Name ______________________ Class ______________ Date ______________

CHAPTER 2 Data in Science

SECTION 1

Tools and Models in Science

California Science Standards

8.9.b, 8.9.f

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do scientists take measurements?
- What is the International System of Units?
- How do scientists use models to explain theories and scientific laws?

What Is a Tool?

Think about a tool that you have used. Whether it was a hammer, a drill, or a pair of scissors, the tool was something that helped you do a task. Scientists use tools when they do experiments, too. Most scientific data are collected by taking measurements. You can use a ruler or meter stick to measure length. The tool for measuring temperature is a thermometer. The figure below shows some of the tools that can be used in an experiment.

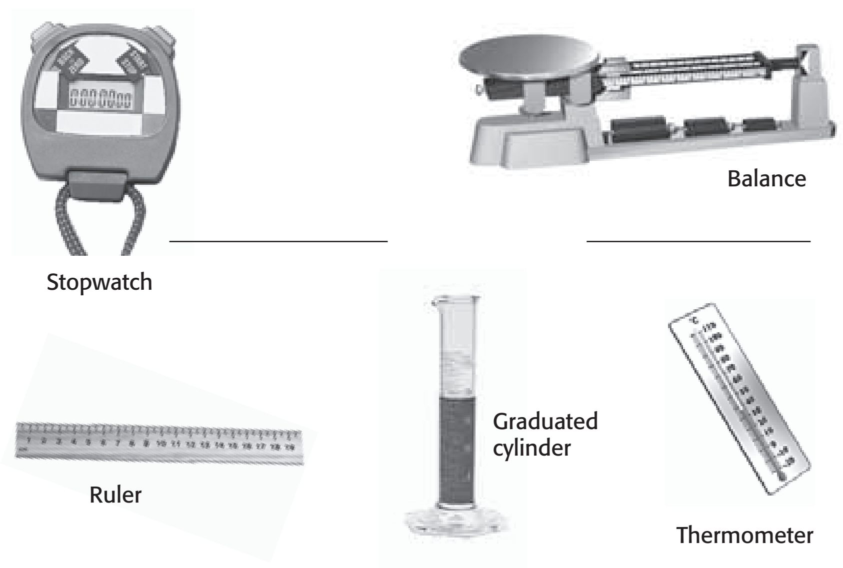
After you collect data, you need other tools to evaluate and analyze your results. Can you think of any tools for that? Calculators and computers are modern tools for analyzing data. You can also use the tools that came before calculators, such as graph paper. ☑

STUDY TIP

Map In your notebook, create a Concept Map about the SI units of measurement.

READING CHECK

1. Identify In the text, circle three tools for handling data.



These are some of the tools that you can use to make measurements.

TAKE A LOOK

2. Identify Fill in each blank with the type of measurement each tool makes.

INTERNATIONAL SYSTEM OF UNITS

Scientists use a metric system of measurement, in which all units are multiples of 10. It is called the International System of Units (SI). The abbreviation SI comes from its French name Système Internationale.

Each type of measurement has a base unit. For example, the meter is the base unit of length. SI uses prefixes for units that are larger or smaller than the base unit. When a prefix is put in front of a base unit, it changes how big the unit is. The table below shows some common prefixes and an example of how it changes the size of the base unit. ☑

READING CHECK

3. Describe When a prefix is put in front of a base unit, what does it do to the base unit?

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Common International System of Units (SI) Prefixes

SI prefix	Symbol	Size	Example
mega	M	one million	1 Mg = 1,000,000 g
kilo	k	one thousand	1 km = 1,000 m
deci	d	one-tenth	1 dg = 0.1 g
centi	c	one-hundredth	1 cm = 0.01 m
milli	m	one-thousandth	1 mg = 0.001 g
micro	μ	one-millionth	1 μm = 0.000001 m
nano	n	one-billionth	1 ng = 0.000000001 g

TAKE A LOOK

4. Identify What does the prefix "d" mean? How many grams are in 1 dg?

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LENGTH

The meter (m) is the SI base unit for length. Most people are between 1 m and 2 m tall. To measure shorter distances, you can use centimeters or millimeters. Scientists who work with atoms and molecules measure nanometers, which are billionths of a meter. A molecule that is 1 nm long is too small to see with the best light microscope. In the lab, you will usually use a meter stick or ruler to measure length.

MASS

Mass is the amount of matter in an object. The SI base unit for mass is the kilogram (kg). A medium-sized textbook has a mass of about 1 kg. You may measure the masses of small objects in grams, which are thousandths of a kilogram. The mass of a very large object, such as a ship or airplane, is often stated in units of metric tons. A metric ton is 1,000 kilograms. In the lab, you will use a balance to measure mass.

Critical Thinking

5. Identify Relationships How many times bigger is a metric ton than a kilogram?

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Common International System of Units (SI) Units		
Length	meter (m)	
	kilometer (km)	1 km = 1,000 m
	decimeter (dm)	1 dm = 0.1 m
	centimeter (cm)	1 cm = 0.01 m
	millimeter (mm)	1 mm = 0.001 m
	micrometer (µm)	1 µm = 0.000001 m
	nanometer (nm)	1 nm = 0.000000001 m
Volume	cubic meter (m^3)	
	cubic centimeter (cm^3)	1cm^3 = 0.000001 m^3
	liter (L)	1 L = 1 dm^3 = 0.001 m^3
	milliliter (mL)	1 mL = 0.001 L = 1 cm^3
Mass	kilogram (kg)	
	gram (g)	1 g = 0.001 kg
	milligram (mg)	1 mg = 0.000001 kg
Temperature	kelvin (K)	0°C = 273 K
		100°C = 373 K

Math Focus

6. Make Comparisons How many mm long is a line that measures 15 cm?

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TEMPERATURE

The **temperature** of a substance is a measure of how hot or cold it is. The units of temperature normally used in the lab are degrees Celsius (°C). Outside the lab, you will often see temperature expressed in degrees Fahrenheit (°F). The SI unit of temperature is the kelvin (K). A temperature change of 1 K is the same as 1°C, but the systems start at different zero values. The degree sign is not used in the Kelvin scale. ☑

READING CHECK

7. Define What is the SI unit for temperature and its symbol?

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Many signs in front of businesses show the temperature in both the Fahrenheit and Celsius scales. On a warm day, a sign might alternate between 82°F and 28°C. The table below compares the Fahrenheit, Celsius, and Kelvin scales.

TAKE A LOOK

8. Compare Determine the difference in temperature between the freezing point and boiling point of water on the Celsius scale and then on the Kelvin scale. How do they compare?

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Fahrenheit, Celsius, and Kelvin Temperature Scales

	Fahrenheit	Celsius	Kelvin
Freezing point of water	32°F	0°C	273 K
Normal body temperature	98.6°F	37°C	310 K
Boiling point of water	212°F	100°C	373 K

TIME

The unit of time in the SI system is the second, the same unit that your watch uses. Many scientific experiments are measured in seconds. Scientists often use nanoseconds or even smaller measures of time to measure the behavior of atoms, molecules, and light.

VOLUME

Length is the measure of an object in one direction. To know how much space the object occupies, you need more information. **Volume** is the amount of space that something occupies. For example, the volume of a rectangular solid is its length multiplied by its width multiplied by its height.

The liter (L) is the unit often used to measure volume of liquids and gases. Liters are based on the meter. The SI unit of volume is the cubic meter (m^3). One cubic meter (1 m^3) is the same volume as 1,000 L. This means a box that is 1 meter on each side will hold exactly 1,000 L. ☑

READING CHECK

9. Define What is the SI unit for volume, and what is its symbol?

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Volumes of Selected Substances	
Substance	**Volume**
12 oz can of soda	355 mL
bar of gold	640 cm^3
tank of helium gas	50 L

How Can Measurements Be Combined?

Some quantities used in science are not measured directly. Instead, they are calculated by combining two or more measurements mathematically. Some important combined measurements are density and speed.

DENSITY

You have already learned that mass and the volume of an object can be measured. The values of mass and volume can then be combined to determine another property of matter, its density. **Density** is the amount of matter in a given volume. It's a measure of how compact matter is. For example, liquid water is denser than steam because it is more compact than steam. ☑

READING CHECK

10. Define What is density?

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You cannot measure density directly. It is calculated by using the mass and volume of a substance in this formula:

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

In this formula, D represents the density of a material, m represents its mass, and V represents its volume. Density units used in science include grams per milliliter, kilograms per liter, and grams per cubic centimeter, but any combination of mass and volume can be used. The density of pure liquid water is 1.0 g/mL or 1.0 kg/L.

SPEED

Speed is a measure of the motion of an object. Speed is calculated by dividing the distance that an object moves by the time it takes to move that distance.

$$s = d/t$$

In this formula, s represents speed, d represents the distance, and t represents time. You are used to hearing speeds expressed in units of miles per hour or kilometers per hour. The most common unit of speed in the science lab is meters per second (m/s), but any combination of distance and time can be used. ☑

READING CHECK

11. Identify What units would you use to measure the speed of a car on the highway?

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What Is the Difference Between Accuracy and Precision?

Most people use the words *accuracy* and *precision* to mean the same thing. However, they do not mean the same thing. An accurate measurement means a measurement that is correct. A precise measurement means a measurement that is the same every time it is taken. This means that precise measurements can be reproduced.

For example, consider a line that is 15.3 mm long. Suppose that when you measure it five times, your measurement is 15.1 mm each time. Your measurement is not accurate, because it should have been 15.3 mm. However, it is precise because you got the same measurement each time.

Measurements that have good accuracy and good precision are called good data by scientists. These data are used to explain nature and make predictions about things that happen in nature.

CALIFORNIA STANDARDS CHECK

8.9.b Evaluate the accuracy and reproducibility of data.

12. Evaluate While doing a lab, a student collects the following data on the speed of a car: 2.5 m/s, 2.0 m/s, 2.3 m/s, and 2.9 m/s. The correct speed is 2.5 m/s. Were any of the data accurate? Explain your answer.

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Do the data show reproducibility? Explain your answer.

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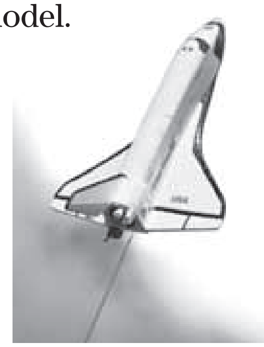
What Are Models?

Look at the illustration below. It appears to be a space shuttle. However, the wire that holds it in place and the lack of exhaust gases shows it is a model.

Model of a Space Shuttle



What Kinds of Models Do Scientists Use?

A **model** is a way to represent an object or a system. A model uses something familiar to help you understand something that is not familiar. For example, a model of a human skeleton can help you understand how the body works. Models are also used to explain the past or to predict the future.

Scientists use three different types of models: physical, conceptual, and mathematical models. These three kinds of models are used to show different things about objects or concepts. Models cannot show everything, because a model is never exactly like the thing it represents.

Say It

Explore Applications A model is never exactly like the thing it represents. Sometimes the model is larger, sometimes smaller. Some models are the same size as the object but simpler. Discuss in a group what types of models you have used and how they help you understand the object and how it works.

PHYSICAL MODELS

Model airplanes, dolls, and drawings are all examples of physical models. A physical model can show the details of something that is too large or too small to observe directly. For example, maps and drawings of bacteria are physical models. Scientists and engineers can build a simple model of an object to investigate how it works.

CONCEPTUAL MODELS

The second kind of model is a conceptual model, which puts many ideas together to explain something. For example, the big bang theory is a conceptual model that explains why the universe seems to be expanding. Astronomers built the model to explain the data that they had collected.

The big bang theory says that 12 billion to 15 billion years ago, an event called the big bang sent matter in all directions. This matter eventually formed the galaxies and planets.

MATHEMATICAL MODELS

Mathematical models use equations and data to explain or predict things. Weather maps are based on mathematical models of thousands of observations. Other mathematical models are the equations used to calculate force and acceleration. Many mathematical models are so complex that you need computers in order to use them. ☑

READING CHECK

13. Explain Why are computers needed for the mathematical models that represent weather?

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How Are Models Used?

Scientists use models to help represent ideas and objects. Models are also used to help you learn new information. Scientists often use models to explain concepts that are hard to understand. For example, an atom is much too small to see. However, a model of an atom can help you picture the parts of an atom and how atoms can combine with each other.

SCIENTIFIC THEORIES

In science, a **theory** is an explanation that combines many hypotheses and observations. A theory not only explains the observations, but it also makes predictions about what may happen in the future. Scientists use models to help organize information as they develop and test theories. ☑

Models can be changed or replaced as new information is added. The model of the structure of an atom has changed many times in the last 150 years. These changes have resulted in the model of an atom we use today.

READING CHECK

14. Describe What do models help scientists do as they develop theories?

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The compressed coils in the spring toy can be used to model the way air particles are crowded together in a sound wave.

TAKE A LOOK

15. Identify Which part of the spring models how molecules of air are close together?

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SCIENTIFIC LAWS

What happens when a model correctly predicts the results of many different experiments? Then a scientific law may be constructed. In science, a **law** is a summary of results and observations of many experiments. A law tells you how things work.

A scientific law is not a theory, because it does not explain why. For example, Newton's laws of motion explain how objects move. They let us accurately predict where an asteroid will be at a certain time 20 years from now. However, the laws of motion do not explain why the asteroid will be there. For that, you need to use the theory of gravity. Gravity explains the forces that cause bodies in space to attract each other over a distance.

Critical Thinking

16. Apply Concepts Picture the motion of a marble shot by a slingshot. Also picture the motion of a car on a race track. Which motion could you explain using a theory? Which could you explain using a law?

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Name ______________________ Class ______________ Date ______________

Section 1 Review

8.9.b, 8.9.f

SECTION VOCABULARY

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

law a summary of many experimental results and observations; a law tell how things work

mass a measure of the amount of matter in an object

model a pattern, plan, representation, or description designed to show the structure or workings of an object, system, or concept

temperature a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particle in an object

theory an explanation that ties together many hypotheses and observations

volume a measure of the size of a body or region in three-dimensional space

1. **Identify** What formula relates mass, volume, and density?

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2. **Classify** Fill in the blanks to complete the table of combined measurments.

What is calculated?	Formula	Unit
	$D = m/V$	kg/m^3
	$V = l \times w \times h$	m^3
Speed		

3. **Analyze Processes** To determine the density of a liquid, you measure its mass and its volume several times. What must the data show if they are good data? What must be the density of the liquid if the data are good?

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4. **Analyze Ideas** Why did scientists agree to use the SI units worldwide instead of the units common at their locations?

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5. **Make Calculations** If a bike rider travels 4 km in an hour, what is his speed measured in miles per hour?

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Name ________________ Class ________________ Date ________________

SECTION 2

Organizing Your Data

California Science Standards

8.9.c, 8.9.e, 8.9.g

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Why do scientists use data tables and graphs?
- What are dependent variables and independent variables in an experiment?
- What are linear and nonlinear graphs?

How Do You Make a Data Table?

STUDY TIP

Ask Questions Read this section silently. In your notebook, write down questions that you have about the section. Discuss your questions in a small group.

Have you ever started to do your homework and found that you have too much information? It can be hard to keep track of everything at one time. Scientists performing experiments also have to deal with a lot of information. For their data to be useful, they must be organized. This section will discuss some of the ways scientists organize data to make them easier to understand.

The first step is to know what kind of information you can gather from the experiment. Then, you can build a data table before you start. That helps keep all of the information organized so that nothing important is missed. A data table records the variables from an experiment. ☑

READING CHECK

1. Identify What is recorded on a data table?

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Too much information can be overwhelming if it is not organized.

INDEPENDENT AND DEPENDENT VARIABLES

Look at the data table below. It has two columns that list two kinds of information that are related to each other. The first column shows the values for the independent variable. The **independent variable** is the factor that the experimenter decides to change or control. This experimenter is studying the number of hours a class exercises each week. The independent variable is the week during which data are recorded.

The second column in the data table shows the values for the dependent variable. The **dependent variable** is the factor that changes because the independent variable has changed. In the data table, the dependent variable is the number of hours exercised. This number varies depending on which week is studied. ☑

READING CHECK

2. Compare How does the independent variable differ from the dependent variable?

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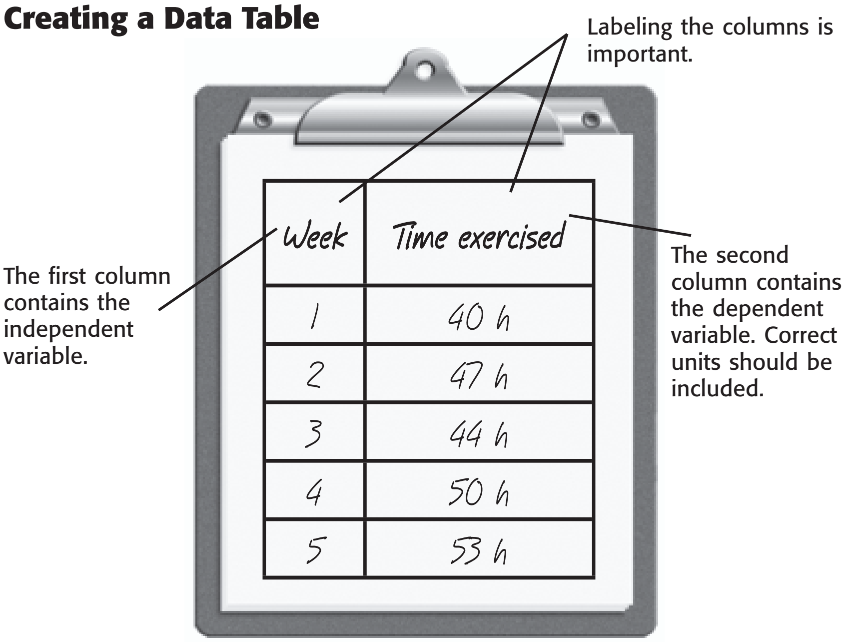
Creating a Data Table



Week	Time exercised
1	40 h
2	47 h
3	44 h
4	50 h
5	53 h

TAKE A LOOK

3. Explain Why is it important to label the columns in a data table?

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VARIABLE AND CONTROLLED PARAMETERS

When you design an experiment, you must consider a number of things. *Controlled parameters* are things or conditions that do not change. For example, in the exercise experiment, the data must include the same student each week. Also, the same activities are recorded as exercise each week. These are controlled parameters. *Variable parameters* change during the experiment. The total number of hours of exercise is a variable parameter in this experiment.

Critical Thinking

4. Evaluate Methods Why do all of the parameters, except the independent variable, have to be controlled?

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How Can You Use Graphs?

Data tables help organize data. Graphs help you understand and use the data. Graphs are used to see trends and to make predictions. By graphing the data in the experiment on the previous page, you can see any changes in the amount of exercise over time.

AXES

The illustration in the figure below shows how to make a graph. First, use a data table to determine the axes (singular, *axis*) of the graph. An **axis** is a reference line that forms one side of a graph. The horizontal axis is called the *x*-axis, and the vertical axis is the *y*-axis. On a graph, the *x*-axis is the independent variable, and the *y*-axis is the dependent variable ☑

Labels on the axes show which variables they represent. In the graph below, the *x*-axis shows which week the data were collected. The *y*-axis shows the number of hours of exercise.

READING CHECK

5. Identify Which axis is generally used for the independent variable?

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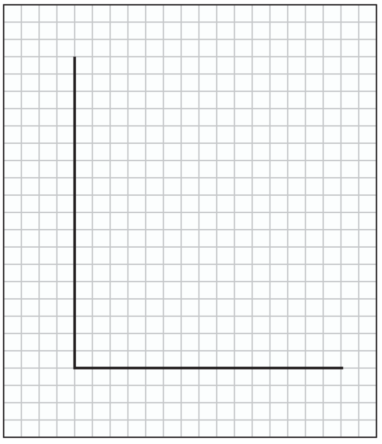
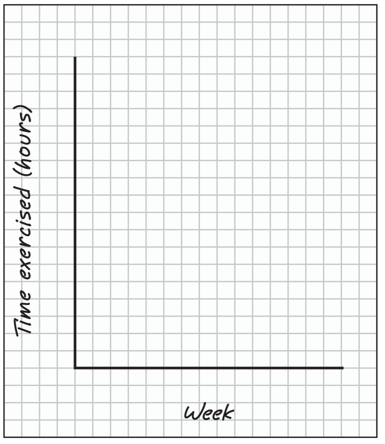


Drawing the Axes Your horizontal and vertical axes should be long enough to fit all of your data.



Labeling Your Axes Each axis should have a label and, when needed, the correct unit.

TAKE A LOOK

6. Describe What two things does each label on a graph tell you?

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RANGE

Each axis has a range, or the spread of values to be recorded. To find the range, subtract the smallest value of the variable from the largest value. For this graph, the range of the *x*-axis (independent variable) is 5 weeks. That means the *x*-axis must cover a time of at least 5 weeks. The range of the *y*-axis (dependent variable) is 53 hours minus 40 hours, or 13 hours. So, the *y*-axis of the graph has to have enough room for at least 13 hours. ☑

READING CHECK

7. Identify What is the term used to describe the spread of values of a variable?

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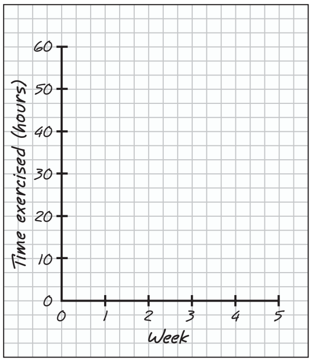
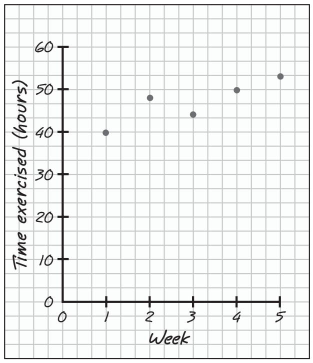
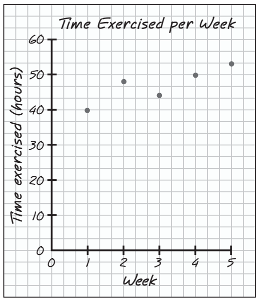


Determining Range and Scale
Each axis on a graph has its own scale so that the data can be easily seen.



Plotting the Data Points
The easiest part of creating a graph is taking pairs of data and putting them where they belong.



Labeling the Graph Every graph needs a good title that tells the reader what the graph is all about.

SCALE AND DATA POINTS

The next step is choosing a scale for the graph, as shown in the figure above. Each axis has a scale—the size used for each box or grid mark. For the exercise data, a scale of 1 week is used. The weeks are spaced so that the range fits across the graph. Each week is marked with a grid mark, or short line. For the *y*-axis, grid marks are placed at a scale of 10 hours.

The scale should be chosen so that the graph spreads out to fill most of the available space. Each axis is labeled to tell what information it shows. If the measurement includes units, such as meters or seconds, these units are also shown on the axis.

Once the scale is marked, you add the data points by putting dots on the graph. Each dot represents one set of information. In this case, each dot represents the amount of time exercised in a particular week. Data points are shown in the figure above.

TITLE

Every graph needs a title that helps the reader figure out what it shows. The title should be fairly short. It usually includes information about the variables.

Math Focus

8. Read a Graph Use one of the graphs to find how many hours the class exercised during week 4.

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CALIFORNIA STANDARDS CHECK

8.9.e Construct appropriate graphs from data and develop quantitative statements about the relationships between variables.

Word Help: **appropriate**
correct for use; proper

9. Analyze Relationships Based on the data on the graph in the figure, did the amount of exercise increase, decrease, or stay the same during the period in which data were recorded?

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What Patterns Do Graphs Show?

The graph below shows the data points that were plotted on the previous page. Notice that a line has been added. Normally, on a graph, points are not connected dot to dot. Instead, a "line of best fit" is drawn to show the pattern in the data.

The pattern shown by a straight line sloping up to the right is called a *direct relationship*. This means that as the independent variable increases, the dependent variable increases. A straight line sloping to the left is called an *inverse relationship*. This means that as the independent variable increases, the dependent variable decreases.

TAKE A LOOK

10. Explain How can you tell that the relationship shown by the graph is a direct relationship?

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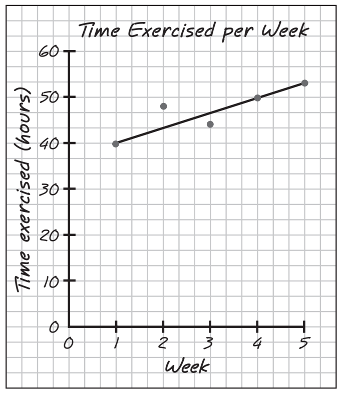
A graph shows the general relationship between two variables. The line that shows the relationship may not go through each point. Instead, it is the **line of best fit** for the data. A straight line shows a linear relationship.



LINEAR AND NONLINEAR GRAPHS

Graphs make it easy to see if something is increasing, decreasing, or staying the same. If the relationship between the independent and dependent variables can be shown with a straight line, as in the figure above, the graph is called a *linear graph*.

Sometimes the relationship between variables is not a straight line, but a smooth curve. If the data cannot be shown with a straight line, the graph is *nonlinear*. The figure below shows two examples of nonlinear graphs.

TAKE A LOOK

11. Identify On a graph, what indicates whether a relationship is nonlinear direct or nonlinear inverse?

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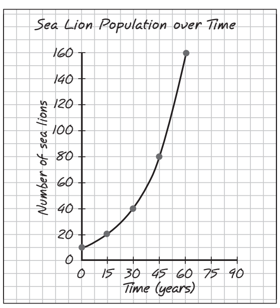
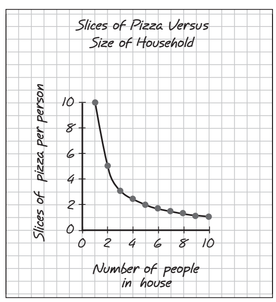
Trends in Nonlinear Graphs



Direct Nonlinear Relationship
The dependent variable increases as the independent variable increases.



Inverse Nonlinear Relationship
The dependent variable decreases as the independent variable increases.

Name ________________ Class ________________ Date ________________

Section 2 Review

8.9.c, 8.9.e, 8.9.g

SECTION VOCABULARY

axis one of two or more reference lines that mark the borders of a graph

dependent variable in an experiment, the factor that changes as a result of manipulation of one or more other factors (the independent variables)

independent variable in an experiment, the factor that is deliberately manipulated

<u>**Wordwise**</u> The prefix *in-* means “not.” Other examples are *ineffective* and *insane*.

1. **Explain** Why are the dependent and independent variables plotted on different axes of a graph?

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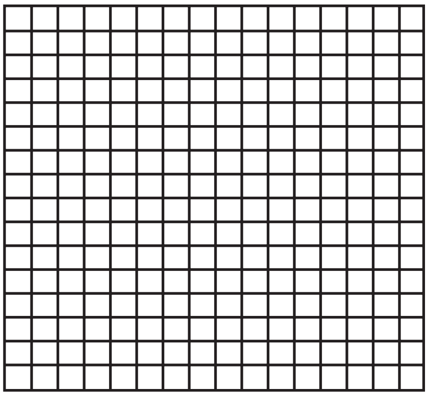
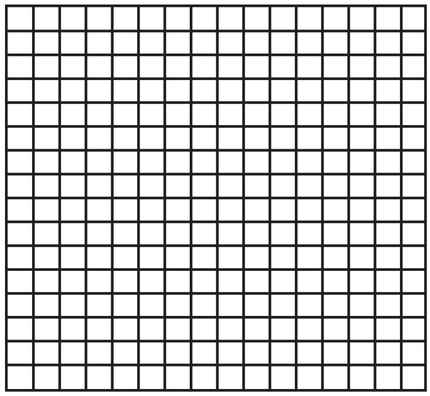
2. **Compare** On the first grid, draw a line showing an inverse linear relationship. On the second grid, draw a line showing a direct nonlinear relationship.

3. **Analyze Processes** Why is it necessary to have an independent variable that is changed by the experimenter during an experiment?

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4. **Draw Conclusions** What conclusion can you draw if the line of best fit on a linear graph does not slope either up or down but is horizontal?

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5. **Apply Ideas** Your class performed an experiment to determine the effect of the amount of light on plant growth. Some plants received 4 hours of light every day, while others received 6, 8, or 10 hours. After two weeks, you measured the height of the plants. What are the dependent and independent variables in the experiment?

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SECTION 3 Analyzing Your Data

California Science Standards

8.9.b, 8.9.d

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Why is mathematics an important tool for scientists?
- How do accuracy and reproducibility of data affect the conclusions of scientific studies?
- How can linear equations and graphs help analyze data?

STUDY TIP

Clarify Concepts Take turns reading this section out loud with a partner. Stop to discuss ideas that seem confusing.

Why Is Mathematics Important?

Mathematical models are used in making complicated aircraft such as the space vehicle shown below. Engineers use mathematics to predict how the vehicles will work before the first one is built.

Mathematics is used by scientists to answer questions. It helps them to find out the properties of materials, and it allows scientists to organize information. This information is used to make predictions. For example, meteorologists gather large amounts of data about hurricanes and use mathematics to predict a hurricane's path.

Mathematics also allows scientists to communicate information. Even if they speak different languages, two scientists from different countries use mathematics in the same way. Because it allows people to share their findings in a common way, mathematics is often called the language of science. ☑

READING CHECK

1. Explain Why is mathematics referred to as the "language of science"?

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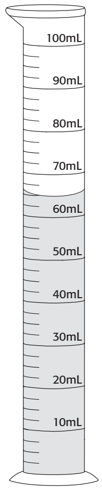
On October 4, 2004, SpaceShipOne rocketed into history. It became the first non-government spacecraft to exceed an altitude of 328,000 ft twice within the span of a 14-day period. For being the first privately owned spacecraft to do this, it won $10,000,000.

Say It

Discuss Why is it important to use mathematical models before building a large flying machine? Discuss in a small group what other kinds of projects would use mathematical models.

The most accurate reading of the liquid's volume is made by looking at the bottom of the meniscus at eye level.



TAKE A LOOK

2. Identify What is the volume of the liquid in the graduated cylinder?

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How Can You Be Sure Data Is Accurate?

When scientists collect data, they want to be certain that it is accurate. That is, they want the results to be correct. For example, suppose a scientist places an object with a mass of 450 g on a balance. If the balance gives a reading of 525 g, the reading is inaccurate. Causes of inaccurate data include broken equipment, using the wrong tool, and using a tool incorrectly.

The first step in getting an accurate measurement is using the right tool. The graduated cylinder in the figure above will let you get much more accurate readings than a kitchen measuring cup will. The ruler that shows millimeter markings allows more accuracy than a ruler whose smallest intervals are centimeters.

Accurate data require more than just the right tool; you also have to use the tool correctly. With a graduated cylinder, you will get an inaccurate result if you don't read the volume with the bottom of the meniscus at eye level. To get an accurate reading on a ruler, you need to look straight down at the object being measured. If your head is to the side, your reading will be a bit different.

Critical Thinking

3. Analyze Methods If you wanted to measure the width of the gym, how would the accuracy of a meter stick compare with that of a 50 m tape? Explain your answer.

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What Is Reproducibility?

When scientists do an experiment, they expect it to be repeated, or reproduced, by other scientists. If someone else uses the same process and equipment, they should get the same result. If the data cannot be reproduced, then other scientists will not accept the results. If you want other people to agree with your conclusions, your data must be reproducible.

How Can You Describe a Data Set?

When scientists analyze data, they often find it helpful to use a single number to describe the entire set of data. Three measures that are used to do this are the *mean*, the *median*, and the *mode*. The figure below shows how these measures are determined.

The **mean** is also called an "average." It is found by adding the data points together, then dividing the total by the number of data points. The **median** is the value of the data point in the middle when the data are placed in order from smallest to largest. The median is useful for describing data when one point is much larger or smaller than the rest of the data. The **mode** is the number that appears most often in a data set. ☑

READING CHECK

4. Identify Which measure refers to the value of the point in the middle of the data set?

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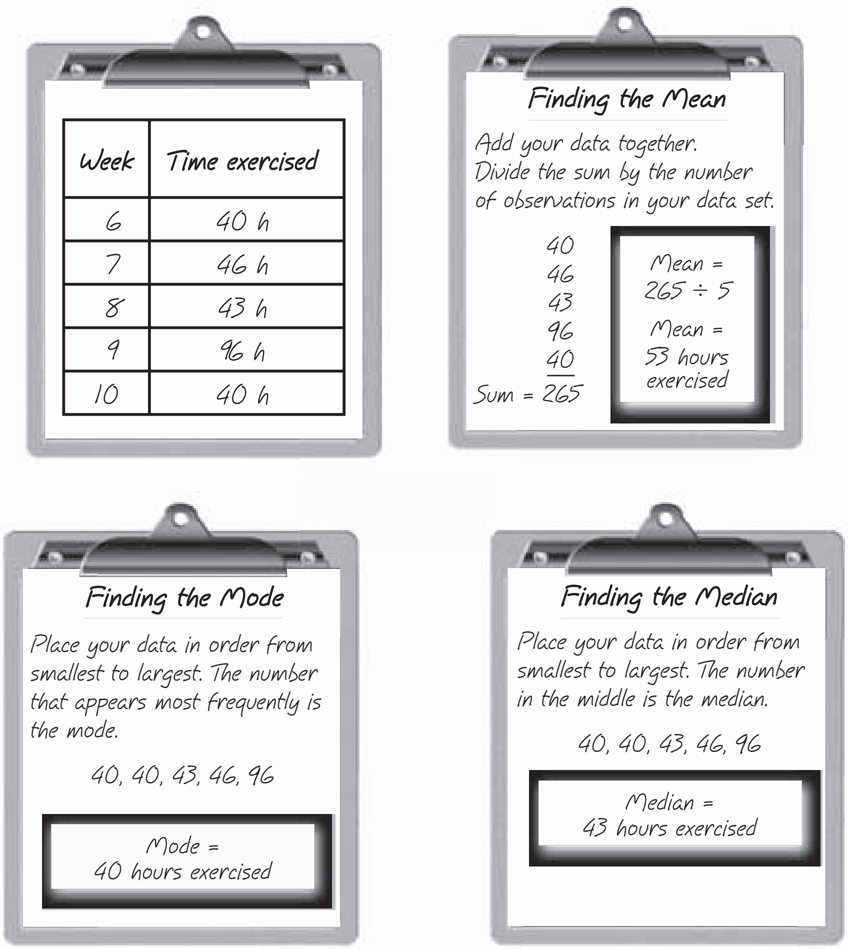
Analyzing the Entire Set of Data



Math Focus

5. Evaluate Data Find the mean and the mode of the following data set: 8, 12, 10, 8, 7.

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6. Apply Concepts What is the median of the following data set: 52, 48, 66, 66, 8?

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How Can You Find and Use the Slope of a Line?

When you talk about skiing downhill, the trail you follow has a slope. In math, **slope** is defined as the degree of slant of a line. To calculate the slope of a line, you use two values called the *rise* and the *run* of the line. The rise is the vertical change. On your graph, the rise is the change in y, or the number of units moved up or down. The run is the change in x, or the number of units moved to the right or left. ☑

The slope of a line is determined by dividing the vertical change by the horizontal change. In other words, the slope of a straight line is found by dividing the rise by the run. This is often called "rise over run."

The slope of the line of graphed data can help you analyze the data. Graphs below show two sets of data. For each line, the value of the slope between any two points will be a constant number.

In this example, the slope represents the speed (in meters per second) of an object moving at a constant rate. Notice that the units of the slope are the units of the y-axis divided by the units of the x-axis. The slope can be positive or negative, as shown. If a line is horizontal, its slope is zero. In this case, a slope equal to zero shows that the object isn't moving. It is stationary.

READING CHECK

7. Identify What kind of change is represented by the rise of a line? By the run?

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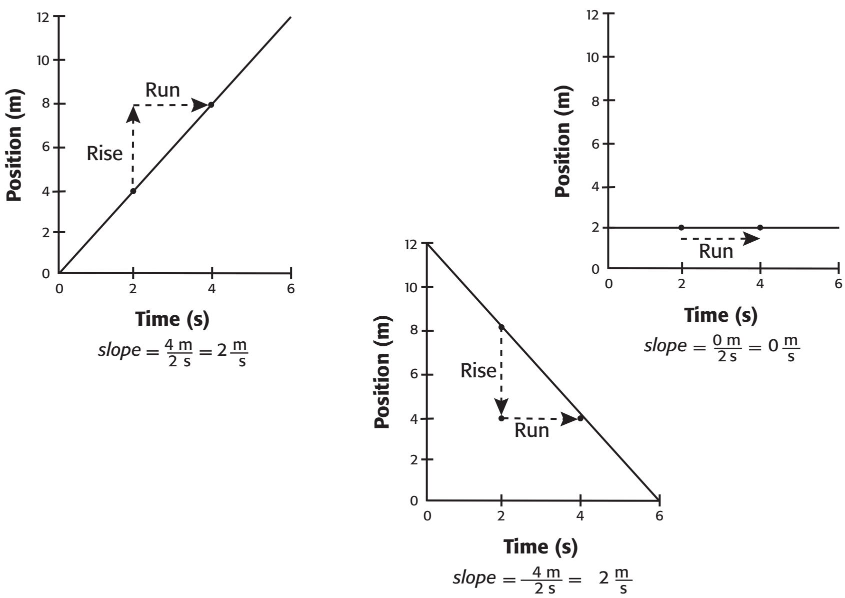

The results of three sets of data can be graphed to analyze data. Here, the slope of a line on a position verses time graph gives the speed of the object.

TAKE A LOOK

8. Define What happens to the value of y as x increases if the slope is negative?

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SLOPE AS A CONSTANT

Some experiments result in a graph that is a straight line beginning at $x = 0$ and $y = 0$, the origin of the graph. In this case, the equation $y = kx$ can be used to represent the data. The letter k represents a constant term, which is equal to the slope of the line. The slope of a straight line has only one value.

This kind of graph is shown below. In this graph, the y-axis represents the measurement of the mass of a piece of lead. The volume measurement is represented by x. The graph is linear, in the form $y = kx$. The value of k is the density of lead. Substituting the letters used for mass, volume, and density in the equation gives the equation $m = DV$.

CALIFORNIA STANDARDS CHECK

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

Word Help: constant
a quantity whose value does not change

9. Analyze Relationships From the graph at right, how do you know that density is a constant?

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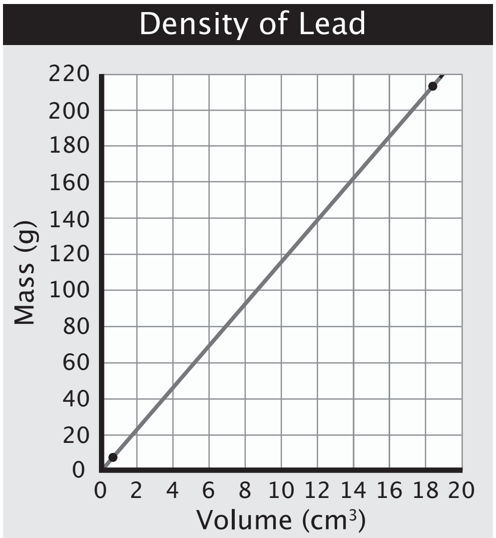

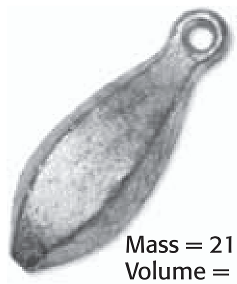

The line in the graph above represents the constant density of lead. When the mass and volume measurements for the two lead fishing weights are plotted, the data points fall on the line in the graph.

How Do Linear and Nonlinear Graphs Compare?

The lines on a graph can help you draw conclusions about the data. The slope of a straight line has only one value. This means that the change in y is always the same amount for a particular change in x.

Many of the relationships that scientists study are not linear. In a nonlinear graph, a change in x does not cause the same change in y. The graph of this kind of relationship forms a curved line instead of a straight line. In a nonlinear relationship, there is no one slope that applies to all the data.

Name ______________________ Class ______________ Date ______________

Section 3 Review

8.9.b, 8.9.d

SECTION VOCABULARY

mean the number obtained by adding up the data for a given characteristic and dividing this sum by the number of individuals

median the value of the middle item when data are arranged in order by size

mode the most frequently occurring value in a data set

slope a measure of the slant of a line; the ratio of rise over run

1. **Calculate** Determine the mean, median, and mode for this data set: 12, 10, 6, 9, 6, 7, 6. Show how you calculated the mean.

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2. **Classify** Fill in the blanks to complete the table.

Measure	**What it is**
	rise over run on a linear graph
Median	
Mode	
	the average value of a data set

3. **Draw Conclusions** You perform an experiment concerning the number of different types of seed and the number of birds at your bird feeder. After collecting data for a week, you plot it on a graph and find that the line of best fit is a horizontal line. What conclusion can you make?

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4. **Apply Concepts** A graph is made that plots the distance a car moves, in meters, on the *y*-axis. The time it takes to move that distance, in seconds, is shown on the *x*-axis. What would calculating the slope tell you about the car's motion? What are the units of the slope?

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5. **Evaluate Data** A student collects the following data for aluminum: mass equals 24 g, and volume equals 6.0 cm^3. The known density of aluminum is 2.7 cm^3. Are the student's data accurate? Show your work.

$$D = \frac{m}{V} \quad \frac{24\text{ g}}{6.0\text{ cm}^3} = 4\text{ g/cm}^3$$

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2. 65 mL
3. The meter stick would be less accurate because you can introduce errors every time you move it as you cross the gym.
4. median
5. 9, 8
6. 52
7. the change in y values; the change in x values
8. The value of y decreases.
9. The density is the slope of the line, and the slope of the line has only one value.

Review

1. Mean is $(12 + 10 + 6 + 9 + 6 + 7 + 6) \div 7 = 8$; median is 9; mode is 6.
2. Slope is rise over run on a linear graph.
   Median is the middle value of a data set arranged least to greatest.
   Mode is the data value that occurs most often in a data set.
   Mean is the average value of a data set.
3. The slope of the line is zero, so a change in number of seed types has no effect on the number of birds at the feeder.
4. The slope will give the speed of the car, in meters per second.
5. The data are not accurate. The density is larger than the known value.

Chapter 3 Properties of Matter

SECTION 1 WHAT IS MATTER

1. volume: liter
   mass: kilogram
   weight: newton
2. the amount of space that an object takes up
3. 1,900 mL
4. the curved surface of a liquid in a container
5. The line should curve downward from the 7 mL line to the 6 mL line and back to the 7 mL line.
6. volume
7. area
8. 1 m^2
9. Possible answer: Put the car into a known volume of water in a graduated cylinder. Measure how much the volume increases.
10. the amount of matter in it
11. weight
12. none, change
13. kilograms, grams, milligrams
14. newton (N)

Review

1. An apple has a mass and takes up space.
2. Mass is a measure of how much matter is in an object. Weight is a measure of the force due to gravity on an object.
3. 19 mL
4. 40 mL
5. $V = A \times h$; $V = 1{,}960\ cm^2 \times 23\ cm = 45{,}080\ cm^3$ No, the luggage is too big.

SECTION 2 PHYSICAL PROPERTIES

1. properties that can be observed and measured without making a new substance
2. its mass or weight, its density, its compressibility
3. the amount of matter in a given space
4. 15 times as much, or 43 more grams
5. $D = m \div V$
   $D = 28\ g \div 1.45\ cm^3$
   $= 19.3\ g/cm^3$
6. at the same temperature and pressure
7. zinc
8. when it is denser than water
9. The diet soda; it floats.
10. it has the smallest density
11. a change that affects the physical properties of a substance
12. melting
13. a change of state
14. A gas can change into a liquid or into a solid.
15. nothing

Review

1. Divide the mass of the substance by its volume.
2. No, because all the substances are more dense than methanol.
3. aluminum
4. The ball with the smaller volume has the larger density.
5. Its volume must increase.

SECTION 3 CHEMICAL PROPERTIES

1. change into new matter