Section 2
Physical Properties

Key Concept Physical properties of matter can be observed or measured without changing the matter's identity.

What You Will Learn
- Examples of physical properties are melting temperature, density, hardness, thermal conductivity, and electrical conductivity.
- Density is the amount of matter in a given space or volume.
- A physical change does not change the identity of the matter that undergoes the change.
- Melting, freezing, cutting, bending, and dissolving are physical changes.

Why It Matters
Understanding the physical properties of matter can help you understand the physical changes that you observe in the matter around you.

Have you ever played the game called *20 Questions?* The goal of this game is to figure out what object a person is thinking of by asking him or her no more than 20 yes-or-no questions.

What should you ask about? You may want to ask about the physical properties of the object. Knowing about the physical properties of an object can help you identify the object.

Identifying Physical Properties
The questions in **Figure 1** ask about four characteristics of an object: color, odor, mass, and volume. These characteristics are physical properties of matter. A **physical property** of matter is a characteristic that can be observed or measured without changing the matter's identity. For example, you can see an apple's color or measure an apple's volume without changing the apple's identity. **Figure 2** shows six physical properties.

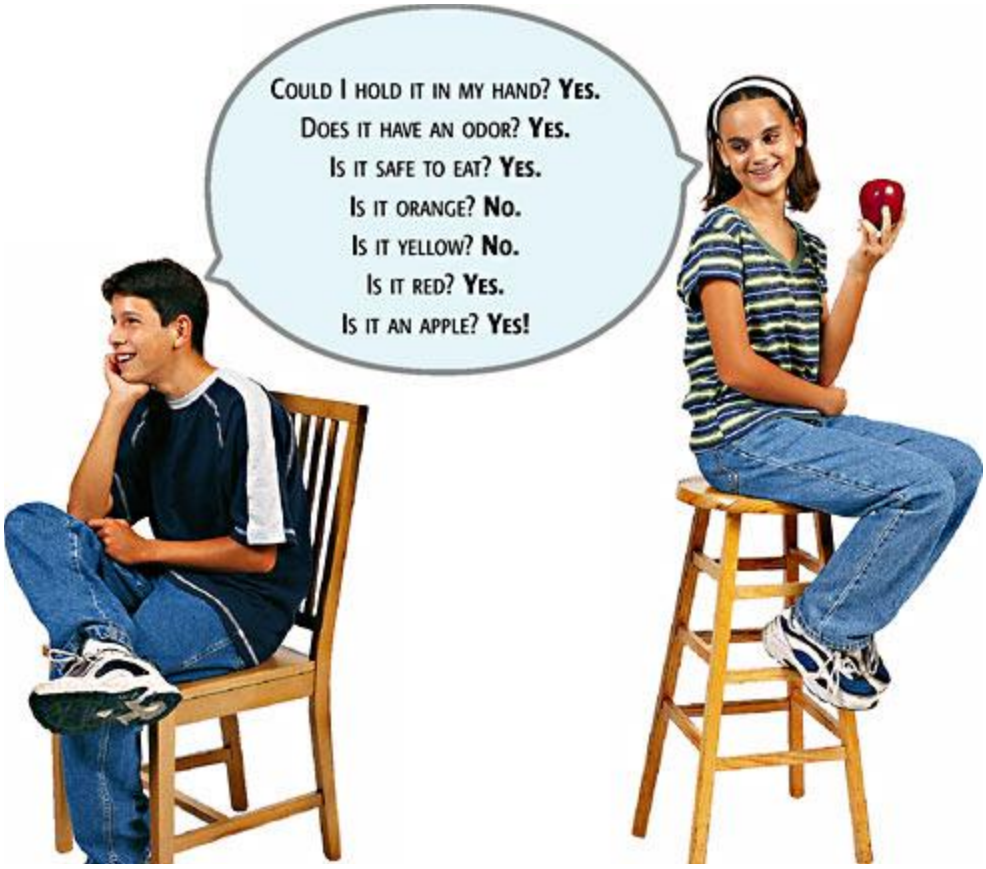

Figure 1 Asking questions about the physical properties of an object can help you identify it.

Other physical properties—such as magnetism, electrical conductivity, strength, and flexibility—can help you identify ways to use a substance. Think of a scooter that has an electric motor. The magnetism produced by the motor is used to convert energy stored in the scooter's battery into energy that turns the scooter's wheels.

Standards Check List four physical properties.

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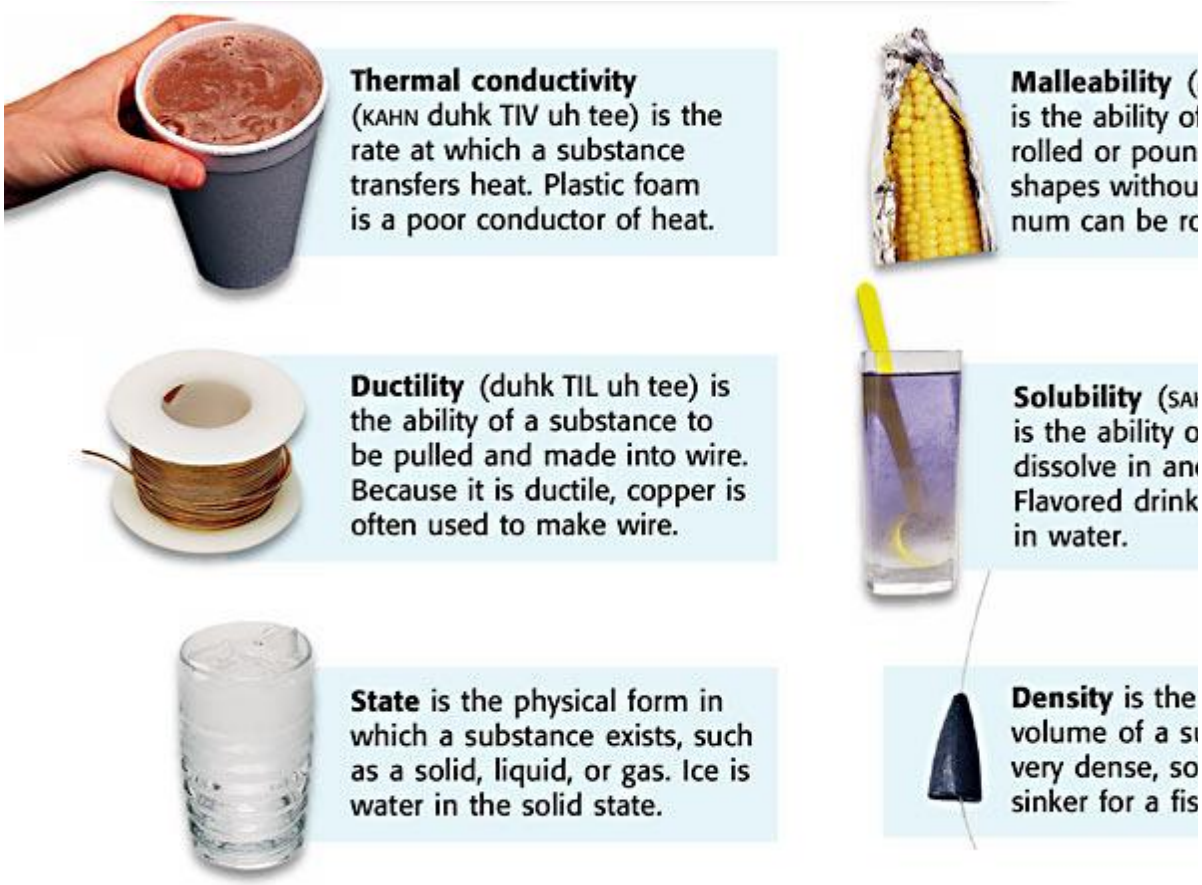
Figure 2 Examples of Physical Properties



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 have similar volumes, as **Figure 3** shows. But a golf ball has more mass than a table-tennis ball does. So, the golf ball has a greater density than the table-tennis ball does.

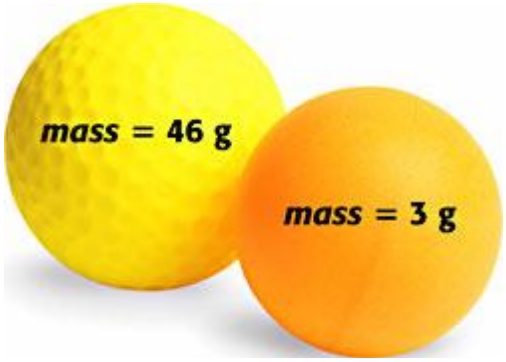


Figure 3 A golf ball is denser than a table-tennis ball because the golf ball contains more matter in a similar volume.

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. The density units most often used are grams per cubic centimeter (g/cm^3) for solids and grams per milliliter (g/mL) for liquids. The density of a given substance remains the same no matter how much of the substance you have. That is, the density of 1 cm^3 of a substance is equal to the density of 1 km^3 of that substance.

Standards Check What is density, and how do you calculate it?

Using Density to Identify Substances

Density is a useful physical property for identifying substances. At a given temperature and pressure, a substance maintains a constant density. **Table 1** shows the densities of several substances.

Table 1 Densities of Common Substances*

Substance	Density* (g/cm^3)	Substance	Density* (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	5.02	Mercury	13.55

(solid)		(liquid)	

*at 20ºC and 1.0 atm

Density of Solids

Which would you rather carry around all day: 1 kg of lead or 1 kg of feathers? They have the same mass, so their masses do not make one easier to carry than the other. But lead is denser than feathers. A kilogram of lead has a volume smaller than a stick of butter. A kilogram of feathers has the volume of a bed pillow. This difference in volume makes the lead less awkward to carry than the feathers.

Density, Floating, and Sinking

Knowing the density of a substance can 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. Cork, most woods, and some plastics are less dense than water. So, they float in water. On the other hand, an object whose density is greater than the density of water will sink in water. Most rocks and metals are denser than water. So, they sink.

Standards Check How can you use density to predict whether an object will float or sink?

Liquid Layers

What do you think causes the liquids in **Figure 4** to look the way they do in the graduated cylinder? Does trick photography make them look that way? No, differences in density do! Six liquids are in the graduated cylinder. Each liquid has a different density. If the liquids are carefully poured into the cylinder, they form six layers because of the differences in density. The densest layer is on the bottom. The least dense layer is on the top. The order of the layers helps you see how the liquids' densities compare with one another.

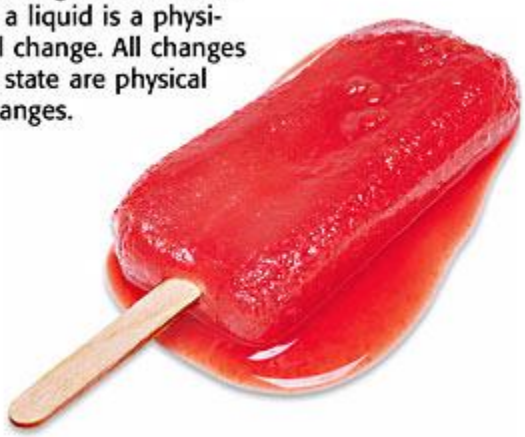
Figure 4 This graduated cylinder contains six liquids that form six layers because of the densities of the liquids. The layers are in order of increasing density from the top to the bottom.

Physical Changes: No New Substances

A change that affects one or more physical properties of a substance is a **physical change.** Imagine that a piece of silver is pounded and made into a heart-shaped charm. This change is a physical one because only the shape of the silver has changed. The piece of silver is still silver. The identity of the substance is the same. **Figure 5** shows more examples of physical changes.

Figure 5 Examples of Physical Changes

A change 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 identity of the can has not changed.

Standards Check How are a substance and its physical properties affected during a physical change?

Examples of Physical Changes

Water freezing to become ice cubes and a piece of wood changing shape as a result of being sanded are examples of physical changes. Such changes do not change the identities of the substances. Ice is still water. And sawdust is still wood. Also, an interesting physical change takes place when one substance dissolves in another substance. For example, when sugar dissolves in water, the sugar seems to disappear. But if the mixture is heated, the water evaporates, and the sugar is still there in the pan. So, sugar dissolving is a physical change.

Reversibility of Physical Changes

Because physical changes do not change the identity of a substance, they are sometimes easy to undo. If you make a bowl from a lump of clay, you change the clay's shape and thus cause a physical change. But because the identity of the clay does not change, you can crush your bowl and form the clay into its original shape.

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Matter and Physical Changes

Physical changes do not change the identity of the matter. A stick of butter can be melted and poured over a bowl of popcorn, as shown in **Figure 6.** Although the shape of the butter has changed, the butter is still butter, so a physical change has happened. In the same way, if you cut the shape of a star out of a piece of paper, you change the paper's shape and cause a physical change. But the identity of the paper does not change. The star and the piece of paper have the same identity—both are paper.

Figure 6 When it melts, butter for pop corn under goes a physical change.

Section Summary

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

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