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Section — "B"
Semester — 2nd
Subject — Engineering Mechanics
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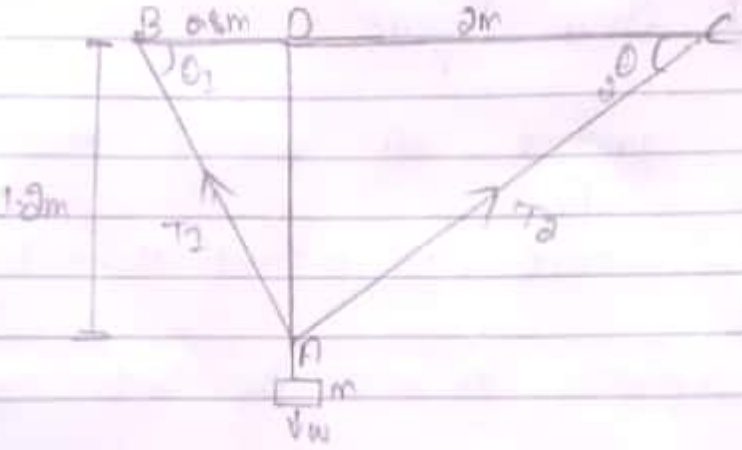
ON 1: Part (a)

Sol:



Total weight

$$W = W_t + W_w$$

W_t: weight of tank; W_w: weight of water

$$W = 400\text{pound} + (3000\text{kg})(9.8\text{ms}^{-2})$$

$$W = 400\text{lb} + 29400\text{N}$$

$$W = \frac{400\text{N}}{0.22} + 29400\text{N}$$

$$\rho = \frac{m}{V}$$

$m = \rho V$

$m = \left(1000\frac{kg}{m^3}\right)(3m^3)$

$\boxed{m = 3000kg}$

$W = 31218N$

From figure

T_1 = amount of weight Hold by cable AB.

T_2 = amount of weight Hold by cable AC.

Now

Resolve T_1 and T_2 into components.

$T_{1x} = T_1 \cos\theta_1$	$T_{2x} = T_2 \cos\theta_2$
$T_{1y} = T_1 \sin\theta_1$	$T_{2y} = T_2 \sin\theta_2$

Now from equilibrium condition

$\sum F_{up} = \sum F_{on}$

$T_{1y} + T_{2y} = W$

$\boxed{T_1 \sin\theta_1 + T_2 \sin\theta_2 = W} \rightarrow (1)$

$\sum F_{rond} = \sum F_{left}$

$T_{2x} = T_{1x}$

$\boxed{T_2 \cos\theta_2 = T_1 \cos\theta_1} \rightarrow (2)$

Now to find $\sin\theta_1$, $\sin\theta_2$, $\cos\theta_1$ and $\cos\theta_2$ using Digram

In $\triangle ABD$

$$(AB)^2 = (BD)^2 + (AD)^2$$

$$AB = \sqrt{(0.8)^2 + (1.2)^2}$$

$$\boxed{AB = 1.44m}$$

So

$$\cos\theta_1 = \frac{0.8m}{1.44m}$$

$$\boxed{\cos\theta_1 = 0.55}$$

$$\sin\theta_1 = \frac{1.2m}{1.44m}$$

$$\boxed{\sin\theta_1 = 0.83}$$

In $\triangle ADC$

$$AC = \sqrt{(CD)^2 + (AD)^2}$$

$$AC = \sqrt{(2)^2 + (1.2)^2}$$

$$\boxed{AC = 2.33m}$$

So

$$\cos\theta_2 = B/H$$

$$\cos\theta_2 = \frac{2m}{2.33m}$$

$$\boxed{\cos\theta_2 = 0.86}$$

$\sin\theta_2 = P/H$

$\sin\theta_2 = \frac{1.2m}{2.33m}$

$\boxed{\sin\theta_2 = 0.52}$

Now from (1)

$T_1 \sin\theta_1 + T_2 \sin\theta_2 = W$

$T_1 \left(\sin\theta_1 + \frac{T_2}{T_1} \sin\theta_1\right) = W \rightarrow (3)$

from (2)

$T_2 \cos\theta_2 = T_1 \cos\theta_1$

$\frac{T_2}{T_1} = \frac{\cos\theta_1}{\cos\theta_2}$

$\boxed{\frac{T_2}{T_1} = \frac{\cos\theta_1}{\cos\theta_2}} \rightarrow (4)$

putting (4) in (3)

$T_1 \left(\sin\theta_1 + \frac{\cos\theta_1}{\cos\theta_2} (\sin\theta_2)\right) = W \rightarrow (5)$

putting value in (5)

$T_1 \left(0.83 + \left(\frac{0.55}{0.86}\right)(0.52)\right) = 3.218$

$T_1 (1.163) = 3.218 N$

$T_1 = 26912N$

So

T_1 = 86% of total weight which is the amount of weight hold by cable AB.

Now

to find T_2

$T_2 \cos\theta_2 = T_1 \cos\theta$

$T_2 = \frac{T_1 \cos\theta_1}{\cos\theta_2}$

$T_2 = (31218)\left(\frac{0.55}{0.86}\right)$

$T_2 = 19965N$

So $T_1 = 26912N$ and $T_2 = 19965N$ are the required tension.

- Q1 (b)

increased weight of tank

$wt' = wt + 0.15wt$

$wt' = 400lb + 0.15(400)lb$

$wt' = 460lb$

$wt' = \frac{460N}{0.22}$

$wt' = 2091N$

Increased weight of water

$W_w = mg$

$W_w' = (4050kg)(9.8ms^{-2})$

$\boxed{W_w' = 39690N}$

So Total increased weight

$W' = W_t' + W_w'$

$W' = 2091 + 39690N$

$\boxed{W' = 41781N}$

Now to find "T_1" using (5)

$$T_1\left(\sin\theta_1 + \frac{\cos\theta_1}{\cos\theta_2}(\sin\theta_2)\right) = W'$$

$T_1(1.163) = 41781N$

$\boxed{T_1 = 35925N}$

While

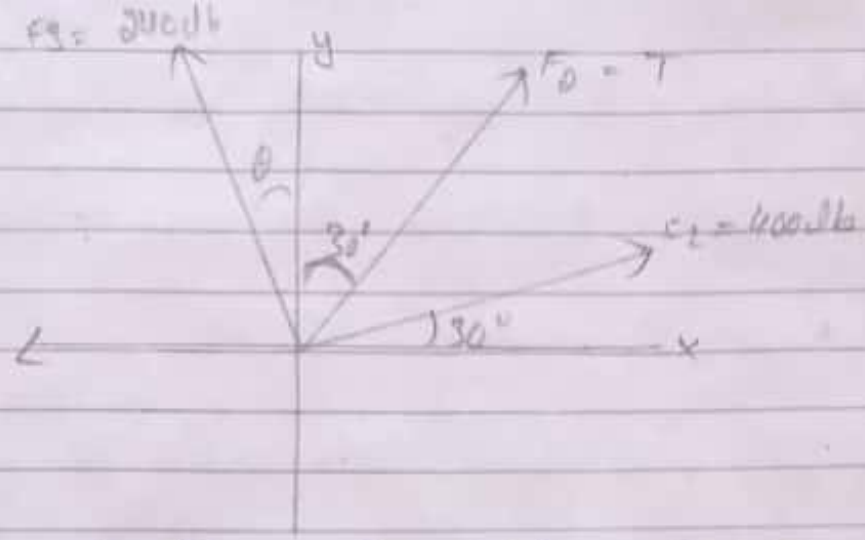
$$T_2 = \frac{T_1\cos\theta_1}{\cos\theta_2}$$

$$T_2 = \frac{(35925)(0.55)}{0.86}$$

$\boxed{T_2 = 22978N}$ so T_1 and T_2 are the required Result while the period of T_1 and T_2 remain same.

Qu#3 Four forces are exerted on the eyebolt as shown below. If the net effect on the bolt is a direct pull of 600 pounds in the y-direction, determine the value of T and θ.

Sol:



$F_1 = 400lb$ $\theta_1 = 30°$ with +ve x-axis

$F_2 = T$ $\theta_2 = 90 - 30 \Rightarrow \theta_2 = 60°$

$F_3 = 240lb$ $\theta_3 = 90 + \theta$

$F_4 = 360lb$ $\theta_4 = 180$

$$\sum F_x = 0 \qquad \sum F_y = 600lb$$

Now

$$\sum F_x = 0$$

$$F_1\cos\theta_1 + F_2\cos\theta_2 + F_3\cos\theta_3 + F_4\cos\theta_4 = 0$$

$$400\cos 30 + T\cos 60 + 240\sin\theta_3 + 360\cos 180 = 0$$

$$346.4 + T(0.5) - 240\sin\theta - 360 = 0$$

$$\boxed{0.5T - 240\sin\theta - 13.6 = 0} \rightarrow (1)$$

$\sum F_y = 600$

$F_1 \sin\theta_1 + F_2 \sin\theta_2 + F_3 \sin\theta_3 + F_4 \sin\theta_4 = 600$

$400 \sin 30 + T \sin 60 + 240 \sin(90+\theta) + F_4 \sin 180 = 600$

$400(0.5) + T(0.866) + 240\cos\theta = 600$

$\boxed{0.866T + 240\cos\theta - 400 = 0} \rightarrow (2)$

From (1) and (2)

$0.5T - 240\sin\theta - 13.6 = 0 \rightarrow (1)$

$0.866T + 240\cos\theta - 400 = 0 \rightarrow (2)$

Xing (1) by 0.866 and (2) by 0.5

So

(1) become $\boxed{0.433T - 207.8\sin\theta - 11.78 = 0} \rightarrow (3)$

(2) become $\boxed{0.433T + 120\cos\theta - 200 = 0} \rightarrow (4)$

Subtracting (4) from (3)

$0.433T - 207.8\sin\theta - 11.8 = 0$

$0.433T + 120\cos\theta - 200 = 0$

$-207.8\sin\theta - 120\cos\theta + 188.22 = 0$

$-207.8\sin\theta - 120\cos\theta + 188.22 = 0$

188.22 188.22

$-1.10\sin\theta - 0.64\cos\theta + 1 = 0$

$$\boxed{1.10\sin\theta + 0.64\cos\theta - 1 = 0}$$

The above equation satisfied by guessing. $\theta = 25°$ approximately.

Now to find T using equation (1)

(1) $0.5T - 240\sin\theta - 13.6 = 0$

$0.5T - 240\sin 25 - 13.6 = 0$

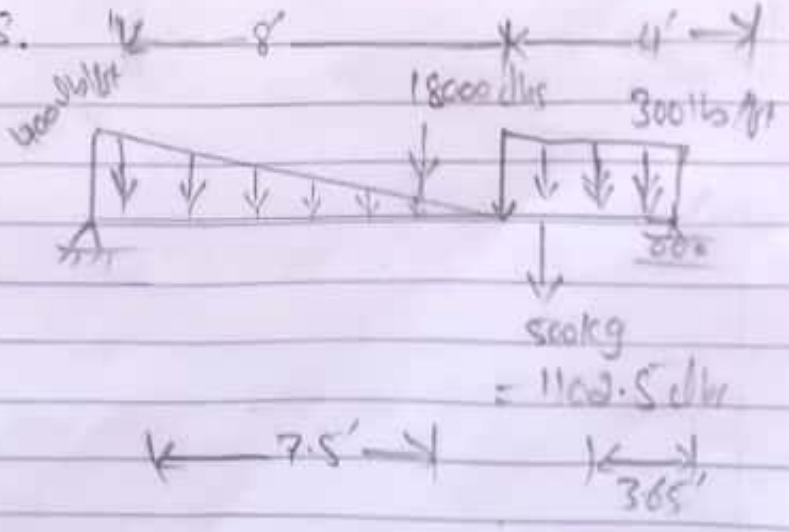
$0.5T - 101.43 - 13.6 = 0$

$0.5T - 115 = 0$

$T = \frac{115N}{0.8}$

$$\boxed{T = 128.6N}$$

Q No 03: Calculate the reaction at supports.



Reactions

$R_A = R_B = ?$

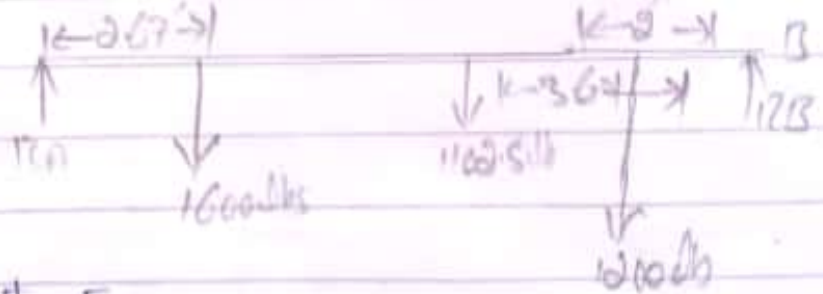
Sol:

$\sum M_B = 0 \quad \curvearrowright^{+} \curvearrowleft^{-}$

$-(1600 \times 2) - (1102.5 \times 3.65)$

$-(1600 \times 9.33) + 12 R_A = 0$

$\boxed{R_A = 1779.34 \text{ lbs}}$



$\sum F_y = 0 \quad \uparrow^{+} \downarrow^{-}$

$R_A + R_B - 1600 - 1200 - 1102.5 = 0$

$\boxed{R_B = 2123.16 \text{ lbs.}}$