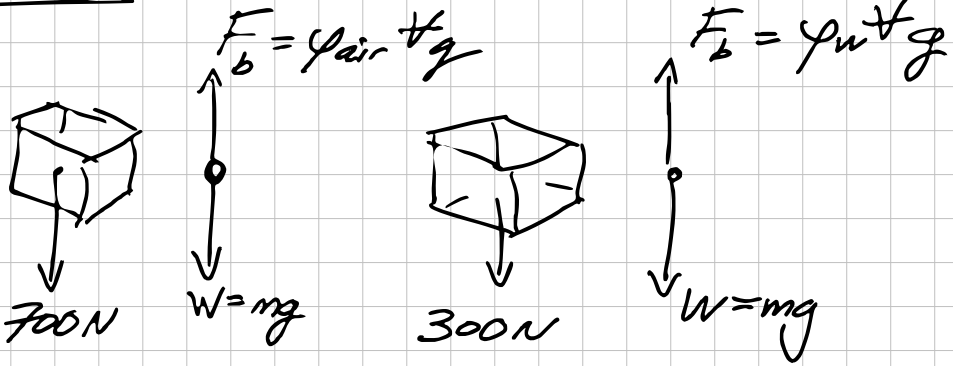
CE3305
E.S-5
SPRING 2024

PROBLEM 1

A block of material of unknown volume is submerged in water and weighs 300N. In air same block weighs 700N.

Find - Volume
- Sp. weight

Sketch



IN AIR

IN WATER

Known

$W_{air} = 700\ N$

$W_{water} = 300N$

$\rho_{air} = 1.225 \text{ kg/m}^3$ $\quad g = 9.8 \text{ m/s}^2$

$\rho_{water} = 999 \text{ kg/m}^3$ @ $15^\circ C$ (Internet lookup!)

UNKNOWN

$\forall_{block}$; sp. weight of block ($\gamma = \frac{W_{block}}{V_{block}}$)

GOVERNING PRINCIPLES

BOUYANCY DEFN. ($F_b = \forall_w \rho_w g$) ← volume displaced

STATICS $\quad \Sigma F = ma \quad a = 0$

SOLUTION

$$(F_b - W)_{air} = (F_b - W)_{WATER}$$

$$\rho_{air} \forall_{block} g - W_{air} = \rho_{wat} \forall_{BLOCK} g - W_{water}$$

$$W_{water} - W_{air} = (\rho_{wat} g - \rho_{air} g) \forall_{block}$$

$$\frac{W_{water} - W_{air}}{(\rho_{wat} - \rho_{air}) g} = \forall_{block}$$

CONTINUED

$$\frac{W_{water} - W_{air}}{(\rho_{wat} - \rho_{air})g} = \forall_{block}$$

$$\frac{700N - 300N}{(999 - 1.225)\frac{kg}{m^3} \cdot \frac{9.8m}{s^2}} = \frac{400 \frac{kg \cdot m}{s^2}}{(997.775)\frac{kg}{m^3}\left(\frac{9.8m}{s^2}\right)}$$

$$= 0.0409\, m^3 \longleftarrow \forall_{BLOCK}$$

density

$$\rho = \frac{700N}{0.0409} \cdot \frac{1}{9.8 m/s^2} = 1746.42 \frac{kg}{m^3}$$

(sinks in water)

sp. weight

$$\gamma_{block} = \rho g = 17114.9 \frac{N}{m^3} \longleftarrow \gamma_{block}$$

DISCUSSION

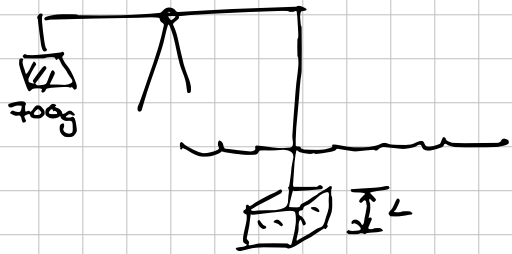
Use definitions of ρ, γ. Use boyancy, don't forget non-zero boyance in air.

PROBLEM 2

A cube ($L = 60mm$) is suspended in CCl_4, balanced by a 700 g counterweight

- Find mass of the cube.

SKETCH



KNOWN

COUNTERWEIGHT MASS = 700g

$$\text{WEIGHT} = 0.7kg\left(9.8 m/s^2\right) = 6.86N$$

$$\text{VOLUME CUBE} = (0.06m)^3 = 0.000216\,m^3$$

$$\rho_{CCl_4} = 1.5867 \frac{g}{cm^3} \quad (\text{liquid}) \quad (\text{Wikipedia})$$

$$= 1.5867 \frac{g}{cm^3} \cdot \frac{kg}{1000g} \cdot \frac{(100cm)^3}{1m^3} = 1586.7 \frac{kg}{m^3}$$

UNKNOWN

mass cube

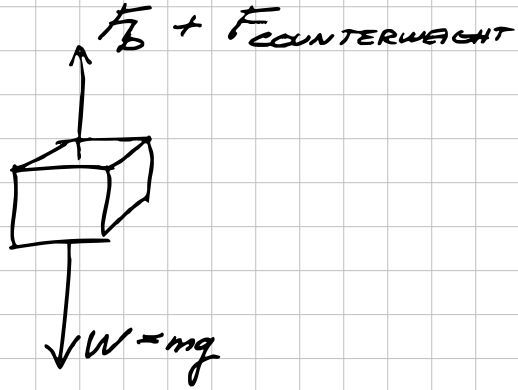
GOVERNING EQUATIONS

$$F_{BOUYANT} = \forall_{displaced} \rho_l g$$

$$\Sigma \underline{F} = m\underline{a} = \underline{0}$$

SOLUTION

FBD block



$$W = F_b + F_{cw}$$

$$m\cancel{g} = \rho_{CCl_4} \forall_{BLOCK} \cancel{g} + m_{cw}\cancel{g}$$

$$m_{block} = \rho_{CCl_4} \forall_{block} + m_{cw}$$

$$m_{block} = 1586.7 \frac{kg}{m^3} (0.000216 m^3) + 0.7\ kg$$

$$m_{block} = \underline{\underline{1.043}}\ kg \longleftarrow m_{block}$$

DISCUSSION

- APPLY DEFINITION(S) OF BOUYANCY & STATIC FORCE BALANCE TO FIND UNKNOWN MASS.