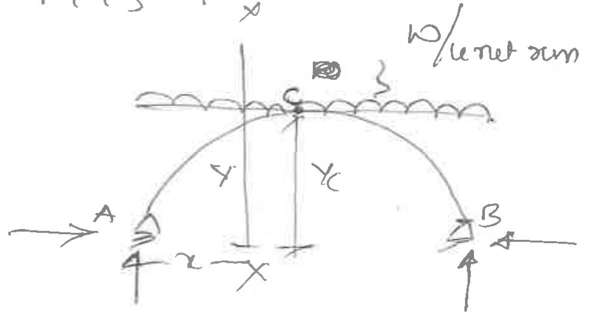
Q.P. code:- 21495 Q.1   Solution CBSGS SAI
May 2018   1

1 (a)



Reactions. $V_A = V_B = \frac{wl}{2}$ — 1 mark —

B.M. C_L

$H_A = \frac{wl^2}{8 y_c}$ → — 1 mark —

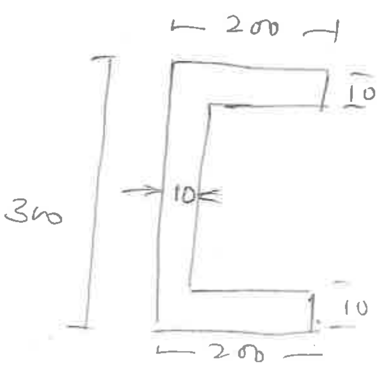
B.M. xx

$V_A(x) - wx\left(\frac{x}{2}\right) - H \cdot y$

$= \frac{wlx}{2} - \frac{wx^2}{2} - \frac{wl^2}{8y_c} \times \frac{4y_c}{l^2}(lx - x^2)$

$= \frac{wxl}{2} - \frac{wx^2}{2} - \frac{wxl}{2} + \frac{wx^2}{2} = 0$ — 3 marks —

(1) b



$\bar{y} = 150\,mm$ (Sym. about xx axis)

$I_{xx} =$ 3 marks

Shear Centre:

$= \frac{h^2 b^2 t_f}{4I} =$ for $I_{xx} = I$

P.T.O.

(Q2)

$$I_{xx} = 2\left[\frac{200\times10^3}{12} + (200\times10)(150-5)^2\right]$$

$$2\left[\left(16.67\times10^5 + 2.9\times10^5\right) + \left[\frac{10\times180^3}{12}\right]\right]$$

$$(4.86\times10^6)$$

$$I_{xx} = 39.14\times10^5 + 4.86\times10^6$$

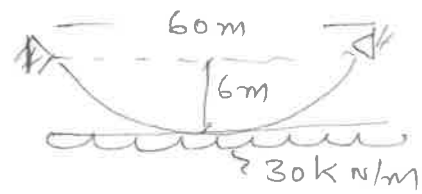
$$= \underline{4\times10^6}\ mm^4$$

Shear Centre: $\dfrac{h^2 b^2 t_f}{4I}$

$$= \frac{300^2\times 200^2\times 10}{4\times4\times10^6}$$

$$=$$

(1) c. Theory part



(1) d $T_{max} = T = H\sqrt{1+\left(\frac{dy}{dx}\right)^2}$

$$\boxed{T_{max} = 2250\cdot\sqrt{1+(0.4)^2} \quad = }$$

3 marks

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

$$= \frac{30\times60^2}{8\times6}$$

$$T_{min} = H = \underline{2250}\ kN.$$

(2) marks

origin from left

$$y = \frac{4\,y_c}{l^2}\,x(L-x)$$

$$\frac{dy}{dx} = \frac{4y_c}{l^2}\cdot(l-2x)$$

Tension Max at $x=0$ = (Supports)

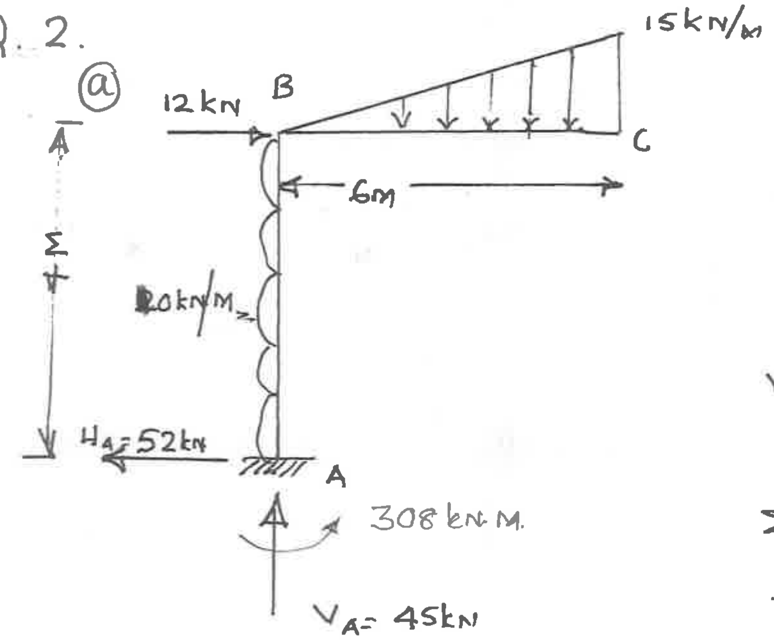
$$\frac{dy}{dx} = \frac{4\times6}{60^2}(60-2\times0)$$

$$= \underline{0.4}$$

Q.2

Q. 2.

(a)



b3

$\Sigma F_y = 0$

$V_A - \frac{1}{2} \times 6 \times 15$

$\underline{V_A = 45 \text{ kN}}$ (↑)

$\Sigma F_x = 0$ (+ve →)

$+H_A + 10 \times 4 + 12 = 0$

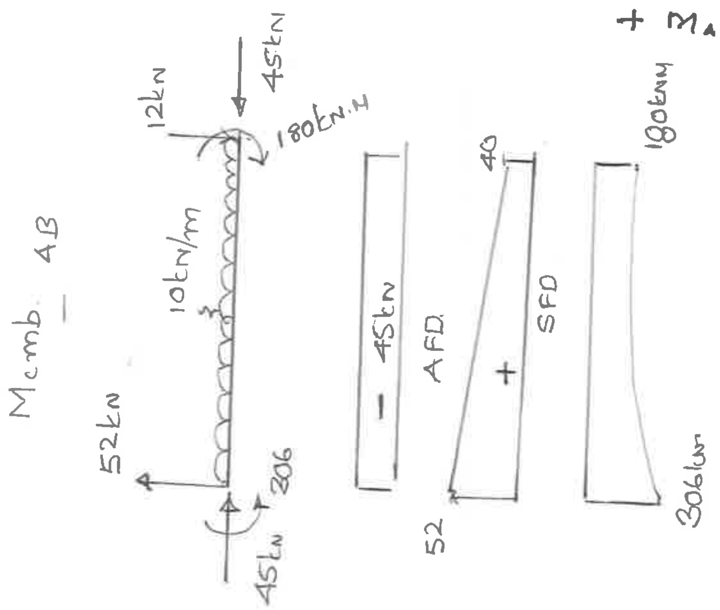
$H_A = 52$ kN (←)

$\Sigma M_A = 0$ (+ve)

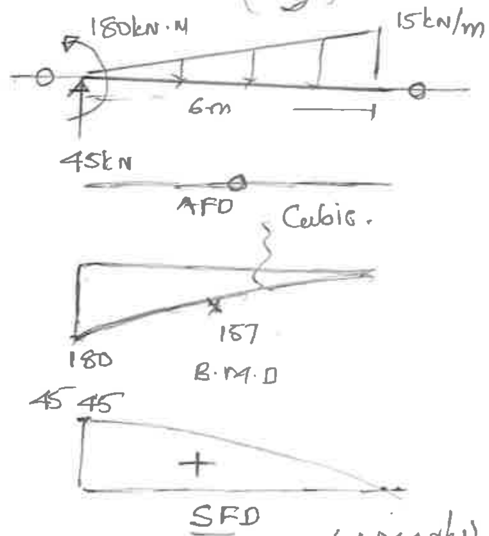
—(2)—

$+M_A + 45 \times 4 + 12 \times 4 + 10 \times 4 \times 2 = 0$

$M_A = 308$ kN.M.

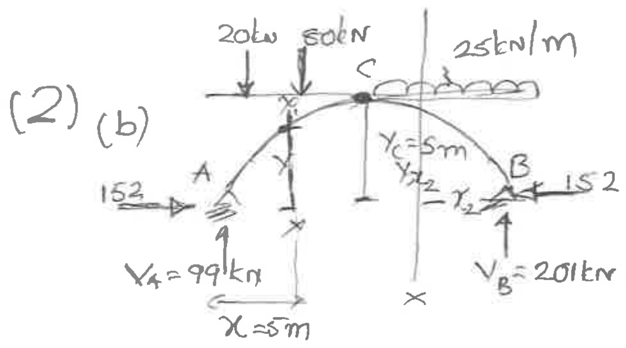


(4 marks)



(4 Marks)

(2) (b)



Reactions $V_A = 99$kN

$V_B = 201$kN

$H_A = H_B = 152$ kN.

(2 marks)

$Y = \frac{4Y_c}{l^2}\left[lx - x^2\right] = 3.75$ m

$\tan\theta = \frac{dy}{dx}$ $\therefore \theta = 26.56°$, $V = 99 - 20$

$= 79$ kN

Normal thrust : $V \sin\theta + H \cos\theta$

$= 171.28$ kN

Radial shear $= 2.69$ kN.

$B.M_{xx} = -115$ kN.M. (5) marks.

P.T.O

04

$$B.M. \text{ at } x_2 = -25\frac{x_2^2}{2} + 201 \cdot x_2 - H \times Y_{x_2}$$

$$Y_{x_2} = \frac{4Y_c}{l^2} x_2(l - x_2)$$

$$Y_{x_2} = x_2 - 0.05x^2$$

$$M_{x_2} = -4.9x_2^2 + 49x_2 \rightarrow A$$

for M_{x_2} to max

$$\frac{dM_{x_2}}{dx} = 0$$

$$0 = 4.9x_2^2 + 49x_2$$

$$x_2 = 5M.$$

from A

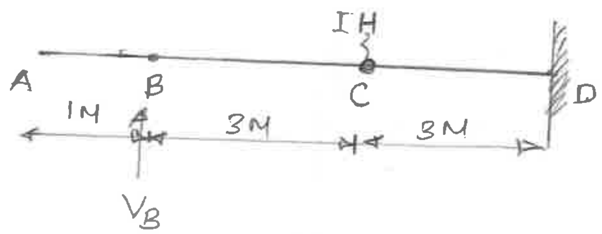
$$B.M_{max} = +122.5 \text{ kN.M.}$$

(3 marks)

Q.3.

3 (a)

05



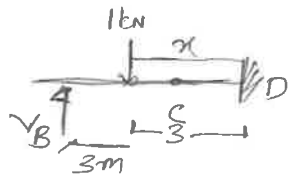
When the unit load in CD

$B.M_{C_L} = 0 \quad 0 \le x < 3$

$V_B \times 3 = 0$

$V_B = 0$

When the unit load in BC



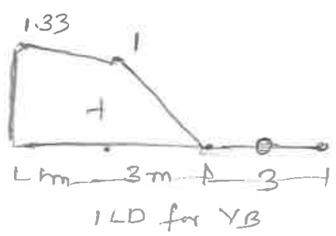
$BM_{C_L} = 0 \quad 3 < x < 7$

$3V_B - 1(x-3) = 0$

$V_B = \left(\frac{x-3}{3}\right)$

ILD for V_B

x	$V_B = \left(\frac{x-3}{3}\right)$
0	0
3	0
6	1
7	1.33



ILD for V_B

— 4 marks —

Now

$0 < x < 7$

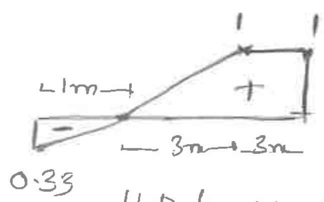
$\Sigma F_y = 0$

$V_B + V_D = 1$

$\boxed{V_D = 1 - V_B}$

ILD for V_B

V_B	x	$V_D = 1 - V_B$
0	0	1
0	3	1
1	6	0
1.33	7	−0.33



ILD for V_D

— 3 marks —

Now

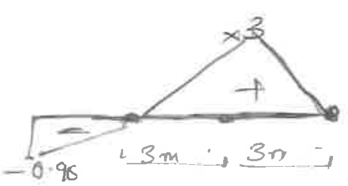
$\Sigma M_D = 0 \quad 0 < x < 7$

$V_B \times 6 - 1x + M_D = 0$

$\boxed{M_D = x - 6V_B}$

ILD for M_D

x	V_B	$M_D = x - 6V_B$
0	0	0
3	0	3
6	1	0
7	~~0.98~~ 1.33	−0.98

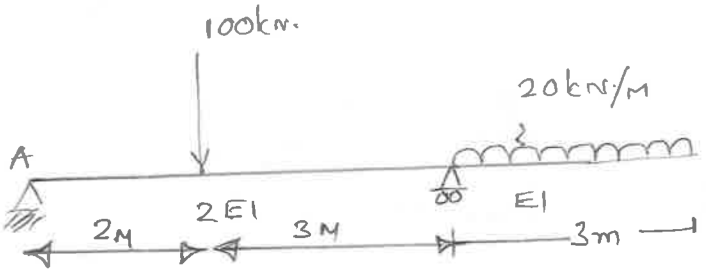


ILD for M_D

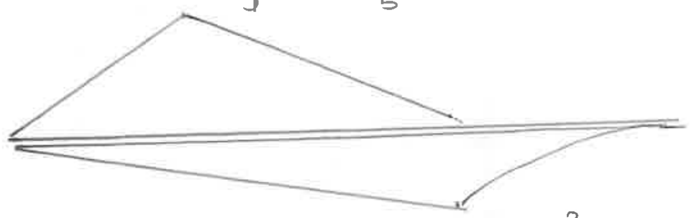
— 3 marks.

06

(3) b

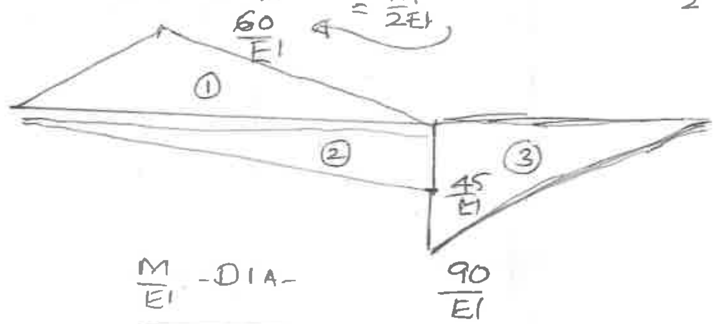


$M = W.\frac{ab}{l} = \frac{100\times2\times3}{5} = 120\,kN.M$



$M = \frac{wl^2}{2} = \frac{20\times3^2}{2} = 90\,kN.M$ (2 marks)

M. DIAGRAM



$\frac{M}{EI}$ -DIA-

(2 marks)

$A_1 = \frac{1}{2}\times5\times60$

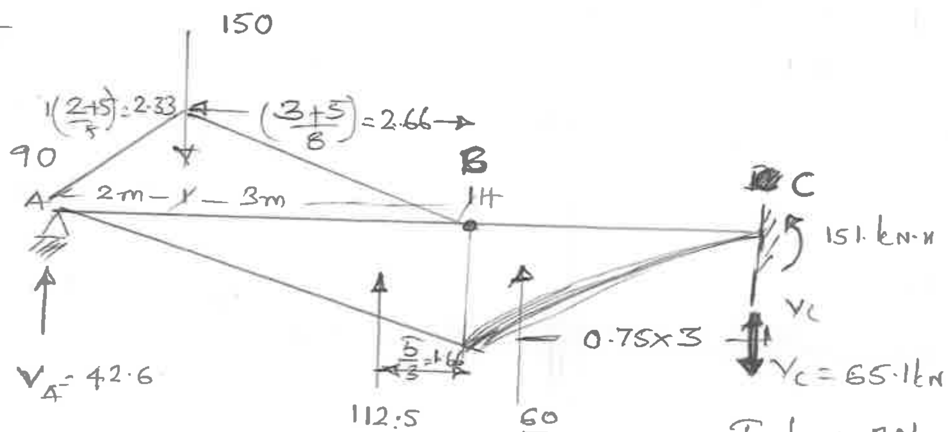
$= \frac{150}{EI}$

$A_2 = \frac{1}{2}\times5\times45$

$= \frac{112.5}{EI}$

$A_3 = \frac{1}{3}\times2\times90$

$= \frac{60}{EI}$



C. Beam.

Taking $BM_{B_L} = 0$

$V_A\times5 - 150\times2.66 + 112.5\times1.66 = 0$

$V_A = \underline{42.6\,kN}$

$\underline{\Sigma F_y = 0}$

$V_A - 150 + 112.5 + 60 + V_C = 0$

$V_C = -\underline{65.1}$

$\underline{\Sigma M_C = 0}$

$M_C + 42.6\times8 - 150\times5.66$
$+ 112.5\times4.66$
$+ 60\times0.75\times3 = 0$

$M_C = -151.\ kN.M$

$M_C = 151\,kN.M$

$\theta_B = \frac{42.6 - 150 + 112.5}{EI} = +\frac{5.1}{EI}$ Rad

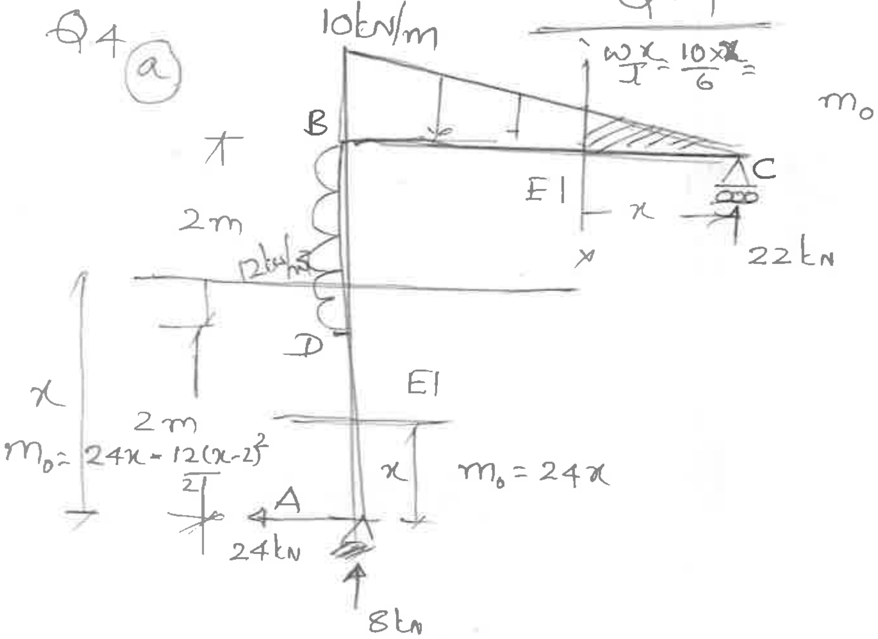
$\theta_C = +\frac{65}{EI}$ rad (from right)

$Y_C = +\frac{151}{EI}$ M (from right)

Q4 (a)

Q.4

07



$m_0 = \frac{1}{2} \times x \times \frac{10x}{6} = 0.833x^2\left(\frac{x}{3}\right) + 22x$

$\Sigma M_A = 0$

$24 \times 3 + \frac{1}{2} \times 10 \times 6 \times 2 - V_c \times 6 = 0$

$V_c = 22\,kN$

$\Sigma F_y = 0$

$V_A + V_C = 30\,kN$

$V_A = 8\,kN$

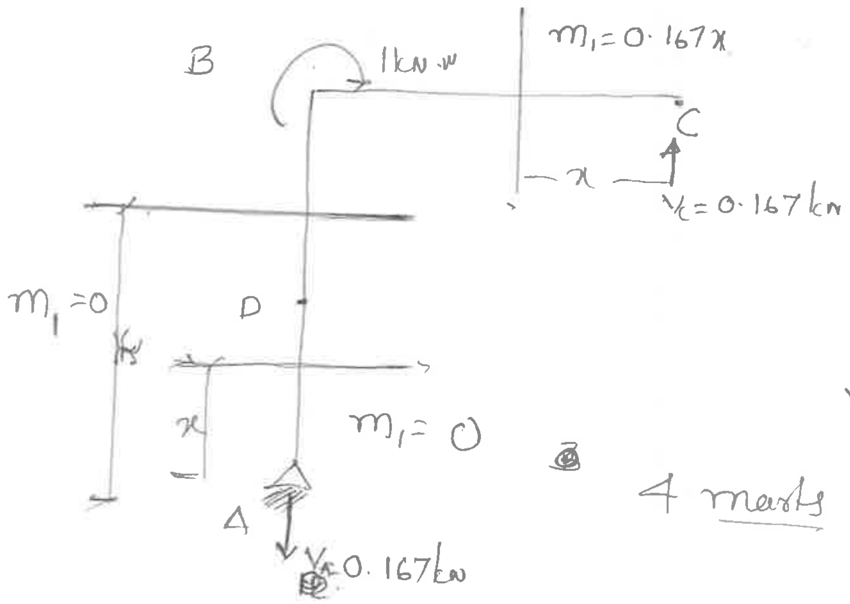
4 marks

$\Sigma F_x = 0$

$+H_A + 24 = 0$

$H_A = 24\,kN\ (\leftarrow)$

($\rightarrow$ 2 marks)



$V_c = 0.167\,kN$

$V_A = 0.167\,kN \downarrow$

4 marks

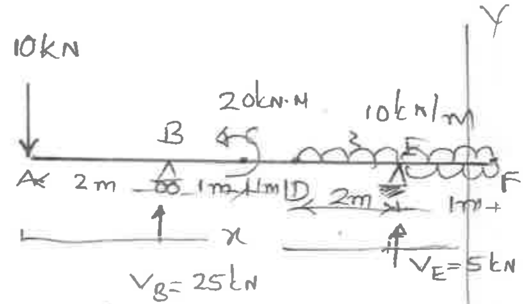
SPAN	origin	limit	EI	m_0	m_1	$= \int_0^L \frac{m_0 m_1}{EI} dx$
AD	A	0–2	EI	$24x$	0	0
BD	A	2–4	EI	$24x - 6(x-2)^2$	0	0
BC	C	0–6	EI	$-\frac{0.833x^3}{3} + 22x$	$0.167x$	$\frac{192.58}{EI}$

$\theta_B = \frac{192.58}{EI}$ rad

2 marks

~~If~~ ~~[illegible]~~ If Students assume fixed support give the marks accordingly.

4 (b) or



$\Sigma F_y = 0$

$V_B + V_E = 30$ kN.

$\Sigma M_B = 0$

$-V_E \times 4 - 20 - 10\times 2 + (10\times 2)\,3 = 0$

$V_E = 5$ kN

$V_A = 25$ kN — 2 mark —

$$EI\,\frac{d^2y}{dx^2} = M_x$$

$$= -10.x + 25(x-2) - 20 - 10\frac{(x-4)^2}{2} + 5(x-6) + 10\frac{(x-6)^2}{2}.$$

$$EI\,\frac{dy}{dx} = -10\frac{x^2}{2} \Big| + 25\frac{(x-2)^2}{2} \Big| - 20x \Big| - 10\frac{(x-4)^3}{6} \Big| + 5\frac{(x-6)^2}{2} \Big| + 10\frac{(x-6)^3}{6}. + C_1$$

$$EI.\,y = -10\frac{x^3}{6} \Big| + 25\frac{(x-2)^3}{6} \Big| - 20\frac{x^2}{2} \Big| - 10\frac{(x-4)^4}{24} \Big| + 5\frac{(x-6)^3}{6} \Big| + 10\frac{(x-6)^4}{24} + C_1x + C_2$$

At ~~x=0~~,

Solve for C_1 & C_2

$\theta_A =$ $x = -2$

$\theta_D =$ $x = 2$

$\theta_F =$ $x = 5$

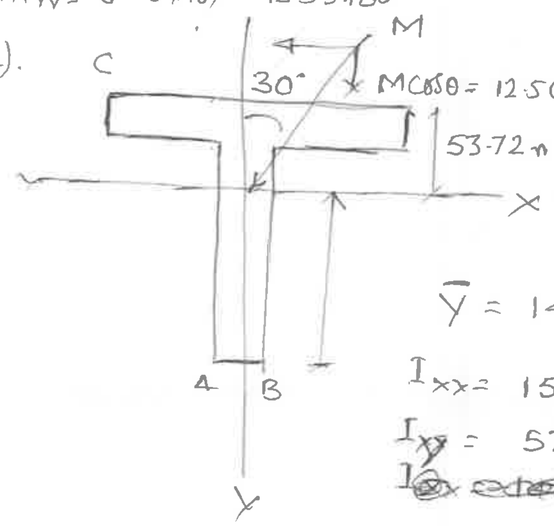
$Y_D =$ $x = +2$

$Y_F =$ $x = 5$

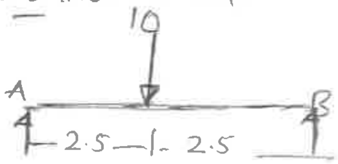
Q.5

5 (a).

$M_{yy} = 6.25\times10^6 / 12.5\sin 30$



$M\cos\theta = 12.5\cos 30 = 10.825\times10^6 = M_{uu}$



$\bar{Y} = 146.28$

$I_{xx} = 15.47\times10^6$

$I_{yy} = 57.05\times10^6$

$\cancel{I_{xy}}\ I(x,y)$

$M = \frac{wl}{4} = \frac{10\times5}{4} = 12.5\,kN\text{-}M$

(4 marks

$$I_{uu} = \left(\frac{I_{xx}+I_{yy}}{2}\right) + \sqrt{\left(\frac{I_{xx}-I_{yy}}{2}\right)^2 + (I_{x,y})^2}$$

$$I_{vv} = \left(\frac{I_{xx}+I_{yy}}{2}\right) - \sqrt{\left(\frac{I_{xx}-I_{yy}}{2}\right)^2 + (I_{x,y})^2}$$

$I_{uu} = 68.29\times10^6\ mm^4$

$I_{vv} = -45.97\times10^6\ mm^4$

$$\sigma_A = \frac{M_{uu}}{I_{uu}}(v) + \frac{M_{vv}}{I_{vv}}(u)$$

$$\sigma_A = \frac{10.825\times10^6}{68.29\times10^6}(-146.28) \quad \frac{6.25\times10^6}{46\times10^6}(-5) = 23.86\ N/mm^2$$

$$= 23.187 + 0.67 =$$

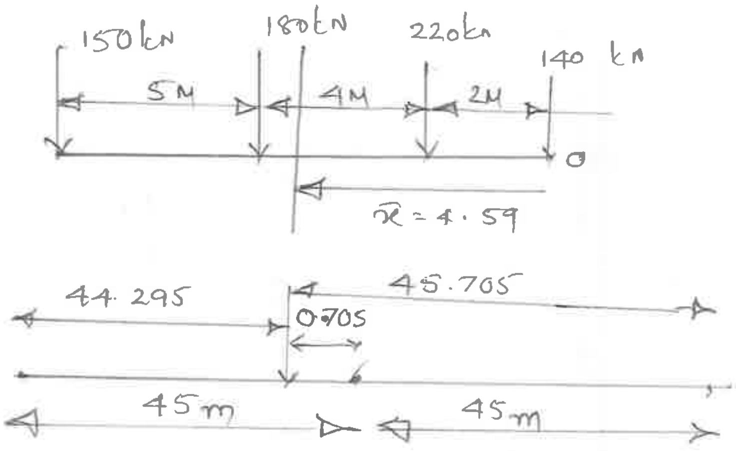
$$\sigma_B = \frac{10.825\times10^6}{68.29\times10^6}(-146.28) + \frac{6.25\times10^6}{46\times10^6}(+5) =$$

$$-23.11 + 0.675 = -22.43\ N/mm^2$$

$$\sigma_C = \frac{10.825\times10^6}{68.29\times10^6}(53.72) + \frac{6.25\times10^6}{46\times10^6}(100) =$$

$$+8.4 + 13.5 = +21.9\ N/mm^2$$

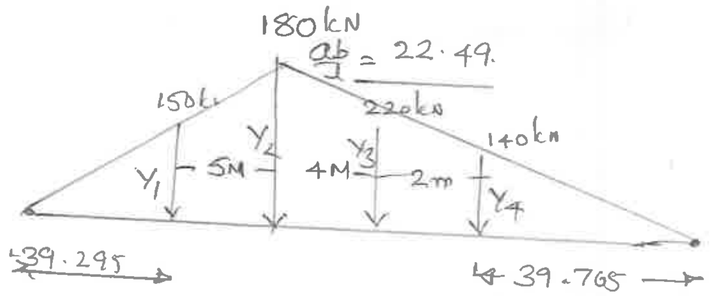
(5) b



$$\bar{X} = \frac{140\times0 + 220\times2 + 180\times6 + 150\times11}{140+220+180+150}$$

$= 4.59\,m$

— 02 marks



— 4 marks —

Ordinates

$$Y_1 = \frac{39.295 \times 22.49}{44.295} = 19.95$$

$$Y_3 = \frac{41.705 \times 22.49}{45.705} = 20.52$$

$$Y_4 = \frac{39.705 \times 22.49}{45.705} = 19.53$$

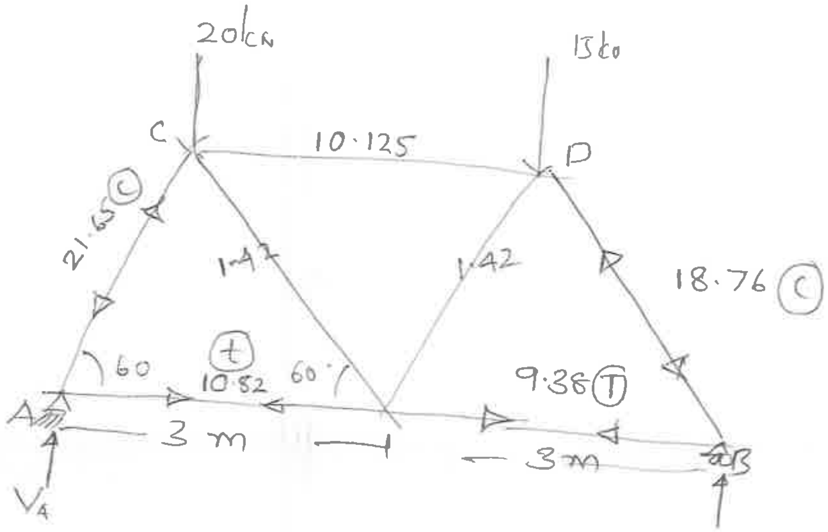
— 4 marks —

Max. abs. B.M $= W_1Y_1 + W_2Y_2 + W_3Y_3 + W_4Y_4$

$= 14289.3$ kN.M

6

a

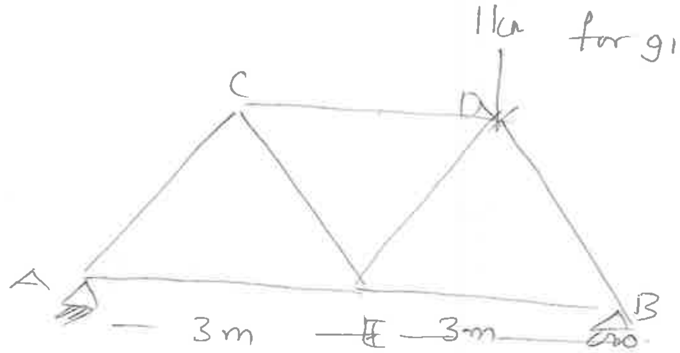


$V_A = 18.75$ $V_B = 16.25$

P Calculation

Reactions. (1) mark

forces in all members for given load (3) marks



K Calculation

Reactions. 1 mar

forces in all members (for unit load) — 3 marks

δ_{V_D}

Memb	A	E	P	K	l	$\Sigma \frac{PKl}{AE}$

— 2 marks —

12

6 b

$D = 200$ mm

$d = 180$ mm

$P = 140$ kN

$e = 30$ mm.

$A = \frac{\pi}{4}\left[200^2 - 180^2\right]$

$= 5.96 \times 10^3$ mm2

$I_{xx} = I = \frac{\pi}{64}\left(200^4 - 180^4\right)$

$I = ?$

(2 marks)

$\sigma_D = \frac{P}{A} = \frac{140}{\frac{\pi}{4}(D^2 - d^2)}$ → 2 marks

$\sigma_b = \frac{M}{I} \cdot Y_{max}$

$= \frac{P \cdot e \times Y_{max}}{I_{xx}}$ → 2 marks

$\sigma_{max} = \sigma_D + \sigma_b$ → 1½ Marks

$\sigma_{min} = \sigma_D - \sigma_{m}$ → ½ mark

Bending stress distribution → 1 mark