Direct Stress & Strain.

classmate EXPRESSIONS YOUNG AUTHOR CONTEST

NAME :

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TOPIC :

① A mild steel bar 1m long & 20 mm dia is subjected to an axial tensile force 62.83 kN. If modulus of elasticity $E = 2 \times 10^5$ N/mm^2, find : (i) stress (ii) strain. (iii) Elongation (iv) final length.

→ Data Given :-

$P = 62.83$ kN $= 62.83 * 10^3$ N

$l = 1$ m $= 1000$ mm

$d = 20$ mm. $\therefore A = \frac{\pi}{4} * 20^2 = 314.15$ mm^2

$E = 2 \times 10^5$ N/mm^2

→ $\sigma = P/A = \dfrac{62.83 * 10^3}{314.15} = \underline{200 \text{ N/mm}^2}$

→ Strain : $\varepsilon = \sigma/E = \dfrac{200}{2 \times 10^5} = \underline{0.001}$

→ Elongation : $\delta l = \dfrac{Pl}{AE} = \dfrac{(62.83) \times 10^3 \times 1000}{314.15 \times 2 \times 10^5}$

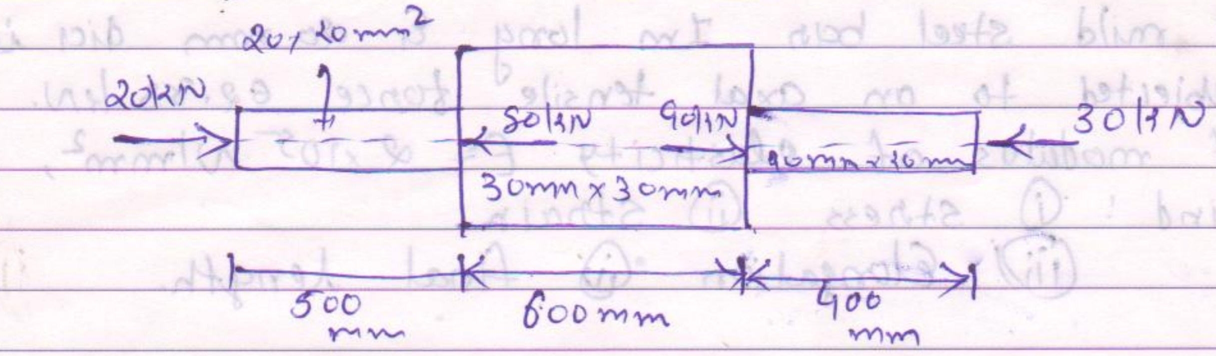
$= 1$ mm ... increase (वाढ)

→ Final length $= 1000 + 1$

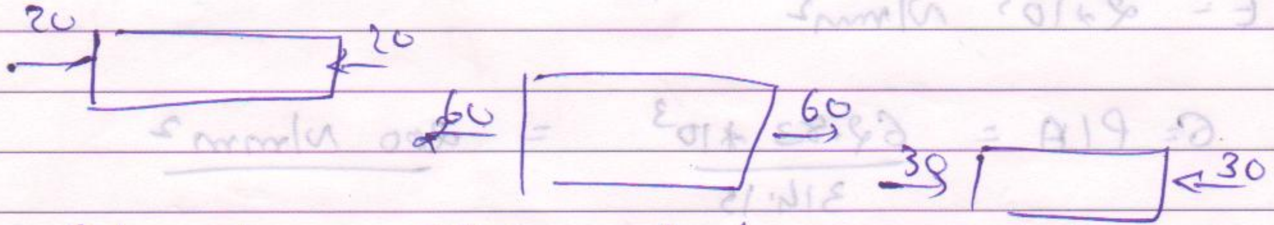
$= 1001$ mm.

SCORE JUDGES SIGNATURE

② A bar PQRS is subjected to axial forces as shown in fig. Find change in length, its nature & final length of bar. $E = 1.5 * 10^5$ N/mm².



→ $A_1 = 20 \times 20 = 400$ mm², $l_1 = 500$mm
$A_2 = 30 * 30 = 900$ mm², $l_2 = 600$mm,
$A_3 = 20 \times 20 = 400$ mm², $l_3 = 400$mm
$E = 1.5 * 10^5$ N/mm²



→ $\delta l = \frac{1}{E} * \left[\frac{P_1 l_1}{A_1} + \frac{P_2 l_2}{A_2} + \frac{P_3 l_3}{A_3}\right]$

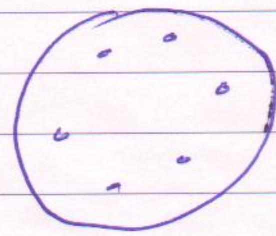
$= \frac{1}{1.5 * 10^5} * \left[\frac{-20 * 10^3 * 500}{400} + \frac{60 * 10^3 * 600}{900} - \frac{30 * 10^3 * 400}{400}\right]$

$= -0.1$ mm ... decrease in length.

→ So final length $= (500 + 600 + 400) - 0.1$
$= 1499.90$ mm.

(3) A circular RCC column of 250 mm dia is reinforced with 6 bars of 22 mm dia. The column is carrying a load of 875 kN. Find stresses developed in concrete & steel. $E_s = 2.1 \times 10^5$ N/mm². $E_c = 0.14 \times 10^5$ N/mm²

→ Dia. of column = 250 mm
6 bars of 22 mm dia.
$P = 875$ kN.



→ $A_s = 6 \times \frac{\pi}{4}(22)^2 = 2280.79 \text{ mm}^2$

$A_c = \frac{\pi}{4}(250)^2 - 2280.79 = 46806.59 \text{ mm}^2$

→ આપણે જાણીએ છીએ કે, (We know that)

$\frac{\sigma_s}{E_s} = \frac{\sigma_c}{E_c} \Rightarrow \sigma_s = \frac{E_s}{E_c} \times \sigma_c$

$\Rightarrow \sigma_s = \frac{2.1 \times 10^5}{0.14 \times 10^5} \times \sigma_c$

$\Rightarrow \boxed{\sigma_s = 15\,\sigma_c}$

→ $P = P_s + P_c$
$= \sigma_s A_s + \sigma_c A_c$
$\Rightarrow 875 \times 10^3 = 15\sigma_c \times 2280.79 + \sigma_c \times 46806.59$

$\Rightarrow \boxed{\sigma_c = 10.50 \text{ N/mm}^2}$ Stress in Concrete.

$\sigma_s = 15\ \sigma_c$

$= \underline{162\ N/mm^2}$ stress in steel.

(4) A bar of 16 mm dia & 12 cm long is subjected to a tensile force of 150 kN. Increase in length & decrease in dia are observed 0.045 cm & 0.002 cm respectively.

Find: (1) Modulus of elasticity.
(2) Poisson's ratio.
(3) Bulk modulus.
(4) modulus of rigidity.

→ Given data: $d = 16\,mm$
$l = 12\,cm = 120\,mm$
$P = 150\,kN$
$\delta l = 0.045\,cm = 0.45\,mm$
$\delta d = 0.002\,cm = 0.02\,mm$
$E = ?\quad \mu = ?\quad K = ?\quad G = ?$

→ $\varepsilon = \dfrac{\delta l}{l} = \dfrac{0.45}{120} = 3.75 \times 10^{-3}$

$\varepsilon' = \dfrac{\delta d}{d} = \dfrac{0.02}{16} = 1.25 \times 10^{-3}$

→ $\mu = \varepsilon'/\varepsilon = \dfrac{1.25 \times 10^{-3}}{3.75 \times 10^{-3}} = \boxed{0.333}$

Poisson's ratio

→ $A = \dfrac{\pi}{4} d^2 = \dfrac{\pi}{4} \times 16^2 = 201.06\,mm^2$

$\rightarrow \sigma = P/A = \frac{150 * 10^3}{201.06} = 746\ mm^2$

$\rightarrow E = \sigma/\varepsilon = \frac{746}{3.75 * 10^{-3}} = \boxed{1.989 * 10^5}\ N/mm^2$

$\rightarrow$ Bulk Modulus:-

$\mu = \frac{1}{m} = 0.333 \therefore \boxed{m = 3.0}$

$K = \frac{mE}{3(m-2)} = \frac{3 * 1.989 * 10^5}{3(3-2)}$

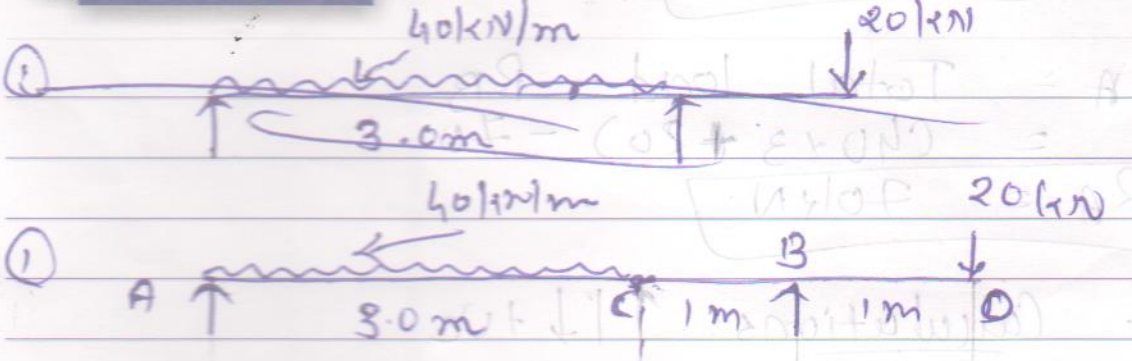
$= \boxed{1.989 * 10^5\ N/mm^2}$

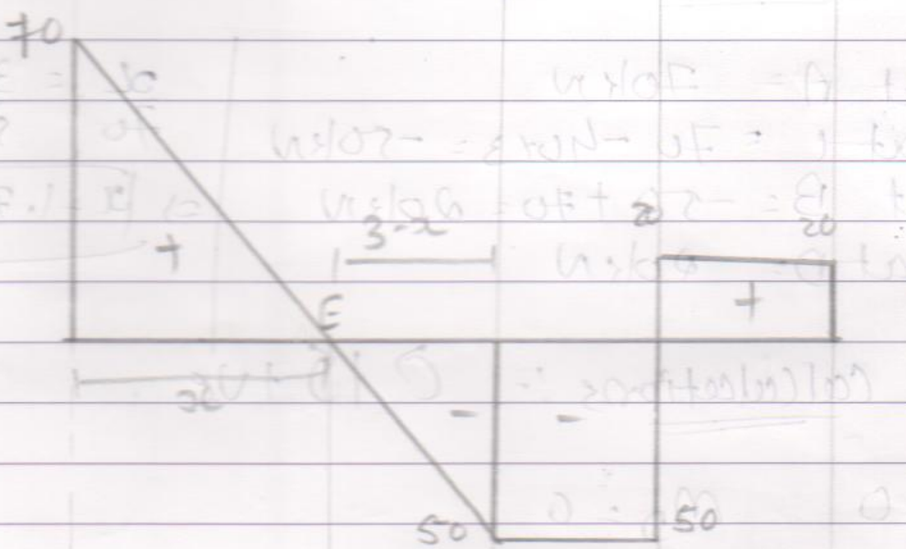
* Modulus of Rigidity:-

$G = \frac{mE}{2(m+1)} = \frac{3 * 1.989 * 10^5}{2(3+1)}$

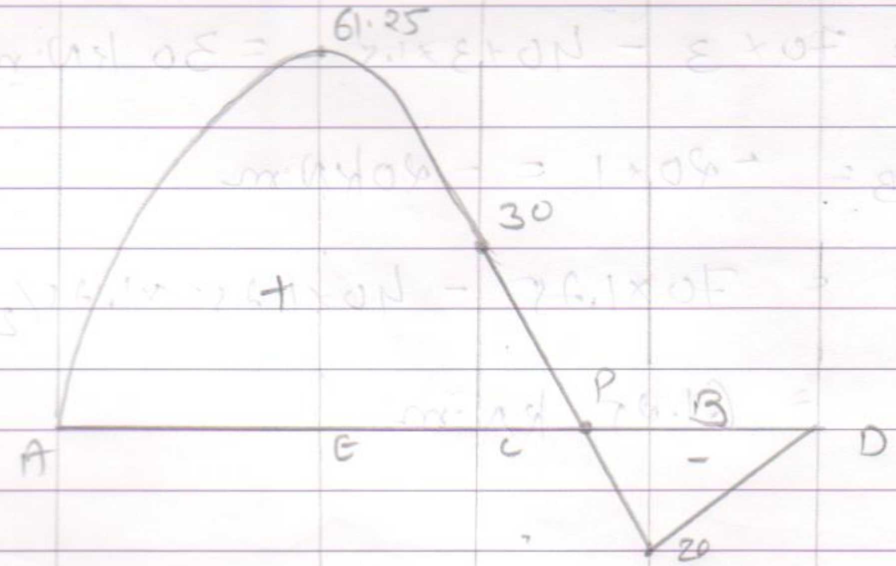
$\boxed{= 74.58 * 10^3\ N/mm^2}$

S.F & B.M.





S.F. Dia.



B.M. Dia.

→ Taking $M@A = 0$

$R_B \times 4 = (40 \times 3 \times 1.5) + (20 \times 5)$

So, $\boxed{R_B = 70 \text{ kN}}$

$R_A = \text{Total load} - R_B$
$= (40 \times 3 + 20) - 70$

$\boxed{R_A = 70 \text{ kN}}$

→ S.F. Calculations: ↑|↓ +ve

S.F. at A = 70kN
S.F. at C = 70 − 40×3 = −50kN
S.F. at B = −50 + 70 = 20kN
S.F. at D = 20kN

$\frac{x}{70} = \frac{3-x}{50}$

$\Rightarrow \boxed{x = 1.75 \text{m}}$

→ B.M. Calculations :- ↻|↺ +ve

$M_A = 0 \qquad M_D = 0$

LHS. $M_C : 70 \times 3 - 40 \times 3 \times 1.5 = 30 \text{ kN·m}$

RHS $M_B = -20 \times 1 = -20 \text{kN·m}$

LHS $M_E = 70 \times 1.75 - 40 \times 1.75 \times 1.75/_2$

$= 61.25 \text{ kN·m}$

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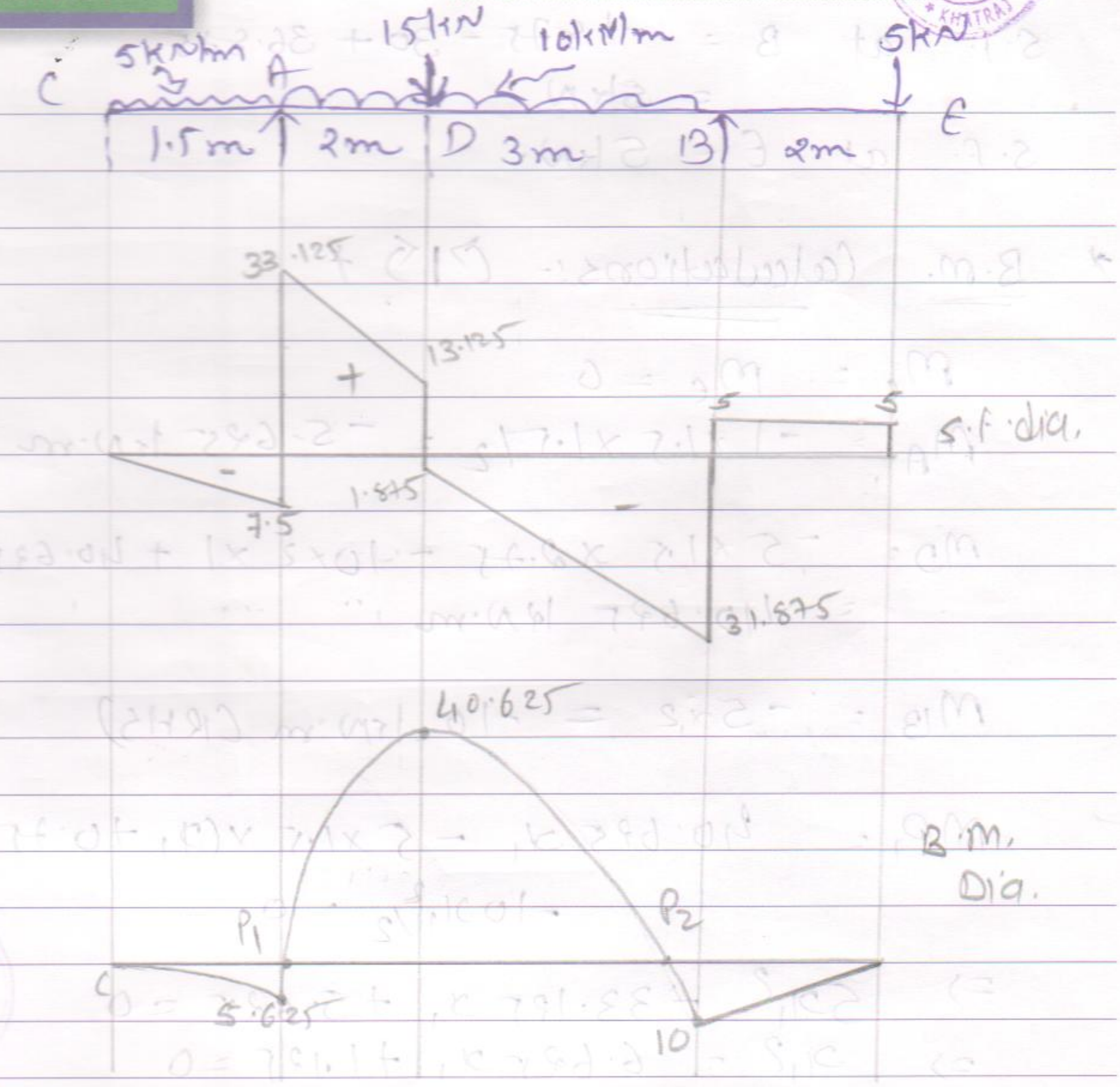


Taking $M_{@A} = 0$

$R_B \times 5 + (5\times1.5\times1.5/2) = (15\times2)+((10\times5)\times2.5) + (5\times7)$

So, $\boxed{R_B = 36.875 \text{ kN}}$

$\boxed{R_A = 40.625 \text{ kN}}$

* $\underline{\text{S.F. Calculations}}$:- $\uparrow | \downarrow$ +ve.

S.F at C = 0

S.F. at A = (−5×1.5) + (40.625) = 33.125 kN

S.F. at D = 33.125 − 20−15 = −1.875 kN

S.F. at B = −1.875 − 30 + 36.875

= 5 kN

S.F. at E = 5 kN.

* $\underline{\text{B.M. Calculations}}$:- $\circlearrowright | \circlearrowleft$ +

$M_C = M_E = 0$

$M_A = -1 \times 1.5 \times 1.5/2 = -5.625$ kN·m

$M_D = -5 \times 1.5 \times 2.75 - 10 \times 2 \times 1 + 40.625 \times 2$

$= 40.625$ kN·m

$M_B = -5 \times 2 = -10$ kN·m (RHS)

$MP_1 = 40.625\, x_1 - 5 \times 1.5 \times (x_1 + 0.75)$

$- 10 x_1^2/2 = 0$

$\Rightarrow 5x_1^2 - 33.125\, x_1 + 5.625 = 0$

$\Rightarrow x_1^2 - 6.625\, x_1 + 1.125 = 0$

So, $x_1 = \dfrac{6.625 - \sqrt{(-6.625)^2 - 4 \times 1 \times 1.125}}{2 \times 1}$

$\boxed{x_1 = 0.1745 \text{ m}}$

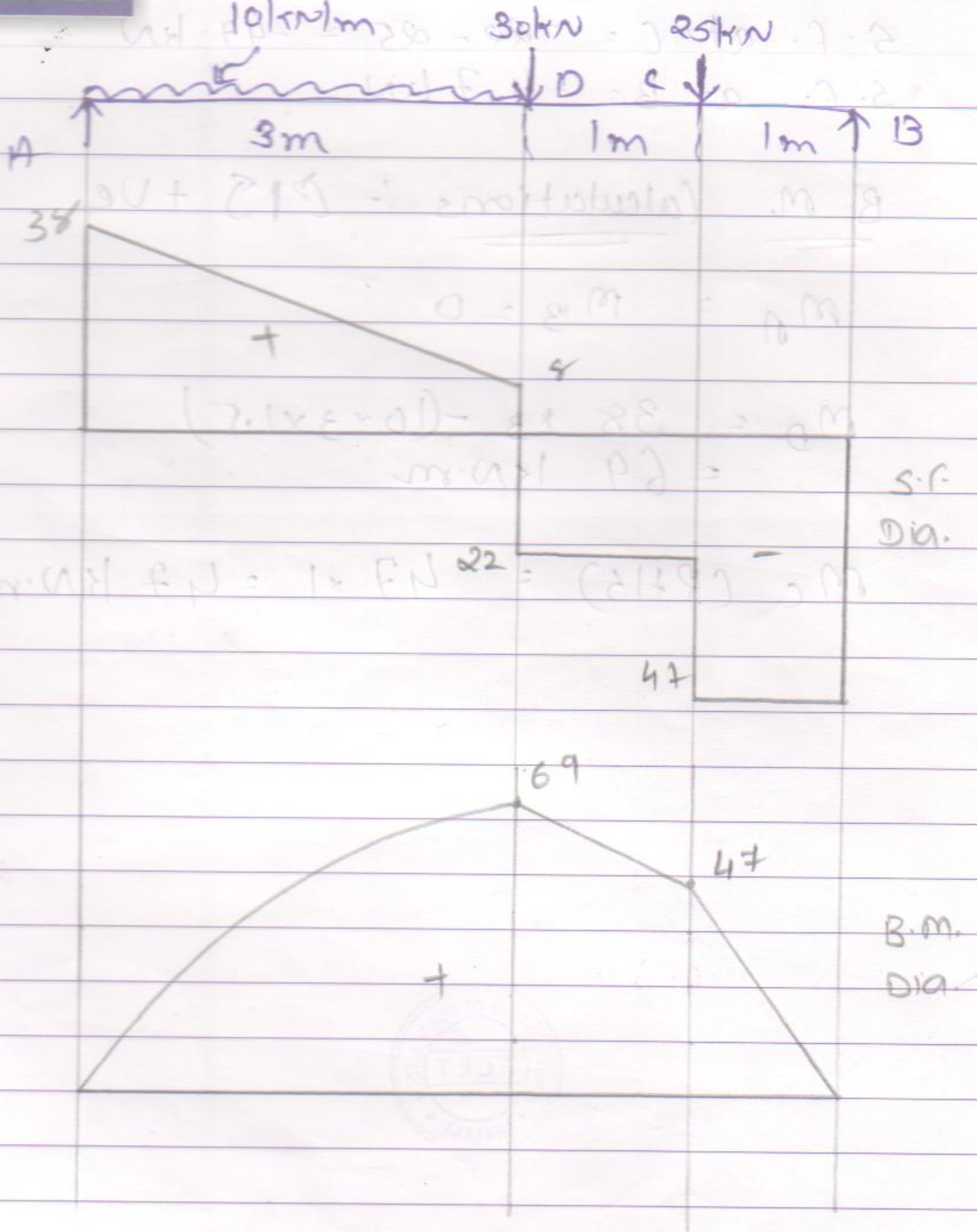
$MP_2 = 36.875\, x_2 - 5(2 + x_2) - 10 x_2^2/2 = 0$

So, $5x_2^2 - 31.875\, x_2 + 10 = 0$

$\Rightarrow x_2^2 - 6.375\, x_2 + 2 = 0$

$\therefore \boxed{x_2 = 0.33 \text{ m}}$

(3)



→ Taking $M@A = 0$

$$R_B \times 5 = (10 \times 3 \times 1.5) + (30 \times 3) + (25 \times 4)$$

$$\Rightarrow \boxed{R_B = 47 \text{ kN}}$$

→ S.F. Calculations: ↑↓ +ve | $R_A + R_B$ = Total load

So $\boxed{R_A = 38 kN}$

S.F. at A = 38 kN

S.F. at D = 38 - 30 - 30
= -22 kN

S.F. at C = -22 - 25 = -47 kN

S.F. at B = -47 kN

→ B.M. Calculations :- ↻↺ +ve

$M_A = M_B = 0$

$M_D = 38 * 3 - (10 \times 3 \times 1.5)$
$= 69$ kN.m

M_C (RHS) = $47 \times 1 = 47$ kN.m

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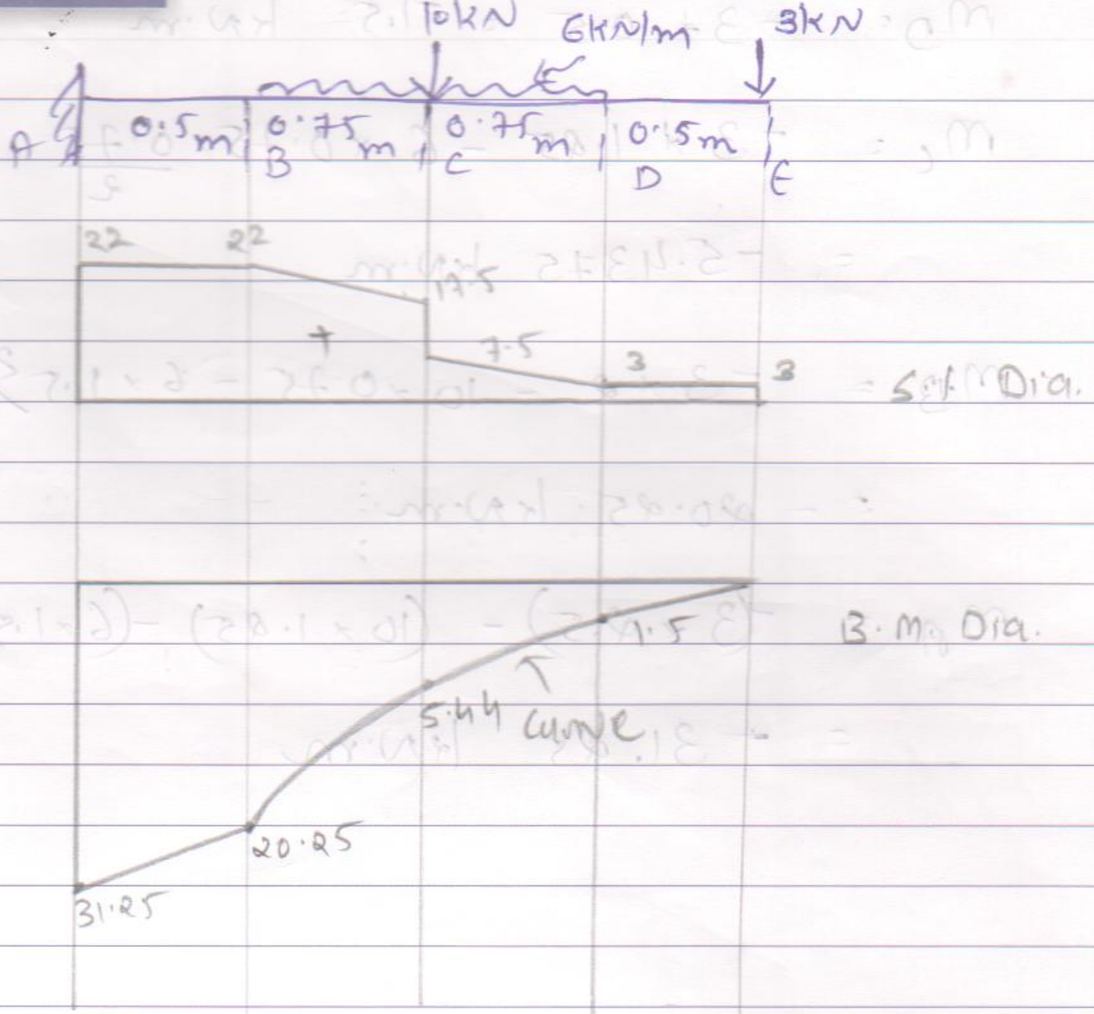
(4)



→ S.F. Calculations: ↑/↓ +ve

S.F. at E = 3kN
S.F. at D = 3kN
S.F at C = 3 + 6 * 0.75 + 10
= 17.5 kN

S.F. at B = 17.5 + 6 * 0.75 = 22kN
S.F at A = 22kN

* **B.M. Calculations** :- G.I.O -Ve

$M_E = 0$

$M_D = -3 * 0.5 = -1.5$ kN·m

$M_C = -3 * 1.25 - 6 \times 0.75 \times \frac{0.75}{2}$

$= -5.4375$ kN·m

$M_B = -3 \times 2 - 10 \times 0.75 - 6 \times 1.5^2/2$

$= -20.25$ kN·m

$M_A = -(3 \times 2.5) - (10 \times 1.25) - (6 \times 1.5 \times 1.25)$

$= -31.25$ kN·m

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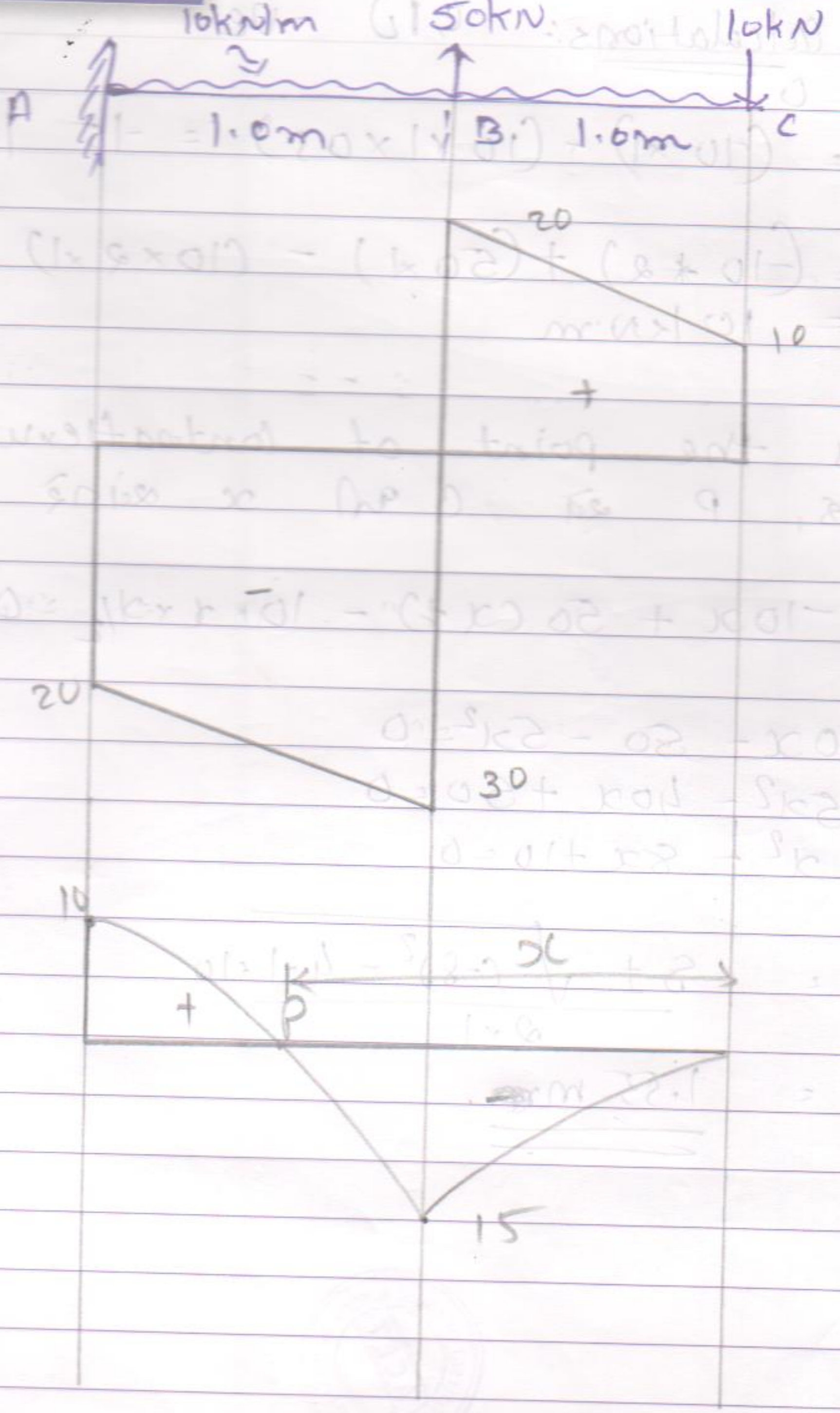
(5)



S.F Dia.

B.M. Dia.

* **S.F. Calculations:-** ↑|↓ +ve

S.F. at C = 10 kN

S.F. at B = 10+10−50 = −30 kN

S.F. at A = −30+10 = −20 kN

* **B.M. Calculations:-** ↺|↻ −ve

$M_C = 0$

$M_B = (10\times1) - (10\times1\times0.5) = -15$ kN.m

$M_A = (-10 * 2) + (50\times1) - (10\times2\times1)$
$= 10$ kN.m

— P is the point of contraflexure.
ધારો કે, P એ C થી x અંતરે છે.

$M_P = -10x + 50(x-1) - 10\times x\times x/2 = 0$

$\Rightarrow 40x - 50 - 5x^2 = 0$

$\Rightarrow 5x^2 - 40x + 50 = 0$

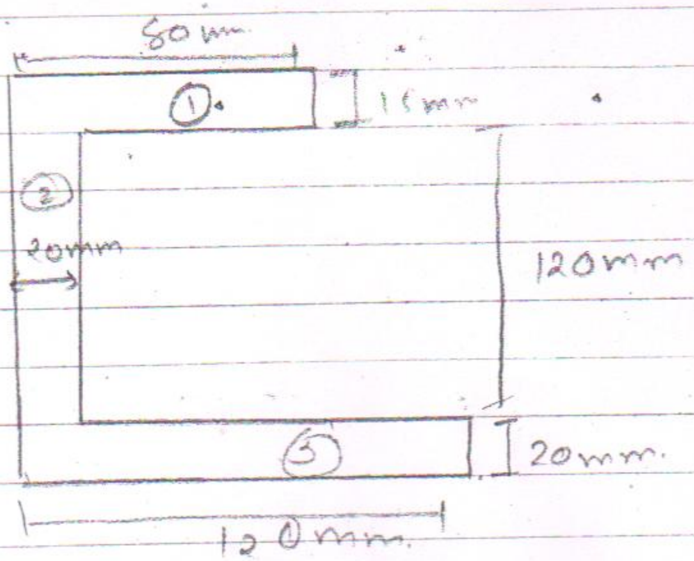
$\Rightarrow x^2 - 8x + 10 = 0$

So, $x = \dfrac{8 \pm \sqrt{(-8)^2 - 4\times1\times10}}{2\times1}$

$= 1.55$ m.

Moment Of Inertia

Ex.



for 1st rectangle:-

$a_1 = 80 \times 15 = 1200 \ mm^2$

$x_1 = 40 \ mm$

$y_1 = 20 + 120 + 7.5 = 147.5 \ mm$

2nd rectangle:-

$a_2 = 120 \times 20 = 2400 \ mm^2$

$x_2 = 10 \ mm^2$

$y_2 = 20 + 60 = 80 \ mm$

3rd rectangle:-

$a_3 = 120 \times 20 = 2400 \ mm^2$

$x_3 = 60 \ mm$

$y_3 = 10 \ mm$

$$\bar{x} = \frac{a_1 x_1 + a_2 x_2 + a_3 x_3}{a_1 + a_2 + a_3}$$

$$= \frac{(1200 \times 40) + (2400 \times 10) + (2400 \times 6}{(1200 + 2400 + 2400)}$$

$= 36\ mm$

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2 + a_3 y_3}{a_1 + a_2 + a_3}$$

$= 65.5\ mm$

$I_{xx_1} = I_g + ah^2$

$= \frac{80 \times 15^3}{12} + 1200\,(147.5 - 65.5)^2$

$= 8.09 \times 10^6\ mm^4.$

$I_{xx_2} = I_g + ah^2$

$= \frac{20 \times 120^3}{12} + 2400\,(80 - 65.5)^2$

$= 3.38 \times 10^6\ mm^4$

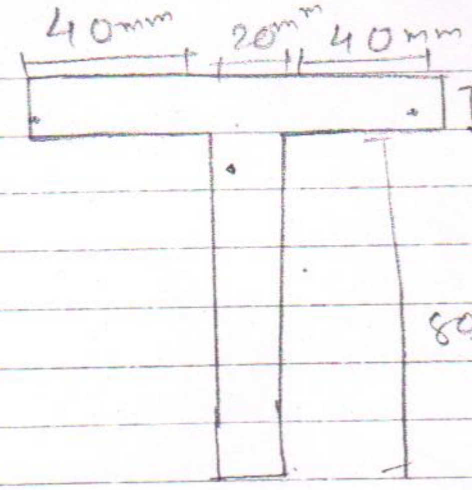
$I_{xx_3} = I_g + ah^2$

$= \frac{120 \times 20^3}{12} + 2400\,(65.5 - 10)^2$

$= 7.47 \times 10^6\ mm^4$

$I_{xx} = 18.94 \times 10^6\ mm^4.$

Ex.



T-section is symmetrical about Y-axis.

so $\bar{X} = \frac{100}{2} = 50$ mm.

$$\bar{Y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$$

$$= \frac{(100 \times 20) \times 90 + (80 \times 20 \times 40)}{(100 \times 20) + (80 \times 20)}$$

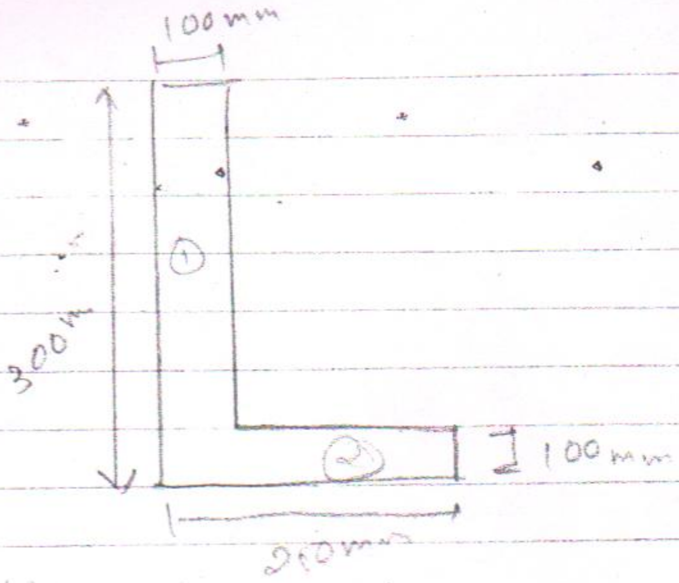
$$= 67.78 \text{ mm}$$

$$I_{xx_1} = I_g + ah^2$$
$$= \frac{100 \times 20^3}{12} + 2000(90 - 67.78)^2$$
$$= 1.054 \times 10^6 \text{ mm}^4$$

$$I_{xx_2} = I_g + ah^2$$
$$= \frac{20 \times 80^3}{12} + 1600(67.78 - 40)^2$$
$$= 2.080 \times 10^6 \text{ mm}^4$$

$$I_{xx} = 3.13 \times 10^6 \text{ mm}^4$$

Ex.



$a_1 = 200 \times 100 = 20,000 \text{ mm}^2$

$y_1 = 100 + 100 = 200 \text{ mm}$

$a_2 = 250 \times 100 = 25,000 \text{ mm}^2$

$y_2 = 50 \text{ mm}$

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2} = \frac{(20,000 \times 200) + (25,000 \times 50)}{(20,000 + 25,000)}$$

$$= \frac{5,250,000}{45,000}$$

$$\bar{y} = 116.67 \text{ mm}$$

$$I_{xx_1} = I_g + ah^2$$

$$= \frac{100 \times 200^3}{12} + 20,000(200 - 116.67)^2$$

$$= 205.54 \times 10^6 \text{ mm}^4.$$

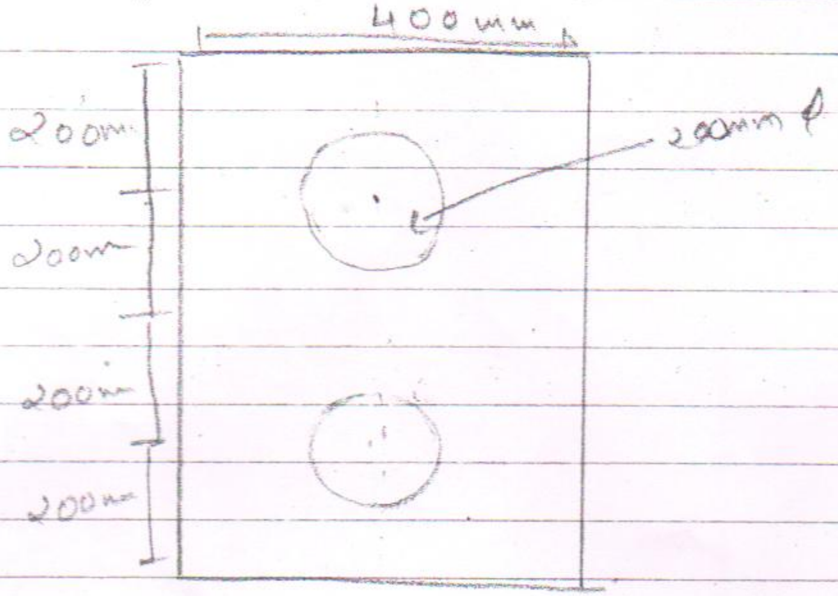
$$I_{xx_2} = I_g + ah^2$$

$$= \frac{250 \times 100^3}{12} + 25{,}000\,(116.67 - 50)^2$$

$$= 131.95 \times 10^6 \text{ mm}^4$$

$$\therefore I_{xx} = 337.49 \times 10^6 \text{ mm}^4$$

Ex.



<u>Rectangle:-</u>

$$I_{xx_1} = \frac{bd^3}{12} + ah^2 \qquad \left(\because h = 0 \;\; \text{as } \bar{y} = 400,\; y_1 = 400\right)$$

$$= \frac{400 \times 800^3}{12}$$

$$= 1.70 \times 10^{10} \text{ mm}^4$$

<u>Circle:-</u>

$$I_{xx_2} = 2\left[I_{cg} + ah^2\right]$$

$$= 2\left[\frac{\pi}{64} \times 200^4 + \frac{\pi}{4}\, 200^2 \times 200^2\right]$$

$$= 2.67 \times 10^9 \text{ mm}^4$$

$$I_{xx} = 1.43 \times 10^{10} \text{ mm}^4$$

$$I_{yy_1} = \frac{db^3}{12} = \frac{800 \times 400^3}{12} = 4.26 \times 10^9 \ mm^4$$

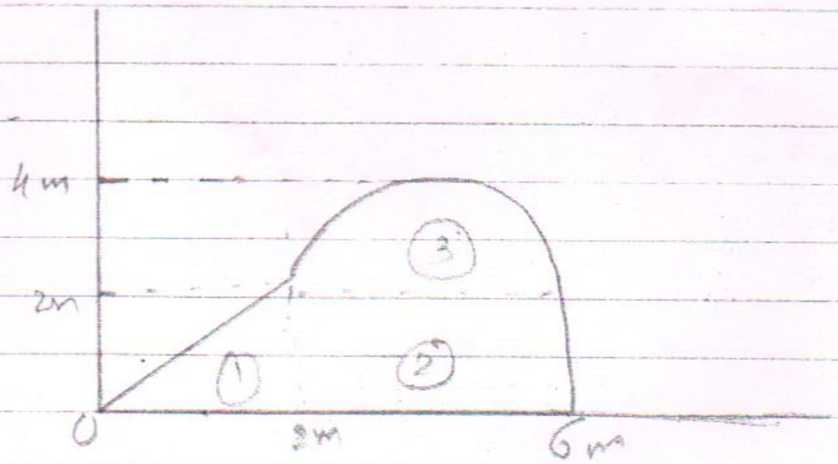
$$I_{yy_2} = 2\left[I_G + ah^2\right]$$
$$= 2\left[\frac{\pi}{64} \times 200^4 + 0\right]$$

$$I_{yy_2} = 157.08 \times 10^6 \ mm^4$$

$$I_{yy} = I_{yy_1} - I_{yy_2}$$
$$= 4.108 \times 10^9 \ mm^4$$

$$I_{xx} = I_{xx_1} - I_{xx_2}$$
$$= 1.43 \times 10^{10} \ mm^4$$

Ex.



Triangle :-

$a_1 = \frac{1}{2} \times 2m \times 2m = 2m$
$x_1 = \frac{2}{3} \times 2 = 1.33 \ m$
$y_1 = 1 \ m$

Rectangle :-

$a_2 = 8 \ m$ $\quad y_2 = 1 \ m$
$x_2 = 4 \ m$

semi circle:-

$a_3 = \frac{1}{2}\pi r^2 = \frac{1}{2} \times 3.14 \times 4 = 6.28\ m.$

$x_3 = 4\ m$

$y_3 = 2.84\ m.$

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2 + a_3 y_3}{a_1 + a_2 + a_3}$$

$$= \frac{(2 \times 1) + (8 \times 1) + (6.28 \times 2.84)}{16.28}$$

$$= 1.709\ m$$

$I_{xx_1} = I_{cg} + ah^2$

(triangle) $\frac{bh^3}{12} + 0$

$= \frac{2 \times 8}{12} = 1.33\ m^4$

(i) I_{xx_2} (rectangle) $= \frac{bd^3}{12} + 8(1.709 - 1)^2$

$= \frac{4 \times 8}{12} + 4.02$

(ii) $= 6.68\ m^4$

I_{xx_3} (semicircle) $= \frac{\pi}{64} d^4 + ah^2$

$= 12.56 + 8.033$

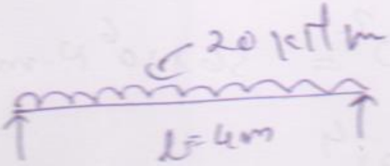
$= 20.59\ m^4$

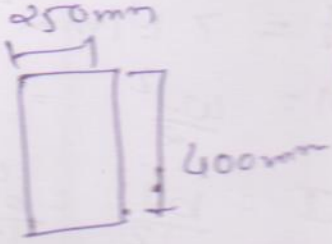
$I_{xx} = 28.6\ m^4$

Bending Stresses in Beam

Ex.1. A simply supported beam has span 4m and 250mm x 400mm cross-section. It carries an udl of 20 kN/m on entire span. Find maximum bending stress and stress on layer 80mm from neutral axis. Draw stress distribution Diagram

Soln.





$$M = \frac{wl^2}{8} = \frac{20 \times (4000)^2}{8} = 40 \times 10^6 \text{ N.mm}$$

$$I = \frac{250 \times 400^3}{12} = 1.33 \times 10^9 \text{ mm}^4$$

$$y = \frac{400}{2} = 200 \text{ mm}$$

$$\frac{M}{I} = \frac{f}{y} \Rightarrow \frac{40 \times 10^6}{1.33 \times 10^9} = \frac{f}{200}$$

$$\boxed{f = 6 \text{ N/mm}^2} \text{ max. bending stress.}$$

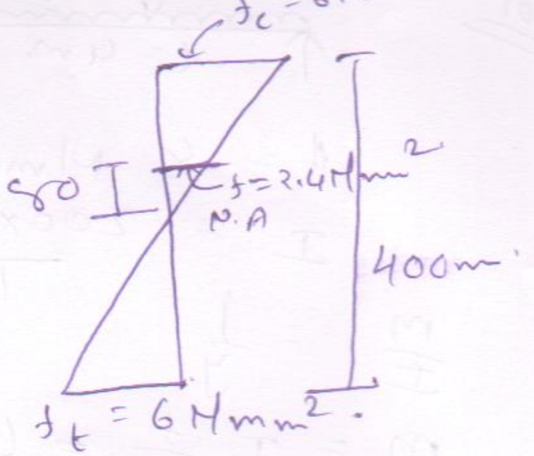
bending stress at 80 mm from N.A.

$y = 80$ mm

$$\therefore \frac{M}{I} = \frac{f}{y}$$

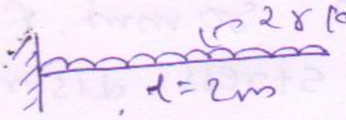
$$\therefore \frac{40 \times 10^6}{1.33 \times 10^9} = \frac{f}{80}$$

$$\therefore \boxed{f = 2.4 \text{ N/mm}^2}$$



Ex.2 A square cantilever beam of span 2m carries a uniformly distributed load of 28 kN/m over entire span. Considering permessible bending stress as 7 N/mm², decide the size of the square beam.

Sol^n.



$f = 7 \ N/mm^2$

$M = \frac{wl^2}{2} = \frac{28 \times (2000)^2}{2} = 56 \times 10^6 \ N.mm$

$I = \frac{bd^3}{12} = \frac{b^4}{12} = 0.0833 b^4$

$y = \frac{b}{2} = 0.5 b$

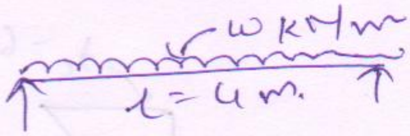
$\frac{M}{I} = f/y \implies \frac{56 \times 10^6}{0.0833 b^4} = \frac{7}{0.5 b}$

$\therefore \boxed{b = 363.5 \ mm}$

$\therefore$ The size of beam is 363.5mm × 363.5mm

Ex.3 A wooden beam 200 mm wide & 300mm deep is simply supported over a span of 4 m. If max. bending stress does not exceed 8 N/mm², find max. UDL on beam

Sol^n



$f = 8 \ N/mm^2$

$I = \frac{200 \times 300^3}{12} = 45 \times 10^7 \ mm^4$

$\frac{M}{I} = \frac{f}{y}$

$M = I \cdot \frac{f}{y} = 45 \times 10^7 \times \frac{8}{150} = 24 \times 10^6 \ Nmm$

For simply supported beam with u.d.l

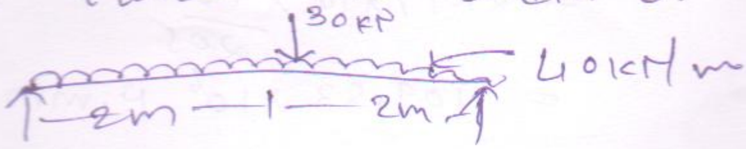
$$M = \frac{wl^2}{8}$$

$$24 \times 10^6 = \frac{w \times 4000^2}{8} = 12 \text{ N/mm}$$

$$w = 12 \text{ kN/m}$$

Ex. 4 A rectangular section is used as a simply supported beam of 4m length. It carries udl of 40 kN/m on full length along with a central point load 30 kN. Find width and depth of the section if max. bending stress in the beam is not to exceed 250 N/mm². The depth of section is twice the width of the section.

sol^n



$f = 250$ N/mm² $\qquad d = 2b$ (given)

$$M = \frac{wl}{4} + \frac{wl^2}{8}$$

$$= \frac{30 \times 4}{4} + \frac{40 \times 4^2}{8} = 110 \times 10^6 \text{ Nmm}$$

$$I = \frac{bd^3}{12} = \frac{b(2b)^3}{12} = 0.67b^4$$

$$y = \frac{d}{2} = \frac{2b}{2} = b$$

$$\frac{M}{I} = \frac{f}{y}$$

$$\frac{110 \times 10^6}{0.67 b^4} = \frac{250}{b}$$

$$b^3 = 6567.41$$

$$\boxed{b = 86.92 \text{ mm}}$$

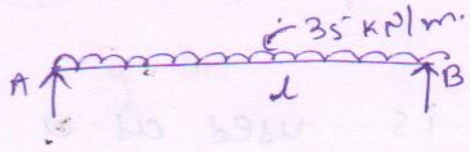
$$d = 2b$$

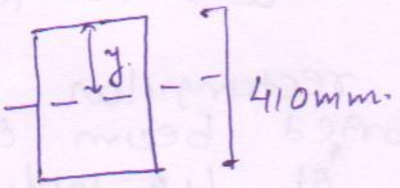
$$= 2 \times 86.92$$

$$\boxed{d = 173.84 \text{ mm}}$$

<u>EX.5</u>. A Beam 410 mm deep has M.I, $I_{xx} = 25017\ cm^4$. If section is used as a simply supported beam to carry udl of 35 kN/m on its entire length and maximum bending stress is not to exceed $90\ N/mm^2$. Find the span of beam.

<u>Soln</u>.





$f = 90\ N/mm^2$

$y = \frac{410}{2} = 205\ mm$

$I_{xx} = 25017 \times 10^4\ mm^4$

$\frac{M}{I} = \frac{f}{y} \Rightarrow M = I \cdot \frac{f}{y}$

$= 25017 \times 10^4 \times \frac{90}{205}$

$= 109.83 \times 10^6\ N.mm$

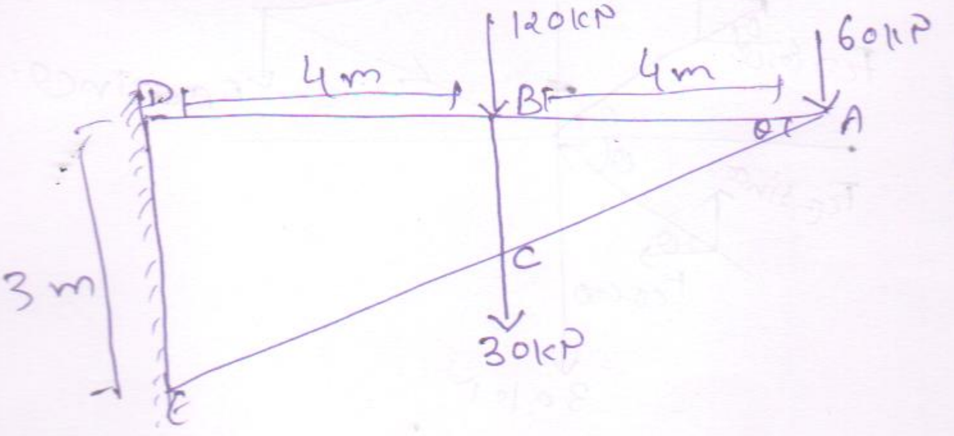
$M = \frac{wl^2}{8}$

$109.83 \times 10^6 = \frac{35 \times l^2}{8}$ $\therefore l^2 = 25104000$

$\boxed{l = 5010\ mm}$

Truss

Ex.1 Find forces in all the member of a cantilever truss as shown in fig.



Sol^n

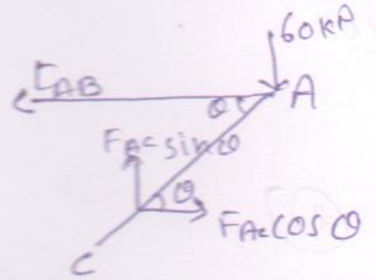
$\tan\theta = \frac{3}{8} = 0.375 \Rightarrow \theta = 20.55^\circ$

$\sin\theta = 0.351$

$\cos\theta = 0.936$

Joint - A :-

Assume tensile force in AB and compressive force in AC.



$\Sigma V = 0$

$\therefore F_{AC} \sin\theta = 60$

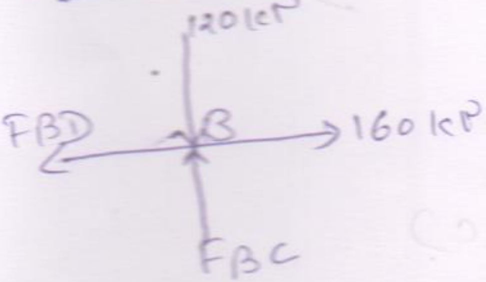
$F_{AC} = \frac{60}{0.351}$

$= 170.94\ kN\ (C)$

$\Sigma H = 0$

$F_{AB} = F_{AC}\cos\theta = 170.94 \times 0.936 = 160\ kN\ (T)$

Joint - B



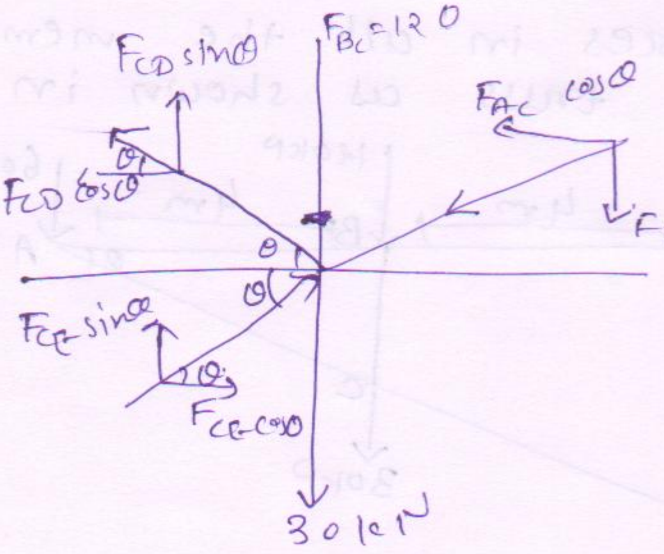
$\Sigma V = 0$

$F_{BC} = 120\ kN\ (C)$

$\Sigma H = 0$

$F_{BD} = 160\ kN\ (T)$

Joint-C



$\Sigma V = 0$

$\therefore F_{CD}\sin\theta + F_{CE}\sin\theta = 120 + 30 + F_{AC}\sin\theta$

$\therefore F_{CD}\times 0.351 + F_{CE}\times 0.351 = 120 + 30 + (170.94\times 0.3$

$\therefore F_{CD}\times 0.351 + F_{CE}\times 0.351 = 210$

$F_{CD} + F_{CE} = 598.29$ —— (1)

$\Sigma H = 0$

$F_{AC}\cos\theta + F_{CD}\cos\theta = F_{CE}\cos\theta$

$\therefore F_{AC} + F_{CD} = F_{CE}$

$\therefore F_{CD} - F_{CE} = -F_{AC}$

$\therefore F_{CD} - F_{CE} = -170.94$ —— (2)

solving eqn (1) & (2)

$F_{CD} + F_{CE} = 598.29$

$F_{CD} - F_{CE} = -170.94$

$2F_{CD} = 427.35$

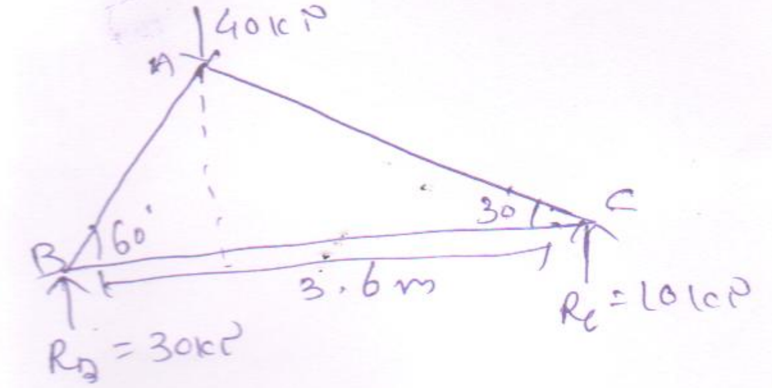
$\boxed{F_{CD} = 213.67\text{ kN}}$ (T)

$F_{CD} + F_{CE} = 598.29$

$213.67 + F_{CE} = 598.29$

$\boxed{F_{CE} = 384.62\text{ kN}}$ (C)

Ex.2 Find forces in all the members of the frame shown by method of joints.



Sol^n From $\triangle ABC$, $\cos 60^\circ = \dfrac{AB}{BC}$

$AB = BC \cos 60 = 3.6 \times 0.5$
$= 1.8$ m

from $\triangle ADB$, $\cos 60^\circ = \dfrac{BD}{AB}$

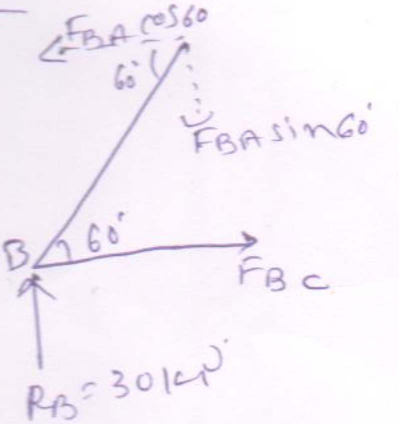
$\therefore$ $BD = AB \cos 60^\circ = 1.8 \times 0.5 = 0.9$ m

Taking moment @ B

$R_C \times 3.6 = 40 \times 0.9$ $\Rightarrow$ $\boxed{R_C = 10 \text{ kN}}$ $\uparrow$

$R_B = 30$ kN

Joint-B.



$\Sigma V = 0$

$\therefore F_{BA} \sin 60^\circ = 30$

$\therefore F_{BA} = 36.64$ kN (C)

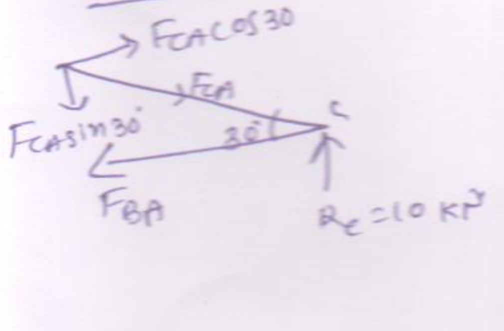
$\Sigma H = 0$

$F_{BC} = F_{BA} \cos 60^\circ$

$= 34.64 \times 0.5$

$= 17.32$ kN (T)

Joint-C



$\Sigma V = 0$

$F_{CA} \sin 30^\circ = 10$

$F_{CA} = 20$ kN (C)