Experiment #1: Determination of Density

Part 1: Determining to Identify of an Unknown Substance

Objectives

To understand the concepts precision vs accuracy.
To determine the mass, volume and density of an object
To determine if mass, volume and density are intensive or extensive properties.
Use density to identify an unknown substance

Materials

- Ruler
- 50 mL graduated cylinder

Background

Density is a derived unit and is defined as mass per unit volume. Mass, volume and density are all physical properties of matter. A given property referred to is extensive if its value depend on the amount of substance or intensive if its value is independent on the amount of material. Density can be used as a means of identification.
The typical units of density is g/mL or g/cm^3, and the SI unit is kg/m^3. The mass of the object can be determined by means of a balance. The volume of an object can be determined by several different methods. For example, the volume of a regular-shaped object can be determined from the object's dimensions (Table-1) and is reported in cm^3 . Whereas the volume of an irregular shaped object can be determined by the volume displacement method and its units is reported in milliliter, mL. Recall that 1 cm^3 = 1 mL.

Table-1: Determining Volume using Dimensions

Object	Volume
Cube	$l \times w \times h \quad (l = \text{length}; w = \text{width}; h = \text{height})$
Cylinder	$\pi \times r^2 \times h \quad (r = \text{radius}; h = \text{height})$
Cone	$\frac{1}{3}\pi \times r^2 \times h \quad (r = \text{radius}; h = \text{height})$

The density of various substances is given in the table below.

Table-2 Density of Various Substances

Material/Description	Density (g/cm^3)
Polystyrene/orange	1.05
Nylon/Yellow	1.15
Acrylic/purple	1.17

PETG/Blue	1.28
Acetal/Green	1.42
CPVC/light gray	1.54
PTFE (Teflon)/White	2.20
Aluminum/metallic silver	2.71

Procedure

In this experiment we will determine density of an unknown substance from its mass and dimensions as well as from the volume displacement method.

Part 1A: Determine the Density using Dimensions

1) Obtain a "tube" containing the cylindrical objects from your laboratory instructor.
2) Select two pieces of the cylindrical object.
3) Using an analytical balance, record the masses of each cylinder to the nearest ±0.001 g in Table-3
4) Measure the length and diameter of each cylinders to the nearest ±0.01 cm and record in Table 3.

Table-3

	Cylinder 1	**Cylinder 2**
Mass of Cylinder, g		
Radius of Cylinder (Diameter/2), cm		
Length of Cylinder (height), cm		
Volume of Cylinder (using dimensions), mL		
Density of Cylinder (using dimensions), mL		

Show calculations for one object:

Part 1B: Determine the Density Using the Volume Displacement Method

1) Add enough water to a 50.00 mL graduated cylinder to completely cover the cylinder.
2) Record the initial volume of water in the graduated cylinder.
3) Slowly add the cylinder to the water (avoid spilling) and record the volume of the water + the cylinder.
4) Determine the volume of the cylinder.
5) Repeat steps 1-4 for the second cylindrical block.
6) Determine the density of the cylinders.

Table-4

	Cylinder 1	**Cylinder 2**
Mass of Cylinder, g		
Initial Volume of water in the graduated cylinder, mL		
Volume of water + cylinder, mL		
Volume of Cylinder (using displacement method), mL		
Density of Cylinder (using displacement method), mL		

Show calculations for one object:

Question:

The cylinders had different size and volume. What did you observe about their density?

Results:

$$\% \text{ error} = \frac{|\text{True Value- Experimental Value}|}{\text{True Value}} \times 100$$

Average Density (using dimensions), g/mL	
Average Density (using displacement method), g/mL	
Identity of Unknown Cylinder (See Table 2)	
% error (from dimensions)	
% error (from displacement method	
Identify the more precise method	
Identify the most accurate method	

Show Calculation

Part 2: What is the Density of an Egg?

Objective of the Lab

Assessing the density and the variation of density of eggs.

Introduction

Back in the days before there were digital balances, people had to get creative to devise ways for (to obtain) relatively accurate measurements, for example for density. In the process of soap making, in addition to using animal fat, wood ash was boiled to extract lye (which was mostly K_2CO_3 and KOH). The concentration of the lye solution was tested by gauging its density with… an egg! If the egg sank, the solution was too dilute, if it floated on the surface, it was too concentrated, and if it freely floated in the solution, it had the right concentration (see Figure 1). In fact, the buoyancy of the egg was a measure of density, which in turn was a measure of the concentration. Later, more sophisticated instruments, such as hydrometers (see Figure 2) were used based on the same principle to measure density more accurately. Even today, hydrometers are used, for example to gauge the density (and the concentration) of battery acid in car batteries.

There is one caveat to the floating egg problem. The eggshell (mostly $CaCO_3$) is porous and it allows water to leave slowly. Also, when the egg starts to go bad, the organic molecules inside start to decompose and form gases, most of which also leave, otherwise the egg would blow up (and if you had the pleasure to experience a cracked bad egg, you must have smelled the gases that formed). Therefore, the mass of the egg can change over time, however its volume doesn't change since it has a hard shell.

Figure 1

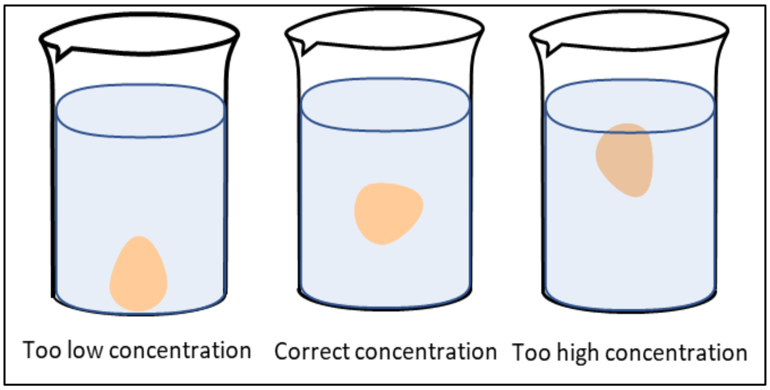
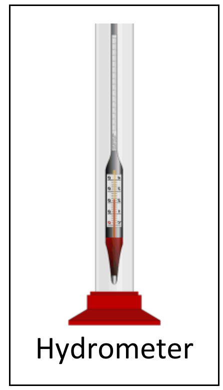


Figure 2



Materials

- 400-mL beaker
- 150 mL beaker (3)
- Spatula
- About 50 g table salt
- Plastic weighing dish
- A fresh and an older egg
- Balance

Procedure/Observations

Step	Description	Observations/Notes
1.	Pour about 300 mL water into a 400-mL beaker.	
2.	Obtain a fresh and an older egg, and record their numbers and expiration dates on the data sheet.	
3.	Fill a plastic weighing dish 2/3rd with table salt. No need to weigh the dish or the salt.	
4.	Using a spatula carefully lower the fresh egg into the water. Record your observation.	
5.	Add a pea-size volume of salt to the water and carefully stir it with a glass rod, so as not to crack the egg, yet to dissolve the salt. Observe the position of the egg.	
6.	Keep adding about the same amount of salt each time, followed by stirring, to dissolve the salt until the egg starts to float and remains floating in the solution. Note: • You can remove the egg carefully before adding more salt to allow more effective stirring. • Make sure there are no crystals left undissolved before adding more salt. • When you think the egg is floating, allow the egg to position itself. You can also move it to the surface, to see if it moves down a bit, and push it to the bottom to see if it rises. Each time allow a few seconds for the egg to position itself. • If you added too much salt and the egg rises to the surface, add a few mL water and mix until the egg floats in the middle.	
7.	When the egg is floating, weigh three 150-mL beakers and record their masses.	Record masses in the table.

8.	Transfer 10.00 mL of the solution, using a 10-mL pipet, into each weighed 150-mL beaker, weigh them again, and record their masses. Note: • Mark the beakers to avoid mixing them up. • Transfer the solutions back into the beaker when done weighing.	Record masses in the table.
9.	Replace the fresh egg with the older one. Record your observation.	
10.	Add a few mL water to the solution and mix it well with the glass rod and observe if the egg floats.	
11.	Keep adding a few mL of water at a time, followed by mixing, until the egg floats.	
12.	Weigh three 150-mL beakers and record their masses.	Record masses in the table.
13.	Transfer 10.00 mL of the solution into each weighed beaker, weigh them again, and record their masses.	Record masses in the table.
14.	Dispose of the solution and clean the used glassware as instructed.	

Data Table

	Fresh egg **Number: Exp. Date:** __/__/__)				**Older egg** **Number: Exp. Date:** __/__/__			
Trial	**Beaker ( )**	**Beaker+solution ( )**	**Solution ( )**	**Volume ( )**	**Beaker ( )**	**Beaker+solution ( )**	**Solution ( )**	**Volume ( )**
1.								
2.								
3.								
		Average:				Average:		
		Density:				Density:		

<u>Note:</u> It is assumed that the volume is 10.00 mL for each measurement. Mark the appropriate units in the table.
Show your calculations of density. Use appropriate units

<u>Note:</u> Incorporate appropriately your observations and the data table in your report.