

# Physical Properties

Have you ever played the game 20 Questions? The goal of this game is to figure out what object another person is thinking of by asking 20 yes/no questions or less.

If you can't figure out the object's identity after asking 20 questions, you may not be asking the right kinds of questions. What kinds of questions should you ask? You may want to ask questions about the physical properties of the object. Knowing the properties of an object can help you find out what it is.

## What You Will Learn

- Identify six examples of physical properties of matter.
- Describe how density is used to identify substances.
- List six examples of physical changes.
- Explain what happens to matter during a physical change.

## Vocabulary

physical property  
density  
physical change

## READING STRATEGY

**Mnemonics** As you read this section, create a mnemonic device to help you remember examples of physical properties.

## Physical Properties

The questions in **Figure 1** help someone gather information about color, odor, mass, and volume. Each piece of information is a physical property of matter. A **physical property** of matter can be observed or measured without changing the matter's identity. For example, you don't have to change an apple's identity to see its color or to measure its volume.

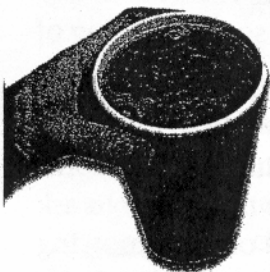
Other physical properties, such as magnetism, the ability to conduct electric current, strength, and flexibility, can help someone identify how to use a substance. For example, think of a scooter with an electric motor. The magnetism produced by the motor is used to convert energy stored in a battery into energy that will turn the wheels.

**Reading Check** List four physical properties. (See the Appendix for answers to Reading Checks.)

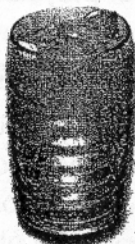
**Figure 1** Asking questions about the physical properties of an object can help you identify it.



**Figure 2** Examples of Physical Properties



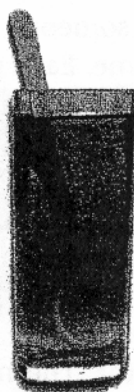
**Thermal conductivity** (KAHN duhk TIV uh tee) is the rate at which a substance transfers heat. Plastic foam is a poor conductor.



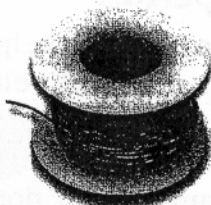
**State** is the physical form in which a substance exists, such as a solid, liquid, or gas. Ice is water in the solid state.



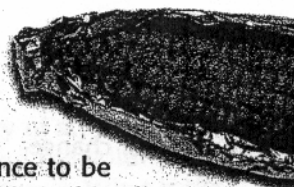
**Density** is the mass per unit volume of a substance. Lead is very dense, so it makes a good sinker for a fishing line.



**Solubility** (SAHL yoo BIL uh tee) is the ability of a substance to dissolve in another substance. Flavored drink mix dissolves in water.



**Ductility** (duhk TIL uh tee) is the ability of a substance to be pulled into a wire. Copper is often used to make wiring because it is ductile.



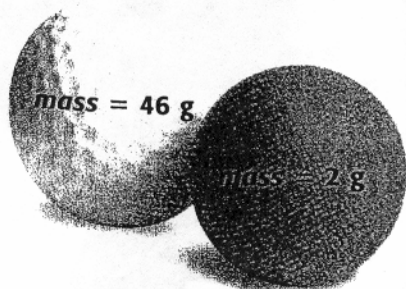
**Malleability** (MAL ee uh BIL uh tee) is the ability of a substance to be rolled or pounded into thin sheets. Aluminum can be rolled into sheets to make foil.

### Identifying Matter

You use physical properties every day. For example, physical properties help you determine if your socks are clean (odor), if your books will fit into your backpack (volume), or if your shirt matches your pants (color). **Figure 2** gives more examples of physical properties.

### Density

Density is a physical property that describes the relationship between mass and volume. **Density** is the amount of matter in a given space, or volume. A golf ball and a table-tennis ball, such as those in **Figure 3**, have similar volumes. But a golf ball has more mass than a table-tennis ball does. So, the golf ball has a greater density.



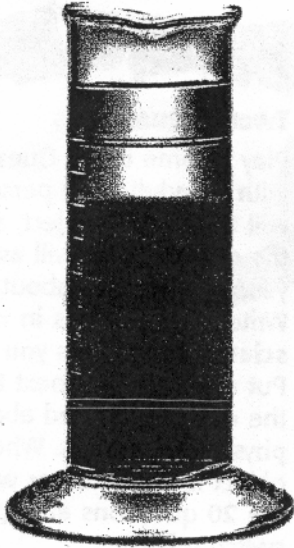
**Figure 3** A golf ball is denser than a table-tennis ball because the golf ball contains more matter in a similar volume.

**physical property** a characteristic of a substance that does not involve a chemical change, such as density, color, or hardness

**density** the ratio of the mass of a substance to the volume of the substance

## Liquid Layers

What do you think causes the liquid in **Figure 4** to look the way it does? Is it trick photography? No, it is differences in density! There are six liquids in the graduated cylinder. Each liquid has a different density. If the liquids are carefully poured into the cylinder, they can form six layers because of the differences in density. The densest layer is on the bottom. The least dense layer is on top. The order of the layers shows the order of increasing density. Yellow is the least dense, followed by the colorless layer, red, blue, green, and brown (the densest).



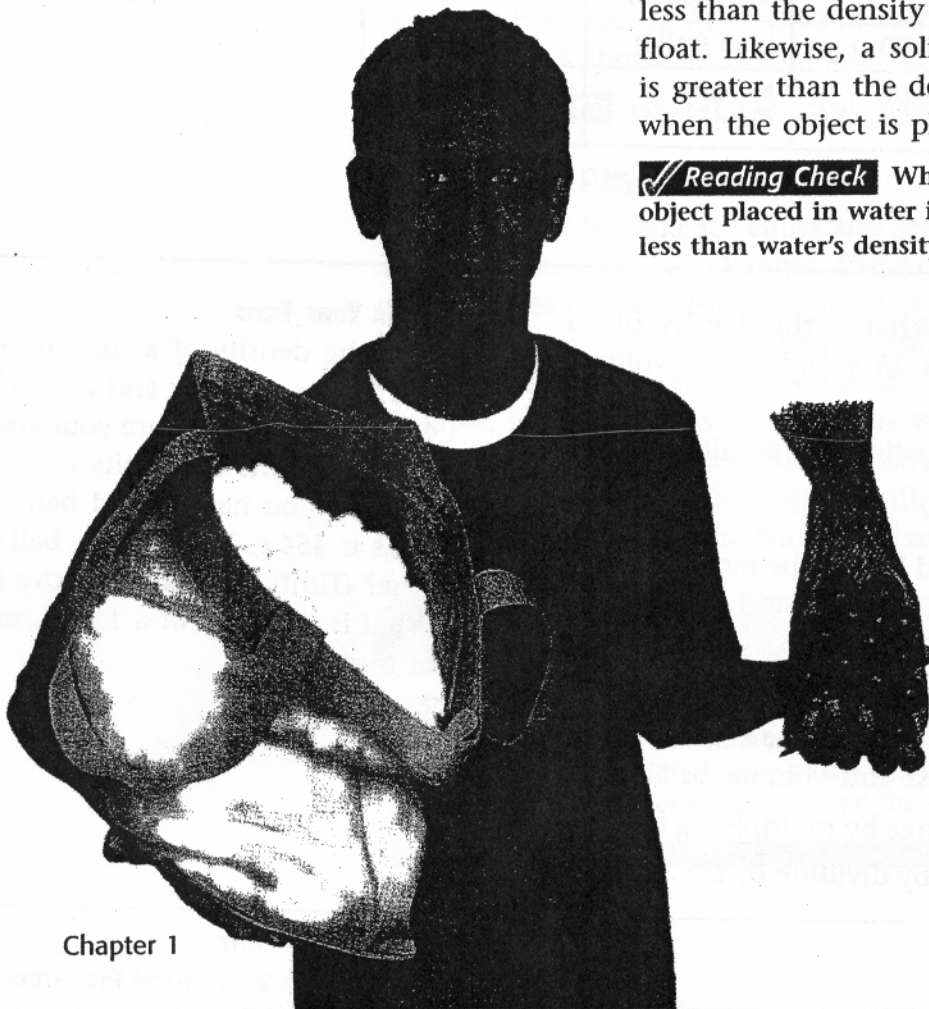
**Figure 4** This graduated cylinder contains six liquids. From top to bottom, they are corn oil, water, shampoo, dish detergent, antifreeze, and maple syrup.

## Density of Solids

Which would you rather carry around all day: a kilogram of lead or a kilogram of feathers? At first, you might say feathers. But both the feathers and the lead have the same mass, just as the cotton balls and the tomatoes have the same mass, as shown in **Figure 5**. So, the lead would be less awkward to carry around than the feathers would. The feathers are much less dense than the lead. So, it takes a lot of feathers to equal the same mass of lead.

Knowing the density of a substance can also tell you if the substance will float or sink in water. If the density of an object is less than the density of water, the object will float. Likewise, a solid object whose density is greater than the density of water will sink when the object is placed in water.

**Reading Check** What will happen to an object placed in water if the object's density is less than water's density?



**Figure 5** The cotton balls and the tomatoes have the same mass. But cotton is much less dense than the tomatoes.

## Solving for Density

To find an object's density ( $D$ ), first measure its mass ( $m$ ) and volume ( $V$ ). Then, use the equation below.

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

Units for density consist of a mass unit divided by a volume unit. Some units for density are  $\text{g/cm}^3$ ,  $\text{g/mL}$ ,  $\text{kg/m}^3$ , and  $\text{kg/L}$ . Remember that the volume of a solid is often given in cubic centimeters or cubic meters. So, the density of a solid should be given in units of  $\text{g/cm}^3$  or  $\text{kg/m}^3$ .

## Using Density to Identify Substances

Density is a useful physical property for identifying substances. Each substance has a density that differs from the densities of other substances. And the density of a substance is always the same at a given temperature and pressure. Look at **Table 1** to compare the densities of several common substances.

Substance	Density* ( $\text{g/cm}^3$ )	Substance	Density* ( $\text{g/cm}^3$ )
Helium (gas)	0.0001663	Zinc (solid)	7.13
Oxygen (gas)	0.001331	Silver (solid)	10.50
Water (liquid)	1.00	Lead (solid)	11.35
Pyrite (solid)	5.02	Mercury (liquid)	13.55

\*at 20°C and 1.0 atm

## MATH FOCUS

**Calculating Density** What is the density of an object whose mass is 25 g and whose volume is  $10 \text{ cm}^3$ ?

**Step 1:** Write the equation for density.

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

**Step 2:** Replace  $m$  and  $V$  with the measurements given in the problem, and solve.

$$D = \frac{25 \text{ g}}{10 \text{ cm}^3} = 2.5 \text{ g/cm}^3$$

The equation for density can also be rearranged to find mass and volume, as shown.

$$m = D \times V \text{ (Rearrange by multiplying by } V\text{.)}$$

$$V = \frac{m}{D} \text{ (Rearrange by dividing by } D\text{.)}$$

## SCHOOL TO HOME

### Twenty Questions

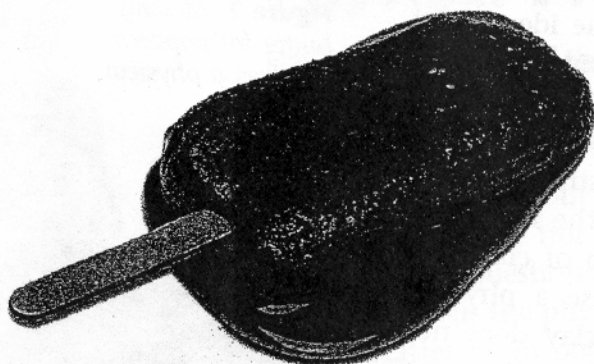
Play a game of 20 Questions with an adult. One person will think of an object, and the other person will ask yes/no questions about it. Write the questions in your **science journal** as you play. Put a check mark next to the questions asked about physical properties. When the object is identified or when the 20 questions are up, switch roles.

## ACTIVITY

### Now It's Your Turn

1. Find the density of a substance that has a mass of 45 kg and a volume of  $43 \text{ m}^3$ . (Hint: Make sure your answer's units are units of density.)
2. Suppose you have a lead ball whose mass is 454 g. What is the ball's volume? (Hint: Use **Table 1** above.)
3. What is the mass of a 15 mL sample of mercury?

**Figure 6** Examples of Physical Changes



Changing from a solid to a liquid is a physical change. All changes of state are physical changes.



This aluminum can has gone through the physical change of being crushed. The properties of the can are the same.

**physical change** a change of matter from one form to another without a change in chemical properties

### Physical Changes Do Not Form New Substances

A **physical change** is a change that affects one or more physical properties of a substance. Imagine that a piece of silver is pounded and molded into a heart-shaped pendant. This change is a physical one because only the shape of the silver has changed. The piece of silver is still silver. Its properties are the same. **Figure 6** shows more examples of physical changes.

**✓ Reading Check** What is a physical change?

### Examples of Physical Changes

Freezing water to make ice cubes and sanding a piece of wood are examples of physical changes. These changes do not change the identities of the substances. Ice is still water. And sawdust is still wood. Another interesting physical change takes place when certain substances dissolve in other substances. For example, when you dissolve sugar in water, the sugar seems to disappear. But if you heat the mixture, the water evaporates. Then, you will see that the sugar is still there. The sugar went through a physical change when it dissolved.

#### CONNECTION TO

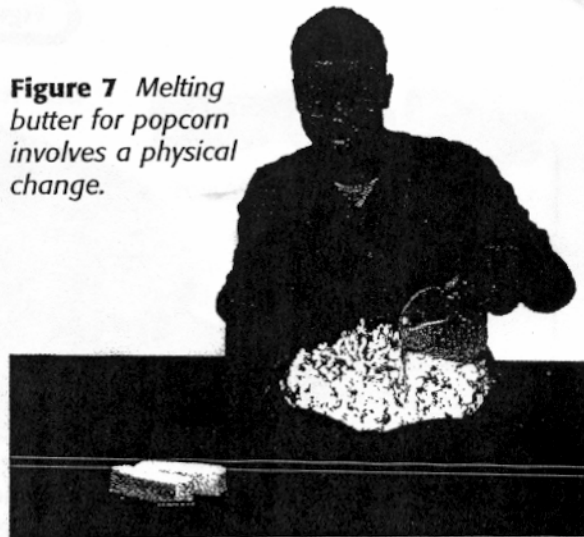
#### WRITING SKILL

**Erosion** Erosion of soil is a physical change. Soil erodes when wind and water move soil from one place to another. Research the history of the Grand Canyon. Write a one-page report about how erosion formed the Grand Canyon.

## Matter and Physical Changes

Physical changes do not change the identity of the matter involved. A stick of butter can be melted and poured over a bowl of popcorn, as shown in **Figure 7**. Although the shape of the butter has changed, the butter is still butter, so a physical change has occurred. In the same way, if you make a figure from a lump of clay, you change the clay's shape and cause a physical change. But the identity of the clay does not change. The properties of the figure are the same as those of the lump of clay.

**Figure 7** Melting butter for popcorn involves a physical change.



## SECTION Review

### Summary

- Physical properties of matter can be observed without changing the identity of the matter.
- Examples of physical properties are conductivity, state, malleability, ductility, solubility, and density.
- Density is the amount of matter in a given space.
- Density is used to identify substances because the density of a substance is always the same at a given pressure and temperature.
- When a substance undergoes a physical change, its identity stays the same.
- Examples of physical changes are freezing, cutting, bending, dissolving, and melting.

### Using Key Terms

1. Use each of the following terms in a separate sentence: *physical property* and *physical change*.

### Understanding Key Ideas

2. The units of density for a rectangular piece of wood are
  - a. grams per milliliter.
  - b. cubic centimeters.
  - c. kilograms per liter.
  - d. grams per cubic centimeter.
3. Explain why a golf ball is heavier than a table-tennis ball even though the balls are the same size.
4. Describe what happens to a substance when it goes through a physical change.
5. Identify six examples of physical properties.
6. List six physical changes that matter can go through.

### Math Skills

7. What is the density of an object that has a mass of 350 g and a volume of 95 cm<sup>3</sup>? Would this object float in water? Explain.

8. The density of an object is 5 g/cm<sup>3</sup>, and the volume of the object is 10 cm<sup>3</sup>. What is the mass of the object?

### Critical Thinking

9. **Applying Concepts** How can you determine that a coin is not pure silver if you know the mass and volume of the coin?
10. **Identifying Relationships** What physical property do the following substances have in common: water, oil, mercury, and alcohol?
11. **Analyzing Processes** Explain how you would find the density of an unknown liquid if you have all of the laboratory equipment that you need.

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SciLinks code: HSM0391; HSM1142