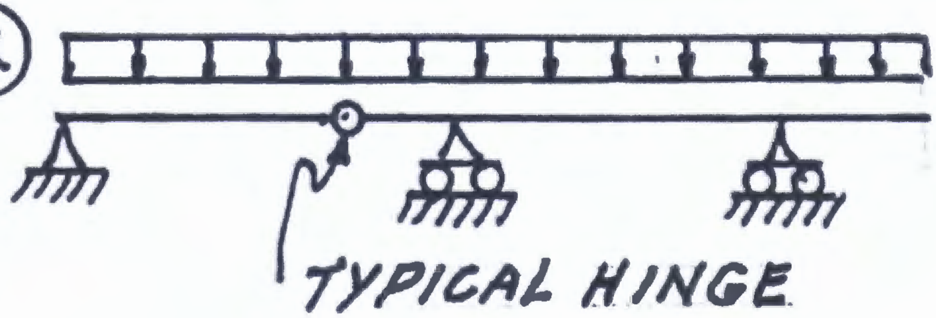
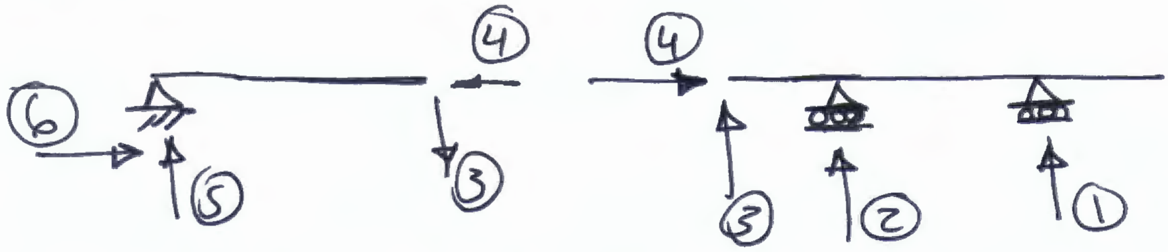
Q1a

(a)



m = number of members in structure

r = number of reactions



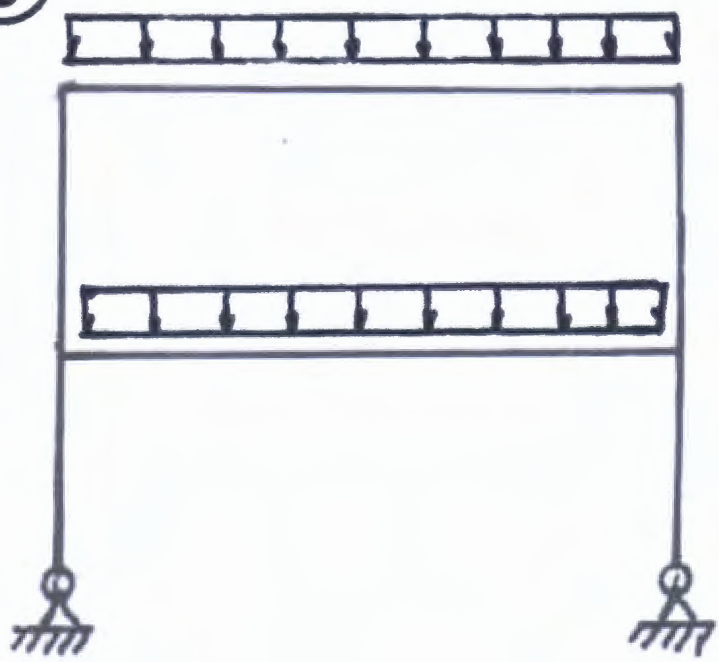
The structure is stable by inspection.

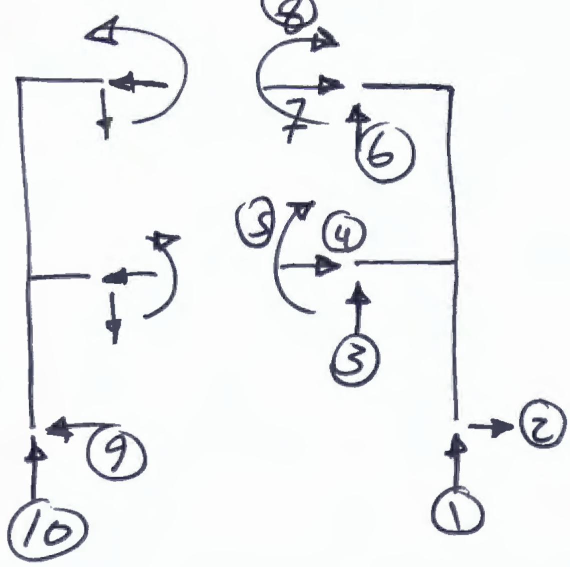
$r = 6$, $m = 2$

$\because r = 3m$ $\therefore$ statically determinate

Q1b

(b)





* stable by inspection

$r = 10$, $m = 2$

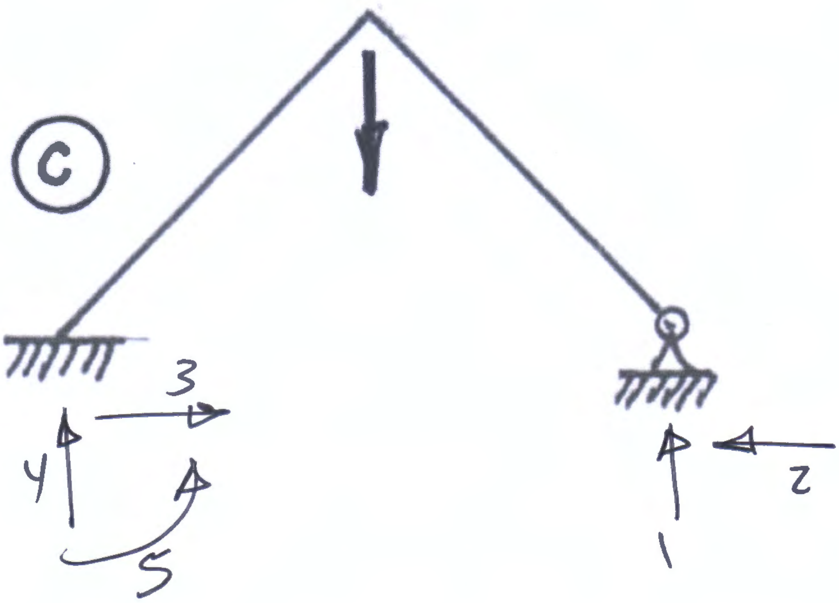
$3m = 6$ $\therefore$ r [redacted] $3m = 4$

$\therefore$ Statically indeterminate to 4^{th} degree

For special loading case stated reactions 3 & 6 may be eliminated to symmetry

Then for special loading it is Statically indeterminate to 2^{nd} degree

Q1c



Stable by inspection

$m = 1 \quad r = 5$

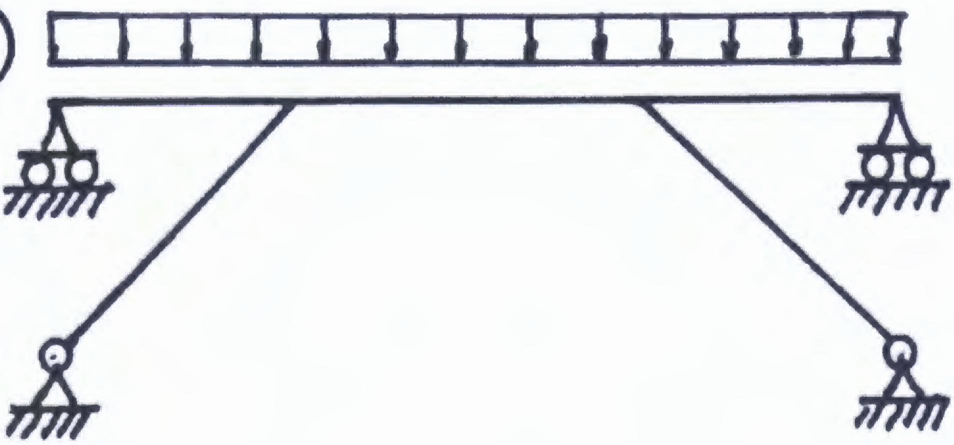
$r - 3m = 2$

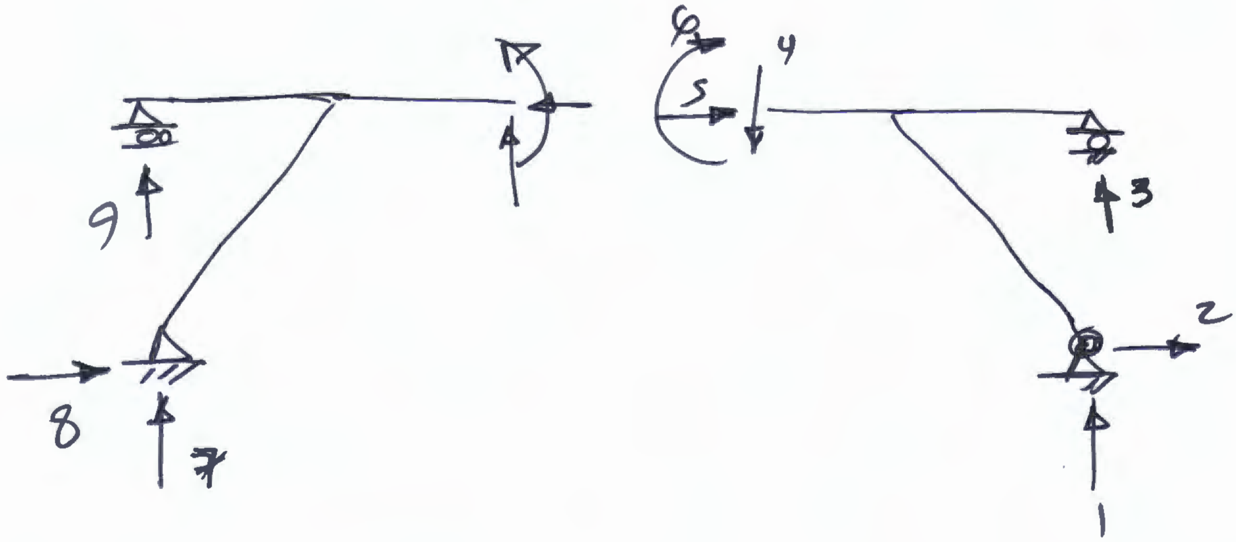
$\therefore$ statically Indeterminate to the 2nd degree

Q1d

stable by inspection.

d



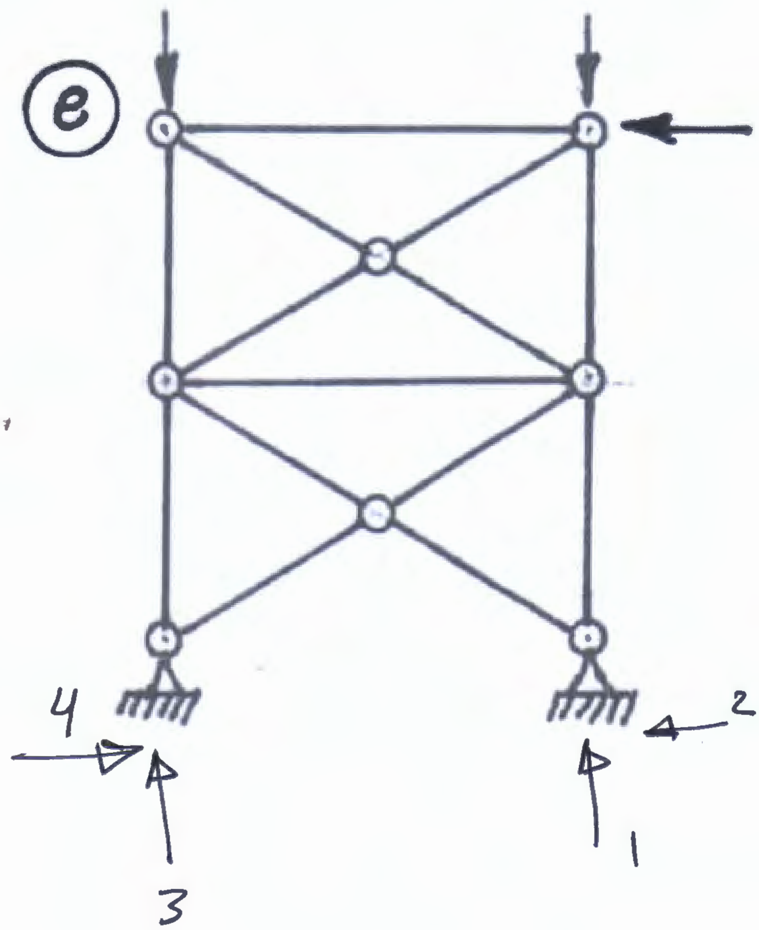


$r = 9$, $m = 2$

$r - 3m = 3$ ∴ statically indeterminate to 3^{rd} degree

due to symmetry it becoms 2^{nd} degree.

Q1e



Stable by inspection

b = number of bars
j = number of joints
r = number of reacti[ons]

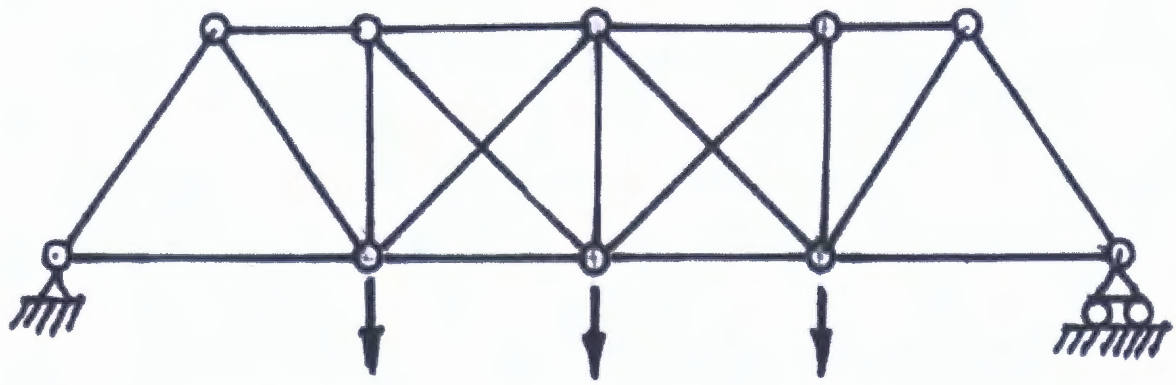
$r = 4$, $b = 14$, $j = 8$

$b + r = 18$

$\therefore b + r > 2j$ $\therefore$ statically indet. to 2^{nd} degree

Q 1f

F



stable by inspection

$r = 3$, $b = 18$, $j = 10$

$b + r = 21 > 2j = 20$

∴ Statically indeterminate to the $(21 - 20 = 1)$ 1st degree

Q2a

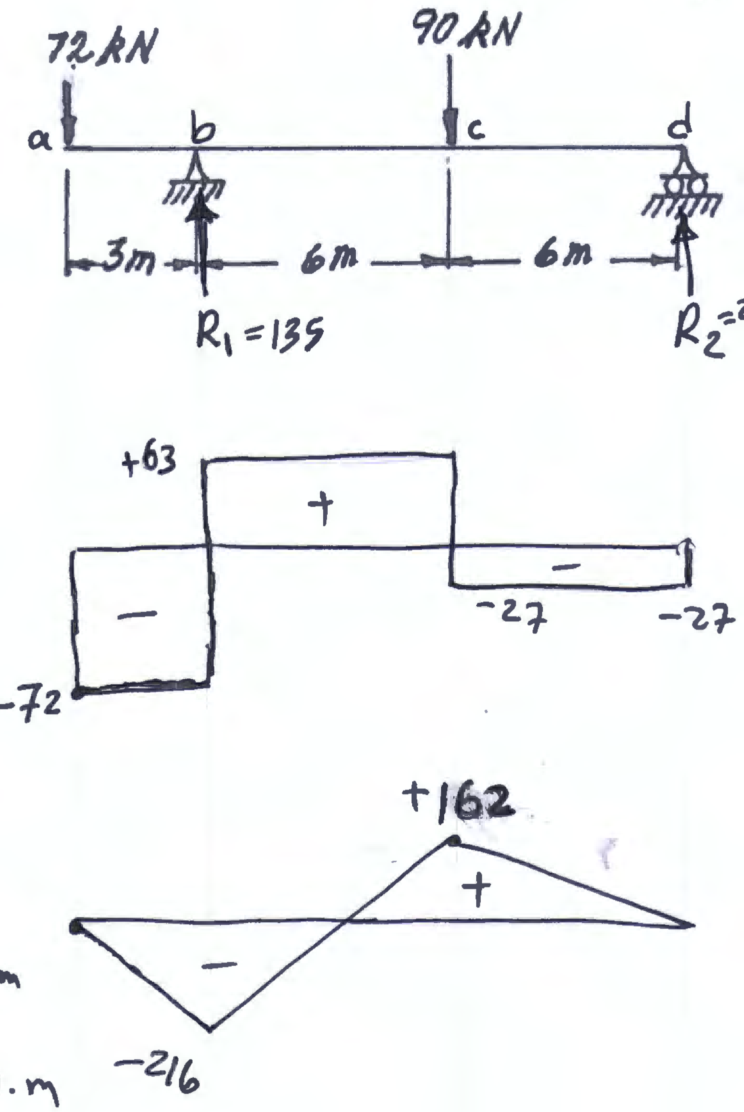
(a)

$\sum M_d = 0$

$$R_1 = \frac{90*6 + 72*15}{12} = 135$$

$\sum M_b = 0$

$$R_2 = \frac{90*6 - 72*3}{12} = 27 \text{ kN}$$



Max. shear − = −72 kN

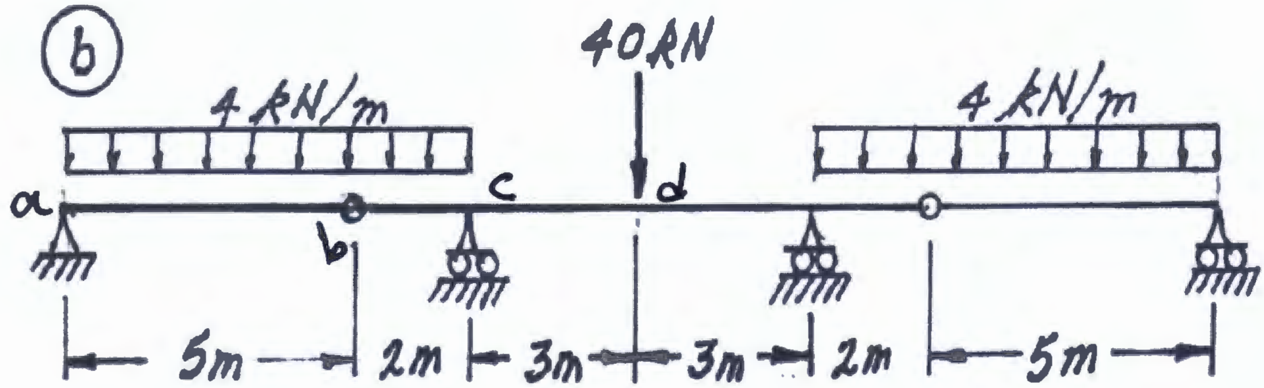
Max. shear + = +63 kN

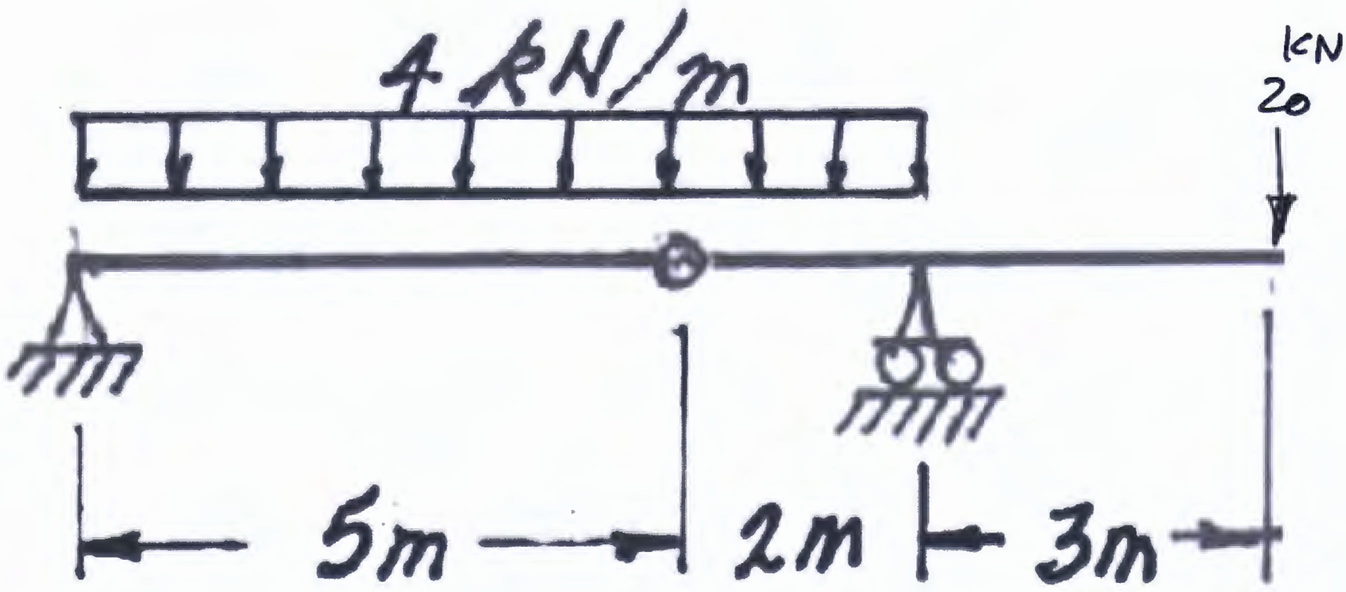
Max. Moment + = +162 kN.m

Max. Moment − = −216 kN.m

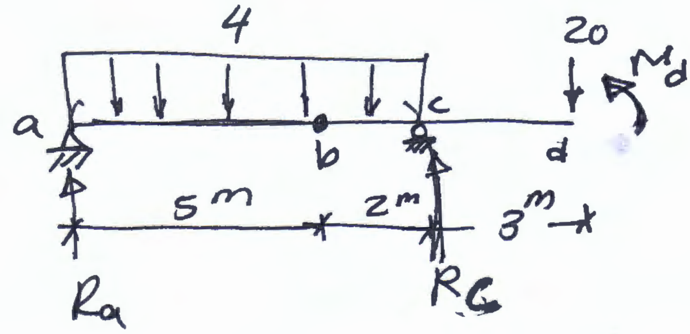
Q2b

b





Q2b



$\circlearrowleft + \sum M_a = 0$

$4 * \frac{7^2}{2} - M_d + 20(10)$

$- R_c * 7 = 0$

$\therefore 7R_c + M_d = 298$ — (1) ✓

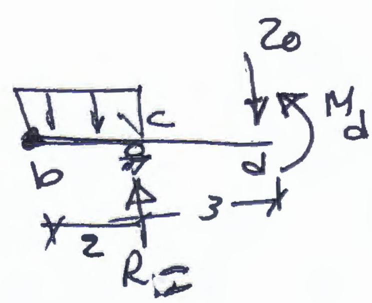
$\circlearrowleft + \sum M_c = 0$

$R_a * 7 - 4 * \frac{7^2}{2} + 20 * 3 - M_d = 0$

$\therefore 7R_a - M_d = +38$ — (2)

Eq. (1) + Eq. (2) $\Rightarrow 7(R_a + R_c) = 298 + 38$

$R_a + R_c = 48$ — (3)



$\circlearrowleft + \sum M_b = 0$

$-R_c * 2 + 4 * \frac{2^2}{2} + 20 * 5 - M_d = 0$

$\therefore M_d + 2R_c = 108$ — (4)

solve (1) & (4) $\Rightarrow$

Eq (1) − Eq (4) $\Rightarrow 5R_c = 298 - 108$

$R_c = 38$ kN — ↑

sub. R_c into (4)

$$M_d + 2 * 38 = 108 \Rightarrow M_d = +32 \text{ kN.m}$$

sub. M_d in (2)

$$\Rightarrow 7R_a - 32 = 38 \Rightarrow R_a = 10^{kN}$$

Max. shear = +20 kN

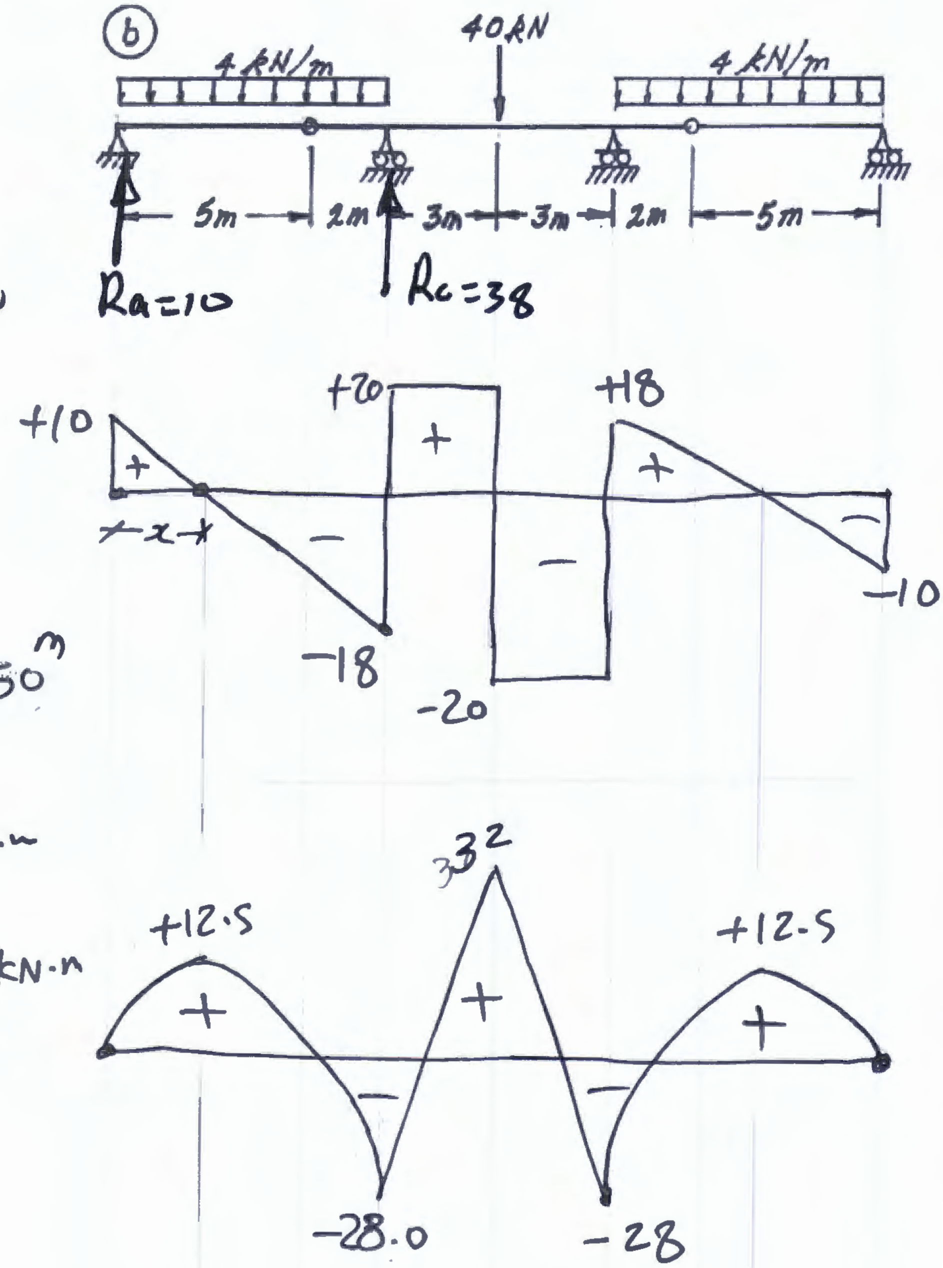
Min. shear = −18 kN

to find (x) for Max. Moment:

$$\frac{x}{10} = \frac{7}{28} \Rightarrow x = 2.50\,m$$

Max. Moment = +32 kN.m

Min. Moment = −28 kN.m



Q2c

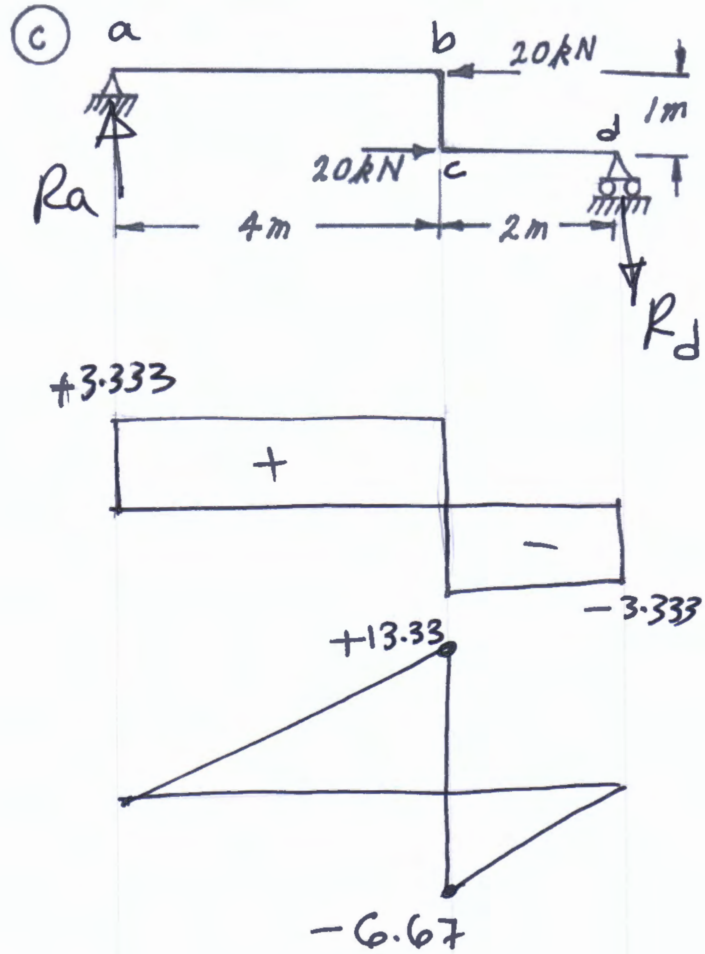
$\circlearrowleft + \sum M_d = 0$

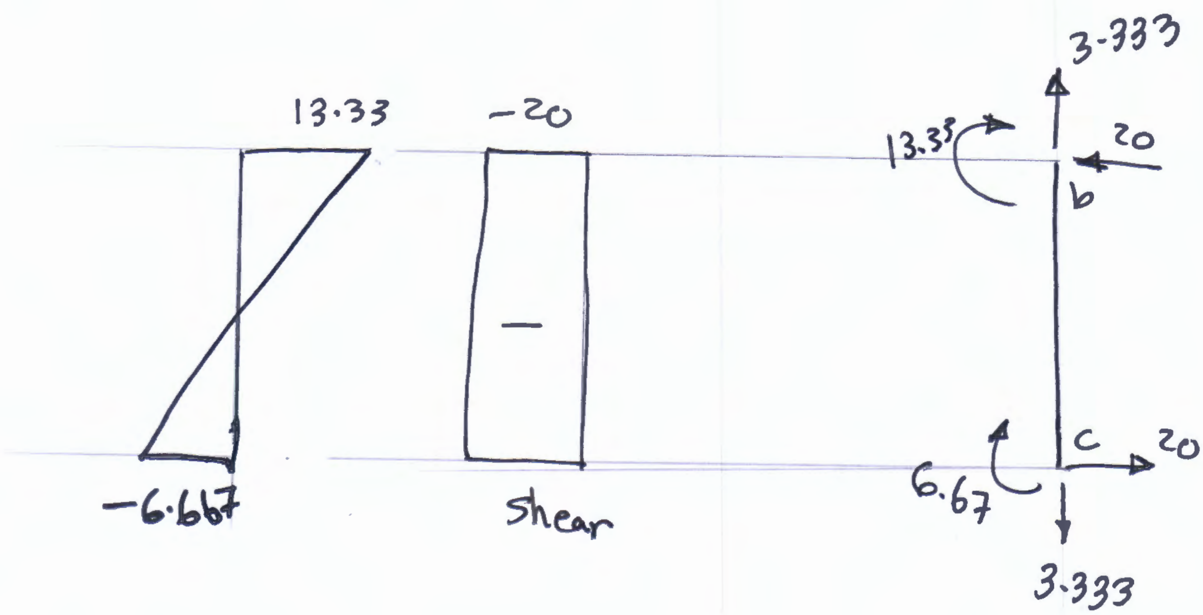
$R_a * 6 - 20 * 1 = 0$

$R_a = 3.333 \text{ kN} \uparrow$

$R_d = 3.333 \text{ kN} \downarrow$

(c)





So:

Max. shear = + 3.33 kN

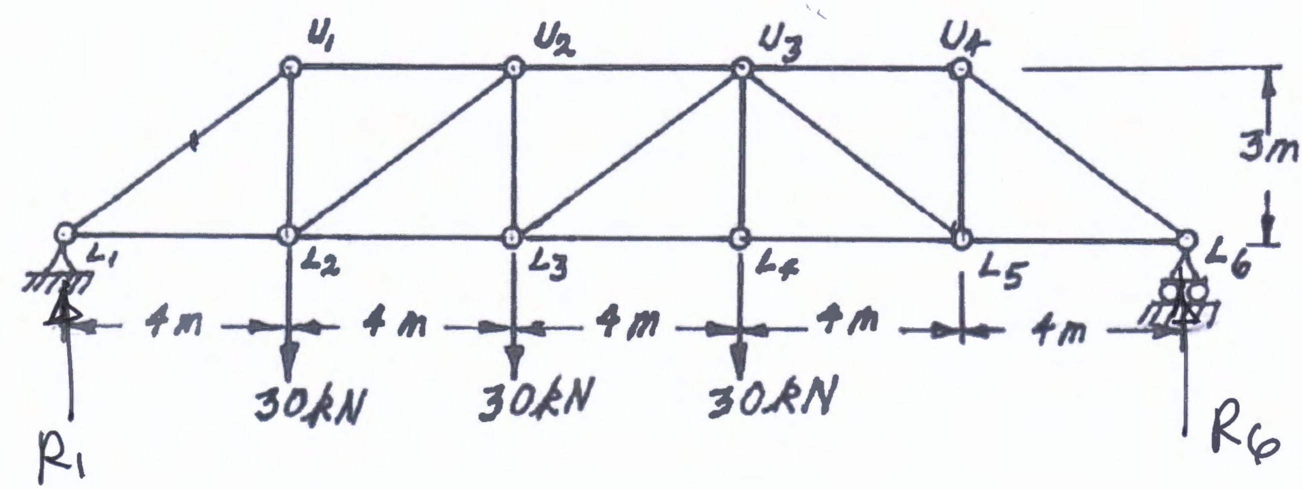
Min. shear = −20 kN

Max. Moment = 13.33

Min. shear = − 6.67 kN

Q3

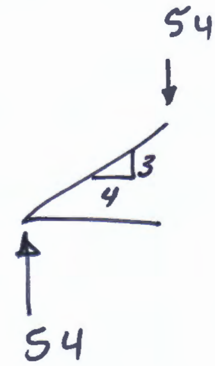
Q3



$$R_1 = \frac{30*8+30*12+30*16}{20} = 54^{kN}$$

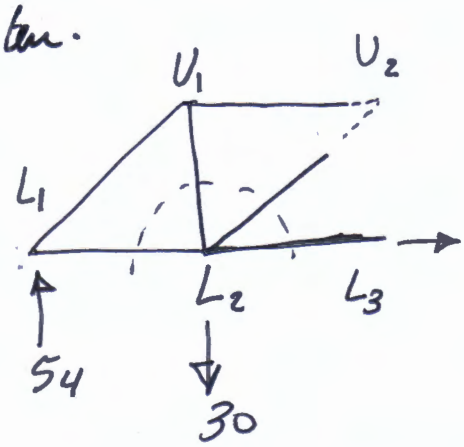
$$R_6 = \frac{30*4+30*8+30*12}{20} = 36$$

$$L_1U_1 = \frac{5}{3}*54 = 90^{kN} \text{ comp.}$$



$$(L_2L_3)(3) - 54*8 = 0$$

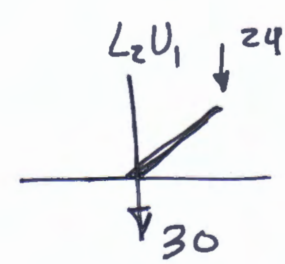
$$L_2L_3 = \frac{54*8-30*4}{3} = 104^{kN} \text{ ten.}$$

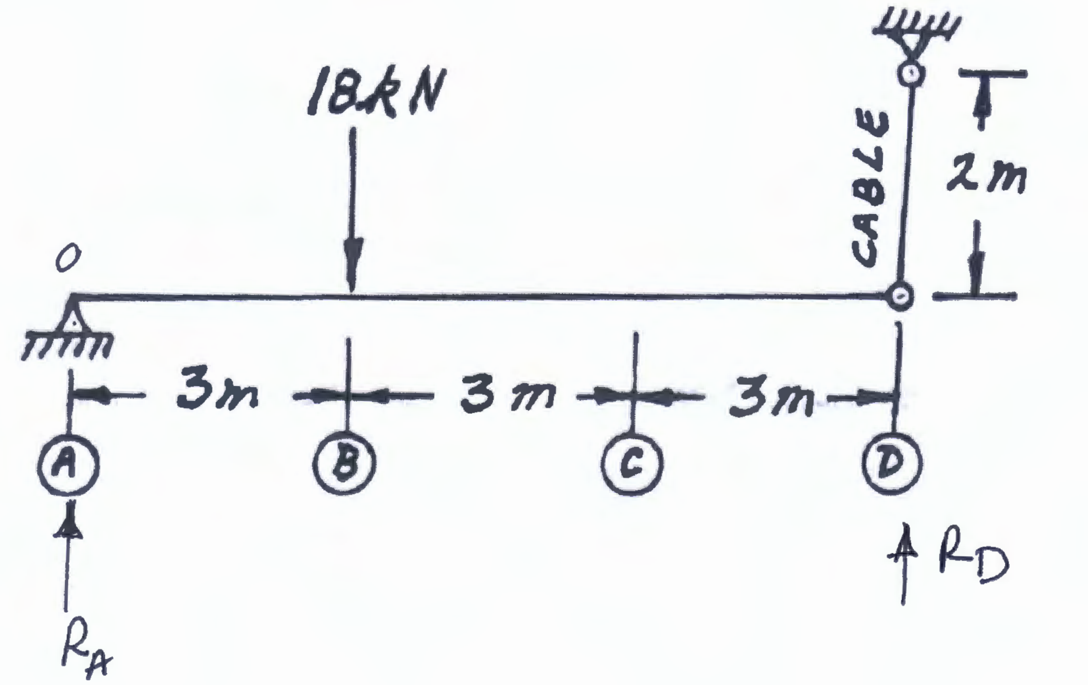


$$L_2U_2 = (54-30)\left(\frac{5}{3}\right)$$

$$L_2U_2 = 40 \text{ comp.}$$

$$L_2U_1 = 24+30 = 54 \text{ tension.}$$





Solution:

a) R_D = force in the Cable $= \dfrac{18*3}{9} = 6^{kN}$

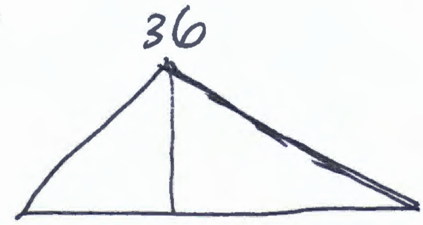
Elongation of cable $= \dfrac{6*2}{2000} = 0.006\ m$

The beam will deflect due to ~~to~~ beam elasticity and elongation of Cable.

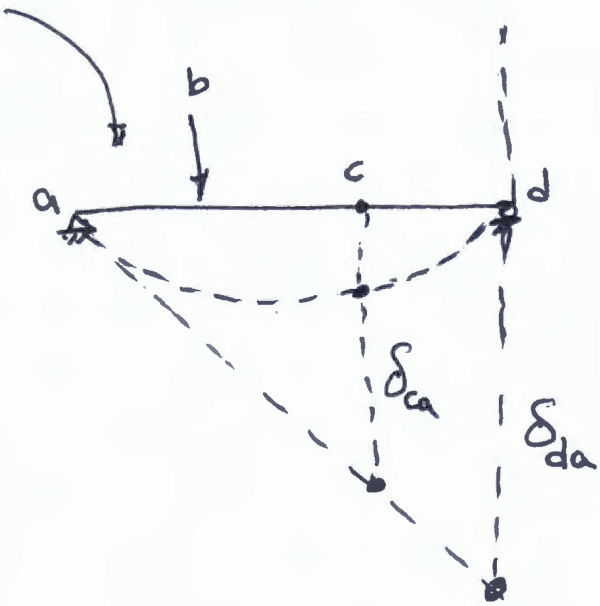
The deflection due to beam elasticity only will be computed by "Area-Moment" Method.

Q4

Bending Moment diagram:



Refer to elastic curve below



$$\delta_{da} = \frac{1}{2} * 36 * 6 * \frac{2}{3} * 6 + \frac{1}{2} * 36 * 3 * \left(6 + \frac{1}{3} * 3\right)$$

$$\delta_{da} = 810/EI$$

$$\delta_{ca} = \frac{1}{2} * 36 * 3 * \left(3 + \frac{1}{3} * 3\right) + \frac{1}{2} * 18 * 3 * \left(\frac{2}{3} * 3\right) + 18 * 3 * 1.5 = 351/EI$$

$$\Delta_c = \frac{810}{EI} * \frac{2}{3} - \frac{351}{EI} + \frac{2}{3} * 0.006$$

$$\Delta_c = \frac{189}{EI} + 0.004$$

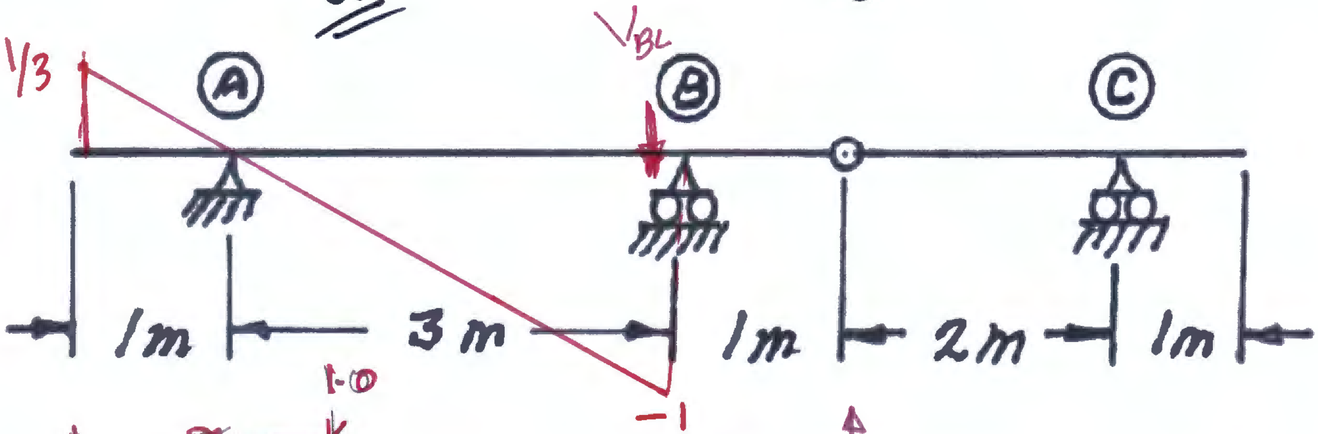
$$\Delta_c = \frac{189}{21000} + 0.004 = 0.013 = 13 \text{ mm}$$

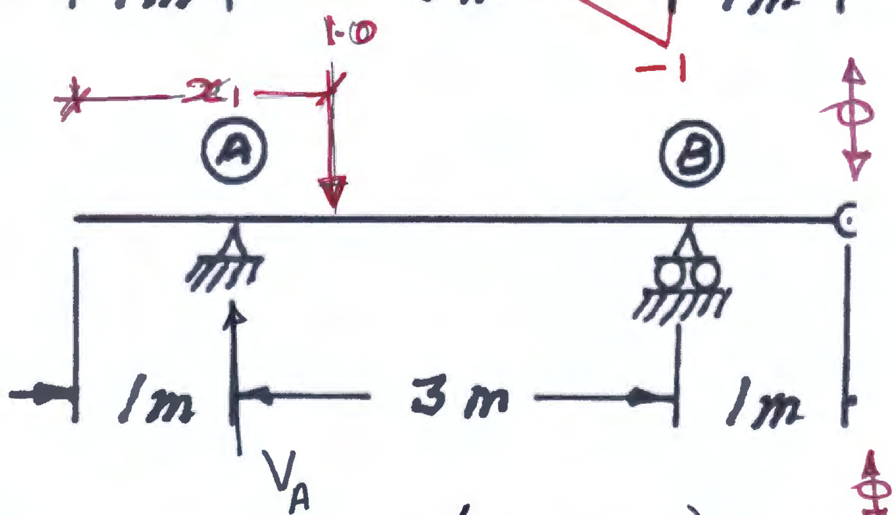
b) $\Delta_b = \Delta_c$

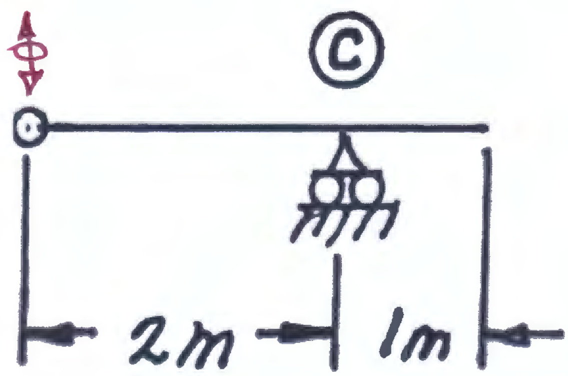
This is attributed to Maxwell's theorem of Reciprocal displacements (Betti's Law)

Q5a

a







(Region 1)

$0 \leq x_1 \leq 4$

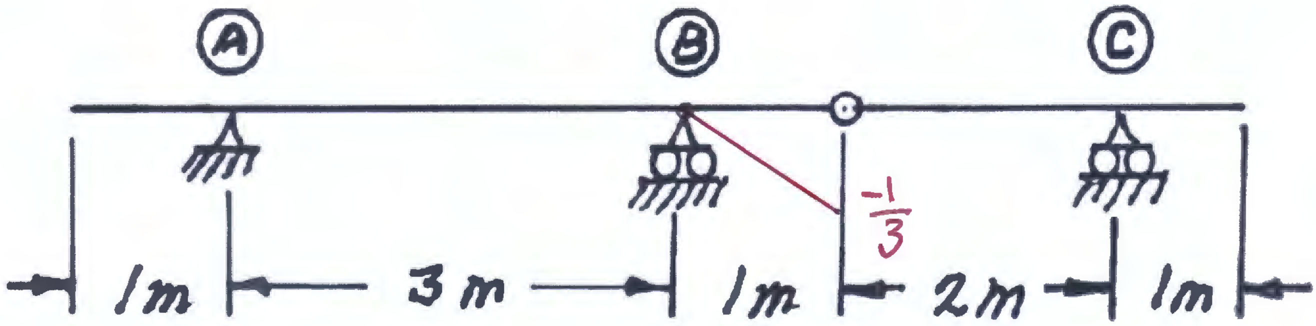
$$V_A = \frac{4 - x_1}{3}$$

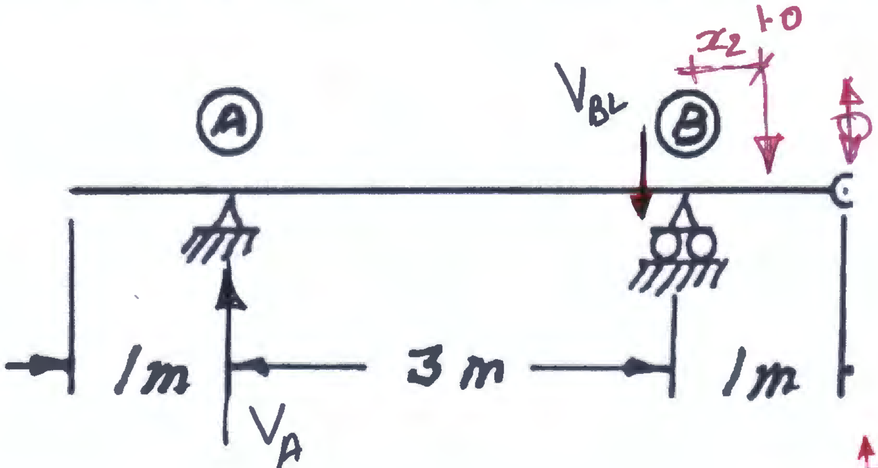
$$V_A = \frac{4}{3} - \frac{x_1}{3}$$

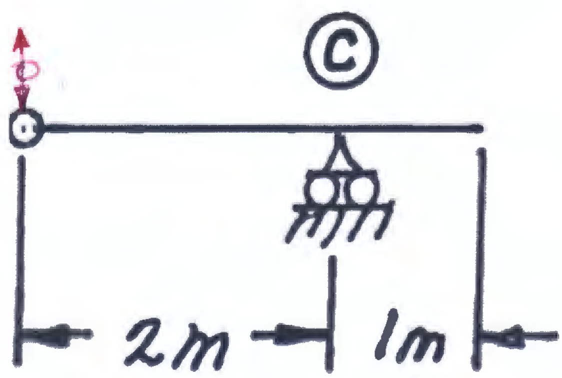
$$\uparrow \sum F_y = 0 \quad V_{BL} + 1 = \frac{4}{3} - \frac{x_1}{3}$$

$$\therefore V_{BL} = \frac{1}{3} - \frac{x_1}{3}$$

Q5a







Region ②

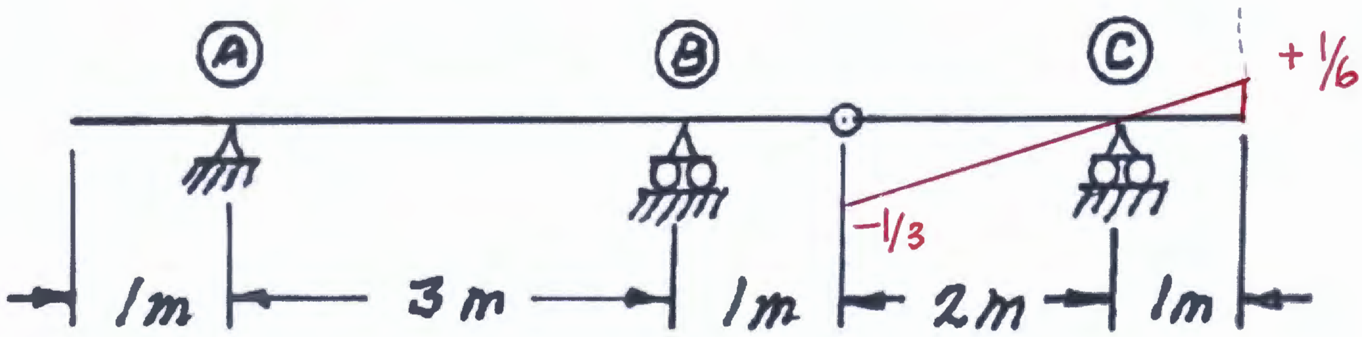
$0 \leqslant X_2 \leqslant 1$

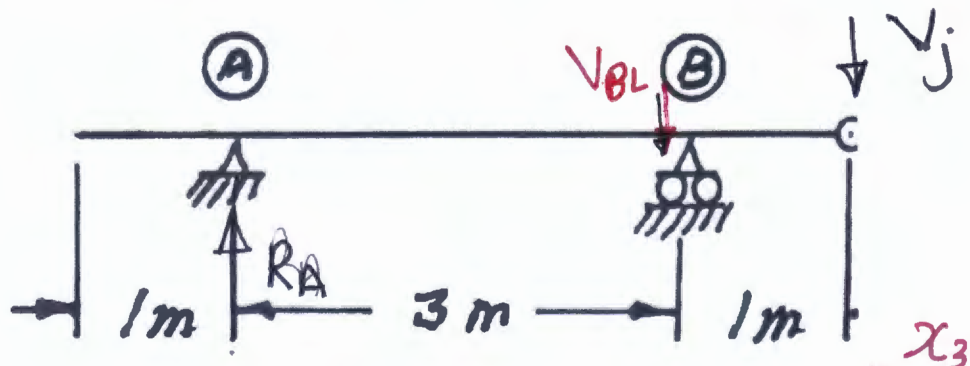
$V_A * 3 + 1 * x_2 = 0$

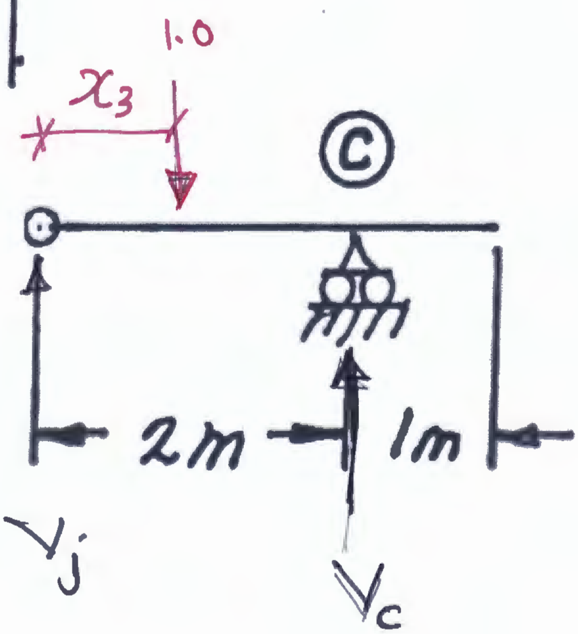
$V_A = \dfrac{-X_2}{3}$

$V_{BL} = V_A \Rightarrow V_{BL} = \dfrac{-X_2}{3}$

Q5a







$0 \leq x \leq 3\,m$ Region 3

$$V_c * 2 = x_3$$

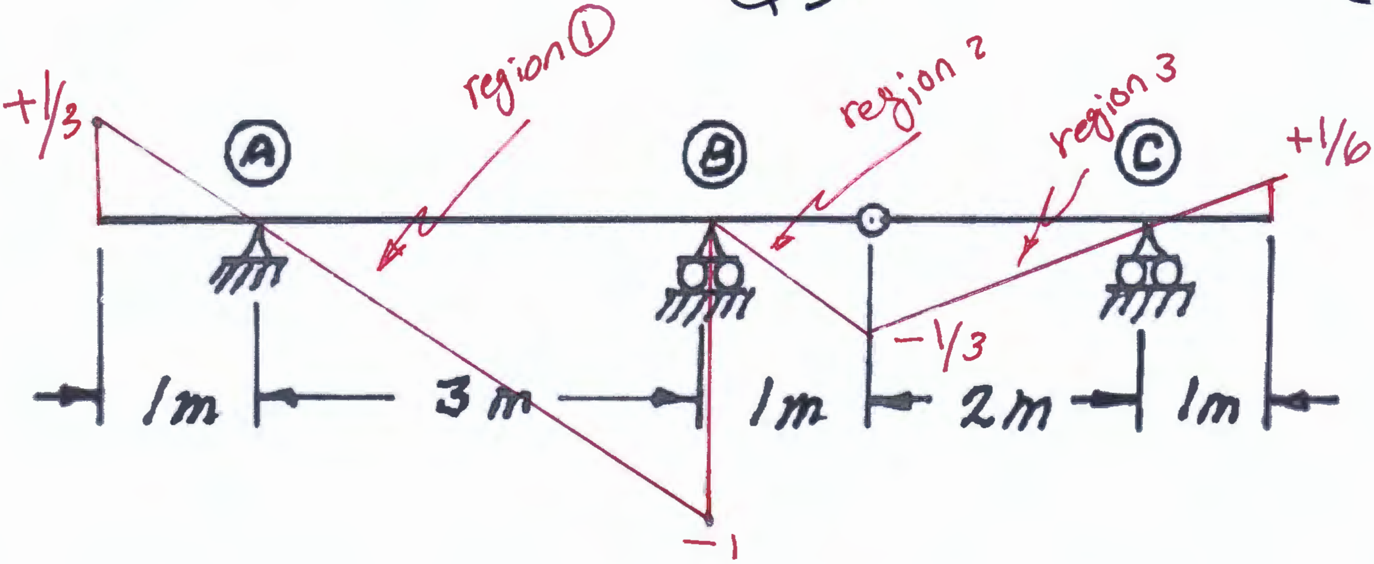
$$V_c = \frac{x_3}{2}$$

$$V_j = 1 - V_c$$

$$V_j = 1 - \frac{x_3}{2}$$

$$R_A * 3 + V_j * 1 = 0$$

$$\therefore V_{BL} = R_A = \frac{-V_j}{3} = \frac{-1}{3} + \frac{x_3}{6}$$



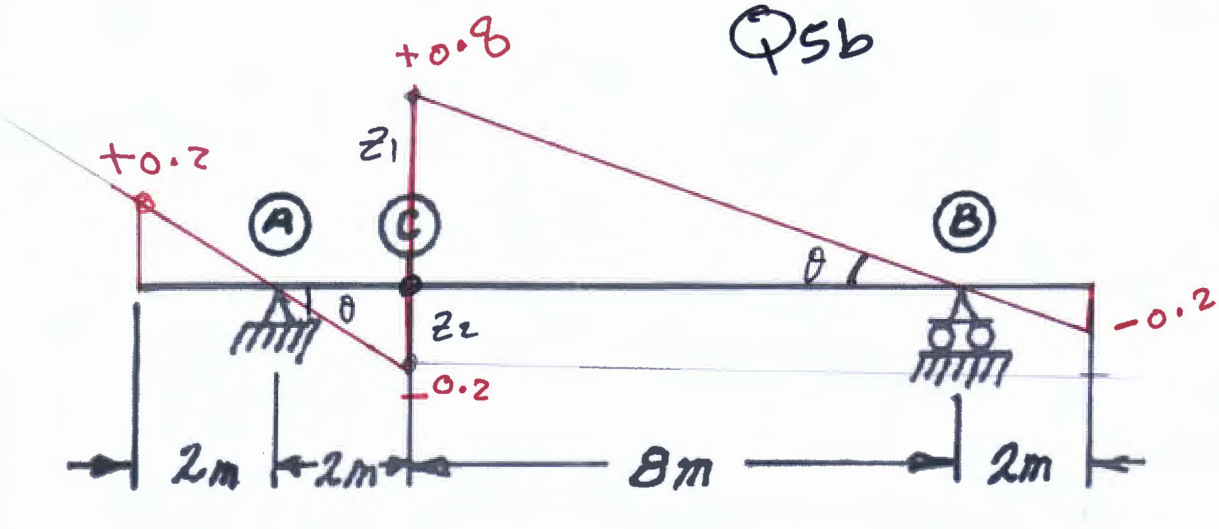
Complete Influence Line for the whole Structure

Maximum + Value = +1/3

Maximum − Value = − 1

Maximum absolute Value = 1

Q5b



<u>Shear @C</u> Use Muller Breslau principle

We split @ C: $z_1 + z_2 = 1$ $\left\{ \begin{array}{l} z_1 = 8\theta \\ z_2 = 2\theta \end{array} \right.$

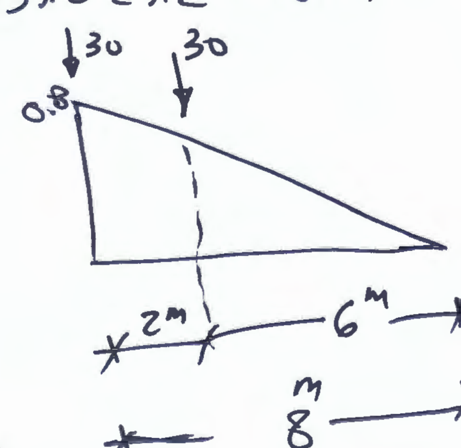
$\therefore \quad 8\theta + 2\theta = 1 \quad \therefore \theta = 1/10$

$\therefore \quad z_1 = 8\theta = 0.8 \quad , \quad z_2 = 2\theta = 0.2$

Max. Absolute shear:

Uniform Distributed Load:

$6 * 0.5 * 0.8 * 8 + 6 * 0.5 * 0.2 * 2 = 20.4^{kN}$



Concentrated loads

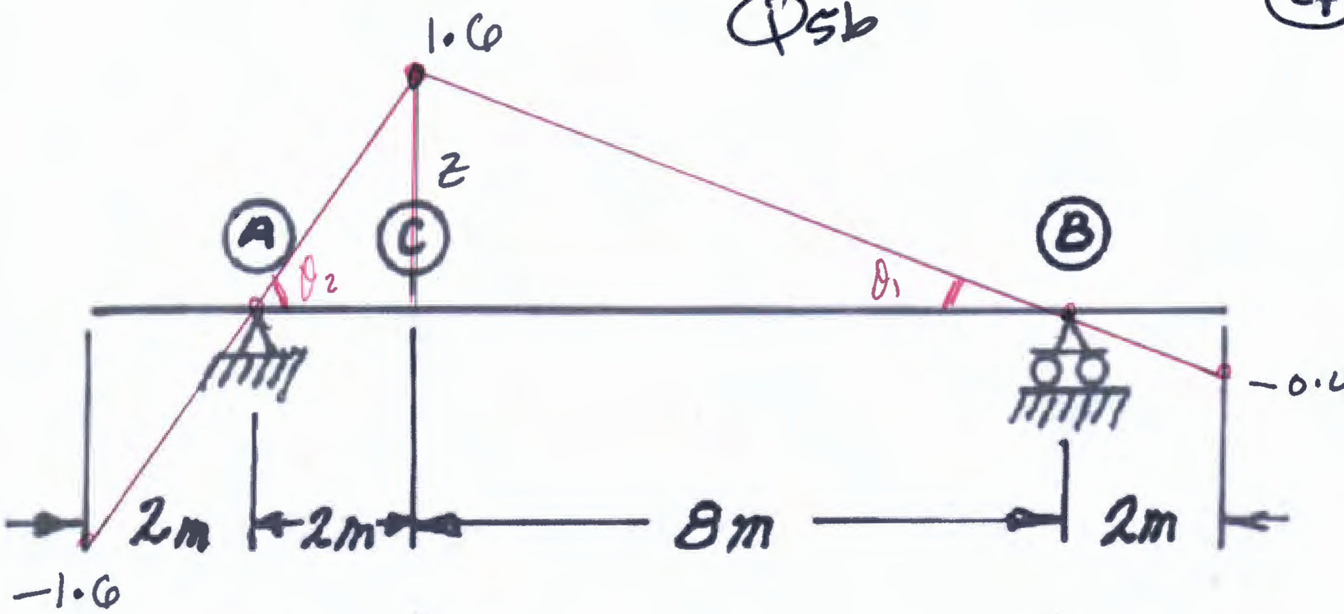
$= 30 * 0.8 + 30 * \frac{6}{8} * 0.8$

$= 42$

Max. Absolute shear $= 20.4 + 42$

$= 62.4^{kN}$

Q5b



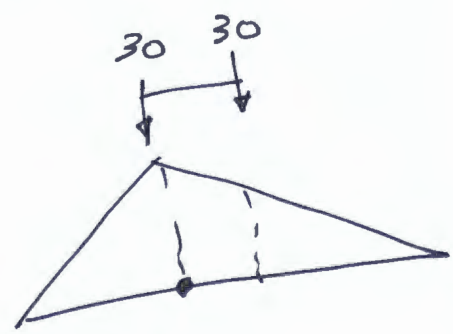
Muller Breslau; Compute ordinate z:

$$\theta_1 + \theta_2 = 1 \rightarrow \frac{z}{8} + \frac{z}{2} = 1$$

$$\therefore z + 4z = 8 \rightarrow 5z = 8 \rightarrow z = \frac{8}{5} = 1.6$$

Max. Absolute Moment @ C:

<u>UDL:</u> $6 * 0.5 * 1.6 * 10 = 48$ kN.m



Concentrated loads:

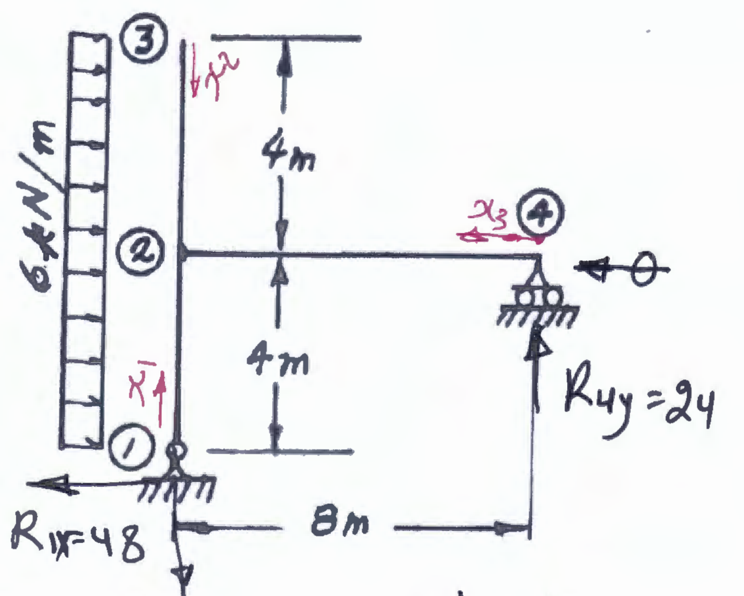
$$= 30 * 1.6 + 30 * \frac{6}{8} * 1.6$$

$$= 84 \text{ kN}$$

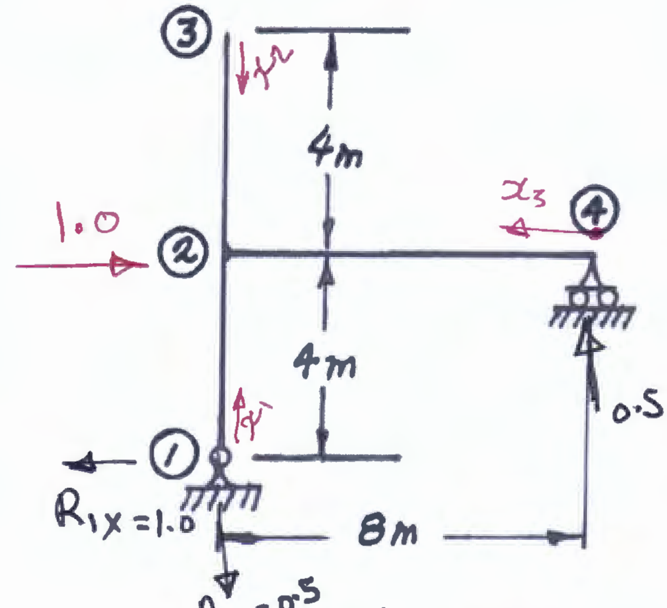
$\therefore$ Max. Absolute Moment @ C:

$$= 48 + 84 = 132 \text{ kN.m}$$

P8



$R_{1y} = 24$ original loading



$R_{1y}=0.5$ Unit-load

$$\sum F_x = 0 \Rightarrow R_{1x} = 6*8 = 48^{kN}$$

$$\sum M_4 = 0 \Rightarrow R_{1x}*4 - R_{1y}*8 = 0$$

$$\therefore R_{1y} = \frac{48*4}{8} = 24 \text{ kN}$$

$$\sum F_x = 0 \Rightarrow R_{1x} = 1.0$$

$$R_{1y}*8 - R_{1x}*4 = 0$$

$$\therefore R_{1y} = 0.5^{kN}$$

$$R_{4y} = 0.5^{kN}$$

Deflection @ 2 : Δ_2

$$\Delta_2 = \int_{\substack{\text{member}\\1-2}} + \int_{\substack{\text{member}\\2-3}} + \int_{4-2}$$

$$\int_{1-2} = \int_0^4 \frac{(48x_1 - 3x_1^2)(x_1)}{EI} dx_1 = \int_0^4 \frac{48x_1^2 - 3x_1^3}{EI} dx_1$$

$$\int_{1-2} = \frac{1}{EI}\left[16x_1^3 - \frac{3}{4}x_1^4\right]_0^4 = 832/EI$$

$$\int_{2-3} = 0$$

Q8

$$\int_{4-2} = \int \frac{(24x_3)(0.5X_3)}{EI} dx_3 =$$

$$= \int \frac{12X_3^2\, dx_3}{EI} = 4X^3\Big]_0^8 = \frac{2048}{EI}$$

$$\therefore \Delta_2 = \frac{832}{EI} + 0 + \frac{2048}{EI} = \frac{2880}{EI}$$

$$\Delta_2 = \frac{2880}{1.8*10^5} = \underline{\underline{0.016\ m}}$$