Calculating Density	Grade 8: Fluids

Lesson Plan

Safety Notes Parental supervision and help is always encouraged!

Description

Students will learn how to calculate the density of objects, and construct and calibrate a homemade hydrometer to measure the relative density of different liquids.

Materials

Object Density:

- Basin with water
- Objects of different sizes/shapes
- Measuring cup
- Ruler
- Scale (*There are free scale apps for Android and IOS!)

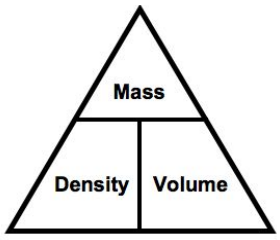
Hydrometer:

- Straw
- Scissors
- Paper Clip
- Marker
- Ruler
- Various liquids

Science Background

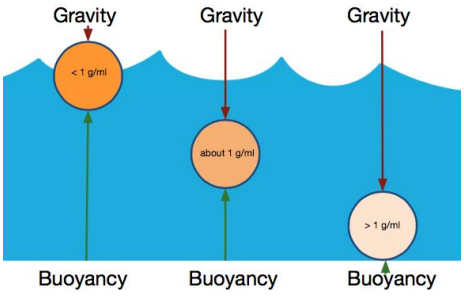
This activity demonstrates multiple scientific concepts.

1. **Density** – everything that has mass has density (ρ). Density is determined by dividing an object's mass (weight) by its volume (the amount of space an object takes up). The density triangle on the side of the page demonstrates how scientists can determine something's density, mass or volume, if provided the other two variables. In general, liquids are more dense than solids because their particles are closer together. This is why it is very difficult to compress a gas compared to a liquid.



Density = Mass ÷ Volume
Mass = Density × Volume
Volume = Mass ÷ Density

2. **Buoyancy** – the ability for an item to float or sink in a fluid. We can figure out if an object will float or sink based on its density compared to the density of the fluid it is placed in. An object that is less dense than the fluid will float and is positively buoyant (left on diagram). An object that is more dense will sink and is negatively buoyant (right on diagram). An object with the same density will float somewhere in the middle of the fluid, this is called neutral buoyancy (middle of diagram).



Activity Procedure

Experiment 1: Calculating density

Find some objects and a container of water to see if they float or sink! Choose objects that will fit into the container and can get wet.

Use the following steps to calculate their density. Remember, water has a density of 1g/ml, and objects with a greater density that 1g/mL will sink in water, while those with a lower density than 1g/ml will float in water.

Calculating density of a solid:

1. Find the mass (weight) of the object in grams (g) and write it down (free scale app on phone)
2. Find the volume of the object by measuring it according to the specific volume of the object (in cm^3) For example:

$$V_{rectangle/square} = \text{length x width x height}$$

$$V_{sphere} = \frac{4}{3} \pi r^3$$

3. Use the formula of $\rho = m/V$. This will give the density in g/cm^3.

Calculating the density of a liquid:

1. Weigh the mass of the liquid and write it down in grams (g).
2. Measure the volume of liquid in milliliters (mL).
3. Use the formula of $\rho = m/V$. This will give the density in g/mL. Note that cm^3 is the same as milliliters (ml) so g/ml is equivalent to g/cm^3.

Calculating the density of a dissolved mixture (ex: salt water):

1. Weigh the mass of the liquid (water) and write it down in grams (g).
2. Weigh the mass of the solute (salt) and write it down in grams (g).
3. Measure the volume of liquid in milliliters (mL) and write it down.
4. Calculate the total mass with the formula $m_{total} = m_{liquid} + m_{solute}$
5. Use the formula of $\rho = m_{total}/V_{liquid}$. This will give the density in g/ml.

Calculating density of Irregular Shaped Objects:

1. Determine the mass (weight) and write it down in grams (g) (free scale app on phone)
2. Find a container that has fluid measurements (mL) listed on the side (measuring cup).
3. Add water to the container and record the volume in millilitres (mL).
4. Add the object to the water and write down the new volume (water and object combined) in mL

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5. Take the starting volume (just water, V1) and subtract it from the new volume (water and object combined V2). The result is the volume of your object.
   E.g. Volume of object = V1 - V2 =225mL - 200mL = 25mL
   Note: 1mL = 1cm³, therefore 25mL = 25cm³.
6. Use the calculation in step 5 to calculate the density of your object with the density equation (ρ =M/V).
   For example: Object mass = 50g, Object volume = 25cm³
   ρ =M/V = 50g/25cm3 = 2g/cm³

Experiment 2: Calculating relative density of liquids using a hydrometer

1. Cut the straw in half, fold the end and secure it with a paperclip, hot glue or clay.
2. Add weight to the straw by adding additional paper clips inside or to the bottom of the straw so that some of the straw sinks when placed in a cup of 100mL water.
3. Using a permanent marker, mark a line on your straw precisely at the water level. At this mark, the density is 1g/mL
4. Determine the relative density of other liquids by placing ~100mL of the liquid (or another known volume) into a cup. Place the hydrometer in the cup and mark the liquid level on the straw.
5. If the new mark is above the 1g/mL mark, the liquid is less dense than water, if it is above the 1g/mL mark, the liquid is more dense than water.

Debrief

A hydrometer can both sink and float, it is weighted on the bottom but still contains air within. Depending on the density of the liquid the hydrometer will sink or be suspended in a liquid at various heights. The buoyancy of the hydrometer depends on the force that is equal to the weight of the dispersed liquid on the submerged portion of the instrument. A liquid with a lower density will allow the hydrometer to sink further down into the liquid, whereas a liquid with a higher density will allow the hydrometer to be suspended or float higher up in the liquid.

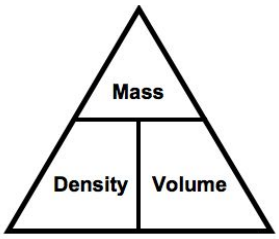
Thank you for participating in our at home experiment for density; have fun trying out the other experiments below!

Additional experiment to try:

Hypothesize whether you think the following will float or sink:

- Can of Cola vs. can of Diet Cola (What is the difference between the two that would affect mass?)
- Orange with peel vs. orange without peel (Larger does not mean more dense in this case)
- Different balls (tennis, basketball, hockey puck, golf ball, bowling ball). Hypothesize what you think they look like on the inside and find out with some research!

ρ = Density	ρ = m ⎮ v	Density = Mass/Volume
m = Mass	m = ρ · v	Mass = Density x Volume
v = Volume	v = m ⎮ ρ	Volume = Mass/Density



1. Generally, which one has the higher density (circle one).

Liquid	Gas	Solid
or	or	or
Gas	Solid	Liquid

2. How can you use water to determine the volume of an irregularly shaped object?

3. Why do the straw and paper clip float differently in each of the liquids tested?

4. Determine the density, mass or volume of the objects in the following questions.

   a. If the mass of the liquid is 200g and the volume is 50mL what is the density?

Equation Needed	Answer

   b. If the density of an object is 10g/mL and the volume is 70mL what is the mass?

Equation Needed	Answer

5. CHALLENGE: Figure out the density of two random items in your home using the method shown to you in the video.

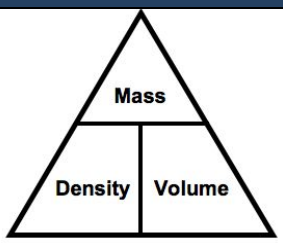
Object	Mass	Volume	Density
1			
2			

Density	Grade 8: Understanding Matter and Energy

ρ = Density
m = Mass
v = Volume

$\rho = m \mid v$
$m = \rho \cdot v$
$v = m \mid \rho$

Density = Mass/Volume
Mass = Density x Volume
Volume = Mass/Density



1. Generally, which one has the higher density (circle one).

Liquid	Gas	Solid
or	or	or
Gas	Solid	Liquid

2. How can you use water to determine the volume of an irregularly shaped object?

   When an object is placed into water, it displaces water equal to its volume. To determine the volume of the irregular object you need to subtract the original volume of the water from the volume when the irregular object is fully submerged in the water.

3. Why do the straw and paper clip float differently in each of the liquids tested?

   The straw and paper clip float differently because each liquid has a different density (therefore buoyancy is different), while the density of the straw and paper clip remain the same.

4. Determine the density, mass or volume of the liquids in the following questions.

   a. If the mass of the liquid is 200g and the volume is 50mL what is the density?

Equation Needed	Answer
$\rho = m \mid v$	$\rho = 200g \mid 50mL$ $\rho = 4g/mL$ Therefore, the density of the liquid is 4g/mL.

   b. If the density of a liquid is 10g/mL and the volume is 70mL what is the mass?

Equation Needed	Answer
$m = \rho \cdot v$	$m = 10g/mL \cdot 70mL$ $m = 700g$ Therefore, the mass of the liquid is 700g.

5. CHALLENGE: Figure out the density of two random items in your home using the method shown to you in the video.

Object	Mass	Volume	Density
1	N/A	N/A	N/A
2	N/A	N/A	N/A

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