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Structural Analysis

Obj + conv. 1. Deflection of beams

Obj 2. Determinacy & Indeterminacy

Obj + conv. 3. Force Method of Analysis

Conv. 4. Displacement methods of analysis
- slope deflection method
- Moment distribution method

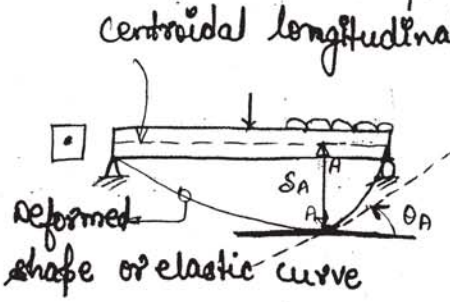
Obj + conv. 5. Truss

Obj 6. Influence line diagram

Obj 7. Matrix methods

Obj 8. Cables and Arches

Chapter 1 : Deflection of beams



Tangent to elastic curve at A

Internal forces { Axial force, Shear force, BM, TM

→ S.F & A.F → deformation neglected

In case of beams & frame, deformation is mainly due to BM.

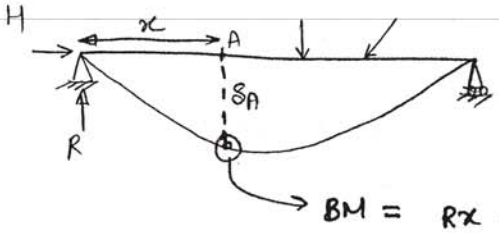
In case of truss deformation is only due to axial force.

θ_A = slope at A

$\delta_A \downarrow$ = Deflection at A

Assumptions & Important points :

- Hooke's law is valid ⟹ linearly elastic (Homogeneous) condition.
- Principal of superposition is valid
  - → linearly elastic
  - → Displacements / deformation are small
    ⇒ small displacement theory is valid.



original position → Due to H no B.M.

but in large displacement → Due to H also B.M will be there

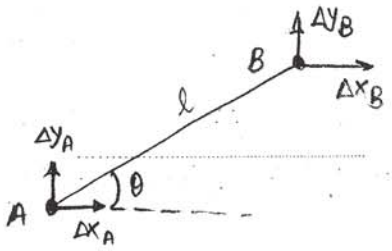
If δ_A is small

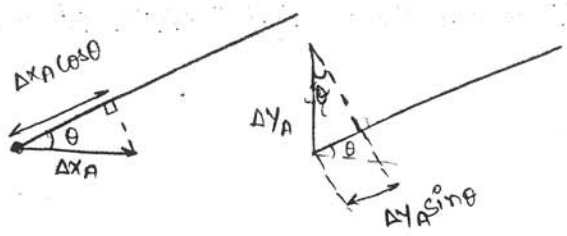
⇒ BM = Rx

→ 1st order analysis

⇒ effect of loading doesn't change due to displacement

- Change in length of member (small displacement theory)

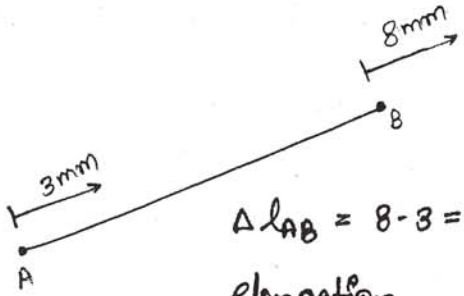




Similarly,

movement of B along AB = $\Delta X_B \cos\theta + \Delta Y_B \sin\theta$

movement of A along AB = $\Delta X_A \cos\theta + \Delta Y_A \sin\theta$

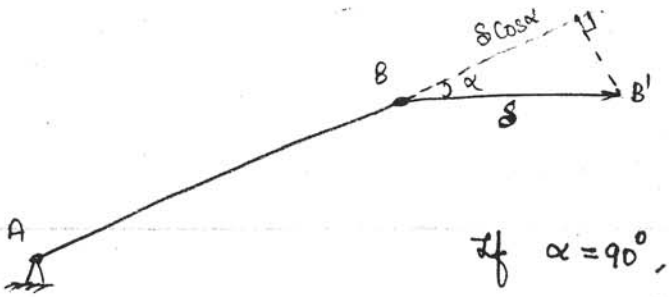


$\Delta l_{AB} = 8 - 3 = 5mm$

elongation

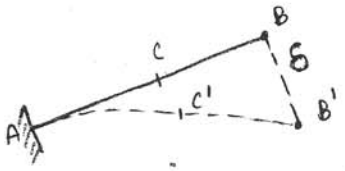
★ Change in length of member

$= [\Delta X_B \cos\theta + \Delta Y_B \sin\theta] - [\Delta X_A \cos\theta + \Delta Y_A \sin\theta]$



$\Delta l_{AB} = \delta \cos\alpha$

If $\alpha = 90°$, $\Delta l_{AB} = 0$

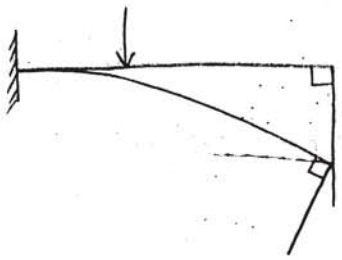


$l_{ACB} = l_{AC'B'}$

$\Delta l_{AB} = 0$

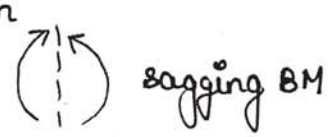
★ If one joint is restrained then for no change in length of member, other joint member move ⊥ular to member.

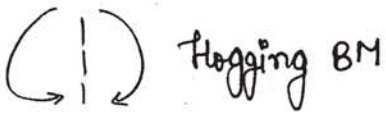
- In beams & frames joints are rigid.



⇒ Angles b/w members doesn't change due to deformation.

- Section



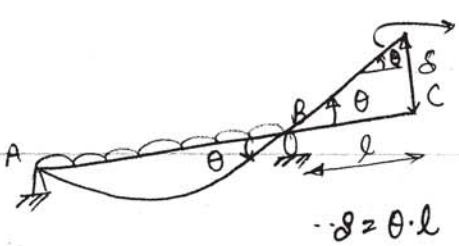


$$\text{Curvature} = \frac{1}{R} = \frac{M}{EI}$$

M = Bending moment

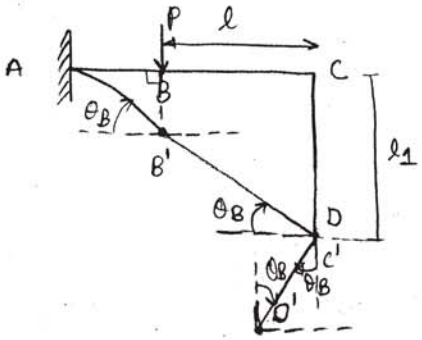
EI = Flexural Rigidity

If M=0 → ——— No curvature



In BC portion, BM=0

⇒ In BC portion, ~~curvature~~ curvature=0

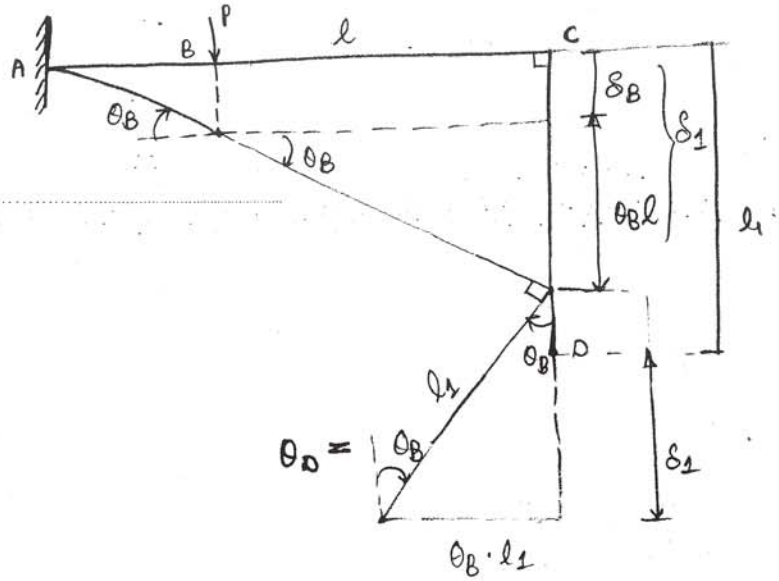


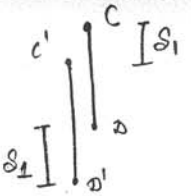
BM in part BCD is zero

⇒ Curvature in part BCD = 0

CC' will be ⊥ular to AC so that length of AC doesn't change.

$l_{ABC} = l_{AB'C'}$





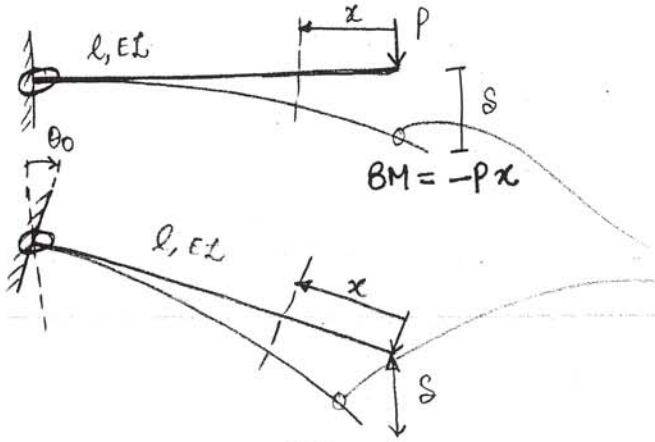
for no change in length of CD.

$\Delta D_H = \theta_B l_1 \leftarrow$

$\theta D_V = \delta_B + \theta_B l \downarrow$

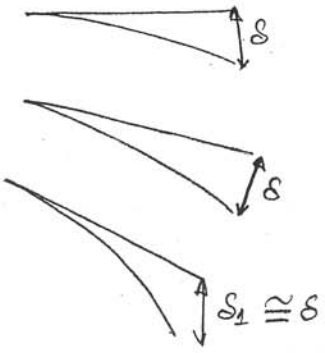
$\theta_D \curvearrowright = \theta_B$

Change in length of members = 0 → assumed in beams & frame i.e. axially rigid members.



Curvature = $\frac{1}{R} = \frac{M}{EI}$

Curvature same

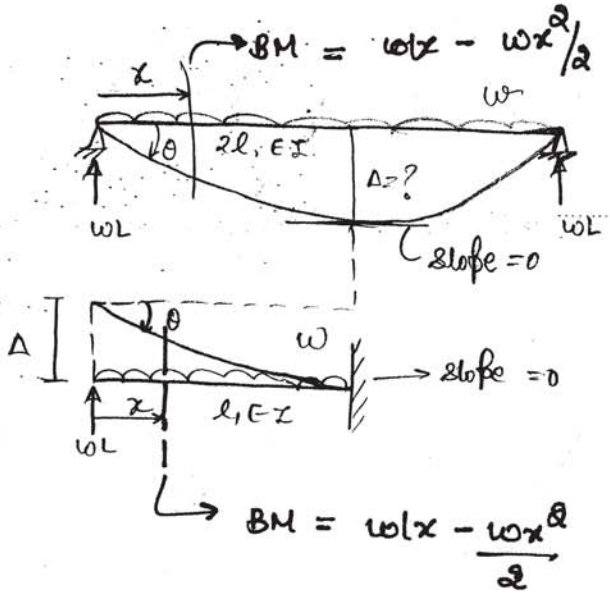


BM same → curvature same

↳ but slope & deflection may not be same

If $\frac{B \cdot M}{EI}$ throughout the length of beam is same in 2 beams then curvature of deflected shape will be same but for slope (w.r.t horizontal) & deflection (w.r.t a point) to be also same, at one corresponding location slope in the 2 beams must be same.

Example :



same $\frac{M}{EI}$

same slope at one corresponding location

↓

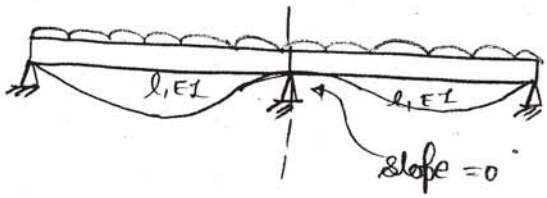
same δ & θ

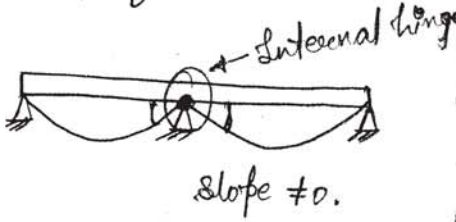
6. Under symmetrical loading a) BMD is symmetrical, b) SFD is antisymmetric

c) deflected shape ⟶ symmetrical

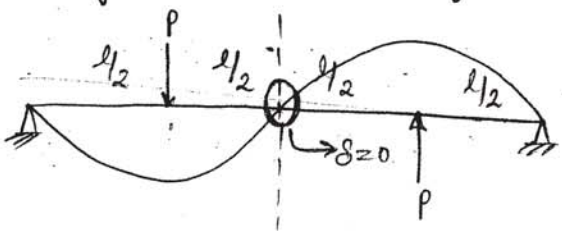
d) SF at axis of symmetry = 0

e) slope at axis of symmetry is zero if there .... is no internal hinge at axis of symmetry.

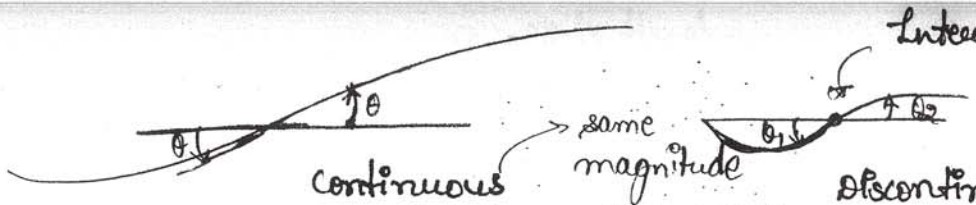




for antisymmetric loading



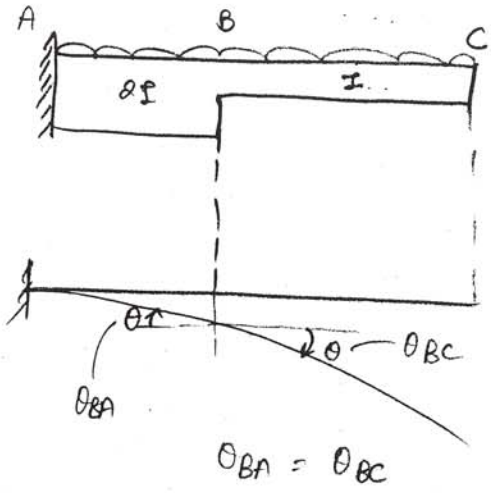
- BM antisymmetric
- SFD ⟶ symmetric
- deflected — Antisymmetric shape
- At axis of antisymmetry deflection = 0



Continuous slope → same dir^{n}

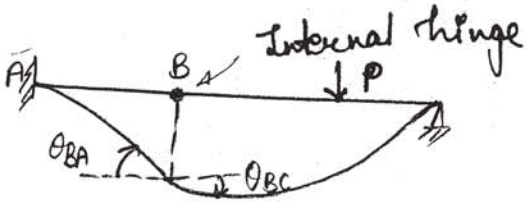
Discontinuous slope.

7.



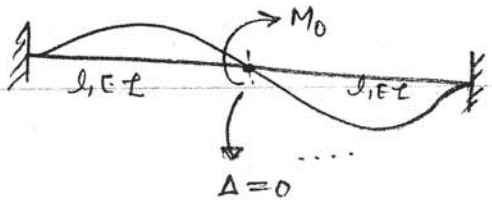
$\theta_{BA} = \theta_{BC}$

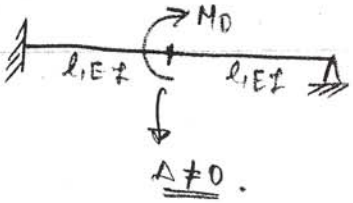
At one section, slope just to the left & slope just to the right will be same except when there is Internal hinge at that location.

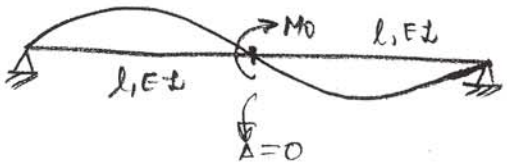


$\theta_{BA} \neq \theta_{BC}$

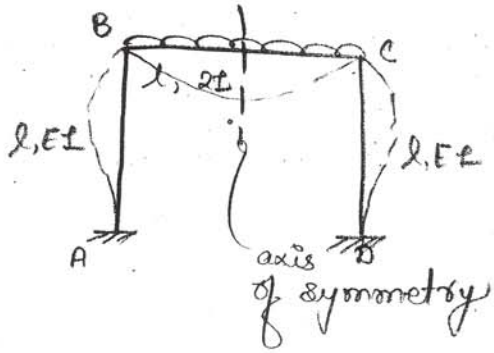
8.



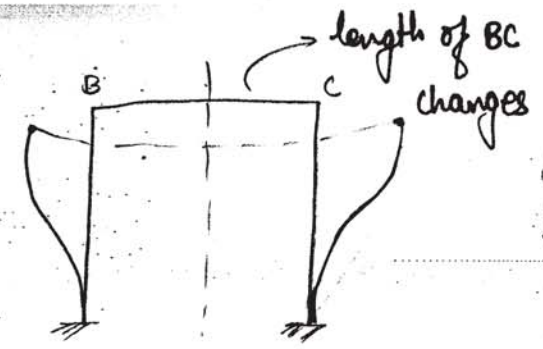




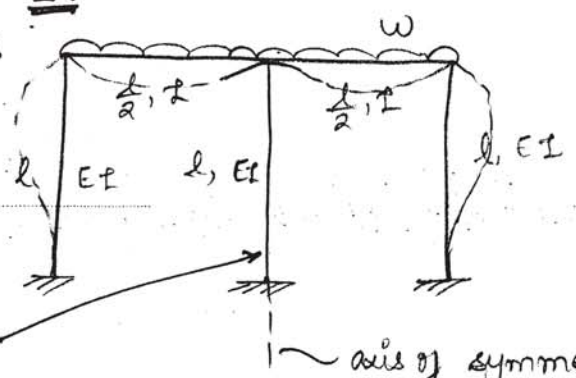
9. In case of symmetrical frames, joints do not sway if axial rigidity of members exist



Joint (B) & (C) will not move from its position if axial rigidity of member is assumed.



10.



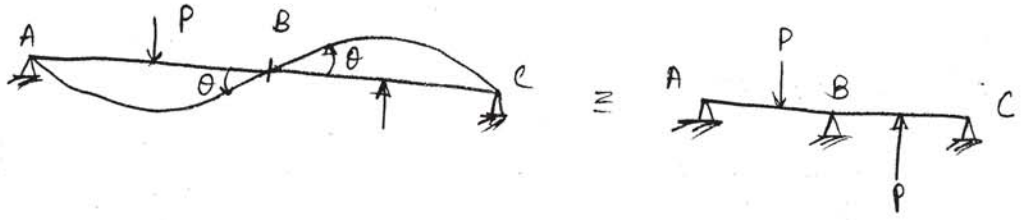
will not bend
⇒ BM = 0

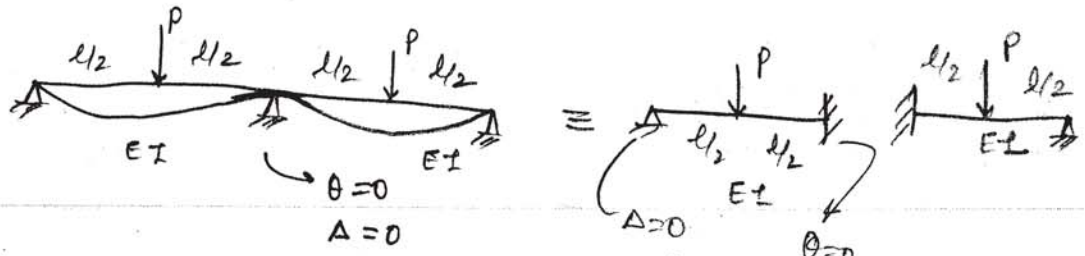
axis of symmetry

Axis of symmetry passes through a column.

↳ This column will not bend & will not carry any BM

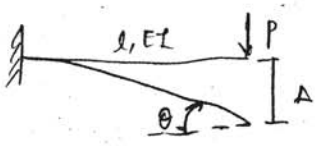
11.





Some standard results :-

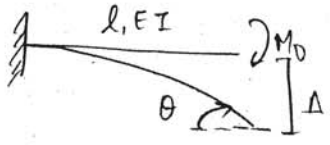
1.



$$\Delta = \frac{Pl^3}{3EI}$$

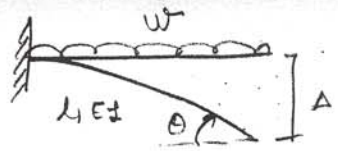
$$\theta = \frac{Pl^2}{2EI}$$

2.

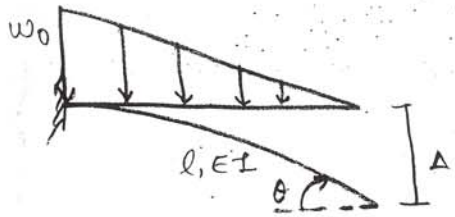


$$\Delta = \frac{M_0 l^2}{2EI}$$

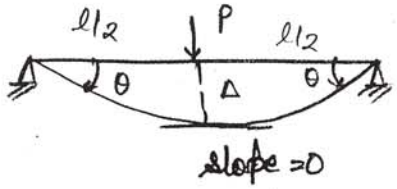
$$\theta = \frac{M_0 l}{EI}$$

3. 

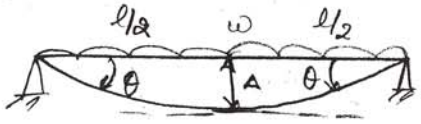
$$\Delta = \frac{wl^4}{8EI} \qquad \theta = \frac{wl^3}{6EI}$$

4. 

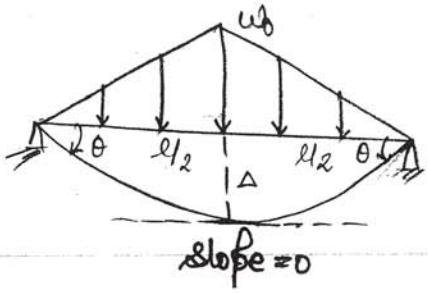
$$\Delta = \frac{w_0 l^4}{30EI} \qquad \theta = \frac{w_0 l^3}{24EI}$$

5. 

$$\Delta = \frac{PL^3}{48EI} \qquad \theta = \frac{PL^2}{16EI}$$

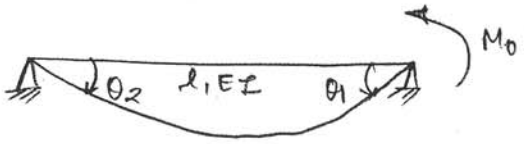
6. 

$$\Delta = \frac{5}{384}\frac{wl^4}{EI} \qquad \theta = \frac{wl^3}{24EI}$$

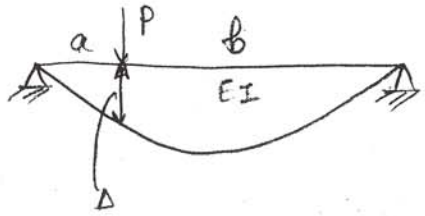
7. 

$$\Delta = \frac{w_0 l^4}{120EI} \qquad \theta = \frac{5w_0 l^3}{192EI}$$

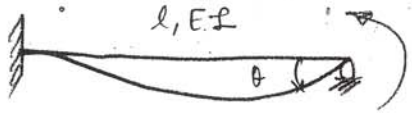
....

8. 

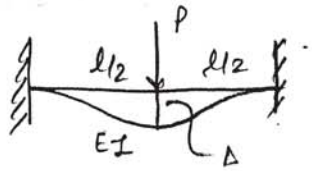
$$\theta_1 = \frac{M_0 l}{3EI} \qquad \theta_2 = \frac{M_0 l}{6EI}$$

9. 

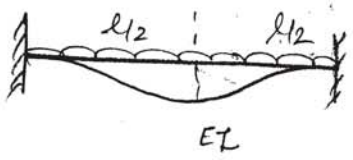
$$a+b = l \qquad \Delta = \frac{Pa^2b^2}{3EIl}$$

10. 

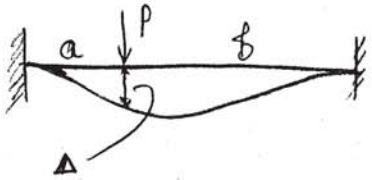
$$\theta = \frac{M_0 l}{4EI}$$

11. 

$$\Delta = \frac{1}{4}\left[\frac{PL^3}{48EI}\right]$$

12. 

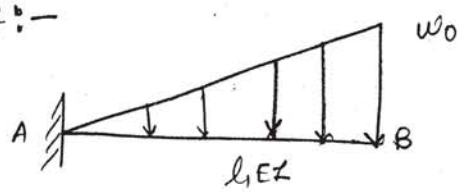
$$\Delta = \frac{1}{5}\left[\frac{5}{384}\frac{\omega l^4}{EI}\right]$$

13. 

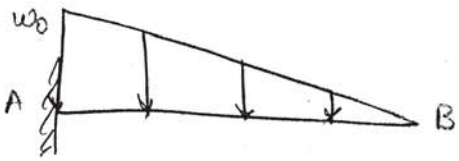
$a+b=L$

$$\Delta = \frac{Pa^3b^3}{3EI\,L^3}$$

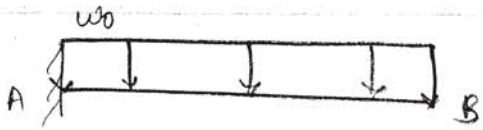
Que :-



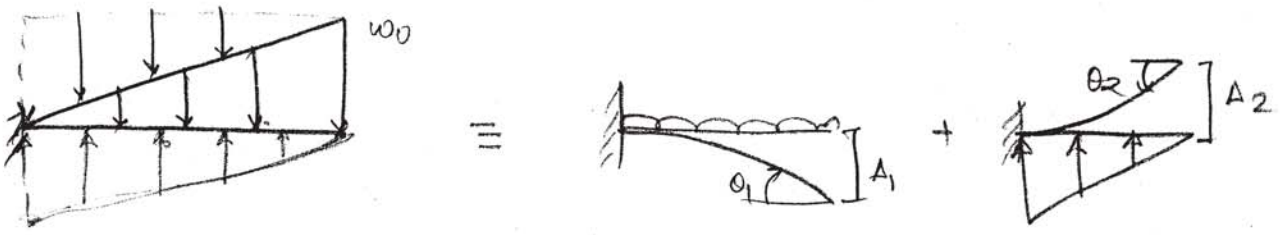
find θ_B & Δ_B



$$\theta_B = \frac{\omega_0 l^3}{24EI} \qquad \Delta_B = \frac{\omega_0 l^4}{30EI}$$



$$\theta_B = \frac{\omega_0 l^3}{6EI} \qquad \Delta_B = \frac{\omega_0 l^4}{8EI}$$



$$\Delta = \Delta_1 - \Delta_2 \qquad \theta = \theta_1 - \theta_2$$

$$\Delta = \frac{\omega_0 l^4}{8EI} - \frac{\omega_0 l^4}{30EI} = \frac{11}{120}\frac{\omega l^4}{EI} \downarrow \qquad \theta = \frac{\omega_0 l^3}{6EI} - \frac{\omega_0 l^3}{24EI}$$

$$\theta = \frac{\omega_0 l^3}{8EI} \circlearrowright$$