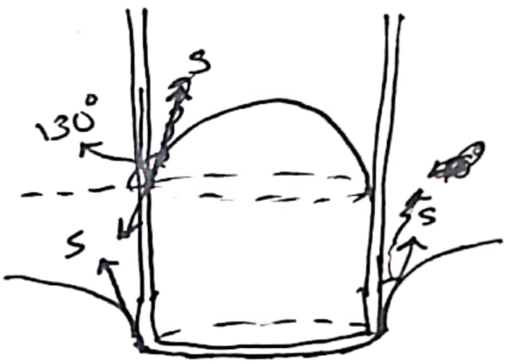
B. EN214

1. $\Delta P = \dfrac{4S}{R}$ $\left(S_{soap} \approx \dfrac{1}{3}(S_{water}) = \dfrac{1}{3}\, 0.123(1-0.00139T)\right)$

$$= \frac{4(0.025)}{2 \times 10^{-3}} = 50\ Pa$$

2. θ = contact angle $= 130^\circ$



$$\therefore\ F = 2\pi r_1 S \cos\theta + 2\pi r_2 S \cos\theta$$

$$= 2\pi S \cos\theta\,(r_1 + r_2)$$

$$= 2\pi \times 486.5 \times 10^{-3} \times \left(\frac{0.35 + 0.25}{2}\right) \times 10^{-3} \times \cos 130^\circ$$

$$= \cancel{0.916\ mN}\ -0.589\ mN$$

3. $P = P_0 + \frac{1}{2}\rho V_\infty \left(\frac{2xyz}{L^3} + 3\left(\frac{x}{L}\right)^2 + \frac{V_\infty t}{L} \right)$

$$\nabla P = \frac{\partial P}{\partial x}\hat{e}_x + \frac{\partial P}{\partial y}\hat{e}_y + \frac{\partial P}{\partial z}\hat{e}_z \qquad (\text{at a fixed time } t)$$

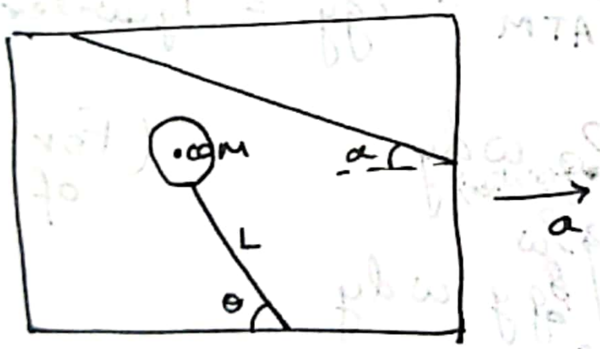
$$\nabla P = \left(0 + \frac{1}{2}\rho V_\infty\left(\frac{2yz}{L^3} + \frac{6x}{L}\right)\right)\hat{e}_x$$

$$+ \left(0 + \frac{1}{2}\rho V_\infty\left(\frac{2xz}{L^3}\right)\right)\hat{e}_y$$

$$+ \left(0 + \frac{1}{2}\rho V_\infty\left(\frac{2xy}{L^3}\right)\right)\hat{e}_z$$

$$\therefore \nabla P = \frac{1}{2}\rho V_\infty\left[\left(\frac{2yz}{L^3} + \frac{6x}{L}\right)\hat{e}_x + \frac{2xz}{L^3}\hat{e}_y + \frac{2xy}{L^3}\hat{e}_z\right]$$

4.

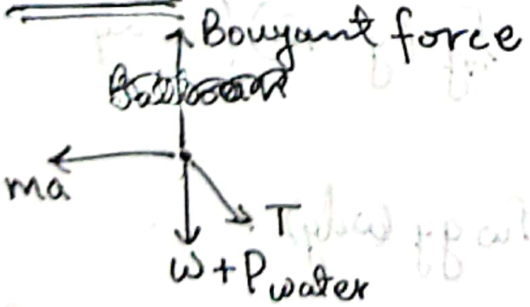


Ballon will move toward the ~~right~~ left.

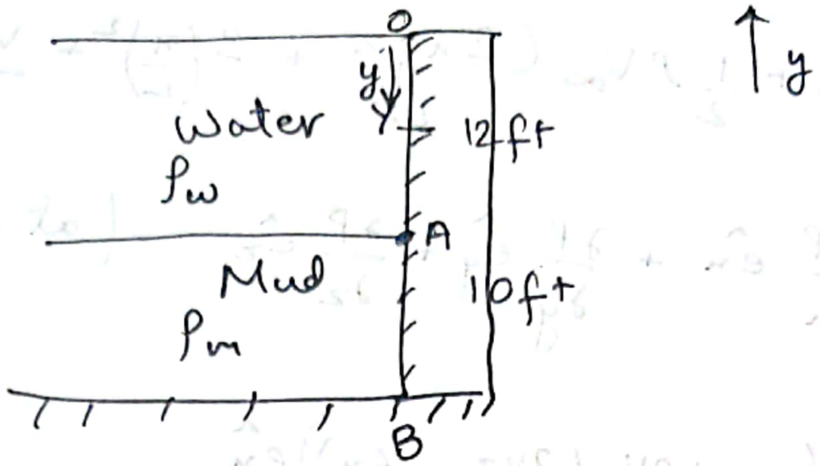
~~due to~~

This can be resolved by taking car as frame of reference and providing a

Balloon



5.



$$\frac{dP}{dy} = -\rho g$$

$$\therefore \int_0^{Y} dP = \int_0^{-y} -\rho g \, dy \qquad (y = \text{positive value})$$

$$P_Y - P_{ATM} = -\rho g(-y)$$

$$\therefore P_Y - P_{ATM} = \rho g y = P_{g(water)}$$

$$\therefore dF = P_{g(water)} \, w \, dy \qquad (\text{For an element of } \cancel{\text{width}} \text{ Area } w \times dy)$$

$$\int_0^A dF = \int_0^{12} \rho_w g y \, w \, dy$$

$$\Rightarrow \int_A^B dF = \int_{12}^{22} [\rho_w g(12) + \rho_m g(y-12)] \, w \, dy$$

$$\therefore \text{Total force} = \int_0^B dF = \int_0^{12} \rho_w g y (w dy)$$

$$+ \int_{12}^{22} [\rho_w g(12) + \rho_m g(y-12)](w dy)$$

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$$\therefore \frac{\text{Total force}}{w} = \left.\frac{\rho_w g y^2}{2}\right]_0^{12} + \left.\rho_w g\, 12 y\right]_{12}^{22} + \left.\rho_m g\left(\frac{y^2}{2} - 12y\right)\right]_{12}^{22}$$

$$= \frac{2 \times \cancel{9.8}^{32.17} \times 144}{2} + 2 \times \cancel{9.8}^{32.17} \times 12 \times (10)$$

$$+ 4 \times \cancel{9.8}^{32.17}\left(\frac{484-144}{2} - 12(10)\right)$$

$$= (1411.2 + 2352 + 1960) \times \frac{32.17}{9.8}$$

Total force per unit width ~~= 5723.2 slugs/m~~

$$= \underline{\underline{18787.28 \text{ lbf}}}$$

Now,

$\bar{y}$ = location of centre of pressure

$$= \frac{\int_0^B y\, dF}{\int_0^B dF}$$

$$= \underbrace{\int_0^{12} y(\rho_w g y\, dy) + \int_{12}^{22} \rho_w g (12)\, dy \times y + \int_{12}^{22} \rho_m g (y-12) y\, dy}$$

Total force per unit width

$$= \frac{\left.\rho_w g\, y^3/3\right]_0^{12} + \left.\rho_w g(12) y^2/2\right]_{12}^{22} + \left.\rho_m g\left(\frac{y^3}{3} - \frac{12y^2}{2}\right)\right]_{12}^{22}}{\cancel{5723.2}\ 18787.28}$$

$$= \frac{2 \times \cancel{9.8}^{32.17} \times \frac{12^3}{3} + 2 \times \cancel{9.8}^{32.17} \times 12\frac{(484-144)}{2} + 4 \times \cancel{9.8}^{32.17}\left(\frac{22^3 - 12^3}{3} - 12 \times \frac{(484-144)}{2}\right)}{18787.28}$$

$$\bar{y} = \frac{(11289.6 + 39984 + 36586.67)}{\cancel{57233} \; 18787.28} \times \frac{32.17}{9.8}$$

$$\boxed{\bar{y} = 15.35 \text{ m}} \text{ from the top}$$

$$\therefore \bar{y}_{bottom} = 22 - 15.35$$
$$= \underline{\underline{6.65 \text{ m}}}$$

6. 

$x V_{Tot} = V_{sub}$

ρ

ρ_w

Now, $F + F_B = W$

$$\therefore F + V_{sub} \rho_w g = V_{Tot} \rho g$$

$$\Rightarrow F = V_{Tot} \rho g - x V_{Tot} \rho_w g$$

$$\cancel{\Rightarrow \frac{F}{V \rho_w g} = 1 - x}$$

$$\cancel{\left(V_{Tot} = V\right)} \quad = \frac{4\pi R^3}{3}$$

$$\therefore \boxed{x = \frac{\cancel{V \rho_w g - F}}{V \rho_w g}}$$

$$\Rightarrow F = V g (\rho - x \rho_w)$$

$$\Rightarrow \frac{F}{Vg} - \rho = -x \rho_w$$

$$\Rightarrow \frac{\rho - \frac{F}{Vg}}{\rho_w} = \boxed{x = \frac{\rho - \frac{3F}{4\pi g R^3}}{\rho_w}}$$