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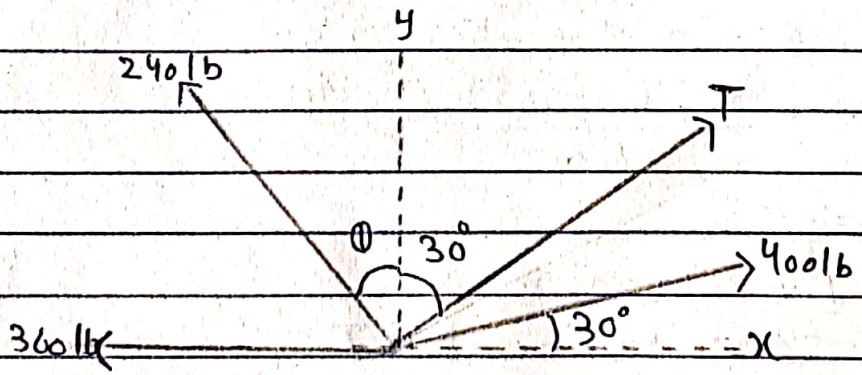
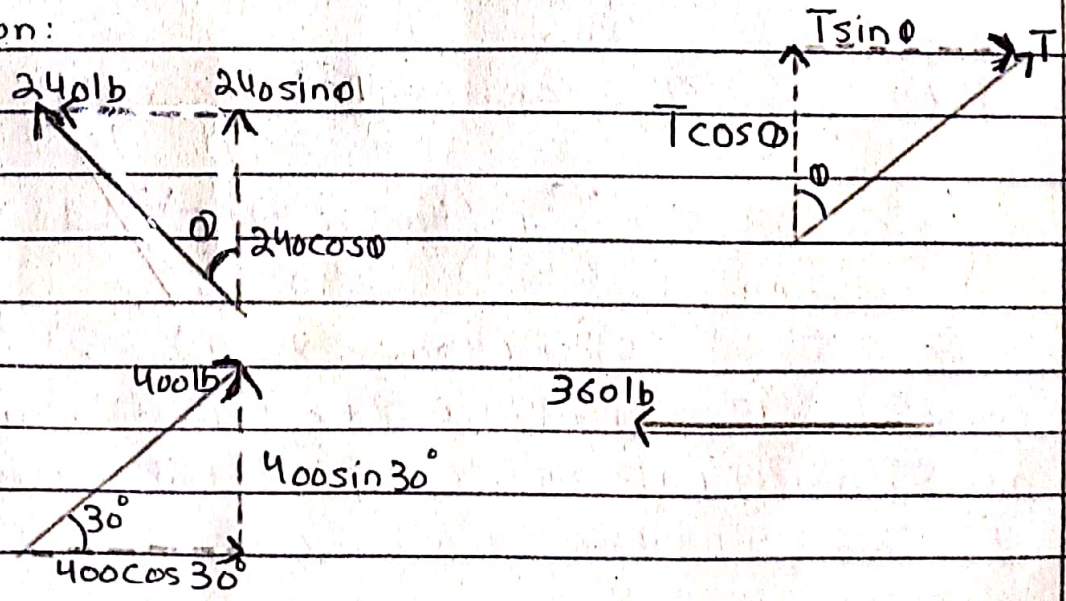
Q:02: Four forces are exerted on the eyebolt as shown below. If the net effect on the bolt is direct pull of 600 pounds in the y-direction, determine the values of T and Θ.



Solution:



$\Sigma F_x = 0 \quad \overset{+}{\rightarrow} \overset{-}{\leftarrow}$

$-240\sin\theta - 360 + T\sin 30^\circ + 400\cos 30^\circ = 0$

$-240\sin\theta + 0.5T - 360 + 346.41 = 0$

$0.5T - 240\sin\theta - 13.59 = 0 \longrightarrow (1)$

$\Sigma F_y = 0 \quad \uparrow + \downarrow -$

$240\cos\theta + T\cos 30^\circ + 400\sin 30^\circ = 600$

$0.866T + 240\cos\theta + 200 = 600$

$0.866T + 240\cos\theta = 600 - 200$

$0.866T + 240\cos\theta = 400 \longrightarrow (2)$

$\therefore \sin^2\theta + \cos^2\theta = 1 \longrightarrow (3)$

Now find value for $\sin\theta$ and $\cos\theta$

Take eq (1)

$0.5T - 240\sin\theta - 13.59 = 0$

$240\sin\theta = 0.5T - 13.59$

$\sin\theta = \dfrac{0.5T - 13.59}{240} \longrightarrow (4)$

Take eq (2)

$0.866T + 240\cos\theta = 400$

$240\cos\theta = 400 - 0.866T$

$\cos\theta = \dfrac{400 - 0.866T}{240} \longrightarrow (5)$

Put eq (4) and eq (5) in eq (3) we get

$$\left(\frac{0.5T - 13.59}{240}\right)^2 + \left(\frac{400 - 0.866T}{240}\right)^2 = 1$$

$(0.5T - 13.59)^2 + (400 - 0.866T)^2 = 240^2$

$0.25T^2 - 13.59T + 184.688 + 0.751^2 - 692.8T + 160000 = 57600$

$0.25T^2 + 0.75T^2 - 13.59T - 692.8T + 184.688 + 160000 - 57600 = 0$

$T^2 - 706.39T + 102584.688 = 0$

using quadratic formula (By Calculator)
we get

$T_1 = 502.065$ lb

$T_2 = 204.325$ lb

Since $\sin^2\theta = \sin^2(-\theta)$ & $\cos^2\theta = \cos^2(-\theta)$

for $T = 502.065$ lb

using eq 4

$$\sin\theta = \left(\frac{0.5 \times 502.065 - 13.59}{240}\right)$$

$$\theta = \sin^{-1}\left(\frac{(0.5 \times 502.065) - 13.59}{240}\right)$$

$\theta = 81.63°$

using eq 5

$$\cos\theta = \frac{400 - (0.866 \times 502.065)}{240}$$

$$\theta = \cos^{-1}\left(\frac{400 - (0.866 \times 502.065)}{240}\right)$$

$\theta = 98.33°$

$81.63° \neq 98.33°$ (solution is not valid)

for $T = 204.325$ lb

using eq (4)

$$\sin\theta = \frac{(0.5 \times 204.315) - 13.59}{240}$$

$$\theta = \sin^{-1}\left(\frac{(0.5 \times 204.325) - 13.59}{240}\right)$$

$\theta = 21.66°$

using eq (5)

$$\cos\theta = \frac{400 - 0.866(204.325)}{240}$$

$$\theta = \cos^{-1}\left(\frac{400 - (0.866 \times 204.325)}{240}\right)$$

$\theta = 21.7^\circ$

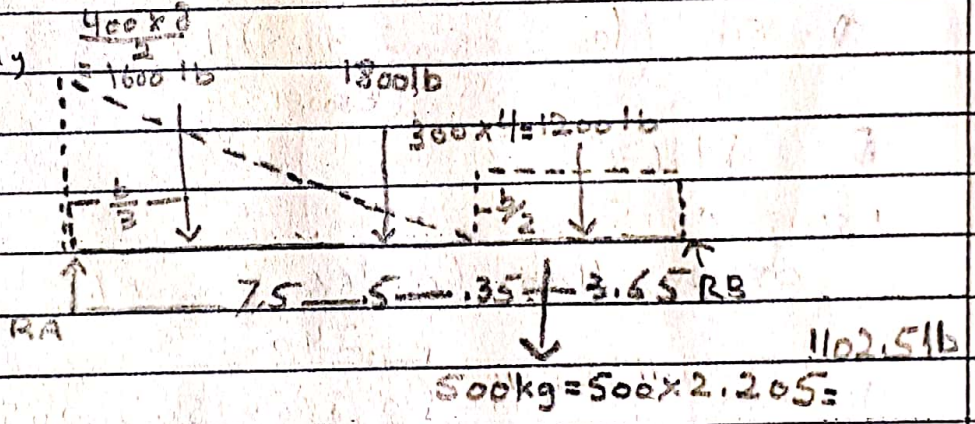
hence 21.7° (solution is valid)

Therefore $T = 204.325$ lb

$\theta = 21.7^\circ$

Q3 Calculate the reactions at supports.

Solution: Free body Digram



$\Sigma M_A = 0$ (+ ↻)

$-(1600 \times 2.667) - (1800 \times 7.5) - (1102.5 \times 8.35) - (1200 \times 10) + RB \times 12 = 0$

$RB \times 12 = 4267.2 + 13500 + 9205.875 + 1200$

$RB \times \frac{12}{12} = \frac{28,173.075}{12}$

$RB = 2347.75625$

$\Sigma F_y = 0$ ↑ + ↓ −

$RA - 1600 - 1800 - 1102.5 - 1200 + RB = 0$

$RA = 1600 + 1800 + 1102.5 + 1200 - RB$

$= 5702.5 - RB$

$= 5702.5 - 2347.75625$

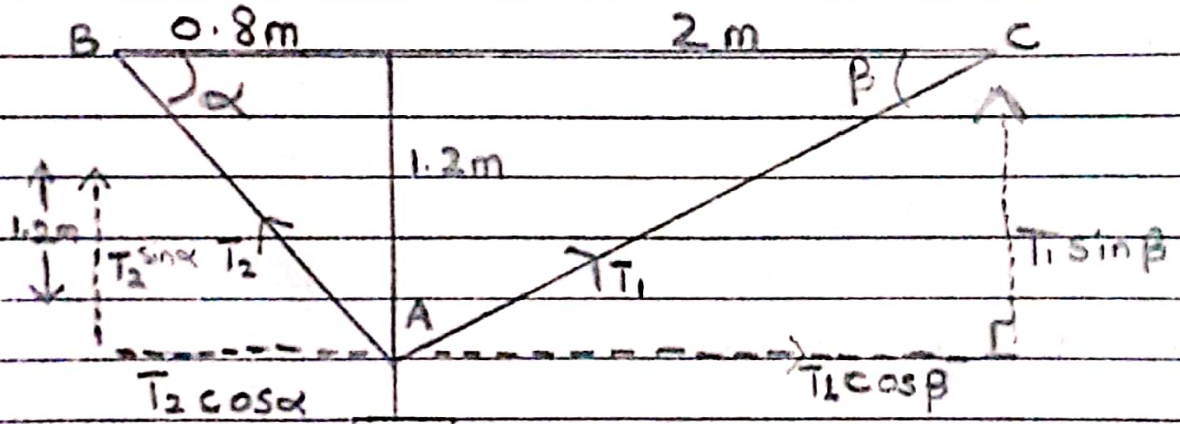
$RA = 3354.74375$ lb

Reactions:

AT A: RA = 3354.74375 lb

AT B: RB = 2347.75625 lb

Q1 a



Part-(a)

Solution:-

m = mass of tank + mass of water

mass of tank = 400 pounds

1 kg = 2.21 pounds

mass of tank = $400/2.21 \Rightarrow 181$ kg

mass of water = ?

volume = 3000 liters

$1\ m^3 = 1000$ liters

volume of water = $3000/1000 = 3\ m^3$

density of water = $1000\ kgm^{-3}$

mass = $3 \times 1000 \Rightarrow 3000$ kg

Total mass (m) = $181 + 3000 = 3181$ kg

weight = 3181×9.81

F = 31205 N

$\sum F_x = 0$

$\sum F_x = \bar{T}_1 \cos\beta = \bar{T}_2 \cos\alpha$ — ①

$\sum F_y = 0$

$\sum F_y = \bar{T}_1 \sin\beta + \bar{T}_2 \sin\alpha = mg$ — ②

From eq ①

$\bar{T}_1 \cos\beta = \bar{T}_2 \cos\alpha$

$\bar{T}_2 = \frac{T_1 \cos\beta}{\cos\alpha}$

Put values in eq ②

$\bar{T}_1 \sin\beta + \frac{\bar{T}_1 \cos\beta (\sin\alpha)}{\cos\alpha} = mg$

$\bar{T}_1 \left[\sin\beta + \frac{\sin\alpha \cos\beta}{\cos\alpha}\right] = mg$

$T_1 = \frac{mg}{\sin\beta + \frac{\sin\alpha \cos\beta}{\cos\alpha}}$

$\alpha = \tan^{-1}\left[\frac{1.2}{1.8}\right]$

$\alpha = 56.30^\circ$

$\beta = \tan^{-1}\left[\frac{1.2}{2}\right]$

$\beta = 31^\circ$

$T_1 = \frac{31205}{\sin(31) + \frac{\sin(56.3) \times \cos(31)}{\cos(56.3)}}$

$\bar{T}_1 = 17333.16\ N$

$\bar{T}_2 = \dfrac{\bar{T}_1 \cos\beta}{\cos\alpha}$

$\bar{T}_2 = \dfrac{17.333.16 \times \cos(31)}{\cos(56.3)}$

$\bar{T}_2 = 26777.63\ N$

$AB\ \% = \dfrac{26777.63}{31205} \times 100$

$AB = 85.81\ \%$

Part-b

tank mass increases 15 %

new mass $= 181 \times 1.15$

$= 208.15\ kg$

Volume of water increases 35%

new volume $= 3 \times 1.35$

$= 4.05\ m^3$

mass of water = 4050

Total mass = 4258.15 kg

F = 41772.45N

T_1 will be = 23203N

T_2 = 35846N

AB% will be same

AB% = 85.81%