Chapter 1

Introduction to Physical Science

CALIFORNIA Standards Preview

S 8.8 All objects experience a buoyant force when immersed in a fluid. As a basis for understanding this concept:

a. Students know density is mass per unit volume.

b. Students know how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.

S 8.9 Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Plan and conduct a scientific investigation to test a hypothesis.

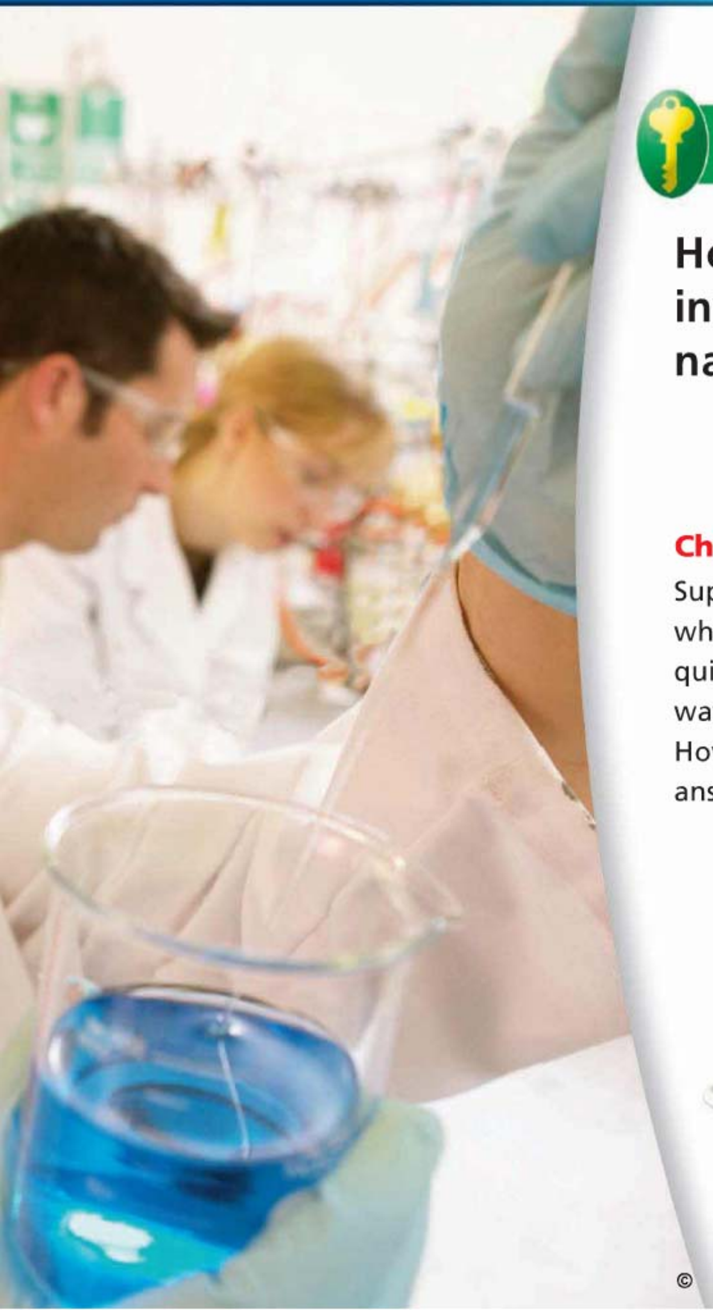
b. Evaluate the accuracy and reproducibility of data.

c. Distinguish between variable and controlled parameters in a test.

d. Recognize the slope of the linear graph as the constant in the relationship $y = kx$ and apply this principle in interpreting graphs constructed from data.

g. Distinguish between linear and nonlinear relationships on a graph of data.

This scientist is busy at work in a laboratory. ▶



Video Preview

Discovery Channel School

The Work of Scientists

Focus on the **BIG Idea** S 8.9

How do scientists investigate the natural world?

Check What You Know

Suppose you want to test whether sugar dissolves more quickly in cold water or hot water. How would you find out? How would you know if your answer is reliable?

Build Science Vocabulary

The images shown here represent some of the Key Terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some Key Terms in this chapter.

Vocabulary Skill

High-Use Academic Words

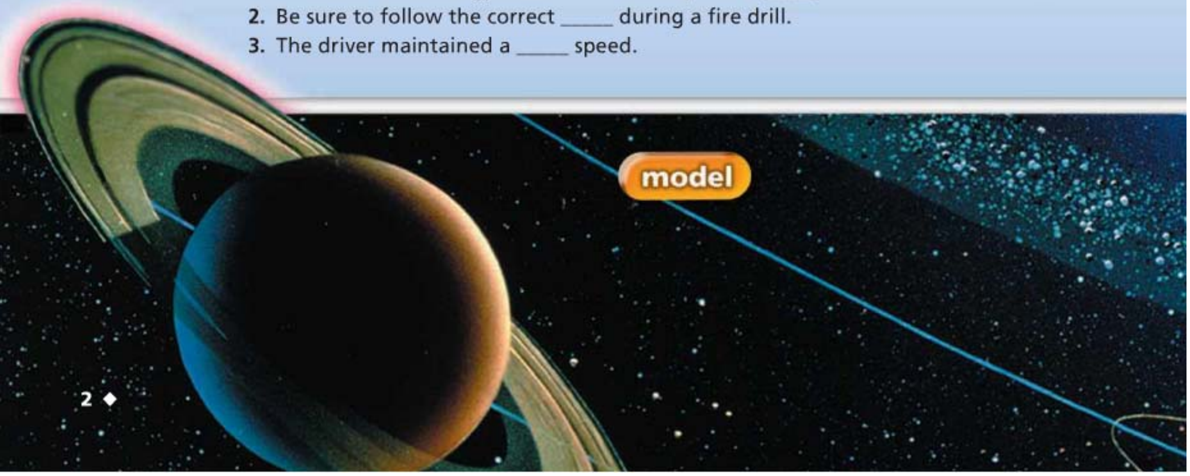
Academic words are terms that are frequently used in classroom reading, writing, and discussions. These words are different from Key Terms because they appear in many science chapters as well as in other subject areas. Look for these words in context as you read this chapter.

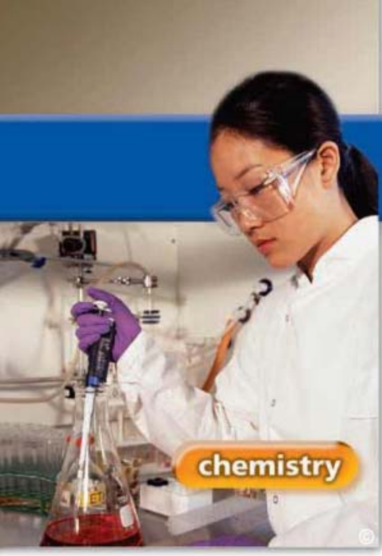
Word	Definition	Example Sentence
constant (**KAHN** stunt) p. 12	*adj.* Staying the same	The temperature was kept constant in the experiment.
procedure (proh **SEE** jur) p. 44	*n.* The method of doing some action, especially the sequence of steps to be followed	Follow the procedure explained in the laboratory manual.
significant (sig **NIF** uh kunt) p. 32	*adj.* Having importance or meaning	A significant number of people voted against the bill.

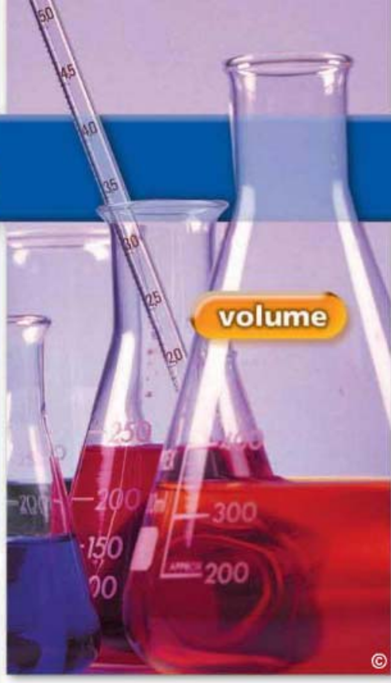
Apply It!

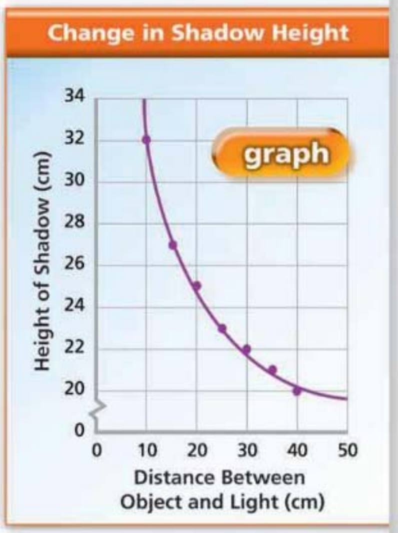
From the table above, choose the word that best completes each sentence.

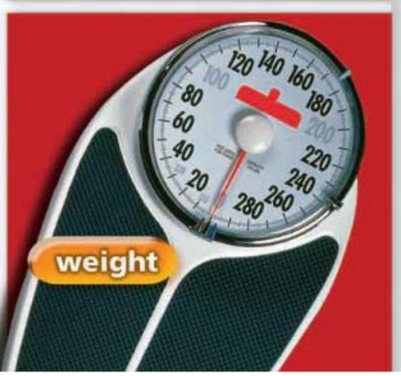
1. The amount of energy needed to move a piano is _____.
2. Be sure to follow the correct _____ during a fire drill.
3. The driver maintained a _____ speed.











Chapter 1 Vocabulary

Section 1 (page 6)
- science
- observing
- inferring
- predicting
- chemistry
- physics

Section 2 (page 10)
- scientific inquiry
- hypothesis
- parameter
- manipulated variable
- responding variable
- controlled experiment
- data
- communicating
- model
- scientific theory
- scientific law

Section 3 (page 16)
- SI
- weight
- mass
- volume
- meniscus
- density
- Celsius scale
- Kelvin scale
- absolute zero

Section 4 (page 30)
- estimate
- accuracy
- reproducibility
- significant figures
- precision

Section 5 (page 34)
- graph
- horizontal axis
- vertical axis
- origin
- coordinate
- data point
- line of best fit
- linear graph
- slope
- nonlinear graph

Interactive Textbook
Build Science Vocabulary *Online*
Visit: PHSchool.com
Web Code: cxj-1010

How to Read Science

Reading Skill

Preview Text Structure

The information in this textbook is organized with red headings and blue subheadings. Before you read, preview each heading and ask a question to guide you as you read the topic. After you read, take notes to answer your questions.

A graphic organizer like the one below can help you take notes.

- Write the heading in column 1.
- Write a question in column 2. Look for words in the heading to guide you in asking a question.
- Answer your question in column 3.

What Is Physical Science?

Heading	Question	Answer
Skills Scientists Use	What skills do scientists use to learn about the natural world?	Scientists use the skills of observing, inferring, and predicting.
The Study of Matter and Energy		

Apply It!

In your notebook, create a graphic organizer for each section in this chapter. Write a question for each heading. After you read, record your answers in column 3.

Lab zone **Standards Investigation**

S 8.8.a

Design and Build a Density-Calculating System

How do you find the density of something if you don't have a balance to measure its mass? Suppose you can't use a graduated cylinder to measure the volume of such items as honey or table sugar. Can you build your own balance and devise a way to find the volume of items that are not easily measured with a ruler?

Your Goal

To design and build a device for collecting data that can be used to calculate the density of powdered solids and liquids

To complete the investigation, you must

- build a device to measure accurately the masses of powdered solids and liquids
- develop a method to measure volume without using standard laboratory equipment
- obtain data you can use to calculate the density of items
- follow the safety guidelines in Appendix A

Plan It!

Preview the chapter to find out how mass, volume, and density are related. Research how balances are constructed and how they work. Build a balance out of the materials supplied by your teacher. Then devise a container with a known volume that you can use to find the volumes of your test materials. When your teacher approves your plan, test your system. Redesign and retest your system to improve its accuracy and reliability.

Section 1

What Is Physical Science?

CALIFORNIA **Standards Focus**

S 8.9 Scientific progress is made by asking meaningful questions and conducting careful investigations.

- What skills do scientists use to learn about the world?
- What do physical scientists study?

Key Terms

- science
- observing
- inferring
- predicting
- chemistry
- physics

Lab zone **Standards Warm-Up**

How Does a Ball Bounce?

1. Your teacher will give you three balls and a meter stick. Hold the meter stick with the zero end touching the floor.
2. Hold one ball beside the top of the meter stick so it doesn't touch. Drop the ball. Have a partner record the height of the first bounce.
3. Repeat Step 2 twice using the same ball.
4. Repeat Steps 2 and 3 for each of the other balls.

Think It Over

Predicting Can you use your data to predict accurately how each ball will bounce in the future? Explain.

As you walk around an amusement park, you may wonder how the rides work. How does a ferris wheel spin? How do the bumper cars work? What makes the neon lights so colorful? Why don't people fall out of the roller coaster as it completes a loop? These are all questions that physical science can help to answer. The designers of amusement parks must know a great deal about physical science to make sure that visitors experience fun and thrills while staying safe.

An amusement park is a great place to observe physical science in action.

Skills Scientists Use

Science is the study of the natural world. Science includes all of the knowledge gained by exploring nature. To think and work like a scientist, you need to use the same skills that they do. **Scientists use the skills of observing, inferring, and predicting to learn more about the natural world.**

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Web Code: cgd-6011

Observing Scientists observe things. **Observing** means using one or more senses to gather information. Your senses include sight, hearing, touch, taste, and smell. Each day of your life, you observe things that help you decide what to eat, what to wear, and whether to stay inside or go out.

Scientists usually make observations in a careful, orderly way. They make both qualitative and quantitative observations. Qualitative observations are descriptions that don't involve numbers or measurements. Noticing that a ball is round, that milk smells sour, or that a car is moving is a qualitative observation. Quantitative observations are measurements. You make a quantitative observation when you measure your height or weight. In science, observations may also be called evidence, or data.

Inferring When you explain your observations, you are **inferring**, or making an inference. Inferences are based on reasoning from what you already know. You make inferences all the time without thinking about it. For example, your teacher gives lots of surprise quizzes. So if your teacher walks into the room carrying a stack of paper, you may infer that the pages contain a quiz. But inferences are not always correct. The papers could be announcements to be taken home.

Predicting Every day, people make statements about the future. **Predicting** means making a forecast of what will happen in the future based on past experience or evidence. For example, some scientists predict the weather based on past experience and current information. Because a weather forecast is based on data, it is a prediction rather than a guess.

Reading Checkpoint What are inferences based on?

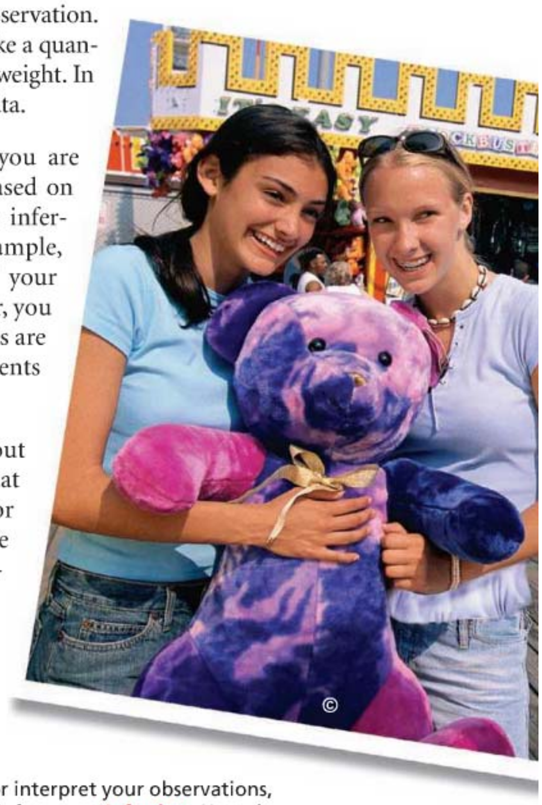
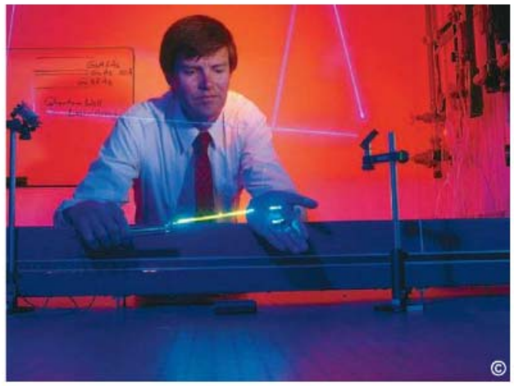


FIGURE 1 Inferring
When you explain or interpret your observations, you are making an inference. **Inferring** *How do you think these young women obtained the stuffed bear? Explain your reasoning.*

▲ A chemist is removing a liquid from a flask.



▲ This physicist is experimenting with lasers.

FIGURE 2
Careers in Physical Science
People who work in physical science study changes in matter and energy. Chemists, physicists, and engineers are examples of people who work in physical science.

The Study of Matter and Energy

Physical science is the study of matter, energy, and the changes they undergo. Matter is all around you. It is anything that has mass and occupies space. Energy is the ability to do work or cause change.

Branches of Physical Science Physical science is divided into two main branches: chemistry and physics. **Chemistry** is the study of the properties of matter and how matter changes. When you study chemistry, you will learn about the particles that make up matter and why different forms of matter have different properties. You will find out how matter can change and why. For example, you'll learn why some materials burn while others do not.

Physics is the study of matter, energy, motion, and forces, and how they interact. When you study physics, you will learn about the different forms of energy and the physical laws that govern energy. You will also find out how the laws of physics apply to Earth, the solar system, and the universe beyond.

All of the people shown in Figure 2 work in some area of physical science. Some careers involve scientific research. Other careers, such as photography, piano tuning, or firefighting, require that you understand physical science. You may be thinking that physical science is important only if you work in careers like these. But you use physical science all the time. For example, when you blow on a spoonful of soup to cool it down, you are using physical science. In this book, you will learn about many more everyday events involving physical science.

▲ Two engineers are installing communications equipment on a mountaintop.

Big Ideas of Physical Science Physical scientists apply certain big ideas in their work. As you read this book, you will begin to grasp four concepts that help to unify physical sciences:

- force and energy;
- the laws of conservation;
- atoms, molecules, and the atomic theory;
- the behavior of particles of matter in solids, liquids, and gases.

These big ideas serve as important organizers that will be required as you continue to learn science. Keep reading to find out how these concepts apply to you and the world around you!

Reading Checkpoint What is physics?

Section 1 Assessment

S 8.9, E-LA: Reading 8.2.0

Target Reading Skill **Preview Text Structure** Complete the graphic organizer for this section. How did you answer your question about The Study of Matter and Energy?

Reviewing Key Concepts

HINT **1. a. Listing** Name three skills that scientists use to learn more about the natural world.

HINT **b. Comparing and Contrasting** How do observing and inferring differ?

HINT **c. Classifying** Is this statement an observation or an inference? *It must be raining outside.* Explain.

HINT **2. a. Defining** What is physical science?

HINT **b. Identifying** What are the two main areas of physical science?

HINT **c. Inferring** How would a knowledge of physical science be useful to a musician? To a photographer?

Lab zone At-Home Activity

Quantitative or Qualitative? Look around your room at home. Write down three qualitative and three quantitative observations. How do these two types of observations differ from one another?

Section 2

Scientific Inquiry

CALIFORNIA Standards Focus

S 8.9.a Plan and conduct a scientific investigation to test a hypothesis.

S 8.9.c Distinguish between variable and controlled parameters in a test.

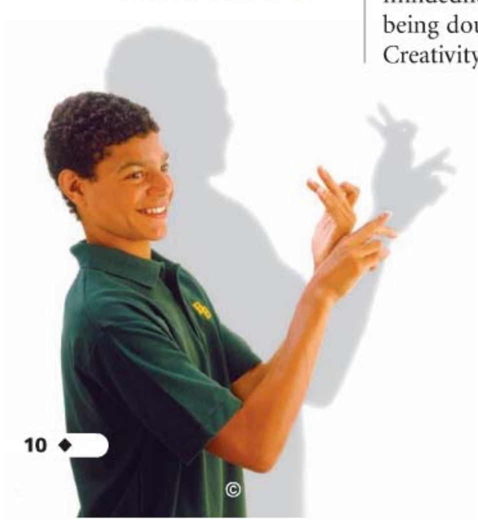
How do scientists investigate the natural world?

What role do models, theories, and laws play in science?

Key Terms

- scientific inquiry
- hypothesis
- parameter
- manipulated variable
- responding variable
- controlled experiment
- data
- communicating
- model
- scientific theory
- scientific law

A shadow puppet ▼



Lab zone Standards Warm-Up

Can You Make a Shadow Disappear?

1. Using a piece of clay as a base, set up a straw so that it stands up straight.
2. Shine a flashlight on the straw from as many directions as you can. Observe the different shadows you create. Record your observations.
3. Determine whether you can make the shadow disappear while using the light. If you can, describe how you did it.

Think It Over

Posing Questions If you had a meter stick among your materials, what are two other questions you could investigate?

Have you ever made shadow puppets on a wall? Shadows are produced when something blocks light from shining on a surface. Making shadow puppets might make you wonder about light and shadows. Your curiosity can be the first step in scientific inquiry. **Scientific inquiry** refers to the different ways scientists study the natural world. It is the ongoing process of discovery in science.

Just like you, scientists often find that being curious is the first step in scientific inquiry. Scientists have other habits of mind as well: honesty, open-mindedness, skepticism, and creativity. Honesty means reporting observations truthfully. Open-mindedness is accepting new and different ideas. Skepticism is being doubtful about information presented without evidence. Creativity involves coming up with new ways to solve problems.

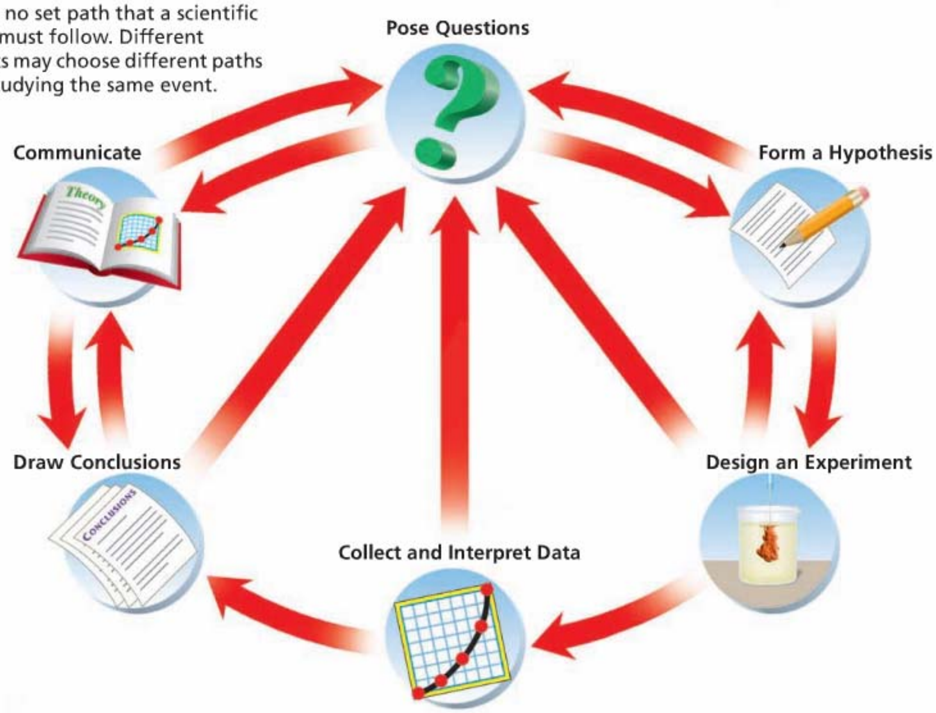
The Process of Inquiry

Scientific inquiry does not always occur in the same way. But, certain processes are often involved. **The processes that scientists use in inquiry include posing questions, developing hypotheses, designing experiments, collecting and interpreting data, drawing conclusions, and communicating ideas and results.** Figure 3 shows some of the ways that these processes can happen.

FIGURE 3

The Nature of Inquiry

There is no set path that a scientific inquiry must follow. Different scientists may choose different paths when studying the same event.



Posing Questions

Suppose you want to learn more about light and shadows. You might ask, Does the size of a shadow depend on the distance between the light and the object? How is a shadow affected by the light's position? Will you get shadows if you have several light sources?

All those questions about light and shadows are scientific questions because you can answer them by making observations. For example, by observing the shadow of a tree over several hours during the day, you can see how the shadow changes with the sun's position.

Not all questions are scientific, however. For example, suppose you ask, "Which is the most interesting photo in a photography contest?" The answer to that question is based on personal opinion, not on evidence. Scientific inquiry cannot answer questions based on opinions, values, or judgments.

Reading Checkpoint **What scientific questions can you ask about light and shadows?**

Go Online
active art
For: The Nature of Inquiry activity
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Developing Hypotheses Scientific inquiry moves forward when ideas can be tested. For example, suppose you want to find out how the distance between the object and the light affects the size of a shadow. Your first step might be to develop a hypothesis (plural: *hypotheses*). A **hypothesis** is a possible answer to a scientific question or explanation for a set of observations. For example, you may say: *Changing the distance between an object and a light source changes the size of the object's shadow.*

It is important to realize that your hypothesis is not a fact. Hypotheses lead to predictions that can be tested. A prediction must be testable by observation or experiment. In that way, information can be collected that may or may not support the hypothesis. Many trials are needed before a hypothesis can be accepted as true.

Designing an Experiment You can test a prediction by designing an experiment. The first step in designing an experiment is to examine all the parameters. A **parameter** is a factor that can be measured in an experiment.

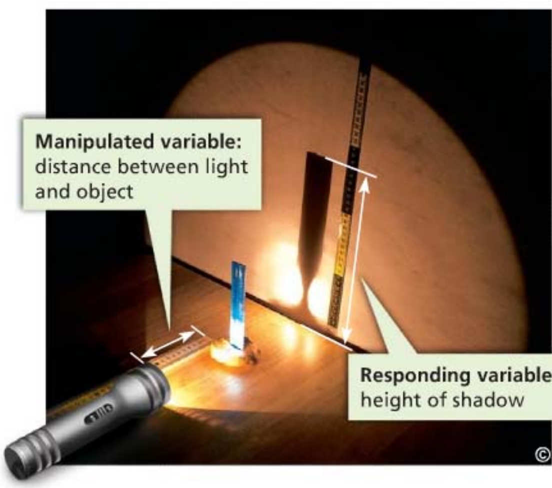
Certain parameters, called variable parameters, are the ones that change during the experiment. In a well-designed experiment, only one variable parameter is purposely changed: the **manipulated variable.** The variable parameter that is expected to change because of the manipulated variable is the **responding variable.**

Look at Figure 4. For your experiment about shadows, the manipulated variable is the distance between the light source and the object. The responding variable is the height of the shadow.

To be sure that changes in the manipulated variable are causing the changes in the responding variable, scientists keep all the other parameters controlled—that is, kept constant. Figure 4 shows some parameters that need to be controlled in your shadow experiment: the type of light, the height and angle of the light, and the distance between the object and the wall. An investigation in which only one parameter is manipulated at a time is called a **controlled experiment.**

Reading Checkpoint **What is a hypothesis?**

FIGURE 4
Investigating Shadows
The photo shows an experiment designed to test two variable parameters: the distance between an object and a light source, and the size of the object's shadow.
Interpreting Diagrams *What is the manipulated variable in the experiment?*



Shadow Experiment	
Distance Between Object and Light (cm)	Height of Shadow (cm)
10	32
15	27
20	25
25	23
30	22
35	21
40	20

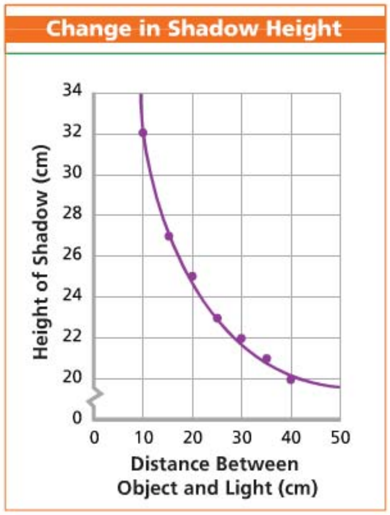
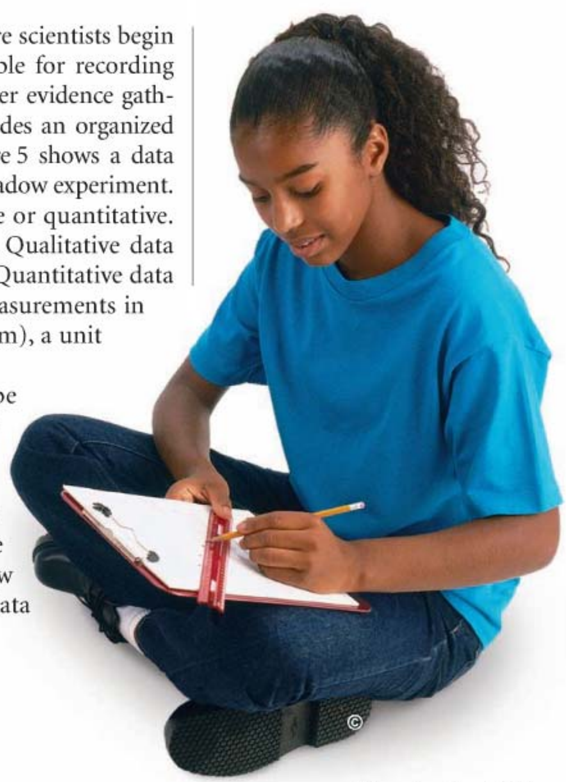


FIGURE 5
Showing Experimental Results
The results of the shadow experiment are shown here as a data table and as a graph.
Interpreting Graphs *What relationship do the data show?*

Collecting and Interpreting Data Before scientists begin an experiment, they usually create a data table for recording their data. **Data** are the facts, figures, and other evidence gathered through observations. A data table provides an organized way to collect and record observations. Figure 5 shows a data table that you might have made during your shadow experiment.

Recall that observations can be qualitative or quantitative. Data can also be qualitative or quantitative. Qualitative data can be recorded as notes in a journal or log. Quantitative data consist of measurements. Notice that the measurements in the data table are expressed in centimeters (cm), a unit of length.

After the data are collected, they need to be interpreted, or explained. Graphs are a useful way to analyze quantitative data because they can reveal trends or patterns in the data. Look at the graph in Figure 5. It shows that as the distance between the object and the light increased, the height of the shadow decreased. You can learn more about using data tables and graphs in the Skills Handbook.



Reading Checkpoint How do scientists collect data?

Video Field Trip
Discovery Channel School
The Work of Scientists

Drawing Conclusions After scientists interpret their data, they draw a conclusion about their hypothesis. A conclusion states whether or not the data support the hypothesis. For the data in the shadow experiment, you would conclude that the height of a shadow decreases as the light is moved farther away from an object.

Communicating An important part of scientific inquiry is communicating. **Communicating** is sharing ideas and conclusions with others through writing and speaking. It is also sharing the process you used in your inquiry. When a scientist shares the design of an experiment, others can repeat that experiment to check the results. Scientists often communicate by giving talks at scientific meetings, exchanging information on the Internet, or publishing articles in scientific journals.

Communicating information about scientific discoveries often leads to new questions, new hypotheses, and new investigations. Scientific inquiry is a process with many paths. Work may go forward or even backward when testing out new ideas.

How Science Develops

Over the years, as scientists studied the natural world, they did more than collect facts. They developed more complete explanations for their observations. **Scientists use models and develop theories and laws to increase people's understanding of the natural world.**

Scientific Models Sometimes, it may be impossible to observe certain objects and natural processes. So a scientist will make a model. A **model** is a picture, diagram, computer image, or other representation of an object or process. Physical models, such as a representation of the solar system, may look like the real thing. Other models can be generated by computers, such as the flight plan of a space vehicle. Still others can be mathematical equations or words that describe how something works. Certain models, such as models of atoms (the particles that make up matter), have been especially important in building up our understanding of the natural world.

Reading Checkpoint **What is a model?**

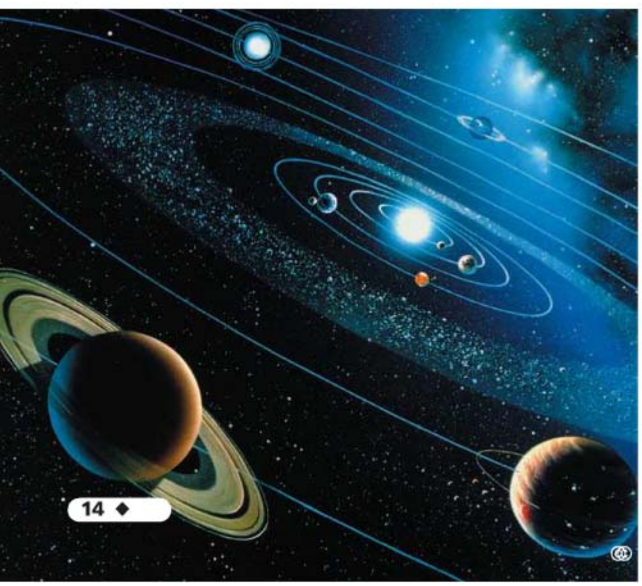


FIGURE 6
A Scientific Model
This illustration is a model of the solar system. The solid blue lines represent the paths followed by the planets as they revolve around the sun.

Scientific Theories In some cases, many observations can be connected by one explanation. This can lead to the development of a scientific theory. A **scientific theory** is a well-tested explanation for a wide range of observations or experimental results. For example, according to the atomic theory, all substances are composed of tiny particles called atoms. The atomic theory helps explain many observations, such as why water freezes or boils at certain temperatures, and why it can dissolve many other materials.

Scientists accept a theory only when there is a large body of evidence that supports it. However, future evidence may not support the theory. If that happens, scientists may modify the theory or discard it altogether.

Scientific Laws Have you ever heard someone say, "What goes up must come down"? When scientists repeatedly observe the same result in specific circumstances, they may develop a scientific law. A **scientific law** is a statement that describes what scientists expect to happen every time under a particular set of conditions.

A scientific law describes an observed pattern in nature without attempting to explain it. You can think of a scientific law as a rule of nature. For example, the law of gravity states that all objects in the universe attract each other. This law has been verified over and over again.

FIGURE 7
A Scientific Law
According to the law of gravity, this parachutist will eventually land back on Earth.

Section 2 Assessment

S 8.9.a, 8.9.c,
E-LA: Reading 8.1.0

Vocabulary Skill **High-Use Academic Words** In an experiment, why would you keep certain parameters *constant*?

Reviewing Key Concepts

HINT
1. a. **Defining** What is scientific inquiry?
HINT
b. **Listing** Name six processes that are often involved in scientific inquiry.
HINT
c. **Inferring** How can an experiment that disproves a hypothesis be useful?
HINT
2. a. **Defining** What is a scientific theory? A scientific law?
HINT
b. **Comparing and Contrasting** How do scientific theories differ from scientific laws?
HINT
c. **Classifying** The students who conducted the shadow length experiment concluded that their results supported their hypothesis. Can their supported hypothesis be called a scientific theory? Why or why not?

Lab zone At-Home Activity

Which Falls Fastest? Design an experiment to determine which falls fastest—an unfolded sheet of paper, a sheet of paper folded in fourths, or a crumpled sheet of paper. Be sure to develop a hypothesis, design a controlled experiment, and collect data. Do your data support your hypothesis? Discuss your results with a family member.

Section 3

Measurement

CALIFORNIA Standards Focus

S 8.8.a Students know density is mass per unit volume.

S 8.8.b Students know how to calculate the density of substances (regular and irregular solids and liquids) from measurements of mass and volume.

- Why do scientists use a standard measurement system?
- What are the SI units of measure for length, mass, volume, density, time, and temperature?

Key Terms

- SI
- weight
- mass
- volume
- meniscus
- density
- Celsius scale
- Kelvin Scale
- absolute zero

Lab zone Standards Warm-Up

Which Has More Mass?

1. Your teacher will provide you with some small objects. Look at the objects, but do not touch them.
2. Predict which object is lightest, which is second lightest, and so on. Record your predictions.
3. Use a triple-beam balance to find the mass of each object.
4. Based on the masses, list the objects from lightest to heaviest.

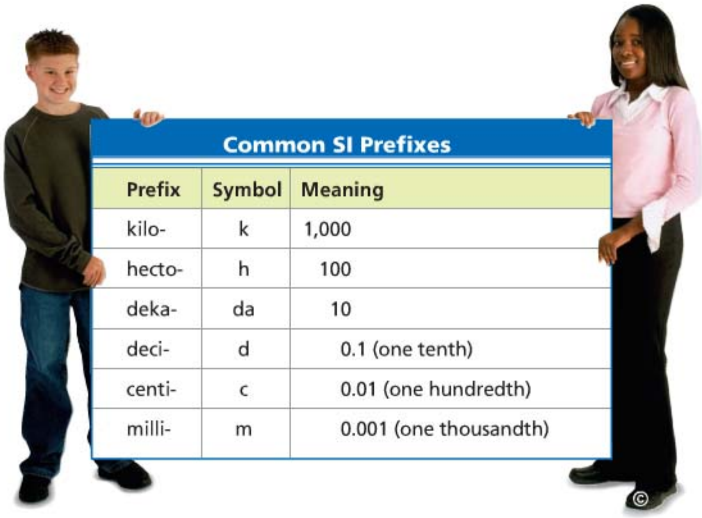
Think It Over

Drawing Conclusions How did your predictions compare with your results? Are bigger objects always heavier than smaller objects? Do objects of the same size always have the same mass? Why or why not?

Did you ever ask a relative for an old family recipe? If so, the answer might have been, "Use just the right amount of flour and water. Add a spoonful of oil and a pinch of salt. Bake it for awhile until it looks just right."

Instructions like these would be difficult to follow. How much flour is "just the right amount"? How big is a spoonful or a pinch? You could end up with disastrous results.

In tasks such as cooking, measurements can be critical to success! ▶



Common SI Prefixes		
Prefix	**Symbol**	**Meaning**
kilo-	k	1,000
hecto-	h	100
deka-	da	10
deci-	d	0.1 (one tenth)
centi-	c	0.01 (one hundredth)
milli-	m	0.001 (one thousandth)

FIGURE 8
SI units, based on multiples of 10, are easy to use. Knowing what the prefixes mean can help you judge how big or small a measurement is.
Calculating *How much larger is a* kilo- *than a* deka-*?*

A Standard Measurement System

The recipe example illustrates the importance of using a standard system of measurement. This is especially true in science. Using the same system of measurement minimizes confusion among scientists all over the world.

More than 200 years ago, most countries used their own measurement systems. Sometimes two or more different systems were used in the same country. In the 1790s, scientists in France developed a universal system of measurement called the metric system. A metric system is a system of measurement based on the number 10.

Modern scientists use an expanded metric system called the International System of Units, abbreviated as **SI** (for the French, *Système International d'Unités)*. Scientists all over the world use SI units to measure length, volume, mass, density, temperature, and time. **Using SI as the standard system of measurement allows scientists to compare data and communicate with each other about their results.** In this book, you will use both SI and other metric units.

Figure 8 lists the prefixes used to name the most common SI units. You may have seen these prefixes before in units such as centimeters or kilograms. Because SI units are based on multiples of 10, you can easily convert from one unit to another. For example, 1 meter equals 100 centimeters. You can learn about converting between SI units in the Skills Handbook.

Reading Checkpoint **SI units are based on multiples of what number?**

Common Conversions for Length
1 km = 1,000 m
1 m = 100 cm
1 m = 1,000 mm
1 cm = 10 mm

Length

How far can you throw a softball? Can you estimate by eye how far the ball travels? A better way to find out would be to measure the distance, or length, that the ball travels. Length is the distance from one point to another. In the case of your softball throw, it would be from the point where you release the ball to the point where it first hits the ground.

Units of Length **The basic unit of length in SI is the meter (m).** One meter is about the distance from the floor to a doorknob. A softball throw would be measured in meters. So would your height. Most students your age are between 1.5 and 2 meters tall.

Science and **History**

Measurement Systems

Like so much else in science, systems of measurement developed gradually over time in different parts of the world.

1400 B.C.
A Simple Balance
The ancient Egyptians developed the first known weighing instrument, a simple balance with a pointer. Earlier, they had been the first to standardize a measure of length. The length, called a cubit, was originally defined as the distance between the elbow and the tip of the middle finger.

640 B.C.
Standard Units of Weight
Merchants in the Middle East and Mediterranean used units of weight to be sure that they received the correct amount of gold and silver in trade and to check the purity of the metal. A *talent* was about 25 kilograms, and a *mina* was about 500 grams. The Lydians minted the first true coins to have standard weight and value.

200 B.C.
Standard Measures
Shih Huang Ti, the first emperor of China, set standards for weight, length, and volume. He also improved travel conditions by setting standards for the widths of roads and for the distance between chariot wheels.

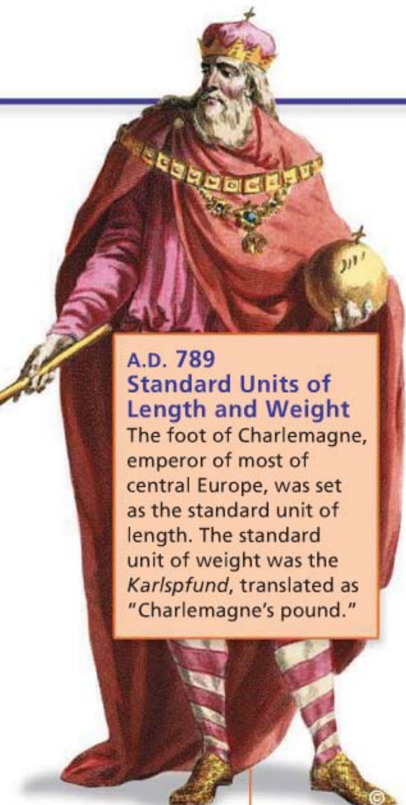
1500 B.C. | 1000 B.C. | 500 B.C. | A.D. 1

To measure objects smaller than a meter, scientists use units called the centimeter (cm) or the millimeter (mm). The prefix *centi-* means "one-hundredth," while the prefix *milli-* means one-thousandth. One meter, then, is equal to 100 centimeters or 1,000 millimeters. The length of a typical sheet of loose-leaf paper is 28 centimeters, which is equal to 280 millimeters.

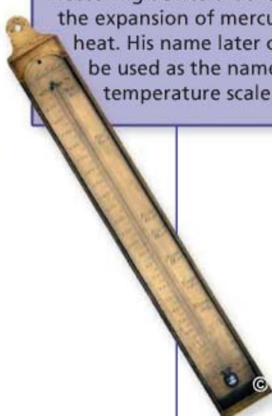
What unit would you use to measure a long distance, such as the distance between two cities? For such measurements, scientists use a unit known as the kilometer (km). The prefix *kilo-* means one thousand. There are 1,000 meters in a kilometer. If you were to draw a straight line between San Francisco and Boston, the line would measure about 4,300 kilometers.

Writing in Science

Research and Write While scientists rely on SI units, people use different measurement units for other purposes. Research the units used in sailing, horse breeding, diamond cutting, farming, or another activity that interests you. Write a few paragraphs about your findings.



A.D. 789
Standard Units of Length and Weight
The foot of Charlemagne, emperor of most of central Europe, was set as the standard unit of length. The standard unit of weight was the *Karlspfund*, translated as "Charlemagne's pound."



A.D. 1714
Thermometer
Gabriel Fahrenheit invented the thermometer, a temperature-measuring device that relies on the expansion of mercury with heat. His name later came to be used as the name for a temperature scale.

A.D. 1983
International Standards
The International Bureau of Weights and Measures in France defined a single set of standard units. Scientists throughout the world use these units in their work. The official kilogram measure, shown above, is kept in a vacuum chamber.

A.D. 500 | A.D. 1000 | A.D. 1500 | A.D. 2000

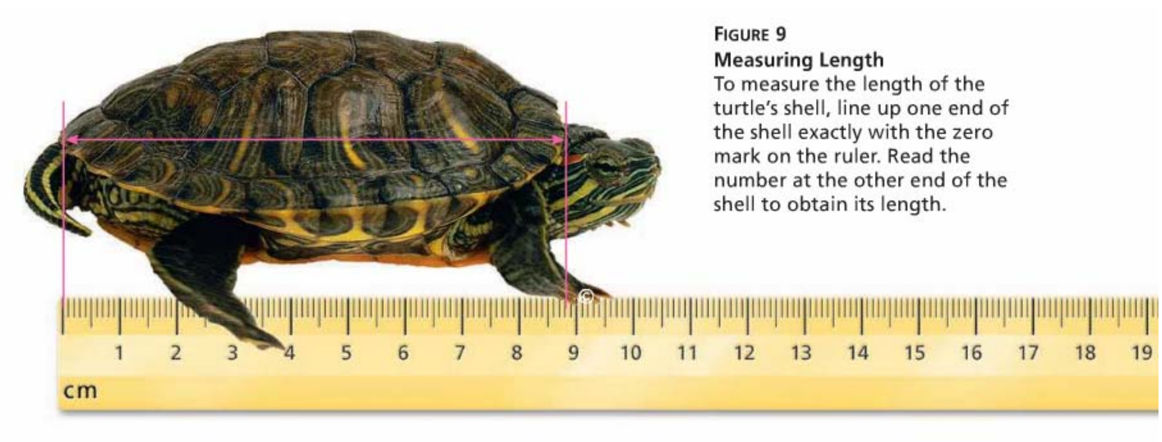


FIGURE 9
Measuring Length
To measure the length of the turtle's shell, line up one end of the shell exactly with the zero mark on the ruler. Read the number at the other end of the shell to obtain its length.

Measuring Length A very common tool used to measure length is the metric ruler. As you can see in Figure 9, a metric ruler is divided into centimeters. The centimeter markings are the longer lines numbered 1, 2, 3, and so on. Each centimeter is then divided into 10 millimeters, which are marked by the shorter lines.

To use a metric ruler, line one end of the object up exactly with the zero mark. Then read the number at the other end of the object. The shell of the turtle in Figure 9 is 8.8 centimeters, or 88 millimeters, long.

Reading Checkpoint **One centimeter is divided into how many millimeters?**

Weight and Mass

Suppose you want to measure your weight. To find the weight, you step on a scale like the one shown in Figure 10. Your body weight presses down on the springs inside the scale. The more you weigh, the more the springs compress, causing the pointer on the scale to turn farther, giving a higher reading. However, your scale would not indicate the same weight if you took it to the moon and stepped on it. You weigh less on the moon, so the springs of the scale would not be compressed as much by your weight. How can your weight change if the amount of matter in your body stays the same?

FIGURE 10
Measuring Weight
You can stand on a scale to measure your body weight.

Weight Your **weight** is a measure of the force of gravity on you. Weight is measured in units such as newtons or pounds. The newton (N) is an SI unit. If you weigh 90 pounds, your weight in SI units is about 400 newtons.

On Earth, all objects are attracted toward the center of the planet by the force of Earth's gravity. On another planet, the force of gravity on you may be more or less than it is on Earth. On the moon, you would weigh only about one-sixth of your weight on Earth.

Mass Why do you weigh less on the moon than on Earth? The force of gravity depends partly on the mass of an object. **Mass** is a measure of the amount of matter an object contains. If you travel to the moon, the amount of matter in your body—your mass—does not change. But, the mass of the moon is much less than the mass of Earth, so the moon exerts much less gravitational force on you. Unlike weight, mass does not change with location, even when the force of gravity on an object changes. For this reason scientists prefer to measure matter by its mass rather than its weight.

Units of Mass **The SI unit of mass is the kilogram (kg).** If you weigh 90 pounds on Earth, your mass is about 40 kilograms. Although you will see kilograms used in this textbook, usually you will see a smaller unit—the gram (g). There are exactly 1,000 grams in a kilogram. A nickel has a mass of 5 grams, and a baseball has a mass of about 150 grams.

Common Conversions for Mass		
1 kg	=	1,000 g
1 g	=	1,000 mg

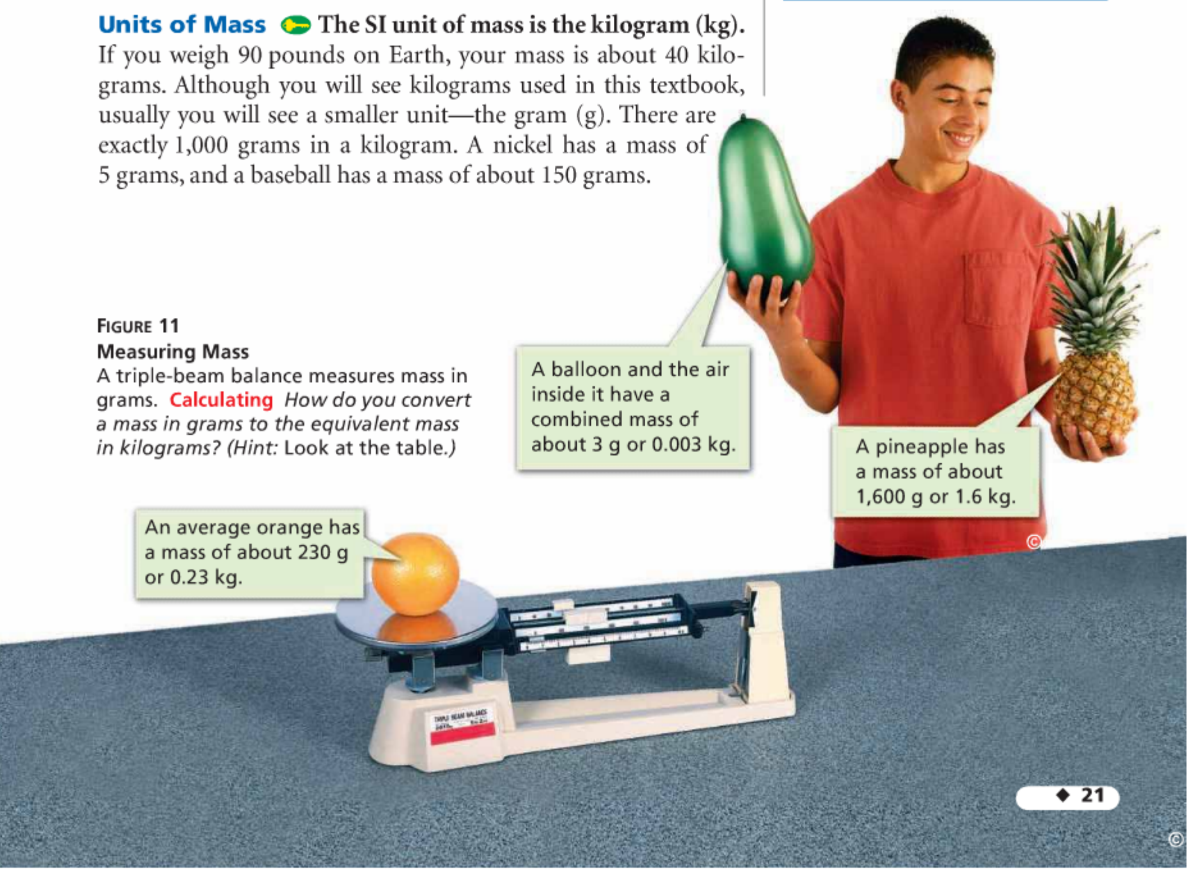


FIGURE 11
Measuring Mass
A triple-beam balance measures mass in grams. **Calculating** *How do you convert a mass in grams to the equivalent mass in kilograms? (Hint:* Look at the table.*)*

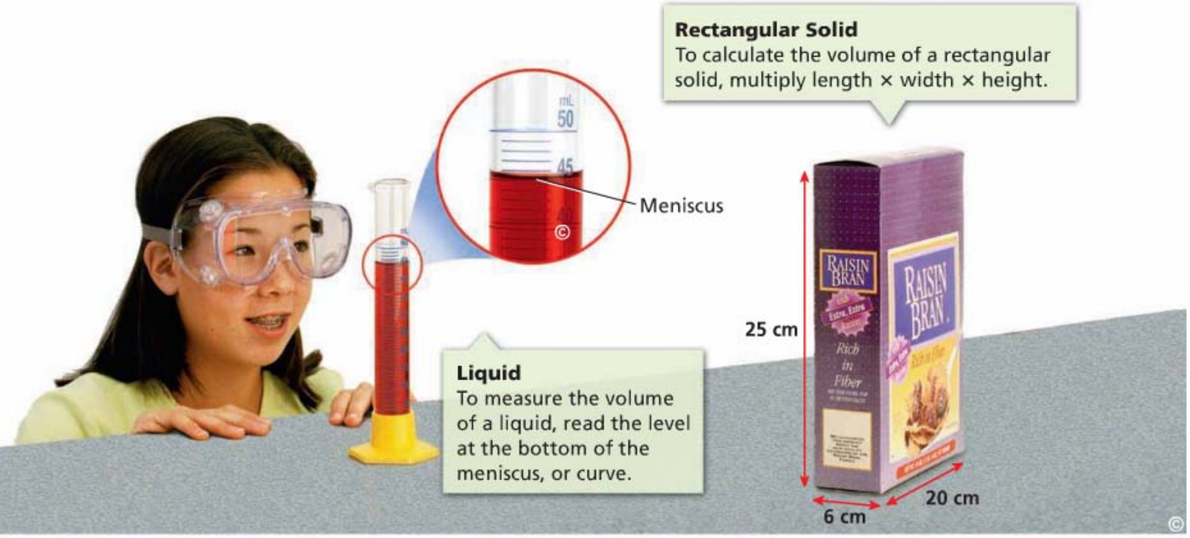


FIGURE 12
Measuring Volume
Volume is the amount of space an object takes up. Measuring the volume of liquids, rectangular solids, and irregular solids requires different methods.
Observing *What is the proper way to read a meniscus?*

Volume

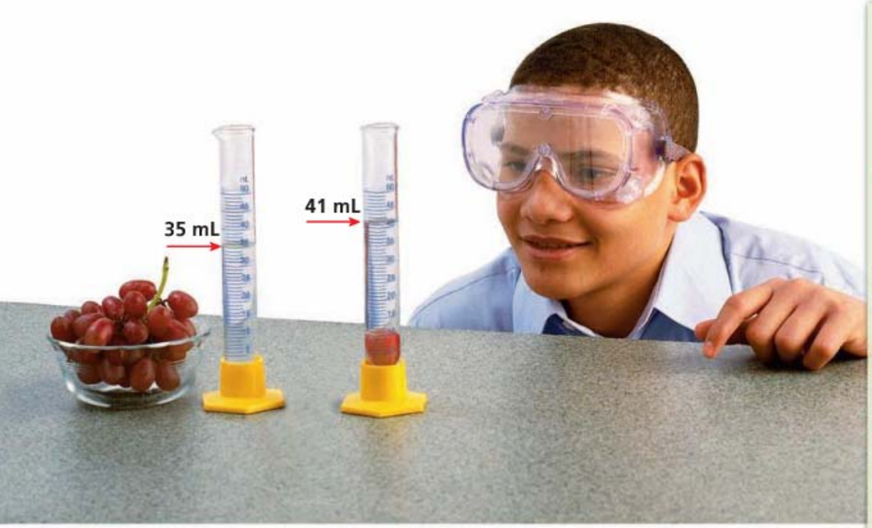
Do you drink milk or orange juice with breakfast? If so, how much do you have? You probably don't measure it out; you just pour it into a glass. You decide when to stop pouring by observing the amount of space it fills in the glass. **Volume** is the amount of space an object takes up.

Units of Volume Common units of volume include the cubic meter (m^3), the liter (L), the milliliter (mL), and the cubic centimeter (cm^3). **The SI unit of volume is the cubic meter (m^3).** However, the volumes you measure in the lab will be much less than 1 cubic meter. So, you will find it easier to express volumes in liters, milliliters, or cubic centimeters.

A liter is equal to the volume of a cube that measures 10 centimeters on each side. You have probably seen 1-liter and 2-liter bottles of beverages at the grocery store. You can measure smaller volumes in milliliters. A milliliter is one one-thousandth of a liter, and is exactly the same volume as 1 cubic centimeter. A teaspoonful of water has a volume of about 5 milliliters. An ordinary can of soda contains 355 milliliters of liquid.

Common Conversions for Volume		
1 L	=	1,000 mL
1 L	=	1,000 cm^3
1 mL	=	1 cm^3

Volume of Liquids You can use a graduated cylinder to measure liquid volumes. The graduated cylinder in Figure 12 is marked off in 1-milliliter segments. Notice that the top surface of the water in the graduated cylinder is curved. This curve is called a **meniscus.** To determine the volume of the water, you should read the milliliter marking at the bottom of the meniscus.



Irregular Solids
To measure the volume of an irregular solid, use the water displacement method.

1. Record the volume of water in the graduated cylinder.
2. Carefully place the irregular solid into the water. Record the volume of the water plus the object.
3. Subtract the volume of the water alone from the volume of the water plus the object.

Volume of Rectangular Solids How can you determine the volume of a cereal box? Volumes of rectangular solids or containers are often given in cubic centimeters. A cubic centimeter is equal to the volume of a cube that measures 1 centimeter on each side. This is about the size of a sugar cube.

You can calculate the volume of a rectangular object by using this formula:

$$\text{Volume} = \underbrace{\text{Length} \times \text{Width}}_{\text{Area}} \times \text{Height}$$

Because the area of a rectangle equals length times width, another way to write this formula is Volume = Area × Height.

Suppose that a cereal box is 20 centimeters long, 6 centimeters wide, and 25 centimeters high. The volume of the box is

$$\text{Volume} = \underbrace{20\text{ cm} \times 6\text{ cm}}_{\text{Area}} \times \underbrace{25\text{ cm}}_{\text{Height}} = 3{,}000\text{ cm}^3$$

Measurements always have units. So, when you multiply the three measurements, you must remember to multiply the units (cm × cm × cm) as well as the numbers (20 × 6 × 25 = 3,000).

Volume of Irregular Solids How can you measure the volume of an irregular object, such as a piece of fruit or a rock? One way is to submerge the object in water in a graduated cylinder. The water level will rise by an amount that is equal to the volume of the object in milliliters. This method is shown in Figure 12.

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FIGURE 13
Comparing Densities
Although the bowling ball and beach ball have the same volume, one contains much more mass than the other.
Inferring *Which item has the greater density?*

Density

As you can see in Figure 13, two objects of the same size can have very different masses. This is because different materials have different densities. **Density** is mass per unit volume. To calculate the density of an object, divide its mass by its volume.

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

Units of Density Because density equals mass divided by volume, the units for density combine the units of those two measurements. **The SI unit of density is the kilogram per cubic meter (kg/m^3).** In this textbook, you will often see density expressed in grams per cubic centimeter (g/cm^3) for solids and grams per milliliter (g/mL) for liquids. In each case, the numerator is a measure of mass, and the denominator is a measure of volume.

Reviewing Math: Number Sense 7.1.2

Math Sample Problem

Calculating Density

Suppose that a metal object has a mass of 57 g and a volume of 21 cm^3. Calculate its density.

1 Read and Understand

What information are you given?

Mass of metal object = 57 g

Volume of metal object = 21 cm^3

2 Plan and Solve

What quantity are you trying to calculate?

The density of the metal object = ■

What formula contains the given quantities and the unknown quantity?

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

Perform the calculation.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{57\text{ g}}{21\text{ cm}^3} = 2.7\text{ g/cm}^3$$

3 Look Back and Check

Does your answer make sense?

The answer tells you that the metal object has a density of 2.7 g/cm^3. The answer makes sense because it is the same as the density of a known metal—aluminum.

Math Practice

1. What is the density of a wood block with a mass of 57 g and a volume of 125 cm^3?
2. What is the density of a liquid with a mass of 45 g and a volume of 48 mL?

Densities of Common Substances The table in Figure 14 lists the densities of some common substances. The density of a substance is the same for all samples of that substance. For example, all samples of pure gold—no matter how large or small—have a density of 19.3 g/cm^3.

Once you know an object's density, you can predict whether the object will float or sink in a given liquid. If the object is less dense than the liquid, it will float. If the object is more dense than the liquid, it will sink. For example, the density of water is 1 g/cm^3. A piece of wood with a density of 0.8 g/cm^3 will float in water. A ring made of pure silver, which has a density of 10.5 g/cm^3, will sink.

Reading Checkpoint **Will an object with a density of 0.7 g/cm^3 float or sink in water?**

Densities of Some Common Substances	
Substance	**Density (g/cm^3)**
Air	0.001
Ice	0.9
Water	1.0
Aluminum	2.7
Gold	19.3

FIGURE 14
The density of a substance stays the same no matter how large or small a sample of the substance is. **Applying Concepts** *How could you use density to determine whether a bar of metal is pure gold?*

Time

The crowd cheers wildly as you near the finish line. You push your legs to run even faster in the final moments of the race. From the corner of your eye, you see your opponent catching up to you. At moments like this, just one second can mean the difference between winning and losing.

Units of Time **The second (s) is the SI unit of time.** Your heart beats about once per second—when you are not running, that is! The second can easily be divided by multiples of 10, like the other SI units. For example, a millisecond (ms) is one-thousandth of a second. Longer periods of time are expressed in minutes or hours. There are 60 seconds in a minute, and 60 minutes in an hour.

Measuring Time You use clocks and watches to measure time. Some digital stopwatches, which are used to time races, can measure time accurately to one hundredth of a second.

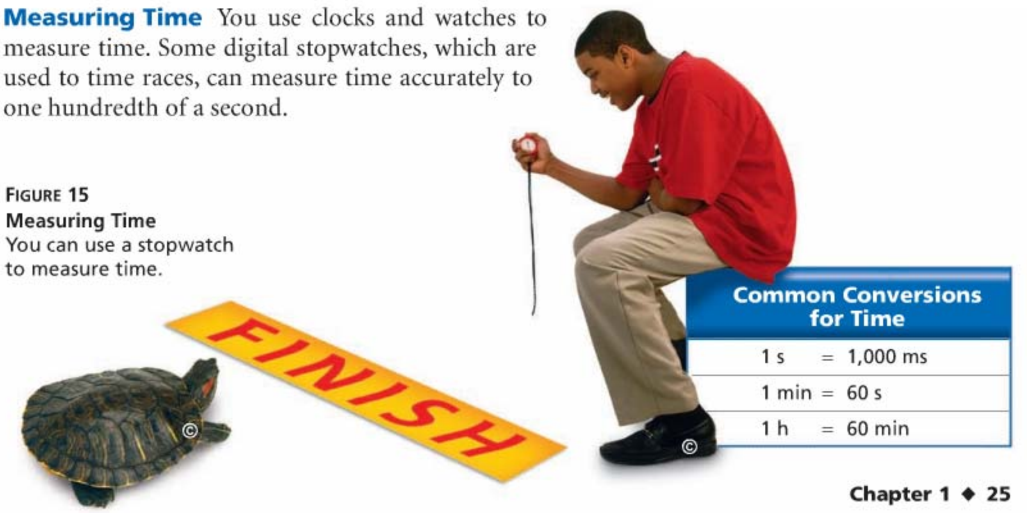

FIGURE 15
Measuring Time
You can use a stopwatch to measure time.

Common Conversions for Time	
1 s	= 1,000 ms
1 min	= 60 s
1 h	= 60 min

Temperature

As you head out the door each morning, one of the first things you might notice is the temperature. Is it cold out this morning? How high will the temperature rise?

Units of Temperature Scientists commonly use the Celsius temperature scale. On the **Celsius Scale,** water freezes at 0°C and boils at 100°C. There are exactly 100 degrees between the freezing point and boiling point of water. Normal human body temperature is about 37°C.

In addition to the Celsius scale, scientists also use another temperature scale, called the **Kelvin scale.** Units on the Kelvin scale are the same size as those on the Celsius scale. **The kelvin (K) is the SI unit of temperature.**

The temperature 0 K on the Kelvin scale is called **absolute zero**. Nothing can get colder than this temperature. Absolute zero is equal to –273°C on the Celsius scale.

Measuring Temperature You can measure temperature using a thermometer. Most thermometers consist of a sealed tube that contains a liquid. The liquid expands or contracts as the temperature changes.

FIGURE 16
Measuring Temperature
Scientists use the Celsius and Kelvin scales to measure temperature.

Section 3 Assessment

S 8.8.a, 8.8.b, E-LA: Reading 8.2.0, Math: 7NS1.2

Target Reading Skill Preview Text Structure Complete the graphic organizer for this section. What question did you ask about Weight and Mass? What was your answer?

Reviewing Key Concepts

HINT
1. a. **Identifying** What is the standard measurement system used by scientists around the world?

HINT
b. **Predicting** Suppose that two scientists use different measurement systems in their work. What problems might arise if they shared their data?

HINT
2. a. **Listing** What are the SI units of length, mass, volume, density, time, and temperature?

b. **Estimating** Estimate the length of a baseball bat and mass of a baseball in SI units. How can you check how close your estimates are? HINT

c. **Describing** Outline a step-by-step method for determining the density of a baseball. HINT

Math Practice

Two solid cubes have the same mass. They each have a mass of 50 g.

3. **Calculating Density** Cube A has a volume of 2 cm × 2 cm × 2 cm. What is its density?
4. **Calculating Density** Cube B has a volume of 4 cm × 4 cm × 4 cm. What is its density?

Lab zone **Skills Lab**

Making Sense of Density

S 8.8.b, 8.9.b

Problem

Does the density of a material vary with volume?

Skills Focus

drawing conclusions, measuring, controlling variables

Materials

- balance
- water
- paper towels
- metric ruler
- graduated cylinder, 100-mL
- wooden stick, about 6 cm long
- ball of modeling clay, about 5 cm wide
- crayon with paper removed

Procedure

1. Use a balance to find the mass of the wooden stick. Record the mass in a data table like the one shown above right.
2. Add enough water to a graduated cylinder so that the stick can be completely submerged. Measure the initial volume of the water.
3. Place the stick in the graduated cylinder. Measure the new volume of the water.
4. The volume of the stick is the difference between the water levels in Steps 2 and 3. Calculate this volume and record it.
5. The density of the stick equals its mass divided by its volume. Calculate and record its density.
6. Thoroughly dry the stick with a paper towel. Then carefully break the stick into two pieces. Repeat Steps 1 through 5 with one piece. Then, repeat Steps 1 through 5 with the other piece.
7. Repeat Steps 1 through 6 using the clay rolled into a rope.
8. Repeat using the crayon.

Data Table

Object	Mass (g)	Volume Change (cm^3)	Density (g/cm^3)
Wooden stick			
Whole			
Piece 1			
Piece 2			
Modeling clay			
Whole			
Piece 1			
Piece 2			
Crayon			
Whole			
Piece 1			
Piece 2			

Analyze and Conclude

1. **Measuring** For each object you tested, compare the density of the whole object with the densities of the pieces of the object.
2. **Drawing Conclusions** Use your results to explain how density can be used to identify a material.
3. **Controlling Variables** Why did you dry the objects in Step 6?
4. **Communicating** Write a paragraph explaining how you would change the procedure to obtain more data. Tell how having more data would affect your answers to Questions 1 and 2 above.

Design an Experiment

Design an experiment you could use to determine the density of olive oil. With your teacher's permission, carry out your plan. Use the library or the Internet to find the actual density of olive oil. Compare your experimental value with the actual value, and explain why they may differ.

S 8.9

Should the United States Go Metric?

On a long car ride, have you ever asked, "Are we there yet?" If the driver answered, "We're 30 kilometers away," would you know whether you were close to your destination or far away?

As a U.S. resident, you probably have no trouble understanding English units, which include miles, feet, pounds, and gallons. Metric units, however, may be more unfamiliar. But most countries in the world use the metric system. Should the United States convert to metric or continue using the English system?

The Issues

Why Change?

People in the United States are comfortable with the English system of measurement. If the country converted to metric, citizens might have a hard time buying products or calculating distances. These problems may not disappear overnight.

Businesses in the United States rely on the English system. Many of the tools and machines that manufacture goods are based on the English system, as are the goods themselves. To go metric, machines would have to be replaced and the goods repackaged. This could cost millions of dollars.

Why Not Change?

Supporters of the metric system point out how easy it is to learn. Because metric units are based on the number 10, converting from kilometers to meters, for example, is simple. In contrast, converting miles to feet, or gallons to ounces, is more complicated. Schoolchildren could master the metric system much more quickly than the English system.

Furthermore, conversion may help the United States stay competitive in foreign trade. Many U.S. businesses sell their products in other countries. But people worldwide prefer products labeled in units they know—in this case, metric units. They may avoid products that are not made to metric standards. In fact, by 2010, products sold in Europe must be labeled in metric units only.

The countries in red currently use the English system of measurement.

Why Not Compromise?

The next time you drink a bottle of juice, look at its label. Most likely, it includes both English and metric units. Labels like these are a compromise. They allow users of both measurement systems to know exactly what they are buying.

Some people feel that such a compromise works well enough. People who need to use the metric system, such as those in science and industry, should be able to use it. However, those who prefer to use English units should be able to do so as well.

You Decide

1. **Identify the Problem**
   In your own words, state the advantages and disadvantages of converting to the metric system.

2. **Analyze the Options**
   Do some research on countries that have recently gone metric. What problems did these countries face? How did they overcome the problems? Did the benefits of converting to the metric system outweigh the costs?

3. **Find a Solution**
   Take a stance on this issue. Then engage in a class debate about whether or not the United States should convert to the metric system. Support your opinion with facts from this feature and from your research.

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Mathematics and Science

CALIFORNIA Standards Focus

S 8.9.b Evaluate the accuracy and reproducibility of data.

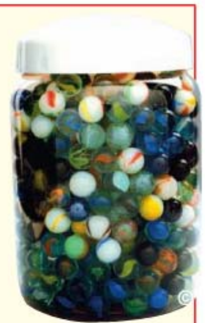
What math skills do scientists use in collecting data and making measurements?

Key Terms

- estimate
- accuracy
- reproducibility
- significant figures
- precision

Lab zone Standards Warm-Up

How Many Marbles Are There?



1. Your teacher will give you a jar full of marbles.
2. With a partner, come up with a way to determine the number of marbles in the jar without actually counting all of them.
3. Use your method to determine the number of marbles. Write down your answer.
4. Compare the method you used to that of another group.

Think It Over

Predicting Which method do you think led to a more accurate answer? Why?

What are some tools that scientists use? You might think of microscopes, thermometers, and calculators. There are also scientific tools that you won't find on a lab bench. Curiosity, skepticism, creativity—these are attitudes that serve as useful tools in scientific inquiry. Knowledge is another important tool. One form of knowledge that is particularly useful in the study of science is mathematics. Mathematics is essential for asking and answering questions about the material world.

Estimation

Have you ever been on stage and wondered how many people there were in the audience? Maybe you counted the number of people in one row and multiplied by the number of rows. This would be one way to arrive at an estimate. An **estimate** is an approximation of a number based on reasonable assumptions. Estimating is not the same as guessing because an estimate is based on known information.

Scientists must sometimes rely on estimates when they cannot obtain exact numbers. Astronomers, for example, can't actually measure the distance between stars. An astronomer's estimate might be based on indirect measurements, calculations, and models.

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Accuracy and Reproducibility

Suppose you were to meet a friend at 4:00 P.M. Your friend arrives at 4:15 and says, "But it's 4:00 according to all the clocks in my house." The problem is that your friend's clocks do not show the accurate, or correct, time. **Accuracy** refers to how close a measurement is to the true or actual value. An accurate clock would read 4:00 P.M. Your friend's clocks may be working properly, but because they are set 15 minutes late, they are always inaccurate.

Reproducibility What would happen if you never told your friend that he was late? Your friend would always be late by 15 minutes. If the two of you tried to meet at 4:00 P.M. on consecutive days, your friend would arrive at 4:15 P.M. each day. Your friend's clocks may be inaccurate, but when used for repeated measurements, they yield consistent results.

The times measured with your friend's clocks can be said to be reproducible. **Reproducibility** refers to how close a group of measurements are to each other.

Accuracy and reproducibility do not mean the same thing. To help you understand the difference, think about a game of darts. As Figure 17 shows, accurate throws land close to the bull's-eye. Reproducible throws, on the other hand, land close to one another. Your friend's clocks show times that are reproducible but inaccurate, like the arrangement of darts in the middle dartboard.

Accuracy and Reproducibility in Measurements

Suppose you want to measure your friend's height. The measurement needs to be accurate, or close to your friend's actual height. The measurement also needs to be reproducible. This means that if you measured your friend's height several times, you would get the same measurement again and again.

Scientists aim for both accuracy and reproducibility in their measurements. To ensure accuracy, you need to make your measurements carefully using the appropriate instruments. To ensure reproducibility, you need to repeat the measurement a few times.

▲ Neither Reproducible nor Accurate

▲ Reproducible but Not Accurate

▲ Both Reproducible and Accurate

FIGURE 17
Accuracy and Reproducibility
In a game of darts, it's easy to see the difference between accurate throws and reproducible throws. In order to hit the bull's-eye consistently, you need both accuracy and reproducibility!

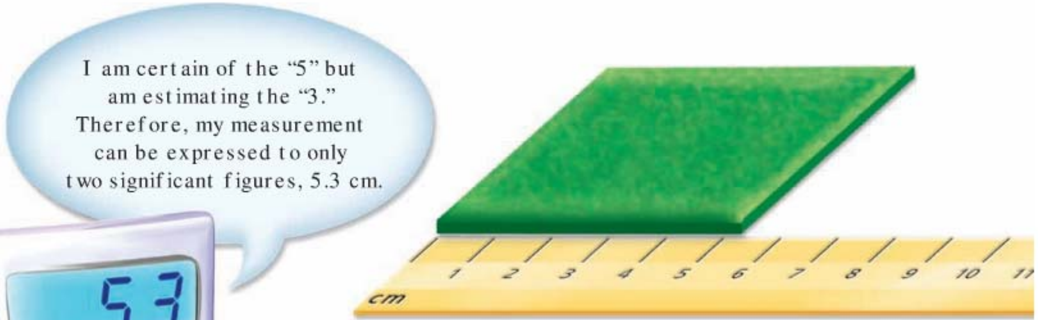


FIGURE 18
Significant Figures
A measurement should contain only those numbers that are significant. **Measuring** *Why can you report the length of the tile to only two significant figures?*

Significant Figures and Precision

Figure 18 shows a tile next to a ruler marked off in 1-centimeter segments. Suppose you measure the length of the tile as 5.3 centimeters. This measurement has two digits that are "significant." The **significant figures** in a measurement include all of the digits that have been measured exactly, plus one digit whose value has been estimated. In measuring the tile to be 5.3 centimeters long, you are certain of the 5, but you have estimated the 3. So, the measurement 5.3 centimeters has two significant figures.

What if the ruler had been marked off in 1-millimeter segments? You would be able to make a more precise measurement. **Precision** is a measure of the exactness of a measurement. With a more precise ruler, you might measure the length of the tile as 5.32 centimeters. The measurement 5.32 centimeters (three significant figures) is more precise than 5.3 centimeters (two significant figures). **Scientists use significant figures to express precision in their measurements and calculations.**

Adding or Subtracting When you add or subtract measurements, the answer should have the same number of decimal places as the measurement with the least number of decimal places. For example, suppose you add a tile that is 5.3 centimeters long to a row of tiles that is 21.94 centimeters long.

5.3 cm (1 decimal place)
+ 21.94 cm (2 decimal places)
27.24 cm ≈ 27.2 (1 decimal place)

In this calculation, the measurement with the least number of decimal places is 5.3 centimeters (one decimal place). So the answer, 27.2 centimeters, should be written to only one decimal place. The correct answer has three significant figures.

Reading Checkpoint **What are significant figures?**

Math Skills

Area

To find the area of a surface, multiply its length by its width. Suppose a sheet of paper measures 27.5 cm by 21.6 cm.

$$\text{Area} = 27.5 \text{ cm} \times 21.6 \text{ cm}$$
$$= 594 \text{ cm}^2$$

Practice Problem What is the area of a ticket stub that measures 3.5 cm by 2.2 cm?

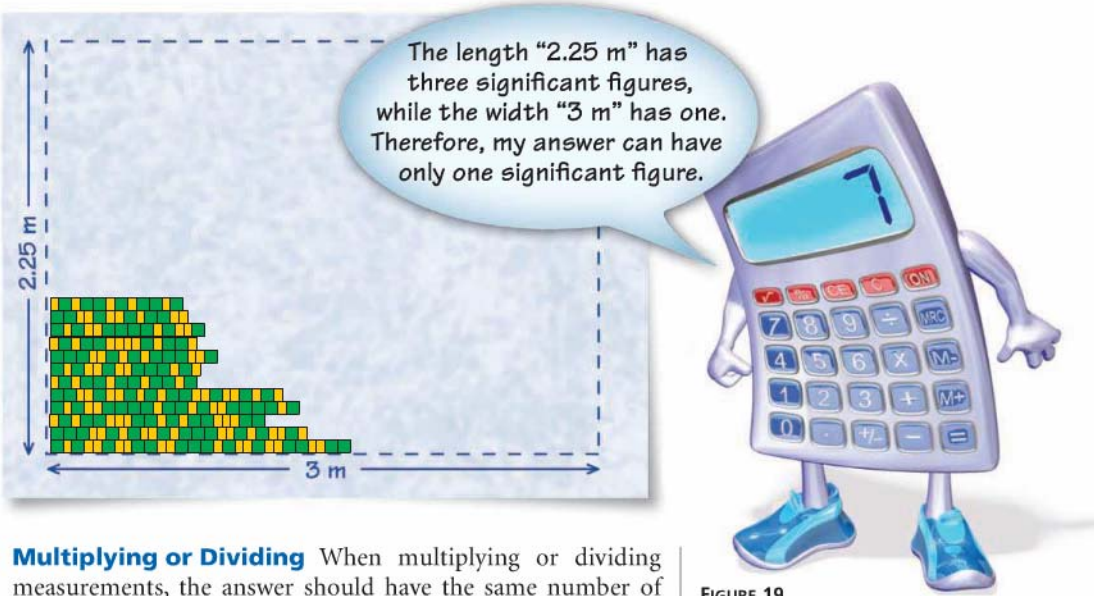


FIGURE 19
Multiplying Measurements
When you multiply measurements, your answer can have only the same number of significant figures as the measurement with the fewest significant figures.

Multiplying or Dividing When multiplying or dividing measurements, the answer should have the same number of significant figures as the measurement with the least number of significant figures. Suppose you need to tile a space that measures 2.25 meters by 3 meters. The calculated area would be:

2.25 m (3 significant figures)
× 3 m (1 significant figure)
$6.75\ m^2 \approx 7\ m^2$ (1 significant figure)

The answer has one significant figure because the measurement with the least number of significant figures (3 meters) has one significant figure.

Section 4 Assessment

S 8.9.b, Math: 7MG 2.1

Vocabulary Skill **High-Use Academic Words** What is the meaning of the word *significant* in the term *significant figures*?

Reviewing Key Concepts

HINT
HINT
HINT

1. a. **Identifying** What math skill do scientists rely on when they cannot obtain exact numbers?
   b. **Explaining** How can you be sure that your measurements are both accurate and reproducible?
   c. **Interpreting Data** Using a metric ruler with millimeter markings, a friend measures the width of a book to be 14.23 cm. How many digits can you be certain of? Explain.

Math Practice

2. **Area** To win a prize at a fair, you must throw a coin into a space that is 7.0 cm long and 4.0 cm wide. What is the area of the space you are aiming for? Express your answer to the correct number of significant figures.

Section 5

Graphs in Science

CALIFORNIA Standards Focus

S 8.9.d Recognize the slope of the linear graph as the constant in the relationship $y = kx$ and apply this principle in interpreting graphs constructed from data.

S 8.9.g Distinguish between linear and nonlinear relationships on a graph of data.

- What type of data can line graphs display?
- How do you determine a line of best fit or the slope of a graph?
- Why are line graphs powerful tools in science?

Key Terms

- graph
- horizontal axis
- vertical axis
- origin
- coordinate
- data point
- line of best fit
- linear graph
- slope
- nonlinear graph

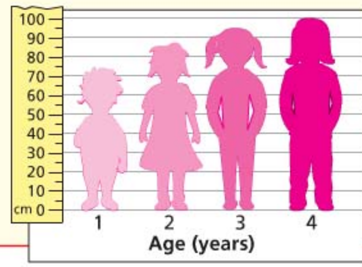
Lab zone Standards Warm-Up

What's in a Picture?

1. Read over the information written below.

   At age 1, Sarah was 75 cm tall. By the time she turned 2, Sarah had grown 10 cm. By age 3, she had grown another 10 cm. At age 4, Sarah was 100 cm tall.

2. Look at the "picture" below.

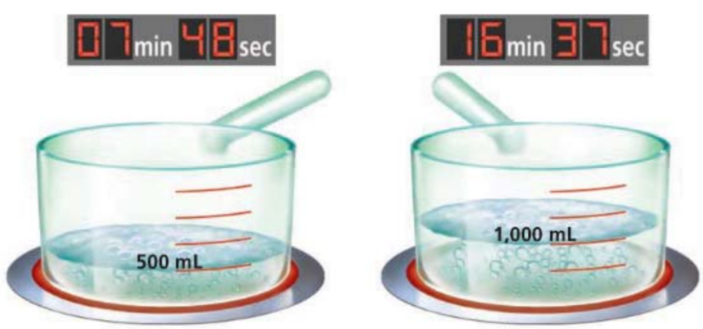


Think It Over

Inferring What are the advantages of showing information in a visual way, rather than with words in paragraph form? What trend do you see in the picture?

It's been a long day and all you can think about is food. You toss down your gym bag and head into the kitchen. Now for some pasta! You set a pot of water on the stove, turn on the heat, and wait eagerly for the water to boil.

Several minutes later, you are still waiting for the first sign of bubbles. Could the saying "A watched pot never boils" really be true? Or is the water taking longer to boil today because you filled the pot more than usual? Is the volume of water related to boiling time? You could do an experiment and collect some data to find out.



The Importance of Graphs

In Section 2, you learned why it is important to organize the data you collect in an experiment. Creating a data table is one way to organize experimental data. Another way to show data is in the form of a graph. You can think of a **graph** as a "picture" of your data. Have you ever heard the saying, "A picture is worth a thousand words"? This is exactly why graphs are such useful tools. Because of their visual nature, graphs can reveal patterns or trends that words and data tables cannot.

The three types of graphs that scientists commonly use are bar graphs, circle graphs, and line graphs. You can learn about these graphs in the Skills Handbook. This section focuses specifically on line graphs—how to create them and how to interpret the patterns they reveal.

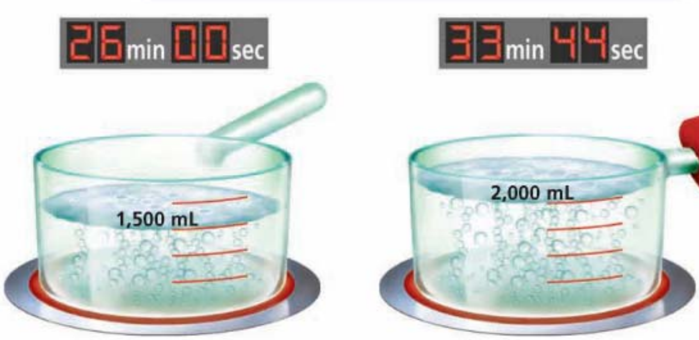
Why Are Line Graphs Useful? Suppose you set up the experiment in Figure 20. You record in a data table the time it takes each pot of water to boil. From your data table, you can tell that as the volume of water increases, the boiling time seems to increase as well. But a line graph could reveal more clearly how these two variables are related.

Line graphs are used to display data to show how one variable (the responding variable) changes in response to another variable (the manipulated variable). In the water-boiling experiment, the responding variable is the time it takes for the water to boil. The manipulated variable is the volume of water in the pot.

FIGURE 20
Collecting Data
How long does it take different volumes of water to boil? You can collect data and plot a line graph to see the relationship between volume and boiling time.
Inferring *Why might a line graph be more useful than a data table?*

Data Table

Volume of Water (mL)	Boiling Time
500	7 min 48 s (7.8 min)
1,000	16 min 37 s (16.6 min)
1,500	26 min 00 s (26.0 min)
2,000	33 min 44 s (33.7 min)



Plotting a Line Graph When should you plot a line graph? The answer is, when your manipulated variable is *continuous*—that is, when there are other points between the ones that you tested. In the water-boiling experiment, volumes of 501 mL, 502 mL, and so on exist between 500 mL and 2,000 mL. Time and mass are other continuous variables.

To plot a line graph of your data, follow these steps.

1. **Draw the axes.** The **horizontal axis,** or *x*-axis, is the graph line that runs left to right. The **vertical axis,** or *y*-axis, is the graph line that runs up and down.

2. **Label the axes.** Label the horizontal axis with the name of the manipulated variable. Label the vertical axis with the name of the responding variable. Be sure to include units of measurement on each axis.

3. **Create a scale.** On each axis, create a scale by marking off equally-spaced intervals that cover the range of values you will show. Both scales should begin at zero when possible. The point where the two axes cross is called the **origin** of the graph. On this graph, the origin has coordinates of (0,0), which represents "0 milliliters and 0 minutes." A **coordinate** is a pair of numbers used to determine the position of a point on a graph.

Data Table	
Volume of Water (mL)	Boiling Time (min)
500	7.8
1,000	16.6
1,500	26.0
2,000	33.7

4. **Plot the data.** Plot a point for each piece of data. The dotted lines show how to plot your first piece of data (500, 7.8). Follow an imaginary vertical line extending up from the horizontal axis at the 500 mL mark. Then follow an imaginary horizontal line extending across from the vertical axis at the 7.8 minutes mark. Plot a point where these two lines cross, or intersect. The point showing the location of that intersection is called a **data point.**

5. **Draw a "line of best fit."** A **line of best fit** is a smooth line that reflects the general pattern of a graph. Though your first instinct might be to simply connect all the dots, that's not the correct approach to drawing a line graph. Rather, you should first stop and look at the points you plotted to identify a general trend in the data. Then draw a smooth line between the points to reflect that general pattern.

   Notice that the resulting line of best fit for this graph is a straight line. A line graph in which the data points yield a straight line is called a **linear graph.**

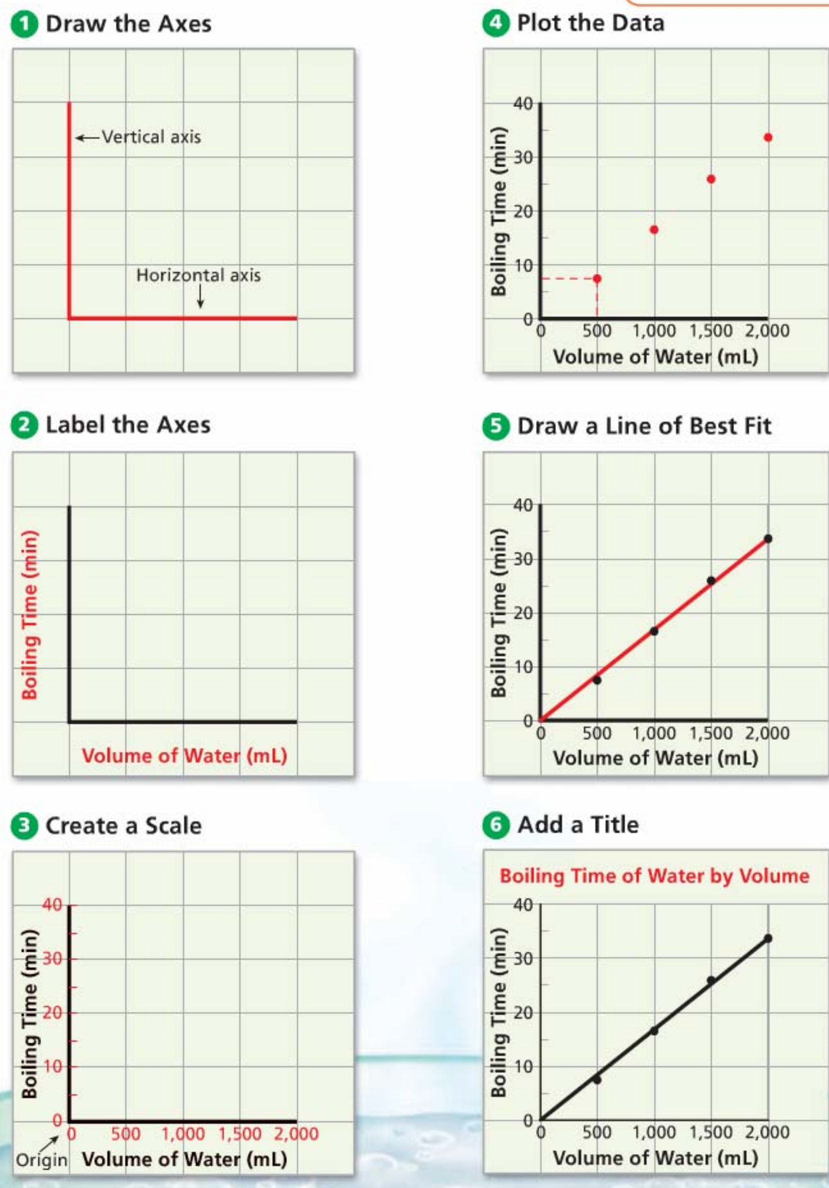
6. **Add a title.** The title should identify the variables or relationship shown in the graph.

Reading Checkpoint **What is a data point?**

FIGURE 21
Plotting a Line Graph
You can obtain a picture of your experimental data by following these six steps.

Go Online active art

For: Plotting a Line Graph activity
Visit: PHSchool.com
Web Code: cgp-6023



Why Draw a Line of Best Fit?

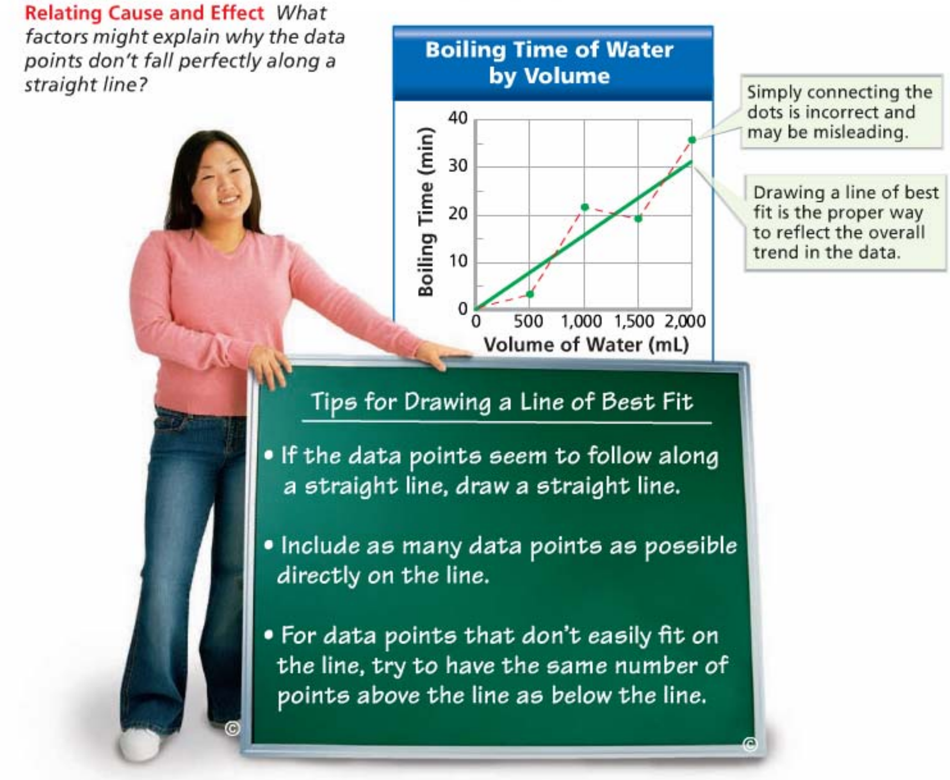
You may be wondering why you cannot simply connect all your data points with a line to create a line graph. To understand why this is the case, consider the following situation. Suppose your friend performs the same water-boiling experiment as you did and plots the graph shown in Figure 22.

Notice that your friend's graph shows the same general trend as yours—points going upwards from left to right. However, if your friend simply connects the dots, the line would be a zigzag, rather than a straight line.

Why don't your friend's data points fall perfectly along a straight line? It is because whenever data is collected, small measurement errors and inaccuracies can be introduced. By simply connecting the dots, you would place too much importance on each individual data point in determining the overall shape of the line. **A line of best fit emphasizes the overall trend shown by all the data taken as a whole.**

Reading Checkpoint **Why shouldn't you automatically "connect the dots" when creating a line graph?**

FIGURE 22
Drawing a Line of Best Fit
For this graph, a line going up from left to right reflects the data more accurately than a zigzag line does.
Relating Cause and Effect *What factors might explain why the data points don't fall perfectly along a straight line?*

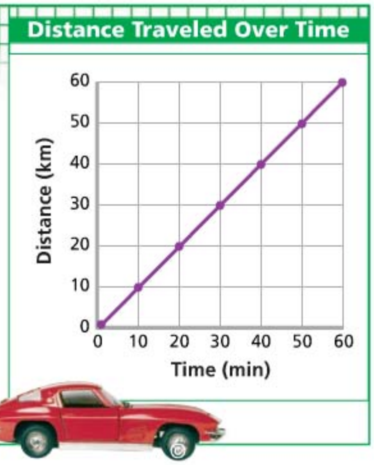


Math Analyzing Data

Car Travel

The graph shows the distance a car travels in a one-hour period. Use the graph to answer the questions below.

1. **Reading Graphs** What variable is plotted on the horizontal axis? The vertical axis?
2. **Interpreting Data** How far does the car travel in the first 10 minutes? In 40 minutes?
3. **Predicting** Use the graph to predict how far the car would travel in 120 minutes. Assume the car continues to travel at the same speed.
4. **Calculating** Calculate the slope of the graph. What information does the slope provide?



Slope

When a line graph is linear, you can determine a value called slope. One way to define **slope** is the steepness of the graph line. **The slope of a graph line tells you how much *y* changes for every change in *x*.**

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

To calculate slope, pick any two points on the line and write down the coordinates. In Figure 23, suppose you chose the points (20, 10) and (50, 25).

$$\text{Slope} = \frac{25\text{ km} - 10\text{ km}}{50\text{ min} - 20\text{ min}} = \frac{15\text{ km}}{30\text{ min}} = 0.5\text{ km/min}$$

In the case of Figure 23, the slope represents the distance the car travels per unit of time, or its speed. So the speed of the car is 0.5 km/min. Note that the speed is constant. On a linear graph, the slope is constant.

If the straight line of a linear graph goes through the origin (0, 0), the graph can be expressed as the following equation:

$$y = kx$$

In this equation, x is the manipulated variable, y is the responding variable, and the constant k is the slope.

Look again at Figure 23. Substituting for the variables x (time), y (distance), and k (0.5 km/min), you can now write:

$$\text{Distance} = (0.5\text{ km/min})\ (\text{Time})$$

FIGURE 23
Slope
The slope of a line indicates how much y changes for every change in x. **Calculating** *What is the slope of this line?*

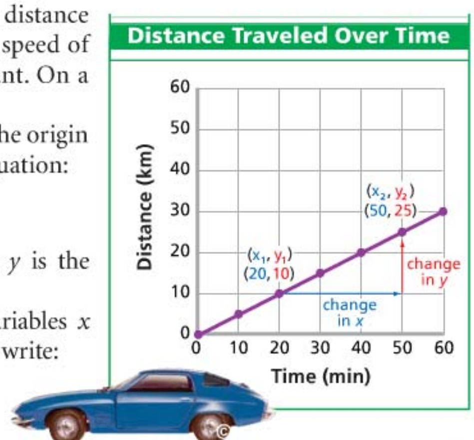
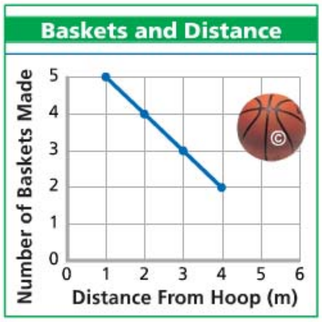
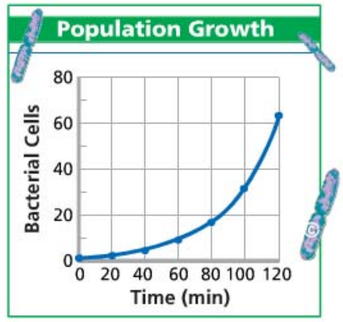


FIGURE 24
Trends in Graphs
Data may yield one of the trends shown in these graphs.
Reading Graphs *Which graph shows no relationship between the two variables?*



A **Linear Trend** As the distance from the hoop increases, the number of baskets made decreases. The graph line descends to the right.



B **Nonlinear Trend** Bacteria reproduce by dividing in two every 20 minutes. The number of bacterial cells increases sharply. The graph is a steep curve.

Using Graphs to Identify Trends

Your data won't always give you a graph with a straight line. A line graph in which the data points do not fall along a straight line is called a **nonlinear graph.**

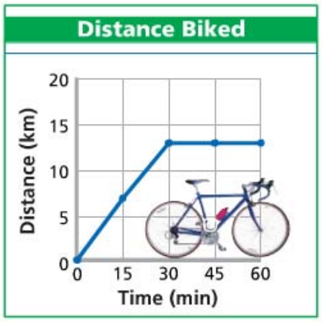
Whether a graph is linear or nonlinear, the information it contains is very useful. **Line graphs are powerful tools in science because they allow you to identify trends and make predictions.**

Linear Trends When a graph is linear, you can easily see how two variables are related. For instance, Graph A in Figure 24 shows that the farther one student stands from a basketball hoop, the fewer baskets she can make.

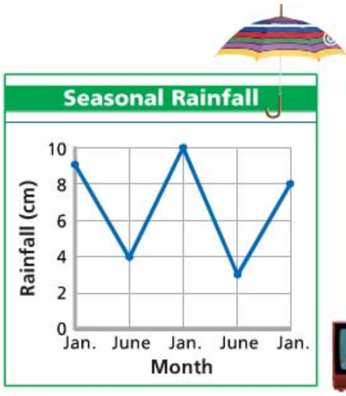
You can also use the graph to make predictions. For example, how many baskets can she make at a distance of 5 meters? If you extend the graph line, you can see that your prediction would be one basket.

Nonlinear Trends There are several kinds of nonlinear graphs. In some nonlinear graphs, the data points may fall along a curve. A curve may be shallow, or it may be steep, as in Graph B. Other nonlinear graphs show different trends. A graph may rise and then level off, as in Graph C. Or, a graph may show a repeating pattern, as in Graph D. Because each of these graphs reveals a trend in the data, they are useful in understanding how the variables are related.

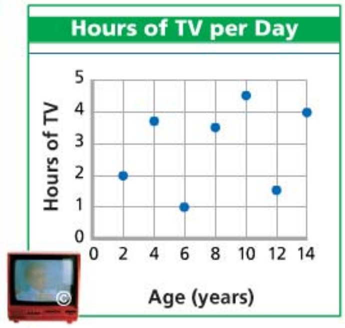
Reading Checkpoint **What is a nonlinear graph?**



C **Nonlinear Trend** On a bike ride, the distance you bike increases with time. If you stop to rest, the distance remains the same and the graph levels off.



D **Nonlinear Trend** In many places, rainfall varies with the seasons. The graph shows a repeating, or cyclical, pattern.



E **No Trend** The amount of television children watch and their ages are not related. The data points are scattered, and the graph shows no recognizable pattern.

No Trend In other nonlinear graphs, the data points may be scattered about in no recognizable pattern, as in Graph E. Would you be surprised to learn that even such graphs are useful? When there are no identifiable trends in a graph, it most likely means that there is no relationship between the two variables.

Section 5 Assessment

S 8.9.d, 8.9.g,
E-LA: Reading 8.2.0

Target Reading Skill **Preview Text Structure** Complete the graphic organizer for this section. What question did you ask about Slope? What was your answer?

Reviewing Key Concepts

HINT
1. a. Reviewing What can graphs reveal that data tables cannot?

HINT
b. Describing What can a line graph tell you about the relationship between the variables in an experiment?

HINT
c. Interpreting Data Could you use a line graph to show data about how body mass (the responding variable) changes with height (the manipulated variable)? Explain.

HINT
2. a. Defining What is a line of best fit?

HINT
b. Explaining What does calculating the slope of a graph line tell you about the data?

HINT
c. Comparing and Contrasting How does a graph line with a steeper slope compare to one with a shallower slope?

3. a. Listing List two things that line graphs allow scientists to do.
HINT

b. Reading Graphs Describe how Graphs A and D in Figure 24 differ.
HINT

Lab zone At-Home Activity

Which Line Is Best? Show a family member how to "draw" a line of best fit by plotting the data points from Figure 22 onto a piece of graph paper. Tape the graph paper onto a thick piece of cardboard. Insert a pushpin into each data point. Then arrange a piece of string so that it best reflects the data. Once you have determined the line of best fit, tape the string to the graph. Explain why a line of best fit need not go through each data point.

Lab zone **Skills Lab**

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Density Graphs

S 8.8.b, 8.9.d

Problem

How can you determine the density of a liquid?

Skills Focus

graphing, calculating

Materials

- graduated cylinder
- balance • graph paper
- 3 sample volumes of the same liquid

Procedure

1. Measure the mass of an empty graduated cylinder. Record the mass in a data table.
2. Pour one of the liquid samples into the graduated cylinder. Measure and record the mass of the graduated cylinder plus the liquid.
3. Calculate the mass of the liquid alone by subtracting the mass of the empty graduated cylinder from the mass in Step 2.
4. Determine the volume of the liquid by reading the level at the bottom of the meniscus.
5. Repeat Steps 2–4 with the two other samples.

Analyze and Conclude

1. **Graphing** Use the data in your data table to create a graph. Graph volume on the horizontal axis (*x*-axis) and mass on the vertical axis (*y*-axis).
2. **Interpreting Data** Look at the points you plotted to identify a general trend in the data. Then draw a line of best fit that reflects the trend in the data.
3. **Calculating** Select two points on the graph line and calculate the slope of the line.

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

4. **Drawing Conclusions** Repeat Step 3 using a different pair of points on the graph line. Compare the two values calculated for the slope. What does the slope represent?
5. **Communicating** Explain why mass and volume measurements for any sample of the liquid should fall along the graph line.

Design an Experiment

Propose a plan to determine which is more dense—a marble, a plastic spoon, or the liquid used in this lab. *Obtain your teacher's permission before carrying out your investigation.*

Data Table				
Sample	Mass of Empty Graduated Cylinder	Mass of Liquid and Graduated Cylinder	Mass of Liquid Alone	Volume of Liquid
A				
B				
C				

Section 6 Science Laboratory Safety

CALIFORNIA Standards Focus

S 8.9 Scientific progress is made by asking meaningful questions and conducting careful investigations.

- Why is preparation important when carrying out scientific investigations in the lab and in the field?
- What should you do if an accident occurs?

Lab zone Standards Warm-Up

Where Is the Safety Equipment in Your School?

1. Look around your classroom or school for any safety-related equipment.
2. Draw a floor plan of the room or building and clearly label where each item is located.

Think It Over

Predicting Why is it important to know where safety equipment is located?

Suppose you and your family decide to go rock climbing. What plans should you make? You'll need to bring rope, some snacks to eat, and water to drink. But you'll also need to plan for everyone's safety.

For the climb to go smoothly, you'll want to make sure that everyone has the proper clothing and safety gear, such as helmets, harnesses, and climbing shoes. You'll check to see whether the equipment is in good condition. You'll also want to make sure that everyone follows proper procedures and knows their role as others take their turn climbing.

FIGURE 25
Climbing Safely
Climbing rocks safely requires careful preparation and the use of proper equipment.

Go Online
SCI LINKS NSTA
For: Links on laboratory safety
Visit: www.SciLinks.org
Web Code: scn-1624

Safety in the Lab

Just as when you go camping, you have to be prepared before you begin any scientific investigation. **Good preparation helps you stay safe when doing science activities in the laboratory.**

Thermometers, balances, and glassware—these are some of the equipment you will use in science labs. Do you know how to use these items? What should you do if something goes wrong? Thinking about these questions ahead of time is an important part of being prepared.

Preparing for the Lab Preparing for a lab should begin the day before you will perform the lab. It is important to read through the procedure carefully and make sure you understand all the directions. Also, review the general safety guidelines in Appendix A, including those related to the specific equipment you will use. If anything is unclear, be prepared to ask your teacher about it before you begin the lab.

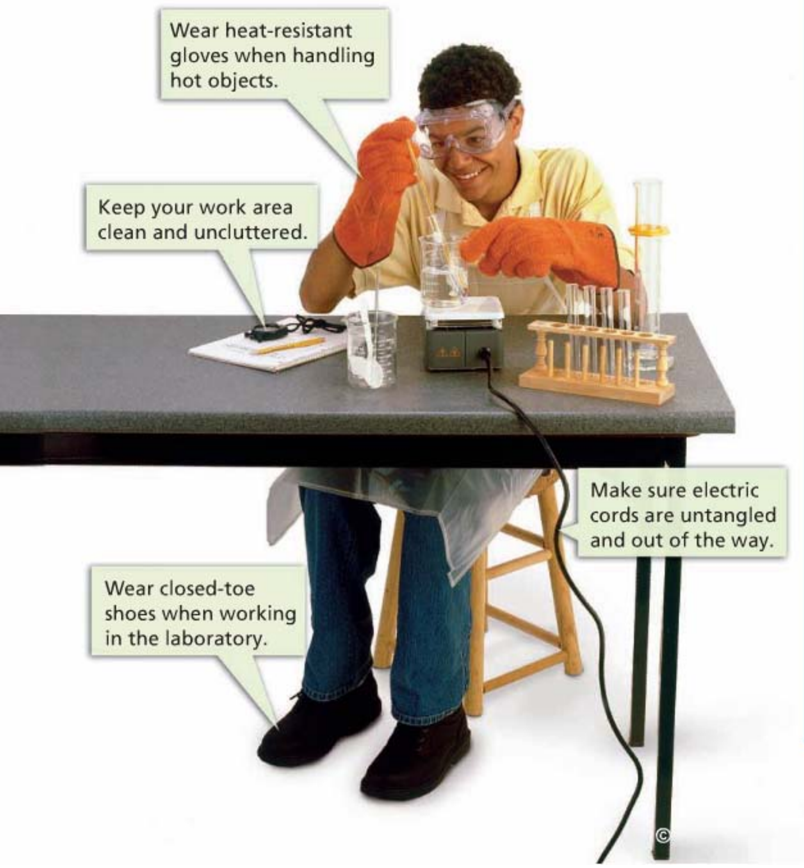
FIGURE 26
Safety in the Lab
Good preparation for an experiment helps you stay safe in the laboratory. **Observing** *List three precautions each student is taking while performing the labs.*

Performing the Lab Whenever you perform a science lab, your chief concern must be the safety of yourself, your classmates, and your teacher. The most important safety rule is simple: Always follow your teacher's instructions and the textbook directions exactly. You should never try anything on your own without asking your teacher first.

Labs and activities in this textbook series include safety symbols like those at the right. These symbols alert you to possible dangers in performing the lab and remind you to work carefully. They also identify any safety equipment that you should use to protect yourself from potential hazards. The symbols are explained in detail in Appendix A. Make sure you are familiar with each safety symbol and what it means.

Another thing you can do to make your lab experience safe and successful is to keep your work area clean and organized. Also, do not rush through any of the steps. Finally, always show respect and courtesy to your teacher and classmates.

Reading Checkpoint **What is the most important safety rule?**



Safety Symbols

- Safety Goggles
- Lab Apron
- Breakage
- Heat-Resistant Gloves
- Plastic Gloves
- Heating
- Flames
- No Flames
- Corrosive Chemical
- Poison
- Fumes
- Sharp Object
- Animal Safety
- Plant Safety
- Electric Shock
- Physical Safety
- Disposal
- Hand Washing
- General Safety Awareness

End-of-Lab Procedures Your lab work does not end when you reach the last step in the procedure. There are important things you need to do at the end of every lab.

When you have completed a lab, be sure to clean up your work area. Turn off and unplug any equipment and return it to its proper place. It is very important that you dispose of any waste materials properly. Some wastes should not be thrown in the trash or poured down the drain. Follow your teacher's instructions about proper disposal. Finally, be sure to wash your hands thoroughly after working in the laboratory.

Safety in the Field

The laboratory is not the only place where you will conduct scientific investigations. Some investigations will be done in the "field." The field can be any outdoor area, such as a schoolyard, a forest, a park, or a beach. **Just as in the laboratory, good preparation helps you stay safe when doing science activities in the field.**

There can be many potential safety hazards outdoors. For example, you could encounter severe weather, traffic, wild animals, or poisonous plants. Advance planning may help you avoid some potential hazards. For example, you can listen to the weather forecast and plan your trip accordingly. Other hazards may be impossible to anticipate.

Whenever you do field work, always tell an adult where you will be. Never carry out a field investigation alone. Ask an adult or a classmate to accompany you. Dress appropriately for the weather and other conditions you will encounter. Use common sense to avoid any potentially dangerous situations.

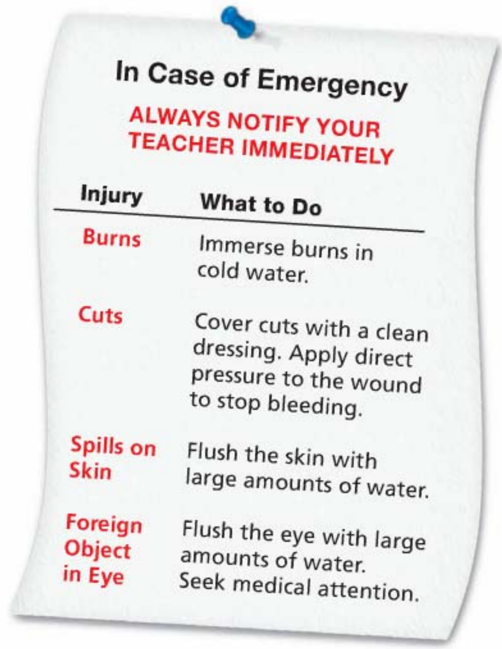
Reading Checkpoint What are some potential outdoor hazards?

FIGURE 27
Safety in the Field
These students are collecting data outdoors.
Applying Concepts *What safety precautions should they keep in mind while performing their activity?*

In Case of an Accident

Good preparation and careful work habits can go a long way toward making your lab experiences safe ones. But, at some point, an accident may occur. A classmate might accidentally knock over a beaker or a chemical might spill on your sleeve. Would you know what to do?

When any accident occurs, no matter how minor, notify your teacher immediately. Then, listen to your teacher's directions and carry them out quickly. Make sure you know the location and proper use of all the emergency equipment in your lab room. Knowing safety and first aid procedures beforehand will prepare you to handle accidents properly. Figure 28 lists some first-aid procedures you should know.


In Case of Emergency

ALWAYS NOTIFY YOUR TEACHER IMMEDIATELY

Injury	What to Do
Burns	Immerse burns in cold water.
Cuts	Cover cuts with a clean dressing. Apply direct pressure to the wound to stop bleeding.
Spills on Skin	Flush the skin with large amounts of water.
Foreign Object in Eye	Flush the eye with large amounts of water. Seek medical attention.

FIGURE 28
First-Aid Tips
These first-aid tips can help guide your actions during emergency situations. Remember, always notify your teacher immediately if an accident occurs.

Section 6 Assessment

S 8.9, E-LA: Reading 8.1.0, Writing 8.2.4

Vocabulary Skill High-Use Academic Words
What should you do after you complete a laboratory activity? Make a list with at least five steps. Use the term *procedures* in the title of your list.

Reviewing Key Concepts

1. a. **Listing** List two things you should do ahead of time to prepare for a lab.
   b. **Interpreting Diagrams** Suppose a lab included the safety symbols below. What do these symbols mean? What precautions should you take?

   c. **Making Generalizations** Why is it more difficult to prepare for a lab activity in the field than for one in a laboratory?

2. a. **Reviewing** Suppose during a lab activity you get a cut and start to bleed. What is the first thing you should do?
   b. **Sequencing** Outline in order the next steps you would take to deal with your injury.
   c. **Making Judgments** Some people feel that most accidents that occur really could have been prevented with better preparation or safer behaviors. Do you agree or disagree with this viewpoint? Explain your reasoning.

Writing in Science

Safety Poster Make a poster of one of the safety rules in Appendix A to post in your lab. Be sure to include the safety symbol, clear directions, and additional illustrations.

Chapter 1

Study Guide

The BIG Idea Scientists investigate the natural world by posing questions, developing hypotheses, designing experiments, analyzing data, drawing conclusions, and communicating results.

1 What Is Physical Science?

Key Concepts — S 8.9

- Scientists use the skills of observing, inferring, and predicting to learn about the natural world.
- Physical science is the study of matter and energy, and the changes that they undergo.

Key Terms

science, observing, inferring, predicting, chemistry, physics

2 Scientific Inquiry

Key Concepts — S 8.9.a, 8.9.c

- Processes used in inquiry include posing questions, developing hypotheses, designing experiments, collecting and interpreting data, drawing conclusions, and communicating.
- Scientists use models and develop laws and theories to increase people's understanding of the natural world.

Key Terms

scientific inquiry, hypothesis, parameter, manipulated variable, responding variable, controlled experiment, data, communicating, model, scientific theory, scientific law

3 Measurement

Key Concepts — S 8.8.a, 8.8.b

- Using SI allows scientists to compare data and communicate with each other about results.
- SI units include: m, kg, m^3, kg/m^3, s, and K.
- $\text{Volume} = \text{Area} \times \text{Height}$
- $\text{Density} = \dfrac{\text{Mass}}{\text{Volume}}$

Key Terms

SI, weight, mass, volume, meniscus, density, Celsius scale, Kelvin scale, absolute zero

4 Mathematics and Science

Key Concepts — S 8.9.b

- When collecting data and making measurements, scientists use math skills involving estimation, accuracy and reproducibility, significant figures, and precision.

Key Terms

estimate, accuracy, reproducibility, significant figures, precision

5 Graphs in Science

Key Concepts — S 8.9.d, 8.9.g

- Line graphs are used to display data to see how one variable (the responding variable) changes in response to another variable (the manipulated variable).
- A line of best fit emphasizes the overall trend shown by all the data taken as a whole.
- $\text{Slope} = \dfrac{\text{Rise}}{\text{Run}} = \dfrac{y_2 - y_1}{x_2 - x_1}$
- Line graphs are powerful tools in science because they allow you to identify trends and make predictions.

Key Terms

graph, horizontal axis, vertical axis, origin, coordinate, data point, line of best fit, linear graph, slope, nonlinear graph

6 Science Laboratory Safety

Key Concepts — S 8.9

- Good preparation helps you stay safe when doing science activities in the laboratory or the field.
- When any accident occurs, no matter how minor, notify your teacher immediately. Then, listen to your teacher's directions and carry them out quickly.

Review and Assessment

Go Online PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cxa-1010

Target Reading Skill

Preview Text Structure Review Section 4 of the chapter. Then, complete the graphic organizer on Mathematics and Science.

Mathematics and Science		
Heading	**Question**	**Answer**
Estimation	What is an estimate?	
Accuracy and Reproducibility	How does accuracy differ from reproducibility?	
Significant Figures and Precision		

Reviewing Key Terms

Choose the letter of the best answer.

HINT
1. A logical interpretation based on reasoning from prior experience is called
   a. scientific inquiry.
   b. a prediction.
   c. an inference.
   d. an observation.

HINT
2. In an experiment where you change only the temperature, temperature is the
   a. responding variable.
   b. manipulated variable.
   c. hypothesis.
   d. controlled parameter.

HINT
3. The amount of matter an object contains is its
   a. length.
   b. mass.
   c. weight.
   d. volume.

HINT
4. Repeated measurements that are close to one another demonstrate
   a. accuracy.
   b. reproducibility.
   c. scientific inquiry.
   d. significant figures.

HINT
5. In the event that a glass beaker breaks during a lab, the first thing you should do is
   a. wash your hands.
   b. clean up the broken glass.
   c. alert your teacher.
   d. obtain another beaker.

Complete the following sentences so that your answers clearly explain the key terms.

6. When a meteorologist **predicts** the weather, she makes a ________. HINT
7. A key process in the scientific method is the collection of **data,** which are ________. HINT
8. You can predict whether an object will float or sink in water if you know the object's **density,** which is ________. HINT
9. The measurement 5.22 centimeters has three **significant figures,** which means that ________. HINT
10. One way to analyze a linear graph of data is to calculate the **slope,** which tells ________. HINT

Writing in Science

Interview You are a sports reporter interviewing an Olympic swimmer who lost the silver medal by a few hundredths of a second. Write a one-page interview in which you discuss the meaning of time and the advanced instruments used to measure time.

Video Assessment
Discovery Channel School
The Work of Scientists

Review and Assessment

Checking Concepts

11. In your own words, briefly explain what physical science is.

12. Why must a scientific hypothesis be testable?

13. In a controlled experiment, why is it important to change just one variable parameter at a time?

14. Why must scientists use standard units of measure in their experiments?

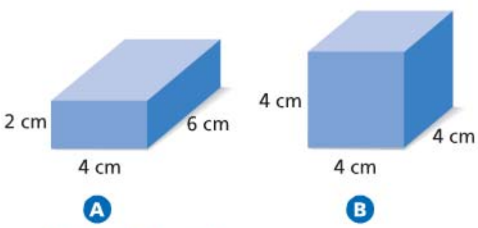
15. Why is it important to be both accurate and precise when you make measurements?

16. When graphing, why should you draw a smooth line that reflects the general pattern, rather than simply connect the data points?

17. List three things you can do to prepare for a lab experiment.

Thinking Critically

18. Comparing and Contrasting Which of the objects below has a greater volume? Explain.



19. Applying Concepts When water freezes, it expands. Use this statement and your knowledge of density to explain why ice cubes float in water.

20. Relating Cause and Effect In a lab activity that involves many measurements and calculations, you and your lab partner rush through the procedures. In the end, you obtain a percent error of 50 percent. Explain what may have led to such a high percent error.

21. Making Judgments Why do you think that, as a general precaution, you should never bring food or drink into a laboratory?

Math Practice

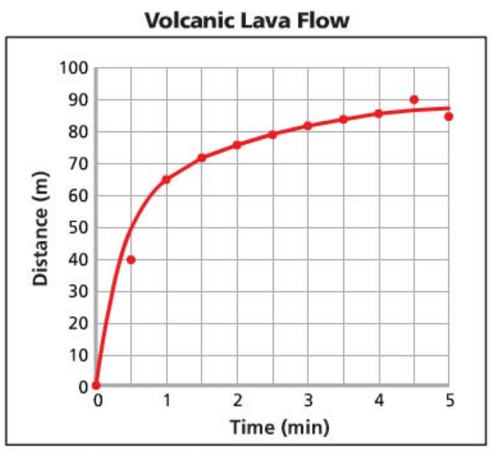
22. Calculating Density A 12.5-g marble displaces 5.0 mL of water. What is its density?

23. Area Calculate the area of a picture frame that measures 17 cm × 12 cm.

Applying Skills

Use the graph to answer Questions 24–26.

A scientist measured the distance a lava stream flowed over 5 minutes.



24. Reading Graphs What is plotted on the horizontal axis? The vertical axis?

25. Interpreting Data Did the stream travel the same distance every minute? Explain.

26. Predicting Predict the movement of the stream between 5 and 6 minutes.

Lab zone Standards Investigation

Performance Assessment Present a brief summary of your experience while building your density-calculating system. Describe the most difficult part of construction. What steps were easiest? Defend the accuracy and reliability of your system, and describe its limitations.

Standards Practice

Choose the letter of the best answer.

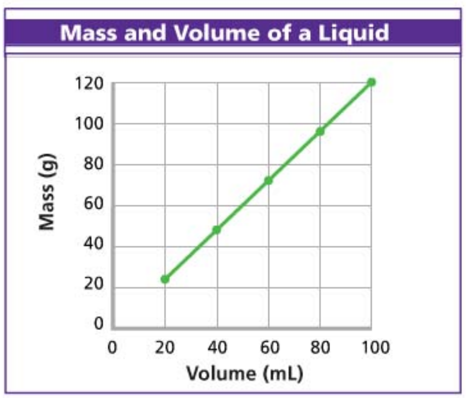
1. Ranida measured the length of a string several times as 21.5 cm, 21.3 cm, 21.7 cm, and 21.6 cm. The actual length is 25.5 cm. Which statement best describes Ranida's measurements?

A The measurements were accurate.
B The measurements were not accurate, but they were reproducible.
C The measurements were both accurate and reproducible.
D The measurements were neither accurate nor reproducible. **S 8.9.b**

2. A sample of sulfur has a mass of 12 g and a volume of 6.0 cm^3. What is the density of sulfur?

A 0.5 g/cm^3
B 2.0 g/cm^3
C 2.0 cm^3/g
D 72 g/cm^3 **S 8.8.b**

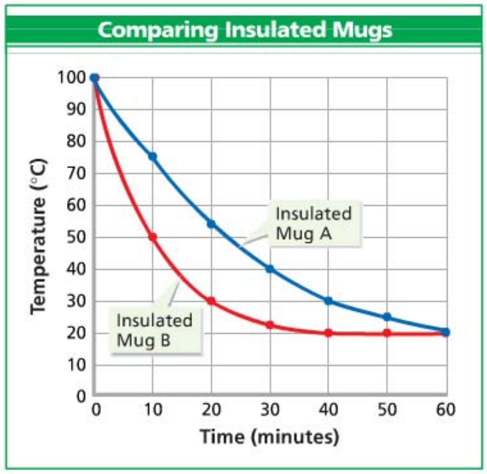
The graph below shows the masses of five different volumes of liquid. Use the graph and your knowledge of science to answer Question 3.



3. What is the slope of the graph line?

A –1.0 g/mL
B 1.0 g/mL
C 1.2 mL/g
D 1.2 g/mL **S 8.9.d**

The graph below compares how well two different brands of insulated mugs retain heat. Each mug was filled with the same volume of boiling water. Use the graph and your knowledge of science to answer Questions 4–5.



4. Which parameter in this experiment was the responding variable?

A the temperature of the water
B the location of the insulated mug
C the brand of insulated mug
D the length of time the water was allowed to cool **S 8.9.c**

5. What conclusion can you draw from this experiment?

A There is no difference between Brand A and Brand B.
B Brand A keeps water warmer than Brand B.
C Brand B keeps water warmer than Brand A.
D Brand B seems to add heat to the water. **S 8.9.a**

Apply the BIG Idea

6. Suppose you are given a sample of a liquid. How can you predict the mass of a much larger sample of the same liquid? Describe the measurements and calculations required to make your prediction. **S 8.8.a, S 8.9.a**