BULE HORA UNIVERSITY

COLLEGE OF ENGINEERING & TECHNOLOGY

CIVIL ENGINEERING DEPARTMENT

THEORY OF STRUCTURES - II / CEng 2103

CHAPTER TWO: INFLUENCE LINES FOR INDETERMINATE STRUCTURES

- WORKED EXAMPLES FOR 2nd Year Civil Engineering

BHS

2012 / 2020

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INFLUENCE LINES FOR INDETERMINATE STRUCTURES

Introduction: an influence line represents the variation of the reaction, shear, moment or deflection at a specific point in a member as a Concentrated force or Uniformily distributed loads moves over the members. Moreover the magnitude of the associated reaction, shear, moment, or deflection at the point Can be Calculated from the Ordinates of the influence lines diagram.

- Since the influence lines for determinate structure Consists of straight lines. Segments of such influence lines where Constructed by evaluating the Ordinates for only a few positions of the Unit load & by Connecting them with straight lines.
- However the influence lines for statically Indeterminate structures are generally Curved lines. it requires Computation of many more Ordinates than necessary in the Case of determinate structures.

INFLUENCE LINES BY METHODS OF CONSISTENT DEFORMATIONS

Procedure for Analysis

1. Determine the degree of Indeterminacy of the structures and select redundant.
2. Select a number of point along the length of the structure at which the numerical values of the Ordinates of the influence lines will be evaluated.
3. To Construct the influence lines for the redundants, place a Unit load successively at each of the points selected in step. 2 and for each position of the Unit load, apply the method of Consistent deformation to Compute the values of the redundants.

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4. Plot the values of the redundant thus Obtained as Ordinates against the position of the Unit load as abscissa, to Construct the influence lines for the redundants.

5. Once the influence lines for the redundants have been determined the influence lines for the other force and or moment response functions of the structure Can be Obtained through equilibrium Considerations.

Qualitative Influence lines by Muller-Breslau's principles.

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Influence lines for any reaction or internal force corresponds to the deflected shape of the structure produced by removing the capacity of the structure to carry the force and then introducing into the modified (or released) structure a unit deformation that corresponds to the restraint removed.

- An influence line ordinate represents the value of an internal force or reaction for which the influence line is constructed.

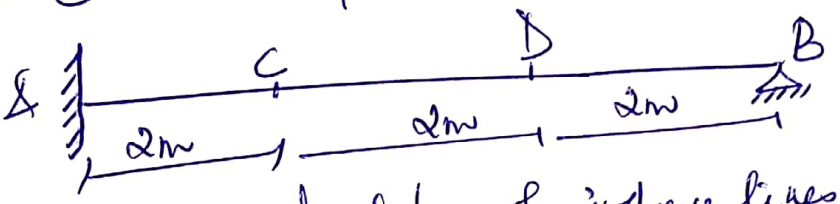
Müller-Breslau principle 3 steps
- Release structure - remove (restraint).
- Unit deformation
- done

1. Release - take the support away
2. Unit deformation - deflection
3) done by obeying

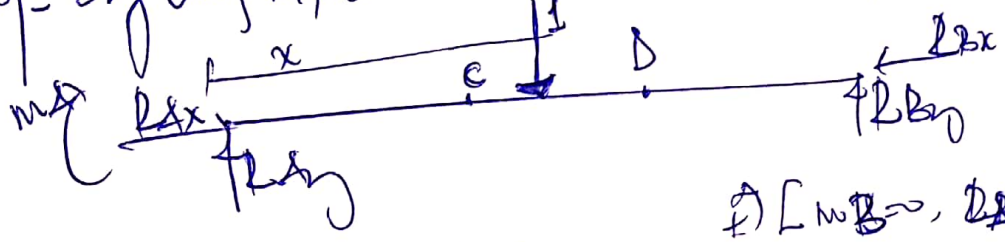
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Influence lines for Indeterminate Beams

Example Draw the influence line for
- the vertical reaction at A and B
- the shear force at C.
- The bending moment at A and C
- EI is Constant. Plot numerical values every 2m.



Sol:- by using Equilibrium Conditions for influence lines of R_B.



$\uparrow [\sum F_y = 0, \quad R_{Ay} + R_{By} - 1 = 0$

$R_{By} = 1 - R_{Ay}$

When $x = 0$, $R_{By} = 1 - 1 = 0$ ($R_{Ay} = 1$ at 0)

$x = 2$, $R_{By} = 1 - \frac{2}{3} = \frac{3-2}{3} = \frac{1}{3}$

$x = 4$, $R_{By} = 1 - \frac{1}{3} = \frac{3-1}{3} = \frac{2}{3}$

$x = 6$, $R_{By} = 1 - 0 = 1$

$\circlearrowleft [\sum M_B = 0, \quad R_{By} \times 6 - 1(6-x) = 0$

$R_{By} = \frac{6-x}{6}$

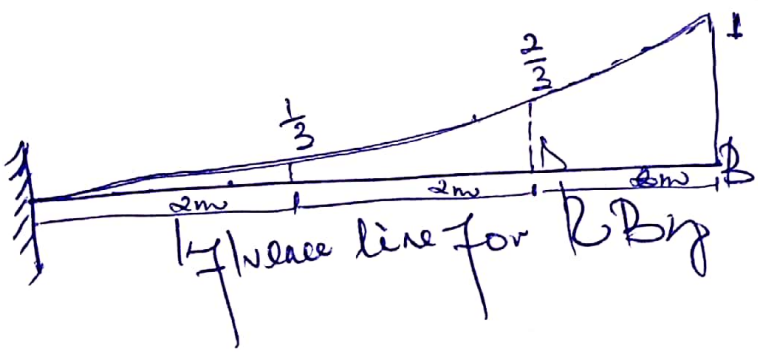
When $x = 0$, $R_{By} = 1$

$x = 6$, $R_{By} = 0$

$x = 2$, $R_{By} = \frac{4}{6} = \frac{2}{3}$

$x = 4$, $R_{By} = \frac{2}{6} = \frac{1}{3}$

$x = 6$, $R_{By} = 0$



$\circlearrowleft [\sum M_A = 0, \quad R_{By} \times 6 - 1(x) = 0$

$R_{By} = \frac{x}{6}$

When $x = 0$, $R_{By} = 0$

$x = 2$, $R_{By} = \frac{2}{6} = \frac{1}{3}$

$x = 4$, $R_{By} = \frac{4}{6} = \frac{2}{3}$

$x = 6$, $R_{By} = \frac{6}{6} = 1$

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for Influence line for R_A

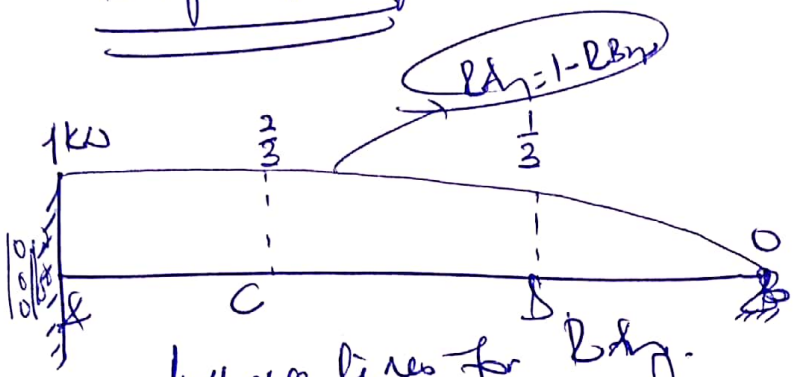
$R_{Ay} = 1 - R_{By}$

When $x=0$, $R_{Ay} = 1 - 0 = 1$

$x = 2m$, $R_{Ay} = 1 - \frac{1}{3} = \frac{3-1}{3} = \frac{2}{3}$

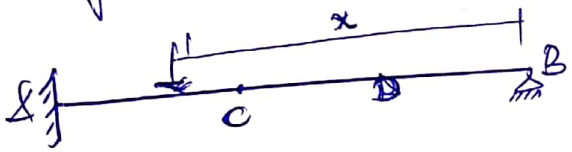
$x = 4m$ $R_{By} = 1 - \frac{2}{3} = \frac{3-2}{3} = \frac{1}{3}$

$x = 6m$ $R_{By} = 1 - 1 = 0$



Influence lines for R_{By}.

Using Equilibrium Condition for Influence lines for shear (V_C)



V_C when Unit load is left of C

$V_C = -R_{By}$ at $x=0 \Rightarrow R_{By} = 0$

at $x = 2m$, $-R_{By} \Rightarrow -\frac{1}{3} = V_C$

at $x = 4m$, $-R_{By} \Rightarrow -\frac{2}{3} = V_C$

at $x = 6m$, $-R_{By} = V_C = -1 = 0$

at right of C $V_C = 1 - R_{By}$

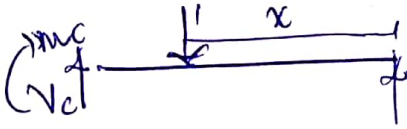
Unit load to the left of C



$\uparrow \Sigma F_y = 0$, $R_{By} + V_C = 0$

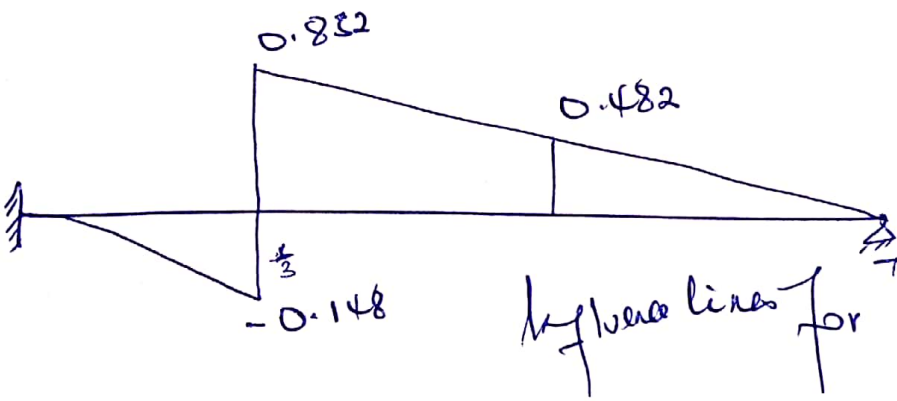
$V_C = -R_{By}$

When Unit load is to the right of C



$\uparrow \Sigma F_y = 0$, $V_C - 1 + R_{By} = 0$

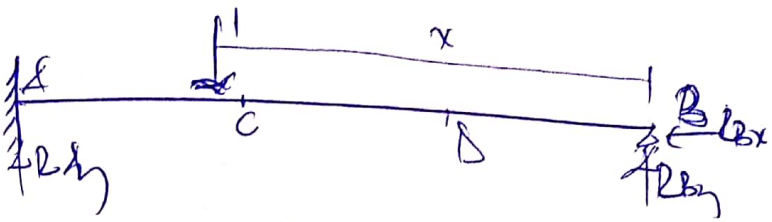
$V_C = 1 - R_{By}$



Influence lines for V_C to left and to right.

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Influence lines for M_A.



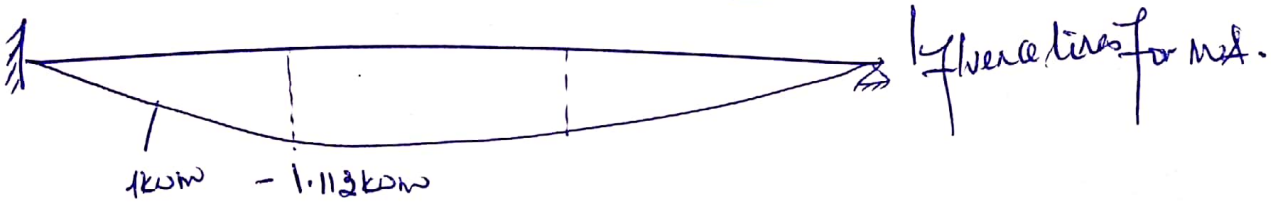
$\curvearrowright \sum M_A = 0, \quad -M_A - 1(6-x) + R_{By} \times 6 = 0$ $\quad \sum M_A =$

$M_A = -6 + x + 6R_{By}$

When $x = 0$, $M_A = -6 + 0 + 6\left(\frac{x}{6}\right)^0$

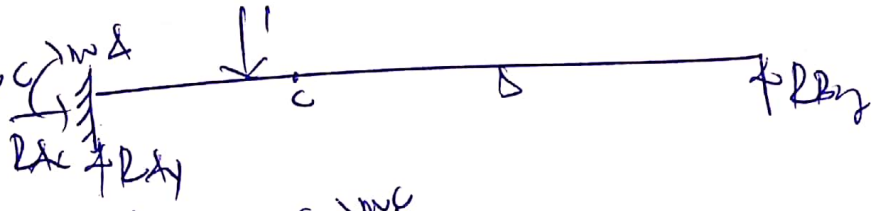
$x = 2$, $M_A = -6 + 2 + 6(0.148) = -1.112$ kNm

$x = 4$m, $M_A = -6 + 4 + 6(0.518) = -0.892$ kNm

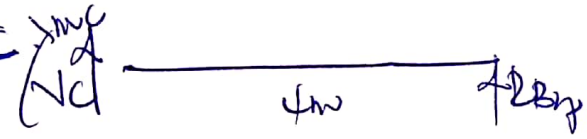


Influence lines for M_A.

Influence lines for M_C



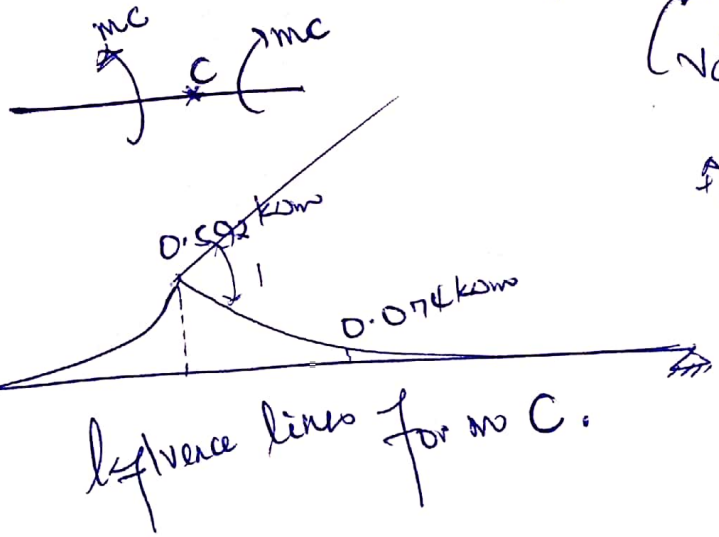
When Unit load is to the left of C



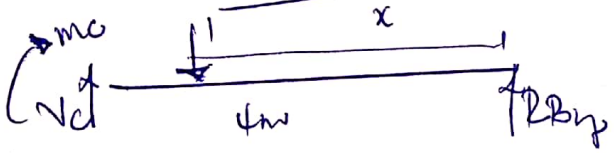
$\curvearrowright \sum M_C = 0, \quad -M_C + 4R_{By} = 0$

$M_C = 4R_{By}$

When Unit load is to Right of C



Influence lines for M_C.



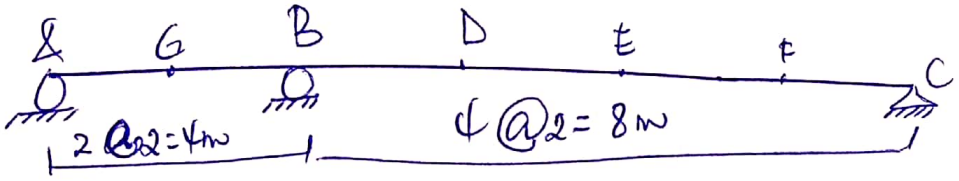
$\curvearrowright \sum M_C = 0 \quad -M_C - 1(4-x) + 4R_{By} = 0$

$M_C = -4 + x + 4R_{By}$

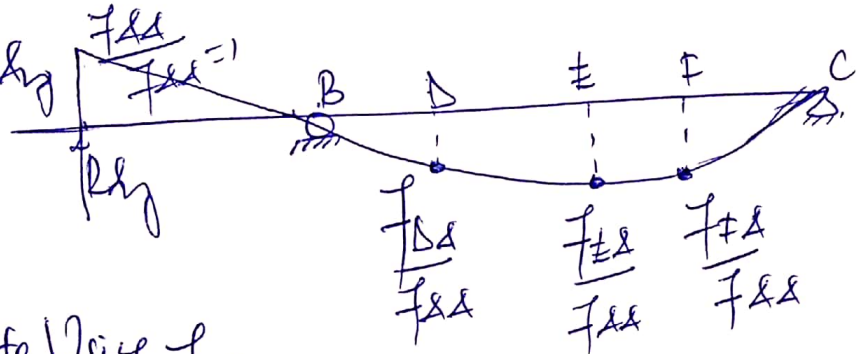
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Example 2

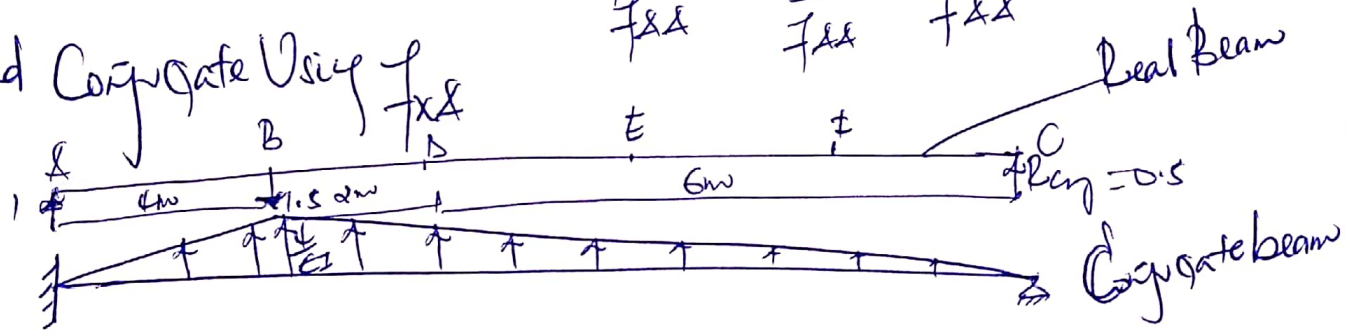
Draw the influence lines and plot numerical values every 2m for
- the Vertical reaction at Support A, B and C.
- Shear at G and E.
- Bending moment at G and E. EI is Constant.

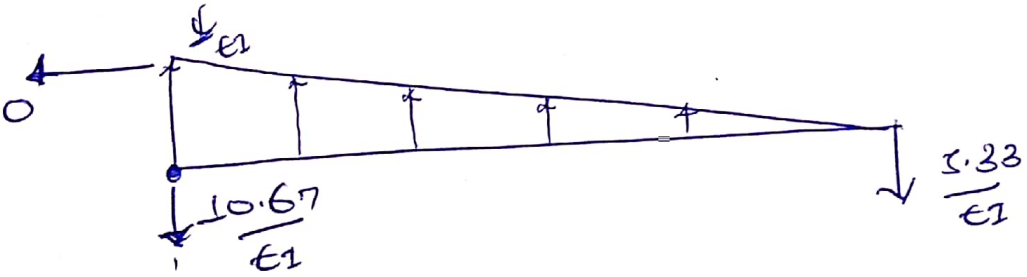


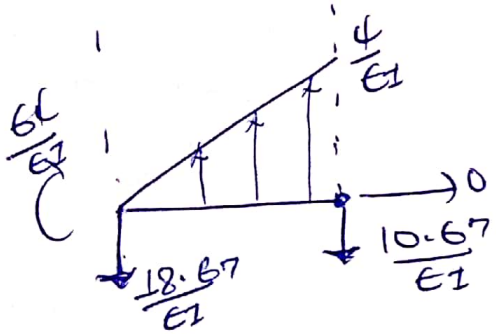
Influence line of R_{Ay}



To find Conjugate Using $\frac{7}{8}xA$

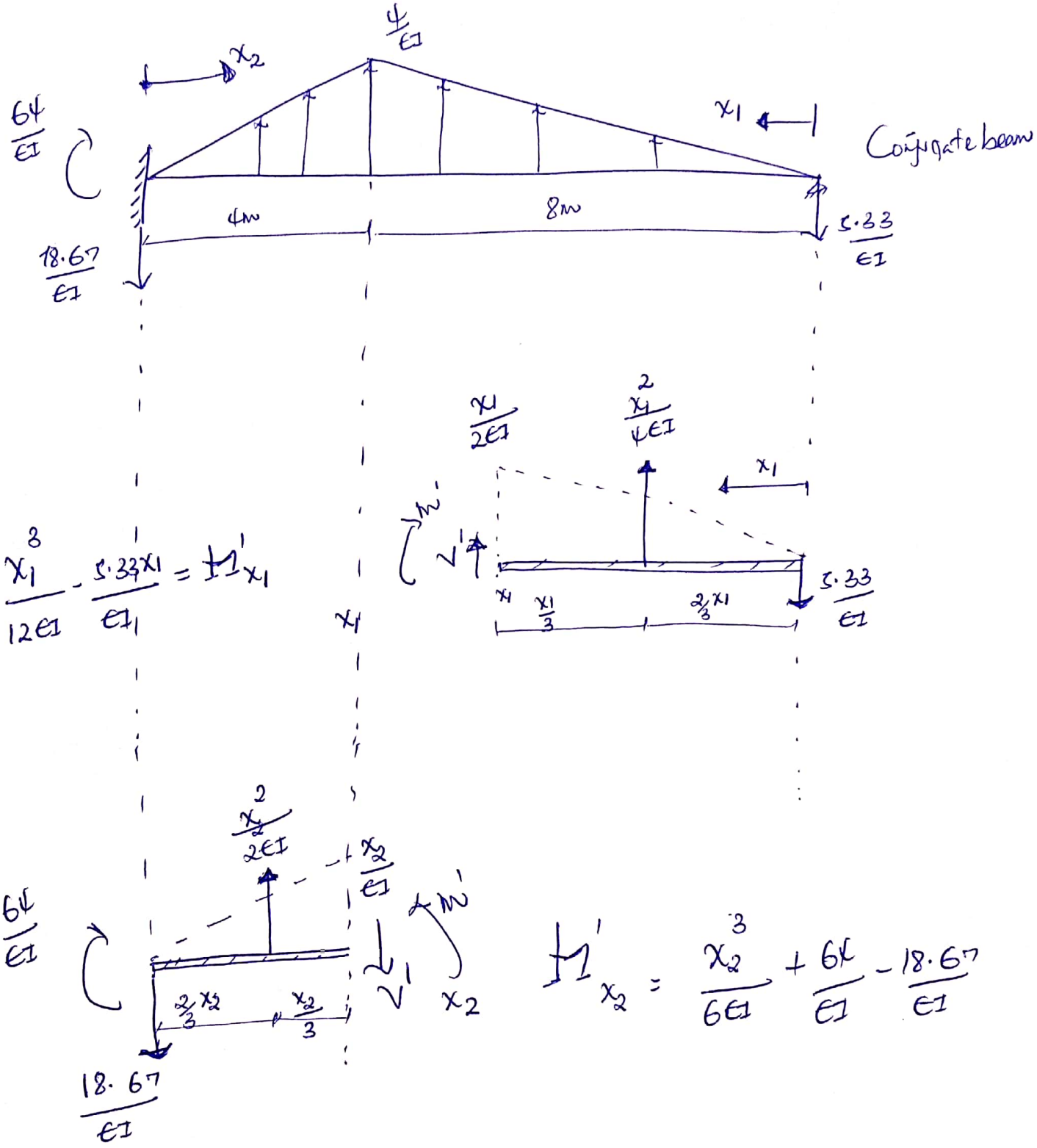






$\Delta\Delta = \frac{7}{8}\Delta' = \frac{6\ell}{EI}$

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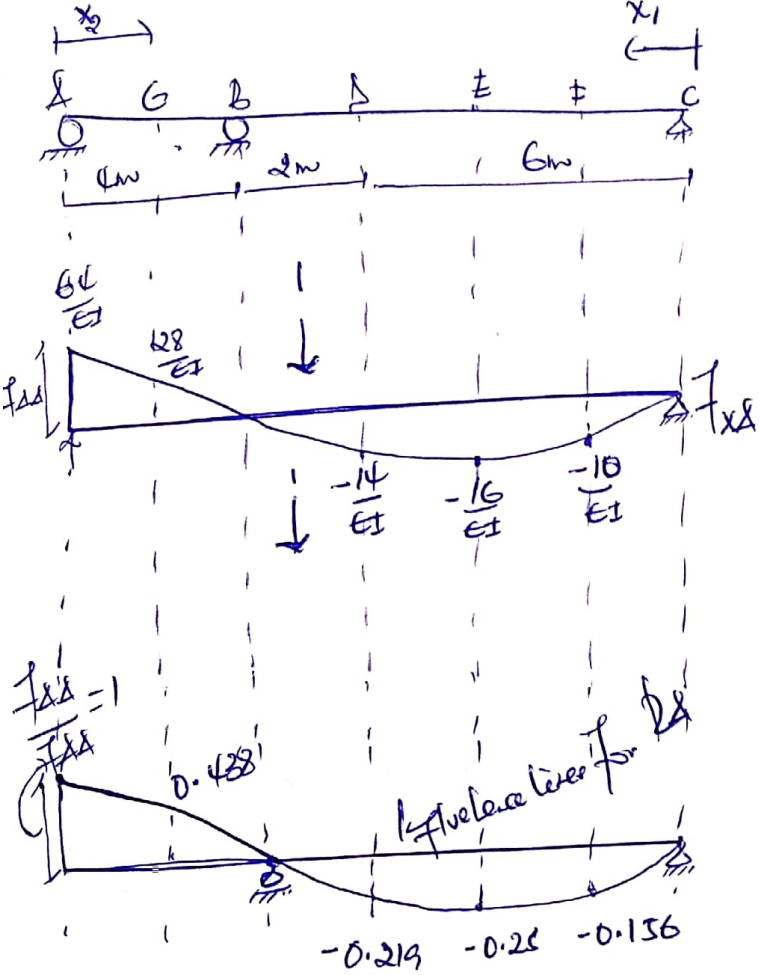
$$\frac{x_1^3}{12EI} - \frac{5.33x_1}{EI} = t'_{x_1}$$

$$t'_{x_2} = \frac{x_2^3}{6EI} + \frac{64}{EI} - \frac{18.67}{EI}$$

$$t_{xA} = t'_{x_1} = \frac{x^3}{12EI} - \frac{5.33x}{EI}, \text{ for } B \text{ to } C$$

$$t_{xA} = t'_{x_2} = \frac{x_2^3}{6EI} - \frac{18.67x_2}{EI} + \frac{64}{EI}, \text{ for } A \text{ to } B.$$

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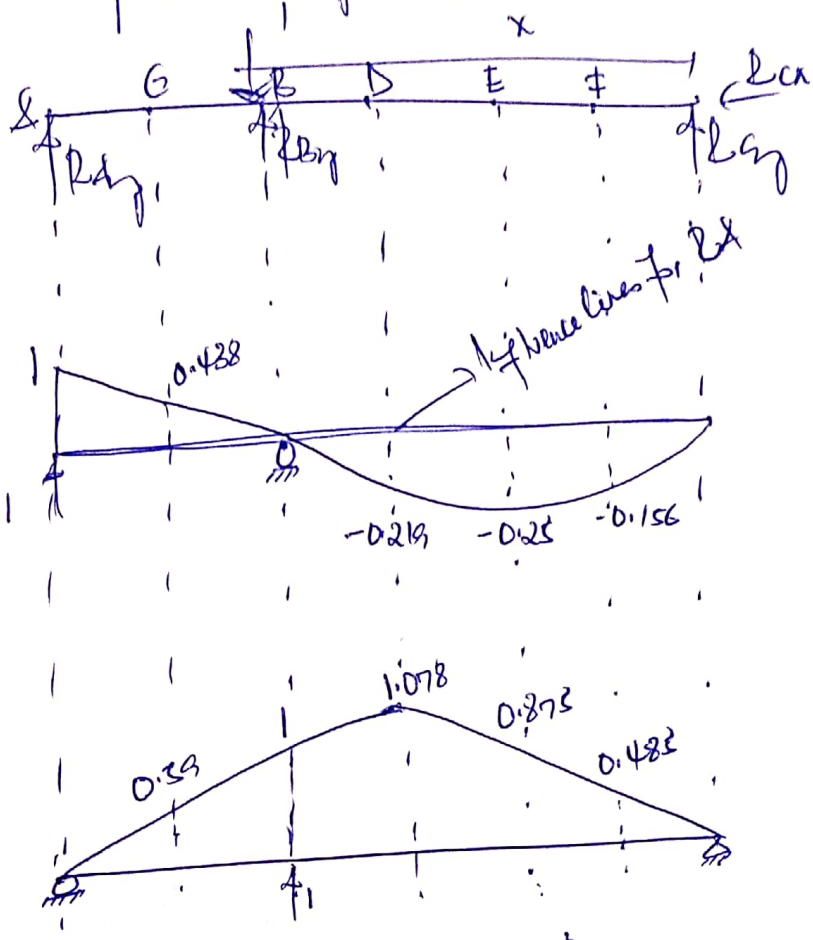


Point	x(m)	f_{xA}	f_{xA}/f_{AA}
C	0	0	0
F	2	$\frac{-10}{EI}$	-0.1562
E	4	$\frac{-16}{EI}$	-0.25
D	6	$\frac{-14}{EI}$	-0.2188
B	8	0	0
G	10	$\frac{28}{EI}$	0.4375
A	12	$\frac{6L}{EI}$	1.

6

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Or By Using Equilibrium Conditions for Influence lines for R_B.



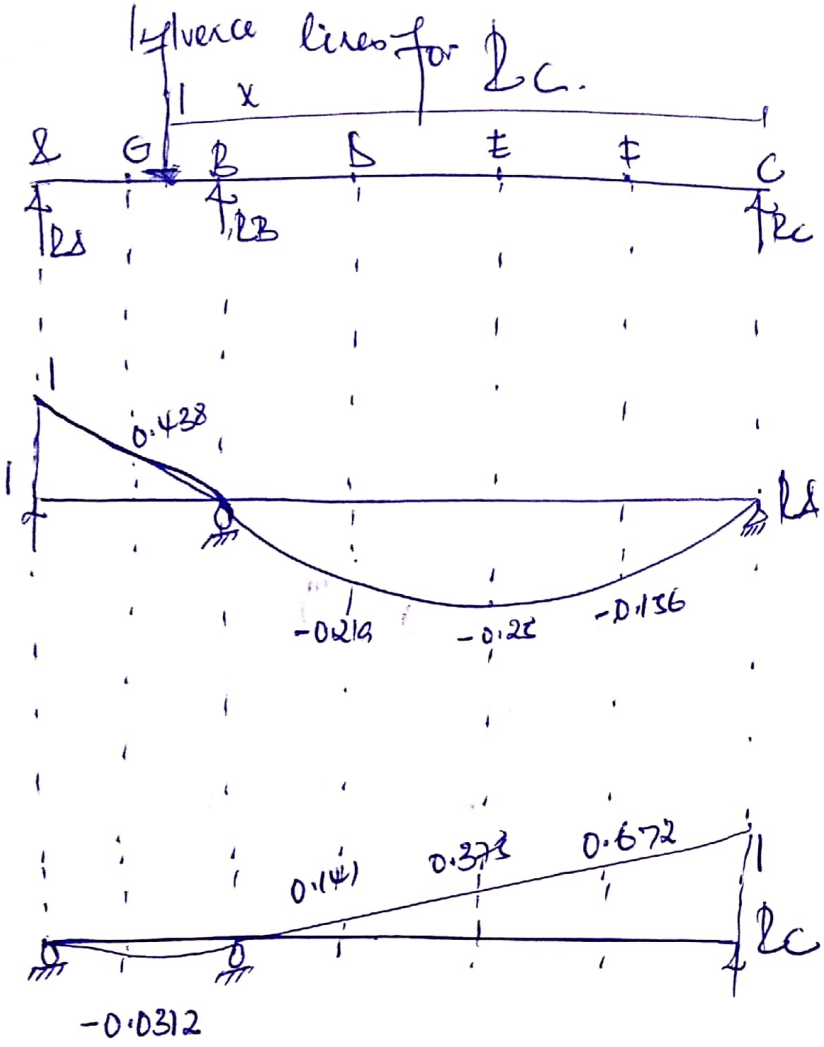
$\zeta + \sum M_C = 0$

$-8R_{By} * x - 12R_{Ay} = 0$

$R_{By} = \frac{x}{8} - \frac{12}{8} R_{By}$

point	x(m)	R_A	R_B
C	0	0	0
F	2	-0.1562	0.484
E	4	-0.25	0.875
D	6	-0.2188	1.078
B	8	0	1
G	10	0.4375	0.5939
A	12	1	0

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$$\curvearrowleft \sum M_B = 0$$

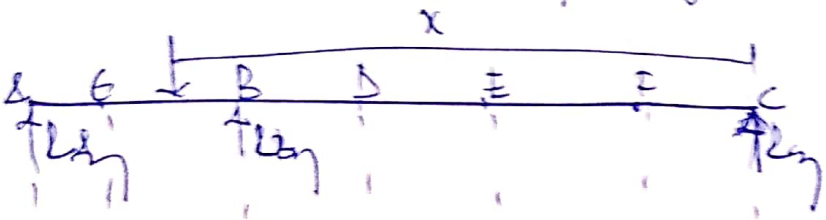
$$4R_{Ay} - 1(x-8) - 8R_{Cy} = 0$$

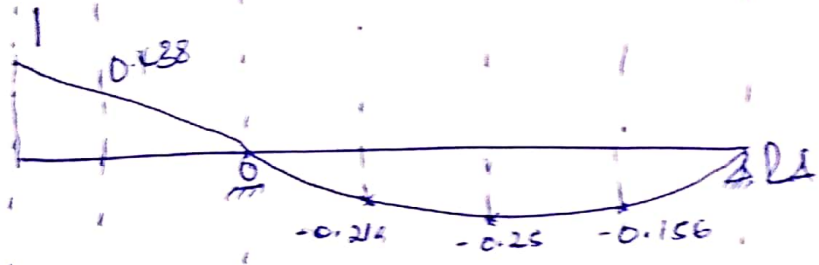
$$R_{Cy} = 0.5R_A - \frac{x}{8} + 1$$

Point	X(m)	R_A	R_C
C	0	0	1
F	2	-0.1562	0.6719
E	4	-0.25	0.375
D	6	-0.2188	0.1406
B	8	0	0
G	10	0.4375	-0.0312
A	12	1	0

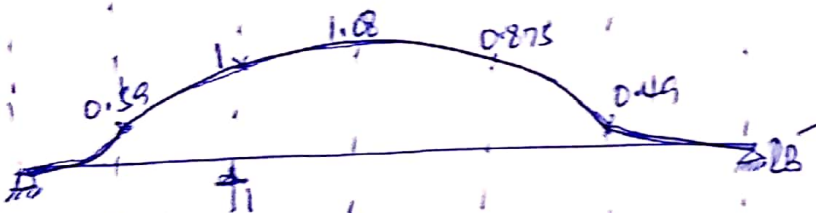
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Check for $\Sigma F_y = 0$, $R_A + R_B + R_C = 1$

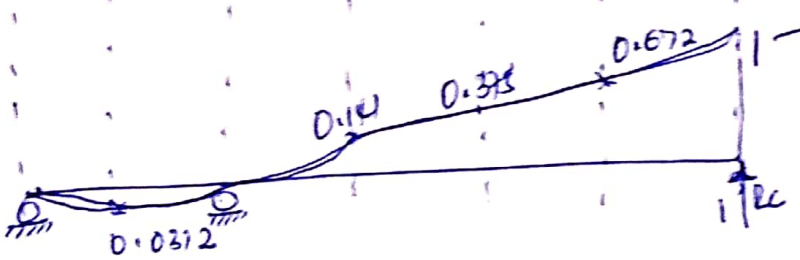




Influence line for R_A



→ Influence line for Reaction R_B

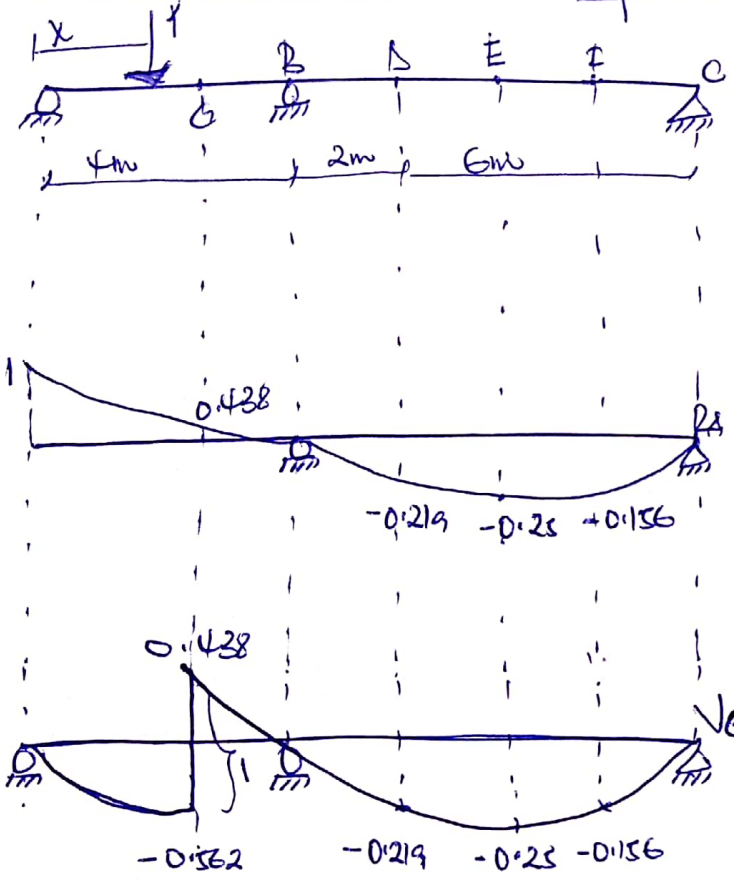


→ Influence line for Reaction R_C

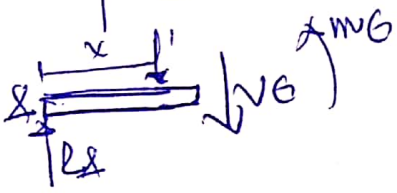
Point	R_A	R_B	R_C	ΣR
C	0	0	1	1
F	-0.156	0.483	0.672	1
E	-0.25	0.875	0.375	1
D	-0.219	1.078	0.141	1
B	0	1	0	1
G	0.4375	0.5939	-0.0312	1
A	1	0	0	1

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Using Equilibrium Condition for Influence line of shear VG.



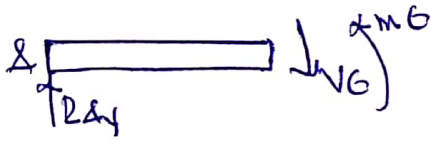
When Unit load is to the left of G.



$+\uparrow \sum F_y = 0, \quad R_A - 1 - V_G = 0$

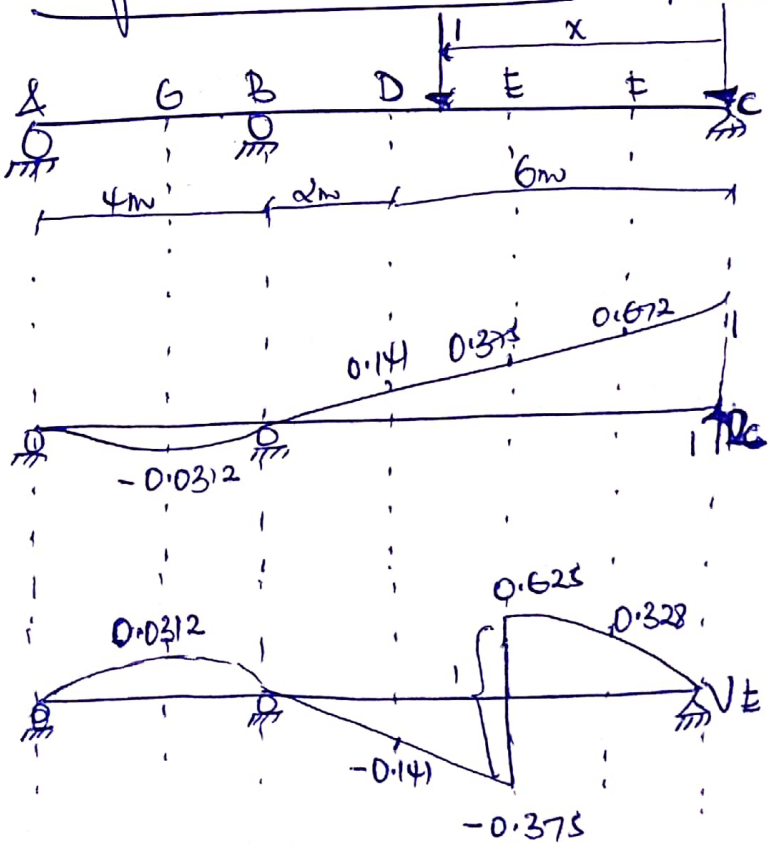
$V_G = R_A - 1$

When Unit load to the right of G

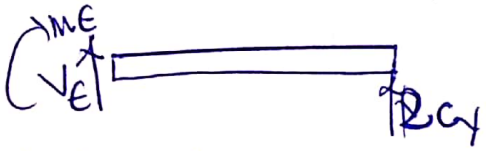


$V_G = R_A$

Using Equilibrium Condition for Influence line of shear VE.



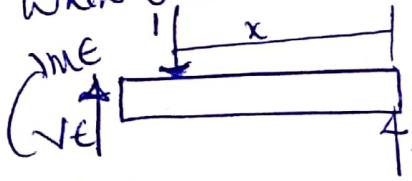
When Unit load to the left of E.



$+\uparrow \sum F_y = 0, \quad R_C + V_E = 0$

$V_E = -R_C$

When Unit load to the right of E

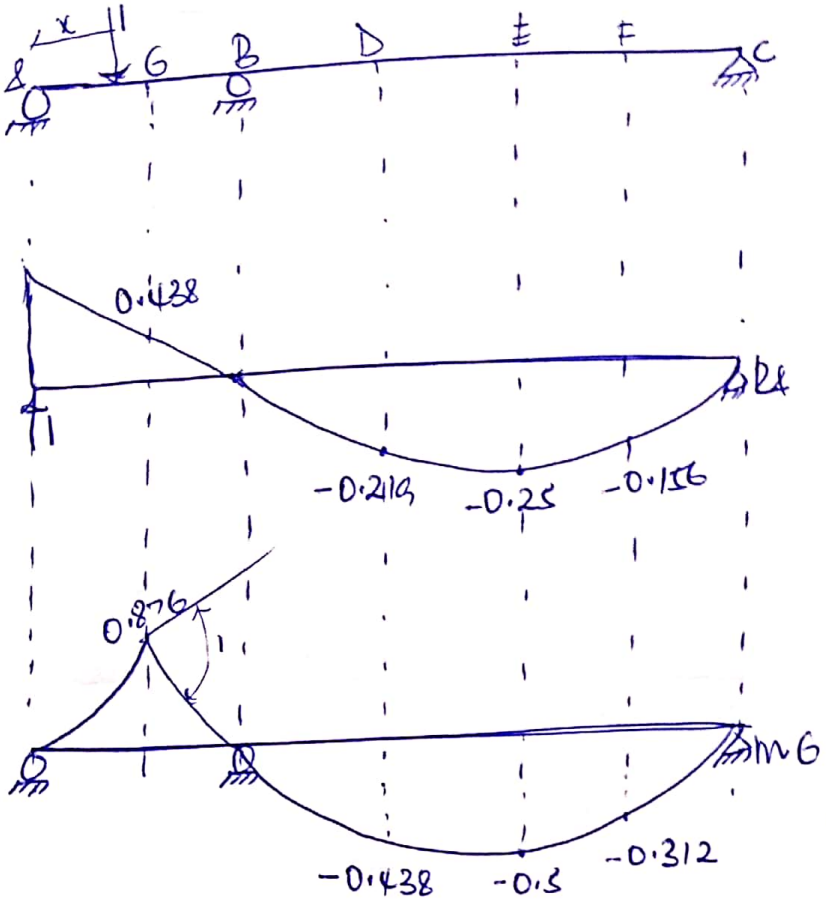


$+\uparrow \sum F_y = 0, \quad V_E - 1 + R_C = 0$

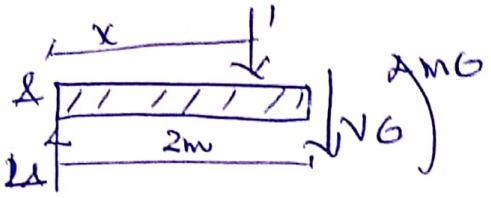
$V_E = 1 - R_C$

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Using Equilibrium Condition for Influence line of moment for G.



When Unit load is to the left of G

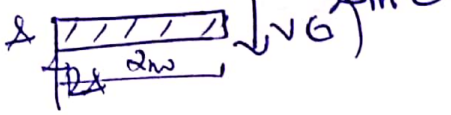


$+\circlearrowleft \sum m_G = 0,$

$m_G + 1(2-x) - 2R_A = 0$

$m_G = -2 + x + 2R_A$

When Unit load is right of G

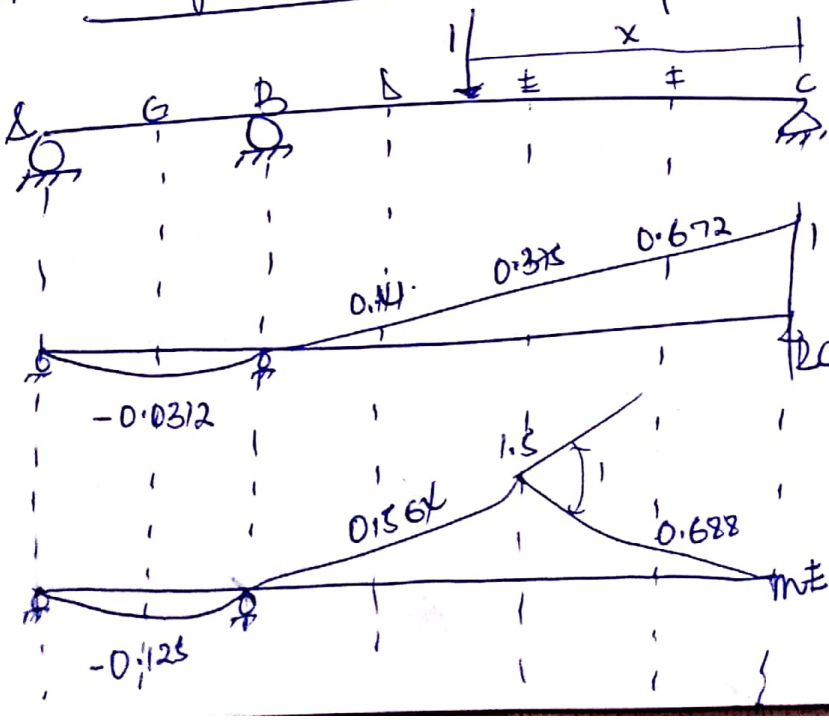


$\circlearrowleft \sum m_G = 0$

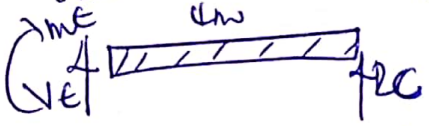
$m_G - 2R_A = 0$

$m_G = 2R_A$

Using Equilibrium Equations for Moment influence of m E.

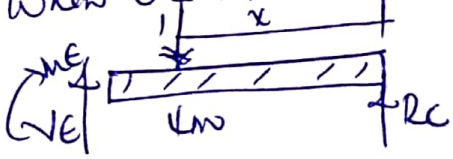


When Unit load to left of E



$\circlearrowleft \sum m_E = 0, \quad m_E = 1R_C$

When Unit load to right of E



$\circlearrowleft \sum m_E = 0, \quad -m_E - 1(1-x) + 1R_C = 0$

$m_E = -1 + x + 1R_C$

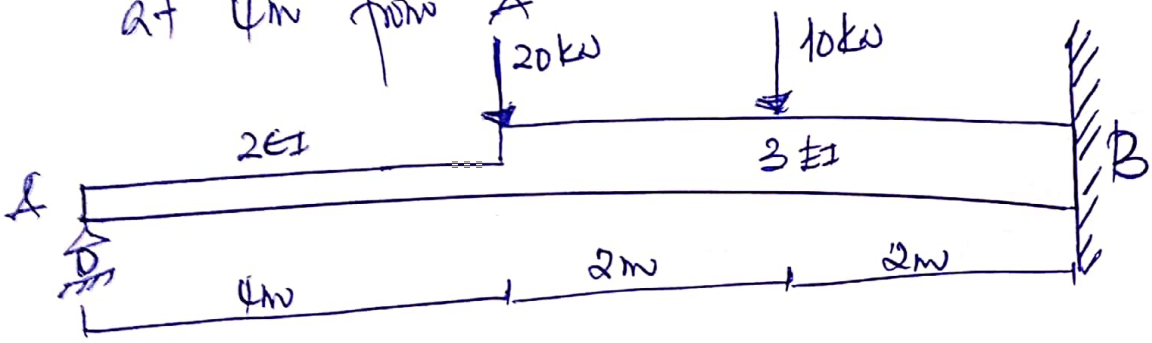
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Qualitative Influence Lines for Indeterminate Beams

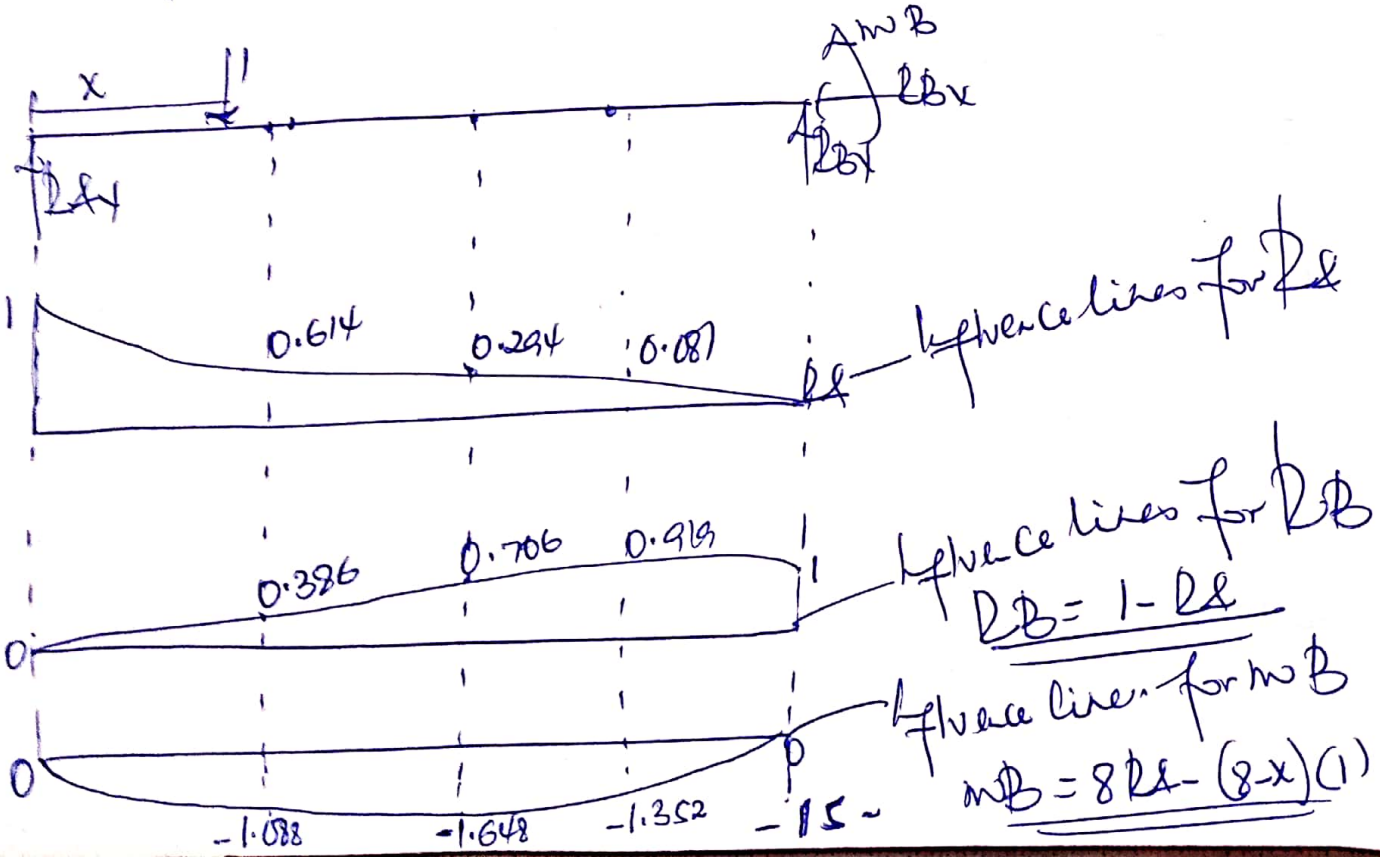
Example for the beam shown below

(a) Draw qualitative influence lines for the reaction at supports A and B, and bending moment at B.

(b) Determine the reactions at supports, and also draw its qualitative shear, bending moment diagrams and qualitative deflected curve -
for ~ Only 10kN downward at 6m from A
~ Both 10kN downward at 6m from A and 20kN downward at 4m from A.

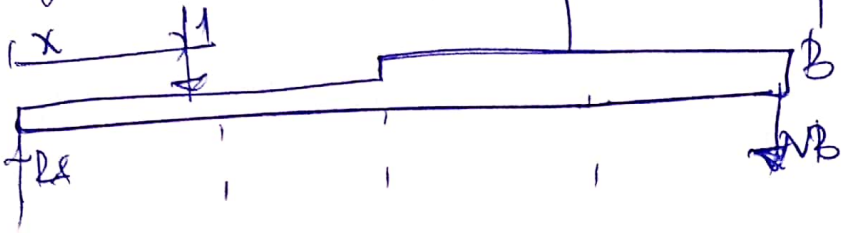


Sol:- Using Equilibrium Condition for the Influence line of RB and MB.

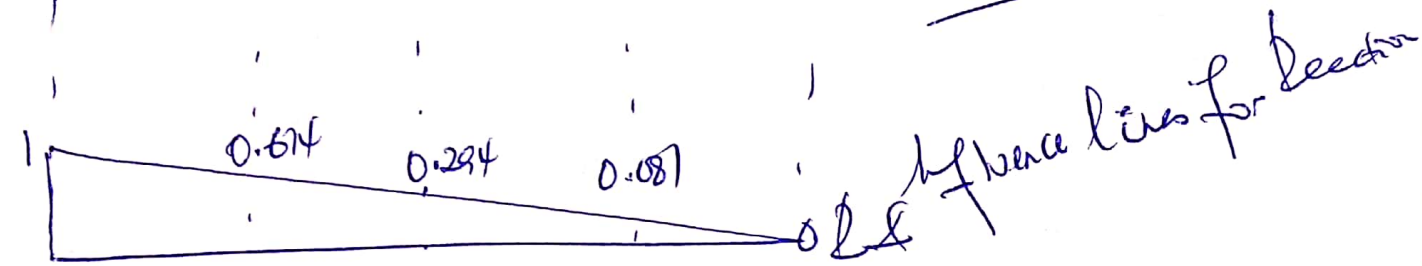


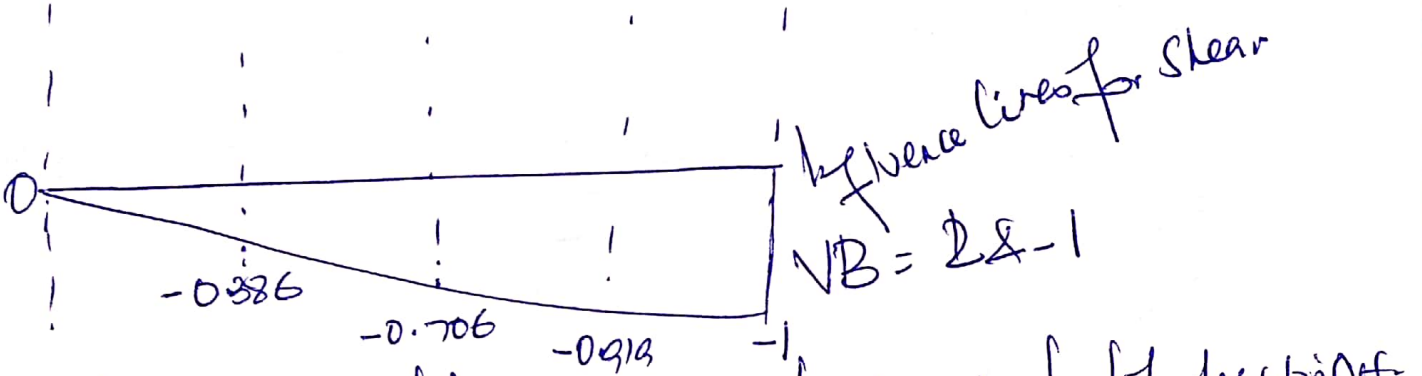
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Using Equilibrium Condition Influence line for shear of VB.

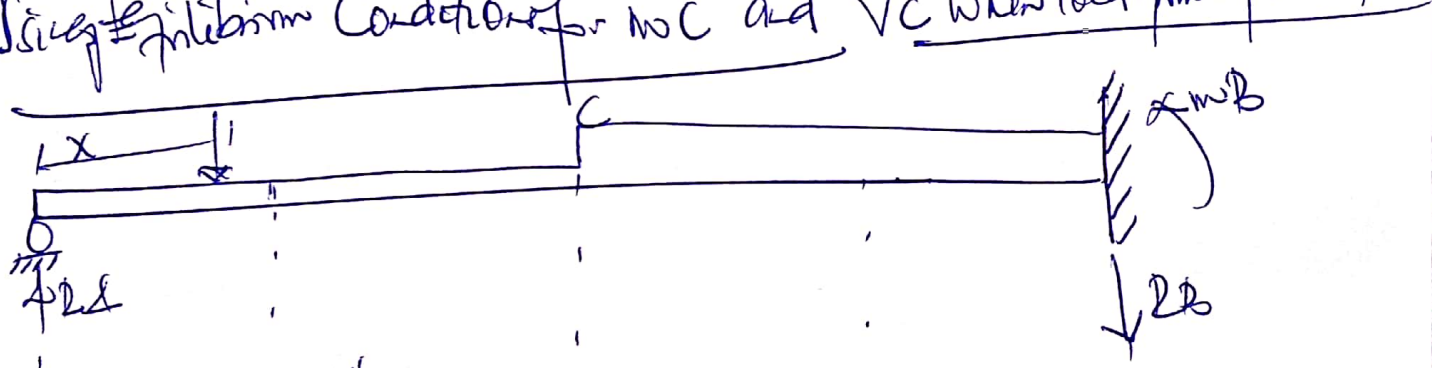


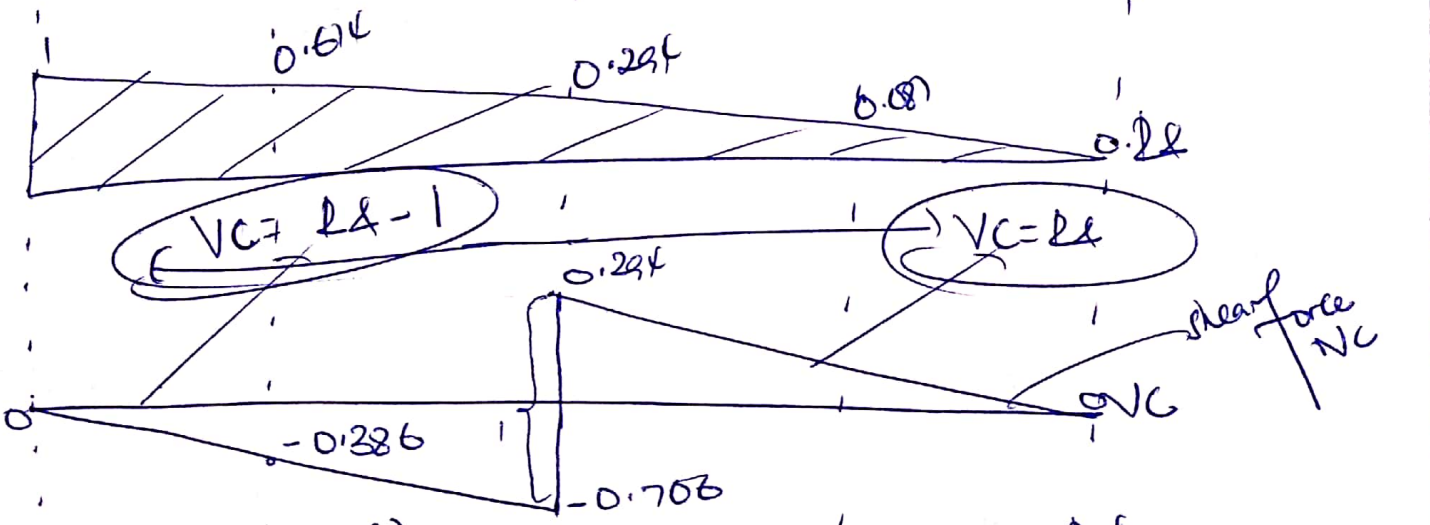
$VB = 2k - 1$

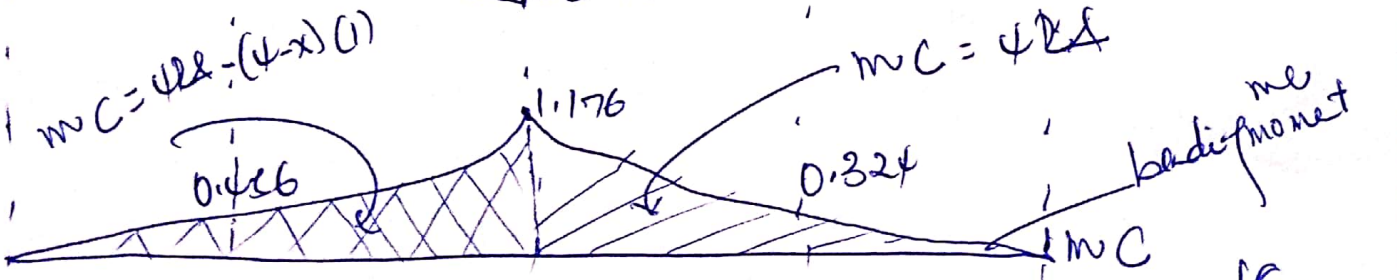




Using Equilibrium Condition for MC and VC when load from left to right

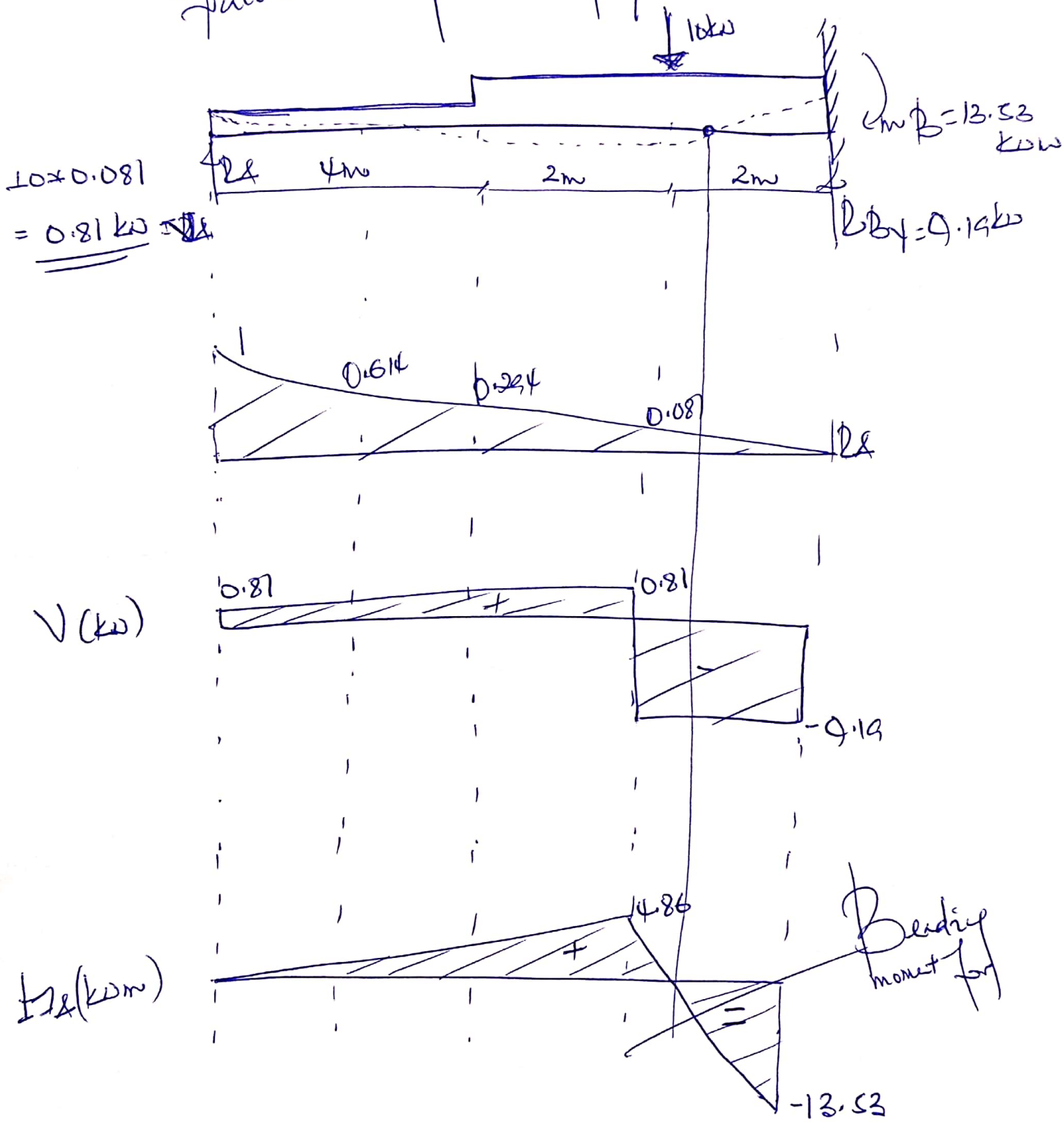






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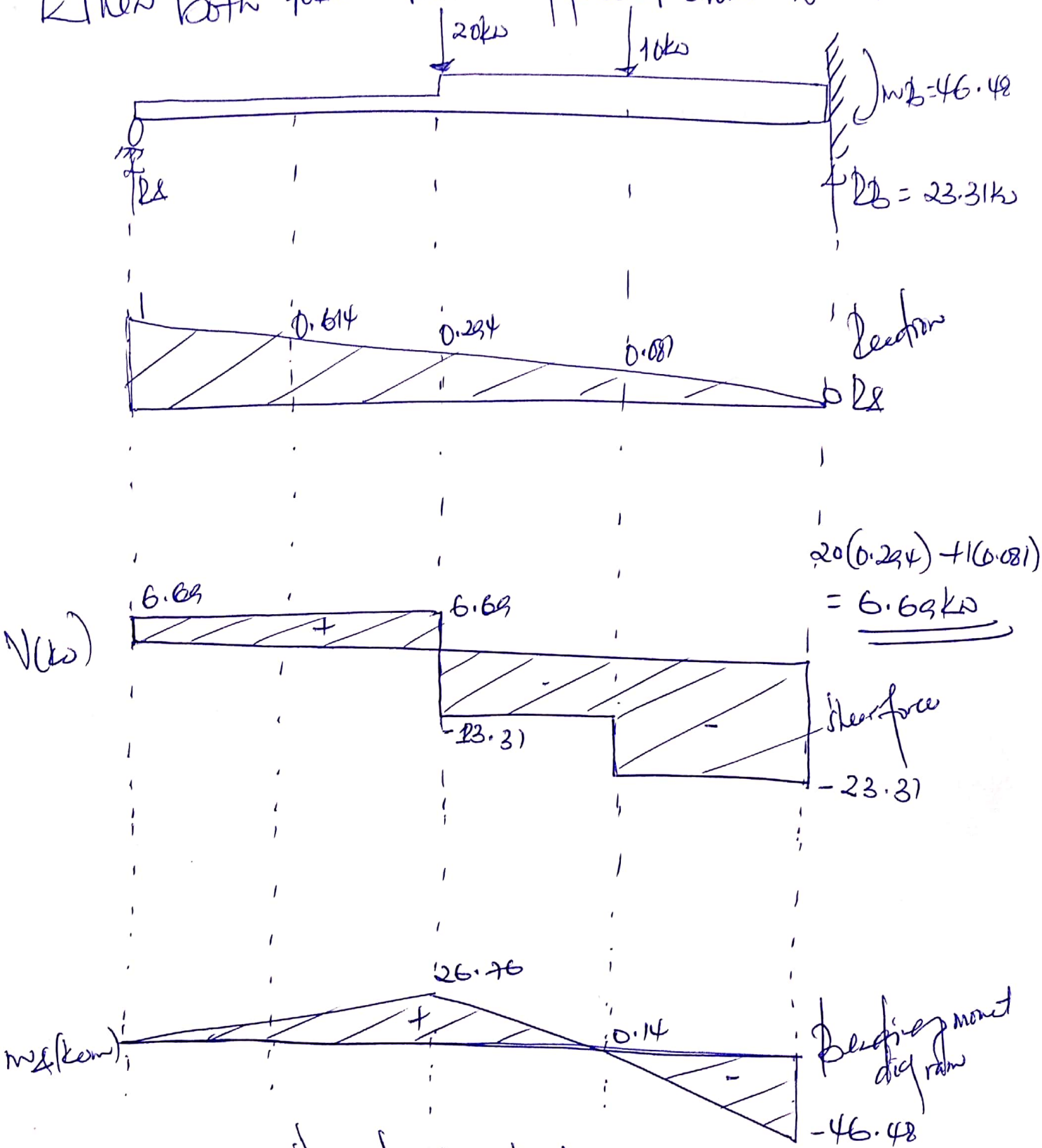
The quantitative shear and Bending moment diagram and qualitative deflected shape (curve).



When only 10kN applied at 6m downward.

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When both 10kN and 20kN applied downward

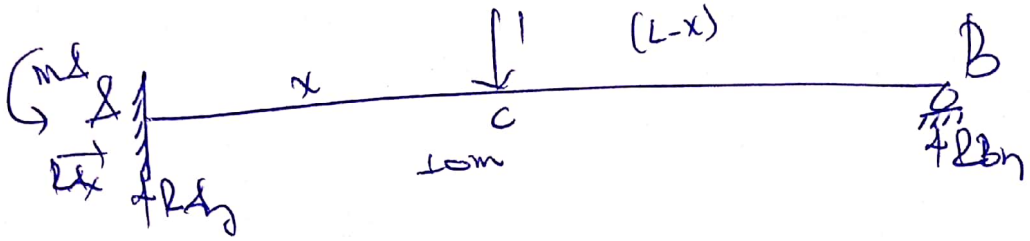


Qualitative shear & bending moment diagram for deflected shape of load 20kN & 10kN.

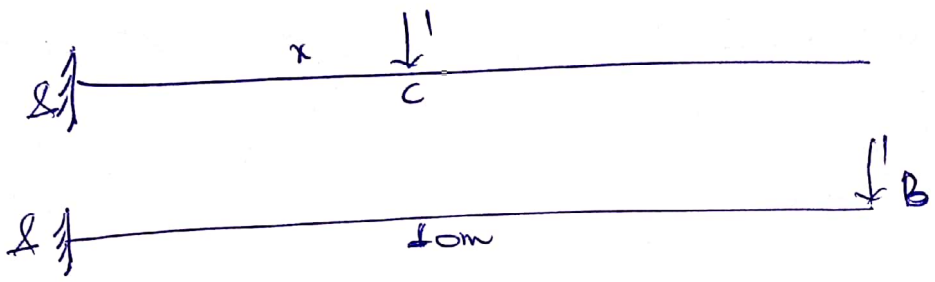
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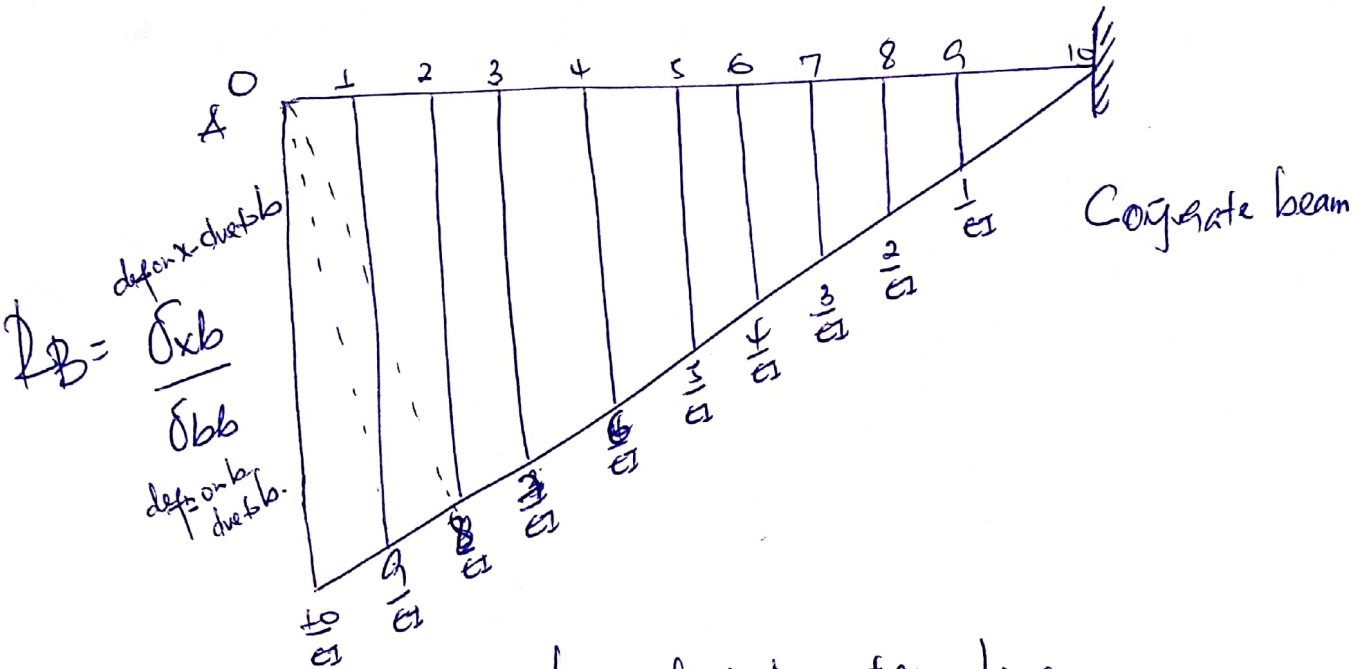
Example Draw the influence line diagram for a propped Cantilever beam shown in figure for.

i) Reaction at A (R_A)
ii) Reaction at B (R_B)
iii) moment at A (M_A)
iv) Calculate the Ordinates at 1m intervals.



So/L





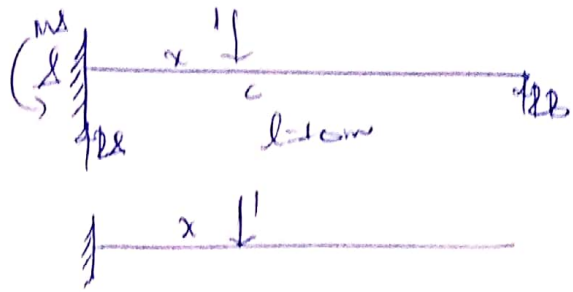
We know that for a Conjugate beam, deflection at any point = Bending moment at that point divided by EI.

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$\delta_0 = 0$ deflection on 1 due to 1 on.

$\delta_1 = \left(\frac{1}{2} * 1 * 10\right) * \frac{2}{3} * 1 + \left(\frac{1}{2} * 1 * 9\right) * \frac{1}{3} * 1 = 4.83$

upper triangle, lower triangle



$\delta_2 = \left(\frac{1}{2} * 2 * 10\right) * \frac{2}{3} * 2 + \left(\frac{1}{2} * 2 * 8\right) * \frac{1}{3} * 2 = 18.66$

$\delta_3 = \left(\frac{1}{2} * 3 * 10\right) * \frac{2}{3} * 3 + \left(\frac{1}{2} * 3 * 7\right) * \frac{1}{3} * 3 = 40.5$

$\delta_4 = \left(\frac{1}{2} * 4 * 10\right) * \frac{2}{3} * 4 + \left(\frac{1}{2} * 4 * 6\right) * \frac{1}{3} * 4 = 69.33$

$\delta_5 = \left(\frac{1}{2} * 5 * 10\right) * \frac{2}{3} * 5 + \left(\frac{1}{2} * 5 * 5\right) * \frac{1}{3} * 5 = 104.2$

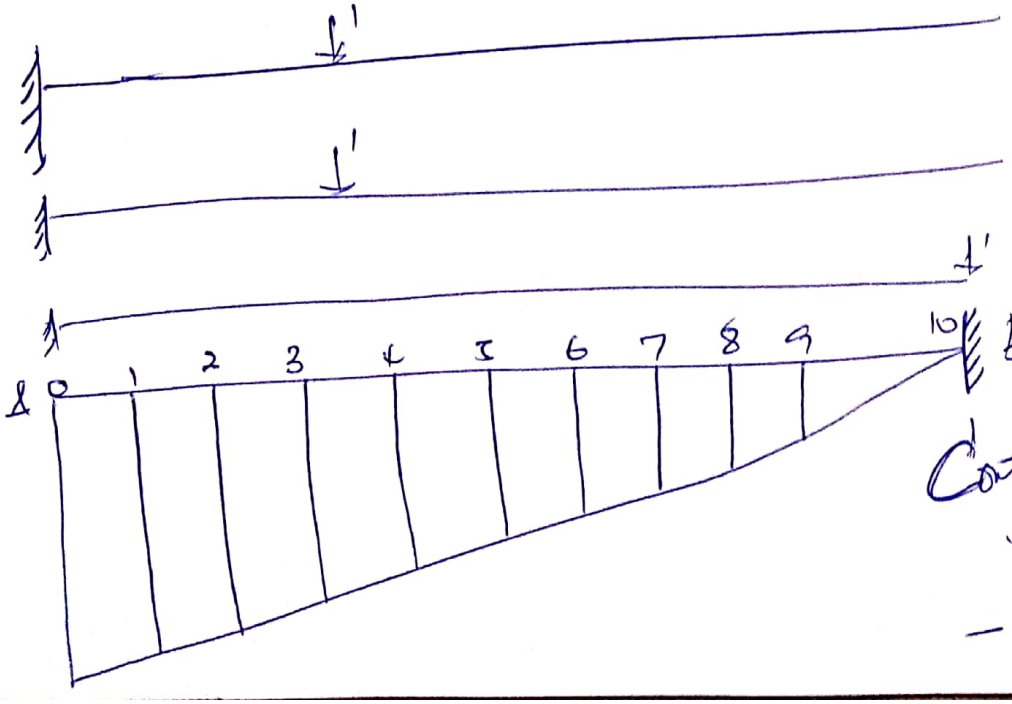
$\delta_6 = \left(\frac{1}{2} * 10 * 6\right) * \frac{2}{3} * 6 + \left(\frac{1}{2} * 4 * 6\right) * \frac{1}{3} * 6 = 144$

$\delta_7 = \left(\frac{1}{2} * 10 * 7\right) * \frac{2}{3} * 7 + \left(\frac{1}{2} * 3 * 7\right) * \frac{1}{3} * 7 = 188$

$\delta_8 = \left(\frac{1}{2} * 10 * 8\right) * \frac{2}{3} * 8 + \left(\frac{1}{2} * 2 * 8\right) * \frac{1}{3} * 8 = 234.6$

$\delta_9 = \left(\frac{1}{2} * 10 * 9\right) * \frac{2}{3} * 9 + \left(\frac{1}{2} * 1 * 9\right) * \frac{1}{3} * 9 = 283.5$

$\delta_{10} = \left(\frac{1}{2} * 10 * 10\right) * \frac{2}{3} * 10 = 333.3$ $\delta_{66} =$



Conjugate beam

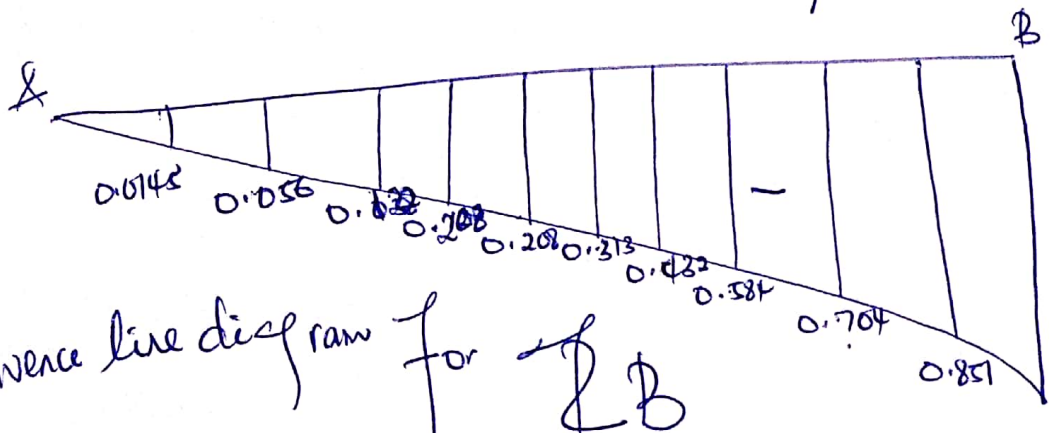
- 20 -

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$\therefore$ $R_B = \frac{\delta_{xb}}{\delta_{bb}}$. deflection at or x due to b / deflection on b due to b . here

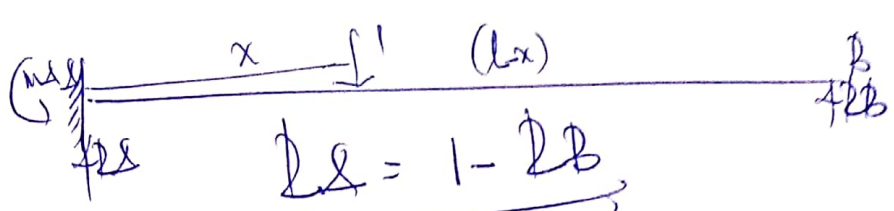
$\delta_{bb} = \delta_{10} = 333.33$

Distance x	R_B
at x = 0	$R_B = 0/333.3 = 0$
at x = 1	$R_B = 4.83/333.3 = 0.0145$
at x = 2	$R_B = 18.66/3333 = 0.056$
at x = 3	$R_B = 40.5/333.3 = 0.122$
at x = 4	$R_B = 69.33/333.3 = 0.208$
at x = 5	$R_B = 104.16/333.3 = 0.313$
at x = 6	$R_B = 144/333.3 = 0.432$
at x = 7	$R_B = 187.83/333.3 = 0.564$
at x = 8	$R_B = 234.66/333.3 = 0.704$
at x = 9	$R_B = 283.5/333.3 = 0.851$
at x = 10	$R_B = 333.3/333.3 = 1$



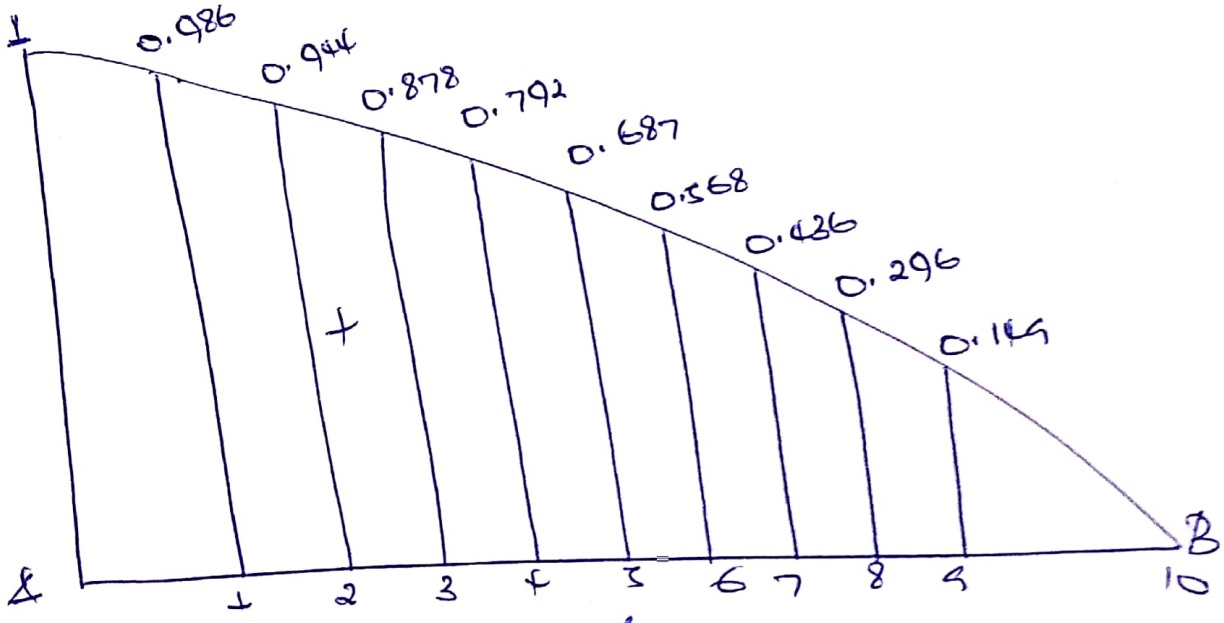
Influence line diagram for R_B

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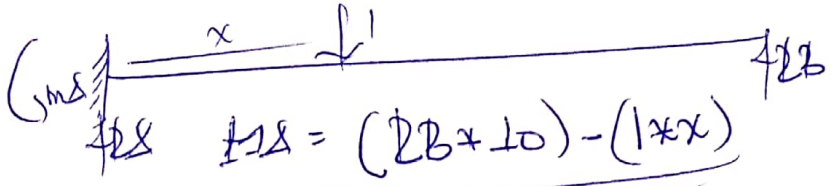
$$I.L_A = 1 - I.L_B$$

Distance x	$I.L_A$
at x = 0	$I.L_A = 1 - 0 = 1$
at x = 1	$I.L_A = 1 - 0.044 = 0.956$
at x = 2	$I.L_A = 1 - 0.056 = 0.944$
at x = 3	$I.L_A = 1 - 0.122 = 0.878$
at x = 4	$I.L_A = 1 - 0.208 = 0.792$
at x = 5	$I.L_A = 1 - 0.313 = 0.687$
at x = 6	$I.L_A = 1 - 0.432 = 0.568$
at x = 7	$I.L_A = 1 - 0.564 = 0.436$
at x = 8	$I.L_A = 1 - 0.704 = 0.296$
at x = 9	$I.L_A = 1 - 0.855 = 0.145$
at x = 10	$I.L_A = 1 - 1 = 0$



Influence line for $I.L_A$.

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$M_A = (R_B \times 10) - (1 \times x)$

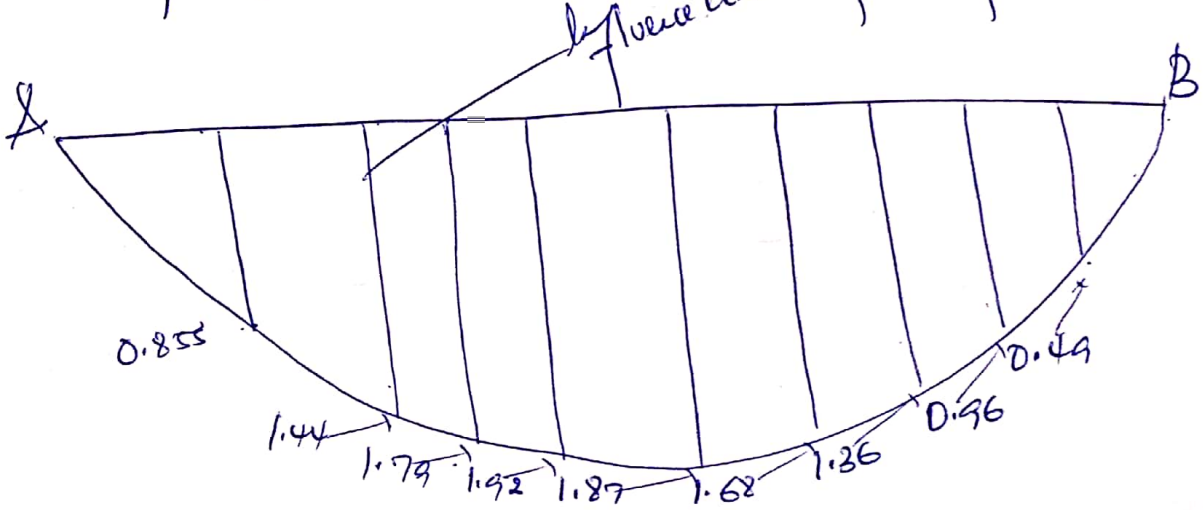
Distance x

$M_A = (R_B \times 10) - (1 \times x)$

at x = 0	$M_A = 0$	at x = 1 $R_B = 0.0145$
at x = 1	$M_A = (0.0143 \times 10) - (1 \times 1) = -0.855$	
at x = 2	$M_B = (0.056 \times 10) - (1 \times 2) = -1.44$	$R_B = 0.056$
at x = 3	$M_A = (0.121 \times 10) - (1 \times 3) = -1.79$	$R_B = 0.121$
at x = 4	$M_A = (0.208 \times 10) - (1 \times 4) = -1.92$	$R_B = 0.208$
at x = 5	$M_A = (0.313 \times 10) - (1 \times 5) = -1.87$	$R_B = 0.313$
at x = 6	$M_A = (0.432 \times 10) - (1 \times 6) = -1.68$	$R_B = 0.432$
at x = 7	$M_A = (0.564 \times 10) - (1 \times 7) = -1.36$	$R_B = 0.564$
at x = 8	$M_A = (0.704 \times 10) - (1 \times 8) = -0.96$	$R_B = 0.704$
at x = 9	$M_A = (0.851 \times 10) - (1 \times 9) = -0.49$	$R_B = 0.851$
at x = 10	$M_A = (0 \times 10) - (1 \times 10) = 0$	$R_B = 1$

Influence line for M_A

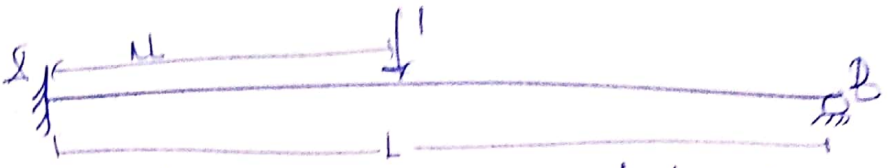
Influence line diagram for M_A.



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Example

$0 \le n \le 1$



Determine the support reaction in terms of n and L. by slope deflection



$$M_{ab} = \frac{2EI}{L}(2\theta_a + \theta_b) + FEM_{ab}$$

$$M_{ba} = \frac{2EI}{L}(\theta_a + 2\theta_b) + FEM_{ba}$$

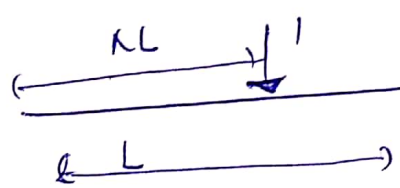
Since the slope of the beam at fixed end is zero.

$$\therefore M_{ab} = \frac{2EI}{L}(2\theta_a + \theta_b) + FEM_{ab} \Rightarrow M_{ab} = \frac{2EI}{L}(\theta_b) + FEM_{ab}$$

$$M_{ba} = \frac{2EI}{L}(\theta_a + 2\theta_b) + FEM_{ba} \Rightarrow M_{ba} = \frac{2EI}{L}(2\theta_b) + FEM_{ba}$$

also the fixed end moments can be written as

$$\frac{nL(L-nL)^2}{L^2} = n(1-n)^2L$$



$$\frac{(nL)^2(L-nL)}{L^2} = n^2(1-n)L$$

Considering Counter Clockwise direction is positive then



$$M_{ab} = \frac{2EI}{L}(\theta_b) + n(1-n)^2L$$

$$M_{ba} = \frac{2EI}{L}(2\theta_b) - n^2(1-n)L$$

slope moment deflection eq

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According to slope-deflection method the moment should be in equilibrium.



$\therefore$ [$\sum M_B = 0 \Rightarrow M_{ba} = 0$ then by substituting in Mba the value

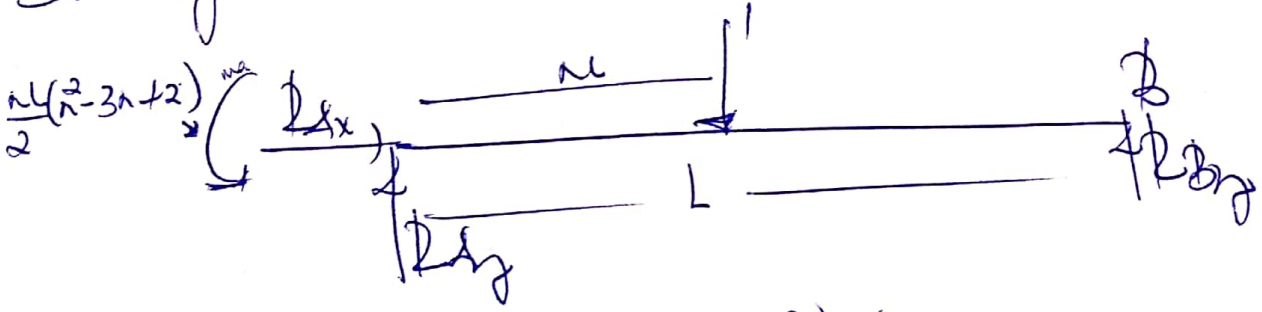
$$= \frac{6EI}{L}\theta_b - \alpha^2(1-\alpha)L = 0$$

$$\theta_b = \frac{L^2}{6EI}(1-\alpha)\alpha^2$$ Substitute the value of θ_b in slope-deflection

$$M_{ab} = \frac{\alpha L}{2}(\alpha^2 - 3\alpha + 2) \Rightarrow M_a = \frac{\alpha L}{2}(\alpha^2 - 3\alpha + 2)$$

$$M_{ba} = 0$$

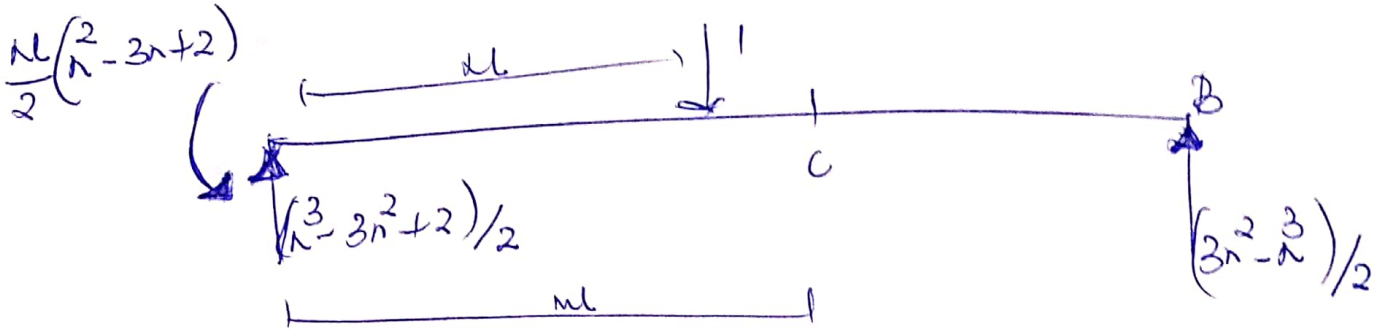
Having we determine the reactions by using equilibrium eqn.



$$[\sum F_y = 0 \Rightarrow R_{By} = (3\alpha^2 - \alpha^3)/2$$

$$[\sum M_B = 0 \Rightarrow R_{Ay} = (\alpha^3 - 3\alpha^2 + 2)/2$$

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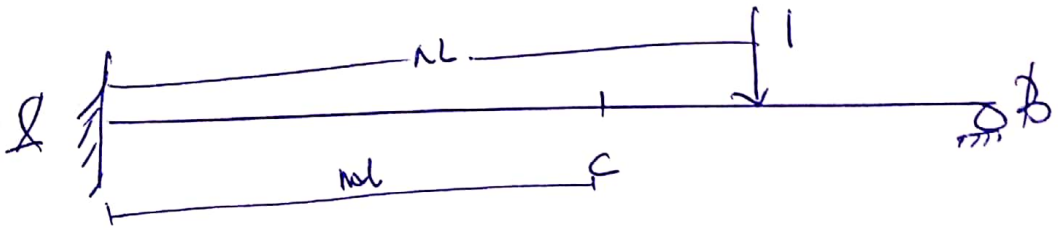
$0 \leq m \leq 1$

Write the expression for bending moment at C.

two moment equation at left & at right

Moment at C = $\begin{cases} n l(3-n)(1-m)/2 & \text{where } n \leq m \\ l(2m-2n+3n^2-3mn^2-n^3+mn^3)/2 & \text{where } n \geq m \end{cases}$

Having this equation: where does the influence lines Cross the x-axis? = at what value moment at C = 0?



Moment at C = $\begin{cases} n l(3-n)(1-m)/2 & n \leq m \\ l(2m-2n+3n^2-3mn^2-n^3+mn^3)/2 & n \geq m \end{cases}$

$l(2m-2n+3n^2-3mn^2-n^3+mn^3)/2 = 0 \Rightarrow n = 1-\dfrac{\sqrt{1-4m+3m^2}}{1-m}$

where n must be between 0 and 1.

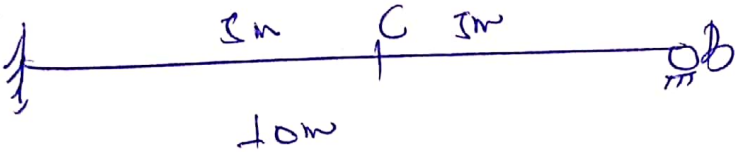
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To get n the value of

$1 - 4m + 3m^2 \leq 0$, $m \leq 1$ or $m \geq \frac{1}{3}$

Example



$m = \frac{1}{2}$

Since $m \leq \frac{1}{3}$ then the Influence line does not Cross the x-axis, moment at C remains positive no matter where the Unit-load is positioned.

We have two Generic moment Equation from w/c we develop eqn.

$$\text{moment at } C = \begin{cases} 2n(3-n)(1-m)/2 & n \leq m \\ l(2m - 2n + 3n^2 - 3mn^2 - n^3 + mn^3)/2 & n \leq m \end{cases}$$

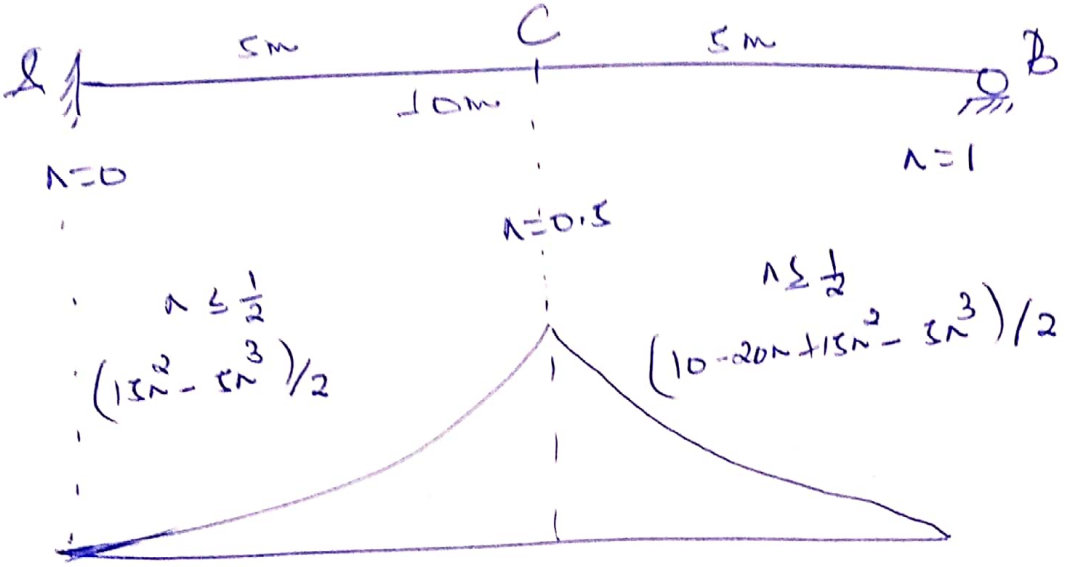
Substitute for L, $\frac{1}{2}$ from we get

$$\text{Moment at } C = \begin{cases} (15n^2 - 5n^3)/2 & n \leq \frac{1}{2} \\ (10 - 20n + 15n^2 - 5n^3)/2 & n \geq \frac{1}{2} \end{cases}$$

Now we Can Construct the Influence line by graph by using this Equations.

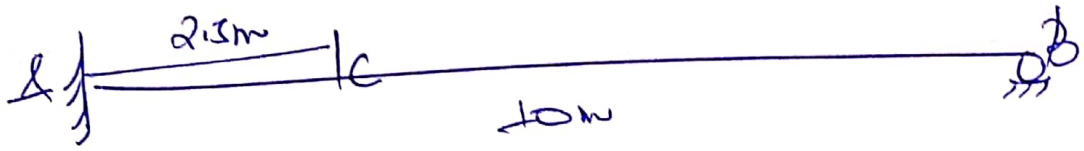
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Influence lines for moment at C

No Graph is below the given line x-axis.
but if the point C is located at $\frac{1}{4}$ of L or 2.5m
towards left support as below shown.



$m = \frac{1}{4}$

Since $m < \frac{1}{2}$ then the Influence line does not Cross the x-axis, moment at C could be positive or negative - depending on the position of the Unit load.

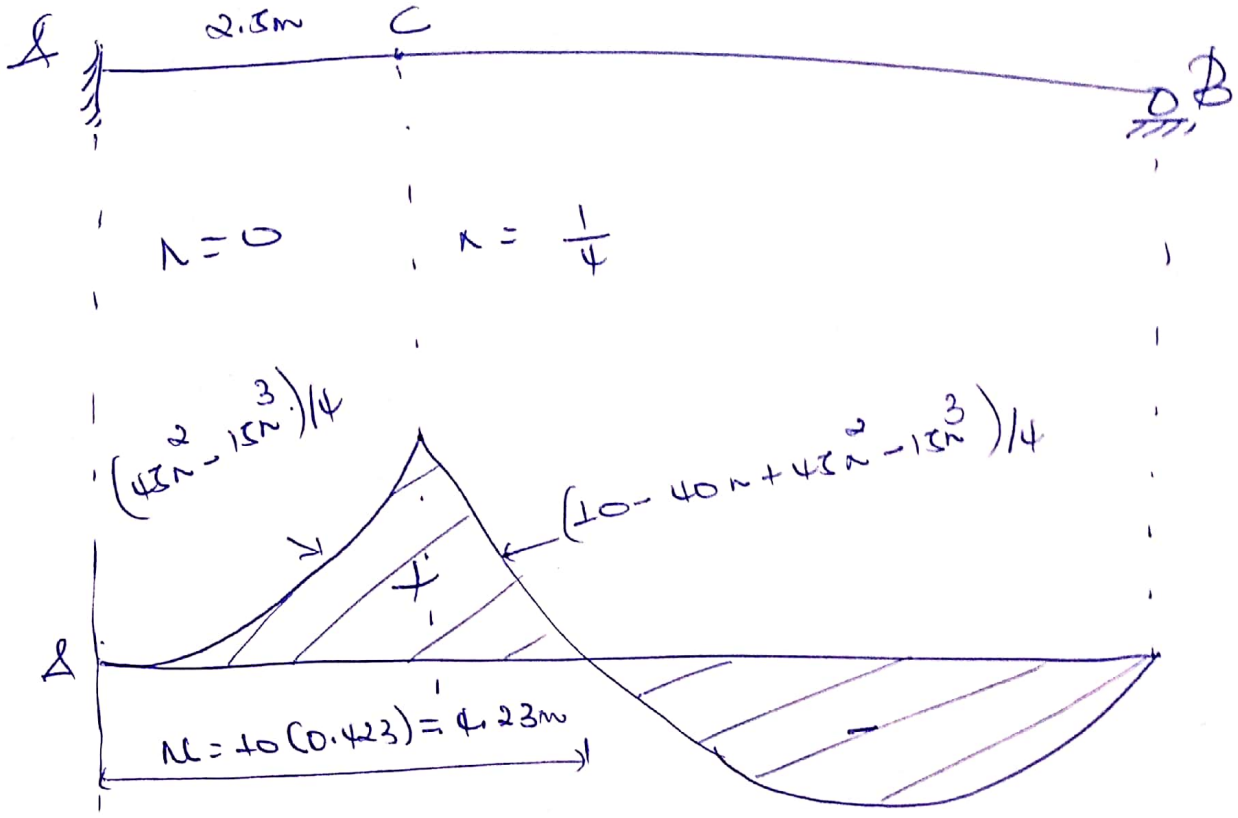
When we substitute 10 for L and $\frac{1}{4}$ for m in moment eqn.

We get moment at C = $\begin{cases} (5x^2 - 15x^3)/4 & x \le \frac{1}{4} \\ (10 - 40x + 45x^2 - 15x^3)/4 & x \ge \frac{1}{4} \end{cases}$

We Can Construct moment equation as below.

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$\lambda = 1 - \sqrt{1 - 4m + 3m^2}$

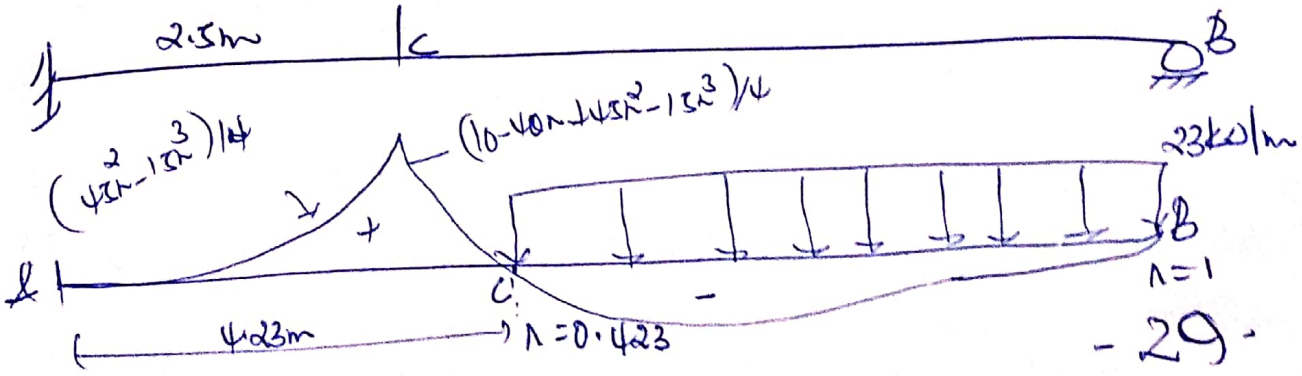
$1 - m$

When $m = \frac{1}{4}$, $\lambda = 1 - \frac{1}{\sqrt{3}} = 0.423$

Thermean negative region on diagram starts at 0.423λ

Which is $0.423 \times l = \lambda l = 10 \times 0.423 = 4.23m$

By following this what is the maximum negative moment long Considering 23kN/m Uniformly distributed load on negative region as shown.



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It is equal to the negative area of influence lines times the intensity of the load.

to Obtain the area We Use Integration

$$\frac{1}{4}\int_{0.423}^{1}(10-40x+45x^2-15x^3)\,dx = -0.1042$$

This is area Under the Curve scaled for Interval [0.1].

Multiply it by the beam length to get the actual area.

Actual area $= -0.1042(16)*10 = -1.042$

finally We multiply the Area with the load to obtain maximum Negative moment at C

Maximum Negative moment at C $= 23\,kN/m * (-1.042m)$

$= -23.96\,kN$

VII

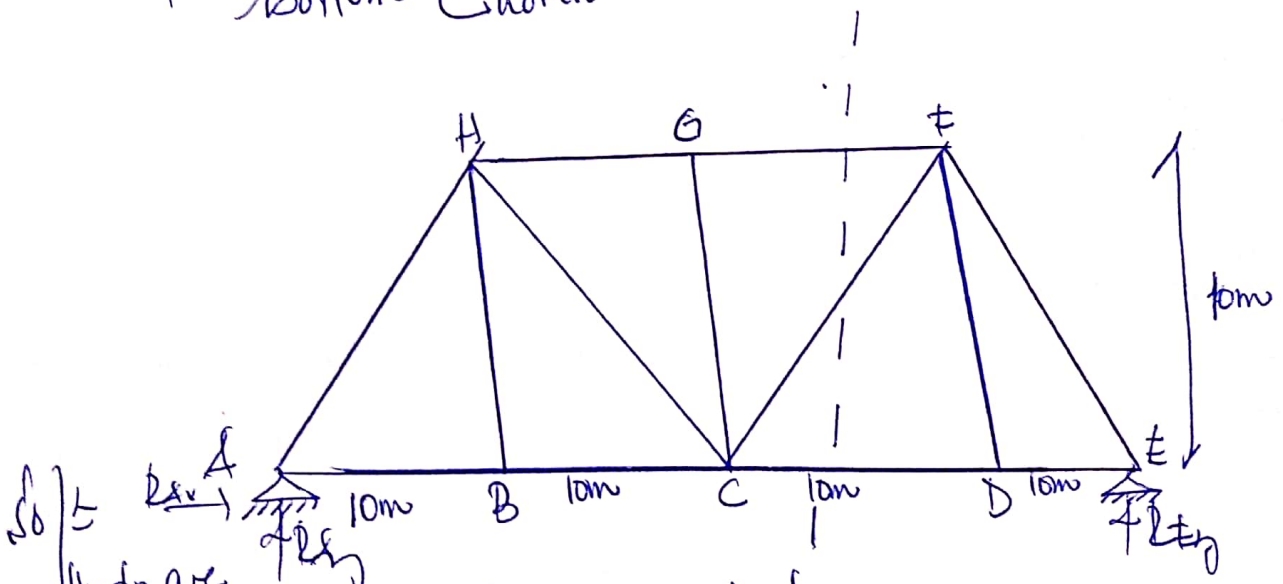
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Influence lines for Trusses

We Use the Influence line to find the maximum effect of live loading.

- Basic Concepts are: Calculating truss member forces Using the method of sections.
  - Constructing an influence line from values at Certain points.
  - Using an influence line to determine the maximum possible internal loading.

Example Construct the influence line for the force in member CE. Then Compute the maximum live load (tension or Compression) that can be developed in this member due to a Uniform live load of 800kg/m which is transmitted to the truss along the bottom Chord.



Solution methods are

1. Decide location to apply a Unit load.
2. Apply Unit load and Calculate force in member F_{CE}
3. Construct the influence line
4. Apply live load to maximize force F_{CE}

No. 1. apply a Unit load at B, C and D where there is no support

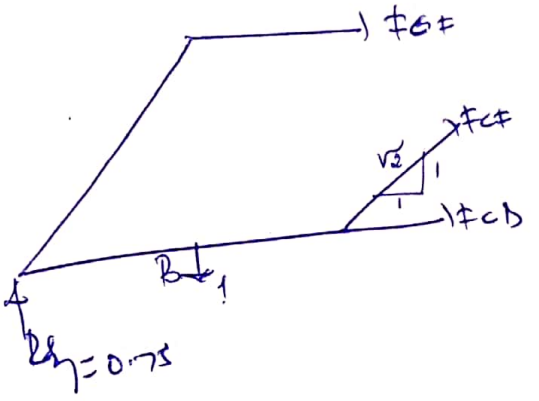
No. 2 let start a Unit load is at B.

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by taking moment at E

$\curvearrowleft +) [M_E = 0, \quad R_y \times 40m - 1(30m) = 0$

$R_y = 0.75 kN (\uparrow)$

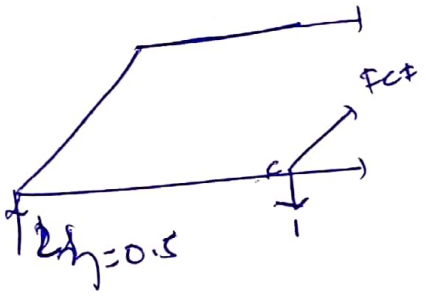


Cut at panel CB & get FCA

$+\uparrow [\sum F_y = 0, \quad 0.75 - 1 + \frac{1}{\sqrt{2}} F_{CA}$

$F_{CA} = 0.35 \sqrt{2}$

move Unit load at C



$\curvearrowleft +) [M_E = 0, \quad R_y \times 40m - 1(20m)$

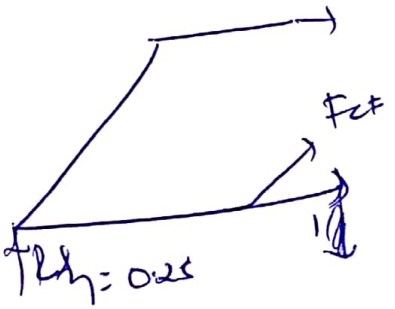
$R_y = +0.5 (\uparrow)$

Cut at panel CB

$+\uparrow [\sum F_y = 0, \quad 0.5 - 1 + \frac{1}{\sqrt{2}} F_{CA}$

$F_{CA} = +0.707$

move Unit load to joint B



$\curvearrowleft +) [M_E = 0, \quad R_y \times 40m - 1(10m)$

$R_y = 0.25 (\uparrow)$

Cut a sec at panel CB

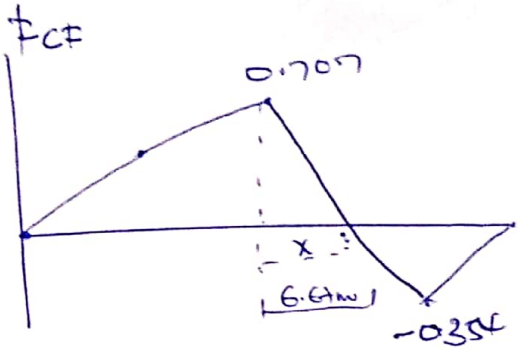
$+\uparrow [\sum F_y = 0, \quad 0.25 + \frac{1}{\sqrt{2}} F_{CA}$

$F_{CA} = -0.356 (\text{Compression})$

No.3 Construct influence line

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Location of unit load	F_{CF}
A	0
B	+0.35f
C	+0.707
D	-0.35f
E	0



From triangle similarity

$$\frac{x}{0.707} = \frac{10m - x}{0.35f}$$

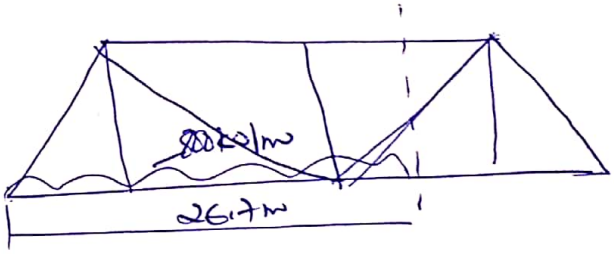
$$0.35fx = 7.07m - 0.707x$$

$$x = 6.67m$$

No. 4 Apply load to Calculate the maximum load (maximize force F_{CF})

Larger area is positive

∴ maximum F_{CF} will be tension



$$F_{CF}^{max} = \frac{1}{2}(0.707)(26.67m) \times 800kN/m$$

$$= \underline{7560\ kN}\ (\text{Tension})$$

Generally we have two area and we apply a Uniformly distributed load on positive area because of maximize force is applied in tension area.

Then we can obtain maximum force at 26.67m in positive region of our Influence line diagram. !!

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