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Sec : B

Subject : Engineering Mechanics

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QUESTION NO. 5

Work:

Work is force applied over distance. It is the measure of energy transfer that occurs when an object is moved over a distance by an external force at least part of which is applied in the direction of the displacement. Work is a mechanical manifestation of energy.

Unit:

The standard unit of work is joul (J), which is equal to newton-meter (N.m).

Examples:

→ Driving a car up a hill.
→ Walking up stairs.
→ Lifting heavy objects.
→ Pushing a shopping trolley.

Formula: $W = F \times d$

ENERGY :-

Energy is the capacity or ability to do work. It is, how things change and move. It is everywhere around us and takes all sorts of forms.

Unit :-

Joul (J) is the unit of Energy. It is equal to the force of 1 newton acting through one meter.

Examples :-

→ Light energy
→ Sound energy
→ Sunlight energy
→ Batteries
→ We use sound energy to learn about our surroundings.

Types :-

Heat energy, Mechanical energy, Gravitational energy, Chemical energy, Nuclear energy atomic energy, etc...

Equations :-

$$K.E = \frac{1}{2} mv^2$$

$$P.E = mgh \text{ (for Gravitational force)}$$

POWER :-

Power is the amount of energy transferred or converted. Or it is the time rate of doing work or delivering energy, expressible as the amount of work done W, or energy transferred, divided by the time interval "t". i-e W/t.

Unit :

The standard unit of power is "Watt". And Watt is equivalent to Joul/sec.

Examples :-

→ A car engine is an example of a machine that is given to power rating.

→ A 12 W light bulb which expends 60 joule of energy per second.

→ **Note:** Power is a scalar Quantity.

Equation :-

$$P = W/\Delta t$$

where,

P = Power
W = work
Δt = elapsed time.

QUESTION NO. 1

Given Data:

$P_1 = 200 + 16188 = 16388\ N$

$P_2 = 500 + 16188 = 16688\ N$

Sol:

$\Sigma F_y = 0$

$R_{y_1} + R_{y_2} - 16388 - 16688 = 0$

$R_{y_1} + R_{y_2} = 16388 + 16688$

$R_{y_1} + R_{y_2} = 33076 \longrightarrow$ eq (1)

Now; $R_{y_1} = \dfrac{(16688 \times 8) + (16388 \times 15)}{18}$

$= \dfrac{(150282) + (245870)}{18}$

$R_{y_1} = \dfrac{396252}{18} = 22014N \rightarrow$ (2)

Putting eq (2) in eq (1)

$22014 + R_{y_2} = 33076$

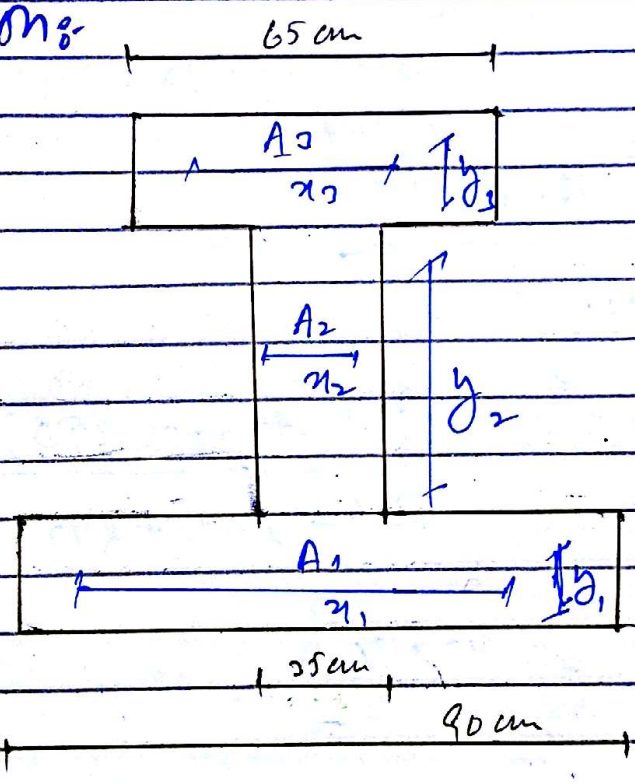
$I_{y_2} = 33086 - 22014$

$I_{y_2} = 11082\ N$

QUESTION NO. 4

part (a)

Solution:-



A_1	$3150\ cm^2$	$x_1 = 45\ cm$	$y_1 = 19.5$
A_2	$2275\ cm^2$	$x_2 = 45\ cm$	$y_2 = 60$
A_3	$975\ cm^2$	$x_3 = 45\ cm$	$y_3 = 10.75$
A_4	$6400\ cm^2$		

$$x_c = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3}$$

$$y_c = \frac{A_1y_1 + A_2y_2 + A_3y_3}{A_1 + A_2 + A_3}$$

$$x_c = \frac{(3150)(45) + (2275)(45) + (875)(45)}{3150 + 2275 + 875}$$

$$\boxed{x_c = 45}$$

NOW:

$$y_c = \frac{(3150)(17.5) + (2275)(50) + (875)(10.75)}{3150 + 2275 + 875}$$

$$\boxed{y_c = 42.76}$$

Part (b)

Area = $60 \times 35 = 2275\ cm^2$

Moment of inertia:

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

$$= 800889.5\ cm^4$$

Radius of Gyration:

$$K = \sqrt{\frac{I}{A}} = \sqrt{\frac{800889.5}{60 \times 35}}$$

$$K = 18.76\ cm$$

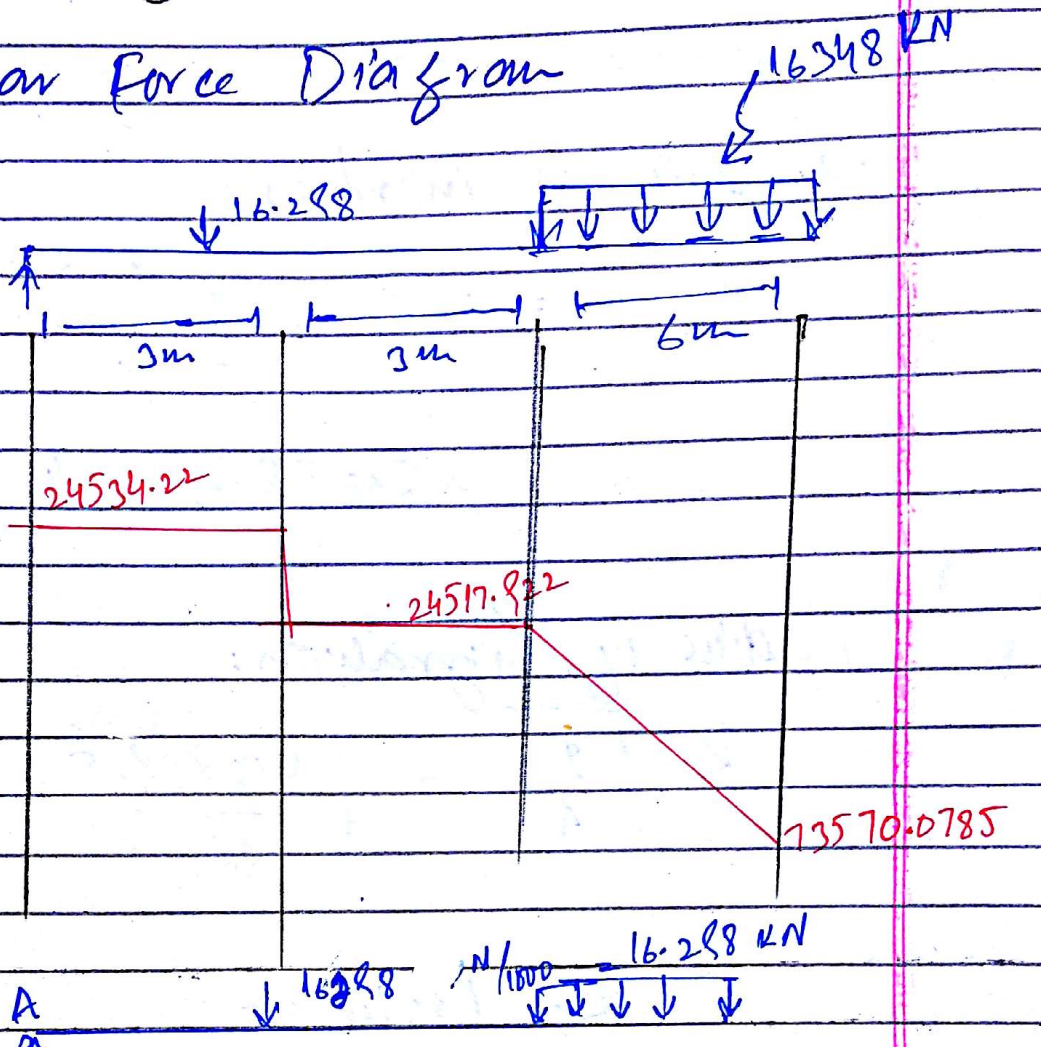
Section Modulii:

$$Z = \frac{b \times d^2}{6} = \frac{35 \times 65^2}{6}$$

$$Z = 24645.8\ cm$$

QUESTION NO. 2

Shear Force Diagram



$\Sigma M_B = 0$

$A_y \times 12 - 16.288 \times 8 - 16348 \times 6 \times \frac{6}{2} = 0$

$A_y \times 12 = 146.682 + 284.$

$A_y \times 12 = 284410.682$

$A_y = 24534.22 \text{ KN}$

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$$\Sigma F_y = 0$$

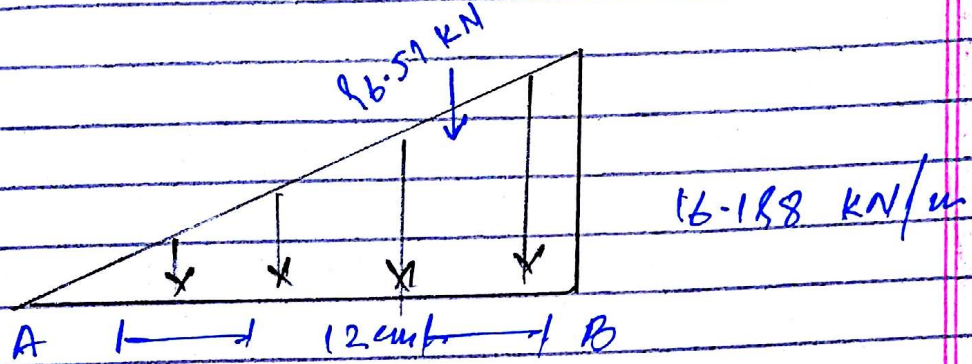
$$A_y - 16.288 - 16348 \times 6 + B_y = 0$$

$$24534.22 - 16.288 - 98088 + B_y = 0$$

$$\boxed{B_y = 73570.08\ KN}$$

QUESTION NO. 3

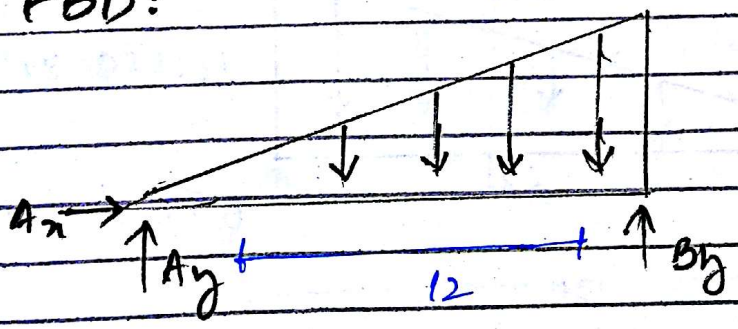
UVL = 16188 / 1000 = 16.188 KN/m



UVL point load = 16.188 × 12 × 1/2

= 97.51 KN

FBD:



Support Rxn:

$\sum F_x = 0 \Rightarrow A_x = 0$

$\sum F_y = 0 \Rightarrow A_y + B_y = 97.51\ KN \rightarrow (1)$

$(+\circlearrowleft) \sum M_A = 0 \Rightarrow (B_y \times 12) - (97.5 \times 8) = 0$

$\Rightarrow B_y \times 12 = 780$

$B_y = 780/12 = 65\ KN$

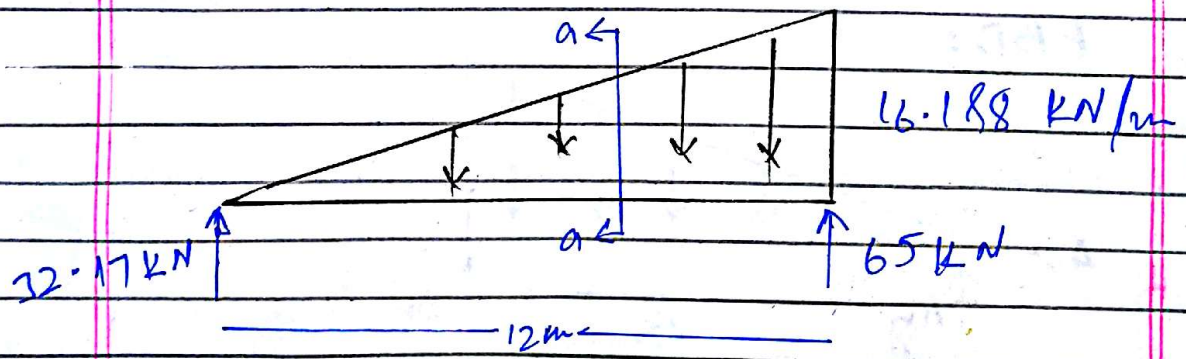
Eq ① $\Rightarrow$

$A_y + 65 = 97.51$

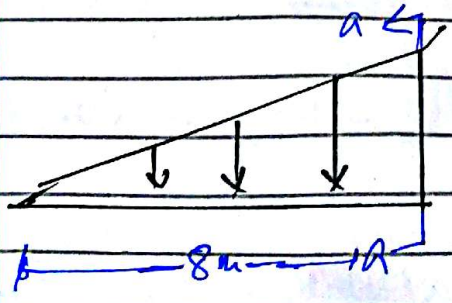
$A_y = 97.51 - 65$

$A_y = 32.51\ KN$

Shear force and Bending moment at different sections :-



Section aa $\quad 0 \leq x \leq 12$



$W_o \Rightarrow P_1 = \frac{16.188\,x^2}{24}$

From law of similar Δs:

$$\frac{16.188}{12} = \frac{w_0\ kN/m}{x}$$

$$w_0 = \frac{16.188\,x}{12}\ kN/m$$

$$P_1 = \left(\frac{16.188\,x}{12}\right)\left(\frac{x}{2}\right)$$

$$P_1 = \frac{16.085\,x^2}{24}$$

$$\sum F_y = 0 \Rightarrow -V_{aa} - \frac{16.188\,x^2}{24} + 32.17 = 0$$

$$\Rightarrow V_{aa} = 32.17 - \frac{16.085\,x^2}{24}$$

$$\Rightarrow V_{aa} = 32.17 - \frac{16.198\,x^2}{24} \rightarrow (a)$$

1) At $x = 0 \Rightarrow V_{aa} = 32.17\ kN$

2) At $x = 12 \Rightarrow V_{aa} = -64.34\ kN$

So, The value of shear force change from +ve to -ve.

So, eq (a) $\Rightarrow 0 = 33.17 - \frac{16.188\, x^2}{12}$

$$\boxed{x = 4.8 \text{ m}}$$

3.) At $x = 4.8 \Rightarrow V_{aa} = 0$ kN