Student's Name: ________________________________ Student's Name: ________________________________

Lab day & time: ____________________ Date: ___________________

Archimedes' Principle (M8) - Data Sheets

(Show all calculations and write all results on the data sheets in ink)

Activity 1: Density *(2 p.)*

Diameter of the aluminum cylinder _______________ (   )

Radius r of the cylinder: r = _______________ (   )

Height of the cylinder: h = _______________ (   )

Volume of the cylinder (V_1):

V_1 = _______________ (   )

Mass of the cylinder m_1 (measured in air) _______________ (   )

Weight of the cylinder (W where $W = m_1 g$ and $g = 9.80\ m/s^2$):

W = _______________ (   )

Density of the aluminum cylinder:

Density $\rho_{aluminum\ 1}$ = _______________ (   )

Calculate the absolute value of the percent difference between your result and the accepted value of the density of aluminum (2700 kg/m^3):

Percent difference = $\left| \frac{2700 - \rho_{aluminum\ 1}}{2700} \right| * 100\%$ = ____________ (%)

Activity 2: Archimedes' Principle *(1.5 p.)*

For the weight W of the aluminum cylinder in air use (copy) the value from Activity 1.

W = _______________ (   )

Record the reading of the scale (m_2) with the aluminum cylinder completely submerged in water.

m_2 = _______________ (   )

Apparent weight of the cylinder (W^*, where $W^* = m_2 g$ and $g = 9.80\ m/s^2$):

W^* = _______________ (   )

Calculate density of the aluminum cylinder based on the Archimedes' principle. Remember that the density of water is equal to: $\rho_w = 1000\ kg/m^3$.

$$\rho_{aluminum\ 2} = \frac{W}{(W - W^*)}\rho_w$$

Density $\rho_{aluminum\ 2}$ = _______________ (   )

Calculate the absolute value of the percent difference between your result and the accepted value of the density of aluminum (2700 kg/m^3):

Percent difference = $\left|\frac{2700 - \rho_{aluminum\ 2}}{2700}\right| * 100\%$ = ____________ (%)

Calculate the absolute value of the percent difference between the two measurements (*Activity* 1 and *Activity* 2) of density of aluminum.

Percent difference = $\left|\frac{\rho_{aluminum\ 1} - \rho_{aluminum\ 2}}{\rho_{alumimum\ 2}}\right| \times 100\%$ = ____________ (%)

<u>Do we need a correction for the density of air?</u>

Strictly speaking, when we measure mass of the aluminum cylinder in air, we should also consider the buoyant force due to the air. Let us make an estimate to see how big is that correction. Consider an aluminum cylinder that has mass m = 0.10 kg (close to the mass of the cylinder that we are using in this experiment). The density of aluminum is 2700 kg/m^3 and the density of air at room temperature 20ºC is equal to ρ_{air} = 1.21 kg/m^3.

The volume of the cylinder $V = m/\rho_{aluminum}$ = 0.10 kg/2700 kg/m^3 = 3.7*10^{-5} m^3

The buoyant force due to the air displaced by the cylinder is equal to:

$F_{b\ air} = \rho_{air}\ Vg$ = 1.21 kg/m^3 * 3.7*10^{-5} m^3 * 9.8 m/s^2 = 4.4*10^{-4} N

The error that we made during the mass measurement because we neglected buoyant force due to displaced air is equal to $F_{b\ air}/g = \rho_{air}\ V$ = 4.5*10^{-5} kg = 0.045 g. You cannot measure mass with this accuracy using the available scale. Therefore, the correction is small enough to be ignored.

Activity 3: Density of Glass *(1 p.)*

In this activity, measure the density of irregularly shaped glass stopper.

Measured mass (in air) $m_{glass\ 1}$ = _______________ ( )

Calculate the weight of the Pyrex glass object in air (W, where W= $m_{glass\ 1}$ g):

W = _______________ ( )

Record the reading of the scale ($m_{glass\ 2}$) with the glass object completely submerged in water.

$m_{glass\ 2}$ = _______________ ( )

Apparent weight of the glass object in water (W^*, where $W^* = m_{glass\ 2}$ g):

W^* = _______________ ( )

Volume of the glass piece (use Eq. (2)):

V_{glass} = _______________ ( )

Calculate density of the Pyrex glass piece based on the Archimedes' principle. Remember that the density of water is equal to: ρ_W = 1000 kg/m^3.

$$\rho_{glass} = \frac{W}{(W - W^*)}\rho_w$$

Density ρ_{glass} = _______________ (   )

Calculate the absolute value of the percent difference between your result and the accepted value of the density of aluminum (2230 kg/m^3):

Percent difference = $\left|\frac{2230 - \rho_{glass}}{2230}\right|$ *100% = ____________ (%)

Activity 4: Two-Metal Cylinder *(2 p.)*

The two-metal cylinder is made with a mix of aluminum and brass. There are no empty cavities inside the mixed cylinder. Your goal is to find what is the composition of this cylinder, i.e., what is the percentage of brass and aluminum.

Measured mass:

m (in air) _______________ (   )

Weight of the brass/aluminum cylinder in air:

W = _______________ (   )

Record the reading of the scale (m_2) with the brass/aluminum cylinder completely submerged in water.

m_2 = _______________ (   )

Apparent weight of the brass/aluminum cylinder in water ($W^* = m_2 g$):

W^* = _______________ (   )

Calculate the volume of the cylinder. (*Hint:* use Eq. (2) from M8 - Theory and Procedures file).

V = _______________ (   )

Calculate the **volume of the brass** in the two-metal cylinder (V_{brass}) using the provided density of brass (ρ_1 = 8600 kg/m^3) and density of aluminum (ρ_2 = 2700 kg/m^3).

$$V_{brass} = W^* \left(\frac{\rho_2}{\rho_w(\rho_1 - \rho_2)g} \right) - W \left(\frac{\rho_2 - \rho_w}{\rho_w(\rho_1 - \rho_2)g} \right)$$

(where: ρ_W = 1000 kg/m^3, ρ_1 = 8600 kg/m^3 and ρ_2 = 2700 kg/m^3)

V_{brass} = ________________ (   )

Percentage of the volume that is brass in the two-metal cylinder (100%*V_{brass} / V):

Volume percentage of brass = ________________ (%)

Volume of the aluminum in the cylinder (V_{Al} = V - V_{brass}):

V_{Al} = __________________ (   )

Percentage of the volume that is aluminum in the two-metal cylinder (100%*V_{Al} / V):

Volume percentage of aluminum= ______________ (%)

Mass of the brass in the two-metal cylinder ($\rho_1 V_{brass}$, where ρ_1 = 8600 kg/m^3):

$\rho_1 V_{brass}$ = ________________ (   )

Percentage of the brass mass in the two-metal cylinder (100%*$\rho_1 V_{brass}$ / m):

Percentage = ______________ (%)

Mass of the aluminum that is in the two=metal cylinder ($\rho_2 V_{Al}$, where: ρ_2 = 2700 kg/m^3):

$\rho_2 V_{Al}$ = ________________ (   )

Percentage of the mass that is aluminum ($100\%*\rho_2 V_{Al} / m$):

Percentage = _____________ (%)

This is the last activity. Dump the water into the lab sink and make sure that there is no water on the table. Wipe the table with paper towels if necessary. Thanks!

Complete the lab report and return it to the lab TA.