Reg.No:

SNS College of Technology, Coimbatore-35.
(Autonomous)
B.E/B.Tech- Internal Assessment -I
Academic Year 2023-2024 (Even Semester)
Fourth Semester
Aerospace Engineering
19AST203– Aircraft Structural Mechanics

B

Time: $1^{1/2}$ Hours **Maximum Marks: 50**

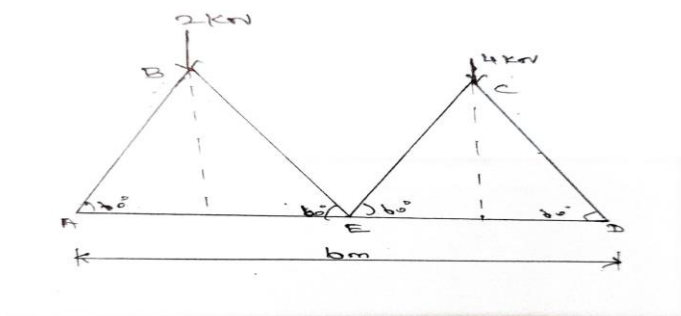
Answer All Questions

PART - A (5x 2 = 10 Marks)

<table>
<tr><th></th><th></th><th>CO</th><th>Blooms</th></tr>
<tr><td>1</td><td>Write the types of statically indeterminate structures.
1. Simple statically indeterminate structures 2. Indeterminate structures of equal lengths 3. Composite structures of equal length</td><td>CO1</td><td>App</td></tr>
<tr><td>2</td><td>Define: Modulus of resilience.
The proof resilience of a body per unit volume. (ie) The maximum energy stored in the body within the elastic limit per unit volume.</td><td>CO1</td><td>Rem</td></tr>
<tr><td>3</td><td>Write the advantages of Continuous beam over simply supported beam.
1. The maximum bending moment in case of continuous beam is much less than in case of simply supported beam of same span carrying same loads.
2. In case of continuous beam, the averaging bending moment is lesser and hence lighter materials of construction can be used to resist the bending moment.</td><td>CO1</td><td>Rem</td></tr>
<tr><td>4</td><td>What are the assumptions followed in Euler’s equation?
1. The material of the column is homogeneous, isotropic and elastic.
2. The section of the column is uniform throughout.
3. The column is initially straight and load axially.
4. The effect of the direct axial stress is neglected.
5. The column fails by buckling only.</td><td>CO2</td><td>App</td></tr>
<tr><td>5</td><td>Differentiate statically determinate and indeterminate structures.
<table>
<tr><th>Sl. No</th><th>Statically determinate structures</th><th>Statically indeterminate structures</th></tr>
<tr><td>1.</td><td>Conditions of equilibrium are sufficient to analyze the structure</td><td>Conditions of equilibrium are insufficient to analyze the structure.</td></tr>
<tr><td>2.</td><td>Bending moment and shear force is independent of material and cross sectional area.</td><td>Bending moment and shear force is dependent of material and independent of cross sectional area.</td></tr>
<tr><td>3.</td><td>No stresses are caused due to temperature change and lack of fit.</td><td>Stresses are caused due to temperature change and lack of fit.</td></tr>
</table></td><td>CO2</td><td>Rem</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

PART – B (2x13 =26 Marks)

				CO	Bloms
6	(a)	Determine the forces in the members of the roof truss shown in Fig.	13	CO1	App



sol:-

$\Sigma M_A = 0$

$2 \times 1.5 = 4.5 \times 4 - 6 \times R_D = 0$

$R_D = 3.5\ kN$

$\Sigma V = 0$

$R_A - 2 - 4 + R_D = 0$

$R_A = 2.5\ kN$

$\Sigma V = 0$

$R_A + F_{AB} \sin 60^\circ = 0$

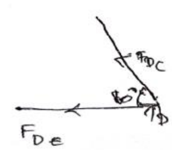
$F_{AB} = 2.89\ kN$

$\Sigma H = 0$

$F_{AE} + F_{AB} \cos 60^\circ = 0$

$F_{AE} = 1.44\ kN$

$\Sigma V = 0$



$R_D + F_{DC} \sin 60^\circ = 0$

$F_{DC} = -4.04\ kN$

$\Sigma H = 0$

$-F_{DE} - F_{DC} \cos 60^\circ = 0$

$F_{DE} = 2.02\ kN$

(or)

	(b)	Derive an derivation of three moment equation in continuous beam.	13	CO1	Eva

Consider a continuous beam supported by n supports and subjected to external loads.

1. Apply Equilibrium Conditions:

Apply equilibrium equations to each section of the beam to derive the moment equations. Let's consider a section x within the beam.

- **Sum of Forces in the y Direction:**
  $\sum F_y = 0$
  $R_A + R_B + \ldots - \text{Total Load} = 0$
- **Sum of Moments about Point A:**
  $\sum M_A = 0$
  $M_A + R_A \cdot x + R_B \cdot (x - a) + \ldots - \text{Total Moment} = 0$

2. Express Moments in terms of Discontinuities:

Introduce the discontinuity moments at each support to express the bending moments in terms of these discontinuities.

Let $M_A(x)$ denote the moment at section x due to the discontinuity at support A, and similarly for other supports.

$$M_A(x) = -R_A \cdot x$$
$$M_B(x) = -R_B \cdot (x - a)$$
$$\vdots$$

3. Derive the Three-Moment Equation:

By substituting the expressions for $M_A(x), M_B(x)$, etc., into the moment equation derived from equilibrium, we obtain the three-moment equation. This equation relates the bending moments at any section of the beam to the discontinuity moments at the supports.

For a continuous beam with n supports, the general form of the three-moment equation is:

$$M(x) = M_A(x) + M_B(x) + \ldots = \text{Total Moment at section } x$$

$$M(x) = -R_A \cdot x - R_B \cdot (x - a) - \ldots + \text{Additional Moment Terms}$$

4. Boundary Conditions:

To solve the three-moment equation, apply boundary conditions such as zero slope or zero deflection at specific points where necessary. These conditions help determine the unknown support reactions and discontinuity moments.

5. Solve for Unknowns:

Using the three-moment equation and boundary conditions, solve for the unknown support reactions and discontinuity moments.

6. Final Form:

Once the unknowns are determined, the three-moment equation provides a mathematical relationship between the bending moments at any section of the continuous beam and the support discontinuity moments.

7. (a) Derive an equation of Euler buckling theory with different end conditions. — 13 — CO2 — Eva

depends on the end conditions of the column. Let's consider different end conditions:

1. Pinned-Pinned End Conditions:

In this case, both ends of the column are free to rotate and translate.

Derivation:

1. Consider a column of length L and cross-sectional area A, subjected to an axial load P.
2. Assume the column to buckle into a sinusoidal shape.
3. Apply the principles of static equilibrium and Euler's formula to derive the critical buckling load P_{cr}.

Equation:

$$P_{cr} = \frac{\pi^2 \cdot E \cdot I}{L^2}$$

Where:

- P_{cr} = Critical buckling load
- E = Modulus of elasticity of the material
- I = Moment of inertia of the cross-section
- L = Length of the column

2. Fixed-Fixed End Conditions:

In this case, both ends of the column are fixed against rotation and translation.

Derivation:

1. Apply the same principles of static equilibrium and Euler's formula with the appropriate boundary conditions.

Equation:

$$P_{cr} = \frac{4 \cdot \pi^2 \cdot E \cdot I}{L^2}$$

3. Pinned-Fixed End Conditions (or Fixed-Pinned):

One end is pinned (free to rotate but fixed against translation), while the other end is fixed against both rotation and translation.

Derivation:

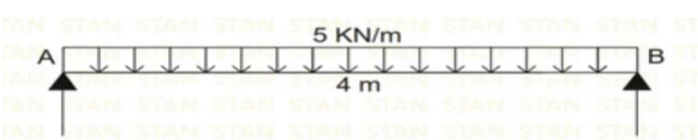
1. Apply the principles of static equilibrium and Euler's formula with the appropriate boundary conditions.

Equation:

$$P_{cr} = \frac{\pi^2 \cdot E \cdot I}{4 \cdot L^2}$$

(or)

	(b)	Write about beams and their classifications. Beams are essential structural elements used to support and transmit loads in various engineering structures, including buildings, bridges, and machines. They are characterized by their ability to resist bending moments and shear forces. Beams are classified based on several criteria, including their geometry, support conditions, material, and structural behavior. Let's explore these classifications: **1. Based on Geometry:** **a. Rectangular Beams:** • Cross-section is rectangular. • Simplest form of beam geometry. • Commonly used in construction due to ease of fabrication. **b. I-Beams (or H-Beams):** • Cross-section resembles the letter "I" (or "H"). • Offers high strength-to-weight ratio. • Efficient in resisting bending moments. • Widely used in building construction and structural engineering. **c. T-Beams:** • Cross-section resembles the letter "T". • Often used in reinforced concrete construction. • Provides enhanced resistance to bending compared to rectangular beams. **d. C-Beams (or Channel Beams):** • Cross-section resembles the letter "C". • Offers high torsional stiffness. • Commonly used in building construction and industrial applications. **2. Based on Support Conditions:** **a. Simply Supported Beams:** • Supported at both ends with no resistance to rotation. • Simplest type of support condition. • Commonly used in bridges and building structures.	13	CO2	App

		b. Fixed (or Built-in) Beams: • Supported at both ends and fixed against rotation and translation. • Offers higher resistance to bending and deflection. • Found in building frames and industrial structures. **c. Cantilever Beams:** • Supported at one end, with the other end projecting freely. • Commonly used in architectural elements, such as balconies and awnings. • Requires careful consideration of bending and torsional effects. **d. Continuous Beams:** • Supported at more than two points along their length. • Provides increased load-carrying capacity and stiffness. • Often used in long-span structures like bridges and multi-story buildings. **3. Based on Material:** **a. Steel Beams:** • Made of steel, offering high strength and ductility. • Widely used in construction due to their versatility and durability. • Available in various shapes and sizes to suit different applications. **b. Concrete Beams:** • Made of reinforced or prestressed concrete. • Suitable for heavy loads and long spans.			
8.	(a)	A beam 4m in length is simply supported as its ends and carries uniformly distributed load of 5KN/m over the entire length. Determine strain energy stored in the beam. E=200GPa and $I=1440cm^2$ 	14	CO1	Eva

a beam subjected to bending. The strain energy stored in a beam due to bending is given by:

$$U = \frac{1}{2}\int_0^L \frac{M^2(x)}{EI}\,dx$$

Where:

- U = Strain energy stored in the beam
- $M(x)$ = Bending moment at a distance x from one end of the beam
- E = Modulus of elasticity of the material
- I = Moment of inertia of the cross-section of the beam
- L = Length of the beam

First, we need to find the expression for the bending moment $M(x)$ along the length of the beam. Since the beam is simply supported and carries a uniformly distributed load, the bending moment at any point x along the beam can be calculated using the equation for bending moment in a simply supported beam with a uniformly distributed load:

$$M(x) = \frac{w}{2}x(L - x)$$

Where:

- w = Uniformly distributed load (5 kN/m in this case)
- x = Distance from one end of the beam
- L = Length of the beam

Given that $E = 200\,\mathrm{GPa} = 200 \times 10^9\,\mathrm{N/m}^2$ and $I = 1440\,\mathrm{cm}^4 = 1440 \times 10^{-8}\,\mathrm{m}^4$, and the length of the beam $L = 4\,\mathrm{m}$, we can now calculate the strain energy stored in the beam using the integral expression:

$$U = \frac{1}{2}\int_0^4 \frac{\left(\frac{w}{2}x(L-x)\right)^2}{EI}\,dx$$

$$U = \frac{1}{2EI}\int_0^4 [10x - 2.5x^2]^2 dx$$

$$= \frac{1}{2EI}\int_0^4 [100x^2 + 6.25x^4 - 50x^3]\,dx$$

$$= \frac{1}{2EI}\left[\frac{100x^3}{3} + \frac{6.25x^5}{5} - \frac{50x^4}{4}\right]_0^4$$

$$= \frac{1}{2EI}\left[\frac{100\times4^3}{3} + \frac{6.25\times4^5}{5} - \frac{50\times4^4}{4}\right]$$

$$= \frac{1}{2EI}[2133.33 + 1280 - 3200]$$

$$= \frac{1}{2EI}[213.33]$$

		$= \frac{1}{2EI} \times 213.33$ $= \frac{1}{2 \times 200 \times 10^6 \times 1440 \times 10^{-8}} \times 213.33$ $= \frac{213.33}{5760}$ $U = 0.03703$ KNm Or $U = 37.03$ Nm Result: Strain Energy stored in the beam, $U = 37.03$ Nm or 37.03 j			
		(or)			
	(b)	Explain about columns and their classifications with neat sketches. Columns are vertical structural members designed to support axial loads, such as the weight of a building or other structures, and transmit these loads to the foundation below. They come in various shapes and sizes, each suitable for different architectural and engineering purposes. Columns can be classified based on several factors, including their cross-sectional shape, material, and structural behavior. Here's an explanation of different column classifications along with neat sketches: **1. Based on Cross-Sectional Shape:** **a. Rectangular Columns:** • Cross-section is rectangular. • Simple and commonly used in building construction. • Offers uniform load distribution. **b. Circular Columns:** • Cross-section is circular. • Provides better resistance to lateral forces. • Often used in bridges and structures requiring high strength. **c. Square Columns:** • Cross-section is square. • Offers simplicity and ease of construction.	14	CO2	Cre

- Suitable for buildings with square or rectangular footprints.

2. Based on Material:

a. Concrete Columns:

- Made of reinforced or prestressed concrete.
- Commonly used in construction due to their durability and fire resistance.
- Available in various shapes and sizes to suit different design requirements.

b. Steel Columns:

- Made of structural steel.
- Offer high strength-to-weight ratio.
- Widely used in high-rise buildings and industrial structures.

c. Wood Columns:

- Made of wood or engineered wood products.
- Lightweight and easy to work with.
- Suitable for low-rise buildings and residential construction.

3. Based on Structural Behavior:

a. Axially Loaded Columns:

- Primarily subjected to axial compression loads.
- Failure occurs due to buckling or crushing.
- Commonly found in buildings and other vertical structures.

b. Eccentrically Loaded Columns:

- Subjected to both axial compression and bending moments.
- Load application is off-center from the centroid of the cross-section.
- Requires careful analysis to prevent lateral buckling.

c. Short Columns:

- Relatively short in length compared to the cross-sectional dimensions.
- Failure primarily occurs due to crushing of material.
- Commonly used in building foundations and short structures.

		d. Long Columns: • Length is significantly greater than the cross-sectional dimensions. • Failure occurs due to buckling under compressive loads. • Require bracing or reinforcement to prevent buckling. These classifications help engineers and architects select the appropriate column type based on the structural requirements, material availability, and design constraints of the project. Each type of column has its advantages and limitations, and the choice depends on various factors such as load conditions, architectural aesthetics, and budget considerations.			
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Abbreviations

Rem- Remember App-Apply Ana-Analyze Eva-Evaluate Cre-Create