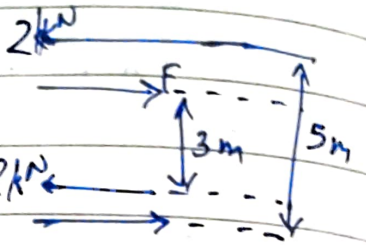
21th October, 2022

# Couple

2/63. $M = 2(5) = 10$

$10 = F(3)$

$F = 3.3$ kN




$\Sigma M = 0$

$2(5) - F(3) = 0$

$F = 3.3$

2/64.

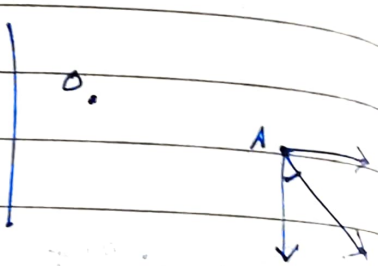
$M = 18(\sin 30)(0.32) - 8\cos 30(3)$

$= 11.28 - 20.78$

$= -22.064$ kNm

$= -19.5$ kNm

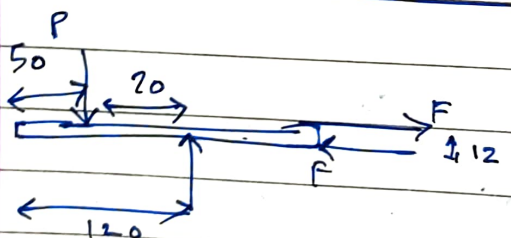
$= 19.5$ Nm C.W




2/65. $\Sigma M = 0$

$300(12) - P(50) - P(120) = 0$

$3600 = 170P$



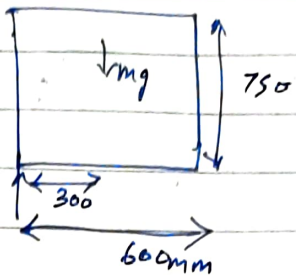

$300(12) - P(70) = 0$

$\frac{300 \times 12}{70} = P$

$P = 51.42$ kN

2/66. $M = 5(0.3)(9.81)$

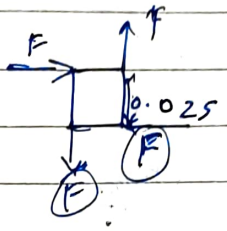
couple $= 1.5$ Nm




~~mg (0.3)~~

2/67. $M = 250(0.7)$

$= 175.0$




$F\left(\frac{0.350+0.350}{2}\right) = 175$

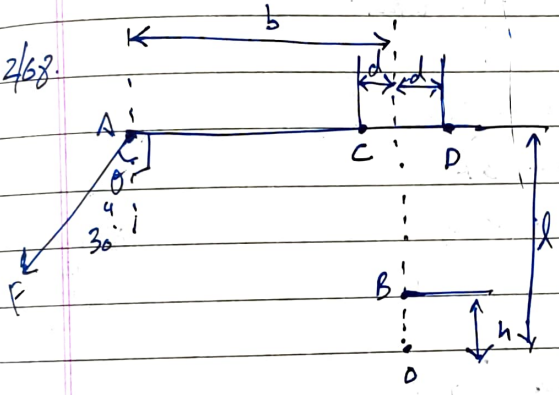
$F(0.35) = 175$

$F = 500$ N

$2F(0.025) = 175$

$F = 3500$

2/68.




$F = 425$
$\theta = 30$
$b = 1.9$
$d = 0.2$
$h = 0.8$
$l = 2.75$

force couple at B : $F = 425$ N @ 120° below Horizontal

$M_B = F\cos\theta\,(b) + F\sin\theta\,(l-b)$

$= 425\cos 30(1.9) + 425\sin 30(2.75 - 0.8)$

$= 699.31 + 414.625$

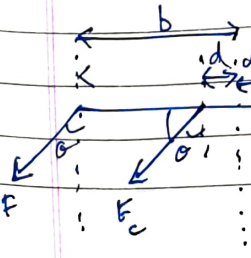
$= 1114$ Nm ccw

~~$= 829.935$ Nm ccw~~

2.75
−1.90
0.85

now replacing F by two forces such that the resultant is in direction of F one at C & one at D

$F_C > F_D$




$F_C - F_D = 425$

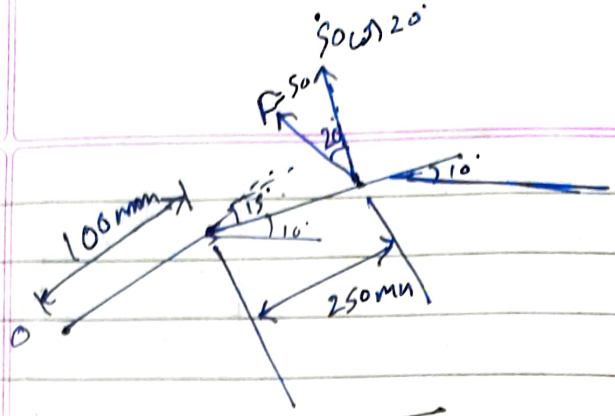
$M_A = 0 \Rightarrow F_C\cos\theta\,(b-d) = F_D\sin\theta\,(b+d)$

$F_C\cos 30(1.7) = F_D\sin 30(2.1)$

$F_C = 1.235 F_D$

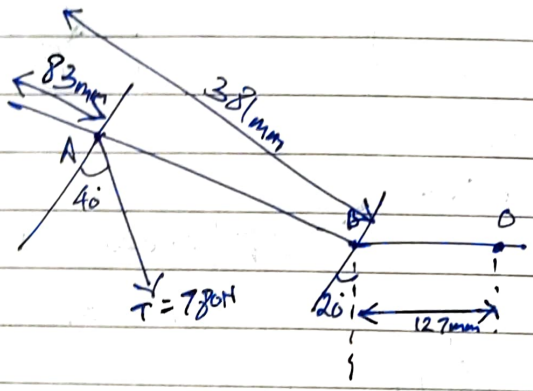
$F_D = 1808$ N @ 60° above Horizontal | $F_C = 2230$ N @ 60° below Horiz

2/69.




~~50 cos 20° (0.25)~~

2/70.

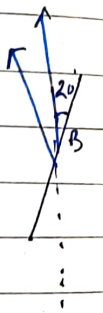



~~$T = 780\cos 40(-\hat{i}) + 780\sin 40(\hat{j})$~~

$M_B =$ ~~$780\cos 40(0.381 - 0.083)$~~

$= 780\cos 40\,(0.381 - 0.083)$

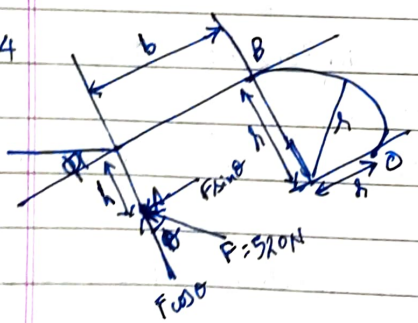
$= 178.05$ N·m CCW




$M_O = M_B +$ ~~$T$~~ $T\cos 20\,(0.127)$

$= 271\,\hat{k}$ N·m

2/74



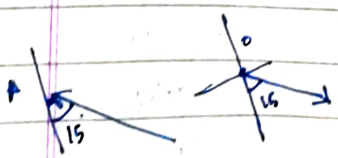

$M_O = -F\cos\theta\,(b+s) + F\sin\theta\,(s-h)$

$= -520\cos 15(0.45 + 0.325) + 520\sin 15\,(0.325 - 0.215)$

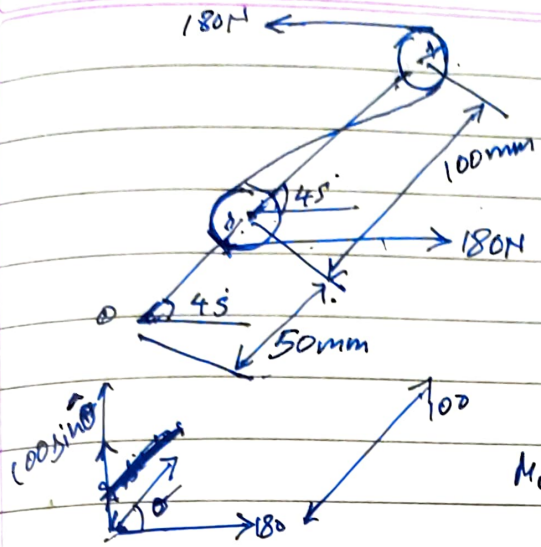
$= -389.26 + 14.80$

$= -374.45$ N·m

$= 374.45$ N·m CW



2/75.




$s = 25\text{mm}$

$M_O = 180[0.1\sin 45 + 0.025 + 0.025]$

$= 180(0.1\sin 45 + 0.025 + 0.025)$

$= 21.7\ \text{Nm ccw}$

2/76.

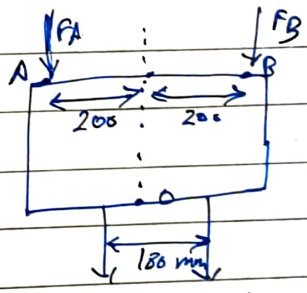
2/77. $M_O = +6.3(10^{-3})(90)(10^{-3}) - 4.1(10^{-3})(90)(10^{-3})$

$= 567.0 - 369$

$= 198\ \text{Nm ccw}$

$F(400)10^{-3} = 198$

$F = \frac{198}{0.4} = 472.5\ \text{N}$




6.3kN 4.1kN

Replacing 6.3 & 4.1 with $F_A$ & $F_B$

$\Rightarrow F_A + F_B = 6.3 + 4.1\ \text{kN}$

$F_A + F_B = 10.4\text{kN} = 10400\text{N}$

&

$F_A(0.2) - F_B(0.2) = 198$

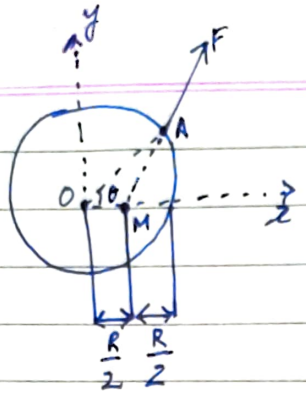
$F_A - F_B = 990\ \text{N}$

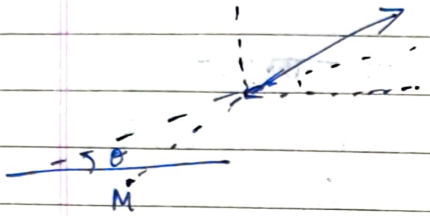
$2F_A = 11390$

$F_A = 5695\ \text{N}$

$F_B = 4705\text{N}$ //

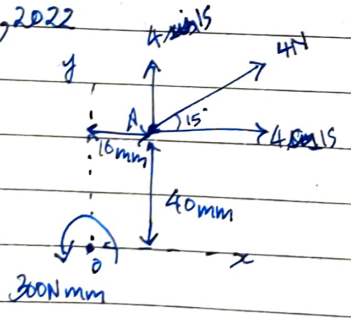
2/18




1st November, 2022

2/26.

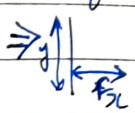



$M_o = 300 - 4\cos 15^{(40)} + 4\sin 15^{(10)}$

$= 300 - 154.54 + 10.35$

$= 155.81$ N mm

to find y-intercept of line of action of force for single equivalent force




$F_x(y) = M_o$

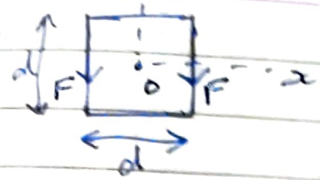
$\Rightarrow 4\cos 15(y) = 155.81$

$3.86\, y = 155.81$

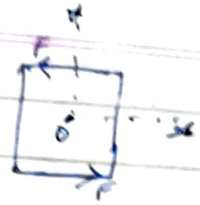
$y = 40.36$

$y = -40.36$

2/82 a)




b)




c)


$M_O = F\frac{d}{2} - F\frac{d}{2}$

$M_O = 0$

Eq. : $R = -2F\hat{j}$

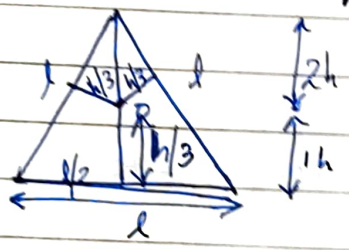
$R = 0$

$M_O = F(d)\hat{k}$

$R = -F\hat{i} + F\hat{j}$

$M_O = -F\left(\frac{d}{2}\right) + F\frac{d}{2} = 0$

2/83.

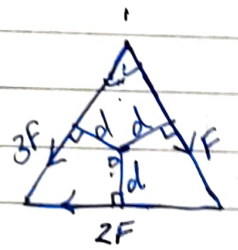


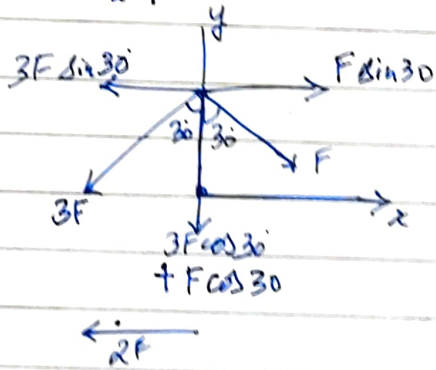

$h = \sqrt{l^2 - \frac{l^2}{4}} = \frac{l\sqrt{3}}{2} = h \Rightarrow \frac{h}{3} = \frac{l\sqrt{3}}{6}$

let $\frac{h}{3} = d$

equilateral Δ centroid divides 2:1

a)



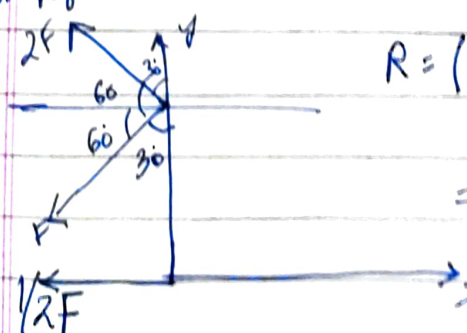

$R = (-3F\sin 30 - 2F + F\sin 30)\hat{i} + (-3F\cos 30 - F\cos 30)\hat{j}$

$= (-3F\hat{i}) + \left(-\frac{4}{2}F\sqrt{3}\right)\hat{j} = -3F\hat{i} - 2F\sqrt{3}\hat{j}$

$M_O = 3F(d) - F(d) - 2F(d) = 0$

see q from pdf

b)



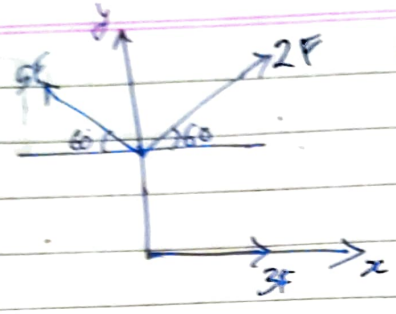

$R = (-2F\cos 60 - F\cos 60 - 1/2F)\hat{i}$

$+ (2F\cos 30 - F\cos 30)\hat{j}$

$= -2F\hat{i} + F\frac{\sqrt{3}}{2}\hat{j}$

$M_O = F(d) + 2F(d) - \frac{1}{2}F(d) = +\frac{5}{2}Fd$

c)




$$R = (2F\cos 60 - 5F\cos 60)\hat{i} + 3F + (7F \sin 60)\hat{j}$$

$$R = \left(F - \frac{5F}{2} + 3F\right)\hat{i} + \frac{7F\sqrt{3}}{2}\hat{j}$$

$$= \frac{3F}{2}\hat{i} + \frac{7\sqrt{3}F}{2}\hat{j}$$

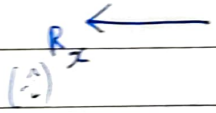
$$M_o = -2F(d) + 5Fd + 3F(d)$$

$$= 6Fd = 6F\frac{l\sqrt{3}}{6} \text{ CCW}$$

Specify the location of force along y-axis ($F_y$)

$\Rightarrow$ dist along y-axis needed

b)




we got $M_o$ as CCW

$\Rightarrow R_x$ should be above O

$\Rightarrow R_x(y) = M_o$

$2F(y) = \frac{5\sqrt{3}}{12}Fl \Rightarrow y = \frac{5\sqrt{3}}{24}$

c)


To produce CCW moment $R_x$ should be below O

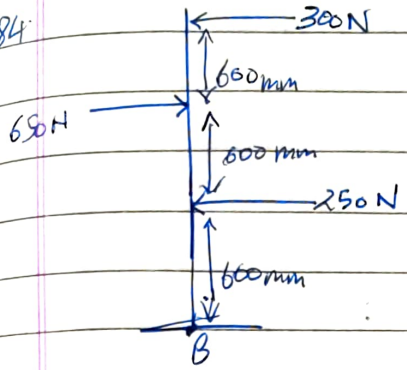
$R_x(y) = M_o$

$\frac{3}{2}F(y) = Fl\sqrt{3}$

$y = \frac{2l}{\sqrt{3}}$ //

Date
Page

2/84.

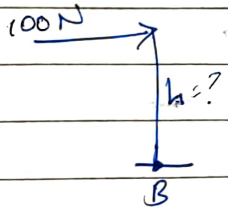



Find h above B where Res. of three forces act

$R = 650 - 300 - 250$

$= 350 - 250$

$= 100\ N$




$M_o = 300(1.8) + 250(0.6) - 650(1.2)$

$= 540 + 150 - 780$

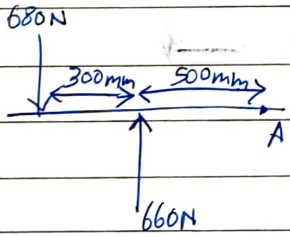
$= -90\ Nm$

$= 90\ Nm\ CW$

$100\ (h) = 90$

$h = 0.9\ m$

2/85.



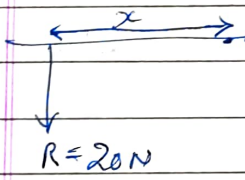

$R = -680 + 660 = -20$

$R = 20\ N$ below A

$M_A = +680(0.8) - 660(0.5)$

$= 544 - 330$

$= 214\ Nm\ CCW$

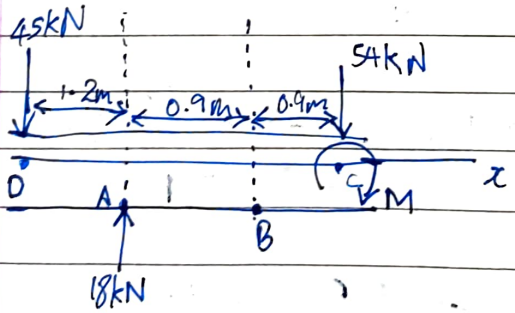



$R(x) = M_A$

$20(x) = 214$

$x = 10.7\ m$ left of A

2/86.




R passes through B

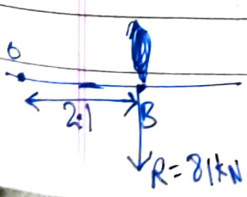
$R = 18 - 45 - 54 =$

$= -81\ kN$

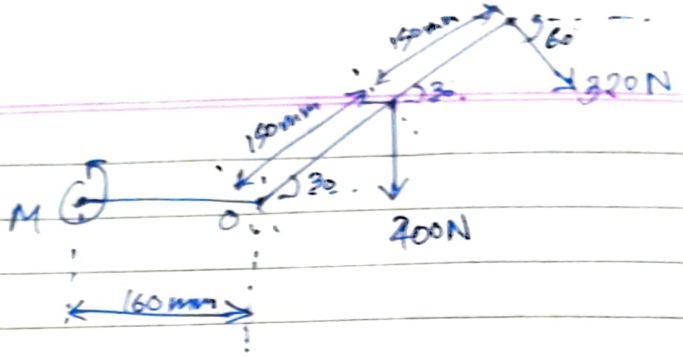
99
-18

$M_o = 81\ (2.1)\ Nm\ CCW$

$= 170.1\ kNm\ CW$



2/87




R passes through O  M = ?

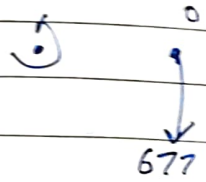
(complete M)

$R_y = 400 + 320 \sin 60$

$= 677.128$ N

$M = 677.128(0.16)$

$= 108.34$ Nm CW



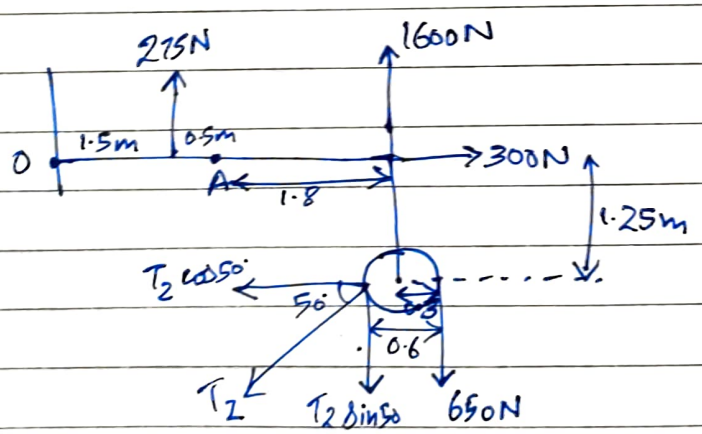

$\Rightarrow M_o = 0$

$M - 400(0.15\cos 30) - 320(0.3) = 0$

$M - 51.96 - 96 = 0$

$M = 147.96$ Nm

2/88




R passes through A $\Rightarrow \sum M_A = 0$

3.24
1.5625
4.8025

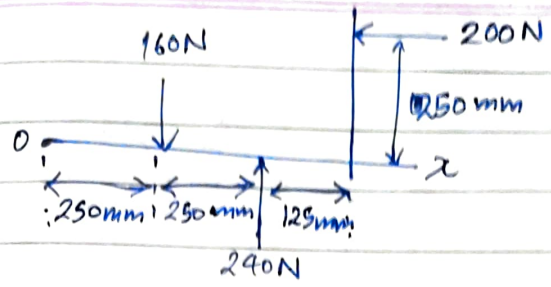
$+T_2(0.3)$ ?

$\sum M_A = 0 \Rightarrow -275(0.5) + 1600(1.8) - T_2\cos 50(1.25) - T_2\sin 50(1.8) - 650(2.4) = 0$

$-137.5 + 2880 - 1365 = T_2(0.8) + T_2(1.378)$

$1377.5 = T_2(2.178)$

2/89.



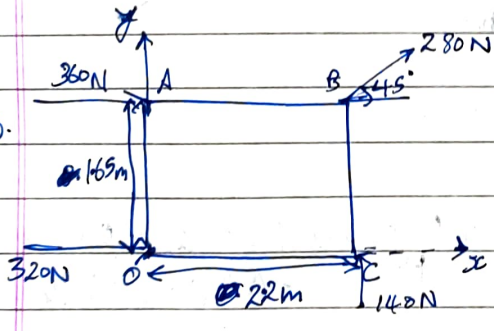

$$R = (240-160)\hat{j} - 200\hat{i}$$
$$= 80\hat{j} - 200\hat{i}$$

$$M_o = -160(0.25) + 240(0.5) + 200(0.25)$$
$$= 10 + 120$$
$$= 130 \text{ Nm ccw}$$

dist from O to point on x-axis $\Rightarrow R_y(x) = 130$
$= x$

$$80x = 130$$
$$x = 1.625 \text{ m}$$ from O towards right
(of 6th pipe)

2/90.




$$R = (360 + 320 + 280\cos 45)\hat{i} + (140 + 280\sin 45)\hat{j}$$
$$= 877.98\hat{i} + 337.98\hat{j}$$

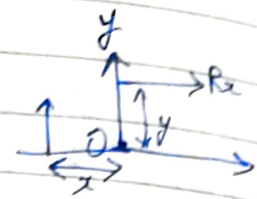
$$M_o = -360(0.165) + 140(0.22) - 280\cos 45(0.165) + 280\sin 45(0.22)$$
$$= -59.4 + 30.8 - 32.66 + 43.55$$
$$= -17.702 \text{ Nm} = 17.702 \text{ Nm cw}$$
$$= 177$$

points on x axis & y axis through which LOA of single R passes:

$R_x(y) = 17.702$ $\quad$ $R_y(x) = 17.702$

$y = 0.02$ 0.2 $\quad$ $x = 0.05$ 0.5

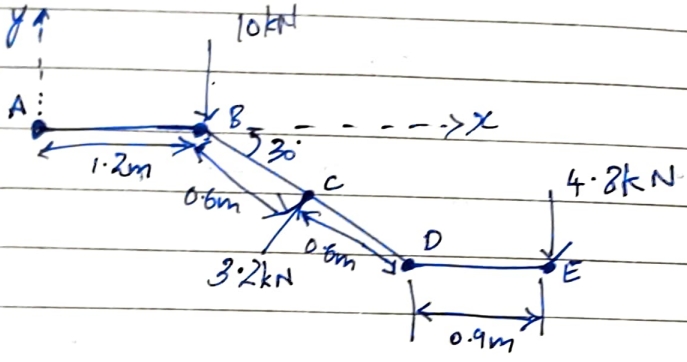
Now $M_O = 177.02$ Nm (C.W)



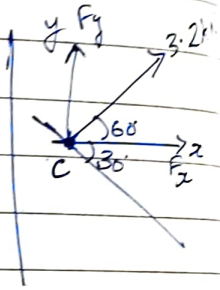

for $M_O$ to be CW
$R_x$ should be above O
$\Rightarrow y = 0.2$ m above O

$R_y$ should be left of O
$x = 0.5$m left of O
$\Rightarrow x = -0.5$m

2/91




$$R = (-10\hat{j} - 4.8\hat{j} + 3.2\sin 60\,\hat{j}) + 3.2\cos 60\,\hat{i}$$
$$= -12.028\,\hat{j} + 1.6\,\hat{i}$$



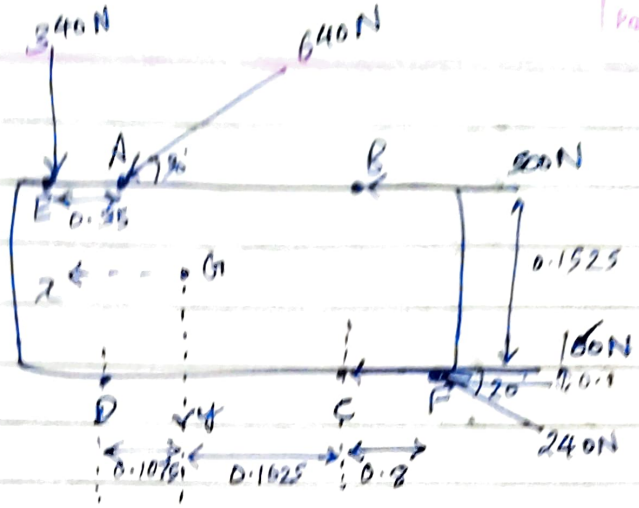

$$M_A = -10(1.2) + 3.2\sin 60(0.6\cos 30 + 1.2) + 3.2\cos 60(0.6\sin 30) - 4.8(0.9 + 1.2\cos 30 + 1.2)$$

$$= -12 + 4.765 + 0.48 - 15.06$$
$$= -21.815\ \text{kNm}$$
$$= 21.815\ \text{kNm CW}$$

x-intercept of LOA of R

$$R_y(x) = M_A$$
$$12.028(x) = 21.815$$
$$x = 1.813\ \text{m}$$

2/92




$$R = (+500 + 160 + 240\cos 20 + 640\cos 30)\hat{i} + (+340 + 640\sin 30 + 240\sin 20)\hat{j}$$

$$= +1439.78\hat{i} + 577.91\hat{j}$$

$$\Sigma M_G = 340(0.35 + 0.1075) + (640\cos 30 + 500 + 240\cos 20)\left(\frac{0.1525}{2}\right)$$

$$340(0.35 + 0.1075) + 640\cos 30\left(\frac{0.1525}{2}\right) + 500\left(\frac{0.1525}{2}\right)$$

$$-160\left(\frac{0.1525}{2}\right) - 240\cos 20\left(0.1 + \frac{0.1525}{2}\right)$$

$$+240\sin 20(0.1625 + 0.8) + 640\sin 60(0.1075)$$

$$= 1515 \text{ Nm CCW}$$

x (or y) intercepts = ?

$R_x(y) = M_G$ $\quad +x \leftarrow G$, $+y$

$y = \frac{1515}{1439.78} = 1.0522$

M is CCW $\Rightarrow R_x$ should be ~~above~~ to G

$(0, -1.0522)$

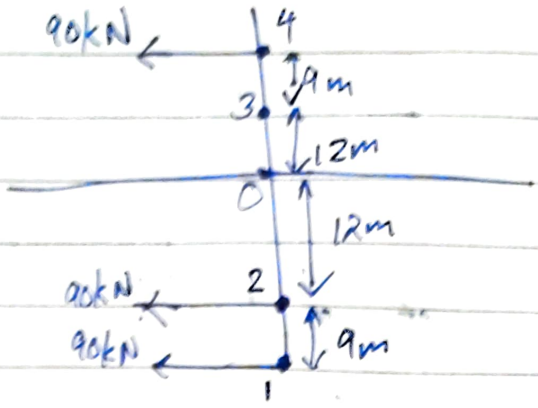
$R_y(x) = M_G$

$x = \frac{1515}{577.91} = 2.62$

$R_y$ ~~left~~ of G

$(+2.62, 0)$

2/93




$R = 270\ kN\ (-\hat{j})$

$M_O = 90(21) - 90(12) - 90(21)$

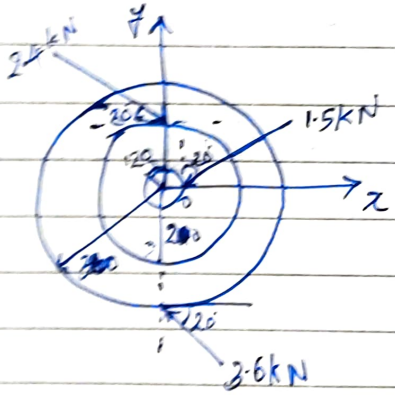
$= -1080\ kNm$

$= 1080\ kNm\ CW$

$R_y(d) = 1080$

$d = \frac{1080}{270} = 4m$ below O

2/94




$R = (2.4\cos 20 - 1.5\sin 20 - 3.6\cos 20)\hat{i}$

$+ (-2.4\sin 20 - 1.5\cos 20 + 3.6\sin 20)\hat{j}$

$= -1.64\hat{i} + -0.999\hat{j}$

$\Sigma M_O = -2.4\cos 20(200) + 1.5\sin 20(0) - 3.6\cos 20(300)$

$- 1.5\cos 20(120) = 1635\ Nm\ CW$

x & y intercepts

$R_y(x) = 439.14$

$x = 439.14$ mm

$0.999$

$x = 439.57$ mm

$R_x(y) = 1635$

$y = 996.95$ below 0

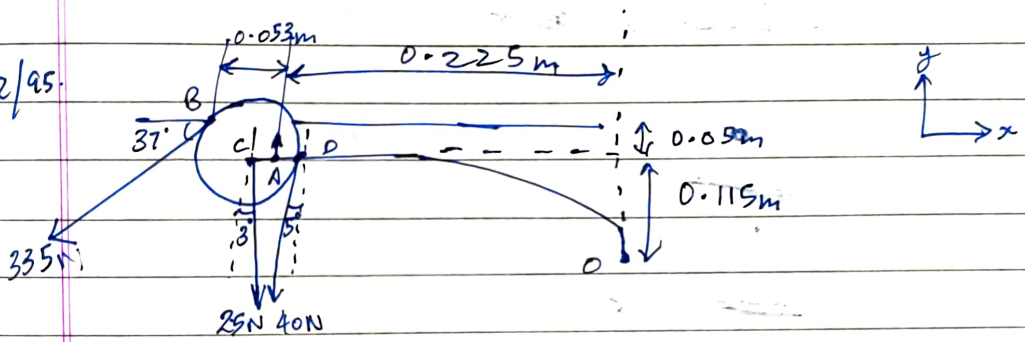
$(0, -996.95)$ mm

$R_y(x) = 1635$ (cw)

$x = 1636.63$ mm right of 0

$(1636.63, 0)$ mm

2/95.




$AC = AD = 0.015m$

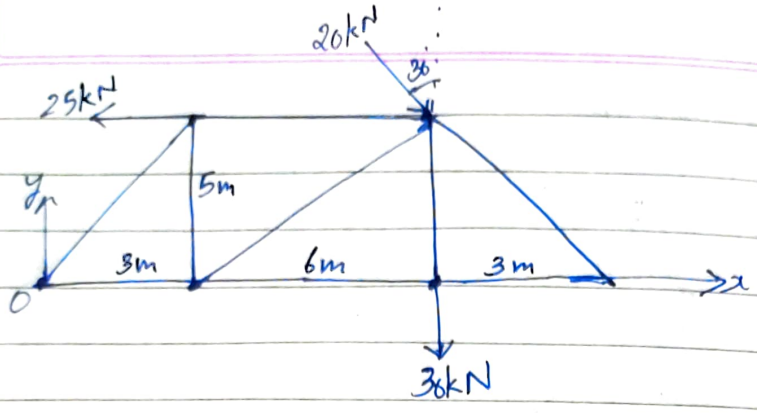
$R = (-335\cos 37 + 25\sin 3^\circ)\hat{i} + (-335\sin 37 - 25\cos 3^\circ - 40\cos 5^\circ - 40\sin 5^\circ)\hat{j}$

$= -269.72\hat{i} + (-266.42)\hat{j}$

$M_o = +335\cos 37(0.165) - 25\sin 3(0.115) + 40\cos 5(0.115)$
$+335\sin 37(0.218) + 25\cos 3(0.21) + 40\cos 5(0.21)$

$= 122.8$ Nm ccw

2/96

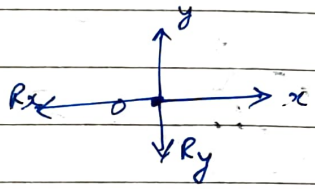



$R = (-25 + 20\sin 30)\hat{i} + (-30 - 20\cos 30)\hat{j}$

$= -15\hat{i} - 47.32\hat{j}$

$M_O = +25(5) - 20\sin 30(5) + 47.32(9)$ kN m

$= 350.88$ kN m CW

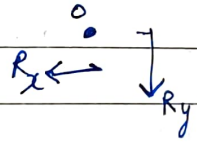



$R_x(y) = 350.88$ CCW

$y = \frac{350.88}{15}$

$y = 23.392$ m fd CW moment

$\Rightarrow$ below O $(0, -23.92)$



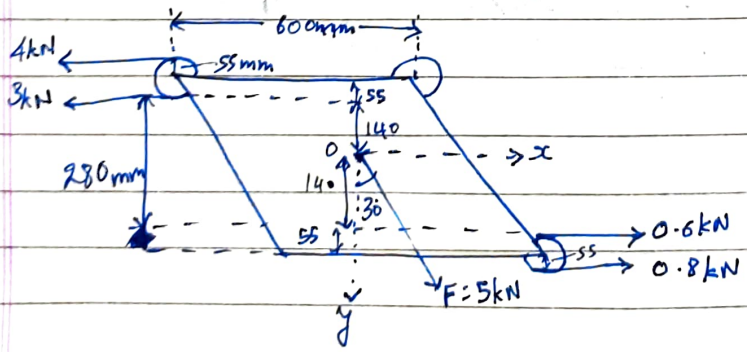

$R_y(x) = 500.88$ CCW

$x = \frac{350.88}{47.32} = 7.41$ m fd CCW moment

right of O

$(7.41, 0)$

2/98.




point on y-axis through which R must pass through

$$R = (1.4 - 7)\hat{i} + (5\cos 30)\hat{i} + 5\sin 30$$

$$R = -3.1\hat{i} + 4.33\hat{i}$$

$$M_o = +4(55+55+140) + 3(140) + (0.6)(140) + (0.8)(140 + 55 + 55)$$

$$= 1000 + 420 + 84 + 200$$

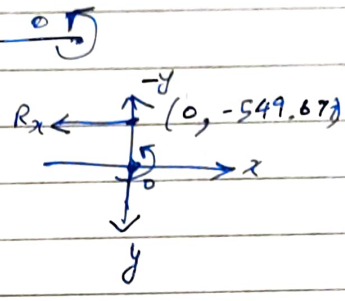
$$= 1704 \text{ Nm} \quad \text{CCW}$$

$$R_x(y) = M_o$$

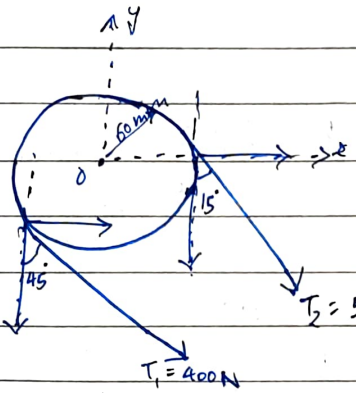
$$2.1\,y = 1704$$

$$y = 549.677$$

$$x, y = (0, -549.677)$$

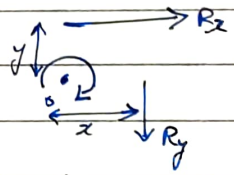


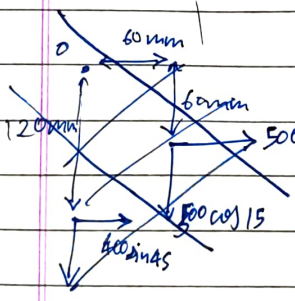

2|99.



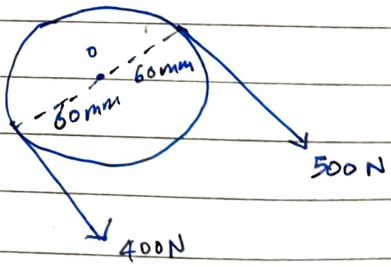

$$R = (500\sin 15 + 400\sin 45)\hat{i} + (-400\cos 45 - 500\cos 15)\hat{j}$$

$$R = 412.25\hat{i} - 765.80\hat{j}$$




$$M_o = (500\sin 15)(0.06) + (400\sin 15)(0.12) + -(500\cos 15)(0.06)$$




$$M_o = -500(0.06) + 400(0.06)$$

$$= -6 \text{ Nm} = 6 \text{ Nm CW}$$

$$R_x\, y = 6$$

$$y = \frac{6}{765.8} = 0.0078\text{m}$$

for $R_x$ to produce CW $\Rightarrow$ $R_x$ to be above O

$(0, 0.078)_m$

$$R_y\, x = 6$$

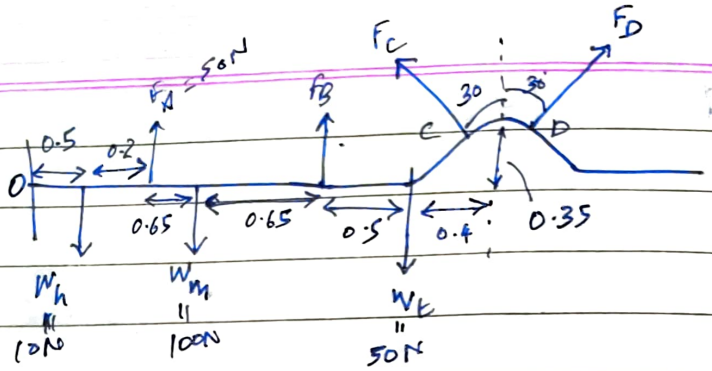
$$x = 0.0145\text{m}$$

for $R_y$ to produce CW

$\Rightarrow$ $R_y$ right of O

$(0.0145, 0)$

2/100




$F_C = F_D = F$

Zero Force - Couple system

$$R = (-F\sin 30 + F\sin 30)\hat{i} + (F_B + \cancel{F} - 10 - 100 - \cancel{50} + F\cos 30 + F\cos 30)\hat{j}$$

$$= 0$$

$$F_B + 2F(\cos 30) - 110 = 0$$

$$F_B + \sqrt{3}F = 110$$

$$\Sigma M_o = 0$$

$$-10(0.5) - 100(1.35) - 50(2.5) + 50(0.7) + F_B(2) + 2F\cos 30(2.9) + F\sin 30(0.35) - F\sin 30(2) = 0$$

on solving $F = F_C = F_D = 6.42N$

$F_B = 98.9N$