Buoyancy:

$$F_B = W_{\text{displaced liquid}}$$

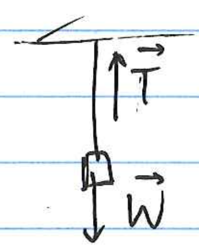
$\uparrow$ buoyant force upwards

$\uparrow$ weight of displaced liquid (value only)

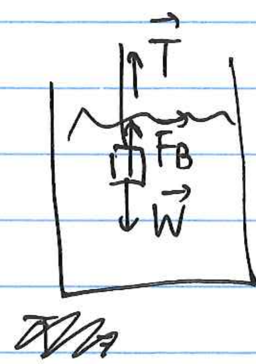
$F_B > W_{object}$ → net upward force → float

$F_B < W_{object}$ → net downward force → sinks

Example: Archimedes measures the weight of the King's crown



$T = W$



$$\vec{F}_{net} = 0 = T + F_B - W$$

$$\downarrow$$

$$T = W - F_B$$

apparent weight is lower

↓

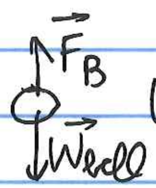
use difference to determine the density of the object

Floating bells : V_{bells} constant
ρ_{bells} constant
m_{bells} constant

What changes ? ρ_{H_2O} changes with temperature

$$F_B = \rho_{H_2O} V_{bell}\, g$$

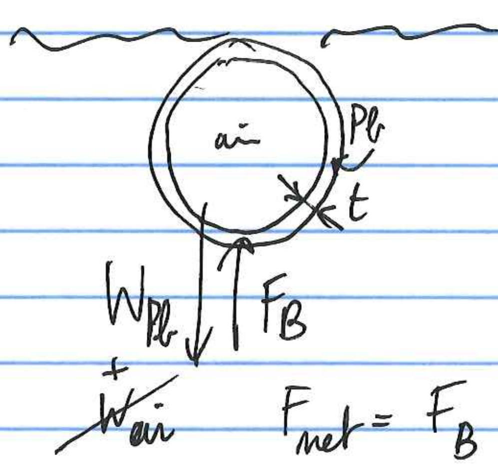
T increases $\rightarrow$ ρ_{H_2O} increase $\rightarrow$ F_B increase



$W_{bell} < F_B$ $\rightarrow$ float upwards

Example: lead sphere : $\rho_{Pb} = 11.3 \times 10^3$ kg/m^3

$R = 10$ cm



$$F_B = \rho_{H_2O}\left(\frac{4}{3}\pi R^3\right) g$$

$$W_{Pb} = \rho_{Pb}\left(4\pi R^2\right) t\, g$$

$$F_{net} = F_B - W_{Pb} = 0$$

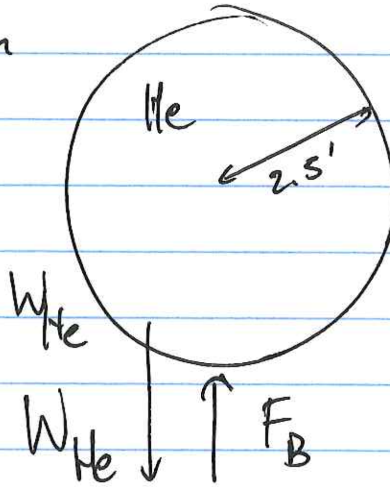
$$\rho_{H_2O}\left(\frac{\cancel{4}}{3}\cancel{\pi} R^{\cancel{3}}\right)\cancel{g} = \rho_{Pb}\left(\cancel{4\pi} \cancel{R^2}\right) t\, \cancel{g}$$

$$\hookrightarrow t = \frac{\rho_{H_2O}}{\rho_{Pb}}\frac{R}{3} = \frac{(\cancel{10^3} \text{ kg/m}^3)(0.1 \text{ m})}{(11.3 \times \cancel{10^3} \text{ kg/m}^3)\ 3} = 3 \times 10^{-3} \text{ m}$$

$$= 3 \text{ mm}$$

Helium balloon launch : how many 5' diameter He-filled balloons does one need to lift one 70 kg person?

Consider 1 balloon



$F_{net} \neq 0$

$F_{net} = F_{lift} = F_B - W_{He}$

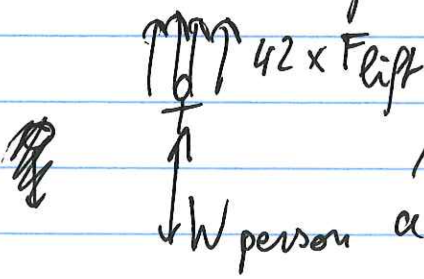
$$\left.\begin{aligned} F_B &= \rho_{Air}\left(\tfrac{4}{3}\pi R^3\right) g \\ W_{He} &= \rho_{He}\left(\tfrac{4}{3}\pi R^3\right) g \end{aligned}\right\} \longrightarrow F_{lift} = (\underbrace{\rho_{Air}}_{1.29\,kg/m^3} - \underbrace{\rho_{He}}_{0.18\,kg/m^3})\left(\tfrac{4}{3}\pi \overset{(25)(0.0254\,m)}{R^3}\right) g$$

$\underline{F_{lift}} = 20.2\ N$

$W_{person} = (70\ kg)\, g > n \times F_{lift}$

$n = \dfrac{W_{person}}{F_{lift}} \approx 40$

$n = 42$ balloons $\rightarrow F_{total\,lift} = 42\, F_{lift} = (42)(20.2N)$
$= \underline{850\ N}$

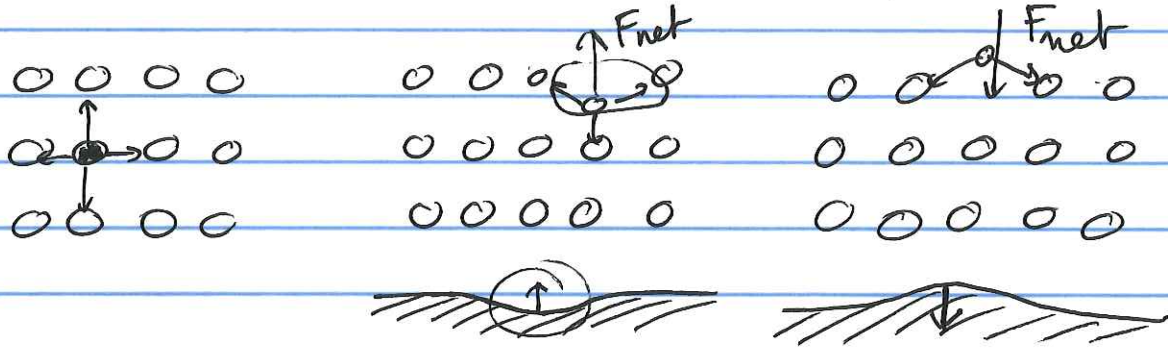


$ma = 42 F_{lift} - W_{person}$

$a = \dfrac{F_{total\,lift} - W_{person}}{m}$

$a = +2.3 \, m/s^2$

* Surface tension : forces between ~~th~~ same type of molecules in a liquid



droplet 

Surface tension $= \gamma = \dfrac{F}{l}$ → l = circumference of the area of contact

$l = 2\pi R$

$\gamma_{water} = 0.0728 \, \dfrac{N}{m}$

$F = \gamma l = 2\pi R \gamma$