

# Foundations for Algebra

## 1A The Language of Algebra

- 1-1 Variables and Expressions
- Lab Create a Table to Evaluate Expressions
- 1-2 Adding and Subtracting Real Numbers
- 1-3 Multiplying and Dividing Real Numbers
- 1-4 Powers and Exponents
- 1-5 Roots and Real Numbers

## 1B The Tools of Algebra

- 1-6 Order of Operations
- 1-7 Simplifying Expressions
- 1-8 Introduction to Functions

### Chapter Focus

- Solve problems with real numbers.
- Make connections between verbal and algebraic representations.

## Discovering the “Magic”

You can use the operations and properties in this chapter to complete a magic square.

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Chapter Project Online  
KEYWORD: MA7 ChProj



# ARE YOU READY?

## ✓ Vocabulary

Match each term on the left with a definition on the right.

- |               |  |
|---------------|--|
| 1. difference | A. the distance around a figure                                    |
| 2. factor     | B. a number that is multiplied by another number to form a product |
| 3. perimeter  | C. a result of division  |
| 4. area       | D. the number of square units a figure covers                      |
|               | E. a result of subtraction   |

## ✓ Whole Number Operations

Add, subtract, multiply, or divide.

- |             |                  |                   |              |
|-------------|------------------|-------------------|--------------|
| 5. $23 + 6$ | 6. $156 \div 12$ | 7. $18 \times 96$ | 8. $85 - 62$ |
|-------------|------------------|-------------------|--------------|

## ✓ Add and Subtract Decimals

Add or subtract.

- |                 |                   |                    |                |
|-----------------|-------------------|--------------------|----------------|
| 9. $2.18 + 6.9$ | 10. $0.32 - 0.18$ | 11. $29.34 + 0.27$ | 12. $4 - 1.82$ |
|-----------------|-------------------|--------------------|----------------|

## ✓ Multiply Decimals

Multiply.

- |                      |                      |                      |                        |
|----------------------|----------------------|----------------------|------------------------|
| 13. $0.7 \times 0.6$ | 14. $2.5 \times 0.1$ | 15. $1.5 \times 1.5$ | 16. $3.04 \times 0.12$ |
|----------------------|----------------------|----------------------|------------------------|

## ✓ Divide Decimals

Divide.

- |                   |                   |                    |                     |
|-------------------|-------------------|--------------------|---------------------|
| 17. $6.15 \div 3$ | 18. $8.64 \div 2$ | 19. $7.2 \div 0.4$ | 20. $92.7 \div 0.3$ |
|-------------------|-------------------|--------------------|---------------------|

## ✓ Multiply and Divide Fractions

Multiply or divide. Give your answer in simplest form.

- |                                      |                                    |                                      |                          |
|--------------------------------------|------------------------------------|--------------------------------------|--------------------------|
| 21. $\frac{3}{5} \times \frac{1}{2}$ | 22. $\frac{2}{3} \div \frac{1}{6}$ | 23. $\frac{7}{8} \times \frac{4}{7}$ | 24. $4 \div \frac{2}{3}$ |
|--------------------------------------|------------------------------------|--------------------------------------|--------------------------|

## ✓ Add and Subtract Fractions

Add or subtract. Give your answer in simplest form.

- |                                 |                                 |                                 |                                 |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 25. $\frac{2}{5} + \frac{2}{5}$ | 26. $\frac{3}{8} - \frac{1}{8}$ | 27. $\frac{1}{2} + \frac{1}{4}$ | 28. $\frac{2}{3} - \frac{4}{9}$ |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|



### Where You've Been

#### Previously, you

- learned words related to mathematical operations.
- identified numbers on a real number line.
- performed operations on whole numbers, decimals, and fractions.
- plotted points in the coordinate plane.

### In This Chapter

#### You will study

- how to evaluate and simplify expressions.
- properties of the real number system.
- the order of operations.
- patterns formed by points plotted in the coordinate plane.

### Where You're Going

#### You can use the skills in this chapter

- to form a solid foundation for the rest of this algebra course.
- in other classes, such as Biology, History, and Physics.
- to determine final costs, stock values, and profit.

### Key Vocabulary/Vocabulario

|                    |                      |
|--------------------|----------------------|
| additive inverse   | inverso aditivo      |
| coefficient        | coeficiente          |
| constant           | constante            |
| coordinate plane   | plano cartesiano     |
| irrational numbers | números irracionales |
| like terms         | términos semejantes  |
| origin             | origen               |
| rational numbers   | números racionales   |
| variable           | variable             |

### Vocabulary Connections

To become familiar with some of the vocabulary terms in the chapter, consider the following. You may refer to the chapter, the glossary, or a dictionary if you like.

1. The word **variable** comes from the word *vary*. What does *vary* mean? Which of the key vocabulary terms above has the opposite meaning?
2. Another word for *inverse* is *reverse*. The word *additive* relates to the operation of addition. What do you think an **additive inverse** is?
3. The prefix *ir-* means “not.” What relationship do you think **rational numbers** and **irrational numbers** may have?
4. To *originate* means “to begin at.” What do you think the **origin** of a coordinate plane is?

## Reading Strategy: Use Your Book for Success

Understanding how your textbook is organized will help you locate and use helpful information.

Pay attention to the **margin notes**. Know-It Note icons point out key information. Writing Math notes, Helpful Hints, and Caution notes help you understand concepts and avoid common mistakes.



### Writing Math

These expressions mean "2 times y":  
 $2y$        $2(y)$

### Helpful Hint

A replacement set is a set of numbers that can be substituted

### Caution!

In the expression  $-5^2$ , 5 is the base because the negative sign is not

The **Glossary** is found in the back of your textbook. Use it as a resource when you need the definition of an unfamiliar word or property.

### Glossary/Glos

**A**

#### ENGLISH

**absolute value** (p. 14) The absolute value of  $x$  is the distance from zero to  $x$  on a number line.

The **Index** is located at the end of your textbook. Use it to locate the page where a particular concept is taught.

### Index

**A**

Aaron, Hank, 42  
**Absolute error**, 555  
**Absolute value**, 14, 148  
 equations, 148–149  
 functions, 366–367

The **Problem-Solving Handbook** is found in the back of your textbook. These pages review strategies that can help you solve real-world problems.

### Problem Sol

#### Draw a Diagram

You can **draw a diagram** when the words of a problem are

## Try This

Use your textbook for the following problems.

1. Use the index to find the page where each term is defined: *algebraic expression*, *like terms*, *ordered pair*, *real numbers*.
2. What mnemonic device is taught in a Helpful Hint in Lesson 1-6, Order of Operations?
3. Use the glossary to find the definition of each term: *additive inverse*, *constant*, *perfect square*, *reciprocal*.

# 1-1

# Variables and Expressions

### Objectives

Translate between words and algebra.

Evaluate algebraic expressions.

### Vocabulary

variable  
constant  
numerical expression  
algebraic expression  
evaluate

### Why learn this?

Variables and expressions can be used to determine how many plastic drink bottles must be recycled to make enough carpet for a house.

A home that is “green built” uses many recycled products, including carpet made from recycled plastic drink bottles. You can determine how many square feet of carpet can be made from a certain number of plastic drink bottles by using *variables*, *constants*, and *expressions*.



Container City, in East London, UK, is a development of buildings made from recycled shipping containers.

A **variable** is a letter or symbol used to represent a value that can change.

A **constant** is a value that does not change.

A **numerical expression** may contain only constants and/or operations.

An **algebraic expression** may contain variables, constants, and/or operations.

You will need to translate between algebraic expressions and words to be successful in math. The diagram below shows some of the ways to write mathematical operations with words.



## EXAMPLE 1 Translating from Algebraic Symbols to Words

### Writing Math

These expressions all mean “2 times  $y$ ”:

$$2y \quad 2(y)$$

$$2 \cdot y \quad (2)(y)$$

$$2 \times y \quad (2)y$$

Give two ways to write each algebraic expression in words.

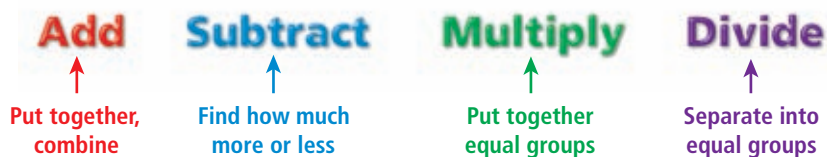
- |   |  |
|---|--|
| <p><b>A</b> <math>x + 3</math><br/>the sum of <math>x</math> and 3<br/><math>x</math> increased by 3</p>  | <p><b>B</b> <math>m - 7</math><br/>the difference of <math>m</math> and 7<br/>7 less than <math>m</math></p>   |
| <p><b>C</b> <math>2 \cdot y</math><br/>2 times <math>y</math><br/>the product of 2 and <math>y</math></p> | <p><b>D</b> <math>k \div 5</math><br/><math>k</math> divided by 5<br/>the quotient of <math>k</math> and 5</p> |



Give two ways to write each algebraic expression in words.

- 1a.  $4 - n$       1b.  $\frac{t}{5}$       1c.  $9 + q$       1d.  $3(h)$

To translate words into algebraic expressions, look for words that indicate the action that is taking place.



## EXAMPLE 2 Translating from Words to Algebraic Symbols

- A** Eve reads 25 pages per hour. Write an expression for the number of pages she reads in  $h$  hours.

$h$  represents the number of hours that Eve reads.

$$25 \cdot h \text{ or } 25h \quad \textit{Think: } h \text{ groups of 25 pages.}$$

- B** Sam is 2 years younger than Sue, who is  $y$  years old. Write an expression for Sam's age.

$y$  represents Sue's age.

$$y - 2 \quad \textit{Think: "younger than" means "less than."}$$

- C** William runs a mile in 12 minutes. Write an expression for the number of miles that William runs in  $m$  minutes.

$m$  represents the total time William runs.

$$\frac{m}{12} \quad \textit{Think: How many groups of 12 are in } m?$$



- 2a.** Lou drives at 65 mi/h. Write an expression for the number of miles that Lou drives in  $t$  hours.

- 2b.** Miriam is 5 cm taller than her sister, who is  $m$  cm tall. Write an expression for Miriam's height in centimeters.

- 2c.** Elaine earns \$32 per day. Write an expression for the amount that she earns in  $d$  days.

To **evaluate** an expression is to find its value. To evaluate an algebraic expression, substitute numbers for the variables in the expression and then simplify the expression.

## EXAMPLE 3 Evaluating Algebraic Expressions

Evaluate each expression for  $x = 8$ ,  $y = 5$ , and  $z = 4$ .

**A**  $x + y$

$$\begin{aligned} x + y &= 8 + 5 && \textit{Substitute 8 for } x \text{ and 5 for } y. \\ &= 13 && \textit{Simplify.} \end{aligned}$$

**B**  $\frac{x}{z}$

$$\begin{aligned} \frac{x}{z} &= \frac{8}{4} && \textit{Substitute 8 for } x \text{ and 4 for } z. \\ &= 2 && \textit{Simplify.} \end{aligned}$$



Evaluate each expression for  $m = 3$ ,  $n = 2$ , and  $p = 9$ .

- 3a.**  $mn$                       **3b.**  $p - n$                       **3c.**  $p \div m$

### EXAMPLE 4 Recycling Application

Approximately fourteen 20-ounce plastic drink bottles must be recycled to produce 1 square foot of carpet.

- a. Write an expression for the number of bottles needed to make  $c$  square feet of carpet.

The expression  $14c$  models the number of bottles needed to make  $c$  square feet of carpet.

- b. Find the number of bottles needed to make 40, 120, and 224 square feet of carpet.

Evaluate  $14c$  for  $c = 40, 120,$  and  $224$ .

| $c$ | $14c$            |
|-----|------------------|
| 40  | $14(40) = 560$   |
| 120 | $14(120) = 1680$ |
| 224 | $14(224) = 3136$ |

To make 40 ft<sup>2</sup> of carpet, 560 bottles are needed.

To make 120 ft<sup>2</sup> of carpet, 1680 bottles are needed.

To make 224 ft<sup>2</sup> of carpet, 3136 bottles are needed.



#### Helpful Hint

A replacement set is a set of numbers that can be substituted for a variable. The replacement set in Example 4 is {40, 120, 224}.



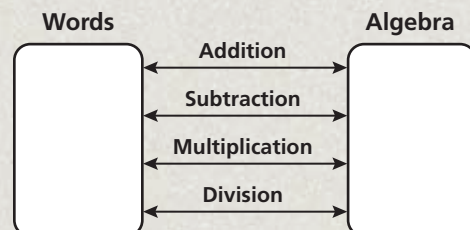
4. To make one sweater, sixty-three 20-ounce plastic drink bottles must be recycled.
- a. Write an expression for the number of bottles needed to make  $s$  sweaters.
- b. Find the number of bottles needed to make 12, 25, and 50 sweaters.

### THINK AND DISCUSS

1. Write two ways to suggest each of the following, using words or phrases: addition, subtraction, multiplication, division.
2. Explain the difference between a numerical expression and an algebraic expression.



3. **GET ORGANIZED** Copy and complete the graphic organizer. Next to each operation, write a word phrase in the left box and its corresponding algebraic expression in the right box.





### GUIDED PRACTICE

1. **Vocabulary** A(n) \_\_\_\_\_? \_\_\_\_\_ is a value that can change. (*algebraic expression, constant, or variable*)

#### SEE EXAMPLE 1

p. 6

- Give two ways to write each algebraic expression in words.

2.  $n - 5$                       3.  $\frac{f}{3}$                       4.  $c + 15$                       5.  $9 - y$   
 6.  $\frac{x}{12}$                       7.  $t + 12$                       8.  $8x$                       9.  $x - 3$

#### SEE EXAMPLE 2

p. 7

10. George drives at 45 mi/h. Write an expression for the number of miles George travels in  $h$  hours.  
 11. The length of a rectangle is 4 units greater than its width  $w$ . Write an expression for the length of the rectangle.

#### SEE EXAMPLE 3

p. 7

- Evaluate each expression for  $a = 3$ ,  $b = 4$ , and  $c = 2$ .

12.  $a - c$                       13.  $ab$                       14.  $b \div c$                       15.  $ac$

#### SEE EXAMPLE 4

p. 8

16. Brianna practices the piano 30 minutes each day.  
 a. Write an expression for the number of hours she practices in  $d$  days.  
 b. Find the number of hours Brianna practices in 2, 4, and 10 days.

### PRACTICE AND PROBLEM SOLVING

#### Independent Practice

| For Exercises | See Example |
|---------------|-------------|
| 17–24         | 1           |
| 25–26         | 2           |
| 27–30         | 3           |
| 31            | 4           |

- Give two ways to write each algebraic expression in words.

17.  $5p$                       18.  $4 - y$                       19.  $3 + x$                       20.  $3y$   
 21.  $-3s$                       22.  $r \div 5$                       23.  $14 - t$                       24.  $x + 0.5$

25. Friday's temperature was  $20^\circ$  warmer than Monday's temperature  $t$ . Write an expression for Friday's temperature.

26. Ann sleeps 8 hours per night. Write an expression for the number of hours Ann sleeps in  $n$  nights.

- Evaluate each expression for  $r = 6$ ,  $s = 5$ , and  $t = 3$ .

27.  $r - s$                       28.  $s + t$                       29.  $r \div t$                       30.  $sr$

31. Jim is paid for overtime when he works more than 40 hours per week.  
 a. Write an expression for the number of hours he works overtime when he works  $h$  hours.  
 b. Find the number of hours Jim works overtime when he works 40, 44, 48, and 52 hours.



32. **Write About It** Write a paragraph that explains to another student how to evaluate an expression.

Write an algebraic expression for each verbal expression. Then write a real-world situation that could be modeled by the expression.

33. the product of 2 and  $x$       34.  $b$  less than 17                      35. 10 more than  $y$



**MULTI-STEP TEST PREP**



36. This problem will prepare you for the Multi-Step Test Prep on page 38.

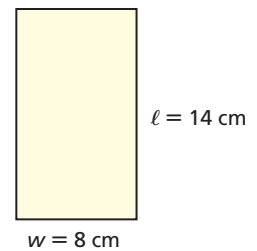
The air around you puts pressure on your body equal to 14.7 pounds per square inch (psi). When you are underwater, the water exerts additional pressure on your body. For each foot you are below the surface of the water, the pressure increases by 0.445 psi.

- What does 14.7 represent in the expression  $14.7 + 0.445d$ ?
- What does  $d$  represent in the expression?
- What is the total pressure exerted on a person's body when  $d = 8$  ft?

37. **Geometry** The length of a rectangle is 9 inches. Write an expression for the area of the rectangle if the width is  $w$  inches. Find the area of the rectangle when the width is 1, 8, 9, and 11 inches.

38. **Geometry** The perimeter of any rectangle is the sum of its lengths and widths. The area of any rectangle is the length  $\ell$  times the width  $w$ .

- Write an expression for the perimeter of a rectangle.
- Find the perimeter of the rectangle shown.
- Write an expression for the area of a rectangle.
- Find the area of the rectangle shown.



Complete each table. Evaluate the expression for each value of  $x$ .

39.

| $x$ | $x + 12$ |
|-----|----------|
| 1   | ■        |
| 2   | ■        |
| 3   | ■        |
| 4   | ■        |

40.

| $x$ | $10x$ |
|-----|-------|
| 1   | ■     |
| 5   | ■     |
| 10  | ■     |
| 15  | ■     |

41.

| $x$ | $x \div 2$ |
|-----|------------|
| 12  | ■          |
| 20  | ■          |
| 26  | ■          |
| 30  | ■          |

**LINK**

**Astronomy**



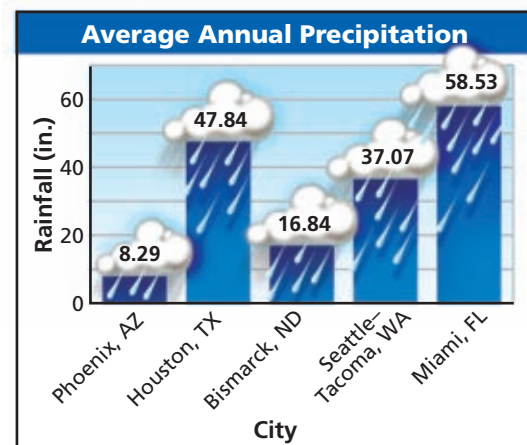
A crater on Canada's Devon Island is geologically similar to the surface of Mars. However, the temperature on Devon Island is about  $37^\circ\text{F}$  in summer, and the average summer temperature on Mars is  $-85^\circ\text{F}$ .

42. **Astronomy** An object's weight on Mars can be found by multiplying 0.38 by the object's weight on Earth.

- An object weighs  $p$  pounds on Earth. Write an expression for its weight on Mars.
- Dana weighs 120 pounds, and her bicycle weighs 44 pounds. How much would Dana and her bicycle together weigh on Mars?

43. **Meteorology** Use the bar graph to write an expression for the average annual precipitation in New York, New York.

- The average annual precipitation in New York is  $m$  inches more than the average annual precipitation in Houston, Texas.
- The average annual precipitation in New York is  $s$  inches less than the average annual precipitation in Miami, Florida.

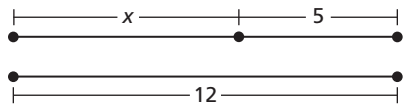
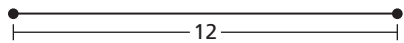


44. **Critical Thinking** Compare algebraic expressions and numerical expressions. Give examples of each.

Write an algebraic expression for each verbal expression. Then evaluate the algebraic expression for the given values of  $x$ .

|     | Verbal                    | Algebraic | $x = 12$     | $x = 14$     |
|-----|---------------------------|-----------|--------------|--------------|
|     | $x$ reduced by 5          | $x - 5$   | $12 - 5 = 7$ | $14 - 5 = 9$ |
| 45. | 7 more than $x$           | ■         | ■            | ■            |
| 46. | The quotient of $x$ and 2 | ■         | ■            | ■            |
| 47. | The sum of $x$ and 3      | ■         | ■            | ■            |



48. Claire has had her driver's license for 3 years. Bill has had his license for  $b$  fewer years than Claire. Which expression can be used to show the number of years Bill has had his driver's license?
- (A)  $3 + b$       (B)  $b + 3$       (C)  $3 - b$       (D)  $b - 3$
49. Which expression represents  $x$ ?
- (F)  $12 - 5$       (H)  $12(5)$       
- (G)  $12 + 5$       (J)  $12 \div 5$       
50. Which situation is best modeled by the expression  $25 - x$ ?
- (A) George places  $x$  more video games on a shelf with 25 games.  
 (B) Sarah has driven  $x$  miles of a 25-mile trip.  
 (C) Amelia paid 25 dollars of an  $x$  dollar lunch that she shared with Ariel.  
 (D) Jorge has 25 boxes full of  $x$  baseball cards each.

## CHALLENGE AND EXTEND

Evaluate each expression for the given values of the variables.

51.  $2ab$ ;  $a = 6$ ,  $b = 3$       52.  $2x + y$ ;  $x = 4$ ,  $y = 5$       53.  $3x \div 6y$ ;  $x = 6$ ,  $y = 3$
54. **Multi-Step** An Internet service provider charges \$9.95/month for the first 20 hours and \$0.50 for each additional hour. Write an expression representing the charges for  $h$  hours of use in one month when  $h$  is more than 20 hours. What is the charge for 35 hours?

## SPIRAL REVIEW

The sum of the angle measures in a triangle is  $180^\circ$ . Find the measure of the third angle given the other two angle measures. (*Previous course*)

55.  $45^\circ$  and  $90^\circ$       56.  $120^\circ$  and  $20^\circ$       57.  $30^\circ$  and  $60^\circ$

Write an equivalent fraction for each percent. (*Previous course*)

58. 25%      59. 50%      60. 75%      61. 100%

Find a pattern and use it to give the next three numbers. (*Previous course*)

62. 4, 12, 20, 28, ...      63. 3, 9, 27, 81, 243, ...      64. 2, 3, 5, 8, 12, ...



# Create a Table to Evaluate Expressions

You can use a graphing calculator to quickly evaluate expressions for many values of the variable.

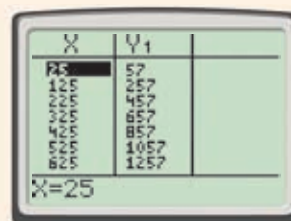
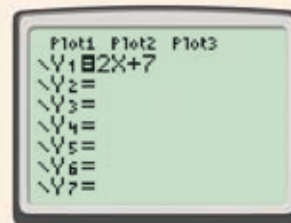
Use with Lesson 1-1



## Activity 1

Evaluate  $2x + 7$  for  $x = 25, 125, 225, 325,$  and  $425$ .

- 1 Press  $\boxed{Y=}$  and enter  $2X+7$  for  $Y1$ .
- 2 Determine a pattern for the values of  $x$ .  
The  $x$ -values start with 25 and increase by 100.
- 3 Press  $\boxed{2nd}$   $\boxed{WINDOW}$  to view the *Table Setup* window.  
Enter **25** as the starting value in **TblStart=**.  
Enter **100** as the amount by which  $x$  changes in  $\Delta Tbl=$ .
- 4 Press  $\boxed{2nd}$   $\boxed{GRAPH}$  to create a table of values.  
The first column shows values of  $x$  starting with 25 and increasing by 100.  
The second column shows values of the expression  $2x + 7$  when  $x$  is equal to the value in the first column.  
You can use the arrow keys to view the table when  $x$  is greater than 625.



## Try This

1. Use the table feature of a graphing calculator to evaluate  $5x - 7$  for  $x = 4, 6, 8, 10,$  and  $12$ .
  - a. What value did you enter in **TblStart=**?
  - b. What value did you enter in  $\Delta Tbl=$ ?
2. Use the table feature of a graphing calculator to evaluate  $3x + 4$  for  $x = -5, -1, 3,$   $7,$  and  $11$ .
  - a. What value did you enter in **TblStart=**?
  - b. What value did you enter in  $\Delta Tbl=$ ?

You can also use a spreadsheet program to evaluate expressions.

## Activity 2

Evaluate  $2x + 7$  for  $x = 3, 5, 7, 9,$  and  $11$ .

- 1 In the first column, enter the values 3, 5, 7, 9, and 11.

|   | A  | B | C | D | E | F | G |
|---|----|---|---|---|---|---|---|
| 1 | 3  |   |   |   |   |   |   |
| 2 | 5  |   |   |   |   |   |   |
| 3 | 7  |   |   |   |   |   |   |
| 4 | 9  |   |   |   |   |   |   |
| 5 | 11 |   |   |   |   |   |   |

- 2 Enter the expression in cell B1.

To do this, type the following:  
 $= 2 * A1 + 7$

|   | A  | B       | C | D | E | F | G |
|---|----|---------|---|---|---|---|---|
| 1 | 3  | =2*A1+7 |   |   |   |   |   |
| 2 | 5  |         |   |   |   |   |   |
| 3 | 7  |         |   |   |   |   |   |
| 4 | 9  |         |   |   |   |   |   |
| 5 | 11 |         |   |   |   |   |   |

- 3 Press Enter.

The value of  $2x + 7$  when  $x = 3$  appears in cell B1.

|   | A  | B  | C | D | E | F | G |
|---|----|----|---|---|---|---|---|
| 1 | 3  | 13 |   |   |   |   |   |
| 2 | 5  |    |   |   |   |   |   |
| 3 | 7  |    |   |   |   |   |   |
| 4 | 9  |    |   |   |   |   |   |
| 5 | 11 |    |   |   |   |   |   |

- 4 Copy the formula into cells B2, B3, B4, and B5.

Use the mouse to click on the lower right corner of cell B1. Hold down the mouse button and drag the cursor through cell B5.

|   | A  | B  | C | D | E | F | G |
|---|----|----|---|---|---|---|---|
| 1 | 3  | 13 |   |   |   |   |   |
| 2 | 5  | 17 |   |   |   |   |   |
| 3 | 7  | 21 |   |   |   |   |   |
| 4 | 9  | 25 |   |   |   |   |   |
| 5 | 11 | 29 |   |   |   |   |   |

For each row in column B, the number that is substituted for  $x$  is the value in the same row of column A.

|   | A  | B  | C | D | E | F | G |
|---|----|----|---|---|---|---|---|
| 1 | 3  | 13 |   |   |   |   |   |
| 2 | 5  | 17 |   |   |   |   |   |
| 3 | 7  | 21 |   |   |   |   |   |
| 4 | 9  | 25 |   |   |   |   |   |
| 5 | 11 | 29 |   |   |   |   |   |

You can continue the table by entering more values in column A and copying the formula from B1 into more cells in column B.

## Try This

3. Use a spreadsheet program to evaluate  $-2x + 9$  for  $x = -5, -2, 1, 4,$  and  $7$ .
  - a. What values did you enter in column A?
  - b. What did you type in cell B1?
4. Use a spreadsheet program to evaluate  $7x - 10$  for  $x = 2, 7, 12, 17,$  and  $22$ .
  - a. What values did you enter in column A?
  - b. What did you type in cell B1?



# 1-2

## Adding and Subtracting Real Numbers

### Objectives

Add real numbers.  
Subtract real numbers.

### Vocabulary

real numbers  
absolute value  
opposites  
additive inverse

### Why learn this?

The total length of a penguin's dive can be determined by adding real numbers. (See Example 4.)



The set of all numbers that can be represented on a number line are called **real numbers**. You can use a number line to model addition and subtraction of real numbers.

### Addition

To model addition of a positive number, move right. To model addition of a negative number, move left.

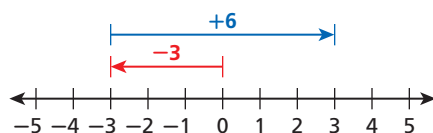
### Subtraction

To model subtraction of a positive number, move left.  
To model subtraction of a negative number, move right.

### EXAMPLE 1 Adding and Subtracting Numbers on a Number Line

Add or subtract using a number line.

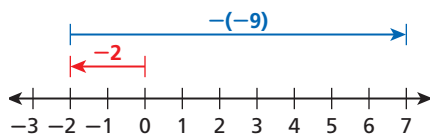
**A**  $-3 + 6$



Start at 0. Move left to  $-3$ .  
To add 6, move right 6 units.

$$-3 + 6 = 3$$

**B**  $-2 - (-9)$



Start at 0. Move left to  $-2$ .  
To subtract  $-9$ , move right 9 units.

$$-2 - (-9) = 7$$



Add or subtract using a number line.

1a.  $-3 + 7$

1b.  $-3 - 7$

1c.  $-5 - (-6.5)$

The **absolute value** of a number is its distance from zero on a number line. The absolute value of 5 is written as  $|5|$ .



$$|5| = 5$$

$$|-5| = 5$$



## Adding Real Numbers

| WORDS  | NUMBERS        |                    |
|--|----------------|--------------------|
| <b>Adding Numbers with the Same Sign</b><br>Add the absolute values and use the sign of the numbers.                                       | $3 + 6$<br>9   | $-2 + (-9)$<br>-11 |
| <b>Adding Numbers with Different Signs</b><br>Subtract the absolute values and use the sign of the number with the greater absolute value. | $-8 + 12$<br>4 | $3 + (-15)$<br>-12 |

### EXAMPLE 2 Adding Real Numbers

Add.

**A**  $-3 + (-16)$   
 $(3 + 16 = 19)$   
 $-19$

*Same signs: add the absolute values.  
Both numbers are negative, so the sum is negative.*

**B**  $-13 + 7$   
 $(13 - 7 = 6)$   
 $-6$

*Different signs: subtract the absolute values.  
Use the sign of the number with the greater absolute value.*

**C**  $6.2 + (-4.9)$   
 $(6.2 - 4.9 = 1.3)$   
 $1.3$

*Different signs: subtract the absolute values.  
Use the sign of the number with the greater absolute value.*



Add.

2a.  $-5 + (-7)$     2b.  $-13.5 + (-22.3)$     2c.  $52 + (-68)$

Two numbers are **opposites** if their sum is 0. A number and its opposite are **additive inverses** and are the same distance from zero. They have the same absolute value.

### Helpful Hint

Because adding 0 to a number does not change the number's value, 0 is called the *additive identity*. Two numbers are additive inverses if their sum is the additive identity.

### Inverse Property of Addition

| WORDS   | NUMBERS                   | ALGEBRA  |
|---|---------------------------|--|
| The sum of a real number and its opposite is 0. | $6 + (-6) = (-6) + 6 = 0$ | For any real number $a$ ,<br>$a + (-a) = (-a) + a = 0$ |

To subtract signed numbers, you can use additive inverses. Subtracting a number is the same as adding the opposite of the number.

### Subtracting Real Numbers

| WORDS  | NUMBERS                      | ALGEBRA            |
|--|------------------------------|--------------------|
| To subtract a number, add its opposite. Then follow the rules for adding signed numbers. | $3 - 8 = 3 + (-8)$<br>$= -5$ | $a - b = a + (-b)$ |

**EXAMPLE 3 Subtracting Real Numbers****Subtract.**

**A**  $7 - 10$   
 $7 - 10 = 7 + (-10)$   
 $(10 - 7 = 3)$   
 $-3$

To subtract 10, add  $-10$ .  
 Different signs: subtract absolute values.  
 Use the sign of the number with the greater absolute value.

**B**  $-3 - (-12)$   
 $-3 - (-12) = -3 + 12$   
 $(12 - 3 = 9)$   
 $9$

To subtract  $-12$ , add 12.  
 Different signs: subtract absolute values.  
 Use the sign of the number with the greater absolute value.

**C**  $-\frac{1}{8} - \frac{3}{8}$   
 $-\frac{1}{8} - \frac{3}{8} = -\frac{1}{8} + \left(-\frac{3}{8}\right)$   
 $\left(\frac{1}{8} + \frac{3}{8} = \frac{4}{8} = \frac{1}{2}\right)$   
 $-\frac{1}{2}$

To subtract  $\frac{3}{8}$ , add  $-\frac{3}{8}$ .  
 Same signs: add absolute values.  
 Both numbers are negative, so the sum is negative.

**D**  $22.5 - (-4)$   
 $22.5 - (-4) = 22.5 + 4$   
 $(22.5 + 4 = 26.5)$   
 $26.5$

To subtract  $-4$ , add 4.  
 Same signs: add absolute values.  
 Both numbers are positive, so the sum is positive.

**Helpful Hint**

On many scientific and graphing calculators, there is one button to express the opposite of a number and a different button to express subtraction.

**Subtract.**

3a.  $13 - 21$

3b.  $\frac{1}{2} - \left(-3\frac{1}{2}\right)$

3c.  $-14 - (-12)$

**EXAMPLE 4 Biology Application**

An emperor penguin stands on an iceberg that extends 10 feet above the water. Then the penguin dives to an elevation of  $-67$  feet to catch a fish. What is the total length of the penguin's dive?

|                      |       |                   |
|----------------------|-------|-------------------|
| elevation of iceberg | minus | elevation of fish |
|----------------------|-------|-------------------|

10

-

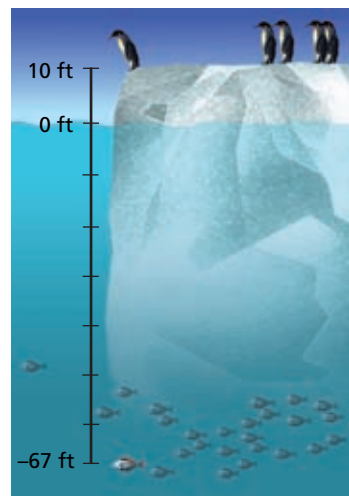
-67

$$10 - (-67) = 10 + 67$$

$$= 77$$

To subtract  $-67$ , add 67.  
 Same signs: add absolute values.

The total length of the penguin's dive is 77 feet.

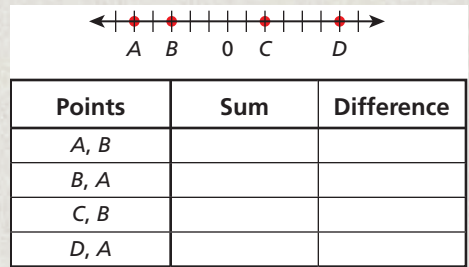


4. **What if...?** The tallest known iceberg in the North Atlantic rose 550 feet above the ocean's surface. How many feet would it be from the top of the tallest iceberg to the wreckage of the *Titanic*, which is at an elevation of  $-12,468$  feet?

## THINK AND DISCUSS

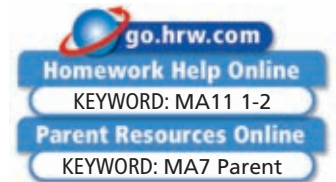


- The difference of  $-7$  and  $-5$  is  $-2$ . Explain why the difference is greater than  $-7$ .
- GET ORGANIZED** Copy and complete the graphic organizer. For each pair of points, tell whether the sum and the difference of the first point and the second point are positive or negative.



# 1-2

## Exercises



### GUIDED PRACTICE

- Vocabulary** The sum of a number and its  $\underline{\quad?}$  is always zero. (*opposite* or *absolute value*)

**SEE EXAMPLE 1** Add or subtract using a number line.

p. 14

2.  $-4 + 7$

3.  $-3.5 - 5$

4.  $5.6 - 9.2$

5.  $3 - \left(-6\frac{1}{4}\right)$

**SEE EXAMPLE 2** Add.

p. 15

6.  $91 + (-11)$

7.  $4\frac{3}{4} + \left(-3\frac{3}{4}\right)$

8.  $15.6 + (-17.9)$

9.  $-\frac{1}{16} + \frac{5}{8}$

**SEE EXAMPLE 3** Subtract.

p. 16

10.  $23 - 36$

11.  $4.3 - 8.4$

12.  $1\frac{1}{5} - 2\frac{4}{5}$

13.  $\frac{7}{10} - \left(-\frac{2}{5}\right)$

**SEE EXAMPLE 4** **14. Economics** The Dow Jones Industrial Average (DJIA) reports the average prices of stocks for 30 companies. Use the table to determine the total decrease in the DJIA for the two days.

p. 16

#### DJIA 1987

|                 |         |
|-----------------|---------|
| Friday, Oct. 16 | -108.35 |
| Monday, Oct. 19 | -507.99 |

### PRACTICE AND PROBLEM SOLVING

#### Independent Practice

For Exercises See Example

15–18 1

19–22 2

23–26 3

27 4

#### Extra Practice

Skills Practice p. S4

Application Practice p. S28

Add or subtract using a number line.

15.  $-2 + 6$

16.  $6 + (-2)$

17.  $\frac{1}{4} - 12$

18.  $-\frac{2}{5} + 6$

Add.

19.  $-18 + (-12)$

20.  $-2.3 + 3.5$

21.  $-15 + 29$

22.  $-4.8 + (-5.4)$

Subtract.

23.  $12 - 22$

24.  $-\frac{3}{4} - \left(-\frac{1}{4}\right)$

25.  $38 - 24.6$

26.  $\frac{2}{3} - \left(-\frac{1}{2}\right)$

- Meteorology** A meteorologist reported that the day's high temperature was  $17^\circ\text{F}$  and the low temperature was  $-6^\circ\text{F}$ . What was the difference between the day's high and low temperatures?



Evaluate the expression  $n + (-5)$  for each value of  $n$ .

28.  $n = 312$       29.  $n = 5.75$       30.  $n = -\frac{7}{12}$       31.  $n = -7\frac{2}{5}$

Add or subtract.

32.  $-8 - 3$       33.  $-9 + (-3)$       34.  $16 - (-16)$       35.  $100 - 63$   
 36.  $5.2 - 2.5$       37.  $-4.7 - (-4.7)$       38.  $\frac{2}{5} - \frac{7}{8}$       39.  $\frac{2}{5} - \frac{3}{10}$

40. **Business** A restaurant manager lost \$415 in business during the month of January. Business picked up in February, and he ended that month with a profit of \$1580.  
 a. What was the manager's profit after January and February?  
 b. **What if...?** The restaurant lost \$245 in business during the month of March. What was the manager's profit after January, February, and March?

Compare. Write  $<$ ,  $>$ , or  $=$ .

41.  $-4 - (-6)$   $\square$   $-7 - 3$       42.  $|-51|$   $\square$   $|0|$       43.  $3 - (-3)$   $\square$   $0 - (-3)$   
 44.  $-3 - 8$   $\square$   $-22 + 11$       45.  $|-10 + 5|$   $\square$   $|-15|$       46.  $9 + (-8)$   $\square$   $-12 + 13$

47. **Travel** Death Valley National Park is located in California. Use the table to determine the difference in elevation between the highest and lowest locations.

| Death Valley National Park |                |
|----------------------------|----------------|
| Location                   | Elevation (ft) |
| Badwater                   | -282           |
| Emigrant Pass              | 5,318          |
| Furnace Creek Airport      | -210           |
| Telescope Peak             | 11,049         |



**Critical Thinking** Tell whether each statement is sometimes, always, or never true. Explain.

48. The value of the expression  $-2 + n$  is less than the value of  $n$ .  
 49. When  $b$  is positive, the expression  $-b + (-b)$  is equal to 0.  
 50. When  $x$  is negative, the value of the expression  $x + 1$  is negative.  
 51. **/// ERROR ANALYSIS ///** Which is incorrect? Explain the error.

**A**

|             |
|-------------|
| $-5 - (-8)$ |
| $-5 + (-8)$ |
| $-13$       |

**B**

|             |
|-------------|
| $-5 - (-8)$ |
| $-5 + (8)$  |
| $3$         |

**MULTI-STEP  
TEST PREP**



52. This problem will prepare you for the Multi-Step Test Prep on page 38.  
 a. A plane flies at a height of 1800 feet directly over a 150-foot-tall building. How far above the building is the plane? Draw a diagram to explain your answer.  
 b. The same plane then flies directly over a diver who is 80 feet below the surface of the water. How far is the plane above the diver? Draw a diagram to explain your answer.  
 c. Subtract the diver's altitude of  $-80$  feet from the plane's altitude of 1800 feet. Explain why this distance is greater than 1800 feet.



53. **Write About It** Explain why addition and subtraction are called inverse operations. Use the following examples in your explanation:

$$8 + (-2) = 8 - 2 \quad 8 - (-2) = 8 + 2$$



54. Which expression is equivalent to  $|-3 + 5|$  ?  
 (A)  $-3 - 5$       (B)  $-3 + 5$       (C)  $3 - 5$       (D)  $3 + 5$
55. At midnight, the temperature was  $-12^\circ\text{F}$ . By noon, the temperature had risen  $25^\circ\text{F}$ . During the afternoon, it fell  $10^\circ\text{F}$  and fell another  $3^\circ\text{F}$  by midnight. What was the temperature at midnight?  
 (F)  $0^\circ\text{F}$       (G)  $3^\circ\text{F}$       (H)  $12^\circ\text{F}$       (J)  $24^\circ\text{F}$
56. The table shows the amounts Mr. Espinosa spent on lunch each day one week. What is the total amount Mr. Espinosa spent for lunch this week?

| Day         | Monday | Tuesday | Wednesday | Thursday | Friday |
|-------------|--------|---------|-----------|----------|--------|
| Amount (\$) | 5.40   | 4.16    | 7.07      | 5.40     | 9.52   |

- (A) \$21.83      (B) \$22.03      (C) \$31.55      (D) \$36.95

## CHALLENGE AND EXTEND

Simplify each expression.

57.  $-1\frac{1}{5} + (-7.8)$       58.  $-\frac{1}{5} + 2.1$       59.  $9.75 + \left(-7\frac{3}{4}\right)$       60.  $-2\frac{3}{10} + 8.5$

For each pattern shown below, describe a possible rule for finding the next term. Then use your rule to write the next 3 terms.

61. 14, 10, 6, 2, ...      62.  $-2, -\frac{8}{5}, -\frac{6}{5}, -\frac{4}{5}, \dots$

63. **Geography** Sam visited two volcanoes, Cotapaxi and Sangay, and two caves, Sistema Huautla and Sistema Cheve. Cotapaxi, in Ecuador, has an elevation of 19,347 ft. Sangay, also in Ecuador, has an elevation of 17,159 ft. The main entrance of Sistema Huautla, in Mexico, has an elevation of 5051 ft. The main entrance of Sistema Cheve, also in Mexico, has an elevation of 9085 ft. What is the average elevation of these places?

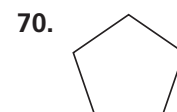
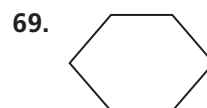


## SPIRAL REVIEW

Write each number as a terminating or repeating decimal. (*Previous course*)

64.  $\frac{3}{16}$       65.  $\frac{2}{9}$       66.  $\frac{15}{12}$       67.  $\frac{4}{11}$

Divide each polygon into triangles to find the sum of its angle measures. (*Hint: Remember that the sum of the angle measures in a triangle is  $180^\circ$ .*) (*Previous course*)



# 1-3

## Multiplying and Dividing Real Numbers



### Objectives

Multiply real numbers.  
Divide real numbers.

### Vocabulary

reciprocal  
multiplicative inverse

### Who uses this?

Hot-air balloon pilots can determine how far away from liftoff they will land by using multiplication. (See Example 4.)

When you multiply or divide two numbers, the signs of the numbers determine whether the result is positive or negative.

| Numbers       | Product/Quotient |
|---------------|------------------|
| Both positive | Positive         |
| One negative  | Negative         |
| Both negative | Positive         |



### Multiplying and Dividing Real Numbers

| WORDS   | NUMBERS                        |  |
|---|--------------------------------|--|
| <b>Multiplying and Dividing Numbers with the Same Sign</b>                  |                                |  |
| If two numbers have the same sign, their product or quotient is positive.   | $4 \cdot 5 = 20$               | $-15 \div (-3) = 5$                      |
| <b>Multiplying and Dividing Numbers with Different Signs</b>                |                                |  |
| If two numbers have different signs, their product or quotient is negative. | $6(-3) = -18$<br>$(-7)2 = -14$ | $-18 \div 2 = -9$<br>$10 \div (-5) = -2$ |

### EXAMPLE 1

#### Multiplying and Dividing Signed Numbers

Find the value of each expression.

**A**  $-12 \cdot 5$   
 $-60$

*The product of two numbers with different signs is negative.*

**B**  $8\left(-\frac{5}{4}\right)$

$= \left(\frac{8}{1}\right)\left(-\frac{5}{4}\right) = -\frac{40}{4}$  *Multiply.*

$= -10$

*The quotient of two numbers with different signs is negative.*



Find the value of each expression.

1a.  $35 \div (-5)$

1b.  $-11(-4)$

1c.  $-6(7)$

### Helpful Hint

Because multiplying by 1 does not change a number's value, 1 is the *multiplicative identity*. Two numbers are multiplicative inverses if their product is the multiplicative identity.

Two numbers are **reciprocals** if their product is 1. A number and its reciprocal are called **multiplicative inverses**.

### Inverse Property of Multiplication

| WORDS   | NUMBERS   | ALGEBRA  |
|---|---|--|
| The product of a nonzero real number and its reciprocal is 1. | $4 \cdot \frac{1}{4} = \frac{1}{4} \cdot 4 = 1$<br>$-3 \cdot \left(-\frac{1}{3}\right) = -\frac{1}{3} \cdot (-3) = 1$ | For any real number $a$ ( $a \neq 0$ ),<br>$a \cdot \frac{1}{a} = \frac{1}{a} \cdot a = 1$ |

To divide by a number, you can multiply by its multiplicative inverse.

### EXAMPLE 2 Dividing with Fractions

Divide.

**A**  $-\frac{4}{5} \div \left(-\frac{8}{15}\right)$

$$-\frac{4}{5} \div \left(-\frac{8}{15}\right) = -\frac{4}{5} \left(-\frac{15}{8}\right)$$

$$= \frac{(-4)(-15)}{5(8)}$$

$$= \frac{60}{40} = \frac{3}{2}$$

To divide by  $-\frac{8}{15}$ , multiply by  $-\frac{15}{8}$ .

Multiply the numerators and multiply the denominators.

$-\frac{4}{5}$  and  $-\frac{8}{15}$  have the same sign, so the quotient is positive.

**B**  $-4 \div 9\frac{1}{4}$

$$-4 \div 9\frac{1}{4} = -\frac{4}{1} \div \frac{37}{4}$$

$$= -\frac{4}{1} \cdot \frac{4}{37}$$

$$= -\frac{4(4)}{1(37)} = -\frac{16}{37}$$

Write 4 as a fraction with a denominator of 1. Write  $9\frac{1}{4}$  as an improper fraction.

To divide by  $\frac{37}{4}$ , multiply by  $\frac{4}{37}$ .

$-4$  and  $9\frac{1}{4}$  have different signs, so the quotient is negative.

### Helpful Hint

You can write the reciprocal of a number by switching the numerator and denominator. A number written without a denominator has a denominator of 1.



Divide.

2a.  $-\frac{3}{4} \div (-9)$

2b.  $\frac{3}{10} \div \left(-\frac{6}{5}\right)$

2c.  $-\frac{5}{6} \div 1\frac{2}{3}$

The number 0 has special properties for multiplication and division.



### Properties of Zero

| WORDS   | NUMBERS                                    | ALGEBRA                                |
|---|--|--|
| <b>Multiplication by Zero</b><br>The product of any number and 0 is 0.            | $\frac{1}{3} \cdot 0 = 0$ $0(-17) = 0$     | $a \cdot 0 = 0$ $0 \cdot a = 0$        |
| <b>Zero Divided by a Number</b><br>The quotient of 0 and any nonzero number is 0. | $\frac{0}{6} = 0$ $0 \div \frac{2}{3} = 0$ | $\frac{0}{a} = 0$ ( $a \neq 0$ )       |
| <b>Division by Zero</b><br>Division by 0 is undefined.                            | $12 \div 0 \times$ $\frac{-5}{0} \times$   | $a \div 0 \times$ $\frac{a}{0} \times$ |



### EXAMPLE 3 Multiplying and Dividing with Zero

Multiply or divide if possible.

- A**  $0 \div 16.568$       *Zero is divided by a nonzero number.  
The quotient of zero and any nonzero number is 0.*
- B**  $63\frac{7}{8} \div 0$       *A number is divided by zero.  
Division by zero is undefined.*  
undefined
- C**  $1 \cdot 0$       *A number is multiplied by zero.  
The product of any number and 0 is 0.*  
0



Multiply or divide if possible.

- 3a.  $0 \div \left(-8\frac{1}{6}\right)$       3b.  $2.04 \div 0$       3c.  $(-12,350)(0)$

### EXAMPLE 4 Recreation Application

A hot-air balloon is taken for a 2.5-hour trip. The wind speed (and the speed of the balloon) is 4.75 mi/h. The balloon travels in a straight line parallel to the ground. How many miles away from the liftoff site will the balloon land?

Find the distance traveled at a rate of 4.75 mi/h for 2.5 hours. To find distance, multiply rate by time.

| rate       | times | time |
|------------|-------|------|
| 4.75       | •     | 2.5  |
| 4.75 • 2.5 |       |      |
| 11.875     |       |      |



The hot-air balloon will land 11.875 miles from the liftoff site.



4. **What if...?** On another hot-air balloon trip, the wind speed is 5.25 mi/h. The trip is planned for 1.5 hours. The balloon travels in a straight line parallel to the ground. How many miles away from the liftoff site will the balloon land?

### THINK AND DISCUSS

1. Explain how to use mental math to find the missing value:  $\frac{4}{5} \cdot ? = 1$ .
2. **GET ORGANIZED** Copy and complete the graphic organizer. In each blank, write “pos” or “neg” to indicate positive or negative.



| Multiplying and Dividing Numbers |                                  |
|----------------------------------|----------------------------------|
| Multiplication                   | Division                         |
| pos × <input type="text"/> = pos | pos ÷ <input type="text"/> = pos |
| pos × <input type="text"/> = neg | pos ÷ <input type="text"/> = neg |
| neg × <input type="text"/> = neg | neg ÷ <input type="text"/> = neg |
| neg × <input type="text"/> = pos | neg ÷ <input type="text"/> = pos |

## GUIDED PRACTICE

1. **Vocabulary** How do you find the *reciprocal* of  $\frac{1}{2}$ ?

SEE EXAMPLE 1 Find the value of each expression.

p. 20 2.  $-72 \div (-9)$  3.  $11(-11)$  4.  $-7.2 \div 3.6$

SEE EXAMPLE 2 Divide.

p. 21 5.  $5 \div \frac{5}{7}$  6.  $\frac{4}{5} \div \left(-\frac{7}{5}\right)$  7.  $-\frac{2}{3} \div \left(-\frac{1}{3}\right)$  8.  $-\frac{16}{25} \div \left(-\frac{4}{5}\right)$

SEE EXAMPLE 3 Multiply or divide if possible.

p. 22 9.  $3.8 \div 0$  10.  $0(-27)$  11.  $0 \div \frac{2}{3}$  12.  $\frac{7}{8} \div 0$

SEE EXAMPLE 4 13. **Entertainment** It is estimated that 7 million people saw off-Broadway shows in 2002. Assume that the average price of a ticket was \$30. How much money was spent on tickets for off-Broadway shows in 2002?

## PRACTICE AND PROBLEM SOLVING

## Independent Practice

| For Exercises | See Example |
|---------------|-------------|
| 14–16         | 1           |
| 17–20         | 2           |
| 21–24         | 3           |
| 25            | 4           |

Find the value of each expression.

14.  $-30 \div (-6)$  15.  $8(-4)$  16.  $-25(-12)$

Divide.

17.  $-\frac{3}{20} \div \left(-\frac{1}{6}\right)$  18.  $\frac{3}{14} \div \frac{15}{28}$  19.  $-4\frac{1}{2} \div 1\frac{1}{2}$  20.  $2\frac{3}{4} \div \left(-1\frac{1}{2}\right)$

Multiply or divide if possible.

21.  $0 \cdot 15$  22.  $-0.25 \div 0$  23.  $0 \div 1$  24.  $\frac{0}{1} \div 3$

25. **Weather** A cold front changes the temperature by  $-3^\circ\text{F}$  each day. If the temperature started at  $0^\circ\text{F}$ , what will the temperature be after 5 days?

Multiply or divide.

26.  $21 \div (-3)$  27.  $-100 \div 25$  28.  $-6 \div (-14)$  29.  $-6.2(10)$

30.  $\frac{1}{2} \div \frac{1}{2}$  31.  $-3.75(-5)$  32.  $-12\frac{1}{2}(-3)$  33.  $17\left(\frac{1}{17}\right)$

34. **Critical Thinking** What positive number is the same as its reciprocal?

Evaluate each expression for  $a = 4$ ,  $b = -3$ , and  $c = -\frac{1}{2}$ .

35.  $ab$  36.  $a \div c$  37.  $bc$  38.  $c \div a$

Let  $p$  represent a positive number,  $n$  represent a negative number, and  $z$  represent zero. Tell whether each expression is positive, negative, zero, or undefined.

39.  $pn$  40.  $pnz$  41.  $\frac{n}{p}$  42.  $-pz$

43.  $-\frac{p}{n}$  44.  $-(pn)$  45.  $\frac{pn}{z}$  46.  $\frac{z}{n}$

## Extra Practice

Skills Practice p. S4

Application Practice p. S28

Evaluate the expression  $y \div \frac{3}{4}$  for each value of  $y$ .

47.  $y = \frac{3}{4}$

48.  $y = -\frac{9}{16}$

49.  $y = \frac{3}{8}$

50.  $y = -2\frac{1}{4}$

Evaluate the expression  $\frac{1}{2} \div m$  for each value of  $m$ .

51.  $m = -\frac{5}{2}$

52.  $m = \frac{7}{8}$

53.  $m = \frac{4}{9}$

54.  $m = -5$



**Diving**



Florida is home to more than 300 freshwater springs, some of which are explored by cave divers.

55. **Education** Benjamin must have 120 credit hours of instruction to receive his college degree. Benjamin wants to graduate in 8 semesters without attending summer sessions. How many credit hours must Benjamin take on average each semester to graduate in 8 semesters?

56. **Diving** An underwater exploration team is swimming at a depth of  $-20$  feet. Then they dive to an underwater cave that is at 7 times this depth. What is the depth of the underwater cave?

Multiply or divide. Then compare using  $<$ ,  $>$ , or  $=$ .

57.  $10\left(-\frac{1}{2}\right) \blacksquare 20 \div 4$       58.  $16 \div (-2) \blacksquare -2(-4)$       59.  $-2\frac{2}{3} \div 3 \blacksquare 5(-2.4)$

60.  $20 \div 4 \blacksquare \frac{3}{4} \div \left(-\frac{1}{2}\right)$       61.  $2.1(-3.4) \blacksquare -3.4(2.1)$       62.  $0\left(-\frac{3}{5}\right) \blacksquare \frac{1}{2} \div \frac{1}{2}$

63. **Critical Thinking** There is a relationship between the number of negative factors and the sign of the product.
- What is the sign of the product of an even number of negative factors?
  - What is the sign of the product of an odd number of negative factors?
  - Explain why the number of negative factors affects the sign of the product.
  - Does the number of positive factors affect the sign of the product? Explain.

Write each division expression as a multiplication expression.

64.  $12 \div (-3)$

65.  $75 \div 15$

66.  $\frac{80}{-8}$

67.  $\frac{-121}{11}$

Determine whether each statement is sometimes, always, or never true. Explain.

68. When  $t$  is negative, the expression  $-\frac{t}{10}$  is negative.

69. When  $n$  is positive, the expression  $-6n$  is positive.

70. The value of the expression  $4c$  is greater than the value of  $c$ .



71. **Write About It** The product of two factors is positive. One of the factors is negative. Explain how you can determine the sign of the second factor.

**MULTI-STEP TEST PREP**



72. This problem will prepare you for the Multi-Step Test Prep on page 38.
- You swam 20 feet in 5 seconds. Use the formula  $r = \frac{d}{t}$  to determine how fast you were swimming.
  - A diver descended at a rate of 15 feet per minute. Make a table to show the diver's depth after 1, 2, and 5 minutes.
  - Show two ways to find how far the diver descended in 5 minutes. Remember that multiplication is repeated addition.

73. A recipe for lemonade calls for  $1\frac{1}{2}$  cups of lemon juice per batch. Berto estimates that he can get about  $\frac{1}{4}$  cup of lemon juice from each lemon that he squeezes. Lemons cost \$0.45 each. What is the approximate amount Berto will need to spend on lemons to make a batch of lemonade?  
 Ⓐ \$0.70      Ⓑ \$1.70      Ⓒ \$2.70      Ⓓ \$3.70
74. Robyn is buying carpet for her bedroom floor, which is a 15-foot-by-12-foot rectangle. If carpeting costs \$1.25 per square foot, how much will it cost Robyn to carpet her bedroom?  
 Ⓕ \$68      Ⓖ \$144      Ⓗ \$180      Ⓙ \$225
75. **Short Response** In music notation, a half note is played  $\frac{1}{2}$  the length of a whole note. A quarter note is played  $\frac{1}{4}$  the length of a whole note. In a piece of music, the clarinets play 8 half notes. In the same length of time, the flutes play  $x$  quarter notes. Determine how many quarter notes the flutes play. Explain your method.

## CHALLENGE AND EXTEND

Find the value of each expression.

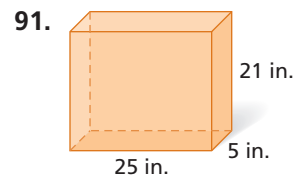
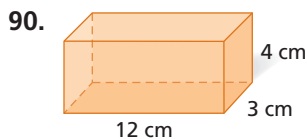
76.  $(-2)(-2)(-2)$       77.  $\frac{5}{7} \cdot \frac{5}{7}$       78.  $5\left(-\frac{4}{5}\right)\left(-\frac{3}{4}\right)$   
 79.  $\left|-\frac{1}{4}\right| \cdot |20|$       80.  $5 \cdot 4 \cdot 3 \cdot 2 \cdot 1$       81.  $\left|-\frac{2}{5}\right| \cdot \left|\frac{5}{2}\right|$   
 82.  $\frac{1}{2} \cdot \frac{2}{3} \cdot \frac{3}{4} \cdot \frac{4}{5}$       83.  $\left(-\frac{3}{4}\right)\left(-\frac{3}{4}\right)\left(-\frac{3}{4}\right)$       84.  $|(-4)(-4)(-4)|$

For each pattern shown below, describe a possible rule for finding the next term. Then use your rule to write the next 3 terms.

85.  $-1, 2, -4, 8, \dots$       86.  $\frac{1}{63}, -\frac{1}{21}, \frac{1}{7}, -\frac{3}{7}, \dots$   
 87.  $-5, 10, -15, 20, -25, \dots$       88.  $0.5, 0.25, 0.125, 0.0625, \dots$   
 89. A cleaning service charges \$49.00 to clean a one-bedroom apartment. If the work takes longer than 2 hours, the service charges \$18.00 for each additional hour. What would be the total cost for a job that took 4 hours to complete?

## SPIRAL REVIEW

Find the surface area of each rectangular prism. (*Previous course*)



92. A prepaid phone card has a credit of 200 minutes. Write an expression for the number of minutes left on the card after  $t$  minutes have been used. (*Lesson 1-1*)

Compare. Write  $<$ ,  $>$ , or  $=$ . (*Lesson 1-2*)

93.  $-12 + 7$   $\square$   $10 + (-5)$       94.  $|-14|$   $\square$   $-2$   
 95.  $|-7 + 11|$   $\square$   $|-4|$       96.  $-20 + (-35)$   $\square$   $-35 - 20$

# 1-4

## Powers and Exponents



### Objective

Simplify expressions containing exponents.

### Vocabulary

power  
base  
exponent

### Who uses this?

Biologists use exponents to model the growth patterns of living organisms.

When bacteria divide, their number increases exponentially. This means that the number of bacteria is multiplied by the same factor each time the bacteria divide. Instead of writing repeated multiplication to express a product, you can use a power.

A **power** is an expression written with an *exponent* and a *base* or the value of such an expression.  $3^2$  is an example of a power.

The base, 3, is the number that is used as a factor.

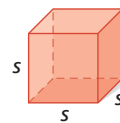
$$3^2$$

The exponent, 2, tells how many times the base, 3, is used as a factor.

When a number is raised to the second power, we usually say it is “squared.” The area of a *square* is  $s \cdot s = s^2$ , where  $s$  is the side length.



When a number is raised to the third power, we usually say it is “cubed.” The volume of a *cube* is  $s \cdot s \cdot s = s^3$ , where  $s$  is the side length.



### EXAMPLE 1 Writing Powers for Geometric Models

Write the power represented by each geometric model.

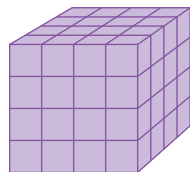
**A**



$$3^2$$

There are 3 rows of 3 dots.  $3 \times 3$   
The factor 3 is used 2 times.

**B**



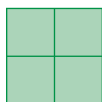
$$4^3$$

The figure is 4 cubes long, 4 cubes wide,  
and 4 cubes tall.  $4 \times 4 \times 4$   
The factor 4 is used 3 times.

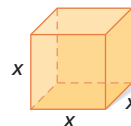


Write the power represented by each geometric model.

1a.



1b.





There are no easy geometric models for numbers raised to exponents greater than 3, but you can still write them using repeated multiplication or a base and exponent.

| Reading Exponents                   |                                     |       |       |
|-------------------------------------|-------------------------------------|-------|-------|
| Words                               | Multiplication                      | Power | Value |
| 3 to the first power                | 3                                   | $3^1$ | 3     |
| 3 to the second power, or 3 squared | $3 \cdot 3$                         | $3^2$ | 9     |
| 3 to the third power, or 3 cubed    | $3 \cdot 3 \cdot 3$                 | $3^3$ | 27    |
| 3 to the fourth power               | $3 \cdot 3 \cdot 3 \cdot 3$         | $3^4$ | 81    |
| 3 to the fifth power                | $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$ | $3^5$ | 243   |

### EXAMPLE 2 Evaluating Powers

Simplify each expression.

**A**  $(-2)^3$   
 $(-2)(-2)(-2)$       *Use  $-2$  as a factor 3 times.*  
 $-8$

**B**  $-5^2$   
 $-1 \cdot 5 \cdot 5$       *Think of a negative sign in front of a power as multiplying by  $-1$ . Find the product of  $-1$  and two 5's.*  
 $-1 \cdot 25$   
 $-25$

**C**  $\left(\frac{2}{3}\right)^2$   
 $\frac{2}{3} \cdot \frac{2}{3}$       *Use  $\frac{2}{3}$  as a factor 2 times.*  
 $\frac{2}{3} \cdot \frac{2}{3} = \frac{4}{9}$

#### Caution!

In the expression  $-5^2$ , 5 is the base because the negative sign is not in parentheses.  
 In the expression  $(-2)^3$ ,  $-2$  is the base because of the parentheses.



Simplify each expression.

2a.  $(-5)^3$

2b.  $-6^2$

2c.  $\left(\frac{3}{4}\right)^3$

### EXAMPLE 3 Writing Powers

Write each number as a power of the given base.

**A** 8; base 2  
 $2 \cdot 2 \cdot 2$       *The product of three 2's is 8.*  
 $2^3$

**B**  $-125$ ; base  $-5$   
 $(-5)(-5)(-5)$       *The product of three  $-5$ 's is  $-125$ .*  
 $(-5)^3$



Write each number as a power of the given base.

3a. 64; base 8

3b.  $-27$ ; base  $-3$

## EXAMPLE 4 Problem-Solving Application



A certain bacterium splits into 2 bacteria every hour. There is 1 bacterium on a slide. If each bacterium on the slide splits once per hour, how many bacteria will be on the slide after 6 hours?

### 1 Understand the Problem

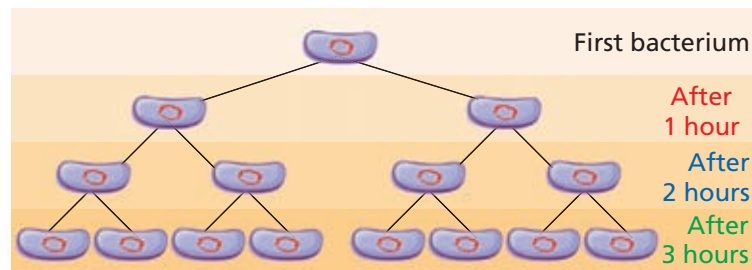
The **answer** will be the number of bacteria on the slide after 6 hours.

List the **important information**:

- There is 1 bacterium on a slide that divides into 2 bacteria.
- Each bacterium then divides into 2 more bacteria.

### 2 Make a Plan

Draw a diagram to show the number of bacteria after each hour.



### 3 Solve

Notice that after each hour, the number of bacteria is a power of 2.

After 1 hour:  $1 \cdot 2 = 2$  or  $2^1$  bacteria on the slide

After 2 hours:  $2 \cdot 2 = 4$  or  $2^2$  bacteria on the slide

After 3 hours:  $4 \cdot 2 = 8$  or  $2^3$  bacteria on the slide

So, after the 6th hour, there will be  $2^6$  bacteria.

$$2^6 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 64 \quad \text{Multiply six 2's.}$$

After 6 hours, there will be 64 bacteria on the slide.

### 4 Look Back

The numbers quickly become too large for a diagram, but a diagram helps you recognize a pattern. Then you can write the numbers as powers of 2.



4. **What if...?** How many bacteria will be on the slide after 8 hours?

## THINK AND DISCUSS

1. Express  $8^3$  in words two ways.

2. **GET ORGANIZED** Copy and complete the graphic organizer. In each box, give an example and tell whether the expression is positive or negative.

|               | Even Exponent | Odd Exponent |
|---------------|---------------|--------------|
| Positive Base |               |              |
| Negative Base |               |              |



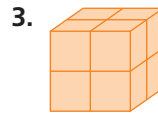
## GUIDED PRACTICE

1. **Vocabulary** What does the *exponent* in the expression  $5^6$  tell you?

## SEE EXAMPLE 1

p. 26

- Write the power represented by each geometric model.



## SEE EXAMPLE 2

p. 27

- Simplify each expression.

5.  $7^2$

6.  $(-2)^4$

7.  $(-2)^5$

8.  $-\left(\frac{1}{2}\right)^4$

## SEE EXAMPLE 3

p. 27

- Write each number as a power of the given base.

9. 81; base 9

10. 100,000; base 10

11.  $-64$ ; base  $-4$

12. 10; base 10

13. 81; base 3

14. 36; base  $-6$

## SEE EXAMPLE 4

p. 28

15. **Technology** Jan wants to predict the number of hits she will get on her Web page. Her Web page received 3 hits during the first week it was posted. If the number of hits triples every week, how many hits will the Web page receive during the 5th week?

## PRACTICE AND PROBLEM SOLVING

## Independent Practice

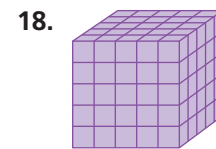
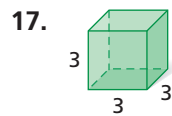
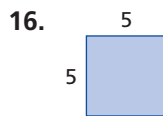
| For Exercises | See Example |
|---------------|-------------|
| 16–18         | 1           |
| 19–22         | 2           |
| 23–28         | 3           |
| 29            | 4           |

## Extra Practice

Skills Practice p. S4

Application Practice p. S28

- Write the power represented by each geometric model.



- Simplify each expression.

19.  $3^3$

20.  $(-4)^2$

21.  $-4^2$

22.  $\left(-\frac{3}{5}\right)^2$

- Write each number as a power of the given base.

23. 49; base 7

24. 1000; base 10

25.  $-8$ ; base  $-2$

26. 1,000,000; base 10

27. 64; base 4

28. 343; base 7

29. **Biology** Protozoa are single-celled organisms. *Paramecium aurelia* is one type of protozoan. The number of *Paramecium aurelia* protozoa doubles every 1.25 days. There was one protozoan on a slide 5 days ago. How many protozoa are on the slide now?



30. **Write About It** A classmate says that any number raised to an even power is positive. Give examples to explain whether your classmate is correct.



- Compare. Write  $<$ ,  $>$ , or  $=$ .

31.  $3^2$   $\square$   $3^3$

32.  $5^2$   $\square$   $2^5$

33.  $4^2$   $\square$   $2^4$

34.  $1^9$   $\square$   $1^4$

35.  $-2^3$   $\square$   $(-2)^3$

36.  $-3^2$   $\square$   $(-3)^2$

37.  $10^2$   $\square$   $2^6$

38.  $2^2$   $\square$   $4^1$

Write each expression as repeated multiplication. Then simplify the expression.

39.  $2^3$

40.  $1^7$

41.  $(-4)^3$

42.  $-4^3$

43.  $(-1)^3$

44.  $(-1)^4$

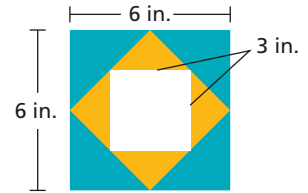
45.  $\left(\frac{1}{3}\right)^3$

46.  $-2.2^2$



47. **Geometry** The diagram shows an ornamental tile design.

- What is the area of the whole tile?
- What is the area of the white square?
- What is the area of the two shaded regions?



Write each expression using a base and an exponent.

48.  $3 \cdot 3 \cdot 3 \cdot 3$

49.  $6 \cdot 6$

50.  $8 \cdot 8 \cdot 8 \cdot 8 \cdot 8$

51.  $(-1)(-1)(-1)(-1)$

52.  $(-7)(-7)(-7)$

53.  $\left(\frac{1}{9}\right)\left(\frac{1}{9}\right)\left(\frac{1}{9}\right)$

54. **Art** A painting is made of 3 concentric squares. The side length of the largest square is 24 cm. What is the area of the painting?

55. **Estimation** A box is shaped like a cube with edges 22.7 centimeters long. What is the approximate volume of the box?

Write the exponent that makes each equation true.

56.  $2^{\square} = 4$

57.  $4^{\square} = 16$

58.  $(-2)^{\square} = 16$

59.  $5^{\square} = 625$

60.  $-2^{\square} = -8$

61.  $10^{\square} = 100$

62.  $5^{\square} = 125$

63.  $3^{\square} = 81$

64. **Entertainment** Mark and Becky play a coin toss game. Both start with one point. Every time the coin comes up heads, Mark doubles his score. Every time the coin comes up tails, Becky triples her score. The results of their game so far are shown in the table.

| Coin Toss Results |       |
|-------------------|-------|
| Heads             | Tails |
| ✓                 | ✓     |
| ✓                 | ✓     |
| ✓                 | ✓     |
| ✓                 |       |
| ✓                 |       |



- What is Mark's score?
- What is Becky's score?
- What if...?** If they toss the coin 50 more times, who do you think will win? Why?

65. **Critical Thinking** The number of zeros in powers of 10 follow a pattern.

- Simplify each of the following:  $10^2$ ,  $10^3$ ,  $10^4$ .
- Explain what relationship you see between the exponent of a power of 10 and the number of zeros in the answer.

**MULTI-STEP TEST PREP**



66. This problem will prepare you for the Multi-Step Test Prep on page 38.

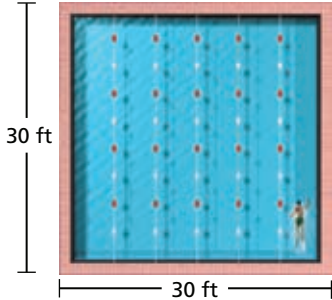

The formula  $p = \frac{F}{A}$  shows that pressure  $p$  is the amount of force  $F$  exerted over an area  $A$  in square units.

- A 50-pound bag of flour sits on a block and exerts a force over an area of  $100 \text{ in}^2$ . What is the pressure exerted on the block by the bag of flour?
- A weight exerts 64 pounds on each square foot of a diver's body. What force is exerted on each square *inch* of the diver's body? (*Hint*: Determine how many square inches are in one square foot.)

67. Which of the following is equal to  $9^2$ ?  
 (A)  $9 \cdot 2$       (B) 27      (C)  $3^4$       (D)  $-9^2$
68. Which expression represents the same value as the product  $(-16)(-16)(-16)(-16)$ ?  
 (F)  $(-16)4$       (G)  $(-16)^4$       (H)  $-16^4$       (J)  $-(16 \cdot 4)$
69. A number raised to the third power is negative. What is true about the number?  
 (A) The number is positive.      (C) The number is even.  
 (B) The number is negative.      (D) The number is odd.
70. A pattern exists as a result of raising  $-1$  to consecutive whole numbers. Which is the best representation of the value of  $-1$  raised to the 100th power?
- |          |          |          |          |          |          |          |
|----------|----------|----------|----------|----------|----------|----------|
| $(-1)^n$ | $(-1)^1$ | $(-1)^2$ | $(-1)^3$ | $(-1)^4$ | $(-1)^5$ | $(-1)^6$ |
| Value    | -1       | 1        | -1       | 1        | -1       | 1        |
- (F)  $-1^{100}$       (G)  $-1$       (H) 1      (J) 0

## CHALLENGE AND EXTEND

Simplify each expression.

71.  $(2^2)(2^2)(2^2)$       72.  $(2^3)(2^3)(2^3)$       73.  $(-4^2)(-4^2)(-4^2)(-4^2)$
74. **Design** The diagram shows the layout of a pool and the surrounding path. The path is 2.5 feet wide.
- What is the total area of the pool and path?
  - What is the area of the pool?
  - What is the area of the path?
  - One bag of pebbles covers 10 square feet. How many bags of pebbles are needed to cover the path?
- 
75. Exponents and powers have special properties.
- Write both  $4^2$  and  $4^3$  as a product of 4's.
  - Write the product of the two expressions from part a. Write this product as a power of 4.
-  **Write About It** Add the exponents in the expressions  $4^2$  and  $4^3$ . Describe any relationship you see between your answer to part b and the sum of the exponents.

## SPIRAL REVIEW

Find the mean of each data set by dividing the sum of the data by the number of items in the data set. (*Previous course*)

76. 7, 7, 8, 8      77. 1, 3, 5, 7, 9      78. 10, 9, 9, 12, 12

Give two ways to write each algebraic expression in words. (*Lesson 1-1*)

79.  $5 - x$       80.  $6n$       81.  $c \div d$       82.  $a + b$

Multiply or divide if possible. (*Lesson 1-3*)

83.  $\frac{4}{5} \div \frac{8}{25}$       84.  $0 \div \frac{6}{7}$       85.  $-20(-14)$       86.  $\frac{1}{2} \left( -\frac{4}{5} \right)$



# 1-5

## Roots and Real Numbers

### Objectives

Simplify expressions containing roots.

Classify numbers within the real number system.

### Vocabulary

square root  
principal square root  
perfect square  
cube root  
natural numbers  
whole numbers  
integers  
rational numbers  
terminating decimal  
repeating decimal  
irrational numbers

### Why learn this?

Square roots can be used to find the side length of a square garden when you know its area. (See Example 3.)

A number that is multiplied by itself to form a product is a **square root** of that product. The radical symbol  $\sqrt{\quad}$  is used to represent square roots. For nonnegative numbers, the operations of squaring and finding a square root are inverse operations. In other words, for  $x \geq 0$ ,  $\sqrt{x} \cdot \sqrt{x} = x$ .

Positive real numbers have two square roots. The **principal square root** of a number is the positive square root and is represented by  $\sqrt{\quad}$ . A negative square root is represented by  $-\sqrt{\quad}$ . The symbol  $\pm\sqrt{\quad}$  is used to represent both square roots.

$$4 \cdot 4 = 4^2 = 16 \rightarrow \sqrt{16} = 4 \quad \leftarrow \text{Positive square root of 16}$$

$$(-4)(-4) = (-4)^2 = 16 \rightarrow -\sqrt{16} = -4 \quad \leftarrow \text{Negative square root of 16}$$

A **perfect square** is a number whose positive square root is a whole number. Some examples of perfect squares are shown in the table.

|       |       |       |       |       |       |       |       |       |       |        |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 0     | 1     | 4     | 9     | 16    | 25    | 36    | 49    | 64    | 81    | 100    |
| $0^2$ | $1^2$ | $2^2$ | $3^2$ | $4^2$ | $5^2$ | $6^2$ | $7^2$ | $8^2$ | $9^2$ | $10^2$ |

A number that is raised to the third power to form a product is a **cube root** of that product. The symbol  $\sqrt[3]{\quad}$  indicates a cube root. Since  $2^3 = 8$ ,  $\sqrt[3]{8} = 2$ . Similarly, the symbol  $\sqrt[4]{\quad}$  indicates a fourth root:  $2^4 = 16$ , so  $\sqrt[4]{16} = 2$ .

### EXAMPLE 1 Finding Roots

Find each root.

**A**  $\sqrt{49}$   
 $\sqrt{49} = \sqrt{7^2}$  *Think: What number squared equals 49?*  
 $= 7$

**B**  $-\sqrt{36}$   
 $-\sqrt{36} = -\sqrt{6^2}$  *Think: What number squared equals 36?*  
 $= -6$

**C**  $\sqrt[3]{-125}$   
 $\sqrt[3]{-125} = \sqrt[3]{(-5)^3}$  *Think: What number cubed equals -125?*  
 $= -5$   $(-5)(-5)(-5) = 25(-5) = -125$

### Writing Math

The small number to the left of the root is the *index*. In a square root, the index is understood to be 2. In other words,  $\sqrt{\quad}$  is the same as  $\sqrt[2]{\quad}$ .



Find each root.

1a.  $\sqrt{4}$

1b.  $-\sqrt{25}$

1c.  $\sqrt[4]{81}$

## EXAMPLE 2 Finding Roots of Fractions

Find  $\sqrt{\frac{1}{4}}$ .

$$\sqrt{\frac{1}{4}} = \sqrt{\left(\frac{1}{2}\right)^2}$$

$$\sqrt{\frac{1}{4}} = \frac{1}{2}$$

Think: What number squared equals  $\frac{1}{4}$ ?



Find each root.

2a.  $\sqrt{\frac{4}{9}}$

2b.  $\sqrt[3]{\frac{1}{8}}$

2c.  $-\sqrt{\frac{4}{49}}$

Square roots of numbers that are not perfect squares, such as 15, are not whole numbers. A calculator can approximate the value of  $\sqrt{15}$  as 3.872983346... Without a calculator, you can use the square roots of perfect squares to help estimate the square roots of other numbers.

## EXAMPLE 3 Gardening Application

Nancy wants to plant a square garden of wildflowers. She has enough wildflower seeds to cover  $19 \text{ ft}^2$ . Estimate to the nearest tenth the side length of a square with an area of  $19 \text{ ft}^2$ .

Since the area of the square is  $19 \text{ ft}^2$ , then each side of the square is  $\sqrt{19}$  ft. 19 is not a perfect square, so find the two consecutive perfect squares that 19 is between: 16 and 25.  $\sqrt{19}$  is between  $\sqrt{16}$  and  $\sqrt{25}$ , or 4 and 5. Refine the estimate.

4.3:  $4.3^2 = 18.49$  too low  $\sqrt{19}$  is greater than 4.3.

4.4:  $4.4^2 = 19.36$  too high  $\sqrt{19}$  is less than 4.4.

4.35:  $4.35^2 = 18.9225$  too low  $\sqrt{19}$  is greater than 4.35.

Since 4.35 is too low and 4.4 is too high,  $\sqrt{19}$  is between 4.35 and 4.4. Rounded to the nearest tenth,  $\sqrt{19} \approx 4.4$ .

The side length of the plot is  $\sqrt{19} \approx 4.4$  ft.

### Writing Math

The symbol  $\approx$  means "is approximately equal to."



3. Estimate to the nearest tenth the side length of a cube with a volume of  $26 \text{ ft}^3$ .

Real numbers can be classified according to their characteristics.

**Natural numbers** are the counting numbers: 1, 2, 3, ...

**Whole numbers** are the natural numbers and zero: 0, 1, 2, 3, ...

**Integers** are the whole numbers and their opposites: ..., -3, -2, -1, 0, 1, 2, 3, ...

### Writing Math

To show that one or more digits repeat continuously, write a bar over those digits.  
 $1.333333333\dots = 1.\overline{3}$   
 $2.14141414\dots = 2.\overline{14}$

**Rational numbers** are numbers that can be expressed in the form  $\frac{a}{b}$ , where  $a$  and  $b$  are both integers and  $b \neq 0$ . When expressed as a decimal, a rational number is either a *terminating decimal* or a *repeating decimal*.

- A **terminating decimal** has a finite number of digits after the decimal point (for example, 1.25, 2.75, and 4.0).
- A **repeating decimal** has a block of one or more digits after the decimal point that repeat continuously (where all digits are not zeros).

**Irrational numbers** are all real numbers that are not rational. They cannot be expressed in the form  $\frac{a}{b}$  where  $a$  and  $b$  are both integers and  $b \neq 0$ . They are neither terminating decimals nor repeating decimals. For example:

0.10100100010000100000... *After the decimal point, this number contains 1 followed by one 0, and then 1 followed by two 0's, and then 1 followed by three 0's, and so on.*

This decimal neither terminates nor repeats, so it is an irrational number.

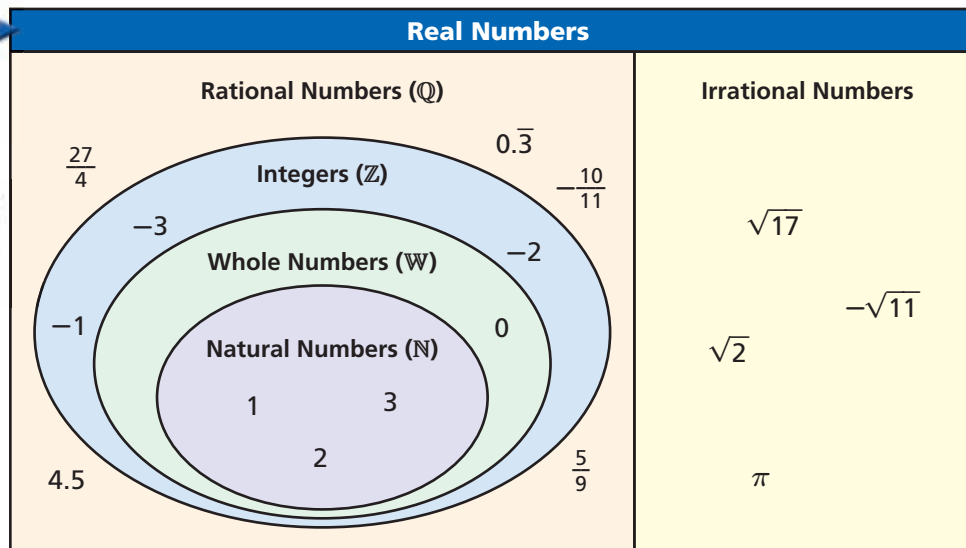
If a whole number is not a perfect square, then its square root is irrational. For example, 2 is not a perfect square, and  $\sqrt{2}$  is irrational.

The real numbers are made up of all rational and irrational numbers.



### Reading Math

Note the symbols for the sets of numbers.  
 $\mathbb{R}$ : real numbers  
 $\mathbb{Q}$ : rational numbers  
 $\mathbb{Z}$ : integers  
 $\mathbb{W}$ : whole numbers  
 $\mathbb{N}$ : natural numbers



### EXAMPLE 4 Classifying Real Numbers

Write all classifications that apply to each real number.

**A**  $\frac{8}{9}$

$\frac{8}{9}$  is in the form  $\frac{a}{b}$ , where  $a$  and  $b$  are integers and  $b \neq 0$ .

$8 \div 9 = 0.8888\dots$

$= 0.\overline{8}$

$\frac{8}{9}$  can be written as a repeating decimal.

rational, repeating decimal

**B** 18

$18 = \frac{18}{1}$  18 can be written in the form  $\frac{a}{b}$ .

$18 = 18.0$  18 can be written as a terminating decimal.

rational, terminating decimal, integer, whole, natural

**C**  $\sqrt{20}$

irrational 20 is not a perfect square, so  $\sqrt{20}$  is irrational.



Write all classifications that apply to each real number.

4a.  $7\frac{4}{9}$

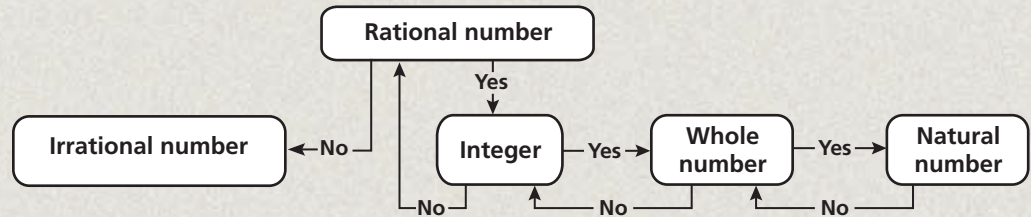
4b. -12

4c.  $\sqrt{10}$

4d.  $\sqrt{100}$

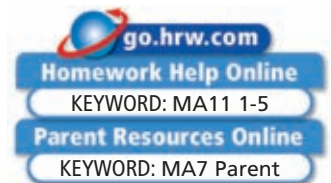
## THINK AND DISCUSS

- Write  $\frac{2}{3}$  and  $\frac{3}{5}$  as decimals. Identify what number classifications the two numbers share and how their classifications are different.
- GET ORGANIZED** Copy the graphic organizer and use the flowchart to classify each of the given numbers. Write each number in the box with the most specific classification that applies.  $4, \sqrt{25}, 0, \frac{1}{3}, -15, -2.25, \frac{1}{4}, \sqrt{21}, 2^4, (-1)^2$



## 1-5

## Exercises



### GUIDED PRACTICE

- Vocabulary** Give an example of a *square root* that is not a *rational number*.

Find each root.

SEE EXAMPLE 1  
p. 32

2.  $\sqrt{64}$

3.  $-\sqrt{225}$

4.  $\sqrt[3]{-64}$

5.  $\sqrt[4]{625}$

p. 32

6.  $\sqrt{81}$

7.  $-\sqrt[3]{27}$

8.  $-\sqrt[3]{-27}$

9.  $-\sqrt{16}$

SEE EXAMPLE 2  
p. 33

10.  $\sqrt{\frac{1}{16}}$

11.  $\sqrt[3]{\frac{8}{27}}$

12.  $-\sqrt{\frac{1}{9}}$

13.  $\sqrt{\frac{9}{64}}$

p. 33

14.  $\sqrt{\frac{1}{36}}$

15.  $\sqrt[3]{\frac{1}{64}}$

16.  $-\sqrt{\frac{4}{81}}$

17.  $\sqrt[3]{-\frac{1}{125}}$

SEE EXAMPLE 3  
p. 33

- A contractor is told that a potential client's kitchen floor is in the shape of a square. The area of the floor is  $45 \text{ ft}^2$ . Estimate to the nearest tenth the side length of the floor.

SEE EXAMPLE 4  
p. 34

Write all classifications that apply to each real number.

19.  $-27$

20.  $\frac{1}{6}$

21.  $\sqrt{33}$

22.  $-6.8$

### PRACTICE AND PROBLEM SOLVING

Find each root.

23.  $\sqrt{121}$

24.  $\sqrt[3]{-1000}$

25.  $-\sqrt{100}$

26.  $\sqrt[4]{256}$

27.  $\sqrt{\frac{1}{25}}$

28.  $\sqrt[4]{\frac{1}{16}}$

29.  $\sqrt[3]{-\frac{1}{8}}$

30.  $-\sqrt{\frac{25}{36}}$

- An artist makes glass paperweights in the shape of a cube. He uses  $68 \text{ cm}^3$  of glass to make each paperweight. Estimate to the nearest tenth the side length of a paperweight.

**Independent Practice**

| For Exercises | See Example |
|---------------|-------------|
| 23–26         | 1           |
| 27–30         | 2           |
| 31            | 3           |
| 32–35         | 4           |

**Extra Practice**

Skills Practice p. S5  
Application Practice p. S28

Write all classifications that apply to each real number.

32.  $\frac{5}{12}$

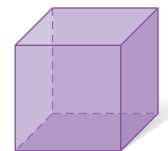
33.  $\sqrt{49}$

34.  $-3$

35.  $\sqrt{18}$

36. **Geometry** The cube root of the volume of a cube gives the length of one side of the cube.

- Find the side length of the cube shown.
- Find the area of each face of the cube.



Volume =  $343 \text{ cm}^3$

Compare. Write  $<$ ,  $>$ , or  $=$ .

37.  $8 \square \sqrt{63}$

38.  $\sqrt{88} \square 9$

39.  $6 \square \sqrt{40}$

40.  $\sqrt{\frac{9}{25}} \square 0.61$

**Travel** During a cross-country road trip, Madeline recorded the distance between several major cities and the time it took her to travel between those cities. Find Madeline's average speed for each leg of the trip and classify that number.



| Madeline's Cross-Country Road Trip |                              |          |              |                |
|------------------------------------|------------------------------|----------|--------------|----------------|
|                                    | Distance (mi)                | Time (h) | Speed (mi/h) | Classification |
| 41.                                | Portland, ME, to Memphis, TN | 1485     | 33           | $\square$      |
| 42.                                | Memphis, TN, to Denver, CO   | 1046     | 27           | $\square$      |
| 43.                                | Denver, CO, to Boise, ID     | 831      | 24           | $\square$      |
| 44.                                | Boise, ID, to Portland, OR   | 424      | 9            | $\square$      |

Determine whether each statement is sometimes, always, or never true. If it is sometimes true, give one example that makes the statement true and one example that makes it false. If it is always true, explain. If it is never true, rewrite the statement so that it is always true.

- Mixed numbers are rational numbers.
- The decimal form of an irrational number is a repeating decimal.
- A terminating decimal is a rational number.
- A negative number is irrational.
- Critical Thinking** A positive number has two square roots, one that is positive and one that is negative. Is the same thing true for the cube root of a positive number? What about the fourth root of a positive number? Explain.

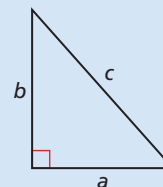
**MULTI-STEP TEST PREP**



50. This problem will prepare you for the Multi-Step Test Prep on page 38.

The equation  $a^2 + b^2 = c^2$  relates the lengths of the sides of a right triangle. Sides  $a$  and  $b$  make the right angle of the triangle.

- What is the value of  $c^2$  when  $a = 5$  and  $b = 12$ ? Determine the square root of  $c^2$  to find the value of  $c$ .
- A diver is a horizontal distance of 50 feet from a boat and 120 feet beneath the surface of the water. What distance will the diver swim if he swims diagonally to the boat?





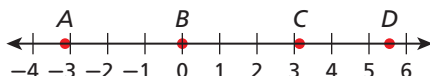
51. **Entertainment** In a board game, players place different-colored stones on a grid. Each player tries to make rows of 5 or more stones in their color while preventing their opponent(s) from doing the same. The square game board has 324 squares on it. How many squares are on each side of the board?



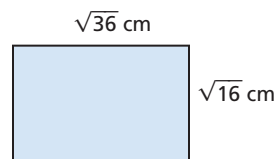
52. **Write About It** Explain why you cannot take the square root of a negative number but you can take the cube root of a negative number.



53. Which point on the number line is closest to  $-\sqrt[3]{36}$  ?



- (A) A                      (B) B                      (C) C                      (D) D
54. What is the area of the figure at right?  
 (F) 24 cm<sup>2</sup>                      (H) 104 cm<sup>2</sup>  
 (G) 52 cm<sup>2</sup>                      (J) 576 cm<sup>2</sup>
55. Which number is irrational?  
 (A)  $-\sqrt{9}$                       (B) 4.0005  
 (C) 2.17                      (D)  $\sqrt{40}$
56. The square root of 175 is between which two whole numbers?  
 (F) 11 and 12                      (G) 12 and 13                      (H) 13 and 14                      (J) 14 and 15



## CHALLENGE AND EXTEND

Find each root.

57.  $\sqrt{0.81}$                       58.  $\sqrt{0.25}$                       59.  $\sqrt[3]{-0.001}$                       60.  $\sqrt{2.25}$

Evaluate each expression for  $a = 9$  and  $b = 7$ .

61.  $\sqrt{a+b}$                       62.  $b\sqrt{a} - a$                       63.  $\sqrt[4]{b+a} + ab$                       64.  $\sqrt{ab+1}$

65. The *Density Property of Real Numbers* states that between any two real numbers, there is another real number.

- a. Does the set of integers have this property? Explain.  
 b. Use the Density Property to write a convincing argument that there are infinitely many real numbers between 0 and 1.

## SPIRAL REVIEW

Add or subtract. (Lesson 1-2)

66.  $-14 + (-16)$                       67.  $-\frac{1}{4} - \left(-\frac{3}{4}\right)$                       68.  $25 - 17.6$

Multiply or divide. (Lesson 1-3)

69.  $\frac{1}{8} \div \left(-\frac{2}{3}\right)$                       70.  $(-2.5)(-8)$                       71.  $-\frac{21}{6}$

Simplify each expression. (Lesson 1-4)

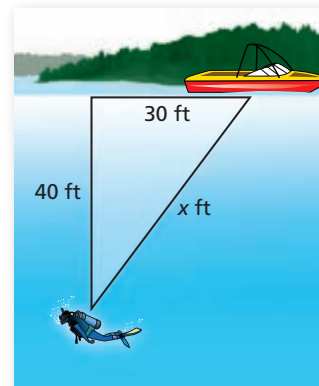
72.  $-3^4$                       73.  $\left(-\frac{2}{5}\right)^3$                       74.  $14^2$                       75.  $4^3$



## The Language of Algebra

**Under Pressure** Atmospheric pressure is 14.7 pounds per square inch (psi). Underwater, the water exerts additional pressure. The total pressure on a diver underwater is the atmospheric pressure plus the water pressure.

- As a diver moves downward in the water, the water pressure increases by 14.7 psi for approximately every 33 ft of water. Make a table to show the total pressure on a diver at 0, 33, 66, and 99 ft below the surface of the water. At what depth would the total pressure equal 73.5 psi? Explain your method.
- A diver is 40 ft below the surface of the water when a hot-air balloon flies over her. The hot-air balloon is 849 ft above the surface of the water. Draw a diagram and write an expression to find the distance between the diver and the balloon when the balloon is directly above her.
- The diver swam 62.5 ft in 5 minutes. How fast was she swimming? What total distance will she have traveled after an additional 4 minutes if she maintains this same speed?
- The total pressure on each square foot of the diver's body is given by the expression  $2116.8 + 64.145d$ , where  $d$  is the depth in feet. At a depth of 66 ft, what is the total pressure on each square foot of her body? What is the total pressure on each square inch of her body at this depth? How does your answer compare to your results for part a?
- The diver realizes that she has drifted horizontally about 30 ft from the boat she left. She is at a depth of 40 ft from the surface. What is the diver's diagonal distance from the boat?



## Quiz for Lessons 1-1 Through 1-5

### 1-1 Variables and Expressions

Give two ways to write each algebraic expression in words.

1.  $4 + n$

2.  $m - 9$

3.  $\frac{g}{2}$

4.  $4z$

5. Bob earns \$15 per hour. Write an expression for the amount of money he earns in  $h$  hours.

6. A soccer practice is 90 minutes long. Write an expression for the number of minutes left after  $m$  minutes have elapsed.

Evaluate each expression for  $x = 3$ ,  $y = 6$ , and  $z = 2$ .

7.  $y \div z$

8.  $xy$

9.  $x + y$

10.  $x - z$

### 1-2 Adding and Subtracting Real Numbers

Add or subtract.

11.  $81 + (-15)$

12.  $27 - 32$

13.  $2 - \left(-1\frac{1}{4}\right)$

14.  $-7 + (-14)$

15. Brandon's bank statement shows a balance of  $-\$45.00$ . What will the balance be after Brandon deposits  $\$70.00$ ?

### 1-3 Multiplying and Dividing Real Numbers

Find the value of each expression if possible.

16.  $9(-9)$

17.  $6 \div \frac{3}{5}$

18.  $9.6 \div 0$

19.  $\left(-\frac{1}{2}\right)\left(-\frac{1}{2}\right)$

20. Simon drove for  $2\frac{1}{2}$  hours to get from his house to the beach. Simon averaged 55 miles per hour on the trip. What is the distance from Simon's house to the beach?

### 1-4 Powers and Exponents

Simplify each expression.

21.  $(-3)^2$

22.  $-3^2$

23.  $\left(-\frac{2}{3}\right)^3$

24.  $\left(-\frac{1}{2}\right)^5$

25. The number of bytes in a kilobyte is 2 to the 10th power. Express this number in two ways.

### 1-5 Roots and Real Numbers

Find each root.

26.  $\sqrt{225}$

27.  $-\sqrt{49}$

28.  $\sqrt[3]{8}$

29.  $\sqrt{\frac{16}{25}}$

30. Mindy is building a patio that is in the shape of a square. The patio will cover 56 square yards. Find the length of a side of the patio to the nearest tenth of a yard.

Write all classifications that apply to each real number.

31.  $\frac{1}{11}$

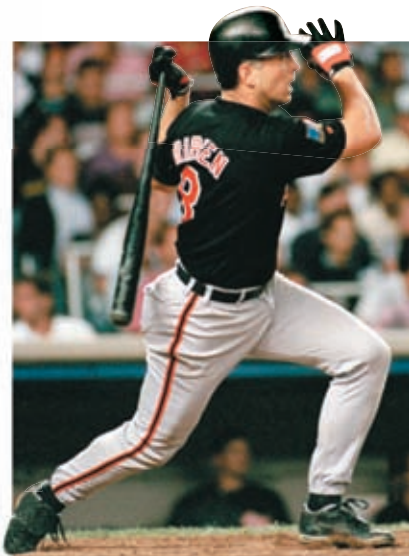
32.  $\sqrt{12}$

33.  $\sqrt{400}$

34.  $-6$

# 1-6

## Order of Operations



### Objective

Use the order of operations to simplify expressions.

### Vocabulary

order of operations

### Who uses this?

Sports statisticians use the order of operations to calculate data. (See Example 5.)

A baseball player must run to first, second, and third bases before running back to home plate. In math, some tasks must be done in a certain order.

When a numerical or algebraic expression contains more than one operation symbol, the **order of operations** tells you which operation to perform first.



| Order of Operations |   |
|---------------------|---|
| First:              | Perform operations inside grouping symbols.             |
| Second:             | Simplify powers and roots.                              |
| Third:              | Perform multiplication and division from left to right. |
| Fourth:             | Perform addition and subtraction from left to right.    |

Grouping symbols include parentheses ( ), brackets [ ], and braces { }. If an expression contains more than one set of grouping symbols, simplify the expression inside the innermost set first. Follow the order of operations within that set of grouping symbols and then work outward.

### EXAMPLE 1 Simplifying Numerical Expressions

Simplify each expression.

**A**  $-4^2 + 24 \div 3 \cdot 2$   
 $-4^2 + 24 \div 3 \cdot 2$   
 $-16 + 24 \div 3 \cdot 2$   
 $-16 + 8 \cdot 2$   
 $-16 + 16$   
 $0$

*There are no grouping symbols.*  
*Simplify powers. The exponent applies only to the 4.*  
*Divide.*  
*Multiply.*  
*Add.*

**B**  $4[25 - (5 - 2)^2]$   
 $4[25 - (5 - 2)^2]$   
 $4[25 - 3^2]$   
 $4[25 - 9]$   
 $4 \cdot 16$   
 $64$

*There are two sets of grouping symbols.*  
*Perform the operation in the innermost set.*  
*Simplify powers within the brackets.*  
*Subtract within the brackets.*  
*Multiply.*

### Helpful Hint

The first letters of these words can help you remember the order of operations.

|        |             |
|--------|-------------|
| Please | Parentheses |
| Excuse | Exponents   |
| My     | Multiply/   |
| Dear   | Divide      |
| Aunt   | Add/        |
| Sally  | Subtract    |



Simplify each expression.

1a.  $8 \div \frac{1}{2} \cdot 3$

1b.  $5.4 - 3^2 + 6.2$

1c.  $-20 \div [-2(4 + 1)]$

## EXAMPLE 2 Evaluating Algebraic Expressions

Evaluate each expression for the given value of  $x$ .

**A**  $21 - x + 2 \cdot 5$  for  $x = 7$

$$21 - x + 2 \cdot 5$$

$$21 - 7 + 2 \cdot 5 \quad \text{First substitute 7 for } x.$$

$$21 - 7 + 10 \quad \text{Multiply.}$$

$$14 + 10 \quad \text{Subtract.}$$

$$24 \quad \text{Add.}$$

**B**  $5^2(30 - x)$  for  $x = 24$

$$5^2(30 - x)$$

$$5^2(30 - 24) \quad \text{First substitute 24 for } x.$$

$$5^2(6) \quad \text{Perform the operation inside the parentheses.}$$

$$25(6) \quad \text{Simplify powers.}$$

$$150 \quad \text{Multiply.}$$



Evaluate each expression for the given value of  $x$ .

**2a.**  $14 + x^2 \div 4$  for  $x = 2$

**2b.**  $(x \cdot 2^2) \div (2 + 6)$  for  $x = 6$

Fraction bars, radical symbols, and absolute-value symbols can also be used as grouping symbols. Remember that a fraction bar indicates division.

## EXAMPLE 3 Simplifying Expressions with Other Grouping Symbols

Simplify each expression.

**A**  $\frac{-22 - 2^2}{5 - 3}$

$$\frac{(-22 - 2^2)}{(5 - 3)}$$

The fraction bar acts as a grouping symbol. Simplify the numerator and the denominator before dividing.

$$\frac{-22 - 4}{5 - 3}$$

Simplify the power in the numerator.

$$\frac{-26}{5 - 3}$$

Subtract to simplify the numerator.

$$\frac{-26}{2}$$

Subtract to simplify the denominator.

$$-13$$

Divide.

**B**  $|10 - 5^2| \div 5$

$$|10 - 5^2| \div 5$$

The absolute-value symbols act as grouping symbols.

$$|10 - 25| \div 5$$

Simplify the power.

$$|-15| \div 5$$

Subtract within the absolute-value symbols.

$$15 \div 5$$

Write the absolute value of  $-15$ .

$$3$$

Divide.

### Helpful Hint

You may need to add grouping symbols to simplify expressions when using a scientific or graphing calculator. To simplify  $\frac{2+3}{5-4}$  with a calculator, enter  $(2 + 3) \div (5 - 4)$ .



Simplify each expression.

**3a.**  $\frac{5 + 2(-8)}{(-2)^3 - 3}$

**3b.**  $|4 - 7|^2 \div (-3)$

**3c.**  $3\sqrt{50 - 1}$



You may need to use grouping symbols when translating from words to numerical or algebraic expressions. Remember that operations inside grouping symbols are performed first.

### EXAMPLE 4 Translating from Words to Math

#### Remember!

Look for words that imply mathematical operations.

*difference* → subtract

*sum* → add

*product* → multiply

*quotient* → divide

Translate each word phrase into a numerical or algebraic expression.

- A** one half times the difference of  $-5$  and  $3$

$$\frac{1}{2}(-5 - 3) \quad \text{Use parentheses so that the difference is evaluated first.}$$

- B** the square root of the quotient of  $-12$  and  $n$

$$\sqrt{\frac{-12}{n}} \quad \text{Show the square root of a quotient.}$$



4. Translate the word phrase into a numerical or algebraic expression: the product of  $6.2$  and the sum of  $9.4$  and  $8$ .

### EXAMPLE 5 Sports Application

Hank Aaron's last season in the Major Leagues was in 1976. A player's total number of bases can be found using the expression  $S + 2D + 3T + 4H$ . Use the table to find Hank Aaron's total bases for 1976.

$$S + 2D + 3T + 4H$$

$$44 + 2(8) + 3(0) + 4(10)$$

$$44 + 16 + 0 + 40$$

$$60 + 0 + 40$$

$$100$$

Hank Aaron's total number of bases for 1976 was 100.

| HANK AARON<br>1976 Statistics |        |
|-------------------------------|--------|
| Base Hits                     | Number |
| Single (S)                    | 44     |
| Double (D)                    | 8      |
| Triple (T)                    | 0      |
| Home run (H)                  | 10     |

First substitute values for each variable.

Multiply.

Add from left to right.

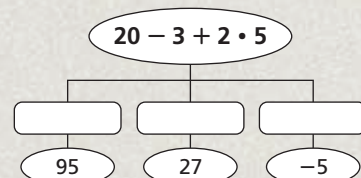
Add.



5. Another formula for a player's total number of bases is  $\text{Hits} + D + 2T + 3H$ . Use this expression to find Hank Aaron's total bases for 1959, when he had 223 hits, 46 doubles, 7 triples, and 39 home runs.

### THINK AND DISCUSS

- Explain whether you always perform addition before subtraction when simplifying a numerical or algebraic expression.
- GET ORGANIZED** Copy and complete the graphic organizer. In each box, show how grouping symbols can be placed so that the expression is equal to the number shown.



### GUIDED PRACTICE

1. **Vocabulary** Explain why the *order of operations* is necessary for simplifying numerical expressions.

**SEE EXAMPLE 1**

p. 40

1. Simplify each expression.

2.  $5 - 12 \div (-2)$

3.  $30 - 5 \cdot 3$

4.  $50 - 6 + 8$

5.  $12 \div (-4)(3)$

6.  $(5 - 8)(3 - 9)$

7.  $16 + [5 - (3 + 2^2)]$

**SEE EXAMPLE 2**

p. 41

2. Evaluate each expression for the given value of the variable.

8.  $5 + 2x - 9$  for  $x = 4$

9.  $30 \div 2 - d$  for  $d = 14$

10.  $51 - 91 + g$  for  $g = 20$

11.  $2(3 + n)$  for  $n = 4$

12.  $4(b - 4)^2$  for  $b = 5$

13.  $12 + [20(5 - k)]$  for  $k = 1$

**SEE EXAMPLE 3**

p. 41

3. Simplify each expression.

14.  $24 \div |4 - 10|$

15.  $4.5 - \sqrt{2(4.5)}$

16.  $5(2) + 16 \div |-4|$

17.  $\frac{0 - 24}{6 + 2}$

18.  $\frac{2 + 3(6)}{2^2}$

19.  $-44 \div \sqrt{12 \div 3}$

**SEE EXAMPLE 4**

p. 42

4. Translate each word phrase into a numerical or algebraic expression.

20. 5 times the absolute value of the sum of  $s$  and  $-2$

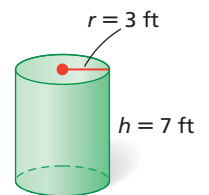
21. the product of 12 and the sum of  $-2$  and 6

22. 14 divided by the sum of 52 and  $-3$

**SEE EXAMPLE 5**

p. 42

23. **Geometry** The surface area of a cylinder can be found using the expression  $2\pi r(h + r)$ . Find the surface area of the cylinder shown. (Use 3.14 for  $\pi$  and give your final answer rounded to the nearest tenth.)



### PRACTICE AND PROBLEM SOLVING

**Independent Practice**

| For Exercises | See Example |
|---------------|-------------|
| 24–32         | 1           |
| 33–41         | 2           |
| 42–49         | 3           |
| 50–53         | 4           |
| 54            | 5           |

**Extra Practice**

Skills Practice p. S5  
 Application Practice p. S28

Simplify each expression.

24.  $3 + 4(-5)$

25.  $20 - 4 + 5 - 2$

26.  $41 + 12 \div 2$

27.  $3(-9) + (-2)(-6)$

28.  $10^2 \div (10 - 20)$

29.  $(6 + 2 \cdot 3) \div (9 - 7)^2$

30.  $-9 - (-18) + 6$

31.  $15 \div (2 - 5)$

32.  $5(1 - 2) - (3 - 2)$

Evaluate each expression for the given value of the variable.

33.  $-6(3 - p)$  for  $p = 7$

34.  $5 + (r + 2)^2$  for  $r = 4$

35.  $13 - [3 + (j - 12)]$  for  $j = 5$

36.  $(-4 - a)^2$  for  $a = -3$

37.  $7 - (21 - h)^2$  for  $h = 25$

38.  $10 + [8 \div (q - 3)]$  for  $q = 2$

39.  $(4r - 2) + 7$  for  $r = 3$

40.  $-2(11b - 3)$  for  $b = 5$

41.  $7x(3 + 2x)$  for  $x = -1$

Simplify each expression.

42.  $-4|2.5 - 6|$

43.  $\frac{8 - 8}{2 - 1}$

44.  $\frac{3 + |8 - 10|}{2}$

45.  $\sqrt{3^2 - 5} \div 8$

46.  $\frac{-18 - 36}{-9}$

47.  $\frac{6|5 - 7|}{14 - 2}$

48.  $\sqrt{5^2 - 4^2}$

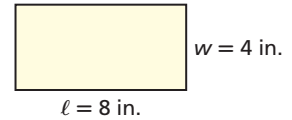
49.  $(-6 + 24) \div |-3|$

Translate each word phrase into a numerical or an algebraic expression.

50. the product of 7 and the sum of 2 and  $d$
51. the difference of 3 and the quotient of 2 and 5
52. the square root of the sum of 5 and  $-4$
53. the difference of 8 and the absolute value of the product of 3 and 5



54. **Geometry** The perimeter of a rectangle can be found using the expression  $2(\ell + w)$ . Find the perimeter of the rectangle shown.



55. Simplify each expression.
- |                         |                      |                         |
|-------------------------|----------------------|-------------------------|
| a. $50 + 10 \div 2$     | b. $50 \cdot 10 - 2$ | c. $50 \cdot 10 \div 2$ |
| d. $50 \div 10 \cdot 2$ | e. $50 - 10 \cdot 2$ | f. $50 + 10 \cdot 2$    |

Translate each word phrase into a numerical or algebraic expression.

56. the difference of 8 and the product of 4 and  $n$
57. 2 times the sum of 9 and the opposite of  $x$
58. two-thirds of the difference of  $-2$  and 8
59. the square root of 7 divided by the product of 3 and 10



**Sports**



In 2004, Paul Hamm became the first American to win a gold medal in the men's all-around gymnastics competition at the Olympics. He won by a margin of 0.012 point.

60. **Sports** At the 2004 Summer Olympics, U.S. gymnast Paul Hamm received the scores shown in the table during the individual all-around competition.

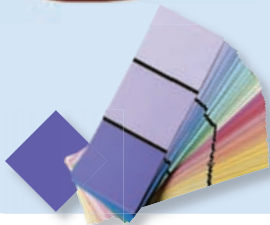
| 2004 Summer Olympics Individual Scores for Paul Hamm |       |              |       |       |               |                |
|--|-------|--------------|-------|-------|---------------|----------------|
| Event  | Floor | Pommel horse | Rings | Vault | Parallel bars | Horizontal bar |
| Score  | 9.725 | 9.700        | 9.587 | 9.137 | 9.837         | 9.837          |

- a. Write a numerical expression to show the average of Hamm's scores. (*Hint:* The average of a set of values is the sum of the values divided by the number of values.)
  - b. Simplify the expression to find Hamm's average score to the nearest thousandth.
61. **Critical Thinking** Are parentheses required when translating the word phrase "the sum of 8 and the product of 3 and 2" into a numerical phrase? Explain.

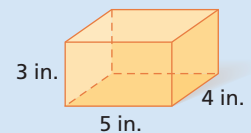
Translate each word phrase into a numerical expression. Then simplify.

62. the sum of 8 and the product of  $-3$  and 5
63. the difference of the product of 3 and 5 and the product of 6 and 2
64. the product of  $\frac{2}{3}$  and the absolute value of the difference of 3 and  $-12$

**MULTI-STEP TEST PREP**

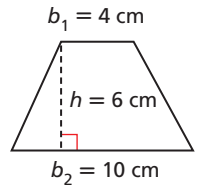


65. This problem will prepare you for the Multi-Step Test Prep on page 60.
- a. Find the area of each face of the prism. Find the sum of these areas to find the total surface area of the prism.
  - b. The total surface area of a prism is described by the expression  $2(\ell w) + 2(\ell h) + 2(wh)$ . Explain how this expression relates to the sum you found in part a.
  - c. Use the expression above to find the total surface area of the prism. Explain why your answers to parts a and c should be equal.





66. **Geometry** The area of a trapezoid is equal to the average of its bases times its height. Use the expression  $\left(\frac{b_1 + b_2}{2}\right)h$  to determine the area of the trapezoid.



67. **Write About It** Many everyday processes must be done in a certain order to be completed successfully. Describe a process that requires several steps, and tell why the steps must be followed in a certain order.

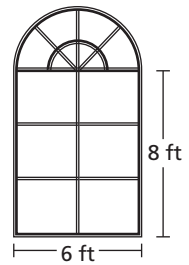


68. Cara's family rented a car for their 3-day vacation to the Grand Canyon. They paid \$29.00 per day and \$0.12 for each mile driven. Which expression represents Cara's family's cost to rent the car for 3 days and drive 318 miles?

- (A)  $29 + 0.12(318)$                       (C)  $29(3) + 0.12(318)$   
 (B)  $29 + 3 + 0.12 + 318$                       (D)  $3[9 + 0.12(318)]$

69. The perimeter of the Norman window shown is approximated by the expression  $2(3 + 8) + 3.14(3)$ . Which is the closest approximation of the perimeter of the window?

- (F) 23.4 feet                                      (H) 31.4 feet  
 (G) 28.4 feet                                      (J) 51.4 feet



70. **Gridded Response** Simplify  $\sqrt{\frac{54 - (-2)(5)}{20 - 4^2}}$ .

## CHALLENGE AND EXTEND

Simplify each expression.

71.  $\frac{3 + 9 \cdot 2}{2 - 3^2}$

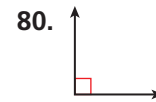
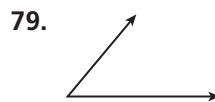
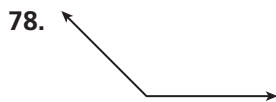
72.  $[(-6 \cdot 4) \div (-6) \cdot 4]^2$

73.  $\sqrt{\frac{8 + 10^2}{13 + (-10)}}$

74. Use the numbers 2, 4, 5, and 8 to write an expression that has a value of 5. You may use any operations, and you must use each of the numbers at least once.
75. Use the numbers 2, 5, 6, and 9 to write an expression that has a value of 1. You may use any operations, and you must use each of the numbers at least once.
76. If the value of  $(\otimes + 5)^2$  is 81, what is the value of  $(\otimes + 5)^2 + 1$ ?
77. If the value of  $(\otimes + 1)^2 - 3$  is 22, what is the value of  $(\otimes + 1)^2 - 5$ ?

## SPIRAL REVIEW

Identify each angle as acute, right, obtuse, or straight. (*Previous course*)



Add or subtract. (*Lesson 1-2*)

81.  $51 - (-49)$

82.  $-5 + \left(-1\frac{1}{3}\right)$

83.  $-3 + (-8)$

84.  $2.9 - 5.3$

Find each square root. (*Lesson 1-5*)

85.  $\sqrt{64}$

86.  $\sqrt{324}$

87.  $\sqrt{\frac{36}{49}}$

88.  $-\sqrt{121}$

# 1-7

## Simplifying Expressions



### Objectives

Use the Commutative, Associative, and Distributive Properties to simplify expressions.

Combine like terms.

### Vocabulary

term  
like terms  
coefficient

### Who uses this?

Triathletes can use the Commutative, Associative, and Distributive Properties to calculate overall times mentally.

A triathlon is an endurance race that includes swimming, biking, and running. The winner is determined by adding the times for each of the three events.

The Commutative and Associative Properties of Addition and Multiplication allow you to rearrange an expression to simplify it.



### Properties of Addition and Multiplication

| WORDS   | NUMBERS  | ALGEBRA  |
|---|--|--|
| <b>Commutative Property</b><br>You can add numbers in any order and multiply numbers in any order.                      | $2 + 7 = 7 + 2$<br>$3 \cdot 9 = 9 \cdot 3$                                 | $a + b = b + a$<br>$ab = ba$                   |
| <b>Associative Property</b><br>When you are only adding or only multiplying, you can group any of the numbers together. | $(6 + 8) + 2 = 6 + (8 + 2)$<br>$(7 \cdot 4) \cdot 5 = 7 \cdot (4 \cdot 5)$ | $(a + b) + c = a + (b + c)$<br>$(ab)c = a(bc)$ |

### EXAMPLE 1 Using the Commutative and Associative Properties

#### Helpful Hint

Compatible numbers help you do math mentally. Try to make multiples of 5 or 10. They are simpler to use when multiplying.

Simplify each expression.

**A**  $4 \cdot 9 \cdot 25$   
 $9 \cdot 4 \cdot 25$   
 $9 \cdot (4 \cdot 25)$   
 $9 \cdot 100$   
 $900$

Use the Commutative Property of Multiplication.  
 Use the Associative Property of Multiplication to make groups of compatible numbers.

**B**  $25 + 48 + 75$   
 $25 + 75 + 48$   
 $(25 + 75) + 48$   
 $100 + 48$   
 $148$

Use the Commutative Property of Addition.  
 Use the Associative Property of Addition to make groups of compatible numbers.



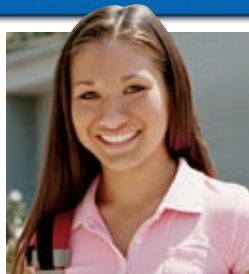
Simplify each expression.

1a.  $15\frac{1}{3} + 4 + 1\frac{2}{3}$     1b.  $410 + 58 + 90 + 2$     1c.  $\frac{1}{2} \cdot 7 \cdot 8$



## Student to Student

### Commutative and Associative Properties



**Lorna Anderson**  
Pearson High School

I used to get the Commutative and Associative Properties mixed up.

To remember the Commutative Property, I think of people commuting back and forth from work. When people commute, they move. I can move the numbers around without changing the value of the expression.

For the Associative Property, I think of associating with my friends. They're the group I hang out with. In math, it's about how numbers are grouped.

The Distributive Property is used with addition to simplify expressions.



### Distributive Property

| WORDS  | NUMBERS                  | ALGEBRA              |
|--|--------------------------|----------------------|
| You can multiply a number by a sum or multiply each addend by the number and then add. The result is the same. | $3(4 + 8) = 3(4) + 3(8)$ | $a(b + c) = ab + ac$ |

The Distributive Property also works with subtraction because subtraction is the same as adding the opposite.

### EXAMPLE 2 Using the Distributive Property with Mental Math

#### Helpful Hint

Break the greater factor into a sum that contains a multiple of 10.

- Write each product using the Distributive Property. Then simplify.
- A**  $15(103)$   
 $15(100 + 3)$       Rewrite 103 as 100 + 3.  
 $15(100) + 15(3)$       Use the Distributive Property.  
 $1500 + 45$       Multiply.  
 $1545$       Add.
- B**  $6(19)$   
 $6(20 - 1)$       Rewrite 19 as 20 - 1.  
 $6(20) - 6(1)$       Use the Distributive Property.  
 $120 - 6$       Multiply.  
 $114$       Subtract.



Write each product using the Distributive Property. Then simplify.

2a.  $9(52)$

2b.  $12(98)$

2c.  $7(34)$

The **terms** of an expression are the parts to be added or subtracted. **Like terms** are terms that contain the same variables raised to the same powers. Constants are also like terms.

$$4x - 3x + 2$$

Like terms      Constant

↓      ↓      ↓

A **coefficient** is a number that is multiplied by a variable. Like terms can have different coefficients. A variable written without a coefficient has a coefficient of 1.

$$1x^2 + 3x$$

Coefficients

Using the Distributive Property can help you combine like terms. You can factor out the common factor to simplify the expression.

$$\begin{aligned} 7x^2 - 4x^2 &= (7 - 4)x^2 && \text{Factor out } x^2 \text{ from both terms.} \\ &= (3)x^2 && \text{Perform operations in parentheses.} \\ &= 3x^2 \end{aligned}$$

Notice that you can combine like terms by adding or subtracting the coefficients and keeping the variables and exponents the same.

### EXAMPLE 3 Combining Like Terms

Simplify each expression by combining like terms.

**A**  $12x + 30x$   
 $12x + 30x$  *12x and 30x are like terms.*  
 $42x$  *Add the coefficients.*

**B**  $6.8y^2 - y^2$   
 $6.8y^2 - y^2$  *A variable without a coefficient has a coefficient of 1.*  
 $6.8y^2 - 1y^2$  *6.8y^2 and 1y^2 are like terms.*  
 $5.8y^2$  *Subtract the coefficients.*

**C**  $4n + 11n^2$   
 $4n + 11n^2$  *4n and 11n^2 are not like terms. Do not combine.*

#### Caution!

Add or subtract only the coefficients.  
 $6.8y^2 - y^2 \neq 6.8$



Simplify each expression by combining like terms.

**3a.**  $16p + 84p$       **3b.**  $-20t - 8.5t$       **3c.**  $3m^2 + m^3$

### EXAMPLE 4 Simplifying Algebraic Expressions

Simplify  $2(x + 6) + 3x$ . Justify each step with an operation or property.

| Procedure             | Justification                    |
|-----------------------|----------------------------------|
| 1. $2(x + 6) + 3x$    |                                  |
| 2. $2(x) + 2(6) + 3x$ | Distributive Property            |
| 3. $2x + 12 + 3x$     | Multiply.                        |
| 4. $2x + 3x + 12$     | Commutative Property of Addition |
| 5. $(2x + 3x) + 12$   | Associative Property of Addition |
| 6. $5x + 12$          | Combine like terms.              |



Simplify each expression. Justify each step with an operation or property.

**4a.**  $6(x - 4) + 9$       **4b.**  $-12x - 5x + 3a + x$

## THINK AND DISCUSS

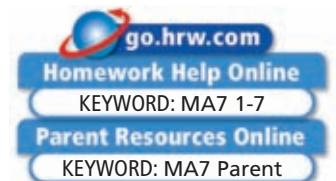
1. Tell which property is described by this sentence: When adding three numbers, you can add the first number to the sum of the second and third numbers, or you can add the third number to the sum of the first and second numbers.
2. **GET ORGANIZED** Copy and complete the graphic organizer below. In each box, give an example to illustrate the given property.



|                      |                      |                      |
|----------------------|----------------------|----------------------|
| Associative          | Commutative          | Distributive         |
| <input type="text"/> | <input type="text"/> | <input type="text"/> |

## 1-7

## Exercises



### GUIDED PRACTICE

1. **Vocabulary** The \_\_\_\_? \_\_\_\_ Property states the following:  
 $(a + b) + c = a + (b + c)$ . (*Associative, Commutative, or Distributive*)

SEE EXAMPLE 1 Simplify each expression.

p. 46

- |                                   |   |                            |
|-----------------------------------|---|----------------------------|
| 2. $-12 + 67 + 12 + 23$           | 3. $16 + 2\frac{1}{2} + 4 + 1\frac{1}{2}$ | 4. $27 + 98 + 73$          |
| 5. $\frac{1}{3} \cdot 8 \cdot 21$ | 6. $2 \cdot 38 \cdot 50$                  | 7. $50 \cdot 118 \cdot 20$ |

SEE EXAMPLE 2 Write each product using the Distributive Property. Then simplify.

p. 47

- |               |               |              |
|---------------|---------------|--------------|
| 8. $14(1002)$ | 9. $16(19)$   | 10. $9(38)$  |
| 11. $8(57)$   | 12. $12(112)$ | 13. $7(109)$ |

SEE EXAMPLE 3 Simplify each expression by combining like terms.

p. 48

- |                |                 |                   |
|----------------|-----------------|-------------------|
| 14. $6x + 10x$ | 15. $35x - 15x$ | 16. $-3a + 9a$    |
| 17. $-8r - r$  | 18. $17x^2 + x$ | 19. $3.2x + 4.7x$ |

SEE EXAMPLE 4 Simplify each expression. Justify each step with an operation or property.

p. 48

- |                          |                         |                          |
|--------------------------|-------------------------|--------------------------|
| 20. $5(x + 3) - 7x$      | 21. $9(a - 3) - 4$      | 22. $5x^2 - 2(x - 3x^2)$ |
| 23. $6x - x - 3x^2 + 2x$ | 24. $12x + 8x + t - 7x$ | 25. $4a - 2(a - 1)$      |

### PRACTICE AND PROBLEM SOLVING

Simplify each expression.

26.  $53 + 28 + 17 + 12$     27.  $5 \cdot 14 \cdot 20$     28.  $6 \cdot 3 \cdot 5$     29.  $4.5 + 7.1 + 8.5 + 3.9$

Write each product using the Distributive Property. Then simplify.

30.  $9(62)$     31.  $8(29)$     32.  $11(25)$     33.  $6(53)$

**Independent Practice**

| For Exercises | See Example |
|---------------|-------------|
| 26–29         | 1           |
| 30–33         | 2           |
| 34–37         | 3           |
| 38–43         | 4           |

**Extra Practice**

Skills Practice p. S5

Application Practice p. S28

Simplify each expression by combining like terms.

34.  $3x + 9x$       35.  $14x^2 - 5x^2$       36.  $-7x + 8x$       37.  $3x^2 - 4$

Simplify each expression. Justify each step with an operation or property.

38.  $4(y + 6) + 9$       39.  $-7(x + 2) + 4x$       40.  $3x + 2 - 2x - 1$

41.  $5x - 3x + 3x^2 + 9x$       42.  $8x + 2x - 3y - 9x$       43.  $7y - 3 + 6y - 7$

44. **Estimation** Tavon bought a binder, 3 spiral notebooks, and a pen. The binder cost \$4.89, the notebooks cost \$1.99 each, and the pen cost \$2.11. About how much did Tavon spend on school supplies?

45. **Sports** In a triathlon, athletes race in swimming, biking, and running events. The athlete with the shortest total time to complete the events is the winner.

| Times from Triathlon |              |              |             |
|----------------------|--------------|--------------|-------------|
| Athlete              | Swim (min:s) | Bike (min:s) | Run (min:s) |
| Amy                  | 18:51        | 45:17        | 34:13       |
| Julie                | 17:13        | 40:27        | 23:32       |
| Mardi                | 19:09        | 38:58        | 25:32       |
| Sabine               | 13:09        | 31:37        | 19:01       |

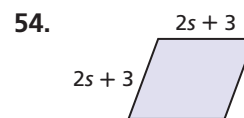
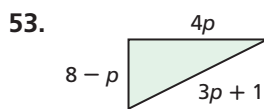
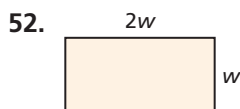
- Find the total time for each athlete. (*Hint*: 1 minute = 60 seconds)
- Use the total times for the athletes to determine the order in which they finished the triathlon.

Name the property that is illustrated in each equation.

46.  $5 + x = x + 5$       47.  $x - 2 = -2 + x$       48.  $2 + (3 + y) = (2 + 3) + y$   
 49.  $3(2r - 7) = 3(2r) - 3(7)$       50.  $(2 + g) + 3 = 2 + (g + 3)$       51.  $45x - 35 = 5(9x) - 5(7)$



**Geometry** Give an expression in simplified form for the perimeter of each figure.

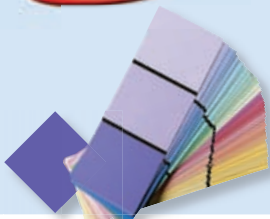


55. **Critical Thinking** Evaluate  $a - (b - c)$  and  $(a - b) - c$  for  $a = 10$ ,  $b = 7$ , and  $c = 3$ . Based on your answers, explain whether there is an Associative Property of Subtraction.



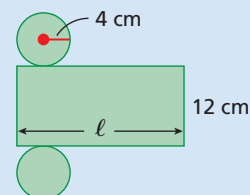
56. **Write About It** Describe a real-world situation that can be represented by the Distributive Property. Translate your situation into an algebraic expression. Define each variable you use.

**MULTI-STEP TEST PREP**



57. This problem will prepare you for the Multi-Step Test Prep on page 60.

- The diagram shows a pattern of shapes that can be folded to make a cylinder. How is the length  $\ell$  of the rectangle related to the circumference of (distance around) each circle?
- An expression for the circumference of each circle is  $2\pi r$ . Write an expression for the area of the rectangle.
- Write an expression for the total area of the figures. Leave the symbol  $\pi$  in your expression.

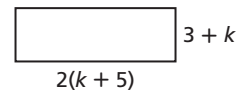


58. Ariel has 19 more CDs than her sister Tiffany has. Victor has 3 times as many CDs as Ariel has. Tiffany has  $x$  CDs. Which expression can be used to show how many CDs the three have in total?

- (A)  $19 + 3x$       (B)  $51 + 3x$       (C)  $76 + 3x$       (D)  $76 + 5x$

59. Which expression can be used to represent the perimeter of the rectangle?

- (F)  $16k$       (H)  $3k + 13$   
 (G)  $32k$       (J)  $6k + 26$



60. Which equation is an example of the Distributive Property?

- (A)  $(25 + 18) + 33 = 25 + (18 + 33)$       (C)  $33 \cdot 25 + 33 \cdot 18 = 33 \cdot (25 + 18)$   
 (B)  $33 + (25 \cdot 18) = (25 \cdot 18) + 33$       (D)  $3 + 25 \cdot 33 + 18 = 18 + 33 \cdot 25 + 33$

## CHALLENGE AND EXTEND

Simplify.

61.  $4[3(x + 9) + 2]$       62.  $-3[(x - 2) + 5(x - 2)]$   
 63.  $(2b + 5) - (8b + 6) + 3(b - 2)$       64.  $\frac{1}{2}[(10 - g) + (-6 + 3g)]$   
 65. Fill in the missing justifications.

| Procedure  | Justification  |
|--|--|
| $11e - 7 - 3e = 11e + (-7) + (-3e)$ $= 11e + (-3e) + (-7)$ $= [11e + (-3e)] + (-7)$ $= [11 + (-3)]e + (-7)$ $= 8e + (-7)$ $= 8e - 7$ | Definition of subtraction<br>a. _____ ?<br>b. _____ ?<br>c. _____ ?<br>d. _____ ?<br>Definition of subtraction |

66. Fill in the missing justifications.

| Procedure  | Justification                                      |
|--|--|
| $\frac{a + b}{c} = \frac{1}{c}(a + b)$ $= \frac{1}{c}(a) + \frac{1}{c}(b)$ $= \frac{a}{c} + \frac{b}{c}$ | Definition of division<br>a. _____ ?<br>b. _____ ? |

## SPIRAL REVIEW

Give the area of the figure described. (*Previous course*)

67. square;  $s = 6$  ft      68. parallelogram;  $b = 7$  mm,  $h = 13$  mm

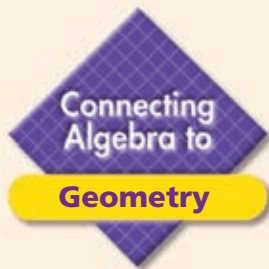
Simplify each expression. (*Lesson 1-4*)

69.  $2^6$       70.  $18^2$       71.  $-\left(\frac{1}{2}\right)^3$       72.  $\left(-\frac{1}{2}\right)^2$

Simplify each expression. (*Lesson 1-6*)

73.  $3 + 4 - 10 \div 2 + 1$       74.  $\frac{8^2 - 6^2}{8^2 + 6^2}$       75.  $2 - [6 - 8 \div (3 + 1)]$





# Perimeter

The distance around a geometric figure is called the *perimeter*. You can use what you have learned about combining like terms to simplify expressions for perimeter.

A closed figure with straight sides is called a *polygon*. To find the perimeter of a polygon, add the lengths of the sides.

## Example 1

- A** Write an expression for the perimeter of the quadrilateral.

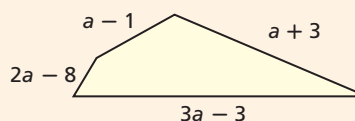
Add the lengths of the four sides.

$$P = (a + 3) + (2a - 8) + (3a - 3) + (a - 1)$$

Combine like terms to simplify.

$$\begin{aligned} P &= (a + 2a + 3a + a) + (3 - 8 - 3 - 1) \\ &= 7a - 9 \end{aligned}$$

*This is a general expression for the perimeter.*



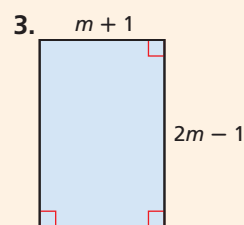
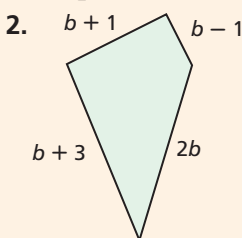
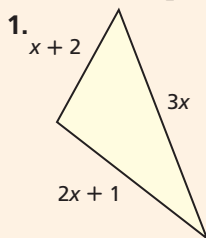
- B** Find the perimeter of this quadrilateral for  $a = 5$ .

Substitute 5 for  $a$ .

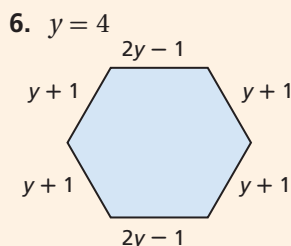
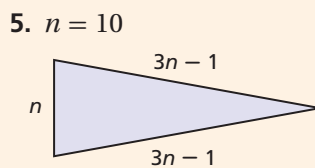
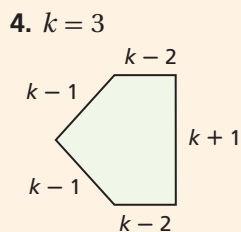
$$\begin{aligned} P &= 7(5) - 9 && \text{Multiply; then subtract.} \\ &= 35 - 9 \\ &= 26 && \text{This is the perimeter when } a = 5. \end{aligned}$$

## Try This

Write and simplify an expression for the perimeter of each figure.



Find the perimeter of each figure for the given value of the variable.



Combining like terms is one way to explore what happens to the perimeter when you double the sides of a triangle or other polygon.

## Example 2

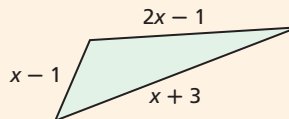
What happens to the perimeter of this triangle when you double the length of each side?

Write an expression for the perimeter of the smaller triangle.  
Combine like terms to simplify the expression.

$$(x - 1) + (2x - 1) + (x + 3)$$

$$(x + 2x + x) + (-1 - 1 + 3)$$

$$4x + 1 \quad \textit{Perimeter of small triangle}$$

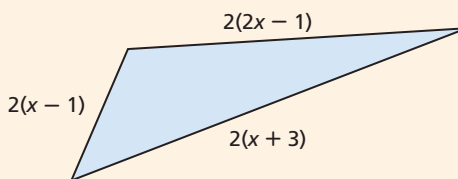


Double the length of each side of the triangle.

$$2(x - 1) = 2x - 2$$

$$2(2x - 1) = 4x - 2$$

$$2(x + 3) = 2x + 6$$



Find the perimeter of the larger triangle.  
Combine like terms to simplify.

$$(2x - 2) + (4x - 2) + (2x + 6)$$

*Add the lengths of the sides.*

$$(2x + 4x + 2x) + (-2 - 2 + 6)$$

*Use the Associative and Commutative Properties of Addition and combine like terms.*

$$8x + 2$$

*Perimeter of large triangle*

Use the Distributive Property to show that the new perimeter is twice the original perimeter.

$$8x + 2 = 2(4x + 1)$$

## Try This

Each set of expressions represents the side lengths of a triangle. Use the Distributive Property to show that doubling the side lengths doubles the perimeter.

7.  $2p + 1$

8.  $c - 1$

9.  $w + 5$

10.  $h - 2$

$3p + 2$

$2c + 1$

$w + 5$

$3h$

$5p$

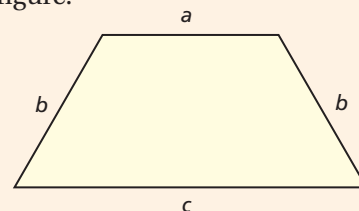
$3c - 1$

$3w - 1$

$2h + 3$

Solve each problem.

- Use the triangles in Example 2. Find the side lengths and perimeters for  $x = 5$ .
- The sides of a quadrilateral are  $2x - 1$ ,  $x + 3$ ,  $3x + 1$ , and  $x - 1$ . Double the length of each side. Then find an expression for the perimeter of the new figure.
- What happens to the perimeter of this trapezoid when you triple the length of each side? Use the variables  $a$ ,  $b$ ,  $b$ , and  $c$  for the lengths of the sides. Explain your answer using the Distributive Property.



# 1-8

# Introduction to Functions

### Objectives

Graph ordered pairs in the coordinate plane.

Graph functions from ordered pairs.

### Vocabulary

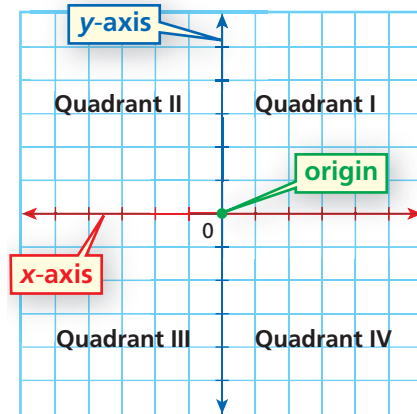
- coordinate plane
- axes
- origin
- x-axis
- y-axis
- ordered pair
- x-coordinate
- y-coordinate
- quadrant
- input
- output

### Why learn this?

You can use functions to determine how the cost of a caricature is affected by the number of people in the picture. (See Example 3.)

The **coordinate plane** is formed by the intersection of two perpendicular number lines called **axes**. The point of intersection, called the **origin**, is at 0 on each number line. The horizontal number line is called the **x-axis**, and the vertical number line is called the **y-axis**.

Points on the coordinate plane are described using ordered pairs. An **ordered pair** consists of an **x-coordinate** and a **y-coordinate** and is written  $(x, y)$ . Points are often named by a capital letter.



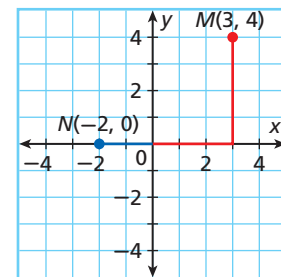
## EXAMPLE 1 Graphing Points in the Coordinate Plane

### Reading Math

The **x-coordinate** tells how many units to move left or right from the origin. The **y-coordinate** tells how many units to move up or down.

Graph each point.

- A**  $M(3, 4)$   
Start at the origin.  
Move 3 units right and 4 units up.
- B**  $N(-2, 0)$   
Start at the origin. Move 2 units left.



Graph each point.

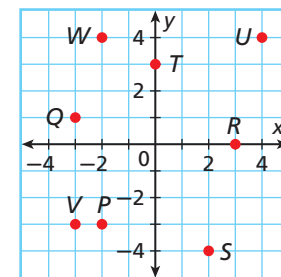
- 1a.  $R(2, -3)$       1b.  $S(0, 2)$       1c.  $T(-2, 6)$

Look at the graph at the top of this lesson. The axes divide the coordinate plane into four **quadrants**. Points that lie on an axis are not in any quadrant.

## EXAMPLE 2 Locating Points in the Coordinate Plane

Name the quadrant in which each point lies.

- A**  $P$       **B**  $Q$   
Quadrant III      Quadrant II
- C**  $R$       **D**  $S$   
no quadrant ( $x$ -axis)      Quadrant IV



Name the quadrant in which each point lies.

- 2a.  $T$       2b.  $U$       2c.  $V$       2d.  $W$

An equation that contains two variables can be used as a rule to generate ordered pairs. When you substitute a value for  $x$ , you generate a value for  $y$ . The value substituted for  $x$  is called the **input**, and the value generated for  $y$  is called the **output**.

Output      Input  
↓            ↓  
 $y = 10x + 5$

In a *function*, the value of  $y$  (the output) is determined by the value of  $x$  (the input). All of the equations in this lesson represent functions.

**EXAMPLE 3 Art Application**

A caricature artist charges his clients a \$5 setup fee plus \$10 for every person in a picture. Write a rule for the artist's fee. Write ordered pairs for the artist's fee when there are 1, 2, 3, and 4 people in the picture.



**Writing Math**

The artist's fee is determined by the number of people in the picture, so the number of people is the input and the artist's fee is the output.

Let  $y$  represent the artist's fee and  $x$  represent the number of people in a picture.

Artist's fee is \$5 plus \$10 for each person.

$$y = 5 + 10x$$

$$y = 5 + 10x$$

| Number of People in Picture | Rule            | Fee          | Ordered Pair |
|-----------------------------|-----------------|--------------|--------------|
| $x$ (input)                 | $y = 5 + 10x$   | $y$ (output) | $(x, y)$     |
| 1                           | $y = 5 + 10(1)$ | 15           | (1, 15)      |
| 2                           | $y = 5 + 10(2)$ | 25           | (2, 25)      |
| 3                           | $y = 5 + 10(3)$ | 35           | (3, 35)      |
| 4                           | $y = 5 + 10(4)$ | 45           | (4, 45)      |



**3. What if...?** The artist increased his fees to a \$10 setup fee plus \$20 for every person. Write a rule for the new fee. Write ordered pairs for the fee when there are 1, 2, 3, and 4 people.

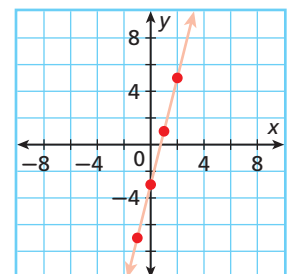
When you graph ordered pairs generated by a function, they may create a pattern.

**EXAMPLE 4 Generating and Graphing Ordered Pairs**

Generate ordered pairs for each function using the given values for  $x$ . Graph the ordered pairs and describe the pattern.

**A**  $y = 4x - 3; x = -1, 0, 1, 2$

| Input | Output           | Ordered Pair |
|-------|------------------|--------------|
| $x$   | $y$              | $(x, y)$     |
| -1    | $4(-1) - 3 = -7$ | $(-1, -7)$   |
| 0     | $4(0) - 3 = -3$  | $(0, -3)$    |
| 1     | $4(1) - 3 = 1$   | $(1, 1)$     |
| 2     | $4(2) - 3 = 5$   | $(2, 5)$     |

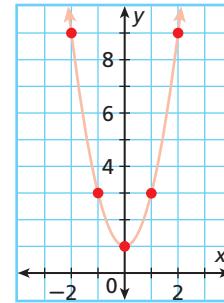


The points form a straight line.

Generate ordered pairs for each function using the given values for  $x$ . Graph the ordered pairs and describe the pattern.

**B**  $y = 2x^2 + 1; x = -2, -1, 0, 1, 2$

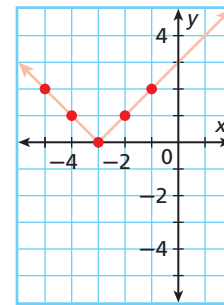
| Input | Output            | Ordered Pair |
|-------|-------------------|--------------|
| $x$   | $y$               | $(x, y)$     |
| -2    | $2(-2)^2 + 1 = 9$ | $(-2, 9)$    |
| -1    | $2(-1)^2 + 1 = 3$ | $(-1, 3)$    |
| 0     | $2(0)^2 + 1 = 1$  | $(0, 1)$     |
| 1     | $2(1)^2 + 1 = 3$  | $(1, 3)$     |
| 2     | $2(2)^2 + 1 = 9$  | $(2, 9)$     |



The points form a U shape.

**C**  $y = |x + 3|; x = -5, -4, -3, -2, -1$

| Input | Output                | Ordered Pair |
|-------|-----------------------|--------------|
| $x$   | $y$                   | $(x, y)$     |
| -5    | $ -5 + 3  =  -2  = 2$ | $(-5, 2)$    |
| -4    | $ -4 + 3  =  -1  = 1$ | $(-4, 1)$    |
| -3    | $ -3 + 3  =  0  = 0$  | $(-3, 0)$    |
| -2    | $ -2 + 3  =  1  = 1$  | $(-2, 1)$    |
| -1    | $ -1 + 3  =  2  = 2$  | $(-1, 2)$    |



The points form a V shape.



Generate ordered pairs for each function using the given values for  $x$ . Graph the ordered pairs and describe the pattern.

4a.  $y = \frac{1}{2}x - 4; x = -4, -2, 0, 2, 4$

4b.  $y = 3x^2 + 3; x = -3, -1, 0, 1, 3$

4c.  $y = |x - 2|; x = 0, 1, 2, 3, 4$

In Chapter 4, you will learn more about functions. You will study the relationship between the shape of a graph and the rule that generates the ordered pairs.

## THINK AND DISCUSS

- Describe how to graph the ordered pair  $(-3, 6)$ .
- Give an example of a point that lies on the  $y$ -axis.

**3. GET ORGANIZED** Copy and complete the graphic organizer. In each blank, write "positive" or "negative."



|                                      |                                     |
|--------------------------------------|-------------------------------------|
| Quadrant II<br>$x$ is ?<br>$y$ is ?  | Quadrant I<br>$x$ is ?<br>$y$ is ?  |
| Quadrant III<br>$x$ is ?<br>$y$ is ? | Quadrant IV<br>$x$ is ?<br>$y$ is ? |

**The Coordinate Plane**



## GUIDED PRACTICE

1. **Vocabulary** Explain why the order in an *ordered pair* is important.

SEE EXAMPLE 1 Graph each point.

p. 54

2.  $J(4, 5)$

3.  $K(-3, 2)$

4.  $L(6, 0)$

5.  $M(1, -7)$

SEE EXAMPLE 2 Name the quadrant in which each point lies.

p. 54

6.  $A$

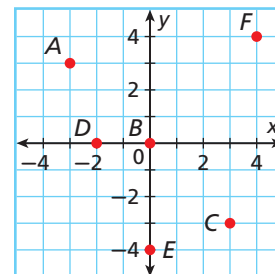
7.  $B$

8.  $C$

9.  $D$

10.  $E$

11.  $F$



SEE EXAMPLE 3

p. 55

12. **Multi-Step** The number of counselors at a summer camp must be equal to  $\frac{1}{4}$  the number of campers. Write a rule for the number of counselors that must be at the camp. Write ordered pairs for the number of counselors when there are 76, 100, 120, and 168 campers.

SEE EXAMPLE 4

p. 55

Generate ordered pairs for each function for  $x = -2, -1, 0, 1,$  and  $2$ . Graph the ordered pairs and describe the pattern.

13.  $y = x + 2$

14.  $y = -x$

15.  $y = -2|x|$

16.  $y = \frac{1}{2}x^2$

## PRACTICE AND PROBLEM SOLVING

## Independent Practice

| For Exercises | See Example |
|---------------|-------------|
| 17–20         | 1           |
| 21–26         | 2           |
| 27            | 3           |
| 28–31         | 4           |

## Extra Practice

Skills Practice p. S5

Application Practice p. S28

Graph each point.

17.  $D(2, 8)$

18.  $E(-2, -7)$

19.  $F(0, -5)$

20.  $G(4, -4)$

Name the quadrant in which each point lies.

21.  $X$

22.  $Y$

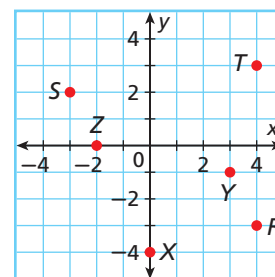
23.  $Z$

24.  $R$

25.  $S$

26.  $T$

27. **Multi-Step** Jeremy's wages include a \$500 base salary plus  $\frac{1}{10}$  of his sales. Write a rule for the total amount of Jeremy's paycheck. Write ordered pairs for the amount of Jeremy's paycheck when his sales are \$500, \$3000, \$5000, and \$7500.



Generate ordered pairs for each function for  $x = -2, -1, 0, 1,$  and  $2$ . Graph the ordered pairs and describe the pattern.

28.  $y = 6 - 2x$

29.  $y = -(x^2)$

30.  $y = 3|x|$

31.  $y = x^2 + 3$



**Geometry** Graph each point and connect them in the order they are listed. Connect the last point to the first. Describe the figure drawn.

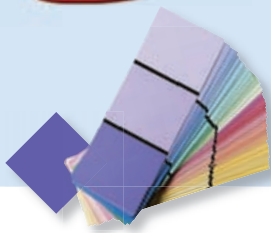
32.  $(-1, 1), (4, 1), (4, -4), (-1, -4)$

33.  $(-6, 3), (2, -2), (-7, -3)$

34.  $(4, 4), (6, 2), (5, -1), (3, -1), (2, 2)$

35.  $(-6, 5), (4, 5), (4, 7), (-6, 7)$

36. **Multi-Step** The salary at Beth's company is \$32,000 for someone with no experience and increases by \$2700 per year of experience. Write a rule for the salary at Beth's company. Write ordered pairs for the salaries for employees with 0, 2, 5, and 7 years of experience.



37. This problem will prepare you for the Multi-Step Test Prep on page 60.
- A room decorator wants to purchase fabric. Each yard of fabric costs \$2.90. Write a rule for the cost of the fabric. Let  $c$  equal the total cost and  $f$  equal the number of yards of fabric.
  - Which variable is the input and which variable is the output?
  - Make a table showing the cost of 1, 2, 3, 4, and 5 yards of fabric.
  - How many whole yards can the decorator purchase if she has \$21.00?

Write an equation for each rule. Use the given values for  $x$  to generate ordered pairs. Graph the ordered pairs and describe the pattern.

38.  $y$  is equal to 3 more than the absolute value of  $x$ ;  $x = -2, -1, 0, 1, \text{ and } 2$ .
39.  $y$  is equal to the sum of one half of  $x$  and  $-3$ ;  $x = -4, -2, 0, 2, \text{ and } 4$ .
40.  $y$  is equal to the sum of  $x$  squared and 1;  $x = -5, -3, -1, 1, 3, \text{ and } 5$ .
41. **Business** An events planner is preparing for a 5K race. She will buy enough water bottles for 50 volunteers, plus  $1\frac{1}{2}$  times the number of runners who preregister for the race.
- Write an equation for the number of water bottles the planner should buy.
  - Generate ordered pairs for the number of water bottles the event planner will buy for the following numbers of preregistered runners: 100, 150, 200, 250, and 300.



**Math History**



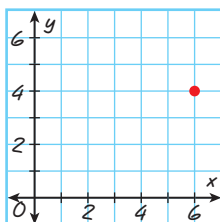
RENÉ DESCARTES

The coordinate plane is also called the Cartesian plane. This name comes from the mathematician René Descartes (1596–1650), who is credited with developing the coordinate system.

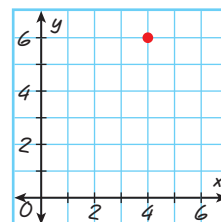
Give the coordinates of three points that fit the given description. Graph the points and describe the pattern.

42. The  $x$ -coordinate is 1 less than the  $y$ -coordinate.
43. The sum of the  $x$ -coordinate and  $y$ -coordinate is 5.
44. The  $x$ -coordinate is 2 times the  $y$ -coordinate.
45. The quotient of the  $x$ -coordinate and  $y$ -coordinate is 3.
46. **Critical Thinking** Lance wrote five ordered pairs for which the  $y$ -coordinate was the opposite of the  $x$ -coordinate. Then he graphed the ordered pairs. What pattern did the points make?
47. **Write About It** Graph the point  $(4, 2)$ .
- How is graphing the point  $(4, 2)$  different from graphing the point  $(2, 4)$ ?
  - How is graphing the point  $(4, 2)$  different from graphing the point  $(-4, -2)$ ?
48. **ERROR ANALYSIS** Two students graphed the point  $(4, 6)$ . Which is incorrect? Explain the error.

**A**



**B**



49. Generate ordered pairs for  $y = x$ , graph the points, and connect them to make a line. Do the same for  $y = x + 2$  using the same values for  $x$ . How is the line for  $y = x + 2$  different from the line for  $y = x$ ?

50. Which equation could be used to generate the ordered pairs (2, 7) and (6, 9)?  
 Ⓐ  $y = 9 - x$       Ⓑ  $y = \frac{3}{2}x^2 + 1$       Ⓒ  $y = \frac{1}{2}x + 6$       Ⓓ  $y = x + 5$

51. Which table of ordered pairs is generated when the values 1, 2, 3, and 4 are substituted for  $x$  in the equation  $y = 2x - 4$ ?

Ⓕ

| $x$ | $y$ |
|-----|-----|
| 1   | -3  |
| 2   | -2  |
| 3   | -1  |
| 4   | 0   |

Ⓖ

| $x$ | $y$ |
|-----|-----|
| 1   | -2  |
| 2   | 0   |
| 3   | 2   |
| 4   | 4   |

Ⓗ

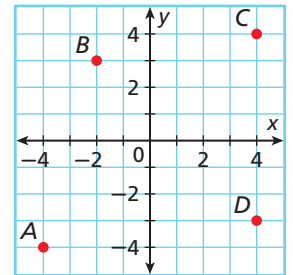
| $x$ | $y$ |
|-----|-----|
| 1   | -2  |
| 2   | 0   |
| 3   | 1   |
| 4   | 2   |

Ⓙ

| $x$ | $y$ |
|-----|-----|
| 1   | -3  |
| 2   | -1  |
| 3   | 2   |
| 4   | 4   |

52. For which point on the graph is  $x > \frac{7}{2}$  and  $y < \frac{8}{3}$ ?

- Ⓐ A      Ⓒ C  
 Ⓑ B      Ⓓ D



53. Which ordered pair describes the point (2, 5) shifted 3 units right and 2 units down?

- Ⓕ (0, 8)      Ⓗ (5, 3)  
 Ⓖ (2, 3)      Ⓙ (5, 5)

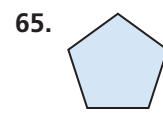
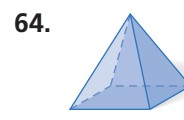
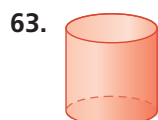
## CHALLENGE AND EXTEND

Graph each point.

54.  $W(x + 4, y - 8)$  for  $x = 5$  and  $y = 2$       55.  $X(5 - x, y^2)$  for  $x = -1$  and  $y = 3$   
 56.  $Y(x + y, y - x)$  for  $x = 6$  and  $y = 3$       57.  $Z(xy, x^2y)$  for  $x = -1$  and  $y = 4$   
 58. Graph several ordered pairs that have an  $x$ -coordinate of 3. Describe the pattern.  
 59. Graph several ordered pairs that have a  $y$ -coordinate of 6. Describe the pattern.  
 60. Find the perimeter of a rectangle whose vertices have the coordinates  $A(3, 6)$ ,  $B(3, -2)$ ,  $C(-1, -2)$ , and  $D(-1, 6)$ .  
 61. **Multi-Step** The coordinates of three vertices of a rectangle are  $J(-4, -2)$ ,  $K(2, -2)$ , and  $L(2, 5)$ . Find the coordinates of the fourth vertex. What is the area of the rectangle?

## SPIRAL REVIEW

Give the name of each figure. (*Previous course*)



Write all classifications that apply to each real number. (*Lesson 1-5*)

66.  $\sqrt{36}$       67.  $\sqrt{6}$       68.  $\frac{1}{9}$       69.  $-32$

Simplify each expression. (*Lesson 1-7*)

70.  $\frac{1}{5} \cdot 18 \cdot 25$       71.  $x^2 + 3x$       72.  $2a - b + a + 4b$

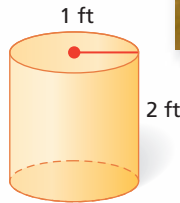
## The Tools of Algebra

**Design Time** Lori's family and Marie's family are redecorating a room in each other's home. They have three days for the decorating project, which will be filmed for a local TV show.

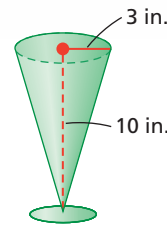
1. Lori decides to paint Marie's room a shade of blue. She measures the height and width of each wall in the rectangular room. She finds that two walls have a width of 12 feet and the other two have a width of 14 feet. The ceiling is 9 feet high. Find the area of each wall. Find the total area of all four walls plus the ceiling.

2. One gallon of paint covers 400 square feet. How many gallons are needed if Lori wants to apply 2 coats of paint to all the walls and the ceiling?

3. Lori decided to build a bedside table in the shape of a cylinder and cover all of its surfaces except the bottom with yellow fabric. The fabric costs \$2.50 per square yard. The table has a radius of 1 foot and a height of 2 feet. What is the cost to cover the table? Use 3.14 for  $\pi$ .



4. Lori will fill a vase with multicolored beads and place it on the bedside table. The vase is in the approximate shape of a cone. The height of the vase is 10 inches, and the radius of the vase at the top is 3 inches. Find the volume of the vase. Use 3.14 for  $\pi$ . (*Hint:* The formula for the volume of a cone is  $V = \frac{1}{3}\pi r^2 h$ , where  $r$  is the radius of the cone and  $h$  is the height of the cone.)



5. Lori wants to create a border around the room using stickers. She can purchase a package of 5 stickers for \$6.00. Make a table to show the cost of 1, 2, 3, 4, and 5 packages of stickers. Make another table to show the cost based on the number of stickers (not the number of packages). How many stickers can Lori purchase if she has \$32 left in her budget?



## Quiz for Lessons 1-6 Through 1-8

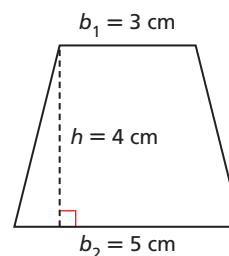
### 1-6 Order of Operations

Simplify each expression.

- $-6 + 12 \div (-3)$
- $30 - 9 + 4$
- $(6 - 8) \cdot (7 - 5)$
- $8 \cdot [8 - (4 - 2)]$
- $\frac{23 - 3 \cdot 5}{4}$
- $|3 - 9| \div 2 + 5$

Translate each word phrase into a numerical expression.

- the quotient of 16 and the difference of 9 and  $-7$
- the product of 5 and the sum of 6 and 4
- The area of a trapezoid can be found using the expression  $\frac{1}{2}(b_1 + b_2)h$ . Find the area of the trapezoid shown.



### 1-7 Simplifying Expressions

Simplify each expression.

- $75 + 32 + 25$
- $5 \cdot 18 \cdot 20$
- $\frac{1}{4} \cdot 19 \cdot 8$

Write each product using the Distributive Property. Then simplify.

- $7(67)$
- $9(29)$
- $17(18)$
- $8(106)$

Simplify each expression by combining like terms.

- $4k + 15k$
- $x^2 + 22x^2$
- $-2g + 5g$

Simplify each expression. Justify each step with an operation or property.

- $3(x + 2) - 3x$
- $x - 6x^2 + 3x + 4x^2$
- $-2(3x + 2y + 4x - 5y)$

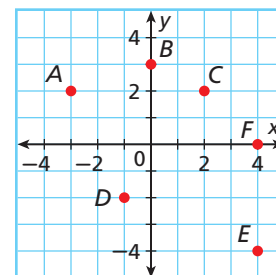
### 1-8 Introduction to Functions

Graph each point.

- $A(0, -3)$
- $B(-2, -3)$
- $C(1, 4)$

Name the quadrant in which each point lies.

- $A$
- $B$
- $C$
- $D$
- $E$
- $F$



Generate ordered pairs for each function for  $x = -2, -1, 0, 1,$  and  $2$ . Graph the ordered pairs and describe the pattern.

- $y = x^2 + 1$
- $y = x - 1$
- $y = -|x|$
- $y = 3x + 3$

- A swimming pool contains 30,000 gallons of water. The pool is drained at a rate of 100 gallons per minute. Write a rule for the amount of water in the pool when  $x$  minutes have gone by. Write ordered pairs for the amount of water in the pool when 30, 60, 90, and 120 minutes have gone by.



**Vocabulary**

|                                |    |                                  |    |                               |    |
|--------------------------------|----|----------------------------------|----|-------------------------------|----|
| absolute value . . . . .       | 14 | like terms . . . . .             | 47 | real numbers . . . . .        | 33 |
| additive inverse . . . . .     | 15 | multiplicative inverse . . . . . | 21 | reciprocal . . . . .          | 21 |
| algebraic expression . . . . . | 6  | natural numbers . . . . .        | 33 | repeating decimal . . . . .   | 34 |
| axes . . . . .                 | 54 | numerical expression . . . . .   | 6  | square root . . . . .         | 32 |
| base . . . . .                 | 26 | opposites . . . . .              | 15 | term . . . . .                | 47 |
| coefficient . . . . .          | 48 | order of operations . . . . .    | 40 | terminating decimal . . . . . | 33 |
| constant . . . . .             | 6  | ordered pair . . . . .           | 54 | variable . . . . .            | 6  |
| coordinate plane . . . . .     | 54 | origin . . . . .                 | 54 | whole numbers . . . . .       | 33 |
| cube root . . . . .            | 32 | output . . . . .                 | 55 | $x$ -axis . . . . .           | 54 |
| evaluate . . . . .             | 7  | perfect square . . . . .         | 32 | $x$ -coordinate . . . . .     | 54 |
| exponent . . . . .             | 26 | power . . . . .                  | 26 | $y$ -axis . . . . .           | 54 |
| input . . . . .                | 55 | principal square root . . . . .  | 32 | $y$ -coordinate . . . . .     | 54 |
| integers . . . . .             | 33 | quadrant . . . . .               | 54 |                               |    |
| irrational numbers . . . . .   | 33 | rational numbers . . . . .       | 34 |                               |    |

Complete the sentences below with vocabulary words from the list above.

1. A(n)     ? is a value that does not change.
2. The     ? include the natural numbers and zero.
3. A(n)     ? is the numerical factor of a term that contains a variable.
4. The     ? is the point where the axes of a coordinate plane intersect.

**1-1 Variables and Expressions (pp. 6–11)****EXAMPLES**

- Barbara has saved  $d$  dollars for a \$65 sweater. Write an expression for the amount of money she still needs to buy the sweater.

$$65 - d \quad \text{Think: } d \text{ dollars less than the price of the sweater.}$$

- Evaluate  $b - a$  for  $a = 7$  and  $b = 15$ .

$$b - a = 15 - 7 \quad \text{Substitute the values for the variables.}$$

$$= 8$$

**EXERCISES**

5. Grapes cost \$1.99 per pound. Write an expression for the cost of  $g$  pounds of grapes.
6. Today's temperature is 3 degrees warmer than yesterday's temperature  $t$ . Write an expression for today's temperature.

Evaluate each expression for  $p = 5$  and  $q = 1$ .

$$7. qp \qquad 8. p \div q \qquad 9. q + p$$

10. Each member of the art club will make the same number of posters to advertise their club. They will make 150 posters total. Write an expression for how many posters each member will make if there are  $m$  members. Find how many posters each member will make if there are 5, 6, and 10 members.

## 1-2 Adding and Subtracting Real Numbers (pp. 14–19)

### EXAMPLES

Add or subtract.

■  $-4 + (-9)$   
 $-4 + (-9)$      *The signs are the same.*  
 $(4 + 9 = 13)$      *Add the absolute values and use*  
 $-13$      *the sign of the numbers.*

■  $-8 - (-3)$   
 $-8 + 3$      *To subtract  $-3$ , add 3.*  
 $-5$

### EXERCISES

Add or subtract.

11.  $-2 + (-12)$     12.  $-6 + 1.4$     13.  $9\frac{1}{4} + (-4\frac{3}{4})$

14.  $\frac{1}{2} - \frac{3}{2}$     15.  $-8 - 16$     16.  $6.7 - (-7.6)$

17. A trail starts at an elevation of 2278 feet. It descends 47 feet to a campsite. What is the elevation of the campsite?

## 1-3 Multiplying and Dividing Real Numbers (pp. 20–25)

### EXAMPLES

Multiply or divide.

■  $-12(9)$     ■  $-\frac{5}{6} \div (-\frac{3}{4})$   
 $-12(9) = -108$      $-\frac{5}{6} \div (-\frac{3}{4}) = -\frac{5}{6} (\frac{-4}{-3})$   
 $= \frac{(-5)(-4)}{6(3)}$   
 $= \frac{20}{18} = \frac{10}{9}$

### EXERCISES

Multiply or divide if possible.

18.  $-5(-18)$     19.  $0 \cdot 10$     20.  $-4(3.8)$

21.  $-56 \div 7$     22.  $0 \div 0.75$     23.  $9 \div 0$

Divide.

24.  $4 \div \frac{4}{9}$     25.  $-\frac{1}{2} \div \frac{3}{4}$     26.  $\frac{6}{7} \div \frac{2}{5}$

27. An exercise program recommends that a person walk at least 10,000 steps every day. At this rate, how many steps would the person walk in 1 year?

## 1-4 Powers and Exponents (pp. 26–31)

### EXAMPLES

■ Simplify  $-3^4$ .  
 $-3^4 = -1 \cdot 3 \cdot 3 \cdot 3 \cdot 3$      *Find the product of  $-1$*   
 $= -81$      *and four 3's.*

■ Write  $-216$  as a power of  $-6$ .  
 $-216 = (-6)(-6)(-6)$      *The product of three*  
 $= (-6)^3$       *$-6$ 's is  $-216$ .*

### EXERCISES

Write each expression as repeated multiplication. Then simplify the expression.

28.  $4^3$     29.  $(-3)^3$     30.  $(-3)^4$

31.  $-5^2$     32.  $(\frac{2}{3})^3$     33.  $(-\frac{4}{5})^2$

Write each number as a power of the given base.

34. 16; base 2    35.  $-1000$ ; base  $-10$

36. 64; base  $-8$     37. 12; base 12

38. The interior of a safe is shaped like a cube with edges 9 inches long. What is the volume of the interior of the safe?

## 1-5 Roots and Real Numbers (pp. 32–37)

### EXAMPLES

Find each root.

■  $-\sqrt{64}$

$$8^2 = 64$$

$$-\sqrt{64} = -8$$

■  $\sqrt{\frac{16}{81}}$

$$\left(\frac{4}{9}\right)^2 = \frac{4}{9} \cdot \frac{4}{9} = \frac{16}{81}$$

$$\sqrt{\frac{16}{81}} = \frac{4}{9}$$

■ Write all classifications that apply to  $-7$ .

$$-7 = \frac{-7}{1} = -7.0$$

rational number, terminating decimal, integer

### EXERCISES

Find each root.

39.  $\sqrt{36}$

40.  $\sqrt[3]{64}$

41.  $-\sqrt{49}$

42.  $-\sqrt{144}$

43.  $\sqrt{\frac{25}{36}}$

44.  $\sqrt[3]{\frac{1}{27}}$

Write all the classifications that apply to each real number.

45. 21

46. 0

47.  $-13$

48. 0.8

49.  $\sqrt{3}$

50.  $\frac{5}{6}$

51. A tabletop is shaped like a square with an area of 13 square feet. Find the length of one side of the table to the nearest tenth of a foot.

## 1-6 Order of Operations (pp. 40–45)

### EXAMPLES

■ Simplify  $18 - 3\left(\frac{15 - 7}{4}\right)^2$ .

$$18 - 3\left(\frac{15 - 7}{4}\right)^2$$

$$18 - 3\left(\frac{8}{4}\right)^2$$

*Simplify the numerator.*

$$18 - 3(2)^2$$

*Simplify inside parentheses.*

$$18 - 3 \cdot 4$$

*Simplify powers.*

$$18 - 12$$

*Multiply.*

$$6$$

*Subtract.*

■ Evaluate  $-5\sqrt{40 - x} + 12$  for  $x = 4$ .

$$-5\sqrt{40 - 4} + 12 \quad \textit{Substitute the value for } x.$$

$$-5\sqrt{36} + 12 \quad \textit{Simplify inside the square root symbol.}$$

$$-5(6) + 12 \quad \textit{Find the square root.}$$

$$-30 + 12 \quad \textit{Multiply.}$$

$$-18 \quad \textit{Add.}$$

### EXERCISES

Simplify each expression.

52.  $5 \cdot 4 + 3$

53.  $17 + 3(-3)$

54.  $[8 + (2 - 6)^2] \div 4$

55.  $\frac{4^2 - 11}{10}$

56.  $|12 - 3 \cdot 7| \cdot (-2)$

57.  $\sqrt{4 \cdot 5 + 5} - 5$

Evaluate each expression for the given value of  $x$ .

58.  $48 - x + 29$  for  $x = 15$

59.  $x + 4 \cdot 6 - 10$  for  $x = -4$

60.  $8(x - 8)^3$  for  $x = 9$

61.  $[(3 - x)^2 + 4] \div 2$  for  $x = 7$

Translate each word phrase into a numerical or algebraic expression.

62. the sum of 8 and the product of 7 and  $-2$

63. the quotient of 12 and the sum of 8 and 3

64. 4 times the square root of  $x$  less than 20

65. The expression  $16t^2 + vt$  can be used to find the distance in feet traveled by a falling object. The initial speed is  $v$  (ft/s), and time is  $t$  (s). Find the distance traveled in 3 s by a falling object with an initial speed of 8 ft/s.

## 1-7 Simplifying Expressions (pp. 46–51)

### EXAMPLES

Simplify each expression.

$$\begin{aligned} & -6f^2 - 8f + 3f^2 \\ & -6f^2 + 3f^2 - 8f && \text{Commutative Property} \\ & -3f^2 - 8f && \text{Combine like terms.} \end{aligned}$$

$$\begin{aligned} & 3x - 4y \\ & 3x - 4y && \text{There are no like terms.} \\ & && \text{It cannot be simplified.} \end{aligned}$$

$$\begin{aligned} & 5x^2 - 3(x - 2) - x \\ & 5x^2 - 3x - 3(-2) - x && \text{Distributive Property} \\ & 5x^2 - 3x + 6 - x && \text{Multiply.} \\ & 5x^2 - 3x - x + 6 && \text{Commutative Property} \\ & 5x^2 - 4x + 6 && \text{Combine like terms.} \end{aligned}$$

### EXERCISES

Simplify each expression.

$$66. 18 + 26 - 8 + 4 \qquad 67. 60 \cdot 27 \cdot \frac{1}{6}$$

Write each product using the Distributive Property. Then simplify.

$$68. 13(103) \qquad 69. 18(99)$$

Simplify each expression.

$$\begin{aligned} 70. 20x - 16x & \qquad 71. 2y^2 + 5y^2 \\ 72. 6(x + 4) - 2x & \qquad 73. -2(x^2 - 1) + 4x^2 \\ 74. -2y + 3y^2 - 3y + y & \qquad 75. 7y + 3y - a - 2y \end{aligned}$$

76. Rita bought a sandwich, 2 bottles of water, and an apple for lunch. The sandwich cost \$4.99, the bottles of water cost \$1.48 each, and the apple cost \$0.89. About how much did Rita spend on lunch?

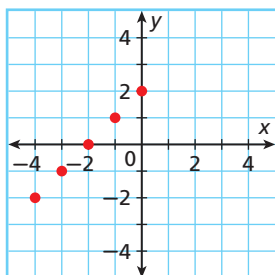
## 1-8 Introduction to Functions (pp. 54–59)

### EXAMPLES

Generate ordered pairs for the function using the given values for  $x$ . Graph the ordered pairs and describe the pattern.

$$y = x + 2; x = -4, -3, -2, -1, 0$$

| Input | Output        | Ordered Pair |
|-------|---------------|--------------|
| $x$   | $y$           | $(x, y)$     |
| -4    | $-4 + 2 = -2$ | $(-4, -2)$   |
| -3    | $-3 + 2 = -1$ | $(-3, -1)$   |
| -2    | $-2 + 2 = 0$  | $(-2, 0)$    |
| -1    | $-1 + 2 = 1$  | $(-1, 1)$    |
| 0     | $0 + 2 = 2$   | $(0, 2)$     |



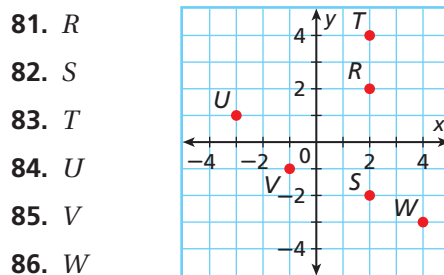
The points form a straight line.

### EXERCISES

Graph each point.

$$\begin{aligned} 77. A(2, 3) & \qquad 78. B(-1, 4) \\ 79. C(0, 8) & \qquad 80. D(5, -3) \end{aligned}$$

Name the quadrant in which each point lies.



81.  $R$   
82.  $S$   
83.  $T$   
84.  $U$   
85.  $V$   
86.  $W$

87. The price of an item with tax is equal to the price of the item plus  $\frac{1}{20}$  of the price. Write a rule for the price with tax. Write ordered pairs for the price with tax of items that cost \$2, \$15, \$30, and \$40.

88. Generate ordered pairs for the function  $y = \frac{1}{4}x^2$  for  $x = -4, -1, 0, 1, \text{ and } 4$ . Graph the ordered pairs and describe the pattern.

Evaluate each expression for  $a = 2$ ,  $b = 3$ , and  $c = 6$ .

1.  $c - a$
2.  $ab$
3.  $c \div a$
4.  $\frac{c}{b}$
5.  $b - a$
6. Give two ways to write  $n - 5$  in words.
7. Nate runs 8 miles each week. Write an expression for the number of miles he runs in  $n$  weeks. Find the number of miles Nate runs in 5 weeks.

Add or subtract.

8.  $-5 + 8$
9.  $-3 - 4$
10.  $4 + (-7)$
11.  $7 - (-2)$

The table shows the lowest temperatures recorded in four states.

| Lowest Temperatures in Four States |                  |
|------------------------------------|------------------|
| Location                           | Temperature (°F) |
| Prospect Creek, Alaska             | -80              |
| Camp Clarke, Nebraska              | -47              |
| Mauna Kea, Hawaii                  | 12               |
| Seminole, Texas                    | -23              |

12. How much greater is the lowest temperature in Hawaii than the lowest temperature in Alaska?
13. How much greater is the lowest temperature in Texas than the lowest temperature in Nebraska?

Multiply or divide if possible.

14.  $(-3)(-6)$
15.  $-\frac{1}{2} \div \frac{1}{4}$
16.  $12 \div (-3)$
17.  $0 \div (-4)$

Simplify each expression.

18.  $5^4$
19.  $\left(-\frac{4}{5}\right)^3$
20.  $2^5$
21.  $-6^2$

Write all classifications that apply to each real number.

22. 30
23.  $\sqrt{6}$
24. -12
25.  $\frac{1}{2}$

Evaluate each expression for the given value of  $x$ .

26.  $\frac{-2-6}{x^2}$  for  $x = 2$
27.  $8(x-1)^2$  for  $x = 11$
28.  $22 + [-2(19-x)]$  for  $x = 7$

29. Does the phrase "2 times the sum of a number and 5" represent the same expression as the phrase "the sum of 2 times a number and 5"? Explain why or why not.

Simplify each expression.

30.  $5\frac{1}{4} + 7 + 2\frac{3}{4}$
31.  $-2(x+5) + 4x$
32.  $3x + 2x^2 - x$

Graph each point.

33.  $W(1, -3)$
34.  $X(-3, 0)$
35.  $Y(5, 3)$
36.  $Z(0, -2)$
37. Generate ordered pairs for  $y = 2x - 1$  for  $x = -2, -1, 0, 1, 2$ . Graph the ordered pairs and describe the pattern.



# COLLEGE ENTRANCE EXAM PRACTICE



## FOCUS ON SAT\*

The SAT is often used to predict academic success at the college level. SAT scores are used to compare the math and verbal reasoning skills of students from all over the world.



In each section of SAT questions, the easier questions are at the beginning of the section and harder questions come later. Answer as many of the easy questions as you can first, and then move on to the more challenging questions.

You may want to time yourself as you take this practice test. It should take you about 8 minutes to complete.

1. The number 0 is NOT an example of which of the following?

(A) Real numbers  
(B) Rational numbers  
(C) Whole numbers  
(D) Integers  
(E) Natural numbers

2. A clothing store opens with 75 pairs of jeans on a sale table. By noon, 10 pairs have been sold. As of 2:00, another 8 pairs have been sold. A clerk then restocks with 12 pairs. Receipts show that 18 pairs of jeans were sold after 2:00. How many pairs of jeans are left at the end of the day?

(A) 23  
(B) 27  
(C) 36  
(D) 51  
(E) 123

3. If Jack is three times as old as his sister Judy, which of the following expressions represents Jack's age if Judy is  $j$  years old?

(A)  $3 \div j$   
(B)  $3j$   
(C)  $j + 3$   
(D)  $3 - j$   
(E)  $\frac{1}{3}j$

4. Which of the following is equal to  $-3^4$ ?

(A) 81  
(B) 12  
(C)  $-12$   
(D)  $-64$   
(E)  $-81$

5. What is the result after applying the following sequence of operations to a number  $n$  in the given order?

1. Subtract 2.                      3. Add 7.  
2. Divide by 3.                    4. Multiply by  $-1$ .

(A)  $\frac{n-2}{3} + 7(-1)$   
(B)  $\frac{(-n-2)+7}{3}$   
(C)  $-(-\frac{2}{3} + 7)n$   
(D)  $-(\frac{n-2}{3} + 7)$   
(E)  $n - \frac{2}{3} + 7(-1)$

6. Which expression is equivalent to  $8(6 + x)$ ?

(A)  $48x$   
(B)  $8x + 14$   
(C)  $8x + 48$   
(D)  $x + 14$   
(E)  $x + 48$

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## Gridded Response: Fill in Answer Grids Correctly

When responding to a test item that requires you to place your answer in a grid, you must fill out the grid on your answer sheet correctly, or the item will be marked as incorrect.

### EXAMPLE 1

Gridded Response: Simplify the expression  $12^2 - 3(10 + 4)$ .

| 1                                   | 0                                   | 2                                   |                          |                          |
|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> |
| 0                                   | <input checked="" type="checkbox"/> | 0                                   | 0                        | 0                        |
| <input checked="" type="checkbox"/> | 1                                   | 1                                   | 1                        | 1                        |
| 2                                   | 2                                   | <input checked="" type="checkbox"/> | 2                        | 2                        |
| 3                                   | 3                                   | 3                                   | 3                        | 3                        |
| 4                                   | 4                                   | 4                                   | 4                        | 4                        |
| 5                                   | 5                                   | 5                                   | 5                        | 5                        |
| 6                                   | 6                                   | 6                                   | 6                        | 6                        |
| 7                                   | 7                                   | 7                                   | 7                        | 7                        |
| 8                                   | 8                                   | 8                                   | 8                        | 8                        |
| 9                                   | 9                                   | 9                                   | 9                        | 9                        |

$$\begin{aligned}
 &12^2 - 3(10 + 4) \\
 &12^2 - 3(14) \\
 &144 - 3(14) \\
 &144 - 42 \\
 &102
 \end{aligned}$$

The expression simplifies to 102.

- Write your answer in the answer boxes at the top of the grid.
- Put only one digit in each box. Do not leave a blank box in the middle of an answer.
- Shade the bubble for each digit in the same column as the digit in the answer box.

### EXAMPLE 2

Gridded Response: Evaluate the expression  $ba \div c$  for  $a = -7$ ,  $b = 2$ , and  $c = -6$ .

| 7                                   | /                                   | 3                                   |                          |                          |
|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> |
| 0                                   | 0                                   | 0                                   | 0                        | 0                        |
| 1                                   | 1                                   | 1                                   | 1                        | 1                        |
| 2                                   | 2                                   | 2                                   | 2                        | 2                        |
| 3                                   | 3                                   | <input checked="" type="checkbox"/> | 3                        | 3                        |
| 4                                   | 4                                   | 4                                   | 4                        | 4                        |
| 5                                   | 5                                   | 5                                   | 5                        | 5                        |
| 6                                   | 6                                   | 6                                   | 6                        | 6                        |
| <input checked="" type="checkbox"/> | 7                                   | 7                                   | 7                        | 7                        |
| 8                                   | 8                                   | 8                                   | 8                        | 8                        |
| 9                                   | 9                                   | 9                                   | 9                        | 9                        |

$$\begin{aligned}
 &ba \div c \\
 &(2)(-7) \div (-6) \\
 &-14 \div (-6) \\
 &\frac{7}{3} = 2\frac{1}{3} = 2.\bar{3}
 \end{aligned}$$

The expression simplifies to  $\frac{7}{3}$ ,  $2\frac{1}{3}$ , or  $2.\bar{3}$ .

- Mixed numbers and repeating decimals cannot be gridded, so you must grid the answer as  $\frac{7}{3}$ .
- Write your answer in the answer boxes at the top of the grid.
- Put only one digit or symbol in each box. On some grids, the fraction bar and the decimal point have a designated box. Do not leave a blank box in the middle of an answer.
- Shade the bubble for each digit or symbol in the same column as the digit in the answer box.



On many grids you cannot grid a negative number because the grid does not include the negative sign. If you get a negative answer to a test item, you may need to recalculate the problem.

Read each sample and then answer the questions that follow.

### Sample A

A student correctly evaluated an expression and got  $\frac{8}{15}$  as a result. Then the student filled in the grid as shown.

| 8                                   | /                                   |                          | 1                                   | 5                                   |
|-------------------------------------|-------------------------------------|--------------------------|-------------------------------------|-------------------------------------|
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            |

1. What error did the student make when filling in the grid?
2. Explain how to fill in the answer correctly.

### Sample B

The square root of 6.25 is 2.5. This answer is displayed in the grid.

|                                     | 2                        | .                        | 5                        |                          |
|-------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

3. What error did the student make when filling in the grid?
4. Explain how to fill in the answer correctly.

### Sample C

A student correctly simplified the expression  $2\frac{1}{8} + 3\frac{5}{8} + \frac{7}{8}$ . Then the student filled in the grid as shown.

| 6                                   | 5                        | /                                   | 8                                   |                          |
|-------------------------------------|--------------------------|-------------------------------------|-------------------------------------|--------------------------|
| <input type="checkbox"/>            | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> |

5. What answer does the grid show?
6. Explain why you cannot fill in a mixed number.
7. Write the answer  $6\frac{5}{8}$  in two forms that could be entered in the grid correctly.

### Sample D

A student added  $-10$  and  $25$  and got an answer of  $15$ . Then the student filled in the grid as shown.

| -                                   | 1                                   | 5                        |                          |                          |
|-------------------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

8. What error does the grid show?
9. Another student got an answer of  $-15$ . Explain why the student knew this answer was wrong.



# STANDARDIZED TEST PREP

## CUMULATIVE ASSESSMENT, CHAPTERS 1

### Multiple Choice

1. Eric is collecting gifts for a charity event. He needs 150 gifts. So far he has collected  $x$  gifts. Which expression represents how many gifts Eric still needs to collect?

(A)  $150 + x$                       (C)  $x - 150$   
(B)  $150 - x$                       (D)  $150 \div x$

2. An online store sells birdhouses for \$34.95 each. For each order, there is a one-time shipping and handling fee of \$7.50. Which expression can be used to represent the cost of ordering  $x$  birdhouses?

(F)  $x + 34.95 + 7.50$   
(G)  $(34.95 + 7.50)x$   
(H)  $7.50x + 34.95$   
(J)  $34.95x + 7.50$

3. Which equation could have generated the table?

| $x$ | $y$ |
|-----|-----|
| -2  | 5   |
| -1  | 2   |
| 0   | 1   |
| 1   | 2   |
| 2   | 5   |

(A)  $y = -2x + 1$   
(B)  $y = x + 1$   
(C)  $y = |2x| + 1$   
(D)  $y = x^2 + 1$

4. The equation  $C = \frac{5}{9}(F - 32)$  relates the Celsius temperature  $C$  to the Fahrenheit temperature  $F$ . What is the Celsius temperature if the Fahrenheit temperature is  $-13$  degrees?

(F)  $-45^\circ\text{C}$                       (H)  $-25^\circ\text{C}$   
(G)  $-39.2^\circ\text{C}$                       (J)  $-10.6^\circ\text{C}$

5. Which equation is NOT true?

(A)  $55 + 27 + 45 = 100 + 27$   
(B)  $5 \cdot 7 \cdot \frac{2}{5} = 2 \cdot 7$   
(C)  $14(126) = 14(100) + 14(26)$   
(D)  $31(152) = 30(150) + 1(2)$

6. The volume of a sphere with radius  $r$  is  $\frac{4\pi r^3}{3}$ . The radius of a ball is 4 inches. What is the volume of the ball in cubic inches?

(F)  $16\pi \text{ in}^3$   
(G)  $\frac{64\pi}{3} \text{ in}^3$   
(H)  $\frac{256\pi}{3} \text{ in}^3$   
(J)  $\frac{4096\pi}{3} \text{ in}^3$

7. Which of the following real numbers is a terminating decimal?

(A)  $\pi$   
(B)  $\frac{3}{2}$   
(C)  $\frac{4}{9}$   
(D)  $\frac{1}{3}$

8. At one time, a U.S. dollar had the same value as 11.32 Mexican pesos. To the nearest hundredth, how many Mexican pesos were equal to 16 U.S. dollars at that time?

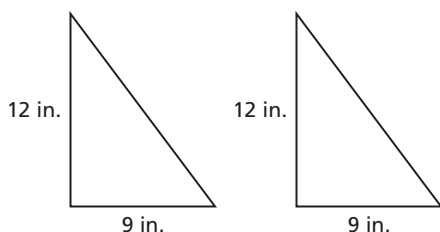
(F) 1.41 pesos  
(G) 4.68 pesos  
(H) 27.32 pesos  
(J) 181.12 pesos



Read each question carefully. Be sure you understand what the question is asking before looking at the answer choices or beginning your calculations.

9. Tickets to a festival cost \$5.00 each, and lunch costs \$8.50 per person. Renting a bus to and from the festival costs \$47.00. Which expression gives the cost of  $x$  people going to the festival?
- (A)  $5.00 + 8.50 + 47.00$   
 (B)  $5.00x + 8.50 + 47.00$   
 (C)  $5.00 + 8.50x + 47.00$   
 (D)  $5.00x + 8.50x + 47.00$

10. Tariq cut a rectangular piece of paper in half to make two triangles, as shown.

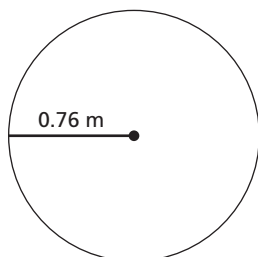


What was the area of the rectangle?

- (F) 42 inches  
 (G) 54 square inches  
 (H) 72 inches  
 (J) 108 square inches

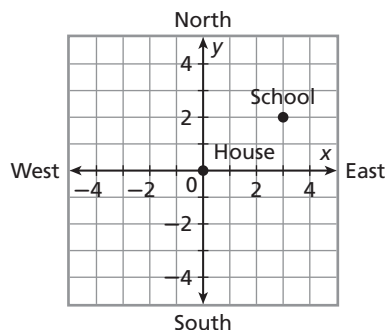
### Gridded Response

11. A scientist prepares 4 beakers of an acid solution. Each beaker contains 70.9 milliliters of the solution. How many milliliters of acid solution did the scientist prepare in all?
12. At an accident scene, an insurance inspector finds a skid mark 60 feet long. The inspector can determine how fast the car was going in miles per hour when the driver applied the breaks by using the expression  $\sqrt{21d}$ , where  $d$  is the length of the skid mark in feet. To the nearest tenth, what was the speed of the car that left the skid mark?
13. The area of a circle with radius  $r$  is  $\pi r^2$ . What is the area in square meters of the robot sumo-wrestling ring shown below? Use 3.14 for  $\pi$ . Round to the nearest tenth.



### Short Response

14. Dee is using a coordinate plane to make a map of her town. Each square on the grid represents 1 square mile. She plots her house at the origin. Her school is 3 miles east and 2 miles north of her house.



- a. Write an ordered pair to show where Dee plotted the point for her school.
- b. The post office is 4 miles east of Dee's house. Write an ordered pair to show where Dee should plot a point for the post office.
- c. The bank is 3 miles north and 3 miles west of the school. Which is closer to Dee's house, the post office or the bank? Explain your answer.
15. As part of a challenge problem, a math teacher writes the following expression on the board:
- $$-(-x).$$
- a. If  $x$  is 12, what is the value of the expression?
- b. If  $x$  is a negative number, is the value of the expression positive or negative? Explain how you found your answer.
- c. Simplify the expression.

### Extended Response

16. Fatima enrolled in a traveler rewards program. She begins with 10,000 bonus points. For every trip she takes, she collects 3000 bonus points.
- a. Write a rule for the number of bonus points Fatima has after  $x$  trips.
- b. Make a table showing the number of bonus points Fatima has after 0, 1, 2, 3, 4, and 5 trips.
- c. Graph the ordered pairs from the table. Describe the pattern formed by the points.
- d. When Fatima has collected 20,000 bonus points, she gets a free vacation. How many trips does Fatima need to take to get a free vacation?