Density, Mass, and Volume  
Grade 3-6

BACKGROUND

**Matter** is everything that takes up space. Matter can be found in three forms, solid, liquid, and gas. The mass of an object is the amount of matter that is in an object. Mass is not the same as weight. **Weight** is a measure of the pull of gravity on an object. An objects weight depends on the objects environment. For example, you would weigh **differently** on Earth than you would on another planet due to the difference in gravitational pull. Pounds, kilograms, and grams are commonly used to measure the mass of matter. Mass can be measured on a balance, while weight can be measured on a spring scale. On a balance, the mass of an object must be compared to a known mass.

Density is defined a mass per unit of volume. Volume is the amount of space that matter takes up. Volume is commonly measured in liters and also can be measured in cubic units. When an object is more dense than another object it will sink in comparison or float if it is less dense.

BASIC LESSON

**Objective(s)**

Students will be able to… recognize the difference between weight and mass, make predictions about two similar size objects and calculate the volume of an object using mathematical formulas.

**State Science Content Standard(s)**

4.2: Select and use the appropriate tools including technology to make measurements (including metric units) and represent results of basic scientific investigations.

- Use appropriate tools to collect data.
- Record all data in metric units.
- Organize data using tables.

<table>
<thead>
<tr>
<th>Materials From the Kit</th>
<th>Provided by Teacher</th>
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</thead>
<tbody>
<tr>
<td>Balance</td>
<td>Rulers/tape measure</td>
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<tr>
<td>Mass set</td>
<td>Mass objects premeasured prior to student measuring</td>
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<tr>
<td>3-D shapes</td>
<td>Calculators for calculating volume and density</td>
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<td>Objects to practice length measurement</td>
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<table>
<thead>
<tr>
<th>Safety</th>
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<tr>
<td>Proper use of equipment should be emphasized</td>
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<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Mastery Questions</th>
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<tr>
<td>Matter</td>
<td>See lessons</td>
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<tr>
<td>Mass</td>
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<td>Weight</td>
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<td>Volume</td>
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<td>Centimeter (cm)</td>
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<td>Inches</td>
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<td>Pounds</td>
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Ask students if they know the difference between weight and mass. Explain using the difference using the Background information.

**Mass Activity**

a. Set out the balances and explain to the students how to use them. They are digital balances so they will just have to read the value of the mass from the balance. Be sure they are set to measure in grams. In the kit is a box filled with plastic masses. On the top of each mass is a value in grams. Have the students practice using the balances by placing different masses on the balance and reading the value.

Please instruct the students to be careful with the balances and not to use them to measure anything other than what they are instructed to measure. Note: Students like to try to mass their hands (not possible unless they cut them off) and pushing down heavily on the balance can break them.

b. You can also give them a number of objects you have already massed before class. Have them write down the name of the object and then its mass in grams. You can collect the sheets or go over them in class to check to see if they are using the balances correctly.

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Ask them what volume measures? (amount of space an object has) Ask them how volume and mass differ?

**Volume Activity**

1. **Calculating Volume**

Provided are volume formulas for some common three-dimensional figure. Review these with your students as described in the procedure following the figures.

**Cube:**

![Cube Diagram]

Volume = \( a^3 = a \times a \times a \)
**Cylinder:**

\[ \text{Volume} = \pi \times r^2 \times h \]

- \( \pi = 3.14 \)
- \( h \) is the height
- \( r \) is the radius

**Rectangular solid:**

\[ \text{Volume} = l \times w \times h \]

- \( l \) is the length
- \( w \) is the width
- \( h \) is the height

**Sphere:**

\[ \text{Volume} = \frac{(4 \times \pi \times r^3)}{3} \]

- \( \pi = 3.14 \)
- \( r \) is the radius
Cone:

\[ \text{Volume} = \frac{(\pi \times r^2 \times h)}{3} \]

\( \pi = 3.14 \)

\( r \) is the radius

\( h \) is the height

Pyramid:

\[ \text{Volume} = \frac{(B \times h)}{3} \]

\( B \) is the area of the base

\( h \) is the height

**Procedure**

A. Ask the students “Think about times in your life when you have measured or have seen someone measure the length of objects.” Have students brainstorm a list of tools used to measure the length of an object. Hold up an example of each tool and discuss what a scientist may measure with each tool. Teacher will model how to use a ruler to measure lines drawn on a transparency or document camera to the nearest half inch and nearest centimeter. Students will practice measuring drawn lines and then real classroom objects (such as paper clips, markers, books, highlighters, crayons, etc.) to nearest half inch and centimeter.

B. Using the 3-D shapes provided in the kit, have the students practice measuring the different dimensions of each shape. Working in teams have them check each other’s measurements for agreement. Each group will have a different shape to start the exercise. After an appropriate amount of time, have them switch shapes with another group and measure again. This time not only have them check answers within the team, have them check with the group they switched with.

C. Now the students are ready to practice determining volume of different shapes. Review or teach the formulas given above. Use all or some of the formulas. Start with simple cubes or rectangular objects. Have students bring in their own or use those provided in the kit.
D. Challenge: Have students practice measuring some of the other shapes in the kit and determine the volume.

A quick review or lesson about milliliters is needed. When calculating volume we usually use units of length such as centimeters (cm). For a solid prism, we calculate it volume in cubic centimeters (cm³). In the metric system, 1 cm³ = 1 mL. As a class go over the following example and possible questions:

A large cube measures 10 cm along each edge. Imagine having several 1 cm by 1 cm x 1 cm cubes to work with.

a. What is the volume of each small cube?
b. How many cubes fit on the bottom layer?
c. What is the volume of the bottom layer?
d. How many layers would it take to fill this cube?
e. What is the volume of the large cube in cm³?
f. What is the volume of the large cube in mL?

Extension

There is another method used to determine volume called displacement. This technique can be used for regular shaped objects or irregular shaped objects in which no mathematical formula can be used. The displacement method is discussed on page 29 of the Volumetric Solids Teacher Guide found in the binder. You can demonstrate this technique for your students if you desire. This guide has many other activities that may be used to help students understand the concept of volume and to determine the volume of many complex shapes.

Assessment

- Check student answers when massing objects to determine if they are able to correctly use the balance.
- Check student answers for consistency when calculating the volume of the different shapes.
- Create a worksheet or quiz to test students' understanding of calculating volume.

Resources

- www.vmrk12.la.us/4th/science/Science_by_Unit08/4th_SC-Unit1/UN1Act2_SC.htm

ADVANCED LESSON

Objective(s)

Students will be able to… recognize the difference between weight and mass, make predictions about two similar size objects, experiment with liquids that have different densities, and learn that measurements can be described by different units.

State Science Content Standard(s)

4.2: Select and use the appropriate tools including technology to make measurements (including metric units) and represent results of basic scientific investigations.
  - Use appropriate tools to collect data.
  - Record all data in metric units.

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<tr>
<td>• Balance</td>
<td>• Ruler</td>
</tr>
<tr>
<td>• 3-D shapes</td>
<td>• Diet soda</td>
</tr>
<tr>
<td>• Density Cubes found in the blue box</td>
<td>• Regular soda of the same brand</td>
</tr>
<tr>
<td>• Activity Sheet: Using Density to Identify an Unknown Substance</td>
<td>• Deep transparent plastic container/aquarium filled with water</td>
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<tr>
<td>• Activity Sheet: Density Column</td>
<td>• Sugar cubes or packets</td>
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</tbody>
</table>

Safety

• None
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<tr>
<td>Matter</td>
<td>• [What questions could a teacher ask his/her students throughout and after the lesson to assess mastery?]</td>
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**Detailed Plan**

Use Basic lesson background and plan if needed to prepare students to be able to measure and calculate density by reviewing mass and volume.

Density – or mass per volume – \( \frac{M}{V} \) (mathematical formula for of a substance is an important scientific concept that can be viewed with the naked eye. We see it all the time with oil and water. Oil has a different density than water and the two liquids do not mix. A cork floats in water because it is less dense. A rock sinks in water because it is denser. Some students will want to say the rock sinks because it is heavier but this is not correct. Ask them which is heavier – a pound of cork or a pound of rocks. Then ask them which will sink – the pound of rocks or the pound of cork? They have the same mass but one still floats.

Another example of the difference between mass and density is take a piece of bread (moist works best). You can demonstrate this or have each student have their own piece of bread. Have the students observe it – feel the mass. Next smash the bread into a small ball and ask them if the mass has changed. Ask them if the density has changed.

**Density Demonstration – Creating a Density Column**

In this experiment your students will look at a number of liquids with different densities and compare them all to water.

**Materials:**

- Light corn syrup
- Water
- Vegetable oil
- Dawn dish soap (blue)
- Rubbing alcohol
- Honey
- Tall clear glass that is somewhat narrow – flower vase works well.
- Food coloring
- Turkey baster
- Plastic cups

**Procedure:**
1. Put some rubbing alcohol into one of the plastic cups and drop some blue food coloring into it until the alcohol becomes dark blue. In a separate plastic cup, do the same with the water except add green coloring to it. In another cup, add orange food coloring to some corn syrup. Stir each one of these until they are uniform in color.

2. Squeeze some honey into the bottom of your large glass. Just enough to give a thin layer - keep in mind that your glass will need to hold 6 layers of different liquids in your glass.

3. Next add the corn syrup. Pour this from the cup and try to pour it into the middle of the large glass slowly.

4. Have your child pour the dish soap in next, remembering to pour it into the middle of the glass.

5. Use your baster to add water to the next level.

6. Pour in vegetable oil next.

7. Finally, help your child use the baster to add the rubbing alcohol.

8. Now you should have 6 layers of density.

What’s Going On?

Why don’t the liquids all blend together? It’s because each of the liquids has a different density! Karo syrup = 1.33. Water with food coloring = 1.00. Vegetable Oil = 0.91. Dish soap = 1.03. Honey = 1.36. Rubbing alcohol = 0.87. The various densities allow you to "stack" liquids on top of each other, resulting in an experiment that is both visually stunning and informative!

Questions for the students. (There is a worksheet written in the binder that matches the following questions.)

1. On a piece of paper, make a sketch of the glass and its liquids, labeling the position of each liquid in your glass.

2. Can you think of several ways that the liquids in the glass are different? Try to describe some properties that differ in each of the liquids in the glass. (One property that is different in all of the liquids is color. Another property unique to each liquid is thickness (viscosity).)

3. The property of the liquids that is responsible for the layering effect is density. Can you guess what the relationship is between the density of a liquid and its position in the glass?

4. Another property that keeps the liquids separate is that some of them are immiscible liquids, in other words they do not mix with each other.

5. Stir up the liquids in the glass and watch what happens to the layers. Have any of the layers mixed (are they miscible in each other)? Wait a few minutes and look again. Have any of the other liquids separated?

Extensions:

- Small objects – paperclip, penny, marble, piece of plastic…..) can be dropped into liquids. Depending on the objects density, they will fall to a different liquid which can tell us approximately the density of the object.

- This demonstration could also be used as a class activity. Teams of students could create their own columns.

- Students could experiment with other liquids and try to make their own unique columns.
Density of Soda Pop Demonstration

Imagine a hot summer day. You’re at a picnic and go to the ice chest where the sodas are staying nice and cool. Which cans are floating in the ice water, and which have sunk to the bottom?

Materials:

- several unopened cans of regular soda of different varieties
- several unopened cans of diet soda of different varieties
- a large aquarium or large clear plastic container or sink

Procedure:

Fill the aquarium or sink almost to the top with water. Place a can of regular soda into the water. Make sure that no air bubbles are trapped under the can when you place it in the water. Does it sink or float? Repeat the experiment with a can of diet soda of the same variety. Does it sink or float?

Why does one can sink, and the other can float? (density!)

The cans of soda have exactly the same volume, or size. But their density differs due to what is dissolved in the soda. Regular soda contains sugar as a sweetener. If you look at the nutrition facts on a can of regular soda, you will notice that it contains sugar...a lot of sugar. In some cases a 12 ounce can of regular soda will contain over 40 grams of sugar. Diet sodas, on the other hand, use artificial sweeteners such as aspartame. These artificial sweeteners may be hundreds of times sweeter than sugar, which means that less than a few grams of artificial sweetener is used in a can of diet soda. The difference in the amount of dissolved sweeteners leads to a difference in density. Cans of regular soda tend to be more dense than water, so they sink. Cans of diet soda are usually less dense than water, so they float.

Are there any varieties of regular soda that will float? Are there any varieties of diet soda that sink? Can you think other factors that might influence which sodas float or sink?

Extension:

Using the balance found in the kit, measure the mass of the regular pop. Record this on a white board or chart. Now put the diet pop on the balance and add sugar cubes or sugar packets until the mass of the diet pop and sugar is the same as the regular pop. This is a great visual to demonstrate the amount of sugar found in soda pop.

Using Density to Identify a Substance

Density is a property that can be used to identify a substance just as color can be used to identify substances. Example, copper is shiny reddish brown. Each substance has its own unique value of density. To identify the substance, its mass and volume must first be determined and then its density can be calculated using:

\[ \text{Density} = \frac{\text{Mass}}{\text{Volume}} \]

The mass is determined by using a balance and reading the value to the nearest whole number in grams. The Volume is calculated by first measuring the sides of the cube and using the equation:

\[ \text{Volume} = L \times W \times H \]

Working in teams the students will be given a cube (lettered) made of an unknown substance to determine its mass and volume and then density. After finding the density, using the provided Density Table, the students will be determine the
identity of the substance of their cube. If the unknown density does not match any listed on the table then the students should go back and reweigh and measure the sample. This is a great activity for checking students’ measuring techniques.

Students may design their own experiment or use the lab activity sheet provided in the kit binder.

Density is used in industry and forensics to determine the identity of unknown substances.

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**Assessment**

Listen to classroom discussion to determine understanding. Collect and evaluate any handouts given to the students.

**Resources**

- [http://scifun.chem.wisc.edu/homeexpts/layeredliquids.htm](http://scifun.chem.wisc.edu/homeexpts/layeredliquids.htm)

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**EXPLORE MORE**

See activities for extension ideas.