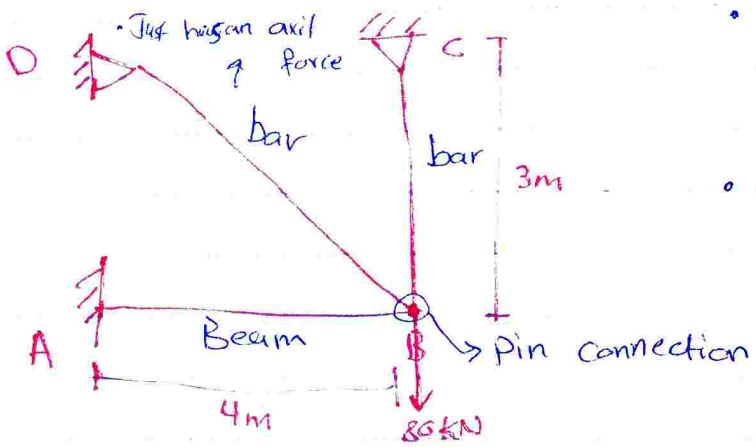
. Force Method :- Combined system.



- Find member forces F_{BD}, F_{BC}.
- Draw B.M diagram AB.

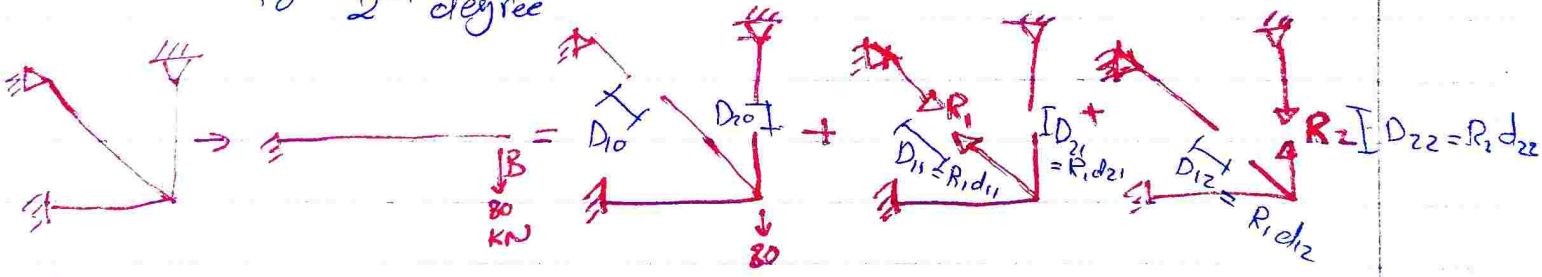
$R_1 = F_{BD}$

$R_2 = F_{BC}$

* unknowns * Eq

5 > 3

Statically Ind. to 2nd degree



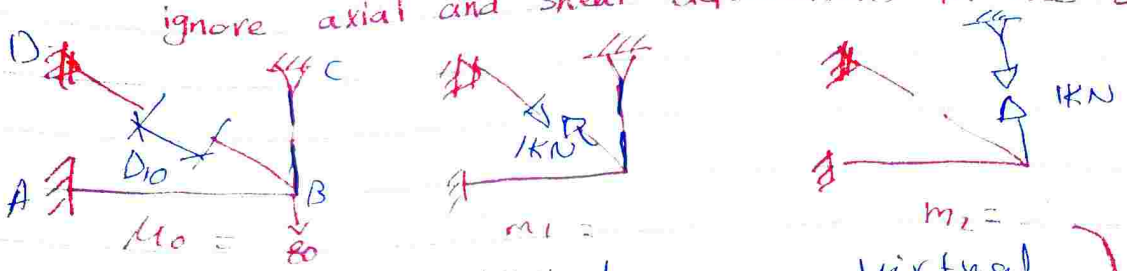
- Relative disp. between cut edges member BD.

$$0 = D_{10} + R_1 d_{11} + R_2 d_{12}$$

- Relative disp. between cut edges member BC

$$0 = D_{10} + R_1 d_{21} + R_2 d_{22}$$

→ In the calculation of the deformations ignore axial and shear deformations in the beam.



M_0 = Real load System

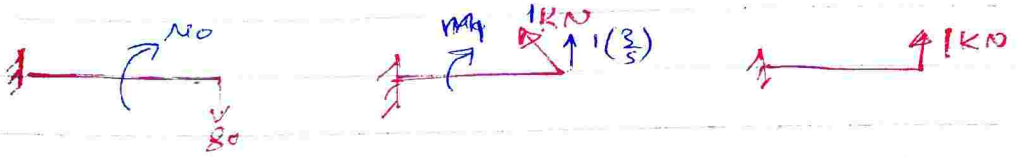
m_1 = Virtual D10

m_2 = Virtual D20

$$D_{10} = \int \frac{M m}{EI} dx + \sum n \frac{NL}{EA}$$

$(N_0)_{BD} = 0$ $(n_1)_{BD} = 1$ $(n_2)_{BD} = 0$

$(N_0)_{BC} = 0$ $(n_1)_{BC} = 0$ $(n_2)_{BC} = 1$



$M_0 = -80x$ $0 \le x \le 4$

$m_1 = 0.6x$ $0 \le x \le 4$

$m_2 = x$ $0 \le x \le 4$

$$\rightarrow D_{10} = \int_0^4 \frac{m_1 M_0}{EI} dx + \sum n \frac{N_0 L}{EA}$$

$$= \int_0^4 \frac{(0.6x)(-80x)}{EI} dx + \left[\frac{(1)(0)(5)}{EA} + \frac{(0)(0)(3)}{EA}\right]$$

$$= -\frac{1024}{EI}$$

$$\rightarrow D_{20} = \int_0^4 \frac{(x)(-80)x}{EI} dx + \left[\frac{(0)(0)(5)}{EA} + \frac{(1)(0)(3)}{EA}\right] = -\frac{1706.67}{EI}$$

$$\rightarrow d_{11} = \int_0^4 \frac{(0.6x)^2}{EI} dx + \left[\frac{(1)^2(5)}{EA} + \frac{(0)^2(3)}{EA}\right] = \frac{7.68}{EI} + \frac{5}{EA}$$

$$\rightarrow d_{22} = \int \frac{(x)^2}{EI} dx + \left[\frac{0(5)^2}{EA} + \frac{(1)^2(3)}{EA}\right] = \frac{21.33}{EI} + \frac{3}{EA}$$

$$\rightarrow d_{21} = \int \frac{m_2 m_1}{EI}\, dx = \int \frac{(0.6x)(x)}{EI} = \frac{12.8}{EI}$$

$$\rightarrow d_{12} = \frac{12.8}{EI}$$

$E = 200 GPa \qquad I_b = 200 \times 10^6\ mm^4 \qquad A = 100^2$

- $EI = (200 \times 10^6\ KN/m^2)(200 \times 10^6\ mm^4)\ \frac{10^{-12}\ m^4}{mm^4} =$

$= 4 \times 10^4\ KN \cdot m^2$

- $EA = (200 \times 10^6\ KN/m^2)(100\ mm^2) \times 10^{-6}\ \frac{m^2}{mm^2}$

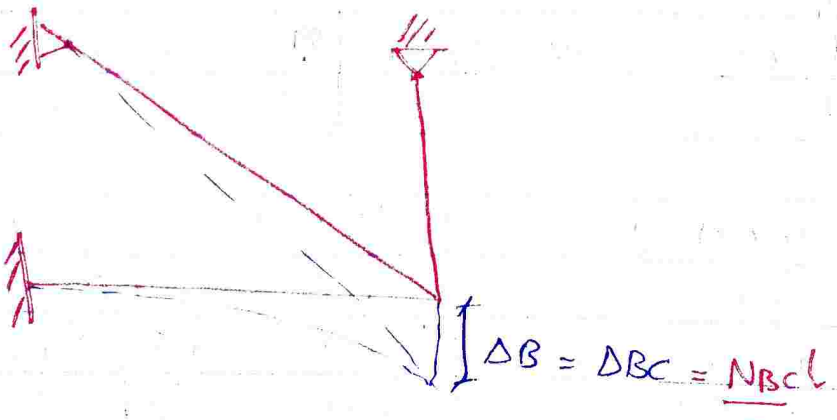
$= 2 \times 10^4\ KN \cdot m$

$$\rightarrow 0 = -\frac{1024}{EI} + R_1\left[\frac{7.68}{EI} + \frac{5}{EA}\right] + R_2\left[\frac{12.8}{EI}\right]$$

$$\rightarrow 0 = -\frac{1706.67}{EI} + R_1\left[\frac{12.8}{EI}\right] + R_2\left[\frac{21.33}{EI} + \frac{3}{EA}\right]$$

$R_1 = F_{BD} = 19.2\ KN\ (T)$

$R_2 = F_{BC} = 53.4\ KN\ (T)$



Influence line and Envelopes

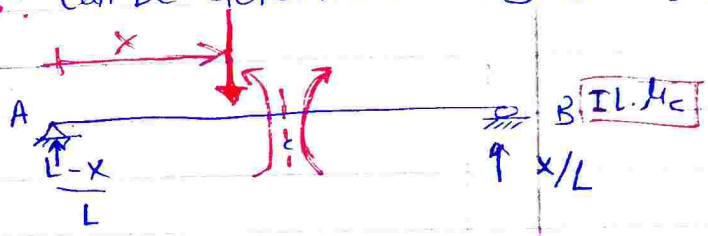
- **Influence line:** is a diagram shows the relation of an objective function (reaction force, Shear, bending moment) with the position of loading.

- Why do we construct Influence lines?

  - live loads are variable in position (gravity loading).
  - To decide the critical load cases when considering the live load, and develop load cases to get the required design values (V, R, M)

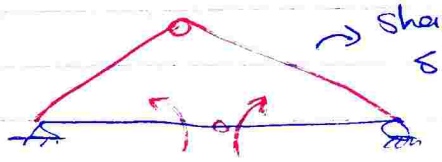
- Influence line of det. Systems? can be determine By 3ways:-

1- Point By Point, $x = 1m \Rightarrow M_c = ?$
$x = 2m \Rightarrow M_c = ?$
....



2- Equations $\Rightarrow M_c(x)$

3- Qualitative approach



→ shape deformed shape

I.L

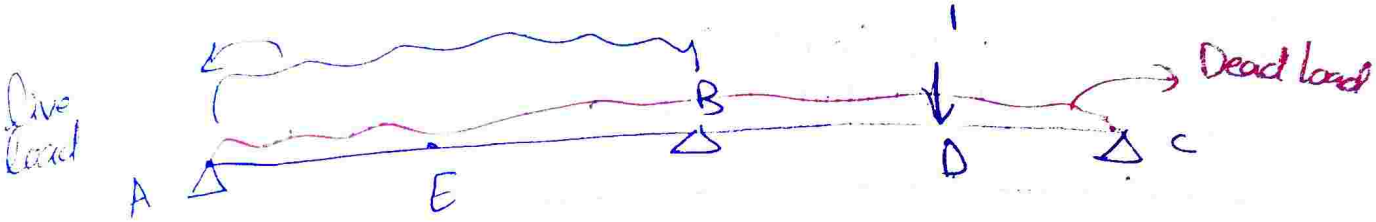
↓

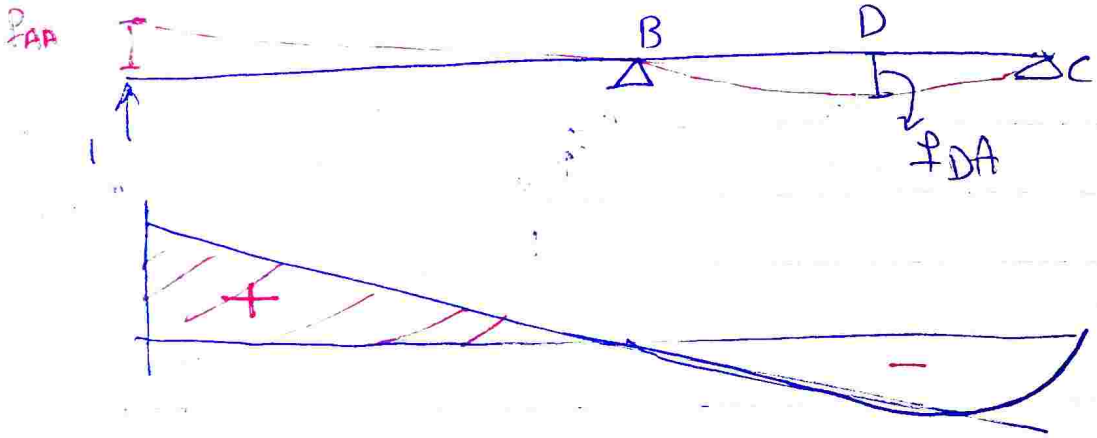
straight line

- Qualitative approach to build influence lines - Muller Breslau principle.

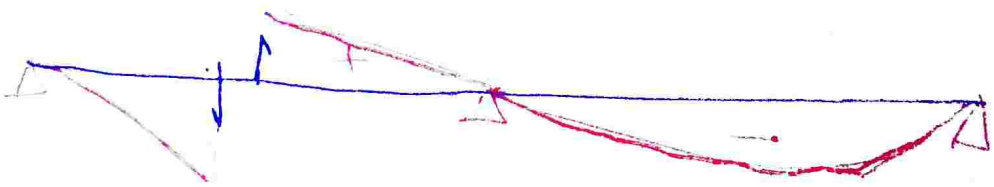
- Induce a unit deformation, the deformed shape due to unit deformation is the shape of the influenced.

- Load case for max Ay. / Reaction force.



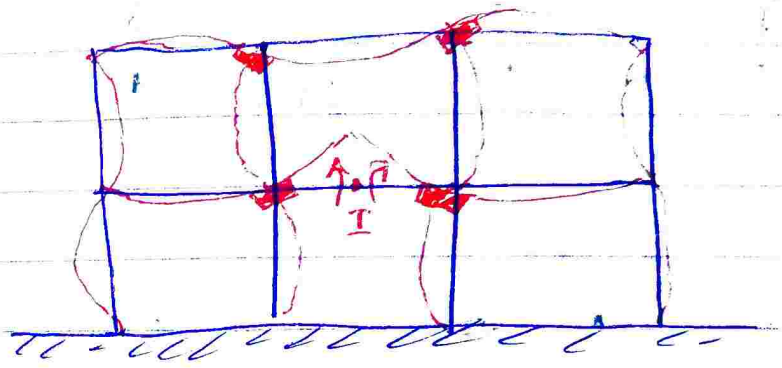


- IL for Shear VE.

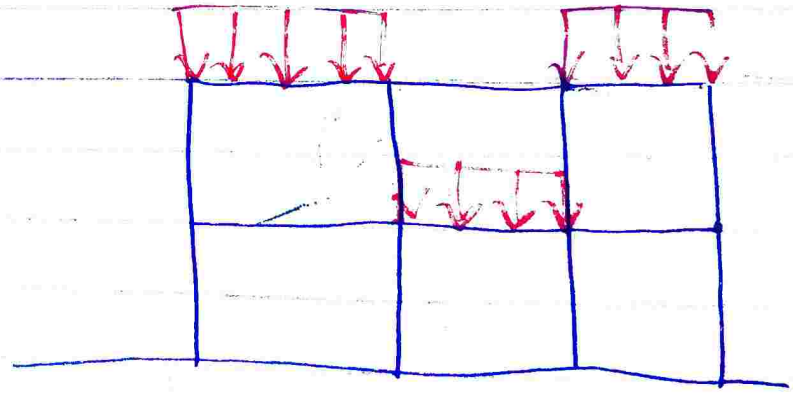


- I.L (M_I)

⇒ I.L M_I



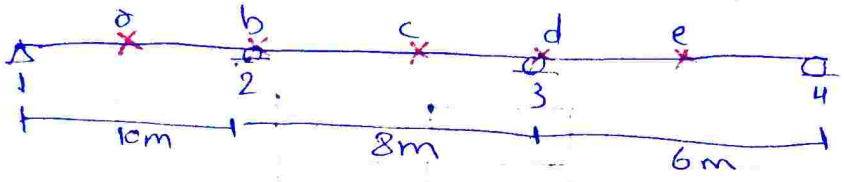
⇒ To get max M_I



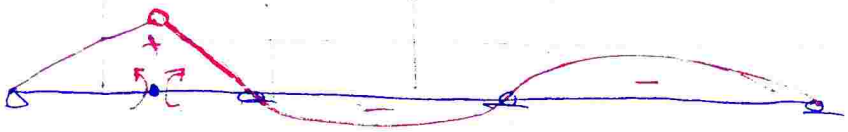
- Example: three span beam.

- Draw qualitative IL for the Bending Moment of the beam, and develop the load Cases.

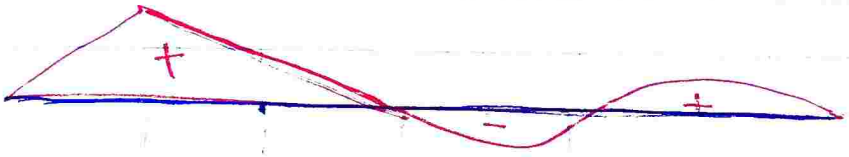
- choose midspans & Interior supports



① ⓐ



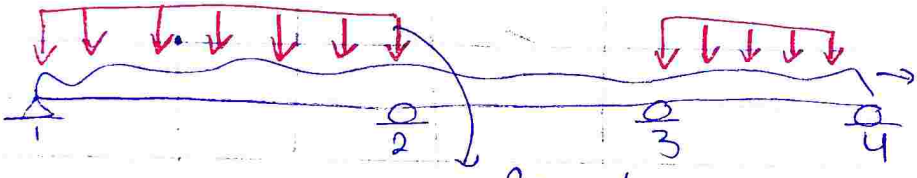
max M_a



I.L. M_a

- load Cases

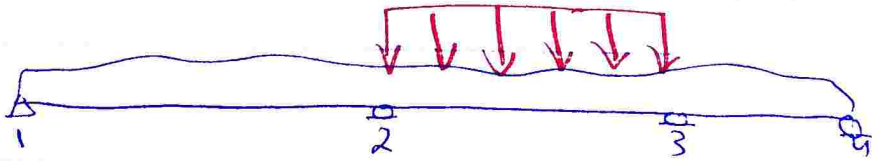
- Load Case (LC1) for max M_a



→ Dead load

live load

- Load Case (LC2) for min M_a

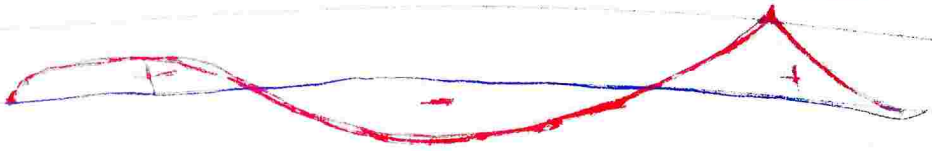


(2) (b) I.L M_A

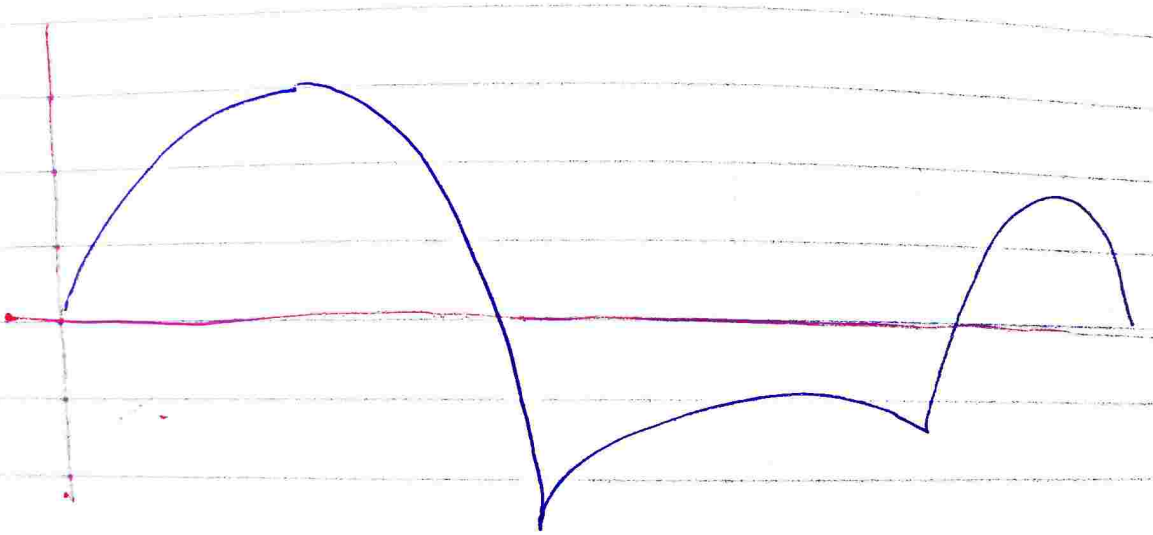
I.L M_B

I.L M_D

I.L M_E



B.M.L.C

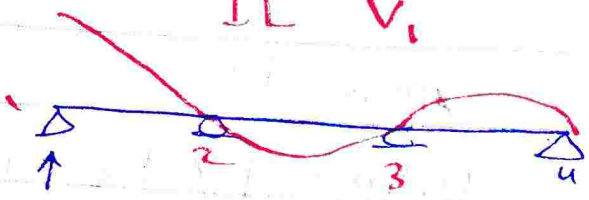


- Draw Bending Moment Diagras for all Cases

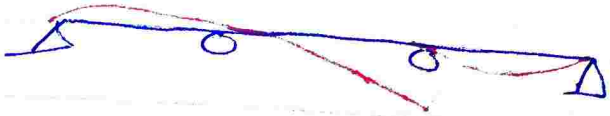
  - then we take the max. Value from all cases

• Influnce Line for shearing forces of the Beam.

IL V_1

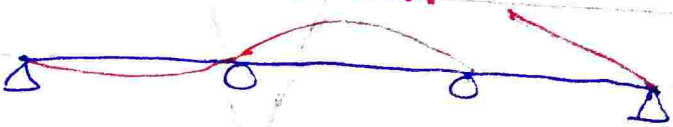


IL $(V_3)_L$

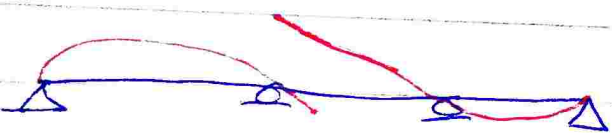


IL $(V_2)_L$

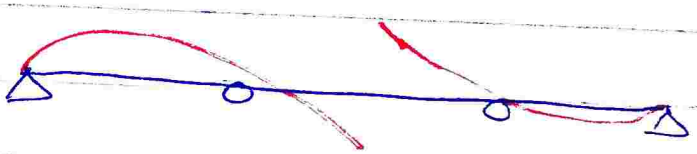
IL $(V_3)_R$



IL $(V_2)_R$



IL' $(V_c)_R$



And So ...