Teacher Guide: Density via Comparison

Learning Objectives

Students will …

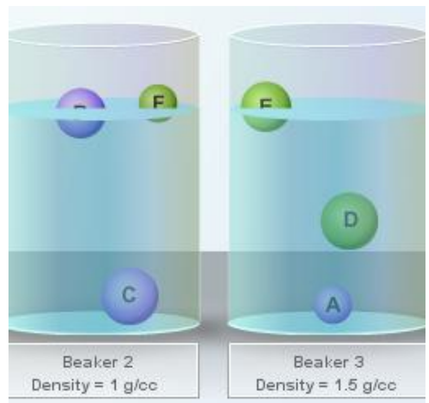
- Understand that a floating object is less dense than the liquid it is in.
- Understand that a sinking object is denser than the liquid it is in.
- Estimate the density of an object by observing its behavior in liquids of various known densities.
- Compare the densities of objects by observing how high they float or how quickly they sink in a liquid.

Vocabulary

density, mass, volume

Lesson Overview

Whether an object floats or sinks in a liquid depends on the density of the object and the density of the liquid. If the object is less dense than the liquid, it will float. If the object is denser than the liquid, it will sink. With the *Density via Comparison* Gizmo™, students can use this principle to estimate the densities of a variety of objects by placing them in liquids of various known densities.



The Student Exploration sheet contains one activity. In this activity, students estimate the densities of objects by placing them in liquids of known densities.

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Floating egg** (10 – 15 minutes)
   Ask each student or group of students to add water to two beakers or cups. Students should mix five to six teaspoons of salt into one beaker to create a saltwater solution. Students can then place an egg into the freshwater and saltwater beakers. Students will observe that the egg sinks in the fresh water and floats in the saltwater solution.

   Ask students to explain their observations. Why did the egg sink in one beaker and float in the other? One clue can be gained by finding the mass of equal volumes of fresh water and salt water. Students can add 100 mL of each liquid to a graduated cylinder and find the mass of each. After subtracting the mass of the graduated cylinder, students will find that 100 mL of fresh water has a mass of 100 g and that 100 mL of salt water has a mass of 102–104 g.

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. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

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 an object floats in a liquid, what can you say about its density?
    - If an object sinks in a liquid, what can you say about its density?
    - How can you compare the densities of two objects that both float in a liquid?
    - How can you compare the densities of two objects that both sink in a liquid?
    - Why do swimmers float so easily in the Dead Sea?

5. **Follow-up activities** (45 – 90 minutes)
Bring in a variety of liquids of varying densities (see the table at right), and pass out a beaker of a liquid to each group of students. Students should first measure the mass of an empty graduated cylinder. Next, have them add a specified amount of liquid to the cylinder, measure the mass, and subtract the mass of the cylinder to find the mass of the liquid. Students then can divide the mass by the volume to obtain the density of the liquid.

Liquid	Density
Rubbing alcohol	0.87 g/mL
Vegetable oil	0.91 g/mL
Water	1.00 g/mL
Dish soap	1.03 g/mL
Glycerine	1.26 g/mL
Corn syrup	1.36 g/mL

After the density of each liquid has been determined, set up a row of liquids in the front of the classroom. Label each liquid with its density. Students then can drop a variety of objects into the liquids to estimate each object's density, just as they did with the Gizmo. Objects could include wood, plastic, eggs, apple slices, potato chunks, ice cubes, etc.

Finally, create a density column by adding the liquids, one at a time, to a large graduated cylinder. Add the liquids in order from the densest to the least dense. You can add food coloring to some of the liquids (corn syrup, water, and alcohol) to help them stand out within the density column. When the column is complete, each liquid will form a distinct layer. Small objects can be dropped into the density column and their density estimated based on where they come to rest.

Scientific Background

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

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

When an object is placed in a liquid, gravity pulls the object down with a force equal to the weight of the object. At the same time, the liquid pushes the object up with a force known as the *buoyant force*. The magnitude of the buoyant force is given by *Archimedes' principle*; it is equal to the weight of the liquid that is displaced by the object.

If an object is denser than the liquid, the weight of the object will be greater than the weight of displaced liquid. The result is a net downward force, and the object sinks. The greater the density of the object, the faster it will sink through the liquid.

If the object is less dense than the liquid, it will sink into the liquid until the weight of displaced liquid is equal to the weight of the object. At this point the downward force of gravity is equal to the buoyant force, and the object floats. An object with less mass will displace less liquid than an object with greater mass. Therefore, the lower the density of the object, the higher it will float in the liquid. In fact, the density of the object can be measured by estimating the proportion of the object that is below the surface of the liquid. For example, if 60% of the object is below the surface of the liquid, the object's density is 60% of the liquid's density.

Technology Connection: Galileo thermometer

Galileo Galilei (1564–1642) is famous for his numerous contributions to physics and astronomy. Galileo was also an avid inventor who helped develop the telescope, microscope, pendulum clock, and one of the earliest thermometers.

During the 1590s, while teaching at the University of Padua near Venice, Galileo discovered that the density of water varies very slightly with temperature. Liquid water has a maximum density of 1.00 g/mL (grams per milliliter) at 4 °C (39 °F) and a minimum density of 0.96 g/mL at 99 °C (210 °F).

A Galileo thermometer is a large cylinder of water that is filled with several glass bulbs. Each glass bulb has a density between 1.00 and 0.96 g/mL and is labeled with the corresponding temperature. At 4 °C (39 °F), the water density is at a maximum and all of the bulbs will float. As the water temperature increases, its density decreases and more of the bulbs sink to the bottom. The water temperature is between the minimum temperature marked on the floating bulbs and the maximum temperature marked on the sunken bulbs.

Selected Web Resources

Floating egg experiment: http://www.reekoscience.com/Experiments/FloatEggInSaltwater.aspx
Buoyancy: http://hyperphysics.phy-astr.gsu.edu/Hbase/pbuoy.html
Measuring density of liquids: http://www.edinformatics.com/math_science/dens_liquid.htm
Archimedes' principle: http://physics.weber.edu/carroll/Archimedes/principle.htm
Density column: http://www.stevespanglerscience.com/experiment/seven-layer-density-column
Galileo thermometer: http://en.wikipedia.org/wiki/Galileo_thermometer

Related Gizmos:
Density: http://www.explorelearning.com/gizmo/id?629
Density Laboratory: http://www.explorelearning.com/gizmo/id?362
Determining Density via Water Displacement: http://www.explorelearning.com/gizmo/id?400
Density Experiment: Slice and Dice: http://www.explorelearning.com/gizmo/id?434
Archimedes' Principle: http://www.explorelearning.com/gizmo/id?603