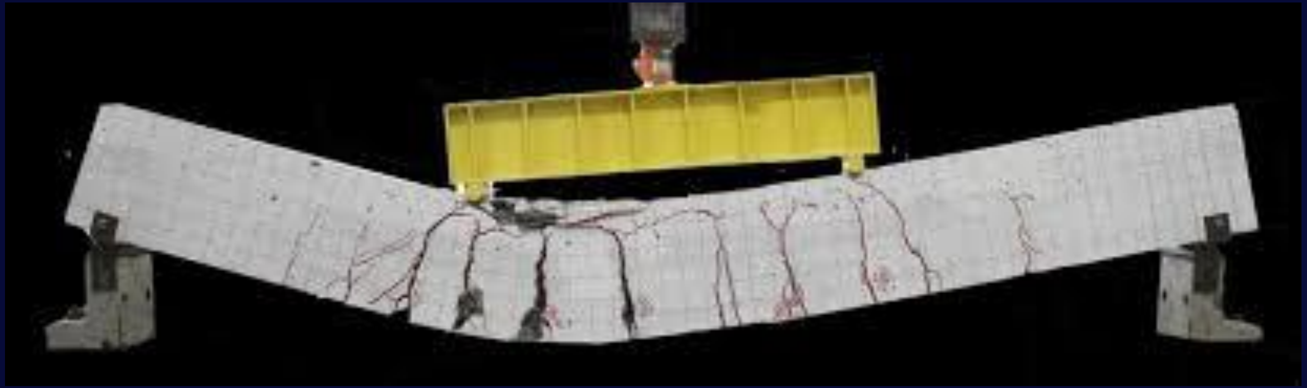
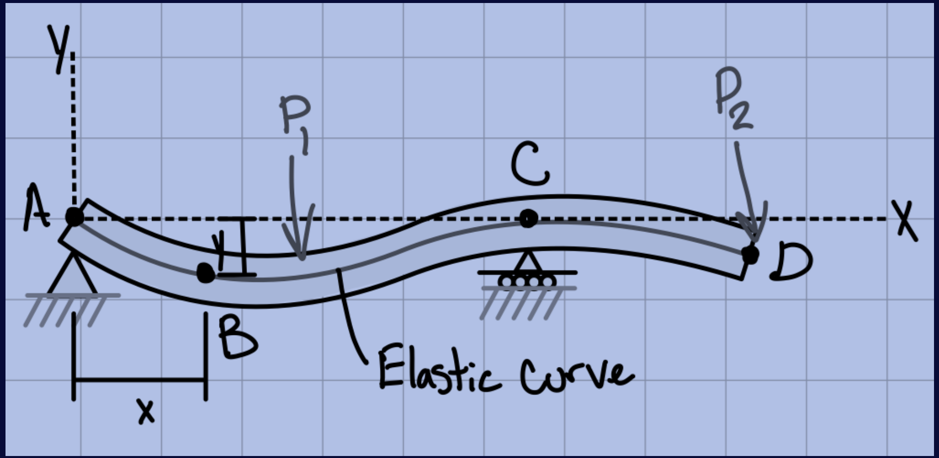
STRUCTURAL ANALYSIS
SLOPE DEFLECTION METHOD





Learning Outcomes-

- ❑Slope Deflection Equation
- ❑Equilibrium Equation
- ❑ Rotation, Deflection & Moments

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Slope Deflection Method

- **Displacements / Slopes** are taken as the unknown quantities, i.e, method is also called the **displacement method.** The unknown displacements are obtained by solving equations of equilibrium.

- By forming slope deflection equations and applying joint and shear **equilibrium conditions**, the rotation angles are calculated.

Assumptions in Slope deflection Method

1) All the joints are rigid. i.e, angle between any two members in a joint does not change even after deformation due to loading.

2) Torsion due to axial deformations are neglected.

3) Shear deformations are neglected.

Sign Conventions in Slope Deflection Method

1) Moments-

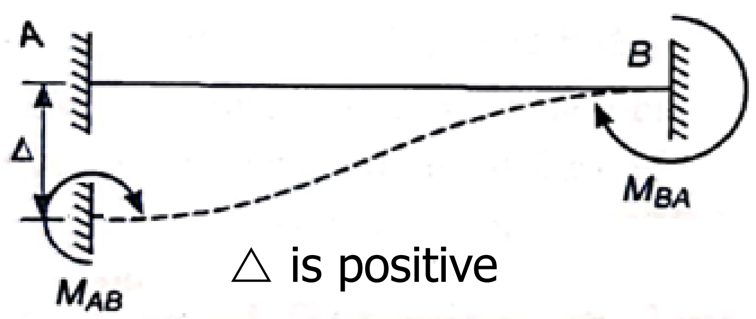
*Clockwise end moments are positive.
*Anti-Clockwise end moments are negative.

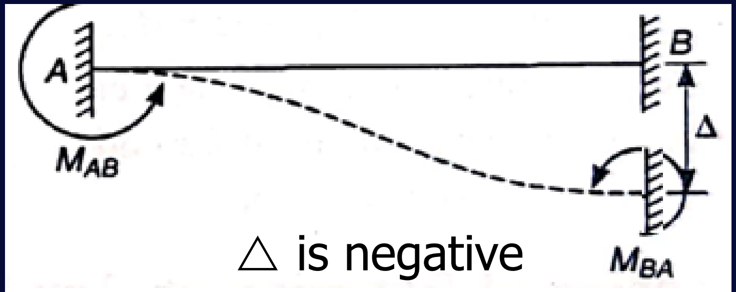
2) Rotations-

*Clock wise rotation of a tangent to elastic curve is positive.
*Anti-Clock wise rotation of a tangent to elastic curve is negative.

3) Settlement-

*If left side support is below the left side support, then the settlement △ is positive.
*If right side support is below the right side support, then the settlement △ is negative.





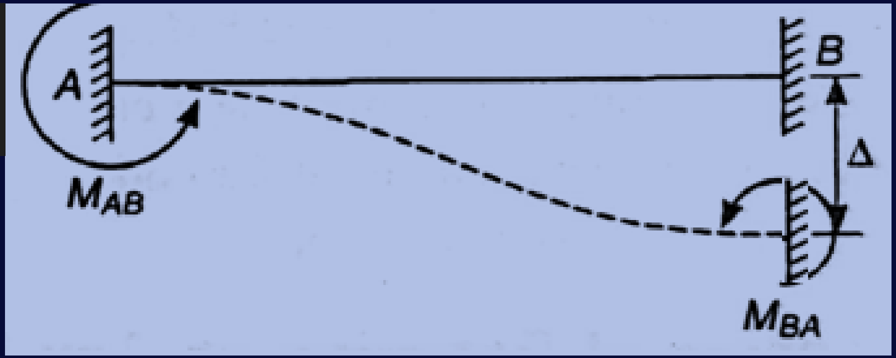
Slope Deflection Equation

Slope deflection equation express the final moments of each member in the following terms-

1. Moment due to rotation at A alone
2. Moment due to rotation at B alone
3. Fixed end moments due to external load
4. Moment due to settlement of support B.

*** Settlement △ is negative. (B is below A)**

$$\frac{6EI\Delta}{L^2}$$



$$\frac{6EI\Delta}{L^2}$$

Slope Deflection Equation

Slope Deflection Equation at end A is given by,

$$M_{AB} = \frac{4EI}{L}\theta_A + \frac{2EI}{L}\theta_B - \frac{6EI}{L^2}\Delta + M_{FAB}$$

$$M_{AB} = 2E\left(\frac{I}{L}\right)\left[2\theta_A + \theta_B - 3\left(\frac{\Delta}{L}\right)\right] + M_{FAB}$$

Slope Deflection Equation at end A is given by,

$$M_{BA} = \frac{2EI}{L}\theta_A + \frac{4EI}{L}\theta_B - \frac{6EI\Delta}{L^2} + M_{FBA}$$

$$M_{BA} = 2E\left(\frac{I}{L}\right)\left[\theta_A + 2\theta_B - 3\left(\frac{\Delta}{L}\right)\right] + M_{FBA}$$

NOTE:

* Two S-D equations for each span.
* Settlement △ is negative. (Right support is below left support)

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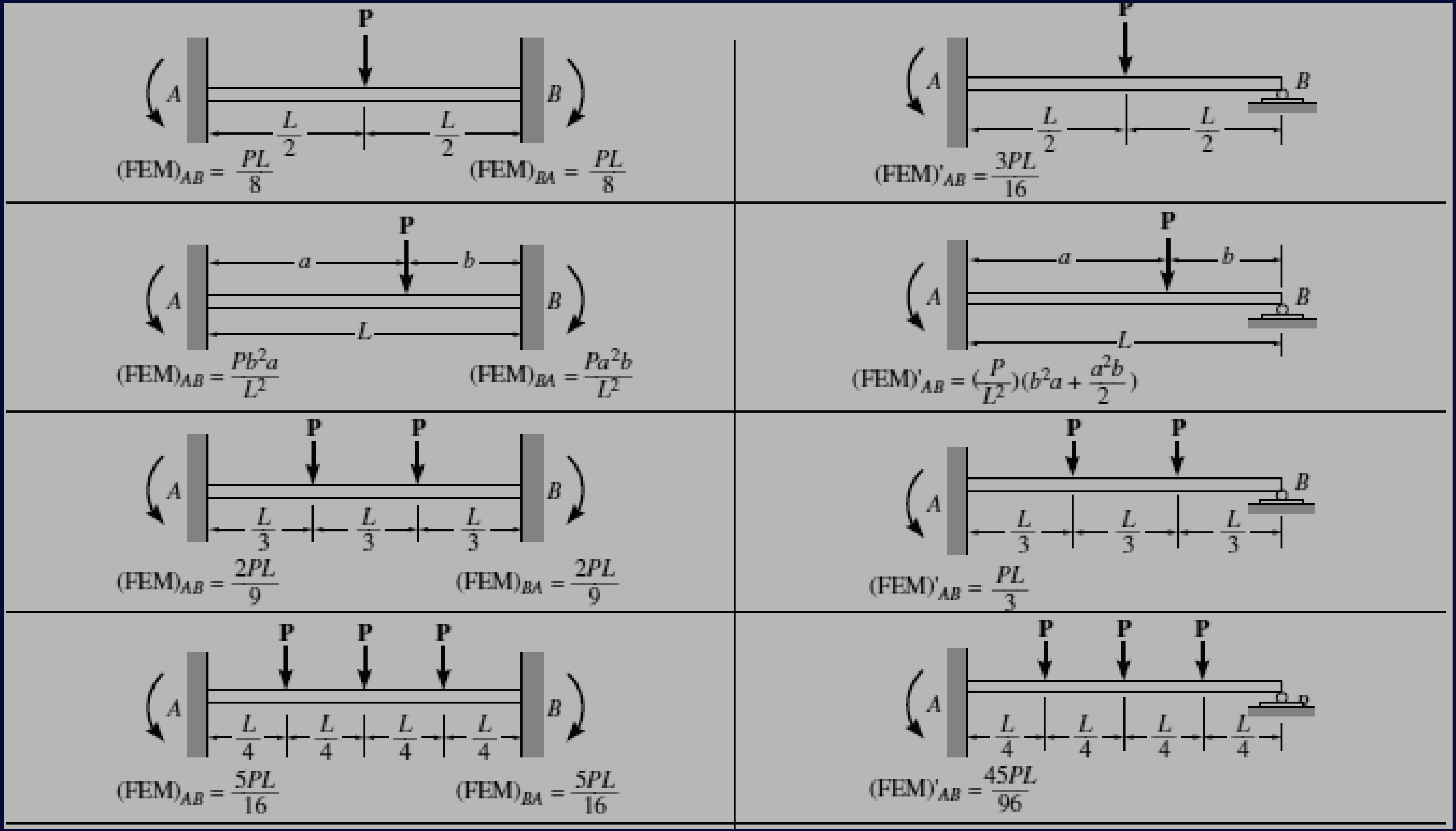
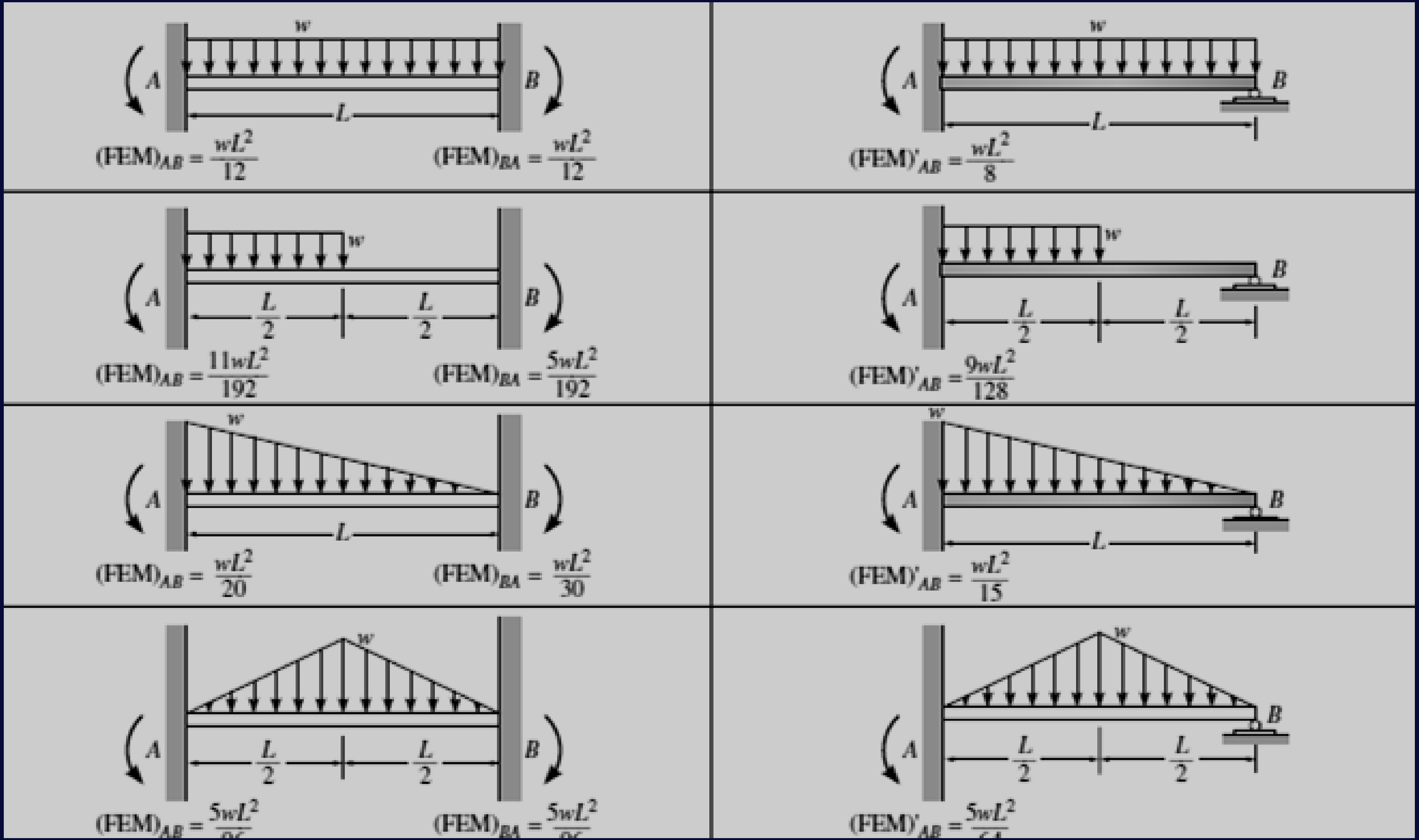
FIXED END MOMENTS



FIXED END MOMENTS



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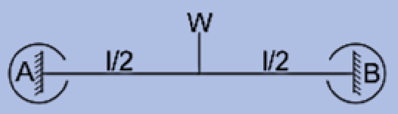
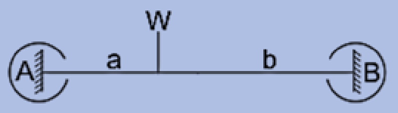
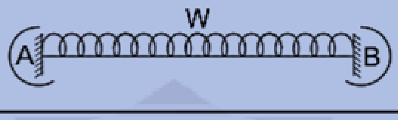
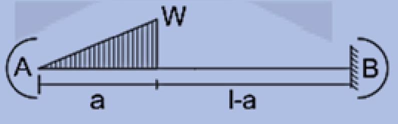
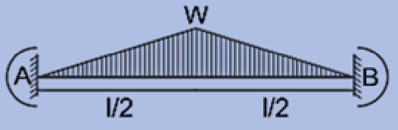
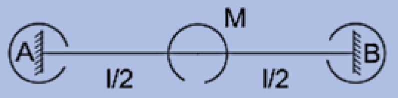
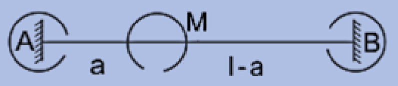
FIXED END MOMENTS

Loading	Fixed End Moment	
	$\overline{M}_{ab}$	$\overline{M}_{ba}$
	$-\dfrac{Wl}{8}$	$+\dfrac{Wl}{8}$
	$-\dfrac{Wab^2}{l^2}$	$+\dfrac{Wab^2}{l^2}$
	$-\dfrac{wl^2}{12}$	$+\dfrac{wl^2}{12}$
	$-\dfrac{wa^2}{30l^2}(10l^2 - 15la + 6a^2)$	$+\dfrac{wa^3}{20l^2}(5l - 4a)$
	$-\dfrac{5}{96}wl^2$	$+\dfrac{5}{96}wl^2$
	$+\dfrac{M}{4}$	$+\dfrac{M}{4}$
	$+\dfrac{Mb(3a - l)}{l^2}$	$+\dfrac{Ma(3b - l)}{l^2}$

Procedure for Slope deflection Method

1. Treat each span as fixed beam and find the fixed end moments.
2. Write S–D equation for each span.
3. Using equilibrium equations find the unknown displacements.
4. Substitute the values of unknowns in slope deflection equation and find the final moments.
5. Combined free bending moment diagram and fixed bending moment diagram to get the final bending moment diagram.
6. Determine the reactions and draw the Shear Force diagram.

PYQs

1. Assertion (A): The slope deflection method is a stiffness method in which the joint displacements are found by applying the equilibrium conditions at each joint.
Reason (R): The displacements at a joint of a member are independent of the displacements of the member at the far end of the joint.

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a) A is true but R is false
b) Both A and R are true is not a correct explanation of A
c) Both A and R are true and R is the correct explanation of A
d) A is false but R is true

Option B : Both A and R are true is not a correct explanation of A

PYQs

2. A fixed beam of span L is subjected to a moment M at the centre of span. The fixed end moment is

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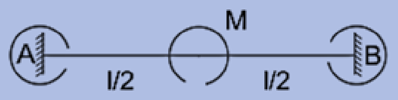
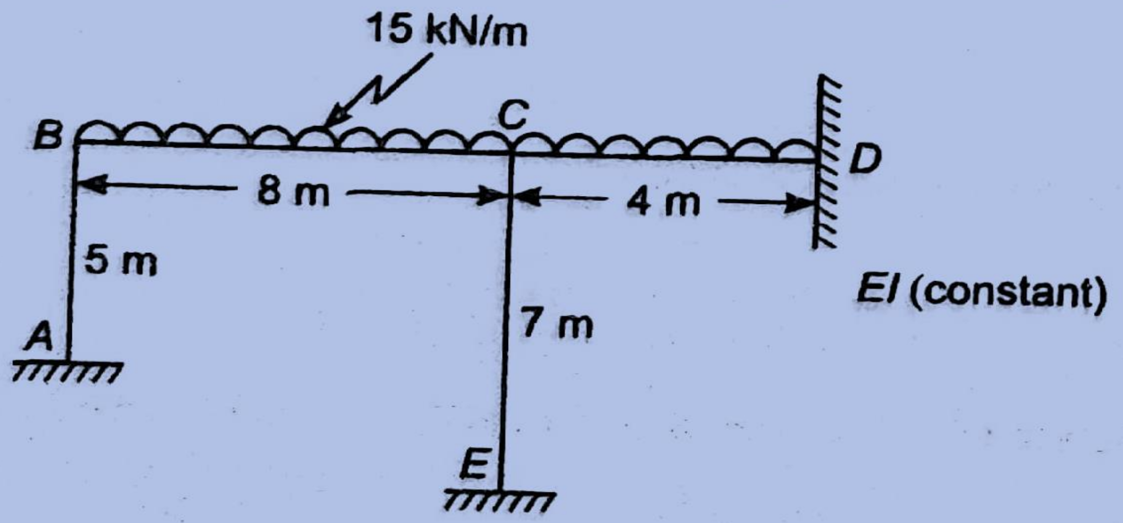
a) M/4
b) M/3
c) M
d) 2M

Loading	Fixed End Moment	
	$\overline{M}_{ab}$	$\overline{M}_{ba}$
	$+\frac{M}{4}$	$+\frac{M}{4}$

Option A : M/4

PYQs

3. The slope deflection equation of the member BC of the frame shown in figure is given by



(a) $M_{BC} = \frac{EI}{4}(2\theta_B + \theta_C) - 80$

(b) $M_{BC} = \frac{EI}{2}(\theta_B + \theta_C) - 80$

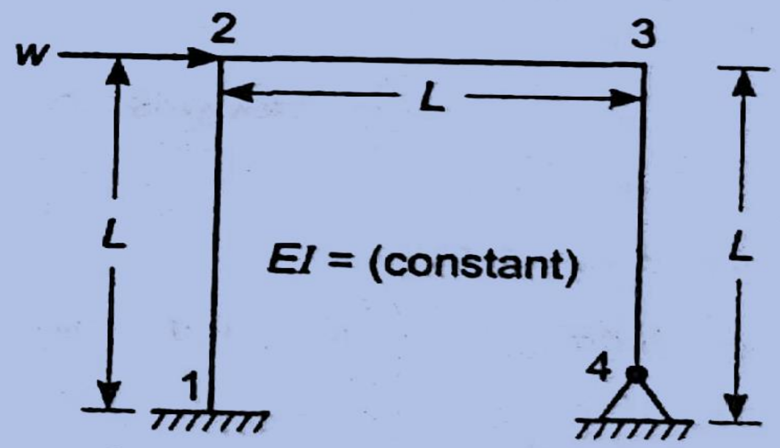
(c) $M_{BC} = \frac{EI}{4}(\theta_3 + 2\theta_C) - 40$

(d) $M_{BC} = \frac{EI}{4}(2\theta_B + \theta_C) - 20$

Option A

PYQs

4. The slope deflection equation at end 2 of the member 1-2 for the frame shown in the figure is given by



(a) $M_{21} = \frac{2EI}{L}(2\theta_1 + 2\theta_2) - wL$

(b) $M_{21} = \frac{2EI}{L}\left(2\theta_1 - \frac{3\delta}{L}\right)$

(c) $M_{21} = \frac{2EI}{L}\left(2\theta_2 - \frac{3\delta}{L}\right)$

(d) $M_{21} = \frac{2EI}{L}\left(\theta_1 + 2\theta_2 - \frac{2\delta}{L}\right) + wL$

Option C

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