NAME ______________________ LAB PARTNERS ______________________

Station Number ______________________ ______________________

Density of Solids

Experiment 1

INTRODUCTION

The density of a substance is one of a large number of physical properties that characterize the substance. The object of this experiment is to determine the density of a brass plate, a coin, and a composite cylinder. The mass and dimensions of each object will be measured directly. In performing this experiment, you will learn to use a balance and a vernier caliper.

THEORY

The density ρ (rho) of a substance is its mass m per unit volume V. The defining equation is

$$\rho = \frac{m}{V}. \tag{1}$$

The units for density depend on the units of mass and volume. It is sometimes convenient to compare the density of a substance to the density of water. The ratio of the density of a substance to that of water at 4.0° C is called the specific gravity of the substance. The specific gravity, being a ratio of densities, is a dimensionless number.

The mass of an object may be determined directly by measuring its mass on a balance, but the equation from which one calculates the volume depends on the shape of the object. The volume V_c of a cylinder having length L and radius R is given by

$$V_c = \pi R^2 L, \tag{2}$$

and the volume V_b of a block of material having length L, width W, and height (or thickness) H is given by

$$V_b = LWH. \tag{3}$$

EXPERIMENT NO. 1

1. Determine the mass of each of the following objects: the brass plate, the cylinder, and the coin (nickel, quarter, or half-dollar).

Brass plate mass = ______________ Cylinder mass = ______________

Coin used = ______________ Coin mass = ______________

2. Determine the reading of the vernier caliper with the jaws closed. This reading is the zero reading, and it must be subtracted from your readings. Recall that a negative reading must be added because – (-) = +.

Vernier caliper zero reading = ______________

3. Measure the length, width, and thickness of the brass plate using the vernier caliper.

Length = ____________ Width = ____________ Thickness = ____________

Calculate the volume and density of the brass plate using Equations (3) and (1).

Volume of brass plate = ______________ Density of brass plate = ______________

The standard value for the density of brass will be given on the information sheet. Calculate the percent error in the measured value for the density of brass. [See page vii, Eq. (1).]

Percent error in measured value of brass = ______________

4. Measure the diameter and thickness of the coin selected. Since the dimensions of the coin are not uniform, take five diameter and five thickness measurements. Determine the average thickness, average diameter, and average radius. Complete the table on the next page.

Trial Number	Thickness	Diameter	Radius
1			
2			
3			
4			
5			
Average			

Average radius = ______________

Use Equations (2) and (1) to calculate the volume and the density of the coin.

Volume of coin = ______________ Density of coin = ______________

5. The composite cylinder you have is composed of two materials. *The rod inside the cylindrical shell should be treated as an unknown material for this part of the experiment.* The diameter of the rod is considered to be a known quantity. Your instructor will tell you what the shell is made of and what the diameter of the rod is. Your task is to determine the density of the unknown substance and identify it. Let us see how to go about this. We know that the total mass of the cylinder m_c is equal to the sum of the mass of each piece. Therefore, we may write

$$m_c = m_r + m_s \tag{4}$$

where m_r and m_s are the masses of the rod and shell, respectively. We also know that a similar relationship exists for the volumes, *i.e.*,

$$V_c = V_r + V_s, \tag{5}$$

where V_c, V_r, and V_s are the volumes of the cylinder, rod, and shell, respectively.

The density of the composite cylinder is then given by

$$\rho_c = \frac{m_c}{V_c} = \frac{m_r + m_s}{V_r + V_s}. \tag{6}$$

Notice that the density of the cylinder is *not* equal to the sum of the densities of the two materials from which the composite cylinder is made.

We will use the procedure outlined below to calculate ρ. Record your measurements and the results of your calculations in the table below. Reminding you again, please consider the material from which the rod is made to be unknown.

(a) Record the information given to you by your instructor.
(b) Measure the length and diameter of the cylinder.
(c) Calculate the radius of the cylinder and the radius of the rod.
(d) Calculate the volume of the cylinder, the volume of the rod, and the volume of the shell.
(e) Calculate the mass of the shell and the mass of the rod.
(f) Calculate the density of the cylinder and the density of the rod.

	Cylinder	Rod	Shell
Material			
Diameter			
Radius			
Length			
Volume			
Mass			
Density			

Please show your calculations in a neat, organized fashion in the space below.

QUESTIONS

1. How errors made in measuring variables in an experiment affect the final result is an important consideration in physics. Let us see how errors made by measuring the length and diameter of a cylinder affect the precision of the volume. In one set of measurements, suppose you make a 10% error in measuring the length of a cylinder but make no error in the diameter measurement. In another set of measurements, suppose you make a 10% error in the diameter measurement but make no error in the length measurement. Which set of measurements results in the largest percent error in the volume? Support your answer by a numerical calculation.

2. Suppose ten rocks, all made from the same material, are added to a graduated cylinder that contains 102.3 cm^3 of water. After the rocks are added, the water level changes to 157.6 cm^3. If all ten rocks have a combined mass of 205.4 g, what is the density of the material from which the rocks are made? What assumptions have you made in order to solve the problem? (Hint: Consider the effect on your results if water evaporates from the graduated cylinder or if the rocks absorb water.) Does this procedure suggest another method for measuring the density of a coin?

density = __________

Assumptions: