Final Term Examination (1)

Coarse title: Engineering Mechanics
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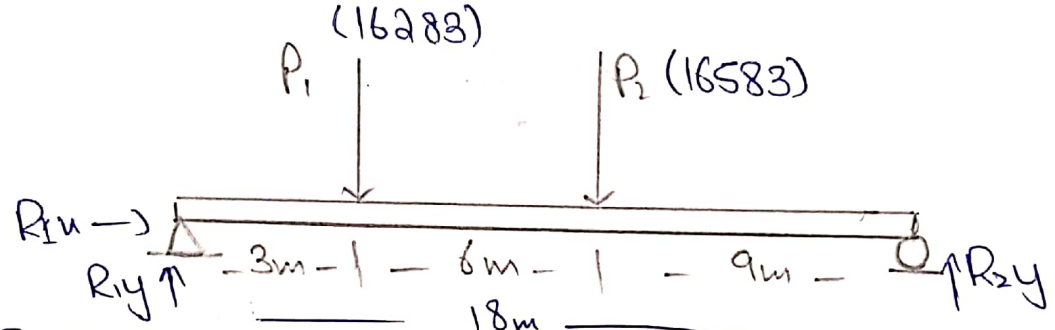
Section: A

Q1. Find the support reactions. Show all the calculations.



Sol. Finding all the support reactions.

$R_{1x} = 0$ $\quad \Sigma F_x = 0$

$R_{1y} + R_{2y} - 16283 - 16583 = 0$ — (1) $\quad \Sigma F_y = 0$

$(R_{2y} \times 18) - (16283 \times 3) - (16583 \times 6) = 0$

$18R_{2y} - 48849 - 99498 = 0$

$18R_{2y} - 148347 = 0$

$\frac{18R_{2y}}{18} = \frac{148347}{18}$

$\boxed{R_{2y} = 8241.5N}$ put in (1)

$R_{1y} + 8241.5 - 16283 - 16583 = 0$

$R_{1y} - 24624.5 = 0$

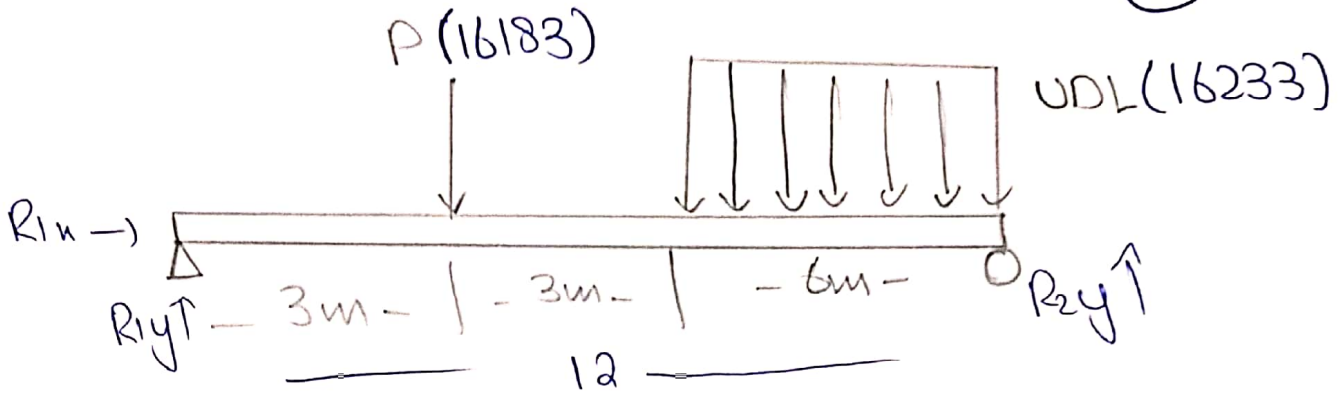
$\boxed{R_{1y} = 24624.5N}$

Support Reactions

$R_{1y} = 24624.5N$

$R_{2y} = 8241.5N$

Q2. Draw the neat shear force diagram. Show all calculations. (2)



Sol. UDL Resultant P = (16233 x 6) = 97398 (acts at centre of UDL)

$R_{1x} = 0$ $\quad \Sigma F_x = 0$

$R_{1y} + R_{2y} - 16183 - 97398 = 0$ — (1) $\quad \Sigma F_y = 0$

$(R_{2y} \times 12) - (16183 \times 3) - (97398 \times 9) = 0$

$12R_{2y} - 48549 - 876582 = 0$

$12R_{2y} - 925131 = 0$

$\frac{12R_{2y}}{12} = \frac{925131}{12}$

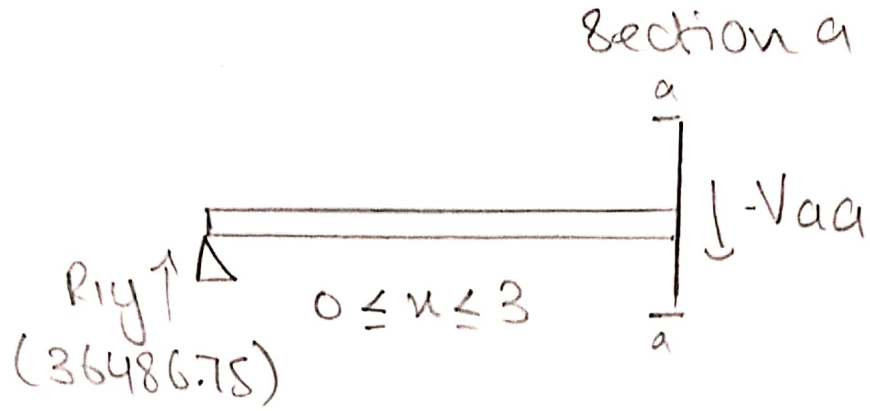
$\boxed{R_{2y} = 77094.25 \text{ kN}}$ put in (1)

$R_{1y} + 77094.25 - 16183 - 97398 = 0$

$R_{1y} - 36486.75 = 0$

$\boxed{R_{1y} = 36486.75 \text{ kN}}$

Now finding shear values.

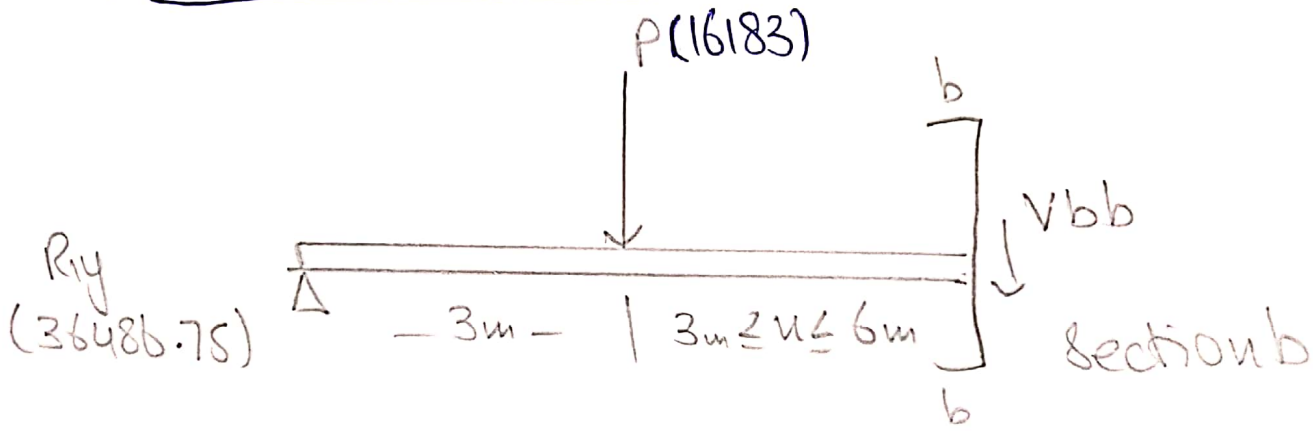


$-Vaa + 36486.75 = 0$

$Vaa = 36486.75$ — ①

at $x=0$, $\boxed{Vaa = 36486.75}$ kN

at $x=3$, $\boxed{Vaa = 36486.75}$ kN



$-Vbb - 16183 + 36486.75 = 0$

$-Vbb + 20303.75 = 0$

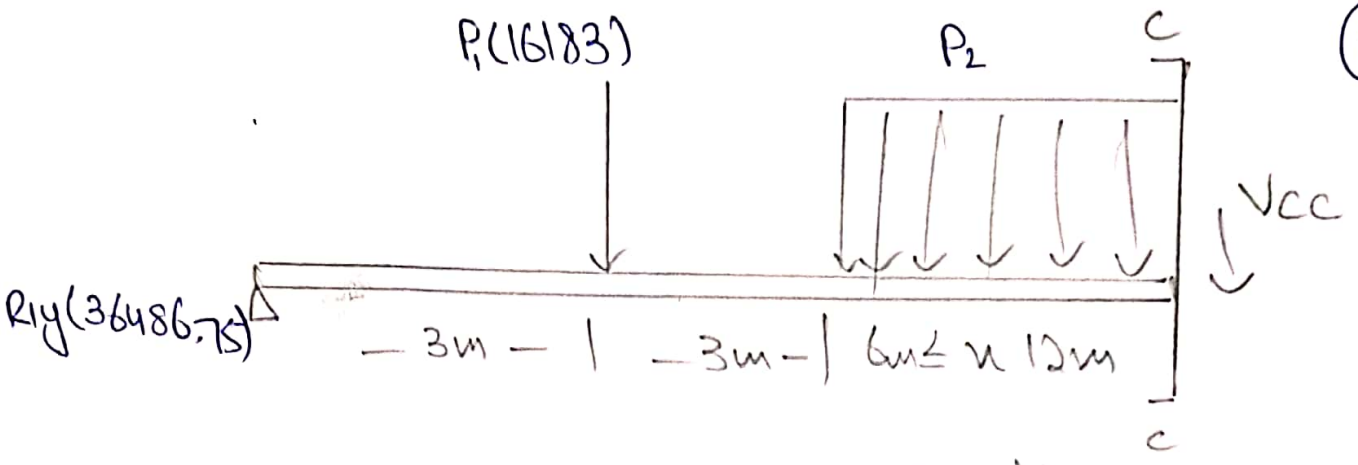
$Vbb = 20303.75$ — ②

at $x=3$, $\boxed{Vbb = 20303.75}$ kN

at $x=6$, $\boxed{Vbb = 20303.75}$ kN

Now Section c

next page →



section c

UDL

Resultant

$P_2 = 16233(x-6)$

$-Vcc - 16233x + 97398 - 16183 = 0$

$-Vcc - 16233x + 81215 = 0$

$Vcc = 81215 - 16233x$ — ③

at $x = 6$, $Vcc = 81215 - 16233(6)$

$\boxed{Vcc = -16183}$ kN

at $x = 12$, $Vcc = 81215 - 16233(12)$

$\boxed{Vcc = -113581}$ kN

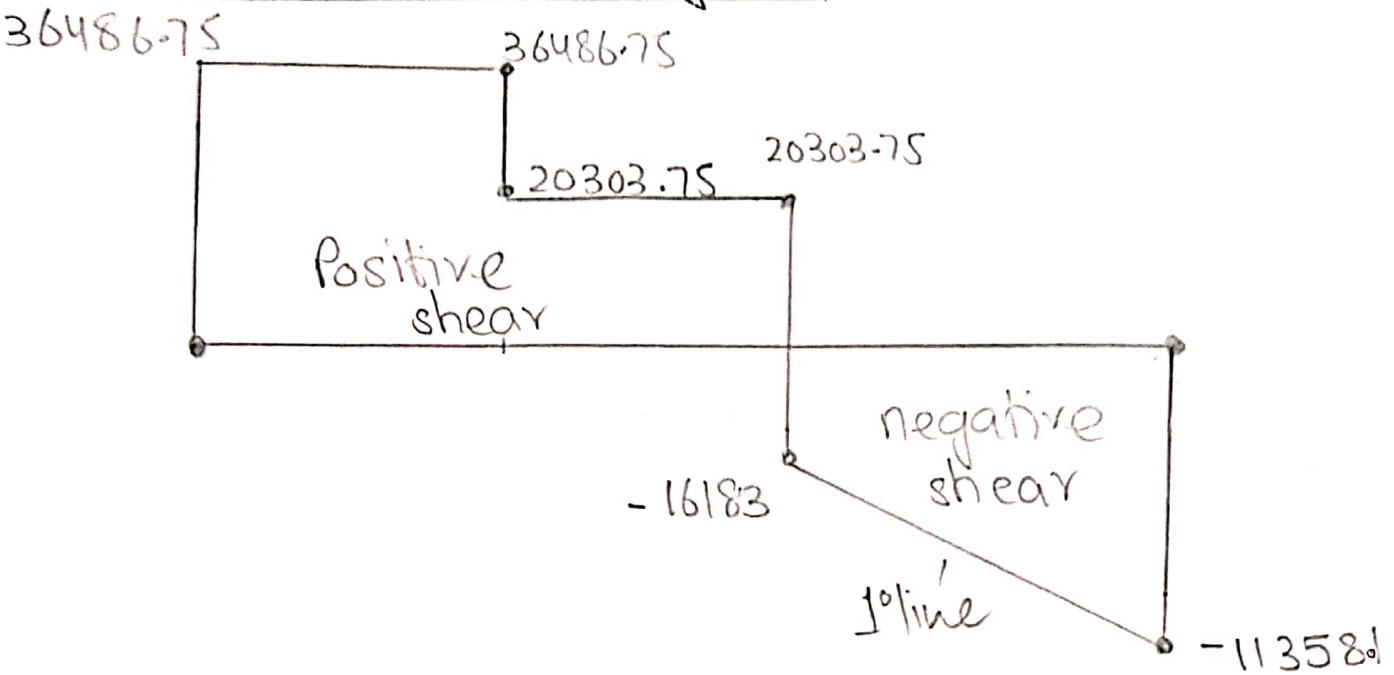
Now to find shear point Vcc = 0 eq ③ = 0

$81215 - 16233x = 0$

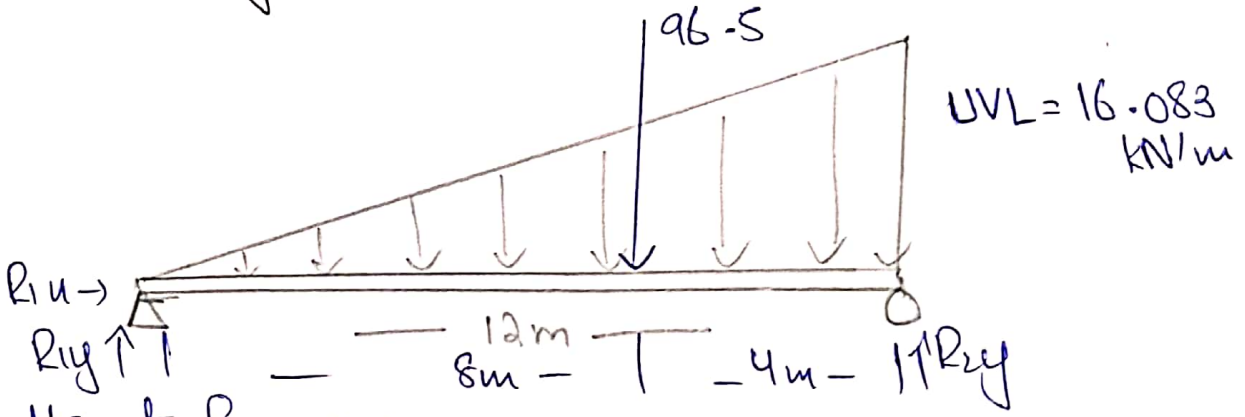
$\frac{16233x}{16233} = \frac{81215}{16233}$

$\boxed{x = 5.003}$ at this value $Vcc = 0$

Shear Force diagram



Q3- Draw neat shear force diagram and bending moment diagram. Show all calculations.



Sol. Resultant for UVL

$$P_2 \left(\frac{16.083 \times 12}{2}\right) = 96.5 \text{ kN/m}.$$

distance from low side $\left(\frac{2}{3} \times 12\right) = 8\text{m}$

distance from high side $\left(\frac{1}{3} \times 12\right) = 4\text{m}$

$R_{1x} = 0$

$R_{1y} + R_{2y} - 96.5 = 0 \quad -(1)$

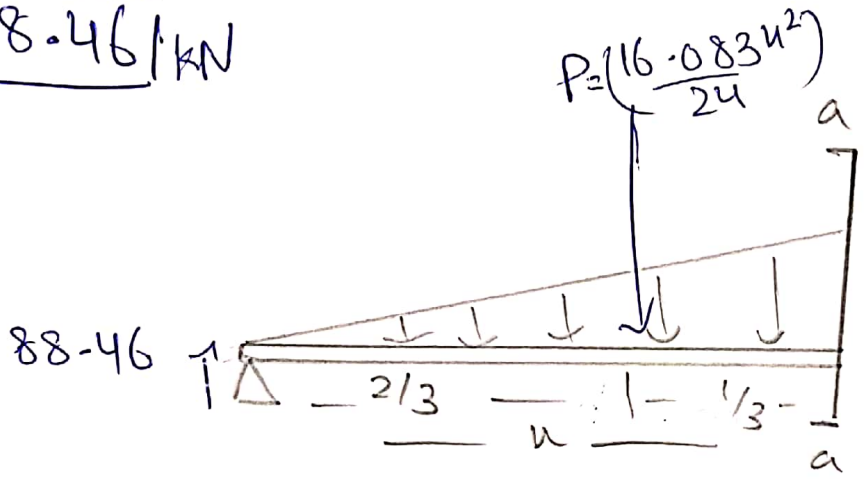
$(R_{2y} \times 12) - 96.5 = 0$

$\frac{12 R_{2y}}{12} = \frac{96.5}{12}$

$R_{2y} = 8.04$ kN put in ①

$R_{1y} + 8.04 - 96.5 = 0$

$R_{1y} = 88.46$ kN



From Law of similar triangles

$\frac{16.083}{12} = \frac{W_o \text{ kN/m}}{x}$

$W_o = \left[\frac{16.083}{12} x\right]$ kN/m

Resultant $P_2 [W_o \times x]/2$

$P_2 \frac{16.083 x^2}{24}$

Now

$-Vaa - \left(\frac{16.083 x^2}{24}\right) + 88.46 = 0$

$Vaa = 88.46 - \left(\frac{16.083 x^2}{24}\right)$ - ①

at $x=0$, $\boxed{V_{aa} = 88.46}$ kN

at $x=12$, $V_{aa} = 88.46 - \left(\frac{16.083 \times (12)^2}{24}\right)$

$V_{aa} = 88.46 - \left(\frac{16.083 \times 144}{24}\right)$

$\boxed{V_{aa} = -8.04}$ kN

To find at which point shear = 0

eq ① = 0

$0 = 88.46 - \left(\frac{16.083 x^2}{24}\right)$

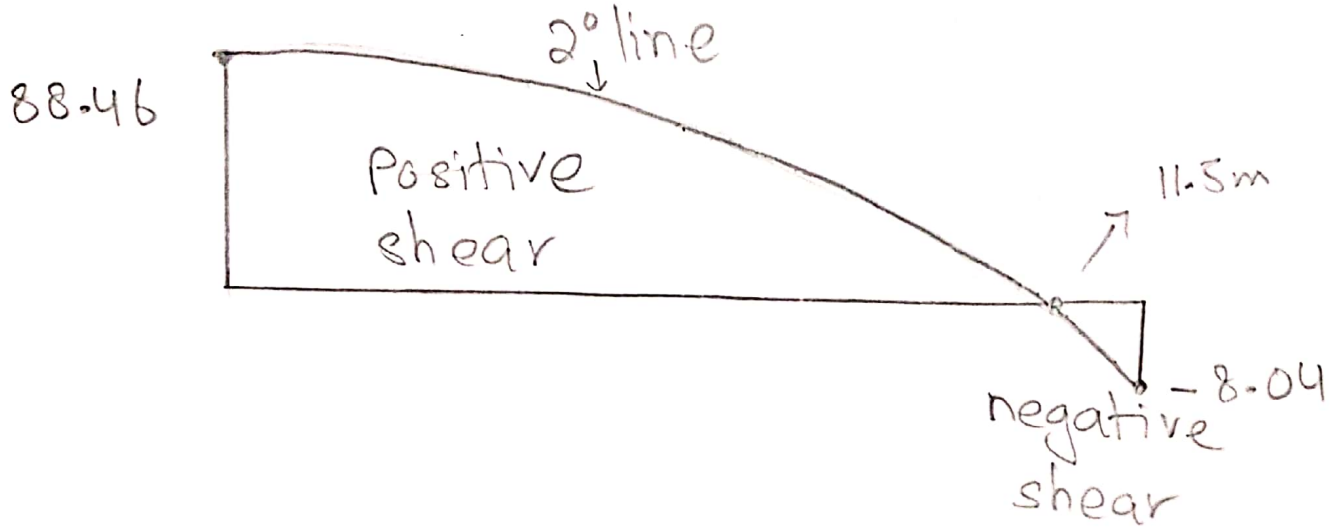
$\frac{16.083 x^2}{24} = 88.46$

$x^2 = \frac{2123.04}{16.083}$

$\sqrt{x^2} = \sqrt{132.005}$

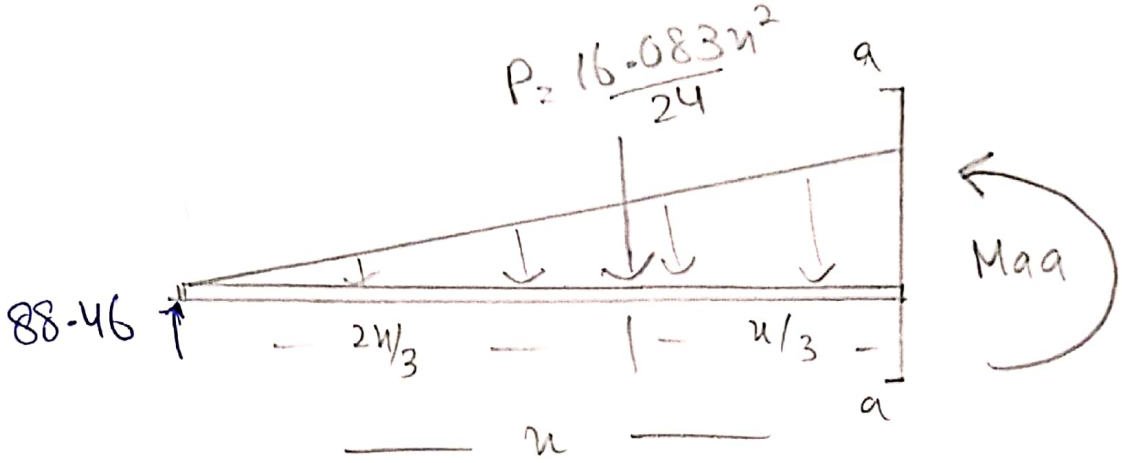
$\boxed{x = 11.5}$ at this point $V_{aa} = 0$

shear force diagram



Now for bending moments.

$R_{1x}=0$ $R_{1y}=88.46$ $R_{2y}=8.04$



$$Maa + P(x/3) - 88.46x = 0$$

$$Maa = -\left(\frac{x}{3}\right)P + 88.46x$$

$$Maa = -\left(\frac{x}{3}\right)\left(\frac{16.083x^2}{24}\right) + 88.46x$$

$$Maa = -\frac{16.083x^3}{72} + 88.46x \quad \text{— (1)}$$

at $x=0$, $\boxed{Maa = 0 \text{ kN/m}}$

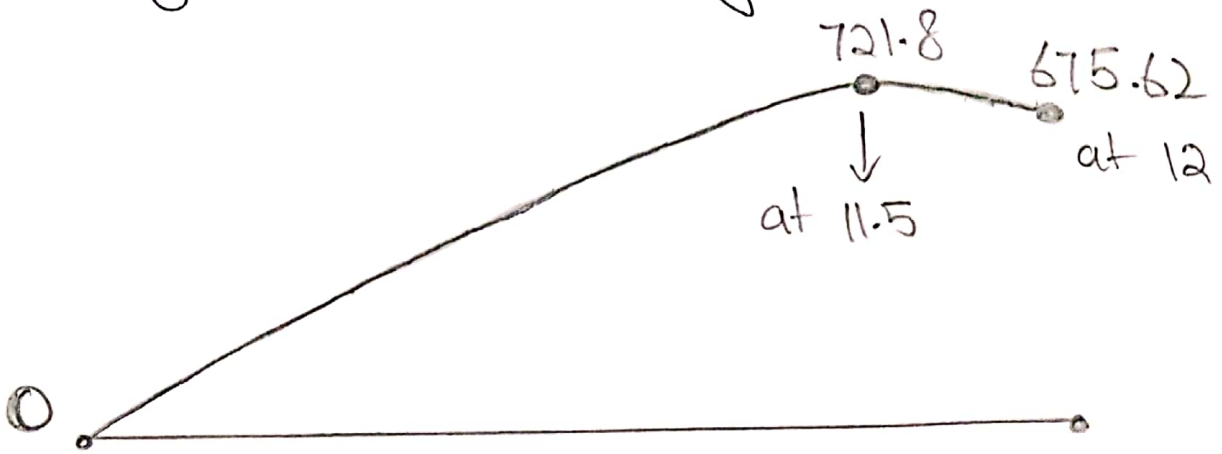
at $x=12$, $Maa = \frac{-16.083(12)^3}{72} + 88.46(12)$

$$Maa = -385.9 + 1061.52$$

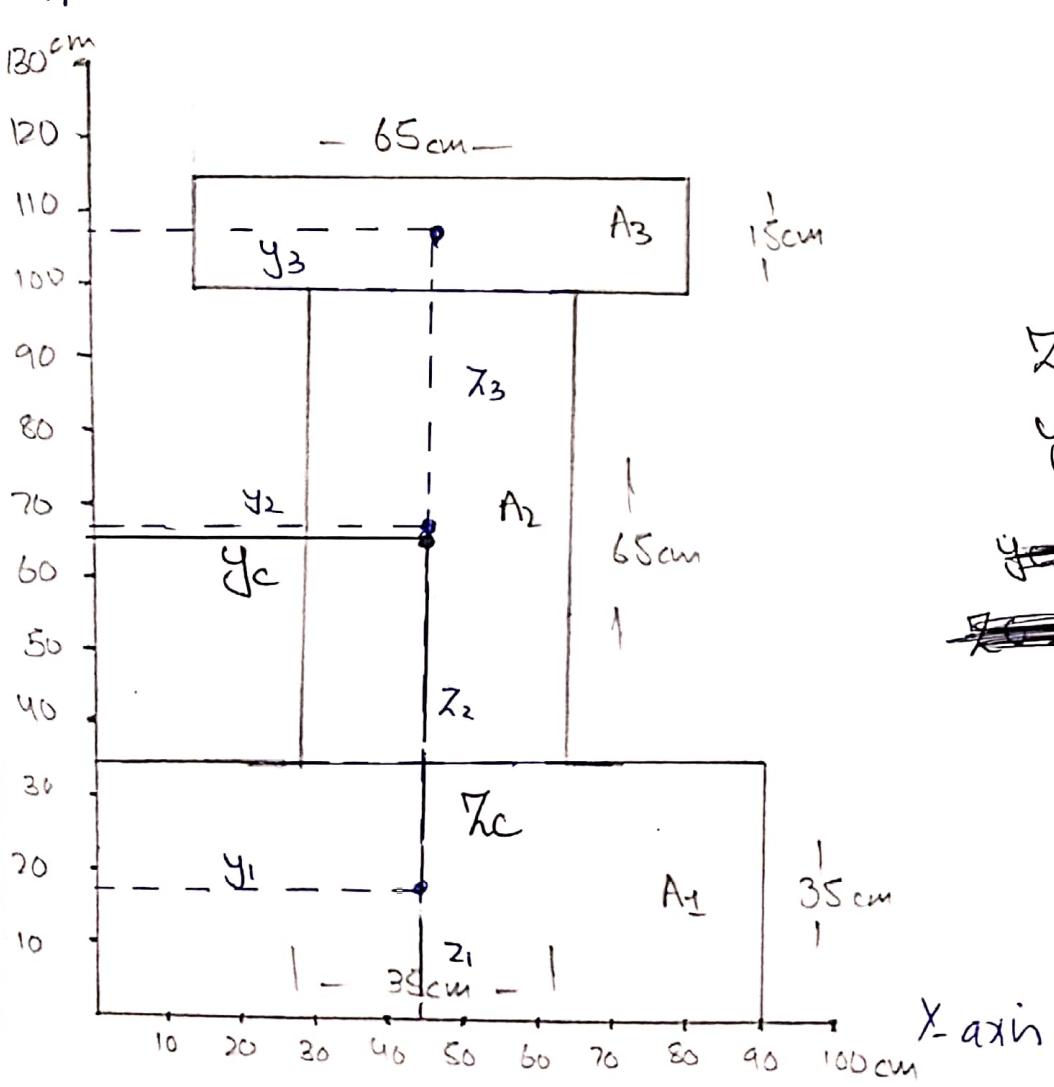
$$\boxed{Maa = 675.62 \text{ kN/m}}$$

At $x = 11.5$, $\boxed{Maa = 721.8}$

Bending moment diagram



Q4 (a) Find the centroid of the given shape, show calculations.



$z_c = 65$ cm

$y_c = 45$ cm

Areas (converted to meters)

$A_1 = (0.9 \times 0.35) = 0.315\ m^2$

$A_2 = (0.35 \times 0.65) = 0.2275\ m^2$

$A_3 = (0.15 \times 0.65) = 0.0975\ m^2$

Now centre points from origin.

$y_1 = 0.9/2 = 0.45\ m$

$y_2 = 0.9/2 = 0.45\ m$

$y_3 = 0.9/2 = 0.45\ m$

$Z_1 = (0.35/2) = 0.175\ m$

$Z_2 = 0.35 + (0.65/2) = 0.675\ m$

$Z_3 = 0.35 + 0.65 + (0.15/2) = 1.075\ m$

Now centroid

$$y_c = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3} = \frac{(0.315 \times 0.45) + (0.2275 \times 0.45) + (.0975 \times 0.45)}{0.315 + 0.2275 + 0.0975}$$

$$y_c = \frac{0.14175 + 0.102375 + 0.043875}{0.64}$$

$$y_c = 0.288/0.64$$

$$y_c = 0.45\ m \quad 45cm$$

Now

$$Z_c = \frac{A_1Z_1 + A_2Z_2 + A_3Z_3}{A_1 + A_2 + A_3} = \frac{(0.315 \times 0.175) + (0.2275 \times 0.675) + (.0975 \times 1.075)}{0.64}$$

$$Z_c = \frac{0.055125 + 0.1535625 + 0.1048125}{0.64}$$

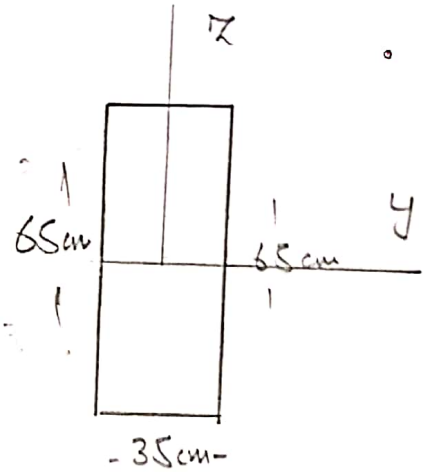
$$\bar{Z}c = \frac{0.4183125}{0.64}$$

$$\boxed{\bar{Z}c = 0.65m} \quad 65cm$$

(b) For mid area (65cm x 35cm) only find the moment of inertia, radius of gyration & section moduli.

Sol. for inertia

we know that



$$I_y = \frac{b \cdot h^3}{12}$$

$$= \frac{35 \times (65)^3}{12}$$

$$I_y = 800989.6 cm^4 \rightarrow \boxed{8009.9 m^4}$$

Now

$$I_z = \frac{b^3 \cdot h}{12}$$

$$= \frac{(35)^3 \times (65)}{12}$$

$$I_z = 232239.6_{cm^4} \rightarrow \boxed{2322.4 m^4}$$

Now Radius of gyration;

we know that

$$r_y = \sqrt{\frac{I_y}{A}}$$

Area = 65 × 35 = 2275 m

$$= \sqrt{\frac{8009.6}{0.2275}}$$

$$= \sqrt{\frac{8009.9}{2275}}$$

$$= \sqrt{352.08}$$

$$\boxed{r_y = 18.76}$$

$$r_z = \sqrt{\frac{I_z}{A}}$$

$$= \sqrt{\frac{2322.4}{22.75}}$$

$$= \sqrt{102.08}$$

$$\boxed{r_z = 10.10}$$

Now Section moduli

For rectangle

$c = \frac{1}{2}h = .65/2 = 0.325 \quad I = 8009.9$

Now

$S = Ze = \frac{I}{c} = \frac{8009.9}{0.325} = 24645.8$

$= \frac{1}{6}bh^2 = \frac{.35 \times (.65)^2}{6} = \boxed{0.0246}$

$Zp = \frac{1}{4}bh^2 = \frac{.35 \times (.65)^2}{4} = \boxed{0.0369}$

Now

$f = \frac{Zp}{Ze} = \frac{0.0369}{0.0246} = \boxed{1.5}$

Q5. Explain work, energy and power in details along with practical examples from daily life.

Ans. **WORK:**

The application of a force through some distance is called as work.

OR

It is defined as the product of force and displacement. It is measured in Joules "J".

Mathematically it is written as;

Work = Force x displacement (or distance travelled)

$$W = F \cdot d$$

W is work done (J)
F = Force applied (N)
d = distance (m)

if the force is at some angle then the work is calculated as

$$W = F d \cos\theta \text{ or } = F \cdot s \cos\theta$$

ENERGY: It is the ability of an object to do work. It has many types; Kinetic energy, Gravitational potential energy, nuclear energy, heat energy etc.

Energy can neither be created or destroyed, it can only be changed from one form to another.

e.g a ball falling has kinetic energy, this kinetic energy is gained from

the gravitational potential energy. It is measured in (Joules).

POWER:

It is defined as the rate at which work is done.

OR

work by time

mathematically

Power = work done / time taken

$P = W/t$

it is measured in watts (W)

PRACTICAL EXAMPLES:

- When water falls from sky, its potential energy is converted into kinetic energy, this energy rotates the turbines which results in electrical energy
- Potential energy of oil in car is converted into heat & sound energy.
- The radiation (solar energy) from sun is converted into electrical energy.