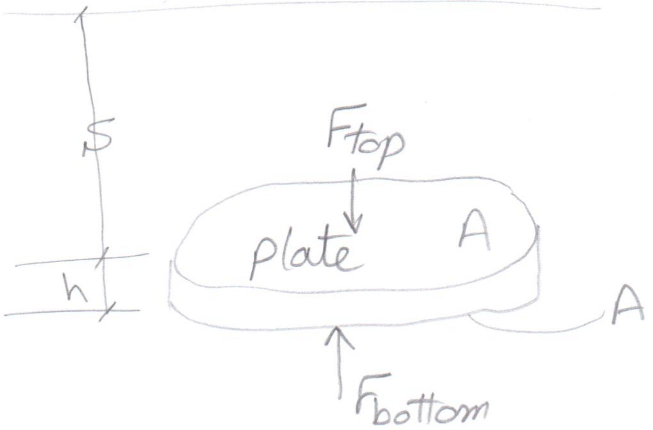
Buoyancy and stability

An object feels lighter and weighs less in liquid than it does in air. Also, objects made of wood or other light materials float on water. These and other observations suggest that a fluid exerts an upward force on a body immersed which is called "buoyant force (F_B)". It is caused by the increase of pressure in a fluid with depth. بالرغم من استنتاج هذه القوانين لأجسام منتظمة إلا أنها تعمل لكل الأشكال



$$F_{top} = \rho_f g S A$$

$$F_{bottom} = \rho_f g (h+S) A$$

$$F_B = F_{bottom} - F_{top}$$

$$= \rho_f g (h+S) A - \rho_f g S A$$

$$= \rho_f g h A = \boxed{\rho_f g V_{sub.} = F_B}$$ as $V = hA =$ Vol. of plate

Buoyant force acting on the plate is equal to weight of liquid displaced by the plate.

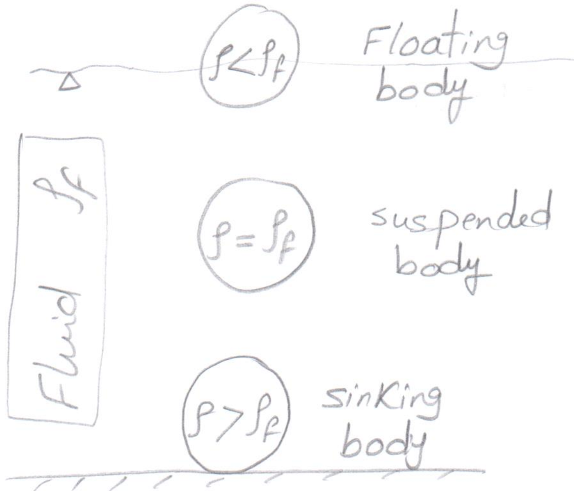
- It is independent of the distance of the body from free surface.
- Also, it is 〃 〃 the density of the solid body.

* For floating bodies, $F_B = W$

* for the same Volume $F_B \propto \rho$

$$\rho_f \, g \, V_{sub.} = \rho_{av.\,body} \, g \, V_{total}$$

$$\boxed{\frac{V_{sub.}}{V_{total}} = \frac{\rho_{av.\,body}}{\rho_f}} \Rightarrow$$



* لو كانت $\rho < \rho_f$ ∴ $V_{total} > V_{sub.}$
الجزء المغمور ليس الجسم كله

* وهكذا $\rho = \rho_f$ ∴ $V_{total} = V_{sub}$
سيتم غمر الجسم كله.

* There is Buoyancy effects in gases but they are neglected.

for a person in air $F_B = \rho_f g V$

$= 1.2 * 9.81 * 0.1 = \underline{1.2\ N}$

& this person's weight $W = 80 * 9.81 = \underline{788\ N}$

* For a helium balloon, it rises as a result of the bouyancy effect until it reaches an altitude where the density of air (which decreases with altitude) equals the density of helium in the balloon.

* Measuring specific gravity by a Hydrometer.

a) relation between sp. gr. & ΔZ

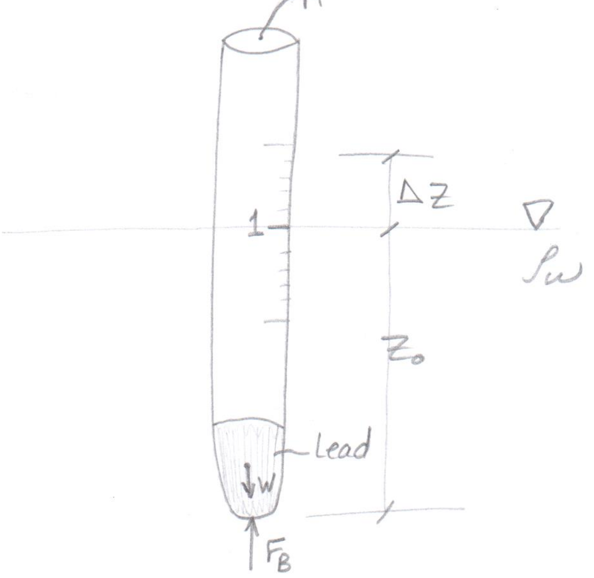
$$W_{hydro} = F_{B,W} = \rho_w g V_{sub}$$

$$= \rho_w g A Z_o$$

$$= \rho_f g A (Z_o + \Delta Z)$$

$$\therefore \rho_w g A Z_o = \rho_f g A (Z_o + \Delta Z)$$

$$\boxed{SG_f = \frac{\rho_f}{\rho_w} = \frac{Z_o}{Z_o + \Delta Z}}$$



b) mass of lead that must be poured into 1cm dia., 20 cm long hydrometer if it is to float halfway (10 cm mark) in pure water

$$W = F_B$$

$$mg = \rho_w g V_{sub.}$$

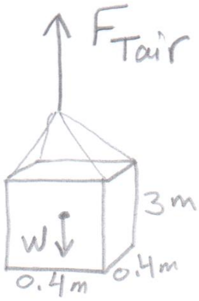
$$m = \rho_w V_{sub} = \rho_w A h_{sub.}$$

$$= 1000 * \frac{\pi}{4} (0.01)^2 * 0.1$$

$$= 0.00785\ Kg = 7.85\ gram$$

Ex.

weight loss of an object in sea water

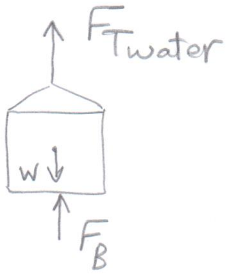


$\rho_f = 1025\ Kg/m^3$

$\rho_{Con.} = 2300\ Kg/m^3$

$F_T = ??$ a) on air b) on water

$V = 0.4 * 0.4 * 3 = 0.48\ m^3$



a) $F_{T_{air}} = W = \rho_{Con.}\, g\, V$

$= 2300 * 9.81 * 0.48 = 10.8\ KN$

b) $F_{T_{water}} = W - F_B \longrightarrow (1)$

$F_B = \rho_f\, g\, V = 1025 * 9.81 * 0.48 = 4.8\ KN$

sub. in (1) $F_{T_{water}} = 10.8 - 4.8 = 6\ KN$

Tension in robe decreases by $= \dfrac{10.8 - 4.8}{10.8} = 55\%$