Reg.No: | | | | | | | |

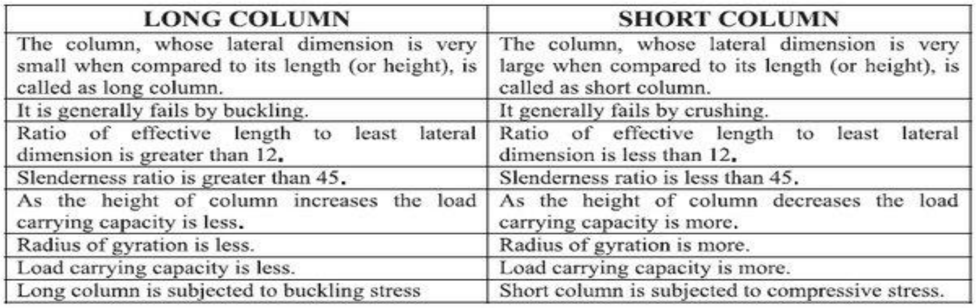
SNS College of Technology, Coimbatore-35.
(Autonomous)
B.E/B.Tech- Internal Assessment -I
Academic Year 2023-2024 (Even Semester)
Fourth Semester
Aerospace Engineering
19AST203– Aircraft Structural Mechanics

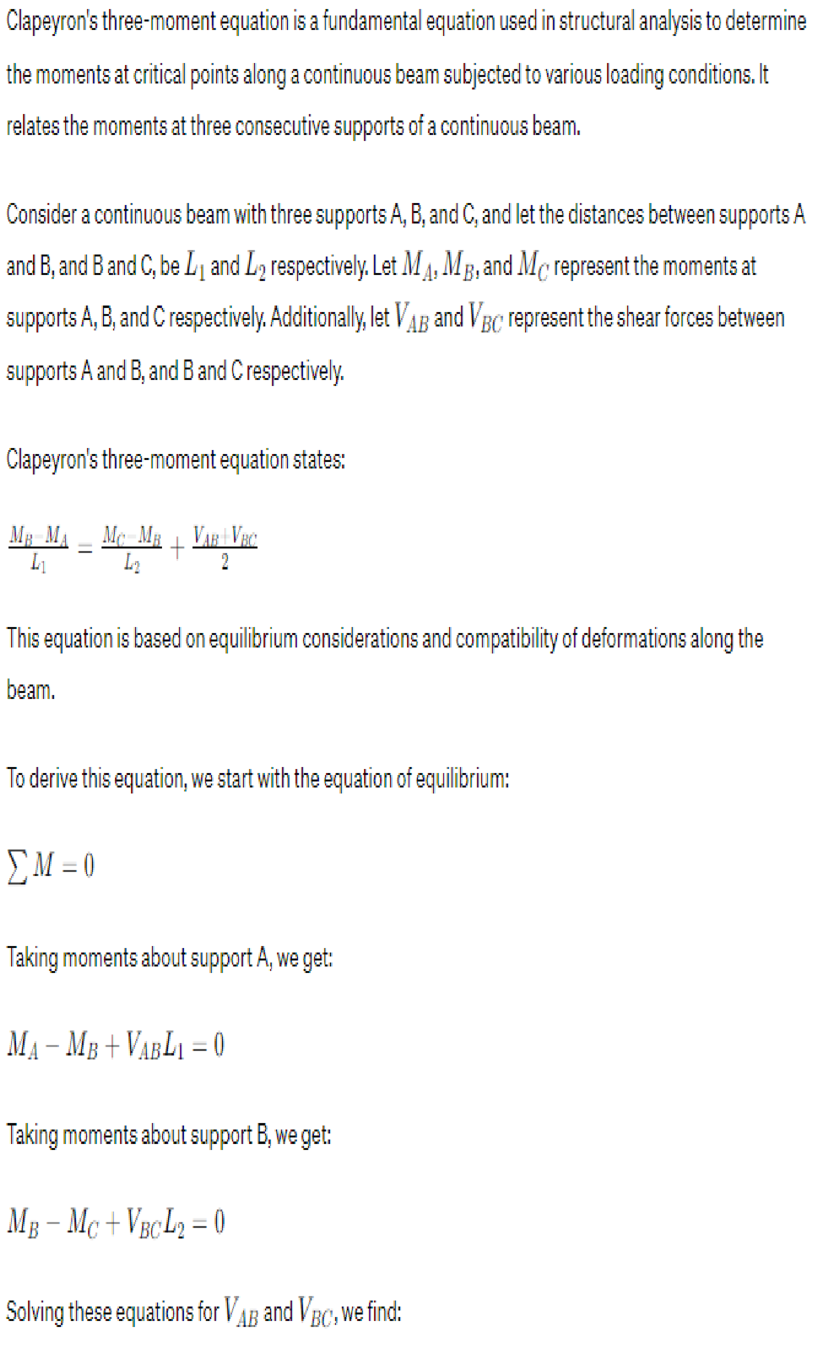
A

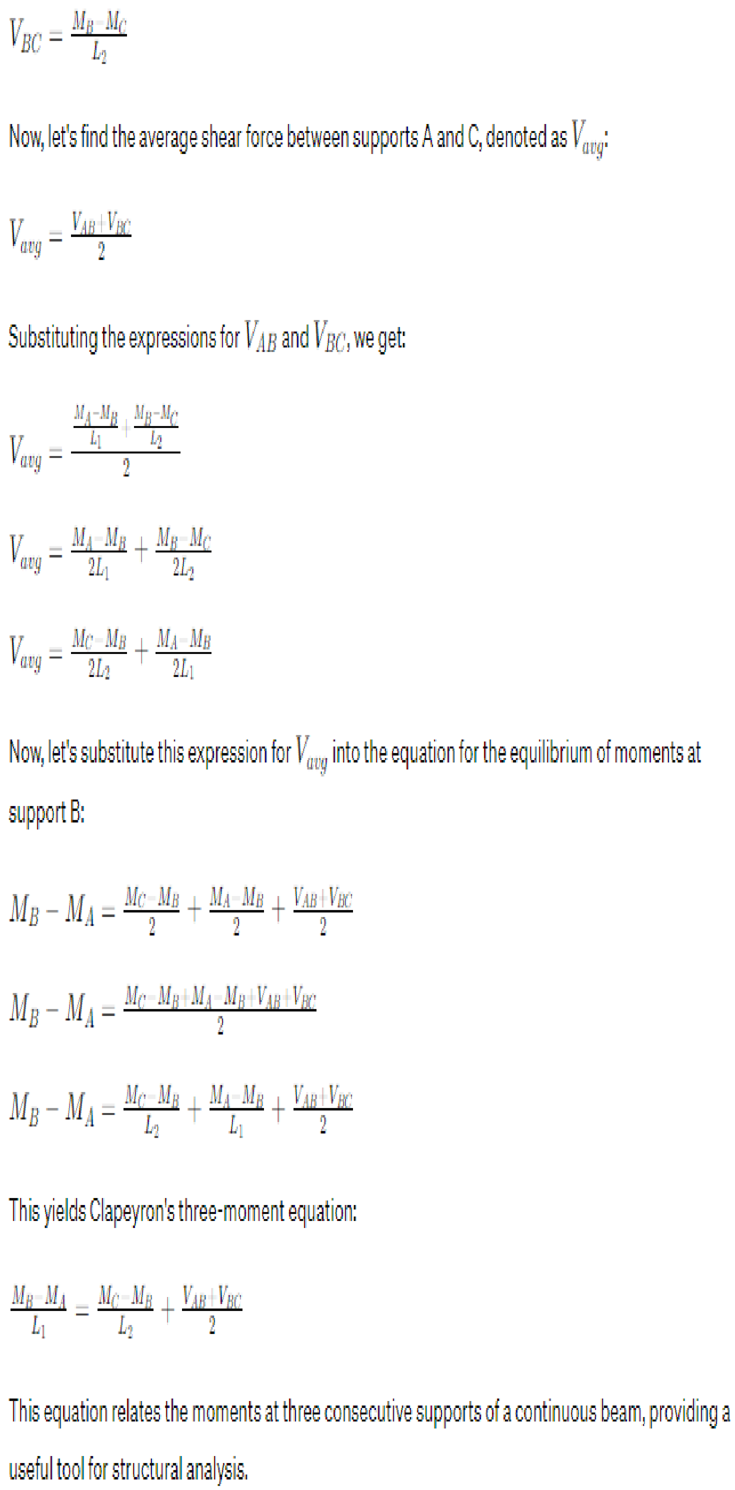
Time: $1^{1/2}$ Hours **Maximum Marks: 50**

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 Castigliano’s first theorem.
In any beam or truss subjected to any load system, the deflection at any point is given by the partial differential coefficient of the total strain energy stored with respect to force acting at a point. δ = Deflection U = Strain Energy stored P = Load</td><td>CO1</td><td>App</td></tr>
<tr><td>2</td><td>Define: Unit load method
The external load is removed and the unit load is applied at the point, where the deflection or rotation is to found.</td><td>CO1</td><td>Rem</td></tr>
<tr><td>3</td><td>Write the formula to calculate the strain energy due to bending.
U=M2L/2EI Where, M = Bending moment due to applied loads. E = Young’s modulus I = Moment of inertia</td><td>CO1</td><td>Rem</td></tr>
<tr><td>4</td><td>What are the various theories of failure in beam and column?
Four types of reinforced concrete beam-column joint failure can occur:
(1) failure of the concrete strut; (2) failure of the truss; (3) confining reinforcement failure; and (4) all of these depend on bond loss possibility</td><td>CO2</td><td>App</td></tr>
<tr><td>5</td><td>Differentiate long and short column.

<table>
<tr><th>LONG COLUMN</th><th>SHORT COLUMN</th></tr>
<tr><td>The column, whose lateral dimension is very small when compared to its length (or height), is called as long column.</td><td>The column, whose lateral dimension is very large when compared to its length (or height), is called as short column.</td></tr>
<tr><td>It is generally fails by buckling.</td><td>It generally fails by crushing.</td></tr>
<tr><td>Ratio of effective length to least lateral dimension is greater than 12.</td><td>Ratio of effective length to least lateral dimension is less than 12.</td></tr>
<tr><td>Slenderness ratio is greater than 45.</td><td>Slenderness ratio is less than 45.</td></tr>
<tr><td>As the height of column increases the load carrying capacity is less.</td><td>As the height of column decreases the load carrying capacity is more.</td></tr>
<tr><td>Radius of gyration is less.</td><td>Radius of gyration is more.</td></tr>
<tr><td>Load carrying capacity is less.</td><td>Load carrying capacity is more.</td></tr>
<tr><td>Long column is subjected to buckling stress</td><td>Short column is subjected to compressive stress.</td></tr>
</table></td><td>CO2</td><td>Rem</td></tr>
</table>

PART – B (2x13 =26 Marks)					
				CO	**Blooms**
6	(a)	Derive an Clapeyron‘s three moment equation of continuous beam.  Clapeyron's three-moment equation is a fundamental equation used in structural analysis to determine the moments at critical points along a continuous beam subjected to various loading conditions. It relates the moments at three consecutive supports of a continuous beam. Consider a continuous beam with three supports A, B, and C, and let the distances between supports A and B, and B and C, be L_1 and L_2 respectively. Let M_A, M_B, and M_C represent the moments at supports A, B, and C respectively. Additionally, let V_{AB} and V_{BC} represent the shear forces between supports A and B, and B and C respectively. Clapeyron's three-moment equation states: $\frac{M_B - M_A}{L_1} = \frac{M_C - M_B}{L_2} + \frac{V_{AB}+V_{BC}}{2}$ This equation is based on equilibrium considerations and compatibility of deformations along the beam. To derive this equation, we start with the equation of equilibrium: $\sum M = 0$ Taking moments about support A, we get: $M_A - M_B + V_{AB}L_1 = 0$ Taking moments about support B, we get: $M_B - M_C + V_{BC}L_2 = 0$ Solving these equations for V_{AB} and V_{BC}, we find:	13	CO1	App

<table>
<tr><td></td><td></td><td>

$$V_{BC} = \frac{M_B - M_C}{L_2}$$

Now, let's find the average shear force between supports A and C, denoted as V_{avg}:

$$V_{avg} = \frac{V_{AB} + V_{BC}}{2}$$

Substituting the expressions for V_{AB} and V_{BC}, we get:

$$V_{avg} = \frac{\frac{M_A - M_B}{L_1} + \frac{M_B - M_C}{L_2}}{2}$$

$$V_{avg} = \frac{M_A - M_B}{2L_1} + \frac{M_B - M_C}{2L_2}$$

$$V_{avg} = \frac{M_C - M_B}{2L_2} + \frac{M_A - M_B}{2L_1}$$

Now, let's substitute this expression for V_{avg} into the equation for the equilibrium of moments at support B:

$$M_B - M_A = \frac{M_C - M_B}{2} + \frac{M_A - M_B}{2} + \frac{V_{AB} + V_{BC}}{2}$$

$$M_B - M_A = \frac{M_C - M_B + M_A - M_B + V_{AB} + V_{BC}}{2}$$

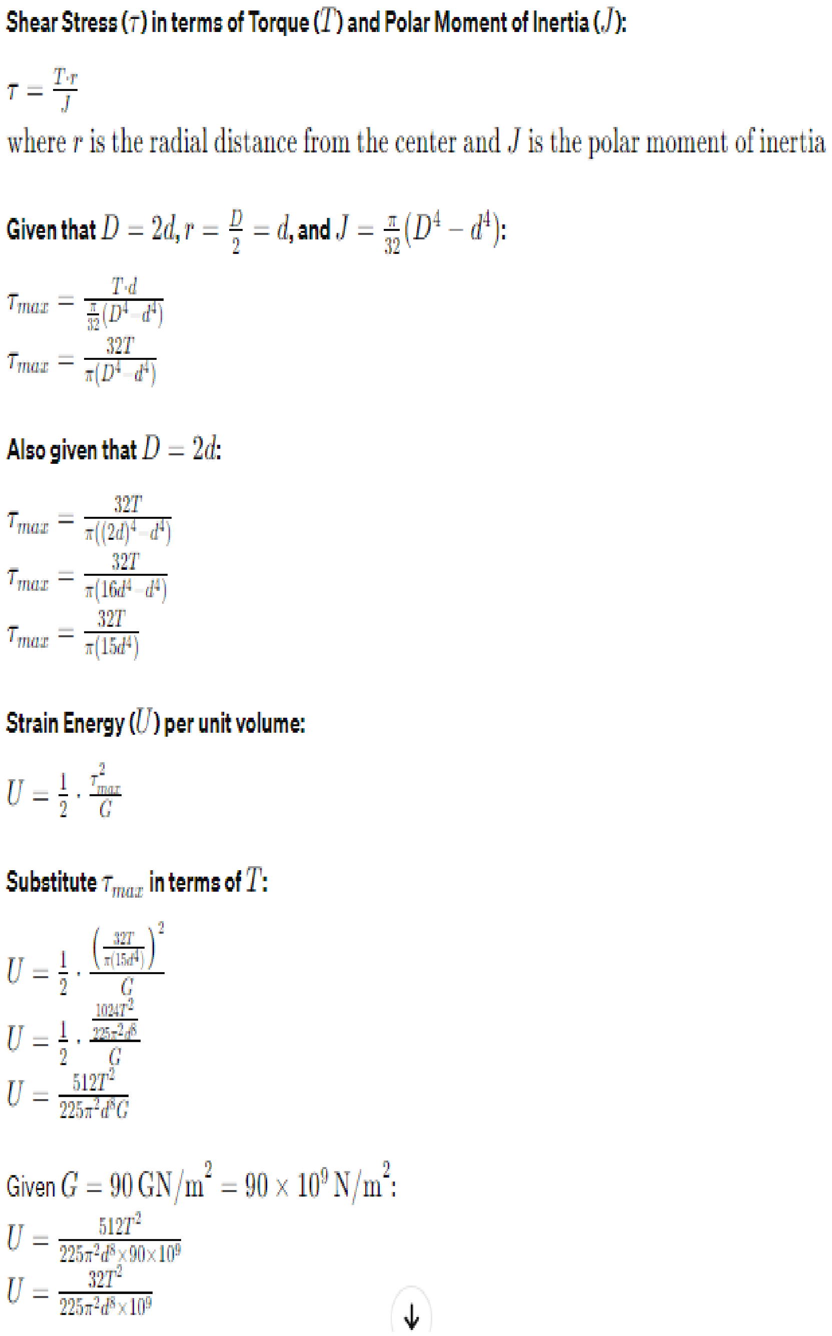
$$M_B - M_A = \frac{M_C - M_B}{L_2} + \frac{M_A - M_B}{L_1} + \frac{V_{AB} + V_{BC}}{2}$$

This yields Clapeyron's three-moment equation:

$$\frac{M_B - M_A}{L_1} = \frac{M_C - M_B}{L_2} + \frac{V_{AB} + V_{BC}}{2}$$

This equation relates the moments at three consecutive supports of a continuous beam, providing a useful tool for structural analysis.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>(or)</td><td></td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>The external diameter of hallow shaft is twice the internal diameter. It is subjected to a pure torque and it attains a maximum shear stress Γ. Show that the strain energy stored per unit volume of the shaft is 5Γ^2/16C. Such a shaft is required to transmit 5400KW at 110rpm with uniform torque, the maximum shear stress not exceeding 84MN/m^2. Determine (i) The shaft diameters (ii) Energy stored per m^3 Take</td><td>13</td><td>CO1</td><td>Eva</td></tr>
</table>

G=90GN/m^2



Shear Stress (τ) in terms of Torque (T) and Polar Moment of Inertia (J):

$$\tau = \frac{T \cdot r}{J}$$

where r is the radial distance from the center and J is the polar moment of inertia

Given that $D = 2d, r = \frac{D}{2} = d$, and $J = \frac{\pi}{32}(D^4 - d^4)$:

$$\tau_{max} = \frac{T \cdot d}{\frac{\pi}{32}(D^4 - d^4)}$$

$$\tau_{max} = \frac{32T}{\pi(D^4 - d^4)}$$

Also given that $D = 2d$:

$$\tau_{max} = \frac{32T}{\pi((2d)^4 - d^4)}$$

$$\tau_{max} = \frac{32T}{\pi(16d^4 - d^4)}$$

$$\tau_{max} = \frac{32T}{\pi(15d^4)}$$

Strain Energy (U) per unit volume:

$$U = \frac{1}{2} \cdot \frac{\tau_{max}^2}{G}$$

Substitute τ_{max} in terms of T:

$$U = \frac{1}{2} \cdot \frac{\left(\frac{32T}{\pi(15d^4)}\right)^2}{G}$$

$$U = \frac{1}{2} \cdot \frac{\frac{1024T^2}{225\pi^2 d^8}}{G}$$

$$U = \frac{512T^2}{225\pi^2 d^8 G}$$

Given $G = 90\,\mathrm{GN/m}^2 = 90 \times 10^9\,\mathrm{N/m}^2$:

$$U = \frac{512T^2}{225\pi^2 d^8 \times 90 \times 10^9}$$

$$U = \frac{32T^2}{225\pi^2 d^8 \times 10^9}$$

		Given $T = 5400\,\mathrm{kW}, D = 2d$, and $\tau_{max} = 84\,\mathrm{MN/m}^2$: $\tau_{max} = \frac{32T}{\pi((2d)^4 - d^4)}$ $84 \times 10^6 = \frac{32\times5400\times10^3}{\pi((2d)^4 - d^4)}$ $(2d)^4 - d^4 = \frac{32\times5400\times10^3}{84\times10^6} \times \frac{32}{\pi}$ $(2d)^4 - d^4 = \frac{32\times5400\times32}{84\times\pi}$ $(2^4 - 1)d^4 = \frac{32\times5400\times32}{84\times\pi}$ $15d^4 = \frac{32\times5400\times32}{84\times\pi}$ $d^4 = \frac{32\times5400\times32}{15\times84\times\pi}$ $d^4 = \frac{32\times32\times5400}{15\times84\times\pi}$ $d^4 = \frac{32^2\times5400}{15\times84\times\pi}$ $d^4 = \frac{2^{10}\times3^3\times5^2\times5400}{3\times5\times7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$ $d^4 = \frac{2^7\times3^2\times5^2\times5400}{7\times\pi}$			
7.	(a)	Explain about columns and their classifications with neat sketches. Columns are structural elements used to support vertical loads, such as the weight of a building, bridge, or other structures. They are commonly found in various architectural and engineering designs. Columns can be classified based on different criteria, 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. • Often used in buildings where space is limited.	13	CO2	Eva

b. Circular Columns:

- Cross-section is circular.
- Offers better resistance to lateral forces.

c. Square Columns:

- Cross-section is square.
- Provides uniform load distribution.

2. Based on Material:

a. Concrete Columns:

- Made of concrete.
- Commonly used in construction due to their strength and durability.

b. Steel Columns:

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

c. Wood Columns:

- Made of wood.
- Used in residential and low-rise commercial buildings.
- Not as strong as steel or concrete.

3. Based on Structural Behavior:

a. Axially Loaded Columns:

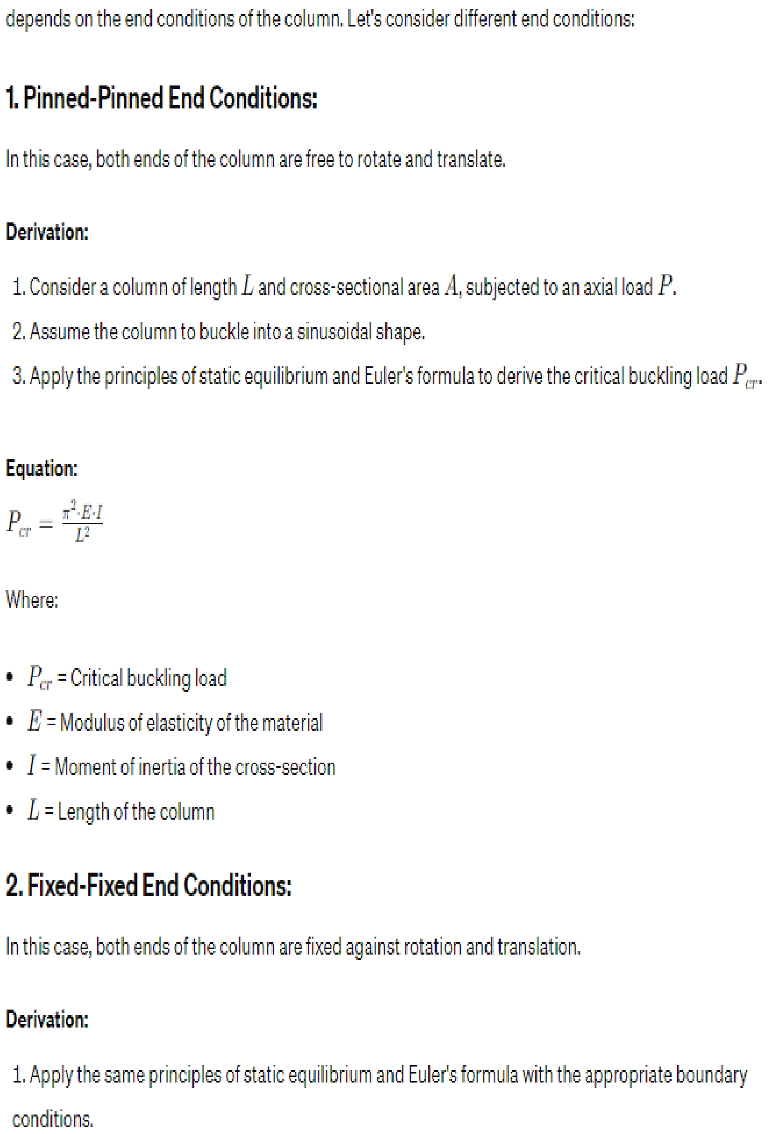
- Primarily subjected to axial compression loads.
- Length is much greater than cross-sectional dimensions.

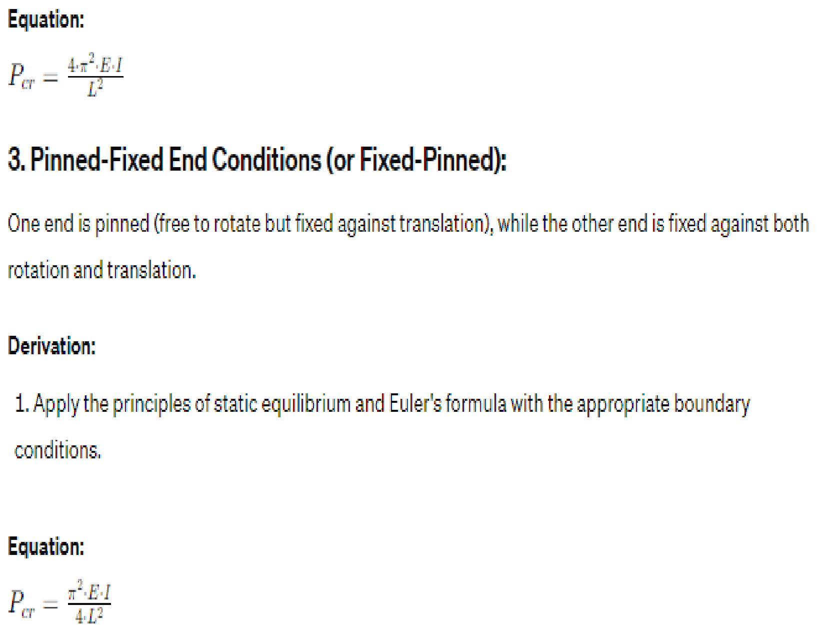
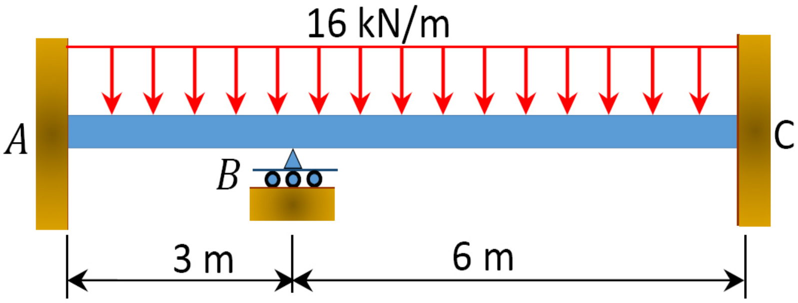
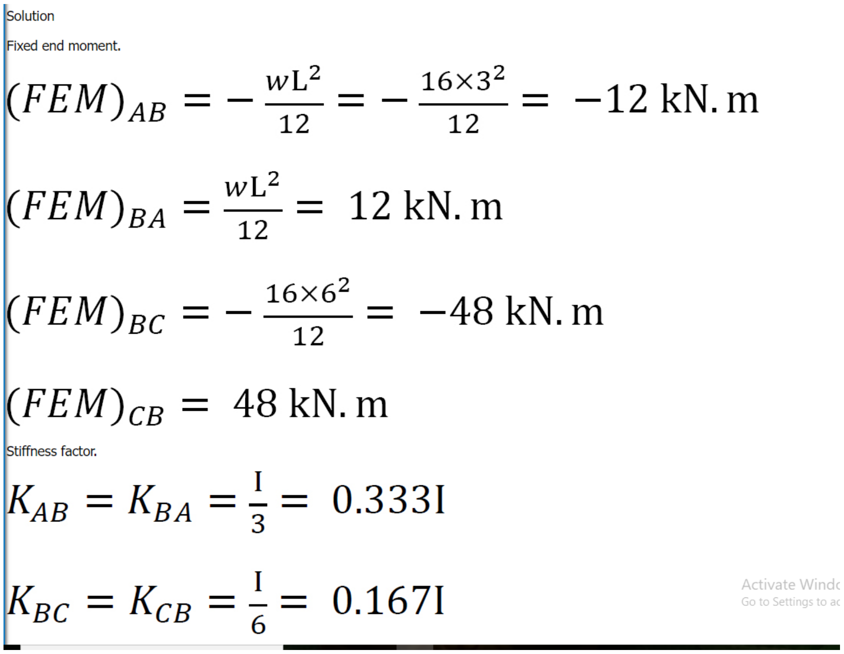
b. Eccentrically Loaded Columns:

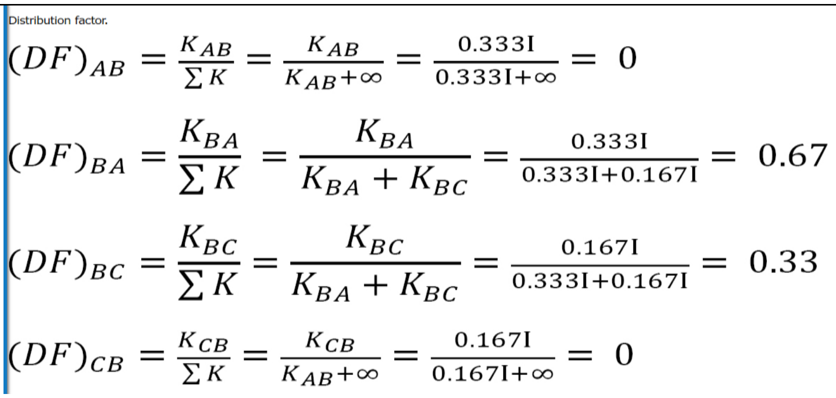
- Subjected to both axial compression and bending moments.
- Load application is off-center from the centroid of the cross-section.

c. Short Columns:

- Relatively short in length compared to cross-sectional

		dimensions. • Failure primarily occurs due to crushing of material. **d. Long Columns:** • Length is significantly greater than the cross-sectional dimensions. • Failure occurs due to buckling. These classifications provide engineers and architects with a framework for selecting the appropriate column type based on the structural requirements and constraints of the project.			
		(or)			
	(b)	Derive an equation of Euler buckling theory with different end conditions.  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.	13	CO2	App

		 **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:** $P_{cr} = \frac{\pi^2 \cdot E \cdot I}{4 \cdot L^2}$			
8.	(a)	Using moment distribution method determine the end moments and reactions at the supports of the beam shown in fig. Draw shear force and bending moment diagrams. EI=Constant   Solution Fixed end moment. $(FEM)_{AB} = -\frac{wL^2}{12} = -\frac{16\times3^2}{12} = -12\ \mathrm{kN.m}$ $(FEM)_{BA} = \frac{wL^2}{12} = 12\ \mathrm{kN.m}$ $(FEM)_{BC} = -\frac{16\times6^2}{12} = -48\ \mathrm{kN.m}$ $(FEM)_{CB} = 48\ \mathrm{kN.m}$ Stiffness factor. $K_{AB} = K_{BA} = \frac{I}{3} = 0.333I$ $K_{BC} = K_{CB} = \frac{I}{6} = 0.167I$	14	CO1	Eva



Distribution factor.

$$(DF)_{AB} = \frac{K_{AB}}{\sum K} = \frac{K_{AB}}{K_{AB}+\infty} = \frac{0.333\text{I}}{0.333\text{I}+\infty} = 0$$

$$(DF)_{BA} = \frac{K_{BA}}{\sum K} = \frac{K_{BA}}{K_{BA} + K_{BC}} = \frac{0.333\text{I}}{0.333\text{I}+0.167\text{I}} = 0.67$$

$$(DF)_{BC} = \frac{K_{BC}}{\sum K} = \frac{K_{BC}}{K_{BA} + K_{BC}} = \frac{0.167\text{I}}{0.333\text{I}+0.167\text{I}} = 0.33$$

$$(DF)_{CB} = \frac{K_{CB}}{\sum K} = \frac{K_{CB}}{K_{AB}+\infty} = \frac{0.167\text{I}}{0.167\text{I}+\infty} = 0$$

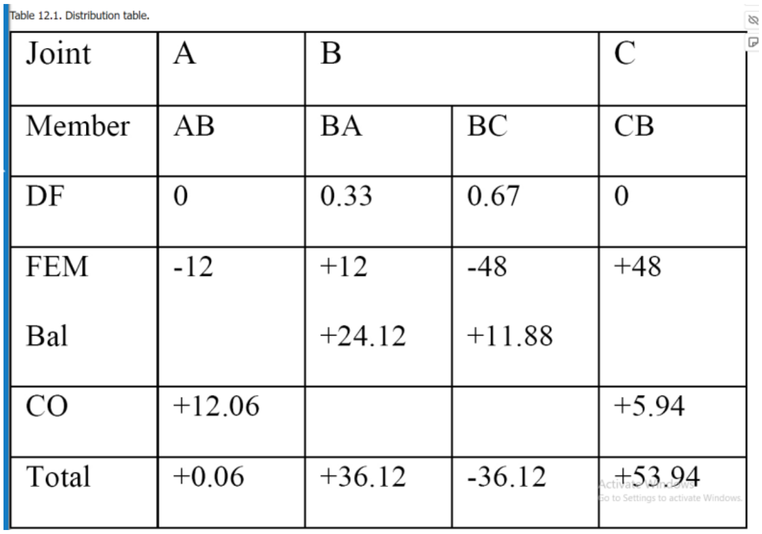
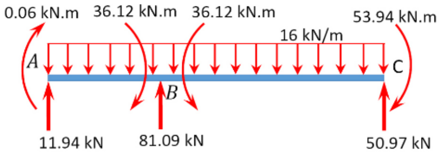


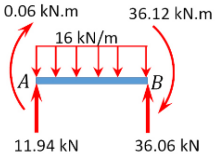
Table 12.1. Distribution table.

Joint	A	B		C
Member	AB	BA	BC	CB
DF	0	0.33	0.67	0
FEM Bal	-12	+12 +24.12	-48 +11.88	+48
CO	+12.06			+5.94
Total	+0.06	+36.12	-36.12	+53.94

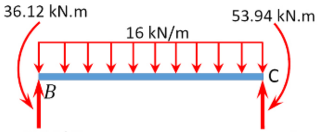
Shear force and bending moment diagrams.



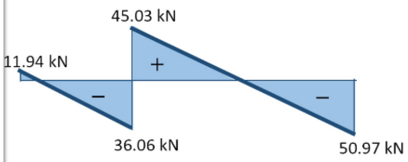
(b)



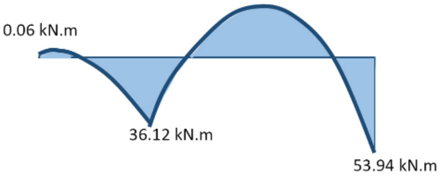
(c)



(d)



(e) Shearing force diagram for the indeterminate beam



(f) Bending moment diagram for the indeterminate beam

(or)

	(b)	Write about beams and their classifications. Beams are structural elements that primarily carry loads perpendicular to their longitudinal axis. They are crucial components in various engineering structures, such as buildings, bridges, and mechanical systems. Beams are classified based on several criteria, including their geometry, support conditions, and the manner in which they resist loads. Here's an overview of beams and their classifications: **1. Based on Geometry:** **a. Rectangular Beams:** • Cross-section is rectangular. • Simple and common design. • Used in a wide range of applications. **b. I-Beams (or H-Beams):** • Cross-section resembles the letter "I" (or "H"). • Efficient in resisting bending moments. • Widely used in construction and structural engineering. **c. T-Beams:** • Cross-section resembles the letter "T". • Suitable for reinforced concrete construction. • Provides enhanced resistance to bending. **d. C-Beams (or Channel Beams):** • Cross-section resembles the letter "C". • Offers high torsional stiffness. • Commonly used in building and construction. **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. **b. Fixed (or Built-in) Beams:**	14	CO2	Cre

- 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 and crane arms.
- 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 Load and Support Conditions:

a. Uniformly Distributed Load (UDL) Beams:

- Load is evenly distributed along the length of the beam.
- Commonly encountered in floors, roofs, and bridges.

b. Point Load Beams:

- Load is concentrated at specific points along the beam.
- Found in situations like support columns and concentrated loads.

c. Partially Distributed Load Beams:

- Combination of uniformly distributed load and point loads.
- Requires careful analysis to determine stress distribution.

4. Based on Material:

a. Steel Beams:

- Made of steel, offering high strength and ductility.
- Commonly used in construction due to their versatility.

		b. Concrete Beams: • Made of reinforced or prestressed concrete. • Suitable for heavy loads and long spans. • Widely used in building and bridge construction. **c. Wooden Beams:** • Made of wood or engineered wood products. • Lightweight and easy to work with. • Commonly used in residential construction and architectural detailing.			
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Abbreviations

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