Mystery Materials: Exploring Mass, Volume & Density

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Introduction

The integrated math and science curriculum for the seventh and eighth graders at the Francis W. Parker Charter Essential School focuses on the Challenge of the Week (COW). COWs are designed to be rich problems that students of all levels can access and be challenged by for about a week. After they receive the challenge, usually on a Friday, class time is devoted to helping them solve the challenge and communicate their solutions. This lesson represents the work of one COW; it is the first COW of a unit on boats. Students spend time exploring density before they build model boats to maximize carrying capacity and speed.

Density is a difficult topic for middle school students to comprehend because they need to differentiate between mass and volume. Density is the ratio, or relationship, of an object's mass to its volume (density = mass/volume). Sometimes it is called an object's "compactness". Different materials have different densities because of their molecular structure. The more air space that a material has, the less dense it will be; conversely, the less air space a material has, the more dense it will be. For example, a cotton ball is filled with air so its density is low. This example is easy to understand, because students can see that there is room for air within a cotton ball. It is more difficult to see why wood is less dense than steel. How can there be air space in a solid object? The reason is that wood has more space between its molecules, but students need a more concrete explanation. One activity that they can try is to fill up a cup with gravel and another with sand. It is clear that there is air space between the gravel where their edges do not fit together. They can measure the amount of space by filling the cup with water and measuring how much water was added. It is not so obvious that there is air space in the sand, the grains are smaller and seem to fit together much better than the gravel. However, if students pour water into the cup, they will learn that the sand also has air space within it.

The way that density was applied in our classes was to see if objects or materials float or sink in water. If water has one density and the object has another, the less dense will rise to the top, or said another way the one with the least mass per unit volume. This raises all sorts of questions such as: how does a steel or iron boat float? What if the liquid wasn't water?

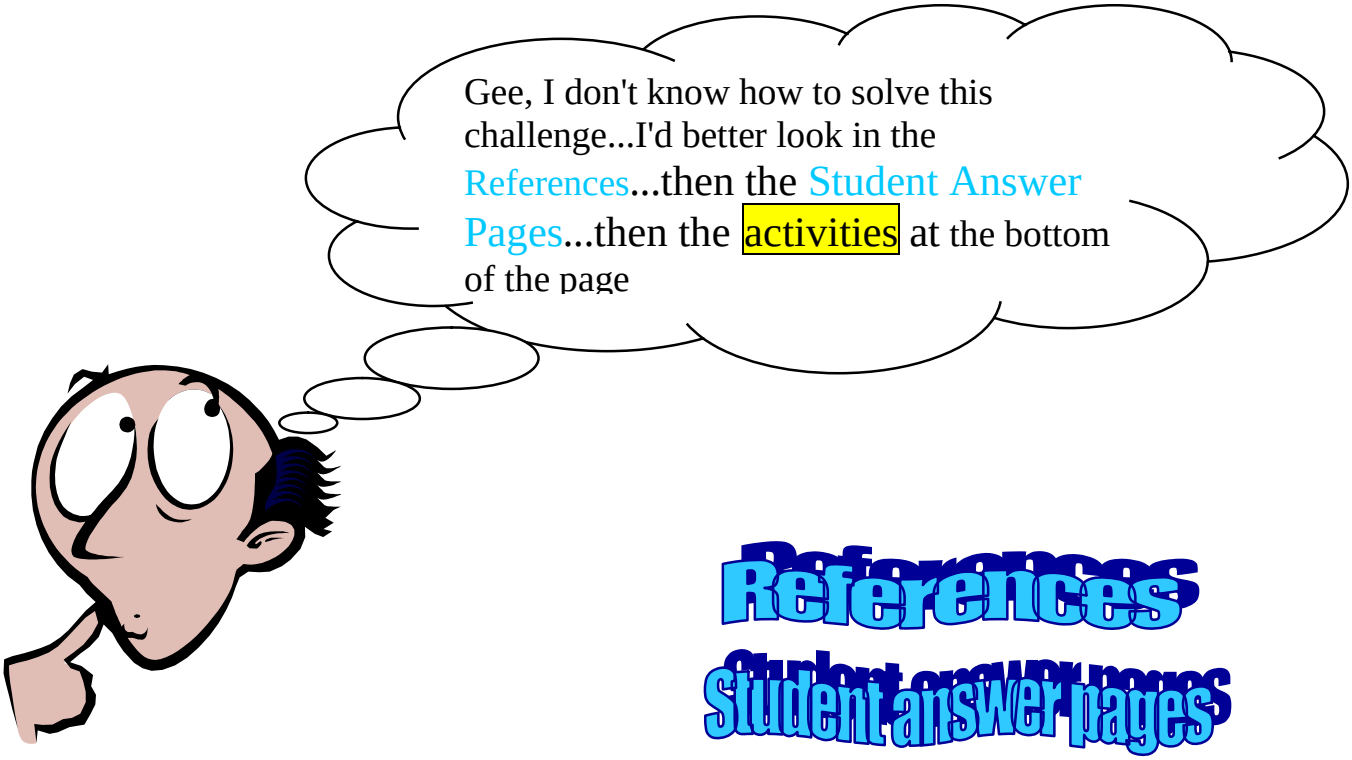
A nice connection to math is that mass and volume are in a direct relationship: if density stays the same, and mass is increased the volume must also increase. Similarly, density is directly related to mass: if volume stays the same and density increases, mass must increase as well. However, density is inversely related to volume. For example, if mass stays the same and density increases, volume must decrease. All equations that are written this way have the same relationships.

National Science Education Standards

By the end of 8th grade, students are expected to understand "*properties and changes of properties in matter*". This lesson helps students differentiate between mass, volume and density, all properties of matter. Through inquiry, they are encouraged to develop their own understanding of the concepts.

How can you find the **MASS** of an unknown material without using a balance?

THE CHALLENGE: to learn about the relationship between **mass, volume** and **density** in order to determine mass *without using a balance*.



ACTIVITIES:

Activity 1: How can you tell if an unknown liquid is more or less dense than water?

Activity 2: Find the densities of these liquids

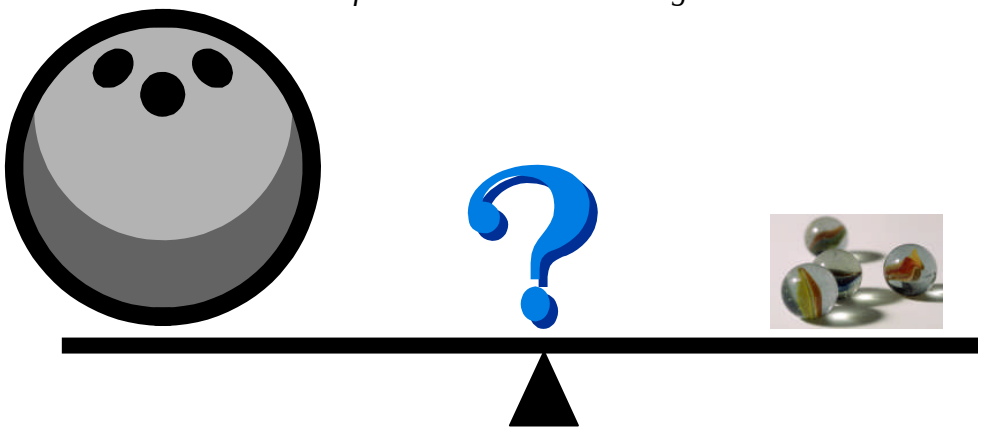
Activity 3: Finding the density of solids

References

KEY TERMS:

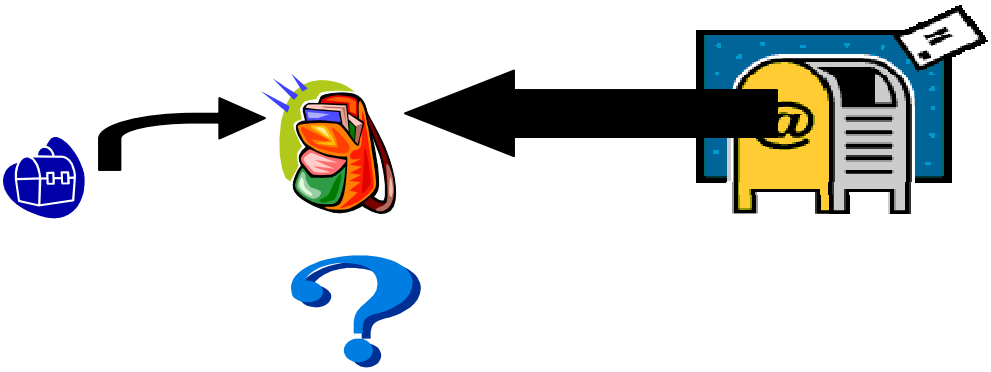
Mass--the amount of matter or material in an object.

Which would be easier to lift... a marble or a bowling ball?



Volume--the amount of space an object takes up.

Which would be easier to fit in your backpack... a lunchbox or a mailbox?



Density--the amount of material in a certain amount of space; the amount of **mass** in a certain **volume**.

APPLY IT!

Activity 1: How can you tell if an unknown liquid is more or less dense than water?

FORMULAS:

Density--the amount of material in a certain amount of space; the amount of **mass** in a certain **volume**.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Example

Solve the equation for **mass**.

$$D = \frac{M}{V}$$

$$\frac{V}{1} \cdot D = \frac{M}{\cancel{V}} \cdot \frac{\cancel{V}}{1}$$

$$V \cdot D = \frac{M}{1}$$

$$V \cdot D = M$$

Solve the equation for **volume** on the student answer page

Name: _____ Date: _____

STUDENT ANSWER PAGE
REFERENCES

1. What is **mass**?

_____

2. What is **volume**?

_____

3. What is **density**?

_____

4. Solve the formula for **volume**:

$$M = D \cdot V$$

$$= V$$

5. If you know the **mass** and **density**, how can you find the **volume**?

_____

6. If you know the **mass** and **volume**, how can you find the **density**?

_____

7. If you know the **density** and **volume**, how can you find the **mass**?

_____

Activity 1: How can you tell if an unknown liquid is more or less dense than water?

FACT: The liquid with higher density will sink and the liquid with lower density will float.

PREDICT which liquids are denser than water, then click to see if you are right.

Water OR Dish soap

Water OR Oil

Water OR Maple syrup

Water OR Corn syrup

Ready for the next step? Go to Activity 2!

Activity 2: Find the densities of these liquids

Student Answer Page

Activity 1: Predicting Densities

My prediction: _____

Actual: _____

My prediction: _____

Actual: _____

My prediction: _____

Actual: _____

My prediction: _____

Actual: _____

Activity 2: Find the densities of these liquids

Go to the student answer pages for your own copy of this table and complete the questions.

Substance	Mass (g)	Volume (ml)	Density (g/ml)
Water	100.0	100	
Oil	90.0	100	
Corn Syrup	147.9	100	
Dish soap	110.0	100	
Maple syrup	125.5	100	

When you have answered questions 1 and 2, click below:

Watch the video clip to see what happens!

Name: _____ Date: _____

STUDENT PAGE

ACTIVITY 2: FINDING DENSITIES

1. Complete the table by calculating density. Check out your **REFERENCES** if you forget how.

Substance	Mass (g)	Volume (ml)	Density (g/ml)
Water	100.0	100	
Oil	90.0	100	
Corn Syrup	147.9	100	
Dish soap	110.0	100	
Maple syrup	125.5	100	

2. Predict what would happen if you poured these liquids into one container:

PREDICTION

3. After watching the video clip in Activity 3, record what actually happened:

ACTUAL

Activity 3: Finding the density of solids

Go to the student answer pages for your own copy and complete the table.

Substance	Mass (g)	Volume (ml)	Density (g/ml)	Predict what layer they would fall in the density column
Oak	6.4	10		
Copper	89.4	10		
Gold	193.2	10		
Granite	26.0	10		
Nylon	11.0	10		
Acrylic	10.7	10		
Cork	1.5	10		

What would happen if you dropped cork, granite, acrylic and copper into the density column?

If the penny were shaped into a 10 ml cube…where would it fall in the density column?

Ready for the big challenge?

How can you find the **MASS** of an unknown material without using a balance?

Name: _____ Date: _____

STUDENT PAGE
FINDING DENSITIES OF SOLIDS

1. Complete the table.

Substance	Mass (g)	Volume (ml)	Density (g/ml)	Predict where they will fall in the column
Oak	6.4	10		
Copper	89.4	10		
Gold	193.2	10		
Granite	26.0	10		
Nylon	11.0	10		
Acrylic	10.7	10		
Cork	1.5	10		

Record what actually happened on the diagram:

How can you find the **MASS** of an unknown material without using a balance?

The unknown object has a **volume** of 5 ml

Click on the picture to put it into the density column

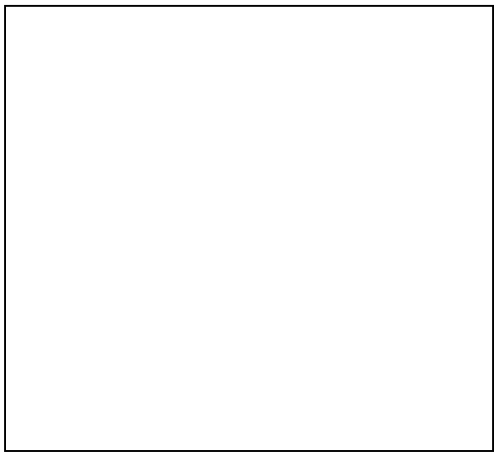
Go to the student answer pages to record the results and **solve the problem**.

Name: _____ Date: _____

STUDENT PAGE
FINAL CHALLENGE

How can you find the MASS of an unknown material without using a balance?

1. Draw what the density column looked like with the unknown material.



2. What do you think the density of the unknown material is?

_____

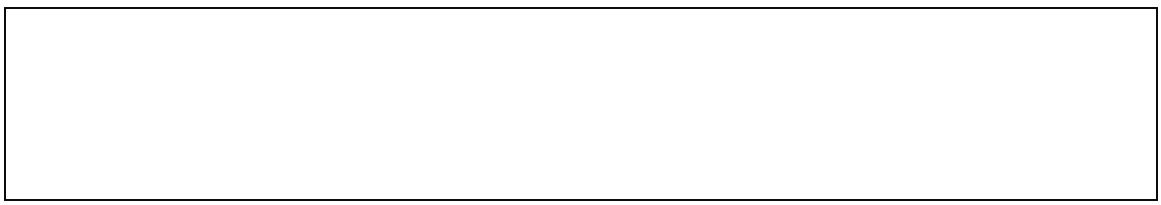
3. Why do you think so? Provide evidence.

_____

_____

_____

4. What is the mass of the material? Show your work.



Teacher answer pages

References:

1. The amount of matter in an object.
2. The amount of space an object takes.
3. The amount of material in a certain space; the amount of mass in a certain volume.
4. M/D=V
5. Mass divided by density equals volume.
6. Mass divided by volume equals density.
7. Density times volume equals mass.

Activity 1: Predicting Densities

1. Predictions will vary
2. Dish soap, Maple syrup and corn syrup are denser than water. Oil is less dense than water.

Activity 2: Find the densities of these liquids

1.

Substance	Mass (g)	Volume (ml)	Density (g/ml)
Water	100.0	100	1
Oil	90.0	100	.9
Corn Syrup	147.9	100	1.47
Dish soap	110.0	100	1.1
Maple syrup	125.5	100	1.255

2. Predictions will vary.
3. Corn syrup sinks to the bottom, then maple syrup, then dish soap, then water then oil is at the top.

Activity 3: Finding the density of solids

1.

Substance	Mass (g)	Volume (ml)	Density (g/ml)	Predict what layer they would fall in the density column
Oak	6.4	10	.64	
Copper	89.4	10	8.94	
Gold	193.2	10	19.32	
Granite	26.0	10	2.60	Predictions will vary
Nylon	11.0	10	1.10	
Acrylic	10.7	10	1.07	
Cork	1.5	10	.15	

Final Challenge: How can you find the mass of an unknown material without using a balance?

1. The unknown material, acrylic falls between dish soap and water.
2. Estimates should fall between water's density (1 g/ml) and dish soap's density (1.1 g/ml).
3. Students should be encouraged to defend why they chose the number that they did (did they average water and dish soap's densities? Did they infer that the material was acrylic?
4. Depending on the density that they estimate, answers will vary. All should use the formula: M=DV and fall between 5g and 5.5 g.