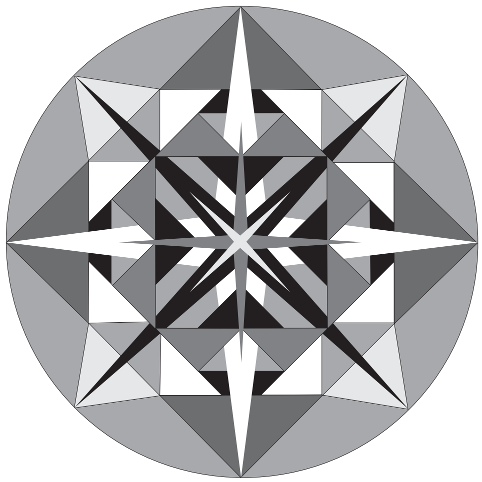
C. Student Activities with Embedded Instructor Notes



Investigation M1: Measuring Mass and Volume and Calculating Density

Goals: *Measure the mass and volume of liquids and solids. Calculate the density of liquids and solids. Use densities to predict whether things sink or float. Define matter by its essential properties.*

Activity M1.1: Will it sink or float?

(Laboratory Activity)

Equipment: Rubbing alcohol, water, saltwater, beakers or other calibrated containers, diet soft drinks in aluminum cans, regular soft drinks in aluminum cans, metal sphere, metal cylinder, metal cube, graduated cylinder, and safety goggles.

Safety Precautions ➠

Wear safety goggles. Do not taste the liquids. (All liquids used are safe to touch.)

Students need to be familiar with the metric system before doing Investigation 1. You may need to give them practice estimating and measuring lengths, surface areas, volumes, and masses. Students also need to know how to convert from one metric unit to another. Conversions from metric to customary units or vice versa are not needed for the Nature of Matter unit.

A clearer salt solution may be obtained by using kosher salt or pickling salt rather than table salt. Table salt often contains sodium silicoaluminate.

1. **WHAT'S YOUR IDEA? Make both quantitative and qualitative predictions about what will happen when you place diet and regular soft drinks (unopened aluminum cans full of soft drinks) into rubbing alcohol, water, and saltwater in calibrated containers.**

?

Students may need clarification of the difference between qualitative and quantitative predictions/observations.

Students may think that fluid ounces are a unit for mass or weight rather than volume.

The students should be hypothesizing about which variables are relevant and which are irrelevant to the amount of liquid displaced by a floating solid object. As students progress through this unit, they will learn that density of the liquid and density of the solid are the relevant variables. You should not tell them this during Lab Activity M1.1.

2. **WHAT ARE THE GROUP'S IDEAS? List all the predictions made by your classmates. Do any of the predictions contradict each other?**

??

Students may hypothesize that solid objects with equal volumes sunk in a liquid displace equal volumes of liquid. You may allow students to explore this relationship at this stage. Have students make predictions, and then put various metal spheres, cylinders, or cubes of equal volumes into various liquids in graduated cylinders or other calibrated containers.

3. MAKING OBSERVATIONS: Place the soft drink can systems (unopened aluminum cans full of soft drinks) into the liquids. What qualitative and quantitative observations can you make?

4. MAKING SENSE: Organize what you have observed in a chart. Make more observations if necessary to complete your chart. What is the same about the soft drink can systems? What is different about the soft drink can systems? What is the same about rubbing alcohol, water, and saltwater? What is different about rubbing alcohol, water, and saltwater?

M1.1(2)

Activity M1.4: How is density related to floating and sinking?

(Laboratory Activity)

Equipment: Rubbing alcohol, water, saltwater, beakers or other calibrated containers, diet soft drinks in aluminum cans, regular soft drinks in aluminum cans, balances and standard masses, overflow cans and catch buckets, rulers, string or tape measures, tape for labeling containers, and safety goggles.

Safety Precautions ➠

Wear safety goggles.
Do not taste the liquids.
(All liquids used are safe to touch.)

1. **WHAT'S YOUR IDEA? Devise an activity to determine the density of the diet and regular soft drink can systems.**

?

One naive idea is that all heavy objects sink while all light objects float. The volume of an object is overlooked as a factor determining whether or not that object floats.

Some students will want to use the volume of the beverage printed on the can instead of measuring the can's volume. Allow them enough time and freedom to try procedures and then to improve them.

2. **WHAT ARE THE GROUP'S IDEAS? How did your classmates plan to find the density of the diet and regular soft drink can systems? Do you think any method is more accurate than the other methods?**

??

Students need to measure the volume of the soft drink can system by water displacement. Tilt the soft drink can system as it is placed in the water and use any other techniques that will prevent an air pocket from forming in the concave section of the bottom of the soft drink can. A pinch of detergent in the water will help prevent small air bubbles from forming on the outside of the soft drink can. Students may check that this volume is the same in rubbing alcohol, water, and saltwater.

You may make overflow cans from copper pipe soldered into large coffee cans or plastic pipe glued into large ice cream containers. An alternative is to use clear plastic one-liter spring water containers or tennis ball canisters. Attach a transparent copy of a ruler to each container or canister so that the water level can be read to the nearest millimeter.

Students may want to find the volume by multiplying the area of the base times the height. The area of the base can be found by setting the can on a sheet of square centimeter graph paper and drawing a line around the can's circumference. Then the number of squares inside can be counted. Obviously, deciding what proportions of squares are enclosed on the periphery makes this method inaccurate. If a group proposes to find the volume of the cans from the formula $V = \pi r^2 h$, discuss the difficulty of getting an accurate value by direct measurement of the radius. Measuring the circumference is usually better than measuring the diameter, and both of these methods are better than measuring the radius. The radius is equal to the circumference divided by two pi or the diameter divided by two. Even with these calculations, the number obtained for the radius will be inaccurate due to the fact that the cans are not perfect cylinders. Likewise, the height is difficult to establish accurately because the tops and bottoms of aluminum cans are not planar. Therefore, this formula is not preferred over the water displacement method. However, students can be encouraged to use this formula as a general check on their water displacement results.

3. **MAKING OBSERVATIONS: Your small group may choose or your instructor may assign a method for finding the density of the diet and regular soft drink can systems. Collect the necessary data and calculate the densities.**

4. **MAKING SENSE: For each of the diet and regular soft drink can systems, find the mean (average) of all your class' density values, excluding any outliers (extreme values). How can you use your mean densities to predict in which liquids (rubbing alcohol, water, and saltwater) each soft drink can system will float?**

➥

Students should conclude that objects will float in liquids of greater density. They may elaborate by stating that only objects with density less than one gram per milliliter will float in water.

Have students look at the variability in the class' density values for each soft-drink can system. Help them use this as a measure of precision.

For further understanding, students can put various objects into water in an overflow can after determining their mass and volume. From their data, they should be able to infer that the water displaced has the same mass as the object if the object floats (Archimedes' principle).

To increase their understanding of metric units, students may measure the length of each side of a plastic centigram cube and calculate its volume to be one cubic centimeter. Then they may drop some of these cubes into a graduated cylinder of water and observe that the water rises one milliliter for each cube. Thus they should see that a cm^3 is the same as a mL. Also, students may find the mass of several cubes to get an average mass of one gram. Have them notice that most of the cubes float barely submerged because the density of the cubes in so close to a g/mL. Students could be encouraged to think about whether or not the density changes when two or more centigram cubes are stuck together. They could get evidence to confirm or disprove their answer by floating the combination of cubes in water.

Notes