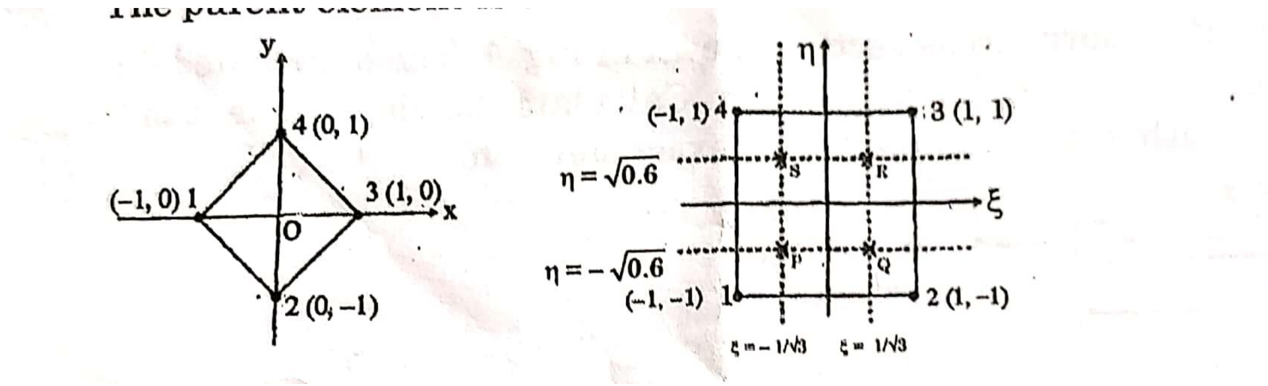
2. The quadrilateral element shown in fig is 20 mm thick and is subjected to surface forces T_x and T_Y. determine the expressions for its equivalent nodal forces if T_x and T_Y are 10 N/mm² and 15 N/mm² respectively (Apr May 19)



3. For the element shown in the fig, determine the Jacobian matrix (Nov Dec 18)



4. Derive the shape function for 4 noded quadrilateral element and also write the equation in matrix form to get the displacement at any point inside the element (Apr May 18)
5. Derive the shape functions for 9 noded quadrilateral elements with the natural co-ordinated (Ɛ,η) (Nov Dec 16)
6. Derive the shape function for 8 noded quadrilateral element and also write the equation in matrix form to get the displacement at any point inside the element (Nov Dec 17)
7. The nodal displacements of a rectangular element having nodal coordinates (0,0), (4,0), (4,2), (0,2) are $u_1 = 0$, $v_1 = 0$, $u_2 = 0.1$ mm, $v_2 = 0.05$mm , $u_3 = 0.05$ mm, $v_3 = -0.005$mm, $u_4 = 0$, $v_4 = 0$. Determine the stress matrix r = 0 and s = 0 using the Isoparametric formulation take E = 210 GPa and Poisso's ratio is 0.25 (May June 16)
8. For the 4 noded quadrilateral element shown in the fig, calculate the Jacobian. The parent element is shown in the fig, (Nov Dec 19)



9. Evaluate the following integral using Gauss Quadrature (two point) method (Nov Dec 19)

$$I = \int_{-1}^{1}(2 + x + x^2)dx \quad \text{and} \quad \int_{-1}^{1} cos\frac{\Pi x}{2}dx$$

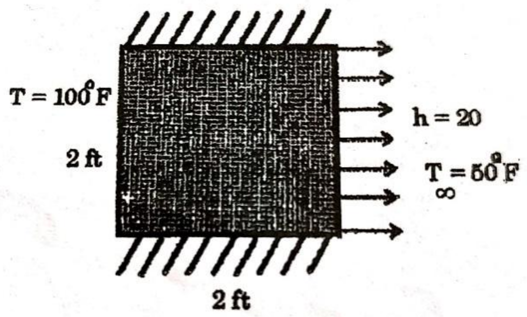
10. Evaluate the integral using Gaussian quadrature method with two point scheme (Nov Dec 18)

$$I = \int_{1}^{-1}\int_{1}^{-1}(2x^2 + 3xy + 4y^2)dxdy$$

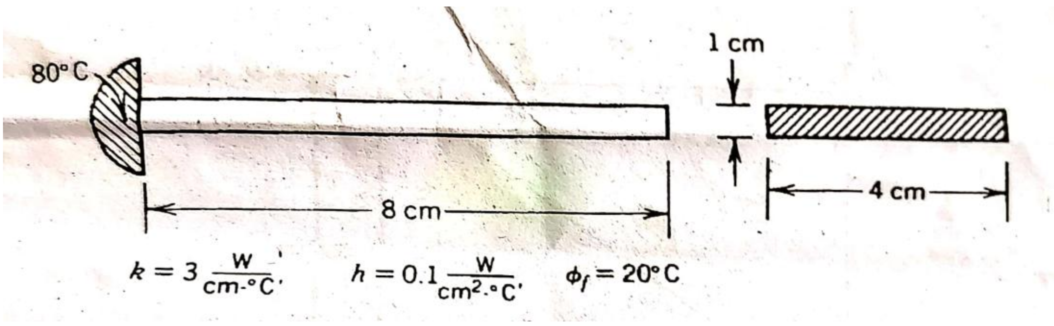
Unit – 5

Field Problems

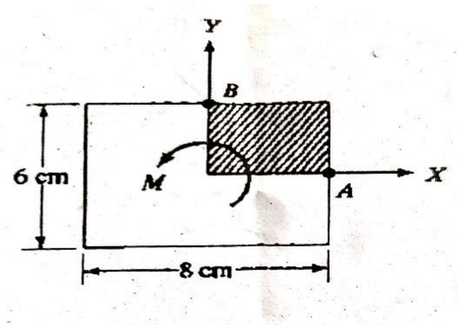
1. For the 2 D body shown in the fig, determine the temperature distribution. The temperature at the left side of the body is maintained at 100° F. the edges on the top and bottom of the body are insulated . there is heat convection from the right side with convective coefficient h = 20 Btu/h-ft^2-° F. the free stream temperature is T∞ = 50° F. the coefficients of thermal conductivity are Kxx = Kyy = 25 Btu/h-ft^2-° F. the dimensions are shown in the fig. assume the thickness is 1 ft. (Nov Dec 19)



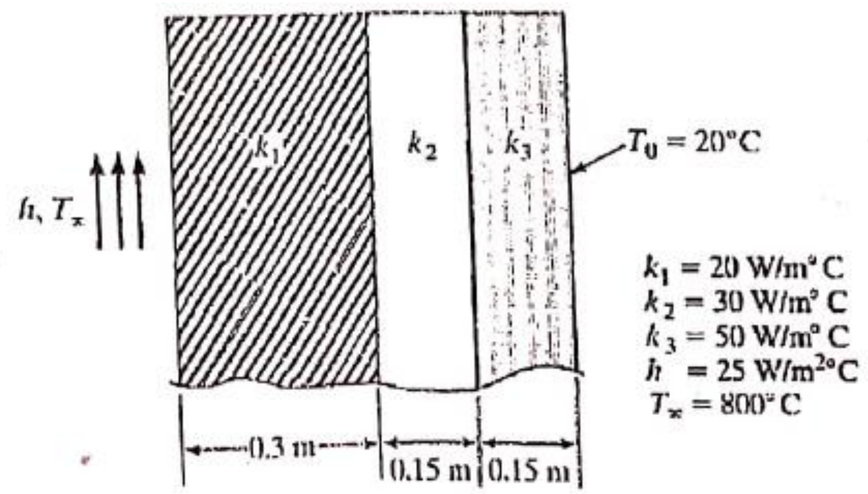
2. Calculate the temperature distribution in a one dimensional fin with the physical properties given in fig, the fin is rectangular in shape, and is 8 cm long, 4 cm wide and 1cm thick. Assume that convection heat loss occurs from the end of the fin. (Apr May 19)



3. Consider the shaft with a rectangular cross section shown in fig, determine in terms of M and G, the angle of twist per unit length (Apr May 19)



4. A composite wall through which heat inside layer with $K_1 = 0.02$ W/cm°C and middle layer $K_2 = 0.05$ W/cm°C and outer layer $K_3 = 0.035$ W/cm°C. the thickness of each layer 13 mm, 80 mm and 25 mm respectively. Inside temperature of the wall is 20°C and outside temperature of the wall is -15°C. Determine the nodal temperatures (Nov Dec 18)
5. A composite wall consist of three materials as shown in fig, the outer temperature is 20°C. convection heat transfer takes place on the inner surface of the wall with 800°C. determine the temperature distribution of the wall (Apr May 18)



6. A steel rod of diameter = 10 mm, length = 6 cm and the thermal conductivity K= 200 W/m°C is exposed to subroundant of a temperature of 250°C, the temperature end is at the left and is 140°C. the rod is not insulated at the free end, the convective heat transfer coefficient is h= 300 W/m^2 °C. find the temperature at the mid point of the rod (Nov Dec 16)
7. Determine the temperature distribution along a circular fin of length 5 cm and radius 1 cm. The fin is attached to a boiler whose wall temperature 140°C and the free end is open to the atmosphere. Assume $T\infty$ = 40°C, h =10 W/cm^2 °C and K = 70 W/cm °C (May June 16)

8. Explain the finite element procedure for carrying out 1-D conduction, convection along with internal heat generation problem using any latest commercial software, say ANSYS (Nov Dec 16)

9. Solve the following simultaneous equationsusing Gauss Elimination method

   2a+b+2c-3d = -2

   2a-2b+c-4d = -15

   A+2c-3d = -5

   4a+4b-4c+d = 4 (Nov Dec 18)

10. Explain the Cholesky method of factorization for solving set simultaneous algebraic equations and using the same to solve the following equations

    5x-3y+2z=-2

    -3x+10y+4z=31

    2x+4y+8z=22 (Apr May 2017)