

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 of a substance is its mass m per unit volume V . The defining equation is

$$\rho = m / V. \quad (1)$$

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

$$V_c = \pi R^2 L, \quad (2)$$

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

$$V_b = L W H. \quad (3)$$

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 negative readings must be added because $-(-) = +$.

Vernier caliper zero reading = _____

3. Measure the length, width, and thickness of the brass plate. You decide which device (meter stick or vernier caliper) is appropriate to measure each dimension.

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 provided by the laboratory instructor. 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 below.

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

$$m_c = m_r + m_s, \quad (4)$$

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.*,

$$V_c = V_r + V_s, \quad (5)$$

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

$$\rho_c = m_c / V_c = (m_r + m_s) / (V_r + V_s). \quad (6)$$

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. 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.

