

# Teacher Guide: Density Laboratory



## Learning Objectives

Students will...

- Measure the mass of objects with a scale.
- Measure the volume of objects by water displacement in a graduated cylinder.
- Calculate the density of objects.
- Understand how density is related to the tendency to float or sink.
- Based on the density of an object and the liquid it is placed in, predict whether the object will sink or float.



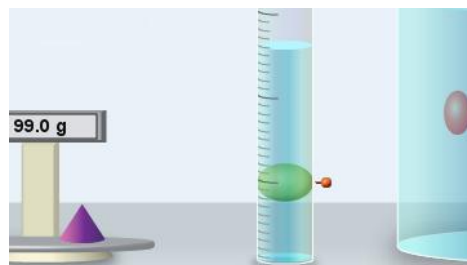
## Vocabulary

buoyancy, density, graduated cylinder, mass, matter, scale, volume



## Lesson Overview

Density is an extremely important concept, but one that students often find confusing. The *Density Laboratory Gizmo™* shows how mass, volume, and the tendency to float are related. If the Gizmo is combined with classroom investigations, students will acquire a deeper understanding of density. (Note: The related *Density Gizmo* lessons cover similar topics at a more basic level.)



The Student Exploration sheet contains two activities and an Extension:

- Activity A – Students measure the mass, volume, and density of irregular objects. Students relate density to the tendency to float or sink.
- Activity B – Students predict whether objects will sink or float in liquids of various densities.
- Extension – Students find the density of three crowns to see which is made of pure gold.



## Suggested Lesson Sequence

### 1. Pre-Gizmo activity: Sink or float? (🕒 20 – 40 minutes)

Ask each student to bring in an object from home that will not be damaged if it gets wet. In addition to the students' objects, provide a paper clip, a deflated balloon, an inflated balloon, and a good-sized chunk of wood. Place all of the objects on a table at the front of the classroom, and allow the students to pick up each object and vote on whether the object will sink or float. List the voting results on the board.

Next, fill a large plastic tub with water. Drop each object into the water to see what happens, and record the results. Discuss with your class what causes objects to float or sink. If necessary, point out that mass alone cannot be the only explanation—after all, the wood is much heavier than the paper clip, but the wood floats and the paper clip sinks! Ask students why the inflated balloon floats while the deflated balloon sinks. (Note: Be sure that no air is trapped in the deflated balloon!)

2. **Prior to using the Gizmo** (🧠 10 – 15 minutes)

Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. If possible, use a projector to introduce the Gizmo and demonstrate its basic operations. You may wish to point out that a pin holds floating objects below the water's surface in the graduated cylinder.

3. **Gizmo activities** (🧠 15 – 20 minutes per activity)

Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (🧠 15 – 30 minutes)

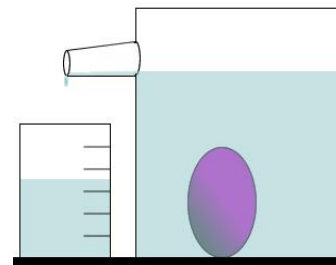
As students are working or just after they are done, discuss the following questions:

- If you know the mass and volume of an object, how can you immediately predict whether it sinks or floats without calculating density? [If an object's mass is less than its volume, it will float. If the mass is greater than the volume, it will sink.]
- What are some ways you can compare the density of floating objects without measuring their mass and volume? [Denser objects will float lower in the liquid.]
- What are some ways you can compare the density of sinking objects without measuring their mass and volume? [Denser objects will sink faster.]
- In the Gizmo, how could you estimate the density of an object without using the scale or graduated cylinder? [You can use the **Liquid Density** slider.]

5. **Follow-up activity: Measuring density** (🧠 45 – 60 minutes)

You can practice the same experiments shown in the *Density Laboratory* Gizmo in the classroom. You will need an electronic scale or triple-beam balance to measure mass, and a graduated cylinder to measure volume. Provide a variety of objects to measure. (Note: the objects must be small enough to fit into the graduated cylinder.) When measuring the volume of the object, remind students to subtract the original volume of water in the cylinder. For example, if a cylinder initially contains 50 mL of water and the water level rises to 64 mL when the object is added, the volume of the object is 14 cm<sup>3</sup>.

For objects that are too big to fit into a graduated cylinder, use an overflow cup. (These are available in many science catalogs, or you can make your own—see the **Selected Web Resources**.) Fill the overflow cup until water starts to spill. Place a beaker under the spigot of the cup. Carefully lower (or push) the object into the overflow cup, and collect the displaced water in the beaker. Finally, use a graduated cylinder to measure the volume of the water in the beaker.



Another great follow-up activity is creating a density column. You can make a four-layer column using corn syrup, blue dish soap, water, and vegetable oil. Dye the water green and the corn syrup red for effect. First, add the corn syrup to a graduated cylinder to form the bottom layer. Next, add the dish soap, then the water, and finally the vegetable oil. Tilt the cylinder to the side and carefully dribble each liquid into the cylinder so the liquids don't mix. See the **Selected Web Resources** for more details.



## Scientific Background

Density is a measure of the mass in a given volume of a substance. To calculate the density of an object, divide the mass by the volume:

$$D = m \div V \quad \text{or, more formally:} \quad \rho = \frac{m}{V}$$

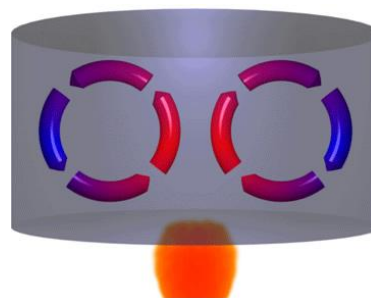
The units of density are units of mass per volume. For small objects, density can be expressed in grams per cubic centimeter ( $\text{g/cm}^3$ ) or grams per milliliter ( $\text{g/mL}$ ). The former unit is used for solids, while the latter is used for liquids. A cubic centimeter is equivalent to a milliliter, so an object with a density of  $2.5 \text{ g/cm}^3$  also has a density of  $2.5 \text{ g/mL}$ . For larger objects, kilograms per cubic meter ( $\text{kg/m}^3$ ) are the preferred units. To convert from  $\text{g/cm}^3$  to  $\text{kg/m}^3$ , divide by 1,000.

The mass of an object can be measured on a balance or a properly calibrated scale. The volumes of regular objects such as rectangular prisms and spheres can be found by measuring their dimensions and applying the appropriate volume formula. To find the volume of an irregular object, it is necessary to submerge the object in liquid. As the object moves into the water, it displaces a volume of water equal to the volume of the object. For example, if a pebble with a volume of  $7 \text{ cm}^3$  is added to a graduated cylinder, the water level will rise 7 mL.



### Earth science connection: Convection and density

When a fluid is heated, the molecules within the fluid move more quickly. The volume of the fluid increases, which causes the density of the fluid to decrease. If you put a pot of water on the stove, the water at the bottom of the pot will be heated, decrease in density, and rise to the top. Once exposed to the cool air above the pot, the water will cool down and sink again. The result is a circular motion called a *convection current*.



Convection currents are found in many places on Earth. If a mass of air is heated, it will tend to rise as cooler air moves in. The result is anything from a cool ocean breeze to hurricane. Convection also drives the motion of tectonic plates. Below the oceans, hot magma rises into mid-ocean ridges, adding new crust to the ocean floor. Older, denser ocean crust sinks back into the mantle in regions called subduction zones.



### Selected Web Resources

Water displacement experiment: <http://www.iit.edu/~smile/ph9504.html>

Density column: <http://www.stevespanglerscience.com/experiment/seven-layer-density-column>

Density bottles: <http://www.thinkingfountain.org/d/density/density.html>

Density activities: [http://www.proteacher.org/c/823\\_Density.html](http://www.proteacher.org/c/823_Density.html)

Related Gizmos:

*Density*: <http://www.explorelearning.com/gizmo/id?629>

*Density via Comparison*: <http://www.explorelearning.com/gizmo/id?396>

*Density Experiment: Slice and Dice*: <http://www.explorelearning.com/gizmo/id?434>

*Determining Density via Water Displacement*: <http://www.explorelearning.com/gizmo/id?400>

*Mineral Identification*: <http://www.explorelearning.com/gizmo/id?640>