

4 Measuring

KEY TERMS

- unit:** amount used to measure something
- meter:** basic unit of length or distance
- mass:** amount of matter in something
- gram:** basic unit of mass
- volume:** amount of space an object takes up
- liter:** basic unit of liquid volume
- meniscus:** curve at the surface of a liquid in a thin tube
- temperature:** measure of the amount of heat energy something contains

Two Systems of Measurements

When you measure, you compare an unknown value with a known value using standard units. A **unit** is an amount used to measure something. The metric system is an international system of measurement. Examples of metric units are the gram, the kilometer, and the liter. In the United States, the English system and metric system are both used. Examples of units in the English system are the pound, the foot, and the gallon.

There is also a more modern form of the metric system called SI. The letters SI stand for the French words *Systeme International*. Many of the units in SI are the same as those in the metric system.

The metric and SI systems are both based on units of 10. This makes them easy to use. Each unit in this system is ten times greater than the one before it. To show change in the size of a unit, you add a prefix to the unit. The prefix tells you whether the unit is larger or smaller. For example, a centimeter is ten times larger than a millimeter.

PREFIXES AND THEIR MEANINGS	
kilo-	one thousand (1,000)
hecto-	one hundred (100)
deca-	ten (10)
deci-	one-tenth (1/10)
centi-	one-hundredth (1/100)
milli-	one-thousandth (1/1,000)

FIGURE 5

Units of Length

Length is the distance from one point to another. In the metric system, the basic unit of length or distance is the meter. A meter is about the length of a doorknob to the floor. Longer distances, such as the distance between cities, are measured in kilometers. A kilometer is 1,000 meters. Centimeters and millimeters measure shorter distances. A centimeter is 1/100 of a meter. A millimeter is 1/1,000 of a meter. Figure 6 compares common units of length. It also shows the abbreviation for each unit.

SI/METRIC UNITS OF LENGTH	
1,000 millimeters (mm)	1 meter (m)
100 centimeters (cm)	1 meter
10 decimeters (dm)	1 meter
10 millimeters	1 centimeter
1,000 meters	1 kilometer (km)

FIGURE 6

Length can be measured with a meter stick. A meter stick is 1 m long and is divided into 100 equal lengths by numbered lines. The distance between each of these lines is equal to 1 cm. Each centimeter is divided into ten equal parts. Each one of these parts is equal to 1 mm.

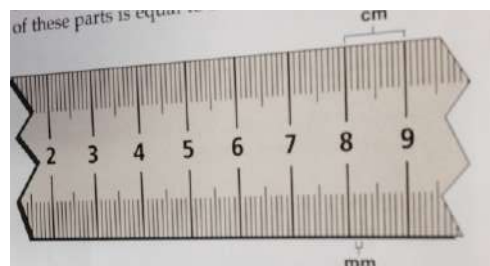
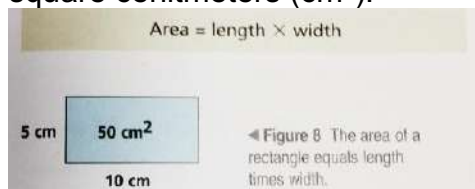


FIGURE 7 A meter stick is divided into centimeters and millimeters.

Measuring Area

Do you know how people find the area of the floor of a room? They measure the length and the width of the room. Then, they multiply the two numbers. You can find the area of any rectangle by multiplying its length by its width. Area is expressed in squared units such as square meters (m²) or square centimeters (cm²).

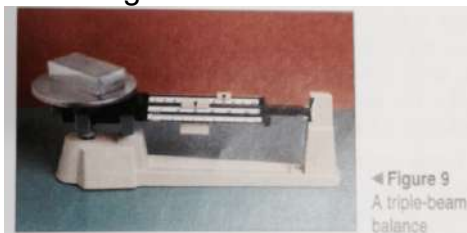


Mass and Weight

The amount of matter in something is its mass. The basic metric unit of mass is called gram (g). A paper clip has about 1 g of mass. Mass is measured with an instrument called a balance. A balance works like a seesaw. It compares an unknown mass with a known mass.

One kind of balance that is commonly used to measure mass is a triple-beam balance. A triple-beam balance has a pan. The balance has three beams. Weights, called riders, are moved along each beam until the object on the pan is balanced. Each rider gives a reading in grams. The mass of the object is equal to the total reading of all three riders.

Mass and weight are related; however, they are not the same. The weight of an object is a measure of the Earth's pull of gravity between Earth and that object. Gravity is the force that pulls objects toward the center of Earth. The strength of the pull of gravity between two objects depends on the distance between the objects and how much mass the each contain. So, the weight changes as its distance from the center of the Earth changes.



◀ Figure 9
A triple-beam
balance

Volume

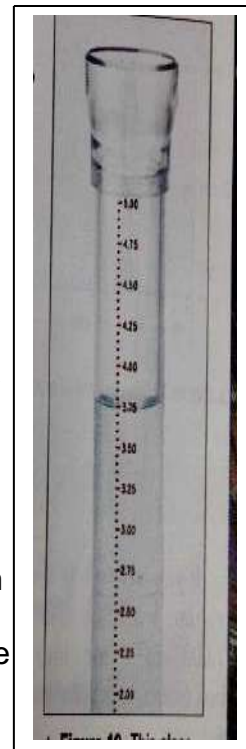
The amount of space an object takes up is its **volume**. You can measure the volume of liquids and solids. Liquid volume is usually measured in **liters**. Soft drinks in the United States often come in 2-liter bottles.

A graduated cylinder is used to measure liquid volume. Graduated cylinders are calibrated, or marked off, at regular intervals. Look at Figure 10. It shows a graduated cylinder. On this graduated cylinder, each small line is equal to 0.05 mL. The longer lines mark off every 0.25 mL up to 5.00 mL. However, every graduated cylinder is not calibrated in this manner. They come in different sizes up to 2,000 mL, with different

calibrations.

Always read the measurement at eye level. If you are using a glass graduated cylinder, you will need to read the mark on the graduated cylinder closest to the bottom of the meniscus. A meniscus is the curve at the surface of a liquid in a thin tube. A plastic cylinder does not show a meniscus.

The volume of solid of objects is often measured in cubic centimeters. One cubic centimeter is the same as a milliliter (mL)



Look at Figure 11. Each side of the cube is 1 cm long. The volume of the cube is 1 cubic centimeter (cm^3). Now look at the drawing of the box in Figure 12. Its length is 3 cm. Its width is 2 cm. Its height is 2 cm. The volume of the box can be found by multiplying length by width by height. In this case, volume equals $3 \times 2 \times 2$. Therefore, the volume of the box in Figure 12 is 12 cm^3

HANDS-ON ACTIVITY

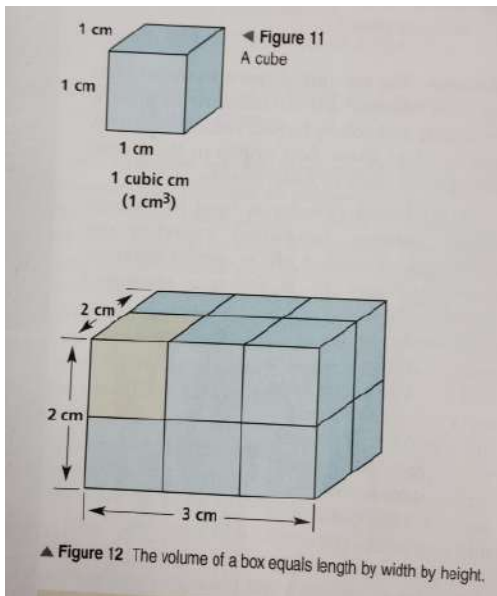
CALCULATING AREA & VOLUME

You will need 3 boxes of different sizes, paper, and a metric ruler.

1. Measure the length, width, and height of each box in centimeters. Record each measurement in your notes.
2. Calculate the volume of each box.
record each volume on your notes.
3. Find the surface area of each box. Read each area in your notes.

Practicing Your Skills

- 4) **ANALYZE** Which of the three boxes has the largest volume?
- 5) **CALCULATE** How many milliliters of liquid will fill each box?
- 6) **ANALYZE** What is the surface area of the largest box?



If you have a box that is 10 cm on each side, its volume would be 1,000 cm³. A liter is the same as 1,000 cm³. One liter of liquid will fill the box exactly.

Temperature

Temperature is a measure of the amount of heat energy something contains. An instrument that measures temperature is called a thermometer.

Most thermometers are glass tubes. At the bottom of the tube is a wider part, called the bulb. The bulb is filled with liquid. Liquids that are often used include mercury, colored alcohol, or colored water. When heat is added, the liquid expands, or gets larger. It rises in the glass tube. When heat is taken away, the liquid contracts, or gets smaller. The liquid falls in the tube. On the side of the tube is a series of marks. You read the temperature by looking at the marks on the tube where the liquid stops.

Temperature can be measured on three different scales. These scales are the Fahrenheit (F) scale, the Celsius (C) scale, and the Kelvin (K) scale. The Fahrenheit scale is part of the English system of measurement. The Celsius scale is usually used in science. Almost all scientists, even in the United States, use the Celsius scale. Each unit on the Celsius scale is in degree Celsius (°C). The degree Celsius is the

metric unit of temperature. Water freezes at 0°C. It boils at 100°C.

Scientists working with very low temperatures use the Kelvin scale. The Kelvin scale is part of the SI measurement system. It begins at absolute zero, or 0K. This number indicates, in theory at least, a total lack of heat.

COMPARING TEMPERATURE SCALES			
	Kelvin	Fahrenheit	Celsius
Boiling point of water	373K	212°F	100°C
Human body temperature	310K	98.6°F	37°C
Freezing point of water	273K	32°F	0°C
Absolute zero	0K	-459.67°F	-273.15°C

▲ Figure 13



FIGURE 14 The Fahrenheit and Celsius scales.