SPECIFIC DENSITY SET 25MM, Set of 9

CAT NO. PH0109A

Experiment Guide

GENERAL BACK GROUND OR THEORY ON THE EXPERIMENT:

Density is the amount of mass an object takes up per unit volume. It is dependent on temperature, phase and pressure. While some objects' density can change easily and vary widely, the density of a foam block or a person for example, some densities are predictable and reliable at standard temperature and pressure. Therefore, most students start to study density by using metals and expand the concept from there. In order to find the density of any given object, the mass and volume of that object must be determined. Common methods for finding mass include triple beam balances, spring scales, and digital balances, depending on what is available to the teacher.

There are two basic methods for finding the volume of a solid. The first is to measure volume using a ruler and some basic geometry. Depending on the shape of your object, the basic formulas you will need are as follows:

Rectangular Prism (including cubes) : Volume = length x width x height

Cylinder : Volume = π x radius^2 x height

Sphere: 4/3 x π x radius^3

A set of calipers can be used to measure the radius of the sphere or cylinder.

The second method for finding the volume of a solid is to find how much water an object displaces. Acquire a graduated cylinder and fill it about 2/3 full with water. Note and record the original volume of water in the cylinder. Add the object carefully to the graduated cylinder, and make sure that the object is completely immersed in the water. Record the new volume of water plus object. Then subtract the original volume of water from the new volume.

Although it is disputed as to if this story is fact or not, it is fun to tell students about Archimedes. A Greek tyrant named Hiero contacts Archimedes with a problem. He suspects his goldsmith of cheating him out of his gold. He asked the goldsmith to make him a crown out of pure gold, but believes that the goldsmith has put silver in the middle of the crown and kept some gold for himself. He asks Archimedes how to figure out if the crown is pure gold without destroying the crown. Back in Archimedes time, baths were something one took in public. It is said that Archimedes was in the bath house and noticed that the further he slid into the bath, the more water was displaced from the bath. In a flash of brilliance he realized he could find the volume of the crown using the amount of water it displaced. Therefore, finding the volume and the mass of the crown would give Archimedes the density. If the density of the crown matched the density of gold, then the crown was real. However, if the density of the crown was less than that of gold, the crown could not be pure gold. Excited he leapt up out of the tub and ran naked all the way home shouting "Eureka! Eureka!" which in Greek means, "I've found it! I've found it!"

Density and Specific Heat Values for some Common Metals Including this Set:

Material	Density (g/cm^3)	Specific Heat (J/g$_*$°C)
Brass#	8.44-8.75*	0.385*
Lead	11.3	0.13
Iron#	7.87	0.45
Copper#	8.96	0.39
Aluminum#	2.70*	0.91
Zinc	7.14	0.39
Silver	10.5	0.23
Gold	19.3	0.13
Hardwood#	0.7-0.9	1.2
Softwood#	0.4-0.6	1.4
Nylon#	1.12	1.7
PVC#	1.39	0.9
Acrylic#	1.15-1.20*	

* These values can change based on how the metal is made

These are materials included in this kit. Cubes are 25mm each side.

RECOMMENDED COMPONENTS (NOT INCLUDED)

Name of Part	Quantity (per student or group)
100 mL graduated cylinder	1
Ruler	1
Triple beam balance	1
Digital Balance	1
Calculator	1
Aluminum foil (11.0 cm x 11.0 cm)	1
Small Plastic Tubs (holds 1 cup liquid)	3
Rubbing Alcohol	Fill ½ the tub
Salt Water	Fill ½ the tub
Paper Towels to put wet masses on	2-3
Displacement Vessel	1
Catch Bucket	1

MAINTENANCE REQUIRED:

Metals will oxidize (rust) if left in water and this will change the mass and density of the cubes. Dry cubes off after use. Store cubes in a dry place.

Activity 1: Finding the Density Two Ways

1. Pick out five materials and make some observations about these materials in the space provided below. At least two should be metal and two should be non-metals.

2. Using your senses, predict which object is the densest and which is the least dense. Justify your hypothesis.

3. Find the mass of your objects using a triple beam balance. Then use a digital balance and record both values in the data table below. Which method do you think is most accurate? Why?

4. Find the volume of your objects using a ruler and/or caliper. Show one sample calculation below using formula and substitution with units.

5. Find the volume of your objects using a graduated cylinder and some water. Show one sample calculation of how you got your volume in the space below. Be sure to include formula and substitution with units. If the diameter of the graduated cylinder is too small to fit the cube into a displacement vessel and catch bucket may be used.

6. Use your most accurate mass and volume to calculate the density of each of your objects. Show one sample calculation below. Be sure to include formula and substitution with units.

7. Ask you teacher for the actual densities of each of your objects and record those values in your data table.

8. Calculate the percent error for each material. Show one sample calculation below. Be sure to include formula and substitution with units.

DATA TABLE:

Object					
Mass 1					
Mass 2					
Volume 1					
Volume 2					
Calculated Density					
Actual Density					
% error					

(Don't forget to add units to your data table!)

9. List your objects in order from most dense to least dense. How did your hypothesis compare to your actual results? Based on your results, were your original ideas correct or incorrect?

Activity 2: Density Challenge (Quiz)

Neatly fold a small 11.0 cm square of aluminum foil around each of the blocks to disguise their color. Use a permanent marker to label the foil around the blocks as follows: Brass-A, Hardwood-B, Iron-C, Copper-D, Aluminum-E, Softwood-F, PVC-G, Acrylic-H, Nylon-I,

Give each student a balance, a ruler, a block, and sheet of paper. They should supply their own pencil and calculator.

Give each student a different block and instruct them not to open the aluminum foil. Have them record the letter of their block at the top of their sheet. Then read them the story of Archimedes. Tell them they have each been given a different piece of Hiero's crown. Their job is to determine which metal the crown in made out of using the tools supplied to them.

Activity 3: Visualizing Density

Density has to do with how closely packed the molecules of a given substance are. Have the students get up out of their seats and play the density game. Have students arrange themselves in a grid evenly spaced apart and tell the students that they are each a molecule in a solid. "Heat up" your solid by putting an imaginary fire under the students, or sticking them in an imaginary oven. How would they behave? They will move apart from one another. (They may even begin to lose some order and become a liquid) As they move apart they take up more room. Ask the students if they weigh any less? Did any student disappear? No, they just got farther apart. Now put your students in the "freezer" if they are cold what will they do? Come together for warmth. As they come together they take up less space, but they still have the same mass. Tell them that they are increasing their density. Once you are convinced your students have the basic concept, then you can shout out orders at your students such as "increase density" "become less dense" or even "become a solid" become a liquid" etc.

Name:_____ Date:_____

Class Period:_____ Cube Letter:_____

Use the Density Table below and your knowledge of density to determine which metal the crown is made out of. Show all work, including a description of how you found the density of the metal, formulas used and substitution of the formula with units.

Material	Density (g/cm^3)
Brass	8.44-8.75*
Lead	11.3
Iron	7.87
Copper	8.96
Tin	2.76
Aluminum	2.70
Zinc	7.14
Silver	10.5
Gold	19.3
Hardwood	0.7-0.9
Softwood	0.4-0.6
Nylon	1.12
PVC	1.39
Acrylic	1.15-1.20

My Metal is :_____

Bonus: How did the aluminum foil wrapped around your block affect your calculated density?

Activity 4: Density Challenge

What you will need : Nylon, softwood, hardwood, aluminum, three clear plastic tubs, rubbing alcohol, water, and salt.

This activity will really test student's understanding of density.

1. Fill one plastic tub half way with rubbing alcohol, fill another tub half way with water, and fill a third tub half way with salt water. You will have to make the solution of salt water yourself. Take tap water as hot as you can get and dissolve as much salt into the water as possible.

2. Test and make sure that the nylon floats in the salt water. If it doesn't add more salt.

3. Test to make sure that the hardwood sinks in the alcohol. If not, some paraffin wax can be substituted for the hardwood.

4. Clearly label each tub. Make sure you are in a well-venlilated area since the rubbing, alcohol gives off fumes.

5. Give the students the three tubes and the hardwood, softwood, aluminum and nylon blocks.

6. Ask the students to put the materials in order from most dense to least dense without using any additional materials.

How it can be done: If an object sinks in a liquid it is more dense than that liquid. If an object floats in a liquid, it is less dense than that liquid. The following chart shows what should happen along with approximate densities for each object.

Liquid	Soft wood ($0.4\text{-}0.6$ g/cm^3)	Hardwood ($0\ 7\text{-}0.9$g/cm^3)	Nylon (1.12 g/cm^3)	Aluminum (2.70 g/cm^3)
Rubbing alcohol (0.785 g/cm^3)	Float	Sink	Sink	Sink
Water (1.0 g/cm^3)	Float	Float	Sink	Sink
Salt Water (Greater than 1.2 g/cm^3)	Float	Float	Float	Sink

Students should be able to reason that the densest object is the aluminium because it sinks in all three liquids. Since everything else floats in salt water, the nylon, hardwood, and softwood are all less dense than the saltwater and therefore the saltwater is denser than all other objects besides the aluminium. The nylon sank in the water, so therefore nylon comes before water on the list from most dense to least dense, and water comes before softwood and hardwood because they both float in water. This leaves rubbing alcohol left to determine. Since the hardwood sank in rubbing alcohol, the hardwood comes next in the list followed by the rubbing alcohol itself and finally the softwood which floats in all three liquids and therefore must be less dense then all three liquids.

In order from most dense to least dense: Aluminum, saltwater, nylon, water, hardwood, rubbing alcohol, and softwood