19AST203-AIRCRAFT STRUCTURAL MECHANICS

TWO MARKS

UNIT-I STATICALLY DETERMINATE AND INDETERMINATE STRUCTURE

1. **Question:** What is the essential difference between a propped cantilever beam and a fixed-fixed beam?

   Answer: A propped cantilever beam has one end supported (propped), while the other end is free, whereas a fixed-fixed beam has both ends rigidly fixed.

2. **Question:** Explain the principle of superposition in structural analysis.

   Answer: The principle of superposition states that the response of a linear system to multiple loads acting simultaneously is equal to the sum of the responses to each individual load acting alone.

3. **Question:** What is Clapeyron's three moment equation used for?

   Answer: Clapeyron's three moment equation is used to determine the bending moments at the supports of a continuous beam subjected to uniformly distributed loads.

4. **Question:** Describe the moment distribution method for analyzing indeterminate beams.

   Answer: The moment distribution method involves the iterative distribution of moments throughout a structure to achieve equilibrium. It accounts for both fixed and rotational stiffness of members to solve indeterminate structures.

   Question: What is strain energy, and how is it related to different loadings in a structure?

5. **Answer:** Strain energy is the energy stored within a material when subjected to deformation. It is related to axial, bending, torsional, and shear loadings as the energy required to deform the material under these different loading conditions.

6. **Question:** Explain Castigliano's theorem and its application in structural analysis.
   Answer: Castigliano's theorem states that the partial derivative of the strain energy

with respect to a force equals the deflection caused by that force. It is used to find displacements or reactions in structures subjected to external loads.

7. **Question:** What are the energy theorems in structural analysis, and how are they applied?

   Answer: Energy theorems, such as the dummy load and unit load methods, relate the work done by external loads to the strain energy stored in a structure. They are used to determine displacements, reactions, or internal forces in statically indeterminate structures.

8. **Question:** How does the dummy load method work in structural analysis?

   Answer: In the dummy load method, a hypothetical load (dummy load) is applied to a structure, and the resulting displacements or reactions are calculated using the principle of virtual work.

9. **Question:** What is the significance of unit load method in structural analysis?
   Answer: The unit load method involves applying a unit load at different points of a structure to determine the deflections or reactions. It simplifies the analysis of indeterminate structures by considering the influence of each support individually.

10. **Question:** How are the concepts of strain energy and Castigliano's theorem related?
    Answer: Castigliano's theorem provides a method for calculating displacements or reactions in a structure using strain energy principles. It allows for the determination of deflections or reactions by taking partial derivatives of the strain energy with respect to external loads.

UNIT-II COLUMNS AND FAILURE THEORIES

1. **Question:** What is the classification of columns based on their behaviour under axial loads?

   Answer: Columns can be classified as short, intermediate, or long depending on their slenderness ratio (L/r), where L is the effective length and r is the radius of gyration.

2. **Question:** Explain Euler buckling and its significance in column design.

   Answer: Euler buckling refers to the sudden lateral deflection or instability of a column under compressive load when its critical buckling load is reached. It provides

a theoretical framework for predicting the critical load at which a column fails due to buckling.

3. **Question:** Describe the different end conditions for columns and their influence on buckling behavior.

   Answer: The end conditions of a column can be categorized as pinned, fixed, or free. Pinned ends allow rotation but no translation, fixed ends restrict both rotation and translation, while free ends allow both rotation and translation. These end conditions affect the critical buckling load and mode of buckling.

4. **Question:** What is Euler's column curve, and how does it relate to column design?
   Answer: Euler's column curve represents the relationship between the slenderness ratio (L/r) and the critical buckling load for idealized columns. It serves as a design tool for determining the maximum allowable load for a given column geometry and material properties.

5. **Question:** Explain inelastic buckling in columns and its implications for structural design.

   Answer: Inelastic buckling occurs when a column undergoes significant deformation or material yielding before buckling. It can lead to reduced load-carrying capacity and structural stability, necessitating considerations of material properties and column cross-sections in design.

6. **Question:** How does initial curvature affect the buckling behavior of columns?
   Answer: Initial curvature introduces a pre-existing deformation in a column, which can influence its buckling mode and critical load. Columns with initial curvature may exhibit different buckling behaviors compared to straight columns, requiring special consideration in design.

7. **Question:** What is the Southwell plot, and how is it used in column analysis?
   Answer: The Southwell plot is a graphical method used to determine the critical buckling load of a column experimentally. It involves plotting the applied load versus the lateral deflection of the column, with the point of maximum slope corresponding to the critical load.

8. **Question:** Discuss the effects of eccentricity on the behavior of columns.

Answer: Eccentricity refers to the misalignment of the axial load with the centroidal axis of the column cross-section. It can lead to additional bending moments and lateral deflections, affecting the column's buckling behavior and load-carrying capacity.

9. **Question:** How are energy methods used in column analysis and design?

   Answer: Energy methods, such as the principle of virtual work or the minimum potential energy principle, can be applied to analyze column stability and predict critical buckling loads. They involve calculating the potential and kinetic energies associated with the deformed column to determine stability criteria.

10. **Question:** What are beam columns, and how do they differ from pure columns?
    Answer: Beam columns are structural members subjected to combined axial and bending loads. Unlike pure columns, which primarily experience axial compression, beam columns must consider both axial and bending stresses in their design to ensure structural stability and performance.

UNIT-III UNSYMMETRICAL BENDING

1. **Question:** What is the general method for analyzing bending in beams, and when is it typically used?

   Answer: The general method involves considering the beam's cross-sectional geometry and applying equilibrium equations to determine bending stresses. It is used for beams with arbitrary cross-sections or loading conditions where other methods may not be applicable.

2. **Question:** Describe the principal axis method for analyzing bending in beams.
   Answer: The principal axis method involves rotating the beam's coordinate system to align with the principal axes of the cross-section, simplifying the analysis of bending stresses. It is particularly useful for beams with symmetric cross-sections.

3. **Question:** Explain the neutral axis method for determining bending stresses in beams.
   Answer: The neutral axis method involves identifying the location of the neutral axis within the beam's cross-section, where the bending stress is zero. It allows for the calculation of maximum bending stresses at the extreme fibers of the beam.

4. **Question:** How does skew loading affect the bending behavior of symmetric beams?

Answer: Skew loading introduces off-center or non-symmetric loading conditions on symmetric beams, resulting in asymmetric bending and shear stresses. It can lead to complex stress distributions and potentially higher stresses compared to symmetric loading.

5. **Question:** What are the bending stresses in beams of unsymmetrical sections, and how are they calculated?

   Answer: Beams of unsymmetrical sections experience bending stresses that vary across the cross-section due to non-uniform geometry. These stresses are calculated using the flexure formula, accounting for the moment of inertia and the distance from the neutral axis.

6. **Question:** How do you determine the principal axes of a beam's cross-section? **Answer:** The principal axes of a beam's cross-section are determined by finding the axes along which the product of inertia is zero. These axes correspond to the directions of maximum and minimum bending stiffness.

7. **Question:** Discuss the significance of the neutral axis in beam bending analysis. **Answer:** The neutral axis is a critical concept in beam bending analysis as it represents the location where the bending stress is zero. Understanding the position of the neutral axis allows engineers to calculate maximum bending stresses and design beams accordingly.

8. **Question:** What factors influence the magnitude of bending stresses in beams of unsymmetrical sections?

   Answer: The magnitude of bending stresses in beams of unsymmetrical sections is influenced by factors such as the geometry of the cross-section, the location of the applied loads, and the material properties of the beam.

9. **Question:** Explain the procedure for determining bending stresses in beams using the principal axis method.

   Answer: The procedure involves transforming the coordinate system to align with the principal axes, calculating the moments of inertia about these axes, and then applying the flexure formula to determine the bending stresses along each principal axis.

10. **Question:** How do engineers account for skew loading effects in the design of symmetric beams?

Answer: Engineers may use empirical correction factors or numerical methods to account for skew loading effects in the design of symmetric beams. Additionally, they may adjust beam geometry or reinforcement to mitigate potential stress concentrations caused by skew loading.

UNIT-IV SHEAR FLOW IN OPEN AND CLOSED SECTIONS

1. Question: Define a thin-walled beam and explain its significance in structural engineering.

   Answer: A thin-walled beam is a structural member with a small thickness compared to its other dimensions. It is significant because it can efficiently resist bending and torsional loads while minimizing material usage.

2. Question: What is shear flow, and how is it related to thin-walled beams?

   Answer: Shear flow refers to the distribution of shear stress across the thickness of a thin-walled beam's cross-section. It plays a crucial role in transmitting shear forces and resisting torsion in such beams.

3. Question: Explain the concept of the shear center in thin-walled beams.

   Answer: The shear center is a point within the cross-section of a thin-walled beam where the applied shear load produces pure shear deformation without causing any twisting or bending. It is essential for determining the structural response under combined bending and torsional loads.

4. Question: How is the shear center of a thin-walled beam determined?

   Answer: The shear center of a thin-walled beam is typically located at the centroid of the cross-sectional area or may be determined analytically using methods such as the Bredt-Batho theory.

5. Question: What is structural idealization, and why is it used in analyzing thin-walled beams?

Answer: Structural idealization involves simplifying complex structures into simplified models for analysis. It is used in analyzing thin-walled beams to reduce computational complexity while retaining essential structural behavior.

6. Question: Describe the Bredt-Batho theory and its application in determining shear flow distribution.

    Answer: The Bredt-Batho theory is used to calculate the distribution of shear flow in thin-walled beams subjected to bending and torsion. It accounts for the effects of both bending and torsional deformations on the shear flow distribution.

7. Question: How does shear flow vary in idealized thin-walled beam sections?

    Answer: In idealized thin-walled beam sections, shear flow varies linearly across the thickness of the wall, reaching maximum values at the outer edges of the cross-section and zero at the mid-thickness.

8. Question: Discuss the shear flow distribution in thin-walled single-cell structures subject to combined bending and torsion.

    Answer: In thin-walled single-cell structures subject to combined bending and torsion, the shear flow distribution varies along the length of the beam due to the combined effects of bending and torsion. It is influenced by the geometry and loading conditions of the structure.

9. Question: What is the significance of distinguishing between walls effective and ineffective in bending in thin-walled beams?

    Answer: Distinguishing between walls effective and ineffective in bending allows engineers to accurately predict the distribution of shear flow and bending stresses in thin-walled beam sections subjected to combined loading conditions.

10. Question: How is the shear center of closed sections determined?

    Answer: The shear center of closed sections, such as closed thin-walled beams or sections with multiple cells, is determined by considering the distribution of shear flow resulting from both bending and torsional deformations. It is typically located at the centroid of the cross-sectional area or may be determined using analytical methods.

UNIT-V BUCKLING OF PLATES AND STRESS ANALYSIS

1. **Question:** Define the term "bending of thin plates" in structural engineering.

    Answer: Bending of thin plates refers to the deformation of flat structural elements subjected to bending moments, resulting in curvatures and stresses across their thickness.

2. **Question:** What is the local buckling stress of thin-walled sections, and why is it important?

    Answer: The local buckling stress is the stress at which small segments or elements within a thin-walled section buckle locally due to compressive loading. It is important as it determines the ultimate strength and stability of thin-walled structures.

3. **Question:** Explain the Needham and Gerard methods for estimating the crippling strength of thin-walled sections.

    Answer: The Needham and Gerard methods are empirical approaches used to estimate the crippling strength of thin-walled sections under compressive loading. They involve considering factors such as material properties, geometry, and loading conditions to predict the onset of local buckling.

4. **Question:** What factors affect the load-carrying capacity of sheet stiffener panels?
    Answer: The load-carrying capacity of sheet stiffener panels is influenced by factors such as the material properties of the sheet and stiffeners, their geometry, the spacing between stiffeners, and the applied loading conditions.

5. **Question:** Describe inter-rivet buckling and sheet wrinkling failures in sheet metal structures.

    Answer: Inter-rivet buckling refers to the buckling of sheet metal panels between rivet lines due to compressive loading, while sheet wrinkling involves the formation of wrinkles or folds in the sheet metal due to tensile or compressive stresses.

6. **Question:** What is meant by the effective width in structural analysis?

    Answer: The effective width is a concept used to simplify the analysis of wide or continuous structural elements by considering them as equivalent beams with reduced widths. It allows for the estimation of the structural response while accounting for boundary conditions and loading conditions.

7. **Question:** Explain the significance of the V-n diagram in aircraft design.

   Answer: The V-n diagram is a graphical representation of the allowable maneuvering envelope for an aircraft, showing the relationship between load factor (n) and airspeed (V). It is essential for ensuring the structural integrity and safety of aircraft during flight.

8. **Question:** How are shear force and bending moment distributed over an aircraft wing and fuselage?

   Answer: Shear force and bending moment distributions over an aircraft wing and fuselage vary along their span and length due to aerodynamic loads, weight distribution, and structural configurations. They are typically highest at the root and decrease towards the wingtip or tail.

9. **Question:** What is tension field beam theory, and how is it applied in structural engineering?

   Answer: Tension field beam theory is a design approach used for the analysis and design of structures subjected to predominantly tensile forces. It involves the use of inclined tension members to carry tensile loads efficiently, often in truss-like configurations.

10. **Question:** Discuss the effects of thermal stresses, impact loading, fatigue, creep, and stress relaxation on structural materials.

    Answer: Thermal stresses arise due to temperature gradients within a structure, impact loading results in sudden and high-intensity forces, fatigue refers to the progressive weakening of materials under cyclic loading, creep is the time-dependent deformation of materials under constant load, and stress relaxation is the gradual decrease in stress over time under constant strain. These factors can significantly influence the mechanical behavior and durability of structural materials.