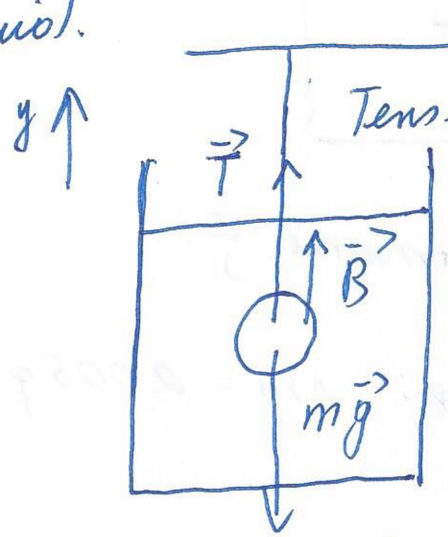
Lab 9 Archimedes Principle Lab

Buoyancy force equals the weight of the displaced liquid.



Tension of the beam $\vec{T} = w' = m'g$

ρ_L = density of the liquid

object with mass m, volume V and density ρ

We weigh the object immersed in the liquid

$\vec{T} + \vec{B} + m\vec{g} = \vec{0}$ $\quad$ T = weight under water w'

$y: \quad T + B - mg = 0$ $\quad$ $m = \rho \cdot V$; $w = \rho V g$

$w' + B = mg = \rho \cdot V g$ $\quad$ $B = \rho_L \cdot V \cdot g$

$w' = ~~\rho~~ mg - \rho_L V g$

$w' = w - \rho_L V g$

$w = \rho V g$

$\frac{w'}{w} = 1 - \frac{\rho_L V g}{\rho V g} = 1 - \frac{\rho_L}{\rho} \quad |(-1)$

$-\frac{w'}{w} = -1 + \frac{\rho_L}{\rho}$;

$\frac{\rho_L}{\rho} = 1 - \frac{w'}{w}$

$$\frac{\rho}{\rho_L} = \frac{1}{1-\frac{W'}{W}} = \frac{1}{1-\frac{m'}{m}}$$

$$\boxed{\rho = \frac{\rho_L}{1-\frac{m'}{m}}}$$

Measure m and m' to determine ρ.

Measure m of the Al cylinder: $\Delta m = 0.005\,g$

$m = 15.412\,g$

m_1 = mass of object in water in basket = 12.365 g

m' = " " " " " without basket = 9.680 g

m_b = " " basket = 2.685 g

$$\rho_A = \frac{1\,g/cm^3}{1-\frac{9.680}{15.412}} = 2.6887\,g/cm^3 = 2.689\,g/cm^3$$

Do this with a large glass sphere and a cast iron (black) cylinder.

Double check with caliper: Every measurement in cm must have 3 decimals

Measure with 3 decimals accuracy:

h = height = 1.962 cm $\Delta h = 0.005$ cm
d = diameter = 1.900 cm $\Delta d = 0.005$ cm } not 0.002 cm

$$V_C = \frac{\pi d^2 h}{4} = 5.5628 \text{ cm}^3$$

$$\rho = \frac{m}{V_C} = \frac{15.412 \text{ g}}{5.5628 \text{ cm}^3} = 2.7705 \text{ g/cm}^3 \checkmark$$

$$\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + \frac{2\Delta d}{d} + \frac{\Delta h}{h} = \frac{0.005}{15.4} + \frac{0.01}{1.9} + \frac{0.005}{1.96}$$

$$= ~~0.8~~\ 8.14 \cdot 10^{-3} = 0.814\%$$

$$\Delta \rho = 0.814\% \cdot 2.7705 \text{ g/cm}^3 = 0.0225 \text{ g/cm}^3$$ (round to 1 sig. fig)

$$\Delta \rho = 0.02 \text{ g/cm}^3$$

$$\rho = (2.77 \pm 0.02) \text{ g/cm}^3$$

Compare: $$\frac{\rho_A - \rho}{\rho} = \frac{2.69 - 2.77}{2.77} = -0.0288 = -2.8\%$$

$\rho_A = \rho$ through Archimedes principle.

< 3% acceptable

< 1% 1 extra point

< 0.5% 2

< 0.25% 4