Density Lab Guide

FASTly
FAITH & SCIENCE TEACHING

Introduction

In this lab, students will work in groups to calculate the density of an object. They will do this by determining mass and volume, so it might be helpful to make sure students have some background understanding of these terms before they begin the activities.

Background

Mass *(M)* and volume *(V)* are characteristics of all matter:

- *Mass:* the amount of matter in an object, commonly measured in grams (g) or kilograms (kg).
- *Volume:* the amount of space an object occupies, commonly measured in milliliters (ml), cubic centimeters (cm^3), liters (l), cubic meters (m^3), or gallons (gal).

Mass and volume are physical properties of matter and vary with different objects:

- If two samples of metal of the same shape are made out of the same material, yet one is smaller than the other, their volumes will differ.
- If the first sample is 1/3 the size of the second, then you would expect that it is also 1/3 the mass.
- If both samples are made of the same material, the ratio of mass to volume (this ratio is called "density") will be the same.

Density *(ρ)* is defined as: the ratio of the mass of an object to the volume of the object. This is represented by the following equation:

$$\rho = \frac{M}{V}$$

The symbol *M* stands for the mass of the object and *V* the volume. Density is expressed in units of mass per units of volume, such as: grams per cubic centimeter (g/cm^3) or kilograms per liter (kg/l).

Sample problem 1

A block has a mass of 20g and occupies a volume of $23cm^3$. What is the density of the block?

Solution

$$\frac{20g}{23cm^3} = 0.87g / cm^3$$

Activity: Determine the Density of an Object—Regular Shape

Needed:

- Sets of six density blocks (one set per group)
- Balance for measuring mass (enough for groups to share)
- Rulers or measuring tapes

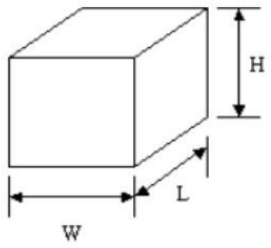
To run this activity, put together a set of six density blocks for each group to use as samples. The sets should all be the same. Consider using one each of the following materials for the blocks: lead, copper, brass, nickel, iron, aluminum, and zinc.

Measure the mass:

- Have students start the activity by measuring the mass of each block.
- Groups should measure each block three times and then calculate the average.
- Students should record their results in the table on the Density Lab Handout.

Determine the volume:

- To determine the volume of a cube, students should use the following equation:



Cube
$V = L \times W \times H$

- Have student groups measure the length (L), width (W), and height (H) of each block.
- They should measure each sample three times and then calculate the average.
- Students should record the readings in the tables on the Density Lab Handout.
- Finally, have groups calculate the volume of each sample, using the equation above.
- Students should show all work for the calculations on their Density Lab Handout.

Calculate the density:

- Now have students calculate the density of each block.
- Groups should have already recorded each block's mass and volume in the tables on their handout.
- Next, groups can calculate the density of each sample using this equation:

$$\rho = \frac{M}{V}$$

- Students should record the results on their tables.

Determining experimental error:

Experimental error is a useful tool for determining the precision of a calculation. You can have students compare their results to known values for these materials.

- The following equation should be used for calculating experimental error:

$$\text{Experimental Error} = \frac{\text{Experimental Value - Known Value}}{\text{Theoretical Value}} \times 100$$

- Experimental Value is the value calculated in the lab.
- Known Value is the accepted value, which is shown in the table below:

Solids	Density
Aluminum	2.67
Brass	8.90
Copper	8.92
Iron	7.90
Lead	11.37
Nickel	8.57
Zinc	7.14

- Groups should calculate the experimental error for each sample and record their results in the table on their handouts.

Once students have finished their calculations, the class can compare results:

- *An experimental error percentage at or close to zero:* the results are very close to the targeted value, and there is very little error in the calculation.
- *Any significant deviation from zero:* there is some experimental error.

Let students know that it is always important to understand the cause of the error, such as whether it is due to imprecision of the equipment, miscalculations, or a mistake in experimental design.

Conclusion

Finally, consider having students engage with the following questions, either as a discussion or as written answers on their handouts:

1. Which sample block had the highest experimental error?

2. Which sample block had the lowest experimental error?

3. What do you think was the biggest contributing factor to any experimental error you experienced?

4. Can two objects of significantly different volumes have the same mass? Why or why not?

Optional Activity: Determine the Density of an Object—Irregular Shape

Student groups will calculate the density of irregularly shaped objects by measuring the mass and volume of each object.

Needed:

- Sets of six irregularly shaped objects (one set per group)
- A graduated cylinder (big enough for an object)
- Water
- Balance for measuring mass (enough for groups to share)
- Rulers or measuring tapes

In advance of the activity, create sets of six irregularly shaped objects for groups to use as samples.

Measure the mass:

- Have groups start the activity by measuring the mass of each object.
- Groups should measure each sample three times and then calculate the average.
- Students should record their results in the table on the Density Lab Handout.

Determine the volume:

The volume of an irregularly shaped object can be determined by using the displacement method.

For each object, groups should:

- Fill their graduated cylinder about halfway with water.
- Note the initial level of the water and record it in the table on their Density Lab Handouts.
- Submerge the sample, note the final water level, and record it in the table.

Calculate the density:

- Students should have already written the volume and mass for each sample in the table on their handout.
- Next, ask the groups to calculate the density of each sample using the formula:

$$\rho = \frac{M}{V}$$

- Have students write the results on their tables.

