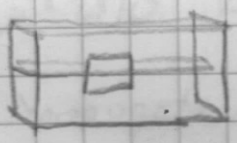
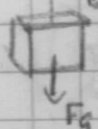
Buoyancy



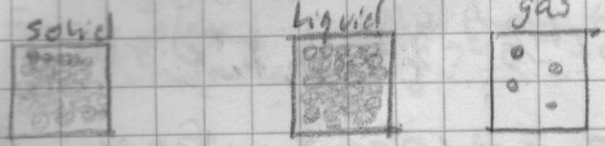


$\rho_{liquid} V_{displaced} g = mg$

Weight of displaced liquid

In other words, a floating object displaces its own weight.

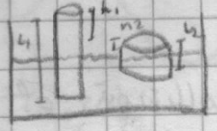
States of matter:



Liquids are as dense as solids, but they can move freely since there are no bonds.

HW 28: Fluid States

1)



For both: $\rho_c = 713\ kg/m^3$, $\rho_{water} = 1025\ kg/m^3$ | $L_1 = 20cm$, $r_1 = 5cm$ | $L_2 = 10cm$, $r_2 = 10cm$

What is h_2/h_1?

$W_{Disp} = W_{submerged}$ $\quad V_{Disp} = \frac{\rho_c}{\rho_w} V$

$W_{Disp} = \rho_w V g = \rho_w (\pi r^2 (L-h)) g$

$W_c = \rho_c V g = \rho_c \pi r^2 L g$ → $\rho_c \pi r^2 L g = \rho_w \pi r^2 (L-h) g$

$\rho_c L = \rho_w (L-h)$

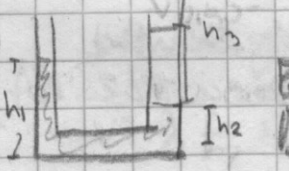
h_1: $713 \cdot (0.2) = 1025 (0.2 - h)$

$h_1 \approx 0.0608 m \approx 6.09 cm$ → $h_2/h_1 = \boxed{1/2}$

h_2: $713 (0.1) = 1025 (0.1 - h)$ $\quad h_2 \approx 0.0304 m \approx 3.04 cm$

713 kg/m³

2)



$h_1 = 0.35m$ $\quad h_2 = 0.13m$ $\quad h_3 = 0.27m$

$\rho_w = 10^3\ kg/m^3$

Pressure $P_A = 101300\ Pa$

a) Absolute water pressure @ the bottom of the tube

$P_1 - P_2 = \rho g h$ → $P = 10^3\ kg/m^3 \cdot 9.81 m/s^2 \cdot 0.35m = 3433.5$ at top of water

+ atmospheric → $\boxed{104733.5\ Pa}$

b) abs pressure @ oil-water interface!

$P_1 - P_2 = 10^3 \cdot 9.81 \cdot 0.22 = 2158.2$ P_2 + atmosphere

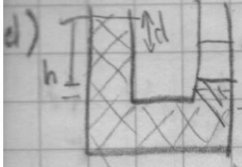
$= \boxed{103458.2\ P_2}$

c) oil density?

$P_3 - P_2 = \rho_{oil} \cdot h_3 \cdot g$

$2158.2 = \rho_{oil} \cdot 0.27 \cdot 9.81$

$\rho_{oil} \approx 814.8\ kg/m^3$

d) 

glycerin $\rho_{glyc} = 1261\ kg/m^3$ $h_3 = 0.27m$

V_{water} same

Abs P @ interface → $P_3 + P_2 = (1261)(9.81)(0.27)$

$= 3340.0107 + P_{atm} \approx$ **104640 Pa**

e) How much higher, d, is the water?

$P_h = P_{h_3} + P_y$ $P_h = P_y$ $3340.0107 = 10^3 \cdot g \cdot h$

$P_y = P_{h_1} + P_{h_3} + P_y$ $h = 0.34047m$

$d = h - h_3 =$ **0.07047m**

f) abs P @ bottom?

From before, the total volume is the same.

So: $h_3 + d + h_3 + 2y = 0.35 + 0.13 + 0.27$

$2y + 2h_3 + d = 0.75$ $2y = 0.13953$

$y = 0.69765$

$P = \rho_w (h + y) g = \rho_w (0.410235)\ 9.81$

$= 4024$ $+ P_{atm} =$ **105324.4054 Pa**

3) 

$\rho_{air} = 1.28\ kg/m^3$

$\rho_{He} = 0.18\ kg/m^3$

$R = 4.6m$

empty balloon + basket $m_b = 126\ kg$

$V_b = 0.056\ m^3$

$m_p = 72\ kg$

$V_p = 0.07\ m^3$

a) $V_{inflated\ b} = ?$ $V = \frac{4}{3}\pi r^3 \Rightarrow \frac{4}{3}\pi (4.6)^3 \approx 407.72\ m^3$

b) F_g without people on whole system?

$F_g = F_{g_b} + F_{g_{He}} = (126\ kg)(9.81) + (407.72)(0.18)(9.81)$

$\approx$ **1956 N**

c) Buoyant force w/o people?

$\rho_{fluid} V_{disp} g = mg$ $F_B = (0.056 + 407.72)(1.28)(9.81) \approx$ **5120 N**

d) F_g on each person? $F_g = 72 \cdot 9.81 =$ **706.32 N**

e) F_B on each person? $F_B = 0.07 \cdot 1.28 \cdot 9.81 =$ **0.99 1987 N**

f) how many people can the balloon lift?

$\sum F_b = -1956 + 5120 = 3164.35$ $3164 / 614 \approx$ **5 people**

$\sum F_{person} = 92 + 706 = -614.16$