Phy 250

Homework 1

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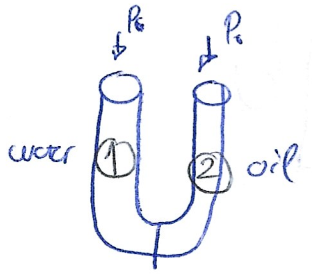


water	oil
0,25m → 25cm	0,25m → 25cm
$\rho = 1\ g/cm^3$	$\rho = 0.80\ g/cm^3$

a) The water is more dense than oil, this means that water will "push" the oil, as the oil "sits" on top of water.
The level of water will decrease by h and the level of oil will increase by the same amount.

We know that the pressure at a certain height is $P = \rho g y + P_0$ due to Pascal's Principle. We also know that the pressure at the center is constant (is the same for the oil and water).

$$\cancel{P_0} + \rho_w g (y_1 - h) = \rho_o g (y_2 + h) + \cancel{P_0}$$

$$y_1 - h = 0{,}8 y_2 + 0{,}8h$$

$$y_1 - 0{,}8 y_2 = 1{,}8h; \quad \text{In this case } \underbrace{y_1 = y_2}_{y} \ (25cm)$$

$$y - 0{,}8y = 1{,}8h; \quad y(1 - 0{,}8) = 1{,}8h; \quad h = \frac{0{,}2y}{1{,}8} = 0{,}11y$$

$$y = 25cm; \quad h = 0{,}111 \cdot 25 = 2{,}777cm$$

Solution: The level of water will ~~increase~~ decrease by 2,777cm → 25 − 2,777 = 22,22cm
and level of oil increases by 2,777cm → 25 + 2,777 = 27,777

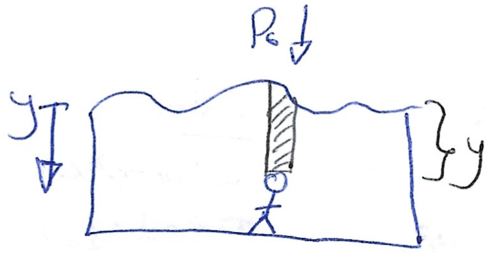
b) I) If both had equal densities the level would remain the same (for example, water on both sides) as both liquids would be almost the same.
The pression on both sides would be the same.

II) If the density was less, the water would "push" the oil much more. The height of oil would increase significantly and the height of water decrease to compensate the difference in density.

(2) Eardrum diameter = 8.2mm = $8,2 \cdot 10^{-3}$ m

" radius = $4,1 \cdot 10^{-3}$ m

$\rho_{water} = 1,03 \cdot 10^3 \ kg/m^3$



Pascal's Principle: $P = \cancel{dg}\ \rho g h + P_0$

$P = \frac{F}{A}$ ~~if the force is $1,5N + P_0 \rightarrow$~~ . ~~$F_1 = 1,5N + P_0$, $\Delta P = 1,5N$~~

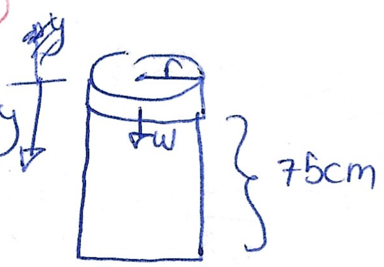
$F_1 = 1,5 + F_{atm.\ pressure}$; $\underline{\Delta F = 1,5N}$

$P = \frac{\Delta F}{A}$; $\Delta F = P \cdot A$; $\Delta F = \rho g y \cdot A$

$\Delta F = \rho g y \cdot \pi r^2$; $y = \frac{\Delta F}{\rho g \pi r^2} = \frac{1,5}{(1,03 \cdot 10^3) \cdot 9,8 \cdot \pi \cdot (4,1 \cdot 10^{-3})^2}$

$= \underline{2,8m}$

(3)



$\rho_{oil} = 0.850 g/cm^3 = 850 kg/m^3$

$r = \cancel{0}.15cm = 0,15m$

$w = m \cdot g$

a) $A_{disk} = \pi \cdot r^2 = 706.5cm^2 = 0,07m^2$

Gauge Pressure $P = \frac{F}{A}$; $P = \frac{45N}{0,07m^2} = \underline{642,85 Pa}$

b) I) 83 N applied $\rightarrow$ 83+45 = 128N

New gauge Pressure $\rightarrow P_g = \frac{128}{0,07} = 1828,6$ Pa

At bottom of tank height = 0,75m ; Pascal's Principle: $P = \rho g y + P_g$

$P = 850 \cdot 9,8 \cdot 0,75 + 1828,6 = \underline{8076,1 Pa}$

II) At middle of tank the height = $0,75/2 = 0.375m$

$P = 850 \cdot 9,8 \cdot 0,375 + 1828,6 = \underline{4952,35 Pa}$

4 a) If fish float its because They have similar density to water (The are submerged)

$\rho_{fish} \cong \rho_{water}$

b) 2.75 kg fish increases volume by 10% ⇒ +10%

Net force?

If They float Then $F_b = w$ (Net force: $F_b - w = 0$)

$w = 2.75 \cdot 9{,}8 = 26{,}95 N$

Arquimedes principle: $F_b = \rho_w \cdot g \cdot \underbrace{A \cdot \Delta y}_{volume}$

As $F_b = w$; $|F_b| = 26{,}95 N$

The volume is increased by $10\% = 0{,}1$

$F_b = \rho_w\, g \cdot 0{,}1 vol + vol = \rho_w\, g \cdot 1{,}1\, Volume = 1{,}1 F_b$

~~$F_b = w = mg$~~ $1{,}1 F_b = 1{,}1 \cdot 26{,}95 = \underline{29{,}7 N}$

c) Net extend force?

Water exerts 29.7 N up and weight 26.95 N down

~~2nd law of Newton~~: $F_b - W = 29.7 - 26.95 = 2.75$ upwards

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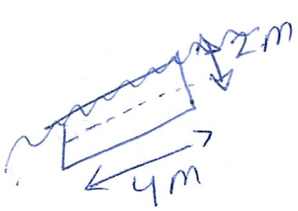
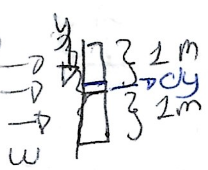


~~Upview~~ side view



We need to calculate torque at every point

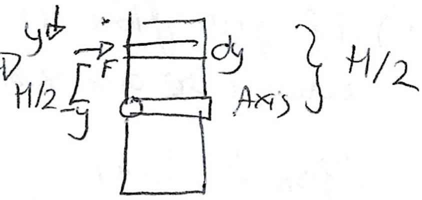
$P = \frac{F}{A}$; $F = PA$; $dF = P \cdot dA$

$dF = \rho g y \cdot dA$ → base · height $= 4 \cdot dy = b \cdot dy$

$dF = \rho g y \cdot b dy$

$\vec{\tau} = \vec{F} \times \vec{r}$; In this case $\vec{r}$ = distance from axis of rotation to where the force is applied

As the hinge is at the center, $\rightarrow r = (H/2 - y)$



τ_1 of upper part: $\displaystyle\int_0^{H/2} d\tau = \int_0^{H/2} \rho g b \cdot r y \cdot dy$

$$= \tau_1 = \rho g b \int_0^{H/2} (H/2 - y) \cdot y\,dy$$

$$= \rho g b \int_0^{H/2} \frac{H}{2} y - y^2 dy = \rho g b \left[\frac{H}{2} \int_0^{H/2} y\,dy - \int_0^{H/2} y^2 dy \right]$$

$$= \rho g b \left[\frac{H}{2} \cdot \frac{y^2}{2} \Big|_0^{H/2} - \frac{y^3}{3} \Big|_0^{H/2} \right]$$

$$= \rho g b \left[\frac{H}{4} y^2 \Big|_0^{H/2} - \frac{y^3}{3} \Big|_0^{H/2} \right]$$

$$= \rho g b \left[\left[\left(\frac{H}{4} \cdot \frac{H^2}{4} \right) - \left(\frac{H}{4} \cdot 0 \right) \right] - \left[\frac{H^3}{8/3} - 0 \right] \right]$$

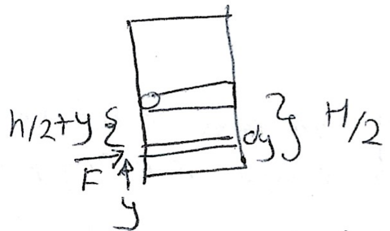
$$= \rho g b \left[\left[\frac{H^3}{16} - 0 \right] - \left[\frac{H^3}{24} \right] \right] = \rho g b \left[\frac{3H^3}{48} - \frac{2H^3}{48} \right]$$

$$= \rho g b \left[\frac{H^3}{48} \right] \Rightarrow \rho_{water} = 1000\ kg/m^3 \Rightarrow 1000 \cdot 9{,}8 \cdot 4 \cdot \frac{8}{48}$$

$$= -6533{,}\overline{3}\ N \cdot m$$

clockwise direction

Lower part



$\uparrow y \quad r = (H/2 + y)$

Apply same as before: $\displaystyle \tau_2 = \int_0^{H/2} \rho g b\,(H/2 + y) \cdot y\,dy = \rho g b \int_0^{H/2} (H/2 + y) \cdot y\,dy$

$$= \rho g b \int_0^{H/2} \frac{H}{2} y + y^2 dy = \rho g b \left[\frac{H}{2} \frac{y^2}{2} \Big|_0^{H/2} + \frac{y^3}{3} \Big|_0^{H/2} \right]$$

$$= \rho g b \left[\frac{H}{4} y^2 \Big|_0^{H/2} + \frac{y^3}{3} \Big|_0^{H/2} \right] = \rho g b \left[\left(\frac{H}{4} \cdot \frac{H^2}{4} \right) + \frac{H^3}{8/3} \right] = \rho g b \left[\frac{H^3}{16} + \frac{H^3}{24} \right]$$

$$= \rho g b \left[\frac{3H^3}{48} + \frac{2H^3}{48} \right] = \rho g b \cdot \frac{5H^3}{48} = 1000 \cdot 9{,}8 \cdot 4 \cdot \frac{5 \cdot 2^3}{48} = +32666{,}66\ N \cdot m$$

counter clockwise direction

solution: $\tau_{total} = \tau_1 + \tau_2 = -6533{,}33 + 32666{,}66$

$$= 26133{,}33\ N \cdot m$$