Teacher Guide: Density

Learning Objectives

Students will:

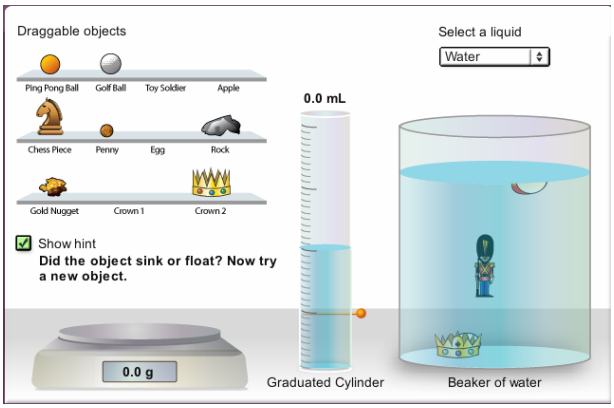
- State the SI units used for mass and volume.
- Measure the volumes of irregular objects using water displacement.
- Discover that density can be measured.
- Predict whether an object will float or sink by measuring its mass and volume.
- Define the relationship among mass, volume, and density.
- Calculate the densities of irregular objects.
- Compare the densities of liquids.

Vocabulary

density, mass, matter, volume

Lesson Overview

The *Density* Gizmo™ allows students to explore and compare the densities of both liquids and solids.



Students measure the mass and volume of an object and then see whether it floats or sinks in specific liquids.

The Student Exploration contains three activities.

- Activity A – Students determine how mass and volume affect whether an object sinks or floats.
- Activity B – Students calculate density and find the relationship between density and sinking/floating.
- Activity C – Students find how a given object behaves in different liquids. This information is used to compare the densities of the liquids.

Suggested Lesson Sequence

1. **Pre-Gizmo activity** (10 – 15 minutes)
   Ask the students to give examples of objects that either sink or float in water. Why do objects sink or float in water? On a chart, list vocabulary words that students use. Next, show students two equally-sized containers, one filled with bottle caps or pop tabs, the other with sand. Ask, “Which of these materials do you think is denser?” Have students explain their thinking. Allow students to hold and compare the two containers. Why is it easier to compare objects in the same size container?

2. **Prior to using the Gizmo** (10 – 15 minutes)
Before students are at the computers, pass out the Student Explorations and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers yet. Afterwards, if possible, use a projector to introduce the Gizmo and to 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** (10 – 15 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the Student Exploration with the help of the Gizmo. Walk around to check student progress and answer questions as students work. Alternatively, you can use a projector and do the Exploration as a teacher-led activity. Calculators are recommended for Activity B. If you do the hands-on activities also, you will probably need to spread the Gizmo activities over multiple days.

4. **Discussion questions** (10 – 20 minutes)
As students work or just after they have finished, discuss some of the following:
    - In the first activity what did you notice when you made the chart and tested the objects in water?
    - Did you have the same results when you dropped the objects in other liquids? Why or why not?
    - Do all heavy objects sink? Do all light objects float?
    - Why do some objects float higher than others?
    - Why do some objects sink faster than others?
    - Which is more dense, a small amount of a substance or a large amount of the same substance? (Students can compare the density of the gold nugget and the gold crown for an answer.)

5. **Follow-up activity: Create a density column** (15 – 20 minutes)
Ask students to guess the densities of water, saltwater, corn syrup, and cooking oil. Students can make a "density column" by slowly pouring each liquid into a tilted graduated cylinder. For best results, add food coloring to the water and corn syrup for visibility. (Pick different colors so you can tell all the liquids apart.) Observe the results. Were the hypotheses correct?

    Alternate activity: Have each student bring in an object from home to test. Take a class vote on whether it will sink or float, then drop it into a bucket of water. What surprises the class? What conclusions can be made? Are there new questions to explore?

Scientific Background
Density refers to the mass found in a given volume of a substance. It is calculated by dividing the mass of a substance by its volume: $D = m / V$. A density of 2 g/mL means that a single milliliter of a substance has a mass of 2 grams.

In general, dense objects can be thought of as being more tightly packed than objects with low densities. As an example, students will understand that sand in a jar is more tightly packed, or dense, than pop tabs in the same size jar.

Because density does not depend on the amount of substance, it can be used to identify substances. Each milliliter of water has a mass of one gram, so water has a density of 1.0 g/mL. Gold has a density of 19.3 g/mL, and silver has a density of 10.5 g/mL. (Note: A milliliter, 1 mL, is equivalent to one cubic centimeter, 1 cm^3 or 1 cc.)

Surprise your students with this experiment. Place a can of soda and diet soda of the same brand in a tank of water. The diet soda will float while the regular soda will sink. Ask the students to explore what the differences could be. (The regular soda has approximately 10 tablespoons more sugar, giving it more mass and making it denser than diet soda.)

Historical Connection

There is a legend about Archimedes, an ancient philosopher and mathematician, which takes place in the third century B.C. The king of Syracuse, Hiero, had given a jeweler a brick of pure gold to make into a crown. When the crown was completed, the king was suspicious that the jeweler had substituted a less precious metal for the gold, so he asked Archimedes to demonstrate whether the crown was pure gold or not.

At that time, there were no tools to measure irregular shapes, so it became quite a perplexing problem for Archimedes. He knew the crown was the same mass as the original bar of gold. Archimedes determined that if the crown had more *volume* than the original bar, it would be less dense and therefore not made of pure gold.

The problem was that Archimedes did not know how to find the volume of the crown. One day he accidentally filled his bathtub to the top. As he stepped into the tub, the water overflowed. He realized that if he collected the water that had overflowed, he would know the volume of his body. Archimedes was so excited by his discovery he jumped out of the tub and ran naked down the street, all the while yelling, “Eureka! I have found it!”

Archimedes in his tub

Archimedes used a balance to measure a block of gold with a mass equal to the crown. He placed the block of gold and the crown into a tank of water. Sure enough, the crown displaced more water than the gold, proving the crown was less dense than pure gold (and was therefore a fake!).

Selected Web Resources

The story of Archimedes: http://www.cde.state.co.us/cdeadult/IGLA/pdf/ScienceSink.pdf
Activities to explore density: http://www.teachers.net/lessons/posts/116.html
Related activities: http://pzweb.harvard.edu/ucp/curriculum/density/index.htm