

11th September, 2022

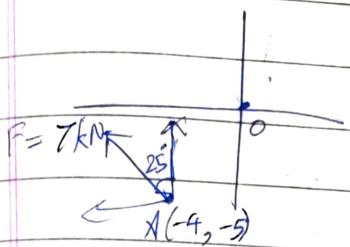
Date _____

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Engineering Mechanics Statics

Pg AT

Z/2



$$F_x = 7 \cos 25^\circ \text{ kN} (-\hat{i})$$

$$= 7 \times 0.9 (-\hat{i})$$

$$= 6.3(-\hat{i}) \text{ kN}$$

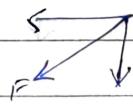
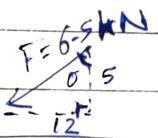
$$F_y = 7 \sin 25^\circ \text{ kN} (+\hat{j})$$

$$= 7 \times 0.423 (+\hat{j})$$

$$= 2.96 (+\hat{j}) \text{ kN}$$

$$F = F_x + F_y = -6.3\hat{i} + 2.96\hat{j} \text{ kN}$$

Z/3



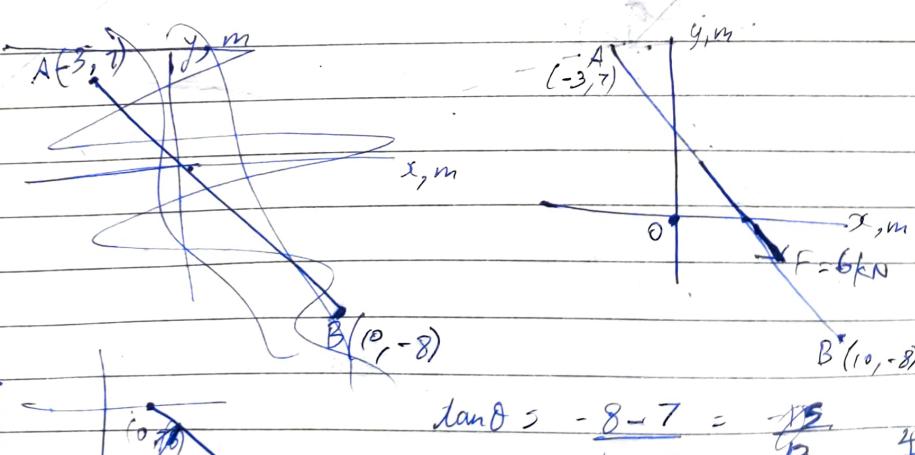
$$F_x = 6.5 \sin 0^\circ (-\hat{i}) = 6.5 \left(\frac{0}{13}\right) (-\hat{i}) \text{ kN}$$

$$= -6.5\hat{i} \text{ kN}$$

$$F_y = 6.5 \cos 0^\circ (-\hat{j}) = 6.5 \left(\frac{5}{13}\right) (-\hat{j}) = -2.5\hat{j} \text{ kN}$$

$$F = -6\hat{i} - 2.5\hat{j} \text{ kN}$$

Z/4



$$\tan \theta = \frac{-8 - 7}{10 + 3} = \frac{-15}{13}$$

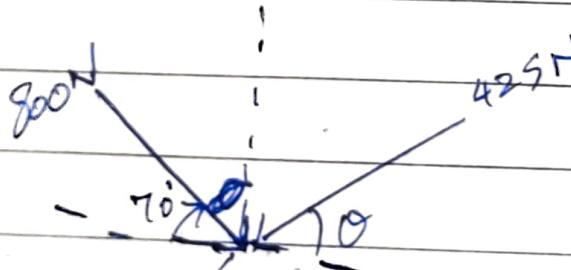
$$\theta = 49^\circ$$

(10, -8)

$$F_{xy} = 6 \sin 49^\circ (+\hat{j}) = 4.52 (+\hat{j}) \text{ kN}$$

$$F_{xz} = 6 \cos 49^\circ (-\hat{i}) = 3.93 (-\hat{i}) \text{ kN}$$

2/6



$$\frac{800}{\sin 70} = \frac{425}{\sin \theta}$$

~~$$\sin \theta = \sin 70 = 0.5$$~~

~~$$\frac{800}{\sin 70} = \frac{425}{\sin \theta}$$~~

~~$$\sin \theta = 1.768$$~~

$$F_R = 800 \sin 70 + 425 \sin \theta$$

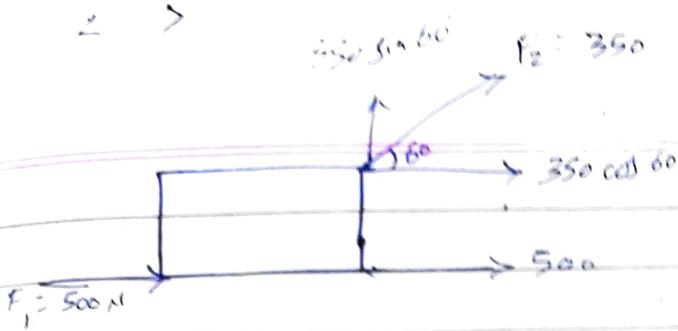
$$800 \sin 70 \quad 425 \cos \theta$$

$$800 \sin 70 = 425 \cos \theta$$

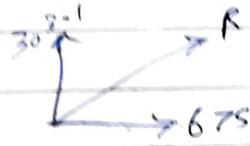
$$\theta = 49.9$$

~~32~~

$$F = \frac{1076.75 N}{R}$$



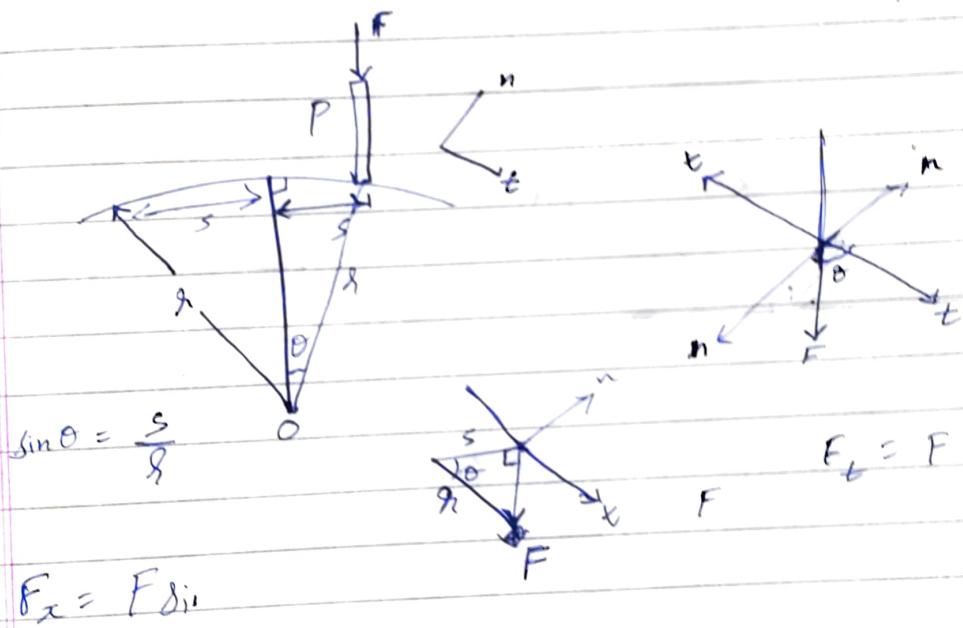
$$455625 + 9809 \\ \Sigma 47434$$



$$R = 739.88 \text{ N}$$

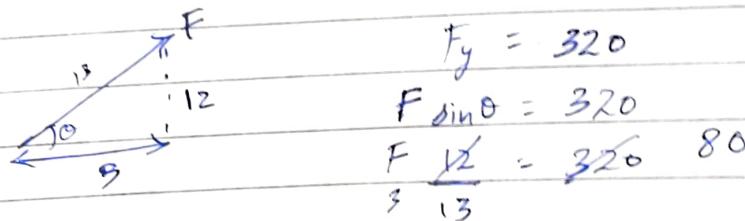
$$\tan \theta = \frac{303}{675}, \quad \theta = 24^\circ 18'$$

2/8



$$F_x = F_{\sin \theta}$$

2/9



$$F = 346 \text{ N}$$

$$(346)^2 = F_x^2 + F_y^2$$

$$119716 - 102400 = F_x^2$$

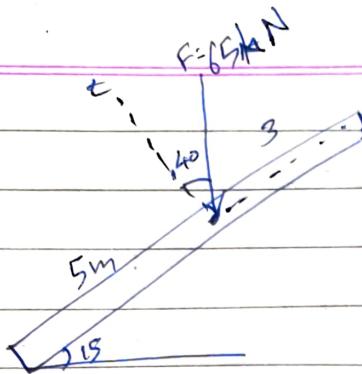
$$17316 = F_x^2$$

$$F_x = 13 \text{ N}$$

163.83

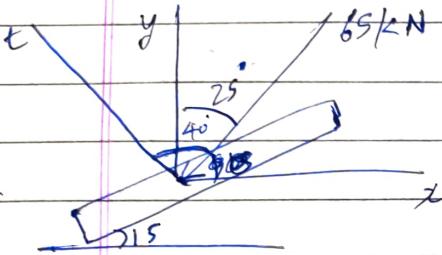
114.71

2/10.



$$F_H = -65 \sin 40 = -41.8 \text{ kN}$$

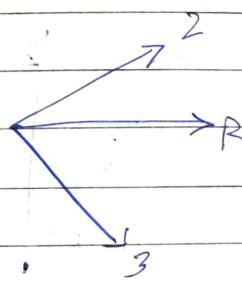
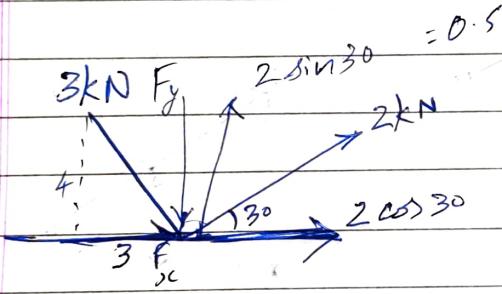
$$F_T = -65 \cos 40 = -49.29 \text{ kN}$$



$$F_x = -65 \sin 25 = -27.5 \text{ kN}$$

$$F_y = -65 \cos 25 = -68.9 \text{ kN}$$

2/11.



$$F_y = 3 \times \frac{4}{5} = \frac{12}{5} = 2.4$$

$$F_x = 3 \times \frac{3}{5} = \frac{9}{5} = 1.8$$

12.46
3.61

$$F_x = 2 \cos 30 + 1.8 = 3.53$$

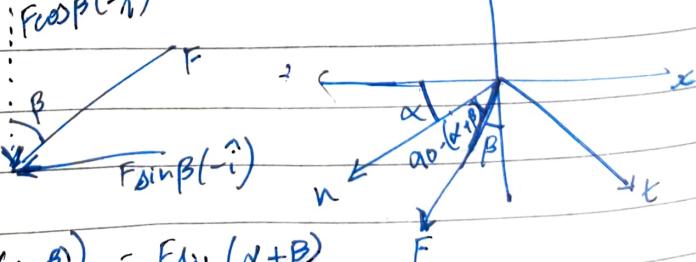
$$F_y = 2.4 - 0.5 = 1.9$$

2/5.

$$\theta = 61.7^\circ$$

$F \cos \beta (-i)$

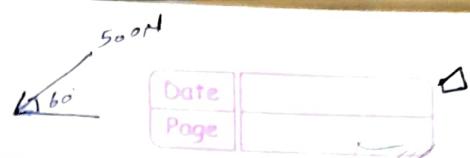
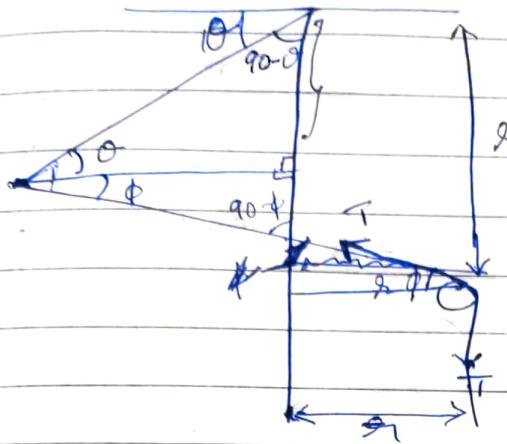
$F \sin \beta (-i)$



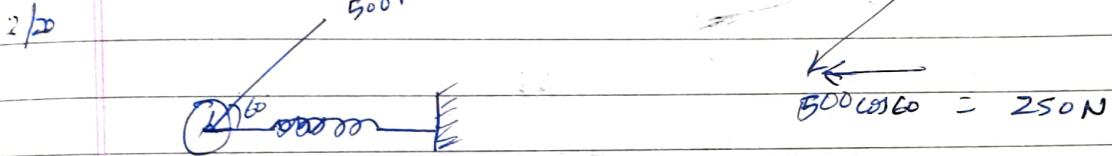
$$F_n = F \cos(\alpha_0 - (\alpha + \beta)) = F \sin(\alpha + \beta)$$

$$F_t = F \sin(\alpha_0 - (\alpha + \beta)) = F \cos(\alpha + \beta)$$

2/18



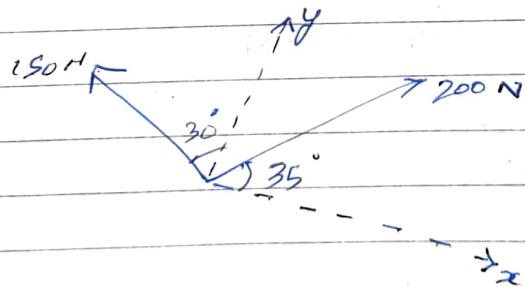
22nd September, 2022



$$\begin{aligned}
 R &= \sqrt{(500)^2 + (250)^2 + 2(500)(250) \cos 60} \\
 R &= \sqrt{250000 + 62500 + 125000} \\
 R &= \sqrt{437500} \\
 R &= 661.4 \text{ N}
 \end{aligned}$$

$$F_{ver.} = 500 \sin 60 = 433.01 \text{ N}$$

2/21.

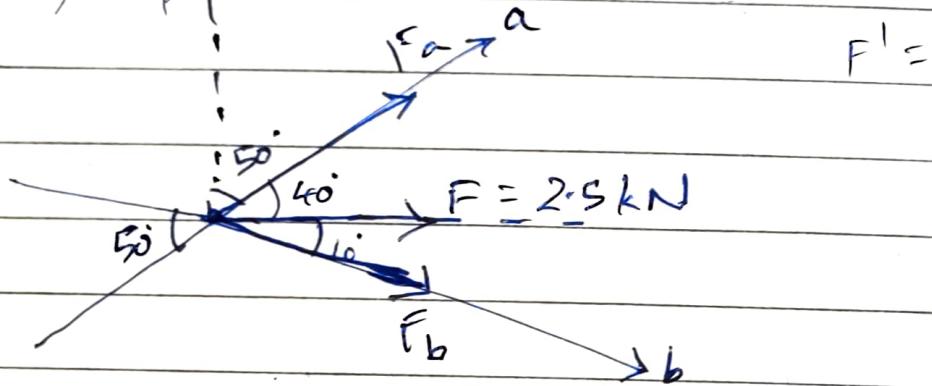


$$\begin{aligned}
 \text{in } y \text{ direction} \quad 200 \sin 35 + 150 \cos 30 &= 244.61 \hat{i} \\
 \text{in } x \text{ direction} \quad 200 \cos 35 - 150 \sin 30 &= 88.83 \hat{j}
 \end{aligned}$$

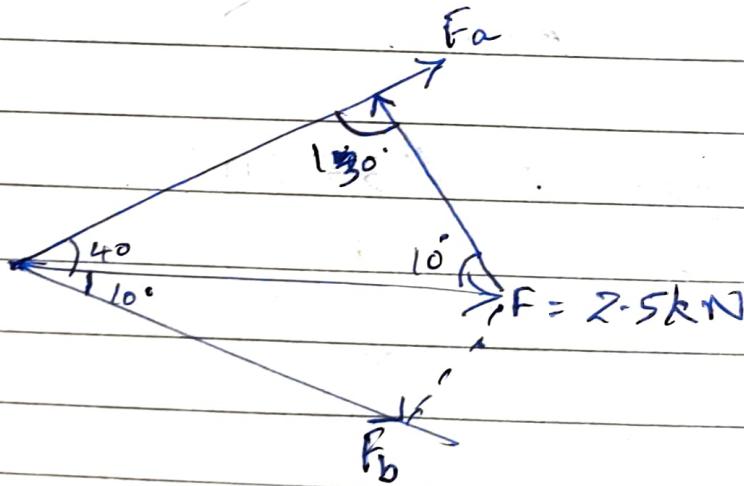
$$F = 88.83 \hat{i} + 244.61 \hat{j}$$

25th September 2022

2/22:



$$\begin{aligned} F_a &= \sqrt{(1.6)^2 + (2.5)^2 - 2(1.6)(2.5) \cos 40^\circ} \\ &= \sqrt{2.56 + 6.25} \\ &= 2.968 \text{ kN} \end{aligned}$$



$$F_a = 2.5 \cos 40^\circ$$

$$\frac{F_a}{\sin 10^\circ} = \frac{2.5}{\sin 130^\circ} = \frac{P_b}{\sin 40^\circ}$$

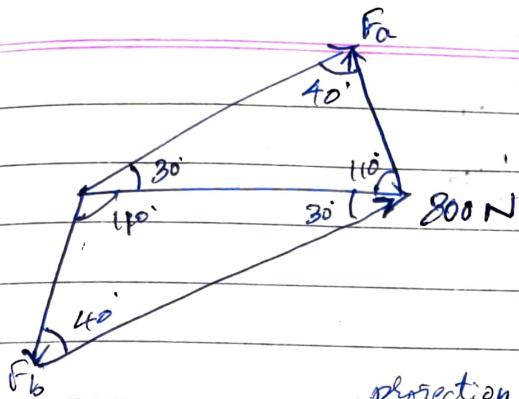
$$F_a = 0.566 \text{ kN}$$

$$\begin{aligned} P_a &= 2.5 \times \cos 40^\circ \\ &= 1.915 \text{ kN} \end{aligned}$$

$$F_b = 2.097 \text{ kN}$$

$$P_b = 2.5$$

2/23.



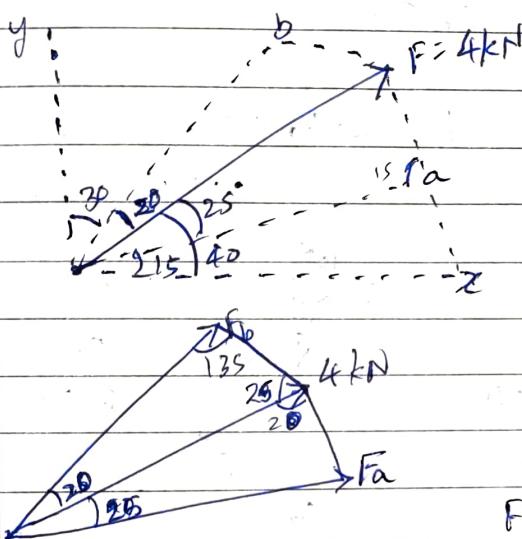
$$\frac{800}{\sin 40} = F_a = \frac{F_b}{\sin 30}$$

$$F_b = 1170 \text{ N}$$

$$F_b = 622 \text{ N}$$

$$\text{projection } F_a = 800 \cos 30 = 693 \text{ N}$$

2/24.

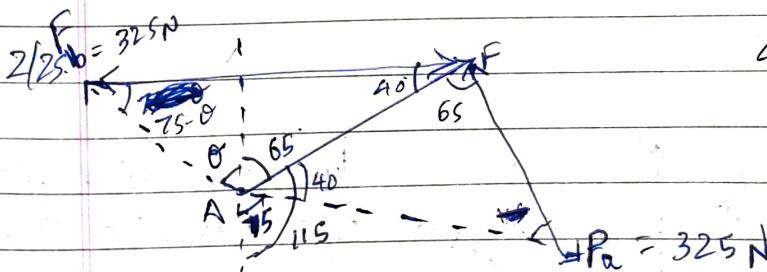


$$\frac{4}{\sin 135} = \frac{F_a}{\sin 20} = \frac{F_b}{\sin 25}$$

$$F_a = 1.934 \text{ kN} \quad F_b = 2.39 \text{ kN}$$

$$F_a = 4 \cos 25 = 3.625 \text{ kN}$$

$$F_b = 4 \cos 20 = 3.758 \text{ kN}$$



$$40^\circ + 65^\circ + \theta + x = 180$$

$$x =$$

$$F_a = 325$$

$$F \cos 40 = 325$$

$$F = 424.25 \text{ N}$$

~~$$\frac{F_b}{\sin 135} = \frac{325}{\sin x}$$~~

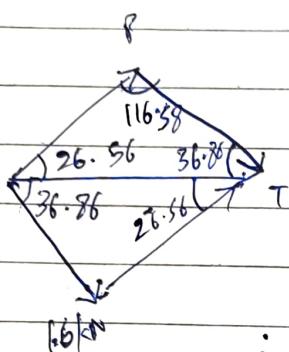
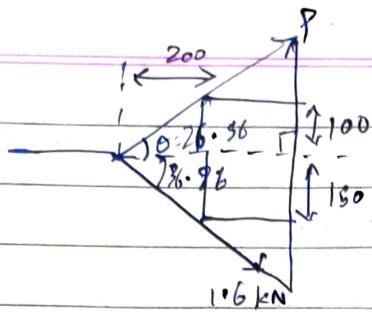
~~$$\frac{325}{\sin(75-\theta)} = \frac{424.25}{\sin 40}$$~~

~~$$\sin(75-\theta) = 0.492$$~~

~~$$75-\theta = 29.4^\circ$$~~

$$\frac{325}{\sin 29.4^\circ} = 18.1^\circ$$

2/26.



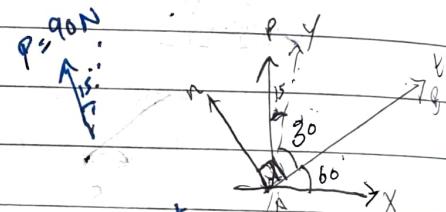
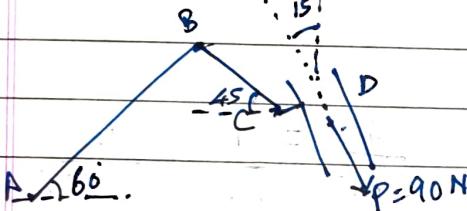
$$\frac{1.6}{\sin 26.56} = \frac{P}{\sin 36.86} = \frac{T}{\sin 116.58}$$

$$P = 2.146 \text{ kN}$$

$$T = 3.2 \text{ kN}$$

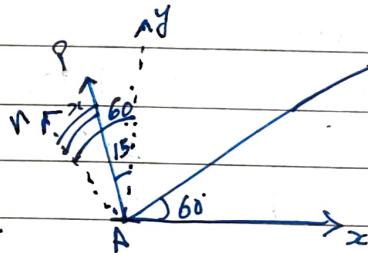
5th October, 2022

2/29.



a) If $CQ \perp$ to AB

$$x = 60 - 15 = 45$$

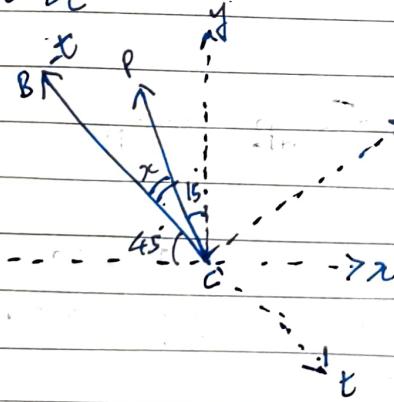


$$P_n = 90 \cos 45^\circ = 63.63 \text{ N}$$

$$P_t = 90 \sin 45^\circ = 63.63 \text{ N}$$

b) If $CQ \perp$ to BC

$$x = 36$$



$$P_t = -P \cos 30^\circ = -77.94 \text{ N}$$

$$P_n = P \sin 30^\circ = 45 \text{ N}$$

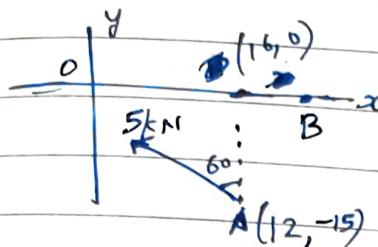
4th October, 2022

0°

⑥ CW

Date _____
Page _____

2/31.



CCW

CW

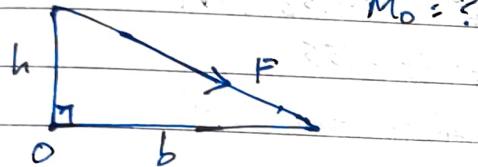
$$M_0 = 5 \cos 60 (12) - 5 \sin 60 (-15)$$

$$= -35 \text{ kNm} = 35 \text{ kNm (CW)}$$

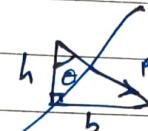
$$M_B = -5 \cos 60 (4) - 5 \sin 60 (+15)$$

$$= -75 \text{ kNm} = 75 \text{ kNm (CW)}$$

2/32



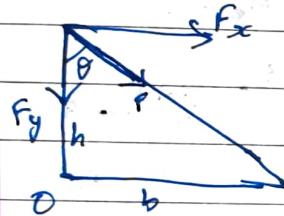
$M_0 = ?$



~~$$M_0 = F \cos \theta (h) + F \sin \theta (b)$$

$$= F \frac{b}{\sqrt{h^2+b^2}} h + F \frac{h}{\sqrt{h^2+b^2}} b$$

$$= \frac{2 F b h}{\sqrt{h^2+b^2}}$$~~



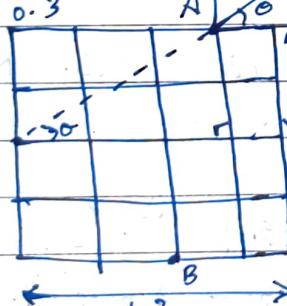
$$M_0 = F_x h = -F \sin \theta (h)$$

$$= -F \frac{b}{\sqrt{h^2+b^2}} h$$

Turning effect of $F_y = 0$

$$= F b h \quad (\text{CW})$$

2/33



$$M_B = 150 \sin \theta (0.3) + (-150 \cos \theta) (1.2)$$

~~$$= 20 \cdot 0.7 \div 161.08$$~~

~~$$= -141 \text{ Nm}$$~~

~~$$= 141 \text{ Nm (CW)}$$~~

~~$$\tan \theta = \frac{0.6}{1.2} = 0.5$$~~

~~$$\cos \theta = \frac{1.2}{\sqrt{1.2^2+0.6^2}} = 0.9$$~~

~~$$\sin \theta = \frac{0.6}{\sqrt{1.2^2+0.6^2}} = 0.831$$~~

~~$$\theta = 26.56^\circ$$~~

$$\sqrt{(0.6)^2 + (0.9)^2}$$

$$\frac{\sqrt{(0.6)^2 + (0.9)^2}}{\sqrt{(0.6)^2 + (0.9)^2}} = 1$$

$$\sqrt{(0.6)^2 + (0.9)^2}$$

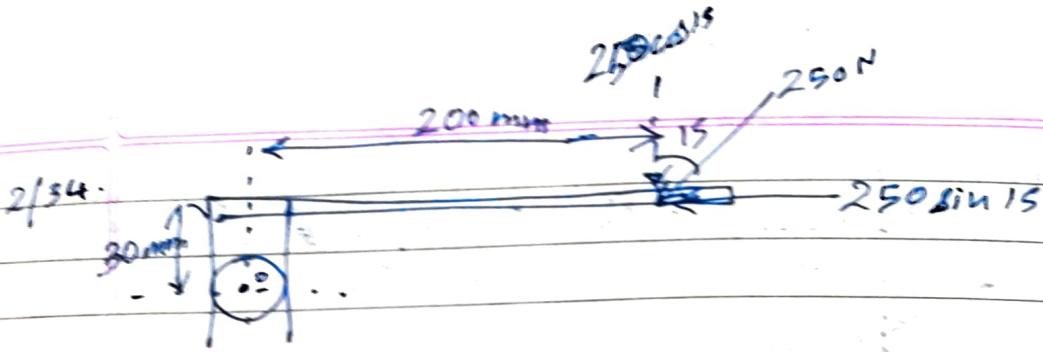
$$\frac{\sqrt{(0.6)^2 + (0.9)^2}}{\sqrt{(0.6)^2 + (0.9)^2}} = 1$$

~~$$378 -$$~~

~~$$24.75 - 149.98$$~~

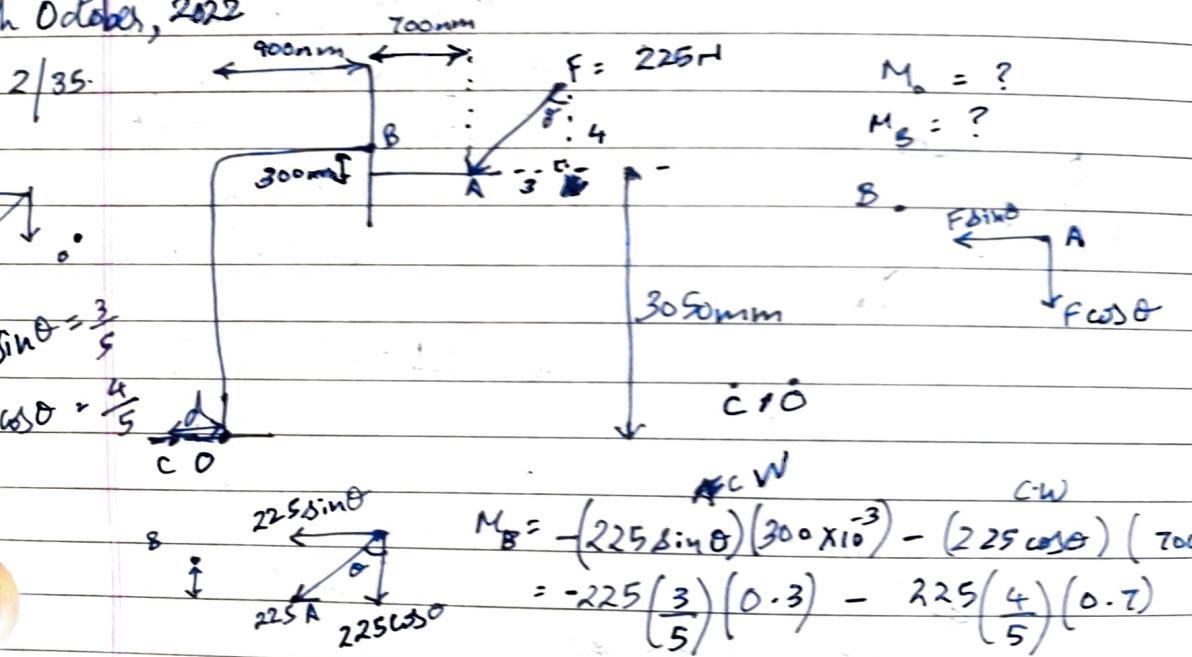
~~$$= 124.83$$~~

$$= 124.83 \text{ (CW)}$$



$$\begin{aligned}
 & -250\cos 15 (200 \times 10^3) + 250\sin 15 (30 \times 10^3) \\
 & -48.296 + 1.941 \\
 & \cancel{-198.9438 \text{ Nm}} \\
 & = -46.355 \text{ Nm} \\
 & = 46.4 \text{ Nm (CW)}
 \end{aligned}$$

5th October, 2022



$$\begin{aligned}
 \sin \theta &= \frac{3}{5} \\
 \cos \theta &= \frac{4}{5} \\
 M_B &= -(225 \sin \theta)(300 \times 10^3) - (225 \cos \theta)(700 \times 10^3) \\
 &= -225 \left(\frac{3}{5}\right)(0.3) - 225 \left(\frac{4}{5}\right)(0.7) \\
 &= -40.5 - 126 = -166.5 \text{ Nm} = 166.5 \text{ W}
 \end{aligned}$$

$$= -855 \text{ Nm} = 85.5 \text{ Nm CW}$$

*why r we
num get x?*

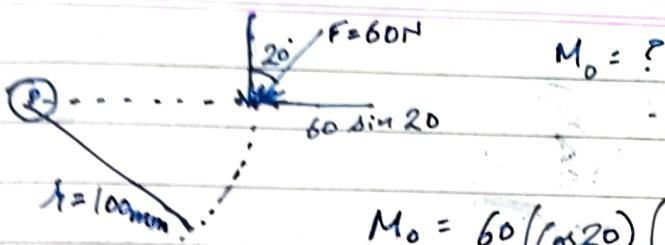
$$\begin{aligned}
 M_B &= +(225 \sin \theta)(3050 \times 10^3) - (225 \cos \theta)(1600 \times 10^3) \\
 &= +225 \left(\frac{3}{5}\right)(3.05) - 225 \left(\frac{4}{5}\right)(1.6) \\
 &= +411.75 - 288 = 123.75 \text{ Nm (CCW)}
 \end{aligned}$$

$$M_p = 0 = -(225 \cos \theta)(1.6 + d) + (225 \sin \theta)(3.05) = 0$$

$$\Rightarrow 225 \left(\frac{4}{5}\right)(1.6 + d) = 225 \left(\frac{3}{5}\right)(3.05)$$

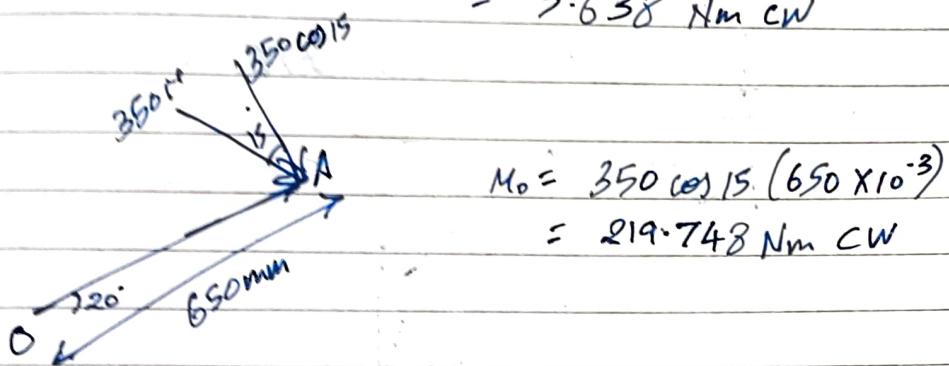
$$\therefore d = 0.675 \text{ left of } O$$

60 cos 20



$$M_A = 60 (\cos 20) (100 \times 10^{-3}) + 0 \\ = 5.638 \text{ Nm CW}$$

2/37.



$$M_O = 350 \cos 15 (650 \times 10^{-3}) \\ = 219.748 \text{ Nm CW}$$

2/38.

$$M_O = -75 \cos 20 (0.3) - 75 \sin 20 (0.098)$$

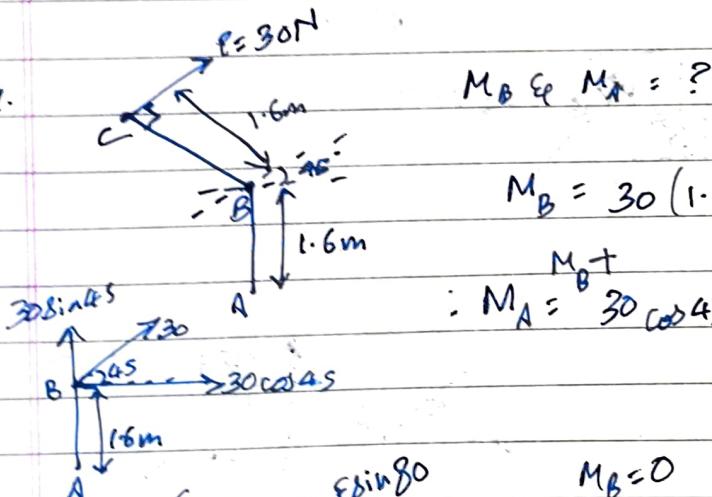
$$\begin{array}{r} 25 \\ + 33 \\ + 35 \\ \hline 98 \end{array}$$

$$\approx -21.143 - 2.513$$

$$= -18.629 - 23.656 \text{ Nm}$$

$$= 23.656 \text{ Nm (CW)}$$

2/39.

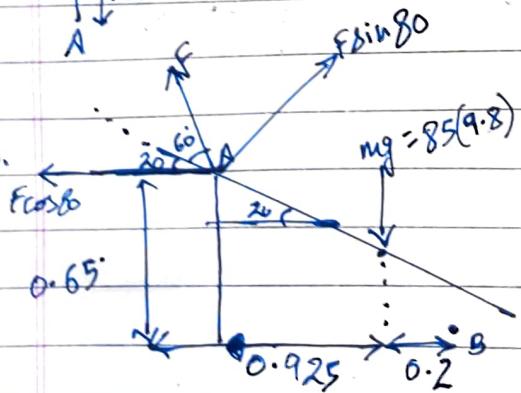


$$M_B \text{ & } M_A = ?$$

$$M_B = 30 (1.6) = 48 \text{ Nm CW}$$

$$\therefore M_A = 30 \cos 45 (1.6) = 48 + 39.3 \text{ Nm} \\ = 81.93 \text{ Nm CW}$$

2/40.



$$M_B = 0$$

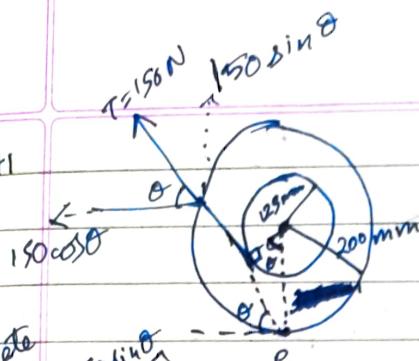
$$\Rightarrow 85(9.8)(0.2) + F \cos 60 (0.65) \\ - F \sin 60 (0.925 + 0.2) = 0$$

$$166.6 = -F(0.112) + F(1.10)$$

$$166.6 = 0.995 F$$

$$F = 167.437 \text{ Nm}$$

2/41



$$M_c = 150(0.125) \text{ Nm CW}$$

$$= 18.75 \text{ Nm CW}$$

accidental fig.

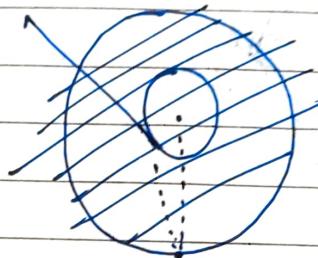
$$150 \cos \theta \leftarrow \quad 150 \sin \theta \uparrow$$

$$M_p = 0 \text{ (given)}$$

~~$$+150 \cos(200) = 0$$~~

$$\cos \theta = \frac{125}{200}$$

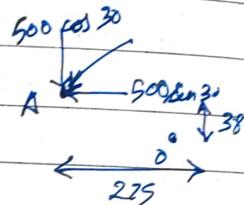
$$\theta = 51.31^\circ$$



$$2/42. M_o : 500 \cos 30 (0.275) + 500 \sin 30 (0.038 + 0.038)$$

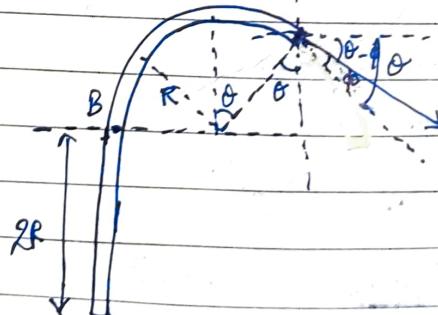
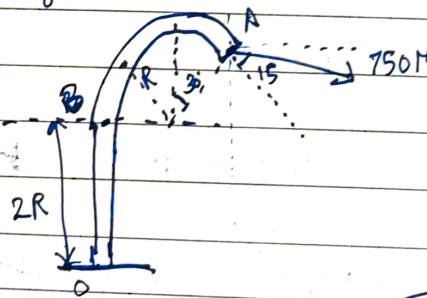
$$= 119.07 + 0.5$$

$$= 120.57 \text{ Nm CCW}$$

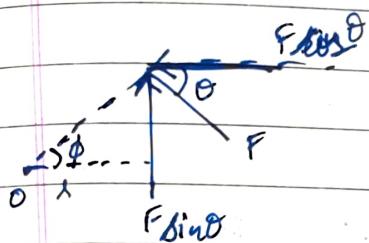
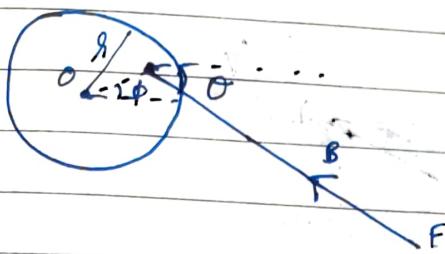


$$2/43. M_B \text{ & } M_o = ?$$

$$R = 2.4 \text{ m}$$



2/44



$$M_O = F_{\text{bind}} \cdot r \cos \phi + F_{\text{load}} \cdot r \sin \phi$$

$$\text{a) } F = 500 \text{ N}, \theta = 60^\circ, \phi = 20^\circ, r = 0.4$$

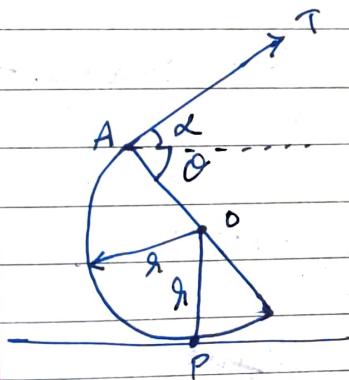
$$M_O = 500 \sin 60^\circ (0.4 \cos 20^\circ)$$

$$+ 500 \cos 60^\circ (0.4 \sin 20^\circ)$$

$$= 162.759 + 34.202$$

$$= 196.961 \text{ Nm CCW}$$

2/45.



$$M_O = T_8 \sin(\alpha + \theta)$$



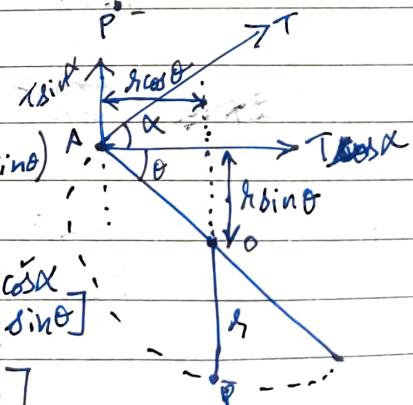
$$M_O = T_8 \sin(\alpha + \theta) r, \text{ CW}$$

$$M_P = T_8 \sin \alpha (r \cos \theta) + T \cos \alpha (r + r \sin \theta)$$

CW

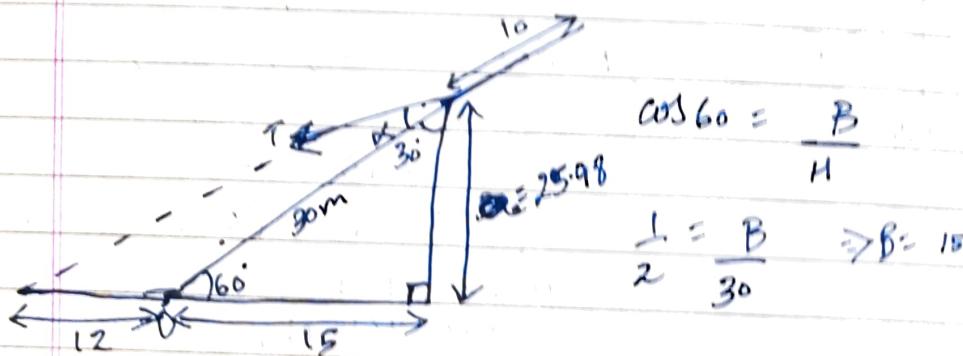
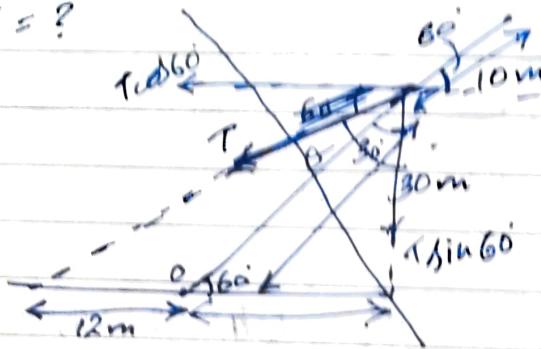
$$= T_8 [\sin \alpha \cos \theta + \cos \alpha + \cos \alpha \frac{\sin \theta}{\sin \theta}]$$

$$= T_8 [\cos \alpha + \sin(\alpha + \theta)]$$



$$2/46. M_0 = 72 \text{ kNm}$$

$$T = ?$$



$$\cos 60 = \frac{B}{H}$$

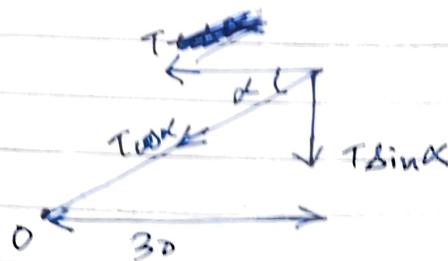
$$\frac{1}{2} = \frac{B}{30} \Rightarrow B = 15$$

$$\sin 60 = \frac{a}{30} \Rightarrow \frac{\sqrt{3}}{2} = \frac{a}{30} \Rightarrow a = 25.98$$

$$\tan(\alpha + 30^\circ) = \frac{25.98}{27} = 1.039$$

$$\alpha + 30 = 46.09^\circ$$

$$\alpha = 16.09^\circ$$

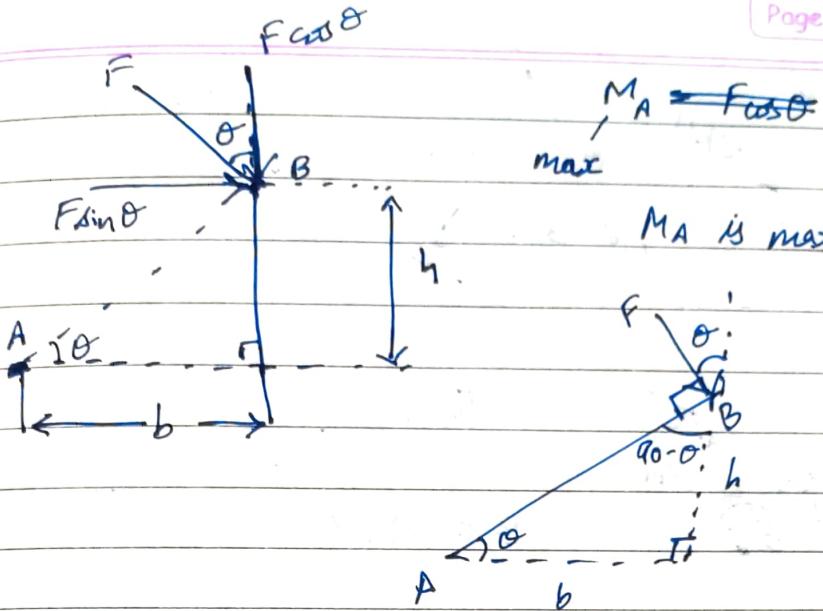


$$72 = T \sin \alpha (30)$$

$$72 = T \sin 16.09 (30)$$

$$T = 8.66 \text{ kN}$$

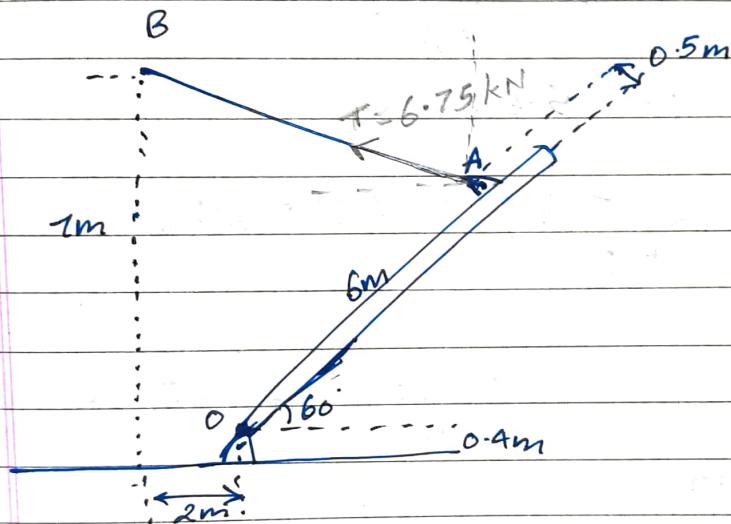
2/47.

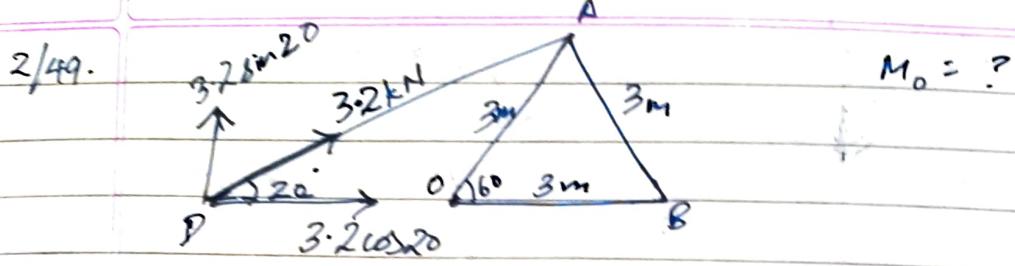


M_A is max when F is \perp to AB

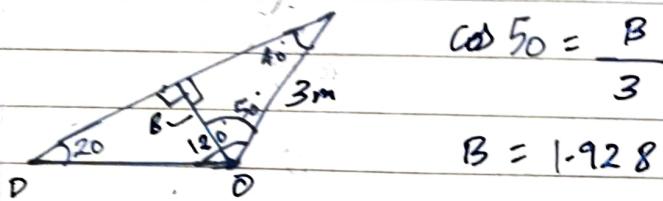
$$\theta = \tan^{-1} \left(\frac{h}{b} \right)$$

2/48





$$M_o = ?$$



$$\cos 50 = \frac{B}{3}$$

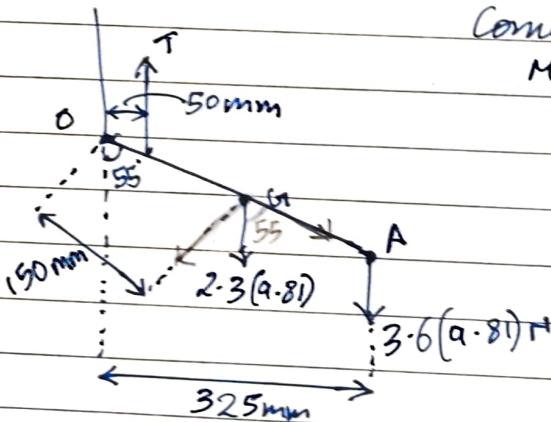
$$B = 1.928$$

$$\sin 20 = \frac{1.928}{OD}$$

$$DO = 5.638 \text{ m}$$

$$M_o = -3.2 \sin 20 (5.638) + 0 = 6.170 \text{ kNm CW}$$

2/50



Combined moment about O

$$M_o = ?$$

$$M_o = 2.3(9.81) \sin 55 (0.15) + 3.6(9.81) (0.375)$$
 ~~$= 2.77$~~ ~~$+ 11.477$~~

T? such that $M_o = 0$

~~13.447~~ = 14.84 Nm CW

$$\Rightarrow -14.84 + T(0.05) = 0$$

$$T = 284.8 \text{ N}$$

2/51 given $P = 175 \text{ N/m}^2$

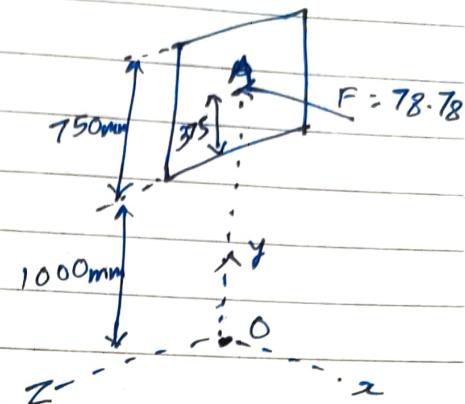
$$F = P \cdot A$$

$$= 175 \times (0.6)(0.75)$$

$$= 78.78$$

$$M = 8 \times F$$

$$= (1.375) \times (78.78)$$



$$\begin{vmatrix} i & i & k \\ 0 & 1.375 & 0 \\ -78.78 & 0 & 0 \end{vmatrix} = \hat{k}(0 - (-78.78)(1.375))$$

$$= 108.3225 \hat{k} \text{ Nm}$$

2/52 $M_0 = 0$

$$+ (5 \cos 30(0.09) + 5 \sin 30(0.06)) - (T \cos \theta(0.12) + T \sin \theta(0.06)) = 0$$

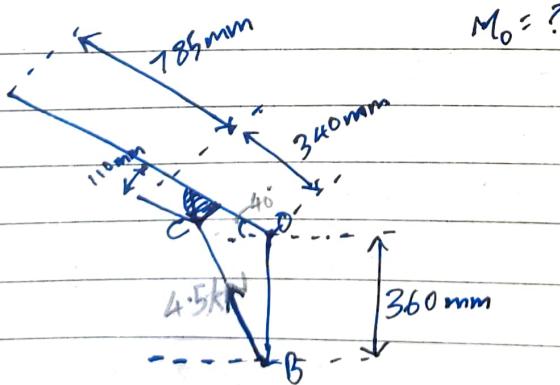
$$0.389 + 0.15 = T \frac{0.6}{\sqrt{29}} + T \frac{0.12}{\sqrt{29}}$$

$$\therefore \cos \theta = \frac{5}{\sqrt{29}} \quad \sin \theta = \frac{2}{\sqrt{29}}$$

$$0.539 = \frac{0.72T}{\sqrt{29}}$$

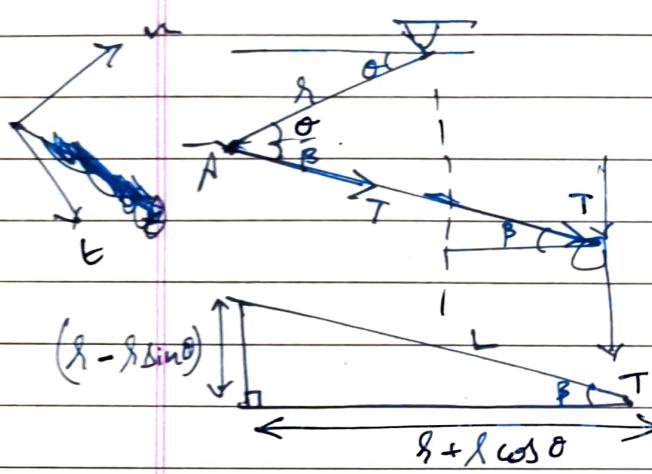
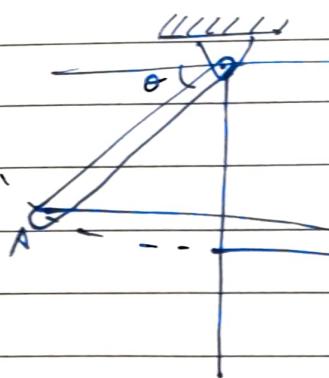
$$T = 4.031 \text{ kN}$$

2/53



Unsolved questions

2/18



$$T_x = T \cos \beta$$

$$T_y = -T \sin \beta$$

$$L^2 = (g - g \sin \theta)^2 + (g + g \cos \theta)^2$$

$$g^2 + g^2 \sin^2 \theta - 2g^2 \sin \theta$$

$$+ g^2 + g^2 \cos^2 \theta + 2g^2 \cos \theta$$

$$L^2 = 3g^2 - 2g^2 \sin \theta + 2g^2 \cos \theta$$

$$L^2 = g^2 (3 + 2 \cos \theta - 2 \sin \theta)$$

$$L = g \sqrt{3 + 2 \cos \theta - 2 \sin \theta}$$

$$\cos \beta = \frac{g(1 + \cos \theta)}{\sqrt{3 + 2 \cos \theta - 2 \sin \theta}}$$

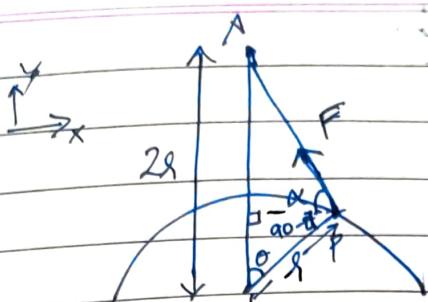
$$\sin \beta = \frac{g(1 - \sin \theta)}{\sqrt{3 + 2 \cos \theta - 2 \sin \theta}}$$

2/19. $\tan \beta = \frac{1 - \sin \theta}{1 + \cos \theta}$

$$T_n = T \cos(\theta + \beta)$$

$$T_t = T \sin(\theta + \beta)$$

2/30



$$F_y = F \sin \alpha$$

$$F_x = -F \cos \alpha$$

$$F = k \delta$$

$$F = k(AP - s)$$

$$\frac{\sin(\alpha + (90^\circ - \theta))}{2s} = \frac{\sin \theta}{AP}$$

$$\sin(\alpha + (90^\circ - \theta)) = \frac{2s \sin \theta}{AP}$$

$$\alpha + 90^\circ - \theta = \sin^{-1} \left(\frac{2s \sin \theta}{AP} \right)$$

$$\alpha = \theta - 90^\circ + \sin^{-1} \left(\frac{2s \sin \theta}{AP} \right)$$

$$AP^2 = s^2 + (2s)^2 - 2 \cdot (s)(2s) \cos \theta$$

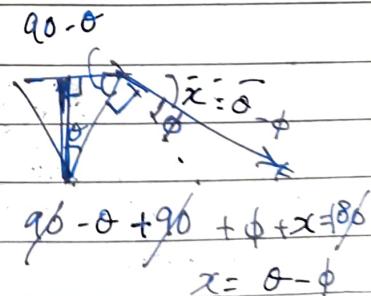
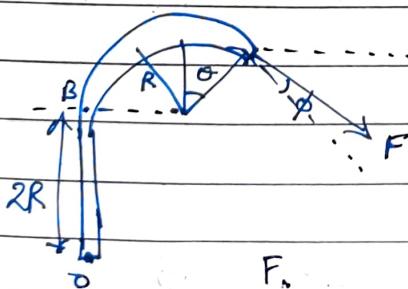
$$AP = s\sqrt{5 - 4 \cos \theta}$$

$$AP = 0.557 \text{ m}$$

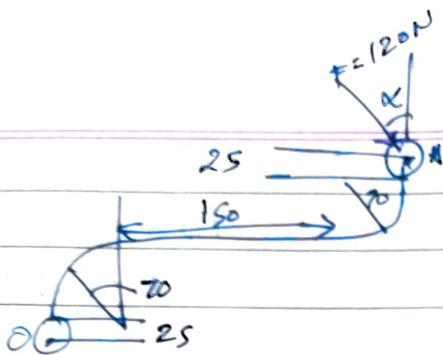
$$\alpha = 62.5^\circ$$

$$F = 1400(0.557 - 0.4) = 219 \text{ N}$$

2/43.



2/54.



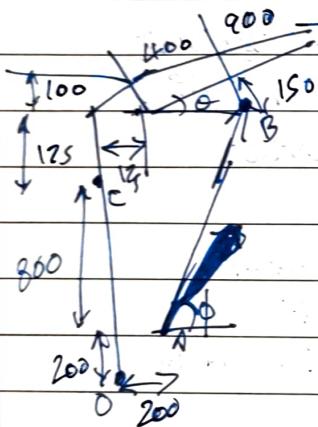
$$\text{if } \alpha = 30^\circ$$

$$N_0 = -120 \cos 30^\circ (70 + 150 + 70) - 120 \sin 30^\circ (25 + 70 + 70 + 25)$$

for max M_0 $\alpha = \tan^{-1} \left(\frac{25 + 70 + 70 + 25}{70 + 150 + 70} \right) = 32.2^\circ$

$$(M_0)_{\max} = 120 \sqrt{(25 + 70 + 70 + 25)^2 + (70 + 150 + 70)^2}$$

2/55.



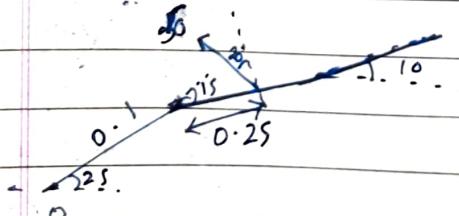
$$\phi = \tan^{-1} \frac{800 + 175 + 100 + 400 \sin \theta}{125 + 400 \cos \theta + 150 \sin \theta - 200}$$

$$= 70.9^\circ$$

$$M_0 = -F_c \cos \phi (0.2) + F_s \sin \phi (0.2)$$

$$M_C = F_s \sin \phi (0.2) + F_c \cos \phi (0.3)$$

2/69.



$$M_0 = 50 \cos 20^\circ (0.1 \cos 25 + 0.25 \cos 10^\circ)$$

$$+ 50 \sin 20^\circ (0.1 \sin 25 + 0.25 \sin 10^\circ)$$

$R = 50$ @ 110° with x axis

