GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO S26 – QUESTION BANK

Subject Name & Code: Finite Element Methods - 3171920

Chapter 1: Fundamental Concepts

Repeated Questions:

1. Approximate Methods:

- **Q.** Explain the Rayleigh-Ritz method for finding an approximate solution. **(SUMMER 2023, 4 Marks; SUMMER 2025, 4 Marks; WINTER 2025)**
- **Q.** Explain Galerkin's residual method. / Compare the solution obtained by Galerkin's method with the exact solution. **(WINTER 2023, 7 Marks OR; WINTER 2022, 7 Marks)**

2. Boundary Conditions & Steps of FEM:

- **Q.** Classify the different boundary conditions & explain them in detail. **(SUMMER 2023, 7 Marks; SUMMER 2025, 7 Marks)**
- **Q.** Explain the general steps of the Finite Element Method in detail. **(WINTER 2023, 7 Marks; SUMMER 2022, 7 Marks; WINTER 2025)**
- **Q.** State the importance of Von Mises Stress. **(WINTER 2022, 3 Marks)**

3. FEA – Approximation, Discretization & Errors:

- **Q.** Why does FEA give an approximate solution? **(SUMMER 2023, 3 Marks; SUMMER 2025, 3 Marks)**
- **Q.** What do you understand by Discretization? What are the factors to be considered for discretizing the domain? **(WINTER 2023, 4 Marks; SUMMER 2025, 4 Marks)**
- **Q.** "Finite Element Analysis plays a crucial role in the new product development process." Comment on this statement. **(WINTER 2024, 4 Marks OR; WINTER 2022, 4 Marks)**
- **Q.** What are the sources of error in FEA? **(SUMMER 2022, 3 Marks; SUMMER 2026, 3 Marks)**

Other Important Questions:

1. Methods of Analysis & Applications:

- **Q.** State the methods of engineering analysis. **(WINTER 2024, 3 Marks OR)**
- **Q.** Why FEA is more popular method to solve complex problems in comparison with analytical method. **(WINTER 2025)**
- **Q.** Discuss the applications of Finite Element Method. **(SUMMER 2026, 4 Marks OR)**

2. Elements, Nodes & Symmetry:

- **Q.** Explain Domain, Node and Element with neat sketch. [Diagram/sketch expected – refer to the original question paper of W25] **(WINTER 2025)**
- **Q.** Discuss the different types of elements used in FEA. **(WINTER 2025)**
- **Q.** Explain how symmetry is used in FEA with applications. **(WINTER 2025, 3 Marks)**
- **Q.** What is element connectivity? **(SUMMER 2026, 3 Marks OR)**

Chapter 2: One-Dimensional Problems (Bars and Thermal Effects)

Repeated Questions:

1. Bar Element & Shape Functions:

- **Q.** Derive the stiffness matrix for a 1D bar element in the local coordinate system. **(WINTER 2023, 7 Marks; SUMMER 2025, 7 Marks OR; WINTER 2025)**
- **Q.** Explain the concept of shape functions for a 1D linear element and list their properties. **(WINTER 2024, 4 Marks OR; WINTER 2022, 4 Marks OR)**

2. Thermal Effects:

- **Q.** How are the thermal effects considered in the analysis of 1D linear elements? / Formulate the additional load vector due to thermal effect in 1D bar elements. **(SUMMER 2023, 4 Marks; SUMMER 2022, 4 Marks; WINTER 2022, 7 Marks OR; SUMMER 2026, 4 Marks)**

3. Stepped & Tapered Bar (Numerical):

- **Q.** Numerical on Stepped Bar: A stepped bar is subjected to an axial force or temperature change. Determine stresses, deflections, nodal displacements, and reactions. **(SUMMER 2022, 7 Marks - c; SUMMER 2025, 7 Marks - c; WINTER 2024, 7 Marks OR; SUMMER 2023, 7 Marks - c)**
- **Q.** Numerical on Tapered Bar: Model a tapered bar into finite elements and determine the global stiffness matrix or displacements. **(WINTER 2022, 7 Marks OR; SUMMER 2025, 7 Marks - c)**

Other Important Questions:

1. 1D Element Theory:

- **Q.** Derive the stiffness matrix for a one-dimensional thermal element. **(WINTER 2024, 7 Marks OR)**
- **Q.** Obtain the stress-nodal displacement relationship for the one-dimensional bar element. **(SUMMER 2023, 3 Marks OR)**
- **Q.** Write the Lagrangian interpolation function. **(WINTER 2024, 3 Marks)**
- **Q.** Explain the FEA procedure to model a tapered bar subjected to an axial load. **(WINTER 2025, 4 Marks)**

2. Bars (Numerical):

- **Q.** For the loaded bar shown in figure, determine the nodal displacement, and elements stresses. Assume $E = 200 \times 10^9$ N/m². [Diagram given – refer to the original question paper of W25] **(WINTER 2025 - OR)**
- **Q.** A stepped bimetallic bar, made of aluminium ($E = 70 \times 10^9$ N/m²) and steel ($E = 200 \times 10^9$ N/m²) is subjected to an axial load of 300 kN at 20°C as in figure. The temperature of bar is then raised to 60°C. The coefficient of thermal expansion for aluminium is 23×10^{-6} per °C while for steel is 11.7×10^{-6} per °C, the cross-sectional area for aluminium and steel are 900 mm² and 1200 mm² respectively. Find the nodal displacement and element stresses. [Diagram given – refer to the original question paper of W25] **(WINTER 2025, 7 Marks)**
- **Q.** A stepped shaft is shown in figure. Determine stresses and the deflections in each of the sections. Take E = 90 GPa and axial force F = 50 kN. [Diagram given – refer to the original question paper of S26] **(SUMMER 2026, 7 Marks)**

Chapter 3: Trusses

Repeated Questions:

1. Truss Element & Assembly:

- **Q.** Explain the local and global coordinate systems for a truss element. **(SUMMER 2023, 4 Marks; SUMMER 2025, 4 Marks)**
- **Q.** Derive the relation between a bar element and a truss element. **(WINTER 2024, 7 Marks)**
- **Q.** Explain the assembly of the global stiffness matrix for banded and skyline solutions. **(SUMMER 2023, 3 Marks; SUMMER 2025, 3 Marks)**
- **Q.** Explain the properties of the stiffness matrix. **(SUMMER 2023, 4 Marks; SUMMER 2025, 4 Marks OR; WINTER 2025)**

2. Truss Numerical Problems:

- **Q.** Numerical on Plane Truss: For a two-member or three-member plane truss, determine the nodal displacements, stresses in each member, and support reactions. Often includes temperature effects. **(SUMMER 2022, 7 Marks - c; SUMMER 2025, 7 Marks OR; WINTER 2022, 7 Marks OR)**
- **Q.** Evaluate the deflection at a node for a given truss element. **(SUMMER 2023, 7 Marks OR; SUMMER 2025, 7 Marks - c)**

Other Important Questions:

1. Boundary Conditions & Matrix Storage:

- **Q.** Write a short note on the penalty approach for handling boundary conditions. **(SUMMER 2025, 7 Marks - c)**
- **Q.** Explain symmetric banded matrices. **(WINTER 2025, 3 Marks)**
- **Q.** Explain skyline method of storing data. **(WINTER 2025, 4 Marks OR)**
- **Q.** Write properties of stiffness matrix K. Show the general node numbering scheme and the half bandwidth. **(SUMMER 2026, 7 Marks OR)**

2. Thermal Effects & 3D Truss:

- **Q.** How are thermal effects considered in a truss element? Give the necessary equation to determine stress considering thermal effects. **(WINTER 2025, 4 Marks)**
- **Q.** For a 3D truss, formulate the modified stiffness equations for an Inclined Support-Plane Constraint (a node can only move in a defined plane). Justify why this constraint requires special treatment. **(SUMMER 2026, 4 Marks)**

3. Truss Numerical Problems:

- **Q.** For the two bar truss as shown in figure, determine the displacements in the bars. Assume E = 70 GPa and A = 200 mm^2 for both members. [Diagram given – refer to the original question paper of W25] **(WINTER 2025, 7 Marks)**
- **Q.** Evaluate the deflection at node 2 for the truss element shown in figure. Take AE/L value as 1000 N/mm. [Diagram given – refer to the original question paper of S26] **(SUMMER 2026, 7 Marks)**

Chapter 4: Beams and Frames

Repeated Questions:

1. Beam Element:

- **Q.** Derive the shape function for a beam element. / Give the potential energy approach to derive beam element equations. **(WINTER 2024, 7 Marks; SUMMER 2023, 7 Marks OR; SUMMER 2026, 7 Marks OR)**
- **Q.** Write Boundary conditions, force vector, and stiffness matrix for Beams. **(WINTER 2024, 3 Marks; WINTER 2022, 3 Marks OR)**
- **Q.** Differentiate between Spring, Bar, and Beam elements. **(SUMMER 2023, 3 Marks OR; SUMMER 2022, 4 Marks)**

2. Plane Frames:

- **Q.** Illustrate the Plane Frames element with a neat sketch indicating degrees of freedom. How is it different from a beam element? Write the element stiffness matrix K, transformation matrix L, and load vector F. **(WINTER 2024, 7 Marks; SUMMER 2023, 7 Marks; SUMMER 2025, 7 Marks OR; WINTER 2025, 7 Marks OR)**

3. Beam Numerical Problems:

- **Q.** Numerical on Beam Design/Analysis: Design a beam for a given loading condition (e.g., uniformly distributed load, point load) to meet stress criteria, or determine the global stiffness matrix. **(WINTER 2024, 7 Marks OR; SUMMER 2025, 7 Marks OR)**

Other Important Questions:

1. Beam (Numerical):

- **Q.** For the beam and loading shown in figure, determine the slopes at 2 and 3 (indicated in figure). Take E = 200 GPa and I = 4×10^6 mm^4. [Diagram given – refer to the original question paper of W25] **(WINTER 2025, 7 Marks)**

Chapter 5: Two-Dimensional Problems using Constant Strain Triangles

Repeated Questions:

1. CST, LST & Shape Functions:

- **Q.** What is a Linear Triangular Element in FEA? Derive its stiffness matrix. **(WINTER 2024, 4 Marks)**
- **Q.** Discuss the terms CST & LST. / Differentiate between CST and LST. **(WINTER 2024, 4 Marks OR; SUMMER 2023, 3 Marks; SUMMER 2025, 3 Marks)**
- **Q.** Define shape function. What are the characteristics of shape function? **(WINTER 2024, 3 Marks; SUMMER 2026, 3 Marks OR)**
- **Q.** Explain isoparametric element. / Define Iso-parametric element. **(WINTER 2025, 4 Marks; SUMMER 2026, 4 Marks OR)**
- **Q.** Discuss the conditions for plane stress and plane strain. **(WINTER 2024, 4 Marks; SUMMER 2023, 3 Marks)**

2. CST Numerical Problems:

- **Q.** Numerical on Shape Function Evaluation: A constant strain triangular element is defined by three nodes. Evaluate the shape functions N1, N2, and N3 at a given interior point P. **(SUMMER 2023, 4 Marks; SUMMER 2025, 4 Marks; WINTER 2023, 4 Marks OR)**
- **Q.** Numerical on CST Stress/Strain: For a CST element with given node coordinates and displacements, determine strains and stresses. **(SUMMER 2022, 7 Marks OR)**

Other Important Questions:

1. Plane Stress/Strain, Mesh & LST:

- **Q.** Give examples of plane stress and plane strain problems. **(WINTER 2025, 3 Marks)**
- **Q.** Classify full automatic techniques for mesh generation. **(WINTER 2024, 3 Marks OR)**
- **Q.** Explain LST element and give its application. **(WINTER 2025, 3 Marks OR)**
- **Q.** Explain the shape function of CST element. **(WINTER 2025, 4 Marks)**
- **Q.** Write short notes on: Gaussian quadrature integration technique. **(SUMMER 2026, 7 Marks)**

2. 2D Numerical Problems:

- **Q.** For the loading as in figure, determine displacements and stresses. Assume $E = 80 \times 10^3$ MPa. [Diagram/loading figure referred – refer to the original question paper of W25] **(WINTER 2025, 7 Marks)**
- **Q.** The triangular element has nodal coordinates (10,10), (40,20) and (30,50) for nodes 1, 2, and 3 respectively. For a point P inside the triangle, determine the x and y coordinates if shape functions N1 and N2 are 0.15 and 0.25 respectively. **(WINTER 2025)**

Chapter 6: Axisymmetric Solids Subjected to Axisymmetric Loading

Repeated Questions:

1. Axisymmetric Problems:

- **Q.** What are the conditions necessary to be followed for considering a problem as axisymmetric? **(SUMMER 2023, 4 Marks OR; SUMMER 2025, 4 Marks OR; WINTER 2022, 4 Marks OR)**
- **Q.** Enlist three examples of practical application of axisymmetric elements. **(SUMMER 2023, 3 Marks OR; SUMMER 2025, 3 Marks OR; WINTER 2022, 3 Marks OR)**
- **Q.** Write down the shape functions for an axisymmetric element. **(WINTER 2024, 3 Marks OR)**

Other Important Questions:

1. Axisymmetric Elements:

- **Q.** Define axisymmetric elements. **(SUMMER 2022, 3 Marks)**
- **Q.** Explain axisymmetric element with example. **(WINTER 2025, 3 Marks)**
- **Q.** Establish the shape functions and derive the strain displacement matrix for an axisymmetric triangular element. **(SUMMER 2023, 7 Marks)**
- **Q.** Differentiate between the Axisymmetric Formulation and the Plane Stress/Strain Formulation in FEM, specifically regarding the degrees of freedom and the stress components involved. **(SUMMER 2026, 3 Marks)**

2. Modelling Applications:

- **Q.** How will you make Finite element models of pressure vessel and Belleville spring. **(WINTER 2025, 3 Marks OR)**

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