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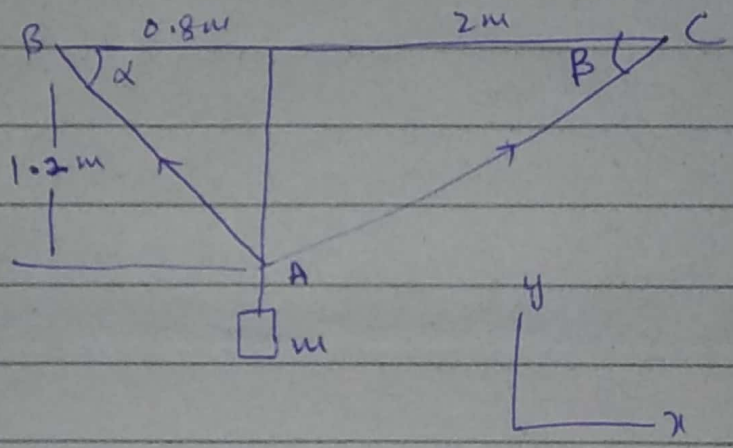
Sec' — "A"
Depatement — BS Civil.
Paper — Engineering mechanics.

Q 1. Part "A"

Sol:



Sol: Part "A"

M = mass of tank + mass of water

mass of tank = 400 pounds.

mass of tank = 400/2.21 = 181 kg.

1kg = 2.21 pounds

mass of water = ?

Volume = 3000 litter

1 m^3 = 1000 Litters

So water volume = 3 m^3

density of water = 1000 $kg\,m^{-3}$

Total mass = 181 + 3000 kg. = 3181 kg.

weight (W) = 3181 kg × 9.81

F = 31205 N.

$\Sigma fx = 0$

$\Sigma fx = T_1 \cos\beta = T_2 \cos\alpha \rightarrow (1)$

$\Sigma fy = 0$

$\Sigma fy = T_1 \sin\beta = T_2 \sin\alpha \rightarrow (2)$

$T_1 \sin\beta = T_2 \sin\alpha = mg.$

From eq (1)

$T_1 \cos\beta = T_2 \cos\alpha$

$T_2 = \frac{T_1 \cos\beta}{\cos\alpha}$

Now put these values in eq (2)

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

$T_1 \left[\sin\beta + \frac{\sin\alpha \cos\beta}{\cos\alpha}\right] = mg.$

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

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

$\alpha = 56.30^\circ$

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

$\beta = 31^\circ$

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

$$T_1 = 17\,333.16\ N$$

$$T_2 = \frac{T_1 \cos\beta}{\cos\alpha}$$

$$T_2 = \frac{17333.16 \times \cos(31)}{\cos(56.3)}$$

$$T_2 = 26777.63\ N$$

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

$$AB = 85.81.$$

Part B

Solution

Tank mass increases 15%

new mass = 181×1.15

= 208.15 kg.

volume of water increases 35%

new volume = 3×1.35

= $4.05\ m^3$

mas of Water = 4050

Total mass = 4258.15 kg.

$F = 41772.45\ N$

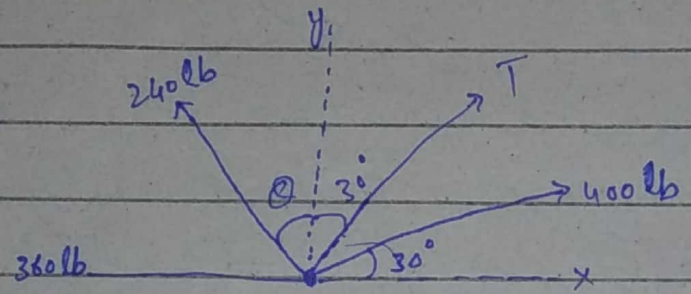
T_1 will be $= 23203\ N$

$T_2 = 35846\ N$

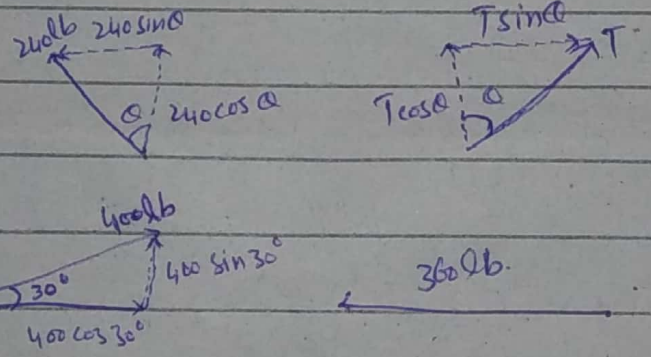
AB% will be same

AB% $= 85.81\ \%$

Q 2:



Solutions



$\Sigma f_x = 0 \quad \xrightarrow{+} \xleftarrow{-}$

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

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

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

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

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

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

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

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

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

Now find $\sin\theta$ & $\cos\theta$.

eq (1) $\Rightarrow$

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

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

$$\sin\theta = \frac{0.5T - 13.59}{240} \longrightarrow (iv)$$

eq (2) $\Rightarrow$

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

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

$$\cos\theta = \frac{400 - 0.866T}{240} \longrightarrow (v)$$

eq (iv) & eq (v) in eq (iii).

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

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

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

$$0.25T^2 + 0.75T^2 - 13.59T - 692.8T + 184.68 + 160000 - 57600 = 0$$

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

Using quadratic formula

we get

$T_1 = 502.065$ lb

$T_2 = 204.325$ lb

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

For $T = 502.065$ lb

Using eq (iv)

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

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

$$\theta = 81.63^\circ$$

Using eq (v).

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

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

$$\theta = 98.33^\circ$$

$81.63^\circ \neq 98.33^\circ$ (Solution is valid)

For $T = 204.325$ lb.

Using eq (iv)

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

(7)

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

$$\theta = 21.7^\circ$$

Using eq (V)

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

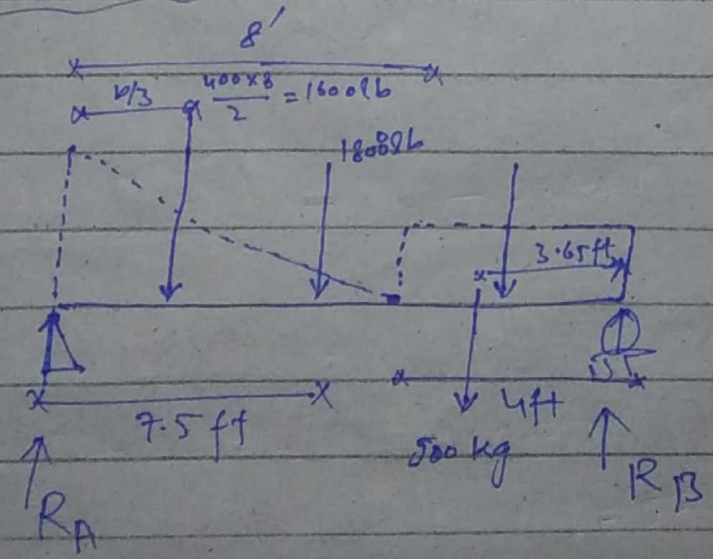
$$\theta = \cos^{-1}\left(\frac{400 - 0.866 \times 204.325}{240}\right)$$

$$\theta = 21.7^\circ \quad \text{(Solution is valid.)}$$

$$\left\{\begin{array}{l} T = 204.325 \text{ lb} \\ \theta = 21.7^\circ \end{array}\right\}$$

Q:3

Solution:



$$\Sigma M_A = 0 \quad (+)$$

$$-(1600 \times 2.667) - (1800 \times 7.5) - (1108.5 \times 8.35) - (1200 \times 10) + R_B \times 12 = 0$$

(8)

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

$RB \times \frac{12}{12} = \frac{28173.075}{12}$

$RB = 2347.756$ lb.

$\Sigma F_y = 0$ ↑ ↓ +

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

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

$= 5702.5 - RB$

$= 5702.5 - 2347.756$

$RA = 3354.7437$ lb.