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SEC: A

ENGINEERING MECHANICS FINAL PAPER

CIVIL ENGINEERING DEPARTMENT

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Q NO 1

Data:

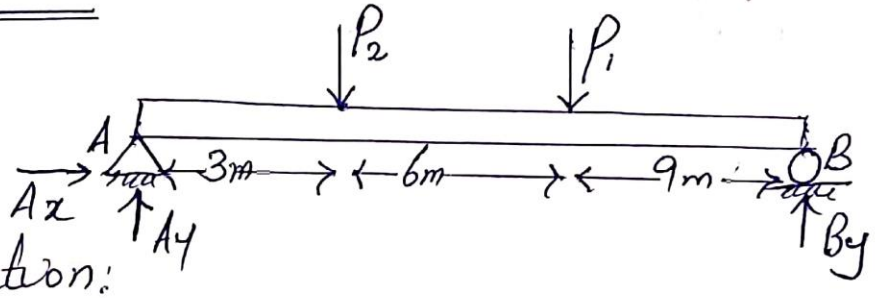
$P_1 = 200 + 16080$ $\quad \because$ ID NO. $= 16080$

$= 16280\ N$

$P_2 = 500 + 16080$

$= 16580\ N$

Diagram:



Solution:

By applying equilibrium equations

$\Sigma F_x = 0$

$A_x = 0$

$\Sigma F_y = 0$

$A_y + B_y = 32860\ N \rightarrow (i)$

$\Sigma M_A = 0$

$B_y \times 18m - P_2(3m) - P_1(9m) = 0$

$18B_y - 49740 - 146520 = 0$

$18B_y = 196260$

$$By = \frac{196260}{18} = 10903.33N$$

Now, putting in (i)

$$Ay + 10903.33 = 32860$$

$$Ay = 21956.67N$$

OR

$$Ay = 21.956KN$$

$$By = 10.903KN$$

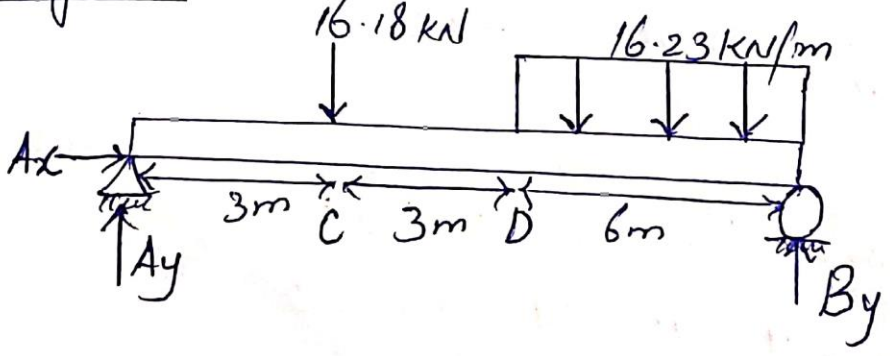
QNO2

Data:

$$P = 100 + 16080 = 16180N = 16.18KN$$

$$UDL = 150 + 16080 = 16.23KN/m$$

Diagram:



Reaction:

$\Sigma F_x = 0 \Rightarrow A_x = 0$

$\Sigma F_y = 0 \Rightarrow A_y + B_y = 16.18 + 16.23(6)$

$= 113.56\ KN$

$\Sigma M_A = 0 \Rightarrow B_y \times 12m - 16.18(3) - 97.38(9)$

$12B_y = 48.54 + 876.42 = 924.96$

$B_y = \frac{924.96}{12} = \underline{77.08\ KN}$

$A_y = 113.56 - 77.08 = \underline{36.48\ KN}$

Shear force:

For section AC:

At 0m: 36.48 KN

At 3m: 36.48 KN

For section CD:

At 3m: 36.48 − 16.18 = 20.3 KN

At 6m: 20.3 KN

For section DB

At 6m: 20.3 − 16.23(x) = 20.3 KN

At 7m: 20.3 − 16.23(1) = 4.07 KN

At 12m: 20.3 − 16.23(6) = −77.08 KN

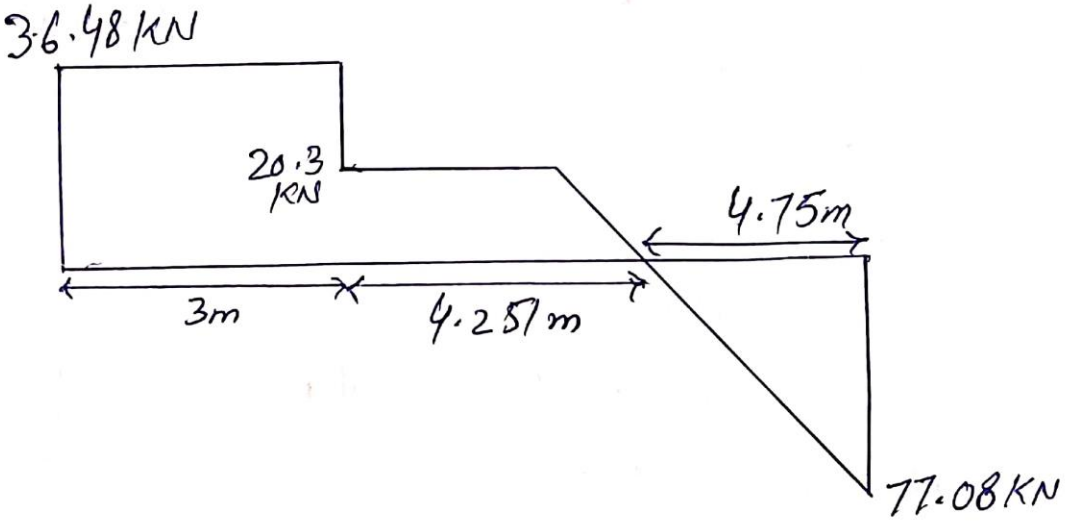
For change of SFD from +ve to -ve we have to find distance so

$$20.3 - 16.23(x) = 0$$

$$x = 1.25 \text{ m}$$

so, at $6 + 1.25 = 7.25$ m.

Shear force diagram:



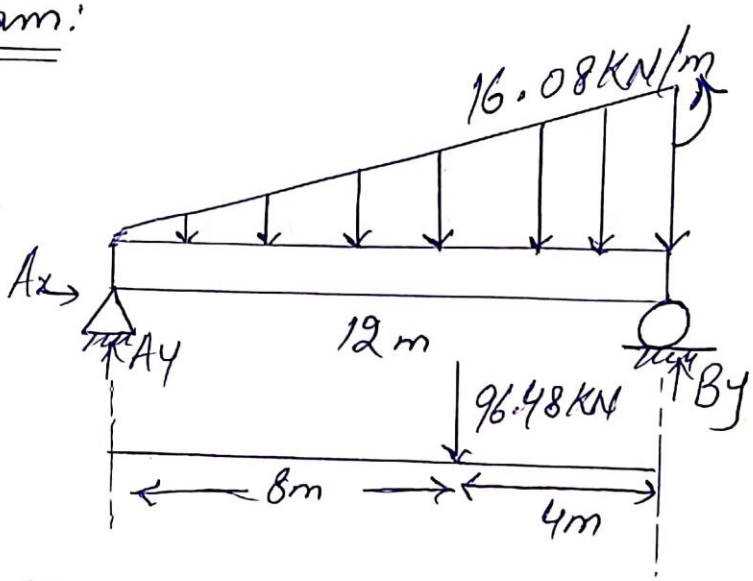
Q NO3

Data:

$$UVL = \frac{16080}{1000}\ KN/m = 16.08\ KN/m.$$

$$Total = \frac{1}{2} \times 16.08 \times 12 = 96.48\ KN$$

Diagram:



Reactions:

$$\Sigma f_x = 0 \Rightarrow A_x = 0$$

$$\Sigma f_y = 0 \Rightarrow A_y + B_y = 96.48\ KN$$

$$\Sigma M_A = 0 \Rightarrow B_y(12) - 96.48 \times 8 = 0$$

$$12B_y = 771.84$$

$$B_y = \frac{771.84}{12} = \underline{64.32\ KN}$$

$$A_y = 96.48 - 64.32 = \underline{32.16\ KN}$$

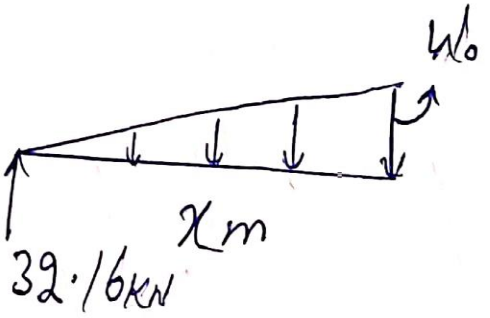
Shear force and Bending moment:

Shear:

At any point in middle shear is calculated by law of Similar triangles

$$W_o(KN/m) = \frac{16.08}{12}(x)\ KN/m.$$

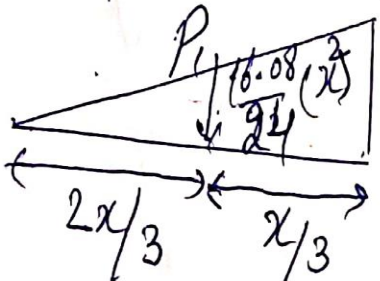
$$\therefore \frac{W_o}{x} = \frac{16.08}{12}$$



Now, equation for SFD is derived as follows;

$$P_1 = \frac{W_o \times x}{2}$$

$$P_1 = \frac{16.08x}{12} \times \frac{1}{2} \times x = \frac{16.08x^2}{24}$$



Equation for SFD becomes

$$\Rightarrow 32.16 - \frac{16.08x^2}{24}$$

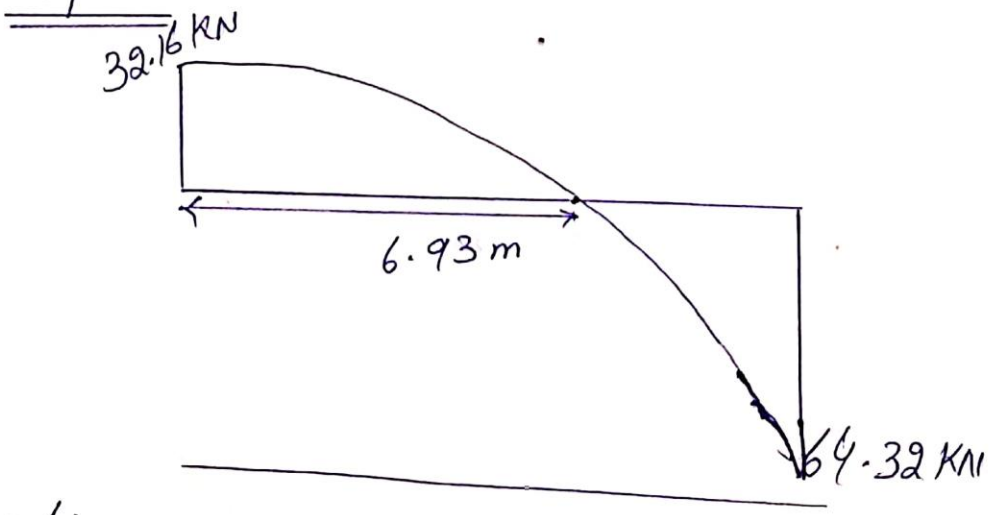
To find point of zero shear force

$$\Rightarrow 32.16 - \frac{16.08x^2}{24} = 0$$

$$\Rightarrow x^2 = \frac{771.84}{16.08} = 48$$

$$x = 6.93\,m$$

SFD:



Bending:

For similar section, moment at any point is given as;

$$M = 32.16x \cdot x - \frac{16.08x^2}{24}(x/3) = 32.16x - \frac{16.08x^3}{72}$$

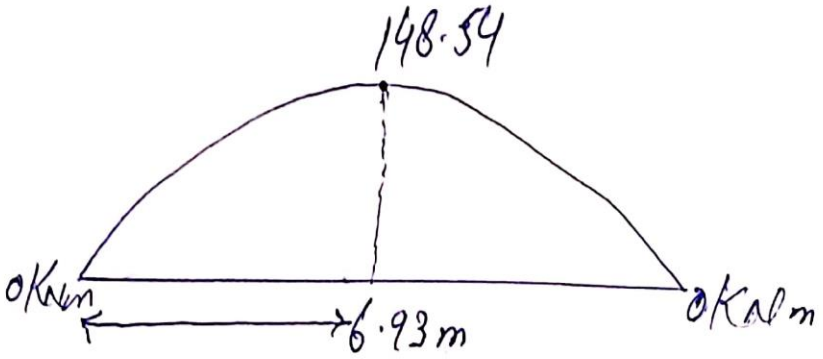
As, moment is maximum where shear force is 0 so putting $x = 6.93m$ we get:

$$M = 32.16(6.93) - \frac{16.08(6.93)^3}{72}$$

$$= 222.87 - 74.33$$

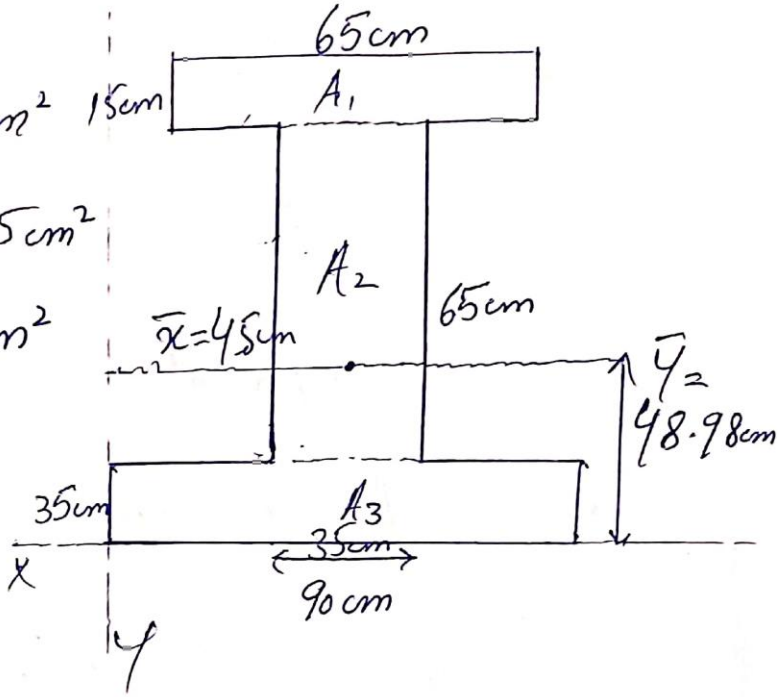
$$= 148.54 \text{ KNm}.$$

BMD



Q NO 4(a)

centroid = ?



$A_1 = 65 \times 15 = 975 cm^2$

$A_2 = 65 \times 35 = 2275 cm^2$

$A_3 = 35 \times 90 = 3150 cm^2$

Now,

$y_1 = 35 + 65 + 7.5$

$= 107.5 cm$

$y_2 = 35 + \frac{65}{2} = 67.5 cm$

$y_3 = 17.5 cm = \frac{35}{2} cm.$

Also,

~~$x = \frac{65}{2} = 32.5$~~

$x_1 = x_2 = x_3 = \frac{90}{2} = 45 cm.$

Now,

$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3} = \frac{975(107.5) + 2275(67.5) + 17.5(3150)}{975 + 2275 + 3150}$

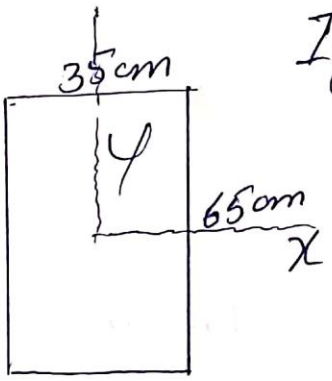
$\bar{y} = 48.98 cm$

Q No 4(b)

(i) Moment of Inertia $= \frac{bd^3}{12} = I_{xx}$

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

$= 800989.6\ cm^4$



$I_{yy} = \frac{b^3 d}{12}$

$= 232239.6\ cm^4$

(ii) Radius of Gyration:

$r_y = \sqrt{\frac{I_y}{A}}$, $r_x = \sqrt{\frac{I_x}{A}}$

$= \sqrt{\frac{232239.6}{65 \times 35}}$, $= \sqrt{\frac{800989.6}{65 \times 35}}$

$= 10.10\ cm$ $= 18.76\ cm$.

(iii) Elastic modulus $= Ze = \frac{1}{6} bh^2 = \frac{1}{6} \times 35 \times 65^2$

$= 24645.8\ cm^3$

Plastic modulus $= Zp = \frac{1}{4} bh^2 = \frac{1}{4} \times 35 \times 65^2$

$= 36968.7\ cm^3$

Q.No 5:

(a) **Work:**

"It is defined as the application of force to move a certain object through distance 'd'"

Work is given by the following formula

$W = F \cdot d$ and unit is joules

Example:

Suppose a person pushes a table in a direction parallel to force of application i.e 130 N and it moves 1 meter then work done = $130 \times 1 = 130$ Joules.

Q.No 5 (b) Power:

"Power is defined as rate at which work is done or energy is transferred."

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$, unit is Watt

Example: A water pump of 10 W will do 10 Joules work per second to pump water whereas 20 W will do more work per second i.e 20 joules.

(c) Energy:

"It is the ability of an object or System to do work."

It differs from work in terms of internal and external aspect. It is intrinsic ability of an object. It is of several types i.e K.E, P.E, GPE, chemical energy or light energy etc.

Example:

When a 50 kg bag is lifted to 30 m height. It has gravitational potential energy stored in it.

$$G.P.E = mgh = 50 \times 9.81 \times 30$$
$$= 14715 \text{ Joules.}$$