Explain

Sink or Float

Introduction

In the Engage activity, *Toying with Matter*, you observed what happened to a candle when it was placed in liquids with different densities. Water has a greater density than paraffin so paraffin floats in water. As a result, the candle floats.

Caption: Will the boat sink? Will people have to swim? Density differences will decide what happens.

Understanding density helps explain what happens in nature, from deep ocean currents to thinning bones among the elderly. Density is important to toy manufacturers because they must be able to determine the density of any solid or liquid they intend to use in a wave toy. Otherwise, the toy will not function as designed. Sales will suffer.

In the *Sink or Float* investigation, you will learn important background knowledge. That knowledge explains how density helps you make sense of the wave toy's function. To determine the density of materials, you will use tools that are important in science—including mathematics.

Process and Procedure

Background knowledge

Is the density of candle wax the same as the density of water? Are the densities of isopropyl alcohol and mineral oil the same? How do you know? Would the same volume of each of these substances read the same value on a laboratory scale? Why? You are about to measure 2 values required to calculate density—mass and volume. Density is the ratio of these 2 values given by the following mathematical relationship:

$$Density = \frac{mass}{volume} = \frac{m}{V}$$

When one material is more massive than another for the same amount of volume, then it has a greater density. Steel for bridges has a high density. Air that we breathe has a low density.

Once you calculate density, you can use it to predict how substances will interact with each other, as in a wave toy.

Part A: Determining the Density of a Liquid

Materials	Cautions
For each team of four students • 4 pairs of safety goggles • 1 100-mL graduated cylinder • 1 plastic pipette • 1 balance • colored pencils • approximately 100 mL each of water, isopropyl alcohol, and mineral oil • 1 calculator	Wear safety goggles at all times. Avoid direct skin contact with the materials. Although the materials in this lab are common household or laboratory materials, it is still important to exercise caution when handling materials in the lab. If you spill a substance on the floor or desk, tell your teacher so he or she can let you know how to clean it up safely.

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1. Develop a step-by-step procedure to determine the density of a liquid. You will have three different liquids and should use three different amounts of each liquid. Record this procedure in your notebook under the heading "Sink or Float — Part I" to help accomplish 1a–e.
    a. Meet with your team to discuss appropriate steps and agree on those steps before proceeding.
    Note: Consult with your teacher if the team cannot reach consensus.
        i. Decide how to measure mass and volume for liquid samples using the equipment provided.
        Note: The mass of a liquid sample *inside* your graduated cylinder is what you use to calculate density. Therefore, incorporating the graduated cylinder's mass with the liquid would give you a false value for density. So don't forget to measure the mass of an empty cylinder!

ii. Include steps for collecting 3 sample sizes of each liquid with volumes varying from 20 to 100 milliliters (mL).
Note: This step eventually gives you feedback on how reliable your measurement technique is.

b. Write the procedure in numbered steps in your notebook.
c. Have your teacher approve your procedure before collecting data.
Note: Scientists are responsible for recording their own data. That way they can review their data away from the lab.

2. Construct a data table in your notebook that has a space for each important observation for each liquid.
   a. Include columns and rows with informative headings and proper measurement units.
   b. Leave spaces for the calculated density of each sample.

3. Collect data efficiently and return all liquids as instructed by your teacher.
Note: Gather your materials and collect your data.

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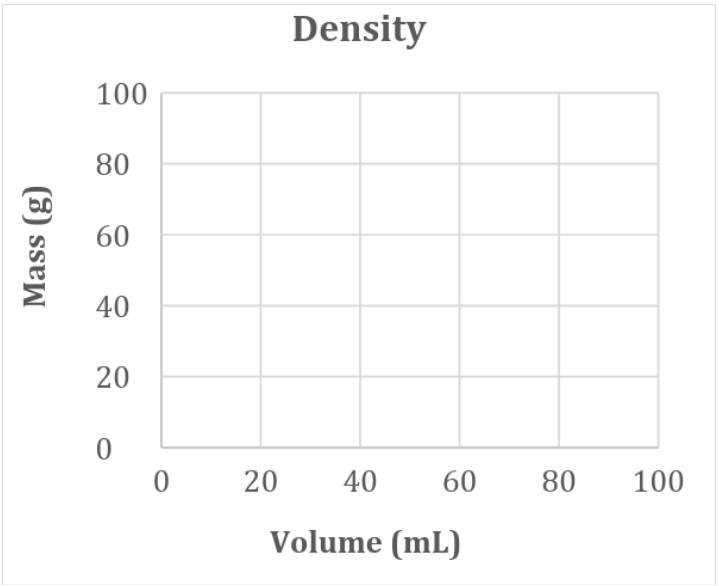
4. Graph your mass and volume data in the graph below.
Note: Graphs help you picture differences in density.
   a. Use different colored pencils for each liquid.



Caption: (question #6)

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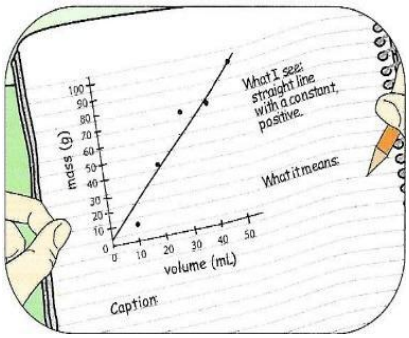
5. Draw a best-fit line for each liquid.

Note: A best-fit line places approximately as many data points above the line as below it. It represents a type of average. Remember, simply "connecting the dots" will not give you the real picture of density.

6. Place a key on your graph, explaining what each color represents.
   a. Look carefully at the best-fit line for water. Consider the key features or *highlights* of what you see and what it means.



   b. Think of a few words that you have learned in other science and mathematics classes to describe what you see.
   c. Write the phrase "What I see:" by the best-fit line for water. Following this phrase, write your short description. This forms *half* of your highlight comments.

Note: Use simple descriptive words like, "the line is straight" of "the line has a positive slope."

Caption: Your graph has labeled axes with units, a best fit line, and highlight comments.

7. Repeat Steps 5 and 6 for *each* liquid. Graph their data on the same set of axes as liquid 1.
8. Compare the highlight comments you wrote beside each "What I See" entry with others in your team. Modify your comments based on what you learned from others. Include those modifications in your notebook.
9. Write "What it means" under each "What I see" comment. This phrase is the other half of your highlight comments. Explain what a constant positive slope means about the density of each liquid.

Note: Math class taught you that constant slope means constant rise/run. For this graph, rise/run is the same as mass/volume if the line passes through the origin. The ratios rise/run and mass/volume have the same numerical value for the same substance.

Stop and Think: Part A

Wave toys depend, in part, on differences in density. Graphs show those differences. They help you understand, because they help you see what the numbers mean. Answer the following questions in your notebook under the heading, "Stop and Think—Part I."

1. Look at all three slopes from your density graph. Are they all the same? What does that mean?
2. Calculate the slopes of each best-fit line and show all your work with proper units and labels.
3. Calculate densities for each sample (you will have 3 calculations for each substance and 3 substances. This results in 9 total values in your data table).
4. Compare those values with the slopes you just calculated.
5. What does it mean if they are very close to each other? What does it mean if they are very far apart?

Part B: Determining the Density of a Solid

Background information

Chemists often want to determine what is unique about a substance. We call these unique attributes characteristic properties. Such properties help us pick and choose materials for specialized uses. But what about the little penguin in the wave toy? It is a solid, not liquid. How do we determine its density? Yes, we still need to measure mass and volume, and we need to use mathematics to calculate density.

Materials	Cautions
• 4 pairs of safety goggles • 1 100-mL graduated cylinder • 1 balance • 1 strainer • water • candles (3 different sizes) • 1 calculator • colored pencils (optional)	Always wear safety goggles in the lab, particularly when you are investigating chemical reactions.

Chapter 1

Process and Procedure

1. When your team agrees on the best way to determine the mass and volume of a solid, ask your teacher to approve your procedure. Write the procedure in your notebook and then carry out your procedure. Record all observations in your notebook under the heading "*Sink or Float—Part II.*"

Note: Don't forget to think about safety.

   a. Construct a data table in your notebook with proper headings, including measurement units. **Note**: Don't forget columns for the water level in your graduated cylinder *before* and *after* you place a solid sample in it.
   b. Record your observations.
   c. Return materials as instructed by your teacher.

Stop and Think: Part B

The procedures in Parts I and II exhibit similarities: they both require you to measure mass and volume, then derive density through calculation. Place your mass versus volume graph from Part I in front of your team and write answers to these questions in your notebook under the heading "Chapter 1: Stop and Think—Part II."

1. As a team, decide where the best-fit line for paraffin will be in relation to your lines for water, isopropyl alcohol, and mineral oil.
   a. Pencil your prediction on your graph and label it "Prediction."
   b. In your notebook, explain why you placed your prediction where you did. **Note**: Be sure to include science concepts and words like slope, density, and ratio in your explanation.

2. Plot the data for all 3 candle samples.
   a. Draw a best-fit line.
   b. Think about what the graph means—what it tells you about wax.

3. Write the following sentence in your notebook. You will choose one of the underlined words:

A candle will (sink or float) in water because the density of paraffin is (greater or less) than the density of water.

4. Generate 2 similar sentences for
   a. a candle in isopropyl alcohol
   b. a candle in mineral oil.
5. Use your answers to Questions 3 and 4 to explain how graphs help show differences in density.
   a. Read your explanation to your teammates.
   b. Include in your notebook what you learned from their feedback.
6. Calculate the density of each solid sample as you did for each liquid and record those values in your data table.
7. Compare your calculated densities of each sample to the slope of your best fit line for your three solid samples. Explain what you notice in a short caption under your graph.

Reflect and Connect

Answer the following questions individually. Record your answers in your science notebook under the heading "Explain: Reflect and Connect."

1. Your teacher needs your help. Several students from another class failed to clean up their unlabeled liquid samples. Your teacher needs you to determine the identity of each of the unlabeled samples. She labeled the samples "A," "B," and "C."
   a. Use the data in the table below and the data in your science notebook to determine the identity of the unlabeled samples. Explain how you got your answers.

Material	Volume of Liquid sample (mL)	Mass of cylinder with liquid sample (g)	Mass of cylinder alone (g)
A	100	142.54	2.54
B	100	93.21	2.54
C	100	83.44	2.54

   b. What other information about the unlabeled samples would be helpful as you try to identify

them? Explain why that new information would be helpful.

c. If 2 samples have the same density, are they the same material? Explain your answer by using an example from outside school.

2. Density is a characteristic physical property of a material. Use your recent experiences to describe what that means.

Note: Characteristic refers to a property that defines or helps identify a material so you can tell what it is.

3. Use your graph from Part I and Part II to answer the following question. What would you predict is the density of 1 liter (L, or 1,000 mL) of isopropyl alcohol? Of 1.35 kilograms (kg) of paraffin? Explain your answers using the concept words slope and density.

4. Thinking back over the activities and learning from this section, what activities from the "How Science Works" chart did you engage in?

End of Explain 1 lesson.