Foundations for Algebra

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
2. factor
3. perimeter
4. area

A. the distance around a figure

B. a number that is multiplied by another number to form a product

C. a result of division

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. 18×96
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. 0.7×0.6
14. 2.5×0.1
15. 1.5×1.5
16. 3.04×0.12

✓ 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. $\frac{2}{3} - \frac{4}{9}$

Study Guide: Preview

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 learned 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 and Writing Math

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.

Know it! Note

Writing Math

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

Helpful Hint

A replacement set a set of numbers t can be substitutec

Caution!

In the expression -5^2, 5 is the base because the nega
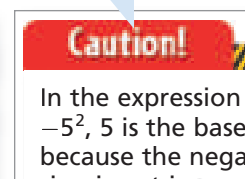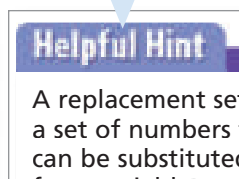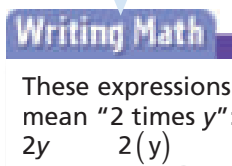
The **Glossary** is found in the back of your textbook. Use it as a resource when you need the definition of an unfamiliar word or property.

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

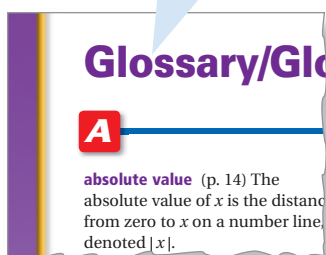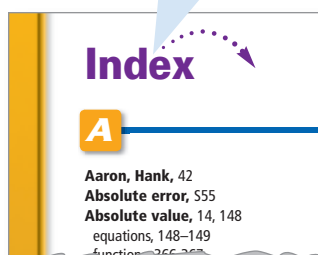The **Skills Bank** is found in the back of your textbook. These pages review concepts from previous math courses, including geometry skills.

Glossary/Glo

A

absolute value (p. 14) The absolute value of x is the distanc from zero to x on a number line, denoted $|x|$.

Index

A

Aaron, Hank, 42
Absolute error, 555
Absolute value, 14, 148
   equations, 148–149
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Skills Bank

Using Multiplicati

EXAMPLE 1 Solve eacl

$4 = 1$
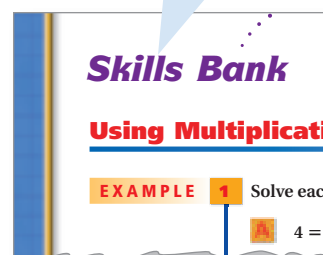
Try This

Use your textbook for the following problems.

1. Use the index to find the page where each word 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 word: *additive inverse, constant, perfect square, reciprocal.*

4. Where can you review the concepts of area and perimeter?

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*.

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 operations.

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

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

✛	―	✕	÷
Plus, sum, increased by	Minus, difference, less than	Times, product, equal groups of	Divided by, quotient

EXAMPLE 1 Translating from Algebra to Words

Give two ways to write each algebraic expression in words.

A $x + 3$
the sum of x and 3
x increased by 3

B $m - 7$
the difference of m and 7
7 less than m

C $2 \cdot y$
2 times y
the product of 2 and y

D $k \div 5$
k divided by 5
the quotient of k and 5

Writing Math

These expressions all mean "2 times y":
$2y \qquad 2(y)$
$2 \cdot y \qquad (2)(y)$
$2 \times y \qquad (2)y$

CHECK IT OUT! Give two ways to write each algebraic expression in words.

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

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

Add   **Subtract**   **Multiply**   **Divide**

Put together, combine | Find how much more or less | Put together equal groups | Separate into equal groups

E X A M P L E   2   **Translating from Words to Algebra**

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.

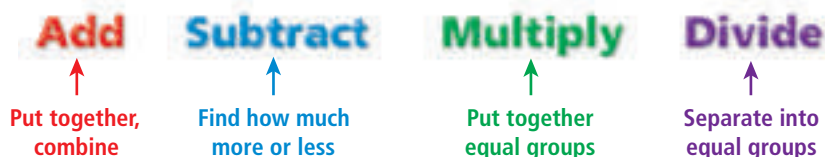$25 \cdot h$ or $25h$ *Think: h groups of 25 pages.*

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.

$y - 2$ *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.

$\dfrac{m}{12}$ *Think: How many groups of 12 are in m?*

CHECK IT OUT!

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.

E X A M P L E   3   **Evaluating Algebraic Expressions**

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

A $x + y$

$x + y = 8 + 5$ *Substitute 8 for x and 5 for y.*

$\quad\quad = 13$ *Simplify.*

B $\dfrac{x}{z}$

$\dfrac{x}{z} = \dfrac{8}{4}$ *Substitute 8 for x and 4 for z.*

$\quad = 2$ *Simplify.*

CHECK IT OUT!   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 ft² of carpet, 560 bottles are needed.
To make 120 ft² of carpet, 1680 bottles are needed.
To make 224 ft² of carpet, 3136 bottles are needed.

CHECK IT OUT!

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.

Words		Algebra
	Addition	
	Subtraction	
	Multiplication	
	Division	

1-1 **Exercises**

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Homework Help Online
KEYWORD: MA7 1-1
Parent Resources Online
KEYWORD: MA7 Parent
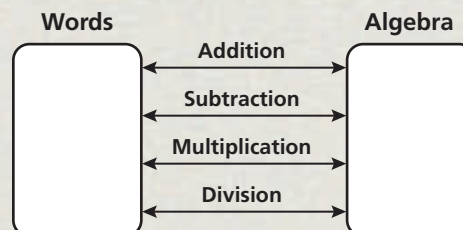
GUIDED PRACTICE

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.** $\dfrac{f}{3}$ **4.** $c + 15$ **5.** $9 - y$

6. $\dfrac{x}{12}$ **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

Extra Practice
Skills Practice p. S4
Application Practice p. S28

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° 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

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.

  a. What does 14.7 represent in the expression $14.7 + 0.445d$?

  b. What does d represent in the expression?

 **c.** 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 the lengths of its sides. The area of any rectangle is the length ℓ times the width w.

  a. Write an expression for the perimeter of a rectangle.

  b. Find the perimeter of the rectangle shown.

  c. Write an expression for the area of a rectangle.

  d. Find the area of the rectangle shown.

$\ell = 14$ cm
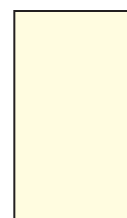
$w = 8$ cm

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	▢

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

  a. An object weighs p pounds on Earth. Write an expression for its weight on Mars.

  b. Dana weighs 120 pounds, and her bicycle weighs 44 pounds. How much would Dana and her bicycle together weigh on Mars?
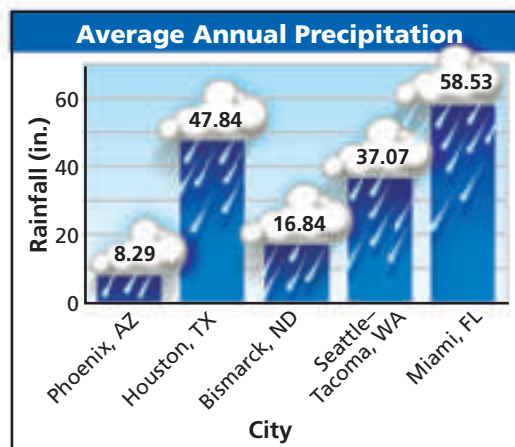
Astronomy

A crater on Canada's Devon Island is geologically similar to the surface of Mars. However, the temperature on Devon Island is about 37°F in summer, and the average summer temperature on Mars is −85°F.

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

  a. The average annual precipitation in New York is m inches more than the average annual precipitation in Houston, Texas.

  b. The average annual precipitation in New York is s inches less than the average annual precipitation in Miami, Florida.

Average Annual Precipitation

City	Rainfall (in.)
Phoenix, AZ	8.29
Houston, TX	47.84
Bismarck, ND	16.84
Seattle–Tacoma, WA	37.07
Miami, FL	58.53

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*.

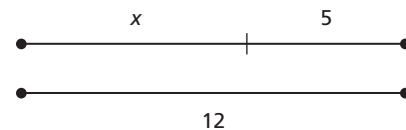|	Verbal	Algebraic	*x* = 12	*x* = 14
	x reduced by 5	$x - 5$	$12 - 5 = 7$	$14 - 5 = 9$
45.	7 more than *x*	■	■	■
46.	The quotient of *x* and 2	■	■	■
47.	The sum of *x* and 3	■	■	■

TEST PREP

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?

Ⓐ $3 + b$ Ⓑ $b + 3$ Ⓒ $3 - b$ Ⓓ $b < 3$

49. Which expression represents *x*?

Ⓕ $12 - 5$ Ⓗ $7 - x$

Ⓖ $x + 5$ Ⓙ $12 - x$

50. Which situation is best modeled by the expression $25 - x$?

Ⓐ George places *x* more video games on a shelf with 25 games.

Ⓑ Sarah has driven *x* miles of a 25-mile trip.

Ⓒ Amelia paid 25 dollars of an *x* dollar lunch that she shared with Ariel.

Ⓓ 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°. Find the measure of the third angle given the other two angle measures. *(Previous course)*

55. 45° and 90°   **56.** 120° and 20°   **57.** 30° and 60°

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 [Y=] and enter **2X+7** for **Y1**.

2 Determine a pattern for values of x.
The x-values start with 25 and increase by 100.

3 Press [2nd] [WINDOW] (TBLSET) to view the *Table Setup* window.
Enter **25** as the starting value in **TblStart=**.

Enter **100** as the amount by which x changes in **△Tbl=**.

4 Press [2nd] [GRAPH] (TABLE) 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.
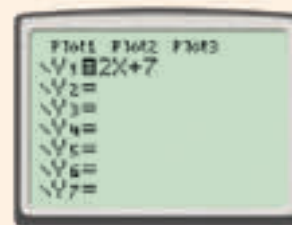
Try This

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 **△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 **△Tbl=?**

You can also use a spreadsheet program to evaluate expressions.

Activity 2

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

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

❷ Enter the expression in cell B1.

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

❸ Press Enter.

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

❹ 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.

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

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?

Adding and Subtracting Real Numbers

Objectives
Add real numbers.

Subtract real numbers.

Vocabulary
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.)

All the numbers 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 $-3 + 6$
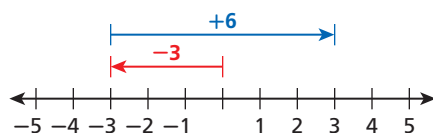
Start at 0. Move left to −3.

To add 6, move right 6 units.

$-3 + 6 = 3$

B $-2 - (-9)$
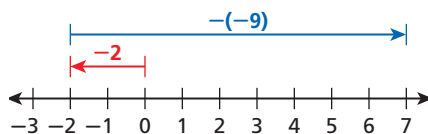
Start at 0. Move left to −2.

To subtract −9, move right 9 units.

$-2 - (-9) = 7$

CHECK IT OUT! 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	
Adding Numbers with the Same Sign		
If two numbers have the same sign, add their absolute values and use the sign of the numbers.	$3 + 6$ 9	$-2 + (-9)$ -11
Adding Numbers with Different Signs		
If two numbers have different signs, find the difference of their absolute values and use the sign of the number with the greater absolute value.	$-8 + 12$ 4	$3 + (-15)$ -12

EXAMPLE 2   Adding Real Numbers

Add.

A $-3 + (-16)$

$-3 + (-16)$

-19

When the signs of the numbers are the same, find the sum of their absolute values: 3 + 16 = 19.

Both numbers are negative, so the sum is negative.

B $x + 7$ for $x = -13$

$x + 7 = (-13) + 7$

$(-13) + 7$

-6

First substitute −13 for x.

When the signs are different, find the difference of the absolute values: 13 − 7 = 6.

Use the sign of the number with the greater absolute value. The sum is negative.

CHECK IT OUT! Add.

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

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

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

— Additive inverses —

$$11 - 6 = 5 \qquad 11 + (-6) = 5$$

Subtracting 6 is the same as adding the inverse of 6.

Subtracting Real Numbers

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

EXAMPLE 3 **Subtracting Real Numbers**

Subtract.

A $7 - 10$

$7 - 10 = 7 + (-10)$ *To subtract 10, add −10.*

When the signs of the numbers are different, subtract the absolute values: 10 − 7 = 3.

Use the sign of the number with the greater absolute value. The sum is negative.

-3

B $-3 - (-12)$

$-3 - (-12) = -3 + 12$ *To subtract −12, add 12.*

When the signs of the numbers are different, subtract the absolute values: 12 − 3 = 9.

Use the sign of the number with the greater absolute value. The sum is positive.

9

C $x - 22$ for $x = -11$

$x - 22 = -11 - 22$ *First substitute −11 for x.*

$-11 + (-22)$ *To subtract 22, add −22.*

When the signs of the numbers are the same, add the absolute values: 11 + 22 = 33.

Both numbers are negative, so the sum is negative.

-33

CHECK IT OUT! Subtract.

3a. $13 - 21$ **3b.** $\dfrac{1}{2} - \left(-3\dfrac{1}{2}\right)$ **3c.** $x - (-12)$ for $x = -14$

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?

Find the difference in the elevations of the iceberg and the fish.

elevation of iceberg	minus	elevation of fish
10	−	−67

$10 - (-67)$

$10 - (-67) = 10 + 67$ *To subtract −67, add 67.*
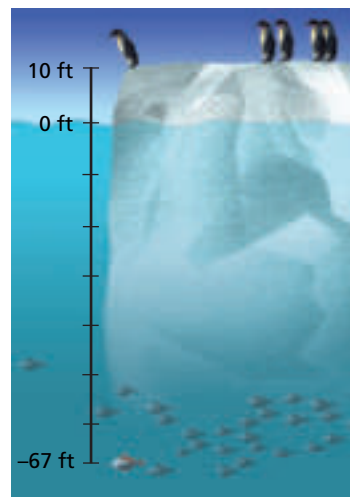
$= 77$ *Find the sum of the absolute values.*

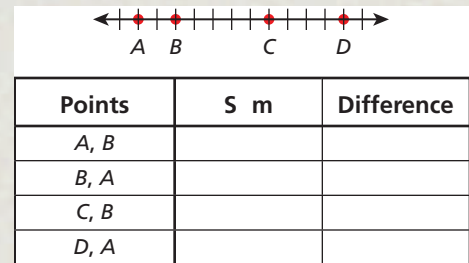The total length of the penguin's dive is 77 feet.

CHECK IT OUT! **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?

1-2 Exercises

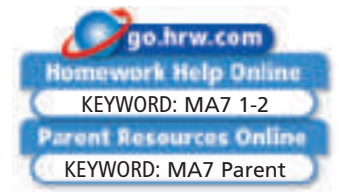### GUIDED PRACTICE

1. Vocabulary The sum of a number and its ___?___ is always zero. (*opposite* or *absolute value*)

SEE EXAMPLE **1**
p. 14

Add or subtract using a number line.

2. $-4 + 7$ **3.** $-3.5 - 5$ **4.** $5.6 - 9.2$ **5.** $3 - \left(-6\frac{1}{4}\right)$

SEE EXAMPLE **2**
p. 15

Add.

6. $91 + (-11)$ **7.** $4\frac{3}{4} + \left(-3\frac{3}{4}\right)$ **8.** $15.6 + x$ for $x = -17.9$

SEE EXAMPLE **3**
p. 16

Subtract.

9. $23 - 36$ **10.** $4.3 - 8.4$ **11.** $x - 2\frac{4}{5}$ for $x = 1\frac{1}{5}$

SEE EXAMPLE **4**
p. 16

12. 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.

DJIA 1987	
Friday, Oct. 16	−108.35
Monday, Oct. 19	−507.99

PRACTICE AND PROBLEM SOLVING

Independent Practice

For Exercises	See Example
13–16	1
17–19	2
20–22	3
23	4

Extra Practice
Skills Practice p. S4
Application Practice p. S28

Add or subtract using a number line.

13. $-2 + 6$ **14.** $6 + (-2)$ **15.** $\frac{1}{4} - 12$ **16.** $-\frac{2}{5} + 6$

Add.

17. $-18 + (-12)$ **18.** $-2.3 + 3.5$ **19.** $x + 29$ for $x = -15$

Subtract.

20. $12 - 22$ **21.** $-\frac{3}{4} - \left(-\frac{1}{4}\right)$ **22.** $38 - x$ for $x = 24.6$

23. Meteorology A meteorologist reported that the day's high temperature was 17°F and the low temperature was −6°F. What was the difference between the day's high and low temperatures?

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

24. $n = 312$ **25.** $n = 5.75$ **26.** $n = -\dfrac{7}{12}$ **27.** $n = -7\dfrac{2}{5}$

Add or subtract.

28. $-8 - 3$ **29.** $-9 + (-3)$ **30.** $16 - (-16)$ **31.** $100 - 63$

32. $5.2 - 2.5$ **33.** $-4.7 - (-4.7)$ **34.** $\dfrac{2}{5} - \dfrac{7}{8}$ **35.** $\dfrac{2}{5} - \dfrac{3}{10}$

36. 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 $=$.

37. $-4 - (-6)$ ▩ $-7 - 3$ **38.** $\left|-51\right|$ ▩ $\left|0\right|$ **39.** $3 - (-3)$ ▩ $0 - (-3)$

40. $-3 - 8$ ▩ $-22 + 11$ **41.** $\left|-10 + 5\right|$ ▩ $\left|-15\right|$ **42.** $9 + (-8)$ ▩ $-12 + 13$

43. 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	−21
Telescope Creek	11, 49

Critical Thinking Use examples to explain whether each statement is sometimes, always, or never true.

44. The difference between two negative numbers is positive.

45. The sum of two negative numbers is negative.

46. The difference of a negative number and a positive number is negative.

47. ⫽⫽ **ERROR ANALYSIS** ⫽⫽ Which is incorrect? Explain the error.

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

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

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

    a. A plane flies at a height of 1800 feet 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 flies 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.

MULTI-STEP TEST PREP

49. Write About It Use the following examples to explain why addition and subtraction are called inverse operations:

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

50. A rectangle has a length of 23.8 cm and a width of 14.5 cm. What is its perimeter?

 Ⓐ 9.3 cm   Ⓑ 38.3 cm   Ⓒ 62.1 cm   Ⓓ 76.6 cm

51. At midnight, the temperature was −12°F. By noon, the temperature had risen 25°F. During the afternoon, it fell 10°F and fell another 3°F by midnight. What was the final temperature?

 Ⓕ 0°F   Ⓖ 3°F   Ⓗ 12°F   Ⓙ 24°F

52. 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

 Ⓐ $21.83   Ⓑ $22.03   Ⓒ $31.55   Ⓓ $36.95

CHALLENGE AND EXTEND

Find the value of each expression.

53. $-1\frac{1}{5} + (-7.8)$ **54.** $-\frac{1}{5} + 2.1$ **55.** $9.75 + \left(-7\frac{3}{4}\right)$ **56.** $-2\frac{3}{10} + 8.5$

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

57. 14, 10, 6, 2, …   **58.** $-2, -\frac{8}{5}, -\frac{6}{5}, -\frac{4}{5}, \ldots$

59. Geography Sam visited two volcanoes and two caves. Cotapaxi, a volcano 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, a cave 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

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

60. rectangle; $\ell = 12$ cm, $w = 5$ cm   **61.** triangle; $b = 8$ in., $h = 11$ in.

Find the length of the third side of the triangle. *(Previous course)*

62. perimeter = 12 cm **63.** perimeter = 30 cm **64.** perimeter = 56 cm

 3 cm   5 cm   7 cm

  4 cm   12 cm   24 cm
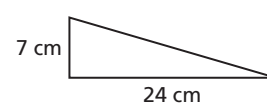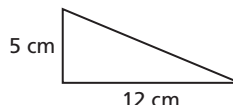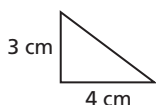
Evaluate each expression for $x = 8$, $y = 4$, and $z = 2$. *(Lesson 1-1)*

65. $x + y$ **66.** $\frac{x}{z}$ **67.** $x - y$ **68.** $\frac{y}{z}$

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 you are multiplying or dividing determine whether the product is positive or negative.

Factors		Product	
3(5)	Both positive	15	Positive
3(−5)	One negative	−15	Negative
−3(−5)	Both negative	15	Positive

Know it!
Note

Multiplying and Dividing Signed Numbers

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

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 $8x$ for $x = -\dfrac{5}{4}$

$8x = 8\left(-\dfrac{5}{4}\right)$ *First substitute $-\frac{5}{4}$ for x.*

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

$= -\dfrac{40}{4} = -10$ *The quotient of two numbers with different signs is negative.*

CHECK IT OUT!   Find the value of each expression.

1a. $35 \div (-5)$ **1b.** $-11(-4)$ **1c.** $-6x$ for $x = 7$

Two numbers are **reciprocals** if their product is 1. A number and its reciprocal are called **multiplicative inverses**. To divide by a number, you can multiply by its multiplicative inverse.

Multiplicative inverses

$$10 \div 5 = 2 \qquad 10 \cdot \frac{1}{5} = \frac{10}{5} = 2$$

Dividing by 5 is the same as multiplying by the reciprocal of 5, $\frac{1}{5}$.

Dividing by a nonzero number is the same as multiplying by the reciprocal of the number.

EXAMPLE 2

Dividing by Fractions

Divide.

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

$-\frac{4}{5} \div \left(-\frac{8}{15}\right) = -\frac{4}{5}\left(-\frac{15}{8}\right)$ *To divide by $-\frac{8}{15}$, multiply by $-\frac{15}{8}$.*

$= \frac{(-4)(-15)}{5\,(8)}$ *Multiply the numerators and multiply the denominators.*

$= \frac{60}{40} = \frac{3}{2}$ *$-\frac{4}{5}$ and $-\frac{8}{15}$ have the same sign, so the quotient is positive.*

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

$-4 \div 9\frac{1}{4} = -\frac{4}{1} \div \frac{37}{4}$ *Write 4 as a fraction with a denominator of 1. Write $9\frac{1}{4}$ as an improper fraction.*

$= -\frac{4}{1} \cdot \frac{4}{37}$ *To divide by $\frac{37}{4}$, multiply by $\frac{4}{37}$.*

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

CHECK IT OUT!

Divide.

2a. $-\frac{3}{4} \div -9$ **2b.** $\frac{3}{10} \div \left(-\frac{6}{5}\right)$ **2c.** $-\frac{5}{6} \div 1\frac{2}{3}$

No number can be multiplied by 0 to give a product of 1, so 0 has no reciprocal. Because of this, division by 0 is not possible. We say that division by 0 is undefined.

Know it! Note

Properties of Zero

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

EXAMPLE 3 **Multiplying and Dividing with Zero**

Multiply or divide if possible.

A $0 \div 16.568$ *Zero is divided by a nonzero number.*

0 *The quotient of zero and any nonzero number is 0.*

B $63\dfrac{7}{8} \div 0$ *A number is divided by zero.*

undefined   *Division by zero is undefined.*

C $1 \cdot 0$ *A number is multiplied by zero.*

0 *The product of any number and 0 is 0.*

CHECK IT OUT! **Multiply or divide.**

3a. $0 \div \left(-8\dfrac{1}{6}\right)$ **3b.** $0 \div 0$ **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. 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

$4.75 \cdot 2.5$

11.875

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

CHECK IT OUT! **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. How many miles away from the liftoff site will the balloon land?

Know it! Note

THINK AND DISCUSS

1. Explain how to use mental math to find the missing value: $\dfrac{4}{5} \cdot ? = 1$.

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 ▢ = pos	pos ÷ ▢ = pos
pos ▢ = neg	pos ÷ ▢ = neg
neg ▢ = neg	neg ÷ ▢ = neg
neg ▢ = pos	neg ÷ ▢ = pos

GUIDED PRACTICE

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

SEE EXAMPLE **1**
p. 20

Find the value of each expression.

2. $-72 \div (-9)$ 3. $11(-11)$ 4. $-7.2 \div x$ for $x = 3.6$

SEE EXAMPLE **2**
p. 21

Divide.

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

SEE EXAMPLE **3**
p. 22

Multiply or divide if possible.

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

SEE EXAMPLE **4**
p. 22

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

Extra Practice
Skills Practice p. S4
Application Practice p. S28

Find the value of each expression.

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

Divide.

17. $\frac{3}{20} \div \left(-\frac{1}{4}\right)$ 18. $\frac{9}{14} \div \frac{15}{28}$ 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 $-3°F$ each day. If the temperature started at $0°F$, 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 $c = -2$.

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. $\frac{z}{n}$

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

47. $y = \dfrac{3}{4}$ **48.** $y = -\dfrac{9}{16}$ **49.** $y = \dfrac{3}{8}$ **50.** $y = -2\dfrac{1}{4}$

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

51. $m = -\dfrac{5}{2}$ **52.** $m = \dfrac{7}{8}$ **53.** $m = \dfrac{4}{9}$ **54.** $m = -5$

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 each semester to graduate in 8 semesters?

56. **Diving** An underwater exploration team is swimming at a depth of -15 feet. Then they dive to an underwater cave that is at 8 times this depth. What is the depth of the underwater cave?

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

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

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

63. **Critical Thinking** There is a relationship between the number of negative factors and the sign of the product.

  a. What is the sign of the product of an even number of negative factors?

  b. What is the sign of the product of an odd number of negative factors?

  c. Explain why the number of negative factors affects the sign of the product.

  d. 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.** $\dfrac{80}{-8}$ **67.** $\dfrac{-121}{11}$

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

68. The quotient of two negative numbers is negative.

69. The quotient of two numbers with the same sign has that sign.

70. The product of two numbers with different signs is positive.

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.

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

  a. You swam 20 feet in 5 seconds. Use the formula $r = \dfrac{d}{t}$ to determine how fast you were swimming. Explain how you found your answer.

  b. 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.

  c. Show two ways to find how far the diver descended in 5 minutes. Remember that multiplication is repeated addition.

73. In which situation below would you multiply 5 • 35 to find the final balance?

    (A) Marc had \$35 in his bank account, and for 5 weeks, he withdrew \$5 a week.

    (B) Marc opened a new bank account, and for the first 5 months, he deposited \$35 a month.

    (C) Marc opened a bank account with \$35. For 5 weeks, he deposited \$5 a week.

    (D) Marc withdrew \$35 a month from his bank account for 5 months.

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?

    (F) \$68   (G) \$144   (H) \$180   (J) \$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.

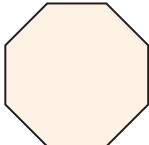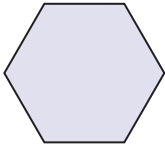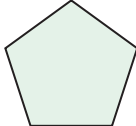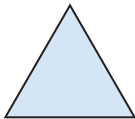## CHALLENGE AND EXTEND

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.** $\left(2^3\right)^2$

For each pattern shown below, verbally describe a 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

Identify each polygon. *(Previous course)*

90.   **91.**   **92.**   **93.**

94. 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)*

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

95. $12 - 18$ **96.** $-6 + 14$ **97.** $3 - (-5)$ **98.** $11 + (-8)$

Powers and Exponents

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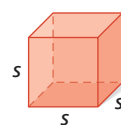
The base, 3, is the number that is used as a factor.

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**

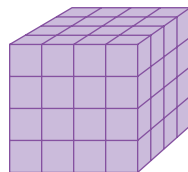Write the power represented by each geometric model.

A

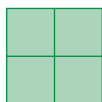*There are 3 rows of 3 dots. 3 × 3*
The factor 3 is used 2 times.

3^2

B

The figure is 4 cubes long, 4 cubes wide, and 4 cubes tall. 4 × 4 × 4
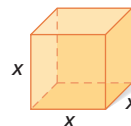*The factor 4 is used 3 times.*

4^3

CHECK IT OUT! Write the power represented by each geometric model.

1a.

1b.

x

x

x

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

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.

B -5^2

$-1 \cdot 5 \cdot 5$ *Think of a negative sign in front of a power as*

$-1 \cdot 25$ *multiplying by −1. Find the product of −1*

-25 *and two 5's.*

C $\left(\dfrac{2}{3}\right)^2$

$\dfrac{2}{3} \cdot \dfrac{2}{3}$ *Use $\frac{2}{3}$ as a factor 2 times.*

$\dfrac{2}{3} \cdot \dfrac{2}{3} = \dfrac{4}{9}$

CHECK IT OUT! Simplify each expression.

2a. $(-5)^3$ **2b.** -6^2 **2c.** $\left(\dfrac{3}{4}\right)^3$

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.*

$(-5)^3$

CHECK IT OUT! Write each number as a power of the given base.

3a. 64; base 8   **3b.** −27; base −3

EXAMPLE 4

Problem-Solving Application

PROBLEM SOLVING

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?

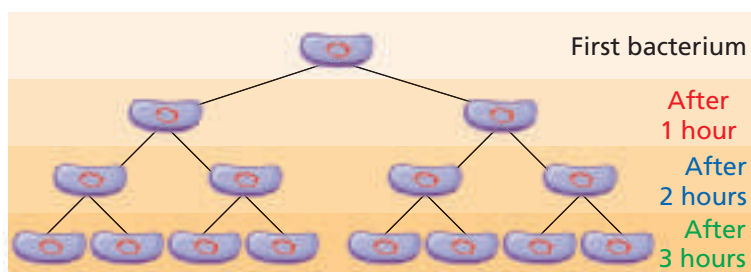### 1 Understand the Problem

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.

First bacterium
After 1 hour
After 2 hours
After 3 hours

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.
$2^6 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 64$ *Multiply six 2's.*
After 6 hours, there will be 64 bacteria on the slide.

4 Look Back

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

CHECK IT OUT!
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.

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

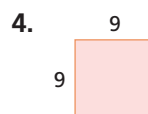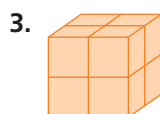|	Even Exponent	Odd Exponent
Positive Base		
Negative Base		

Exercises

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.

2. (dot grid model)   **3.** (cube model)   **4.** (square model, sides 9)

SEE EXAMPLE 2
p. 27

Simplify each expression.

5. 7^2 **6.** $(-2)^4$ **7.** $(-2)^5$ **8.** $-\left(\dfrac{1}{2}\right)^4$

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?
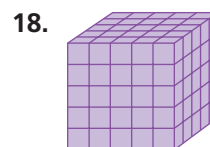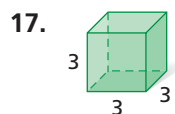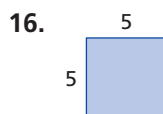
PRACTICE AND PROBLEM SOLVING

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.

16. (square model, sides 5)   **17.** (cube model, sides 3)   **18.** (cube model)

Simplify each expression.

19. 3^3 **20.** $(-4)^2$ **21.** -4^2 **22.** $\left(-\dfrac{3}{5}\right)^2$

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. $3^2 \,\blacksquare\, 3^3$ **32.** $5^2 \,\blacksquare\, 2^5$ **33.** $4^2 \,\blacksquare\, 2^4$ **34.** $1^9 \,\blacksquare\, 1^4$

35. $-2^3 \,\blacksquare\, (-2)^3$ **36.** $-3^2 \,\blacksquare\, (-3)^2$ **37.** $10^2 \,\blacksquare\, 2^6$ **38.** $2^2 \,\blacksquare\, 4^1$

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

39. 2^3 **40.** 1^7 **41.** $(-4)^3$ **42.** -4^3
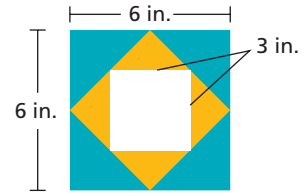
43. $(-1)^3$ **44.** $(-1)^4$ **45.** $\left(\dfrac{1}{3}\right)^3$ **46.** -2.2^2

47. Geometry The diagram shows an ornamental tile design.

a. What is the area of the whole tile?

b. What is the area of the white square?

c. What is the area of the two shaded regions?

6 in.

3 in.

6 in.

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.** $\left(\dfrac{1}{9}\right)\left(\dfrac{1}{9}\right)\left(\dfrac{1}{9}\right)$

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.

a. What is Mark's score?

b. What is Becky's score?

c. **What if...?** If they toss the coin 50 more times, who do you think will win? Why?

Coin Toss Results	
Heads	Tails
✓	✓
✓	✓
✓	✓
✓	
✓	

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

a. Evaluate each of the following: 10^2, 10^3, 10^4.

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

a. A 50-pound bag of flour sits on a block and exerts a force over an area of 100 in². What is the pressure exerted on the block by the bag of flour?

b. 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?

    Ⓐ $9 \cdot 2$ Ⓑ 27   Ⓒ 3^4 Ⓓ -9^2

68. Which power represents the same value as the product $(-16)(-16)(-16)(-16)$?

    Ⓕ $(-16)4$ Ⓖ $(-16)^4$ Ⓗ -16^4 Ⓙ $-(16 \cdot 4)$

69. A number raised to the third power is negative. What is true about the number?

    Ⓐ The number is positive.   Ⓒ The number is even.

    Ⓑ The number is negative.   Ⓓ 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

    Ⓕ -1^{100} Ⓖ -1 Ⓗ 1   Ⓙ 0

CHALLENGE AND EXTEND

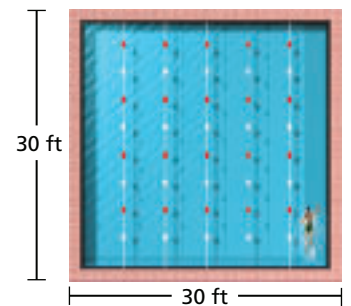**Simplify each expression.**

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.

    a. What is the total area of the pool and path?

    b. What is the area of the pool?

    c. What is the area of the path?

    d. One bag of pebbles covers 10 square feet. How many bags of pebbles are needed to cover the path?

30 ft

30 ft

75. Exponents and powers have special properties.

    a. Write both 4^2 and 4^3 as a product of 4's.

    b. Write the product of the two expressions from part **a.** Write this product as a power of 4.

    c. 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 Square Roots and Real Numbers

Why learn this?

Square roots are used to find the side length of a square when you know the area of the square, like when covering a square plot with flower seeds. (See Example 2.)

COUNT OFF BY THE SQUARE ROOT OF 7!

UHH....

Deep down inside, Coach Knott had always wanted to be a math teacher.

A number that is multiplied by itself to form a product is called a **square root** of that product. The operations of squaring and finding a square root are inverse operations.

The radical symbol, $\sqrt{}$, is used to represent square roots. Positive real numbers have two square roots.

$$4 \cdot 4 = 4^2 = 16 \longrightarrow \sqrt{16} = 4$$ ← Positive square root of 16

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

The nonnegative square root is represented by $\sqrt{}$. The negative square root is represented by $-\sqrt{}$.

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

EXAMPLE 1 Finding Square Roots of Perfect Squares

Find each square root.

A $\sqrt{49}$

$7^2 = 49$ *Think: What number squared equals 49?*

$\sqrt{49} = 7$ *Positive square root → positive 7*

B $-\sqrt{36}$

$6^2 = 36$ *Think: What is the opposite of the square root of 36?*

$-\sqrt{36} = -6$ *Negative square root → negative 6*

Reading Math

The expression $\sqrt{-36}$ does not represent a real number because there is no real number that can be multiplied by itself to form a product of -36.

CHECK IT OUT! Find each square root.

1a. $\sqrt{4}$ **1b.** $-\sqrt{25}$

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

EXAMPLE 2 *Problem-Solving Application*

PROBLEM
SOLVING

Nancy wants to plant wildflowers in a square-shaped plot. She has enough wildflower seeds to cover 19 ft². Estimate to the nearest tenth the side length of a square plot with an area of 19 ft².

1. **Understand the Problem**

The **answer** will be the side length of the square garden.

List the **important information:**
• The garden has an area of 19 feet.

2. **Make a Plan**

The side length of the square is $\sqrt{19}$ because $\sqrt{19} \cdot \sqrt{19} = 19$. 19 is not a perfect square, so $\sqrt{19}$ is not a whole number. Estimate $\sqrt{19}$ to the nearest tenth.
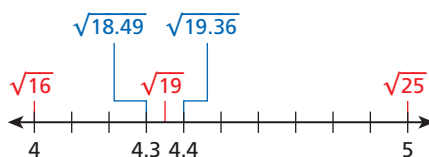
Find the two whole numbers that $\sqrt{19}$ is between. 19 is between the perfect squares 16 and 25, so $\sqrt{19}$ is between $\sqrt{16}$ and $\sqrt{25}$, or between 4 and 5. 19 is closer to 16 than to 25, so $\sqrt{19}$ is closer to 4 than to 5.
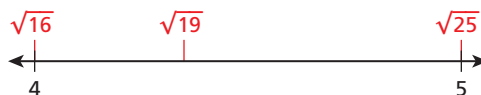
You can use a guess-and-check method to estimate $\sqrt{19}$.

3. **Solve**

Guess 4.3: $4.3^2 = 18.49$ too low   *$\sqrt{19}$ is greater than 4.3.*
Guess 4.4: $4.4^2 = 19.36$ too high   *$\sqrt{19}$ is less than 4.4.*

Because 19 is closer to 19.36 than to 18.49, $\sqrt{19}$ is closer to 4.4 than to 4.3.
$\sqrt{19} \approx 4.4$

4. **Look Back**

A square garden with a side length of 4.4 ft would have an area of 19.36 ft². 19.36 is close to 19, so 4.4 ft is a reasonable estimate.
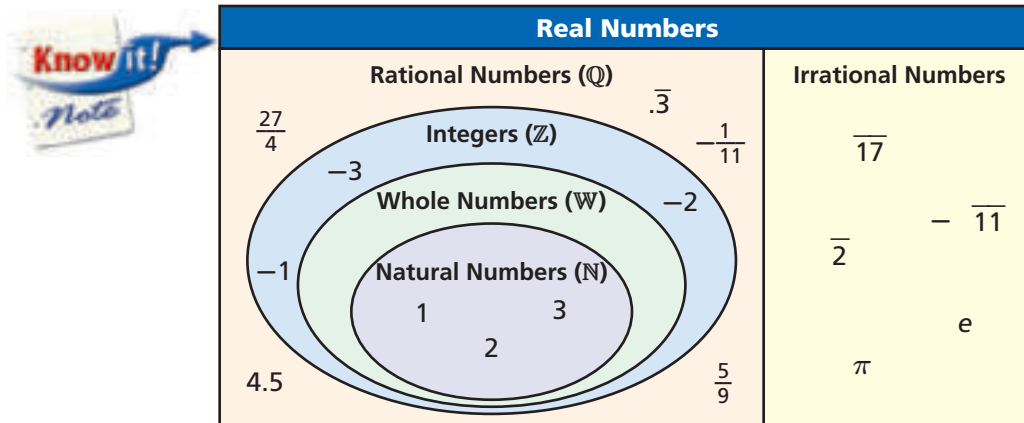
Writing Math

The symbol $\approx$ means approximately equal to.

CHECK IT OUT!

2. What if…? Nancy decides to buy more wildflower seeds and now has enough to cover 38 ft². What is the side length of a square garden with an area of 38 ft²?

All numbers that can be represented on the number line are called **real numbers** and 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 whole numbers and their opposites: $-3, -2, -1, 0, 1, 2, 3, …$

- **Rational numbers** can be expressed in the form $\frac{a}{b}$, where a and b are both integers and $b \neq 0$: $\frac{1}{2}, \frac{7}{1}, \frac{9}{10}$

- **Terminating decimals** are rational numbers in decimal form that have a finite number of digits: 1.5, 2.75, 4.0

- **Repeating decimals** are rational numbers in decimal form that have a block of one or more digits that repeats continuously: $1.\overline{3}, 0.\overline{6}, 2.\overline{14}, 6.2\overline{7}$

- **Irrational numbers** cannot be expressed in the form $\frac{a}{b}$. They include square roots of whole numbers that are not perfect squares and nonterminating decimals that do not repeat: $\sqrt{2}, \sqrt{11}, \pi$

EXAMPLE 3 | **Classifying Real Numbers**

Write all classifications that apply to each real number.

A $\dfrac{8}{9}$

$8 \div 9 = 0.888… = 0.\overline{8}$ *$\frac{8}{9}$ can be written as a repeating decimal.*

rational number, repeating decimal

B 18

$18 = \dfrac{18}{1} = 18.0$ *18 can be written as a fraction and a decimal.*

rational number, terminating decimal, integer, whole number, natural number

C $\sqrt{20}$

$\sqrt{20} = 4.472135…$ *The digits of $\sqrt{20}$ continue with no pattern.*

irrational number

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

CHECK IT OUT! Write all classifications that apply to each real number.
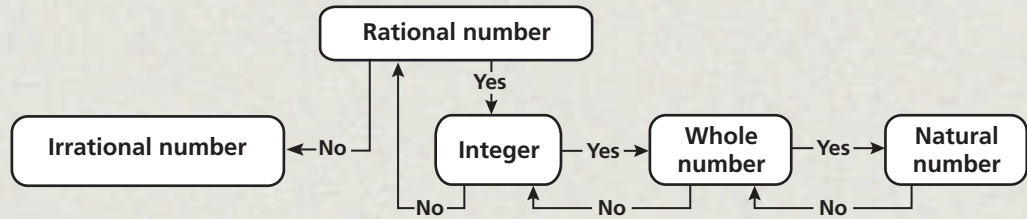
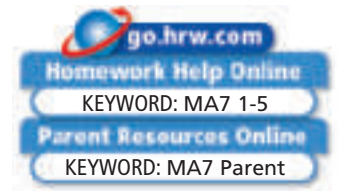3a. $7\dfrac{4}{9}$ 3b. -12 3c. $\sqrt{10}$

THINK AND DISCUSS

1. Write $\frac{2}{3}$ and $\frac{3}{5}$ as decimals. Identify what number classifications the two numbers share and how their classifications are different.

2. 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. $4, \sqrt{25}, 0, \frac{1}{3}, -15, -2.25, \frac{1}{4}, \sqrt{21}, 2^4, (-1)^2$

```
                    ┌──────────────────┐
                    │  Rational number │
                    └──────────────────┘
                          │ Yes
                          ↓
┌──────────────────┐  No  ┌─────────┐  Yes   ┌──────────┐  Yes   ┌──────────┐
│ Irrational number│←─────│ Integer │───────→│  Whole   │───────→│ Natural  │
└──────────────────┘      └─────────┘        │  number  │        │  number  │
                           No    No           └──────────┘ No      └──────────┘
```

1-5

Exercises

go.hrw.com
Homework Help Online
KEYWORD: MA7 1-5
Parent Resources Online
KEYWORD: MA7 Parent

GUIDED PRACTICE

1. Vocabulary Give an example of an *integer* that is not a *whole number*.

SEE EXAMPLE **1**
p. 32

Find each square root.

2. $\sqrt{64}$ **3.** $\sqrt{225}$ **4.** $-\sqrt{1}$ **5.** $\sqrt{169}$

SEE EXAMPLE **2**
p. 33

6. 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 ft². Find the side length of the floor to the nearest tenth.

SEE EXAMPLE **3**
p. 34

Write all classifications that apply to each real number.

7. -27 **8.** $\frac{1}{6}$ **9.** $\sqrt{12}$ **10.** -6.8

PRACTICE AND PROBLEM SOLVING

Independent Practice

For Exercises	See Example
11–14	1
15	2
16–19	3

Extra Practice

Skills Practice p. S4
Application Practice p. S28

Find each square root.

11. $\sqrt{121}$ **12.** $\sqrt{9}$ **13.** $-\sqrt{100}$ **14.** $\sqrt{400}$

15. Mr. and Mrs. Phillips are going to build a new home with a foundation that is in the shape of a square. The house will cover 222 square yards. Find the length of the side of the house to the nearest tenth of a yard.

Write all classifications that apply to each real number.

16. $\frac{5}{12}$ **17.** $\sqrt{49}$ **18.** -3 **19.** $\sqrt{18}$

Compare. Write <, >, or =.
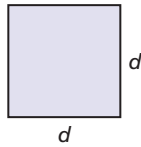
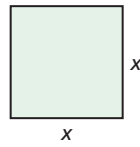**20.** $\sqrt{88}$ ▢ 9   **21.** 8 ▢ $\sqrt{63}$ **22.** 6 ▢ $\sqrt{40}$ **23.** $\sqrt{169}$ ▢ 13

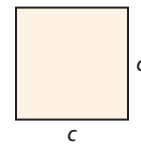**Geometry** Give the side length of each square. Round your answer to the nearest whole number, if necessary.

24. Area $= 81$ cm^2

d
d

25. Area $= 34$ in^2

x
x

26. Area $= 169$ m^2

c
c

Travel During a cross-country road trip, Madeline recorded the distance between several major cities and the time it took 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
27. Portland, ME, to Memphis, TN	1485	33	■	■
28. Memphis, TN, to Denver, CO	1046	27	■	■
29. Denver, CO, to Boise, ID	831	24	■	■
30. Boise, ID, to Portland, OR	424	9	■	■

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

31. Natural numbers are whole numbers.

32. Negative numbers are integers.

33. Mixed numbers are rational numbers.

34. A positive number has two square roots.

Tell whether whole numbers, integers, or rational numbers are the most reasonable to describe each. Explain your answer.

35. number of pets
36. body temperature
37. recipe measurements

38. money owed
39. distances
40. home runs

41. Critical Thinking Tell how you would classify the square roots of all positive integers that are not perfect squares.

42. Write About It Tell whether the square root of an integer is sometimes, always, or never an integer. Explain.


MULTI-STEP TEST PREP

43. 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.

a. 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.

b. 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?


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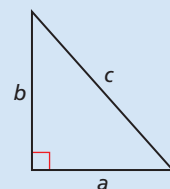
44. Entertainment In a game called Pente, players place different-colored stones on a grid. Each player tries to make rows of 5 or more stones in their color while preventing their opponent(s) from doing the same. The square game board has 324 squares on it. How many squares are on each side of the board?

45. Which point on the number line is closest to $-\sqrt{11}$?

A A   B B   C C   D D

46. What is the area of the figure at right?

F 24 cm^2 H 104 cm^2

G 52 cm^2 J 576 cm^2

$\overline{36}$ cm

$\overline{16}$ cm

47. Which number is closest to $\sqrt{111}$?

A -50 B 10

C -10 D 50
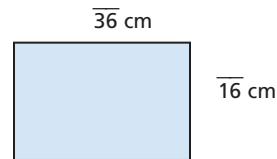
CHALLENGE AND EXTEND

Find each square root.

48. $\sqrt{0.81}$ **49.** $\sqrt{0.25}$ **50.** $\sqrt{1.69}$ **51.** $\sqrt{2.25}$

Number Theory Use the following information for Exercises 52 and 53.

A set of numbers is said to be *closed* under a certain operation if, when you perform the operation on any two numbers in the set, the result is also a number in the set.

The set of real numbers is closed under addition. This means that when you add any two real numbers, the sum is also a real number.

52. Is the set of real numbers closed under subtraction? Explain.

53. Is the set of whole numbers closed under subtraction? Explain.

SPIRAL REVIEW

Use the formula $V = \ell wh$ to find the volume of a rectangular prism with the given dimensions. *(Previous course)*

54. $\ell = 3$ cm, $w = 2$ cm, $h = 5$ cm   **55.** $\ell = 7$ in., $w = 4$ in., $h = 6$ in.

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

56. $-14 + (-16)$ **57.** $-\dfrac{1}{4} - \left(-\dfrac{3}{4}\right)$ **58.** $25 - x$ when $x = 17.6$

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

59. -3^4 **60.** $\left(-\dfrac{2}{5}\right)^3$ **61.** 14^2 **62.** 4^3

MULTI-STEP TEST PREP

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.

1. 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.

2. 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.

3. 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?

4. 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?**

5. 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?

3 ft

4 ft

x ft

READY TO GO ON?
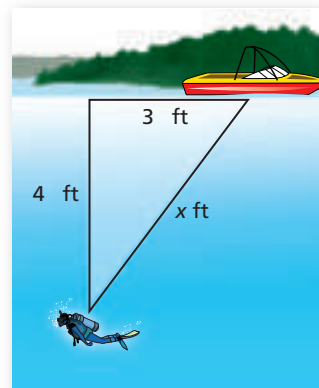
Quiz for Lessons 1-1 Through 1-5

1-1 Variables and Expressions

Give two ways to write each algebraic expression in words.

1. $4 + n$ **2.** $m - 9$ **3.** $\dfrac{g}{2}$ **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.** $x + (-14)$ for $x = -7$

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.** $6 \div \dfrac{3}{5}$ **18.** $9.6 \div 0$ **19.** $-\dfrac{1}{2}x$ for $x = -\dfrac{1}{2}$

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.** $\left(-\dfrac{2}{3}\right)^3$ **24.** $\left(-\dfrac{1}{2}\right)^5$

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

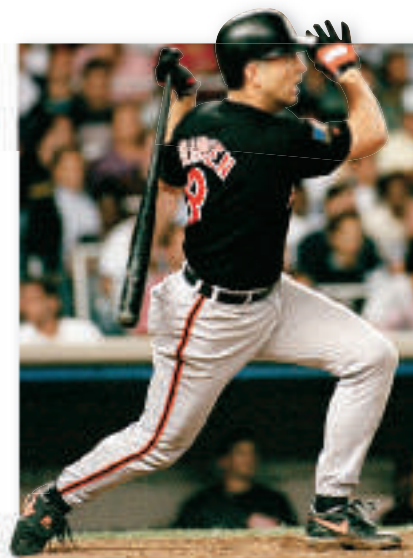### 1-5 Square Roots and Real Numbers

Find each square root.

26. $\sqrt{225}$ **27.** $-\sqrt{49}$ **28.** $\sqrt{144}$ **29.** $\sqrt{\dfrac{16}{25}}$

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.

Classify each real number. Write all classifications that apply.

31. $\dfrac{1}{11}$ **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.

Know it! Note

Order of Operations	
First:	Perform operations inside grouping symbols.
Second:	Simplify powers.
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 $-4^2 + 24 \div 3 \cdot 2$

$-4^2 + 24 \div 3 \cdot 2$	*There are no grouping symbols.*
$-16 + 24 \div 3 \cdot 2$	*Simplify powers. The exponent applies only to the 4.*
$-16 + 8 \cdot 2$	*Divide.*
$-16 + 16$	*Multiply.*
0	*Add.*

B $4\left[25 - (5-2)^2\right]$

$4\left[25 - (5-2)^2\right]$	*There are two sets of grouping symbols.*
$4\left[25 - 3^2\right]$	*Perform the operations in the innermost set.*
$4\left[25 - 9\right]$	*Simplify powers.*
$4 \cdot 16$	*Perform the operations inside the brackets.*
64	*Multiply.*

Helpful Hint

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

Please	**P**arentheses
Excuse	**E**xponents
My	**M**ultiply/
Dear	**D**ivide
Aunt	**A**dd/
Sally	**S**ubtract

CHECK IT OUT!

Simplify each expression.

1a. $8 \div \dfrac{1}{2} \cdot 3$ **1b.** $5.4 - 3^2 + 6.2$ **1c.** $-20 \div \left[-2(4+1)\right]$

Evaluating Algebraic Expressions

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

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

$21 - x + 2 \cdot 5$

$21 - 7 + 2 \cdot 5$ *First substitute 7 for x.*

$21 - 7 + 10$ *Multiply.*

$14 + 10$ *Subtract.*

24 *Add.*

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

$5^2(30 - x)$

$5^2(30 - 24)$ *First substitute 24 for x.*

$5^2(6)$ *Perform the operation inside the parentheses.*

$25(6)$ *Simplify powers.*

150 *Multiply.*

CHECK IT OUT! **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.

E X A M P L E **3** **Simplifying Expressions with Other Grouping Symbols**

Simplify each expression.

A $\dfrac{-22 - 2^2}{5 - 3}$

$\dfrac{(-22 - 2^2)}{(5 - 3)}$ *The fraction bar acts as a grouping symbol. Simplify the numerator and the denominator before dividing.*

$\dfrac{-22 - 4}{5 - 3}$ *Simplify the power in the numerator.*

$\dfrac{-26}{5 - 3}$ *Subtract to simplify the numerator.*

$\dfrac{-26}{2}$ *Subtract to simplify the denominator.*

-13 *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 $(2 + 3) \div (5 - 4)$.

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.*

CHECK IT OUT! **Simplify each expression.**

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

Translate each word phrase into a numerical or algebraic expression.

A one half times the difference of −5 and 3

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

B the square root of the quotient of −12 and n

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

> **Remember!**
>
> Look for words that imply mathematical operations.
>
> *difference* → subtract
> *sum* → add
> *product* → multiply
> *quotient* → divide

CHECK IT OUT! **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.

HANK AARON
1976 Statistics

Base Hits	Number
Single (S)	44
Double (D)	8
Triple (T)	0
Home run (H)	10

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

$$44 + 2(8) + 3(0) + 4(10)$$ *First substitute values for each variable.*

$$44 + 16 + 0 + 40$$ *Multiply.*

$$60 + 0 + 40$$ *Add from left to right.*

$$100$$ *Add.*

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

CHECK IT OUT! **5.** Another formula for a player's total number of bases is 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

1. Explain whether you always perform addition before subtraction when simplifying a numerical or algebraic expression.

2. **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.

$$20 - 3 + 2 \cdot 5$$

| 95 | 27 | −5 |

1-6 Exercises

go.hrw.com
Homework Help Online
KEYWORD: MA7 1-6
Parent Resources Online
KEYWORD: MA7 Parent
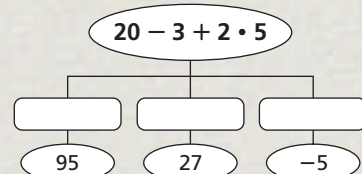
GUIDED PRACTICE

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

SEE EXAMPLE 1
p. 40

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. $16 + \left[5 - \left(3 + 2^2\right)\right]$

SEE EXAMPLE 2
p. 41

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. $12 + \left[20(5 - k)\right]$ for $k = 1$

SEE EXAMPLE 3
p. 41

Simplify each expression.

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

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

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

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

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

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

SEE EXAMPLE 4
p. 42

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 π and give your final answer rounded to the nearest tenth.)
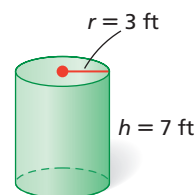
$r = 3$ ft

$h = 7$ ft

PRACTICE AND PROBLEM SOLVING

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. $13 - \left[3 + (j - 12)\right]$ for $j = 5$

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

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

38. $10 + \left[8 \div (q - 3)\right]$ 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. $\dfrac{8 - 8}{2 - 1}$

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

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

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

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

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.

$w = 4$ in.

$\ell = 8$ in.
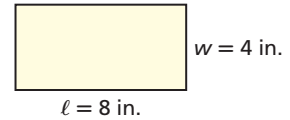
55. Simplify each expression.

   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 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.

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
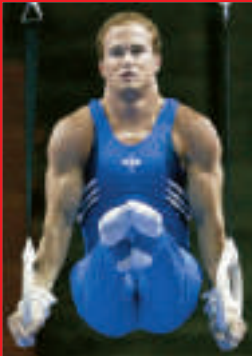
MULTI-STEP TEST PREP
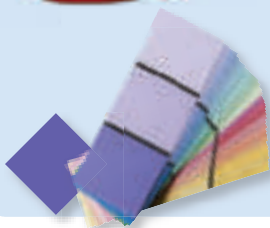
65. This problem will prepare you for the Multi-Step Test Prep on page 60.

   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.

   3 in.

   4 in.

   5 in.

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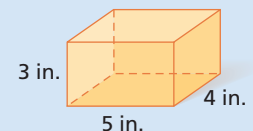
66. Geometry The area of a trapezoid is equal to the average of its bases times its height. Use the expression $\left(\frac{b_1 + b_2}{2}\right)h$ to determine the area of the trapezoid.

$b_1 = 4$ cm
$h = 6$ cm
$b_2 = 1$ cm
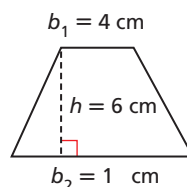
67. Write About It Many everyday processes must be done in a certain order to be completed successfully. Describe a process that requires several steps, and tell why the steps must be followed in a certain order.

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) $29 + 0.12(318)$

(B) $29 + 3 + 0.12 + 318$

(C) $29(3) + 0.12(318)$

(D) $3\big[9 + 0.12(318)\big]$

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 ft

(G) 28.4 ft

(H) 31.4 ft

(J) 51.4 ft

8 ft
6 ft
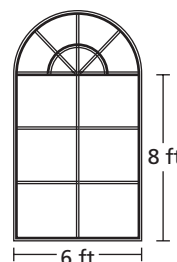
70. Gridded Response Evaluate $\sqrt{\dfrac{54 - (-2)(5)}{20 - 4^2}}$.

CHALLENGE AND EXTEND

Simplify each expression.

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

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

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

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)*

78.

79.

80.
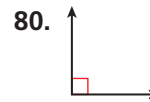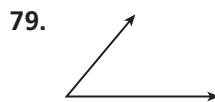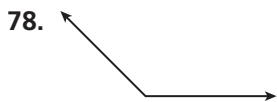
Add or subtract. *(Lesson 1-2)*

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. $\sqrt{\dfrac{36}{49}}$

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.

Know It! Note

Properties of Addition and Multiplication

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

E X A M P L E **1** **Using the Commutative and Associative Properties**

Simplify each expression.

A $4 \cdot 9 \cdot 25$
$\quad 9 \cdot 4 \cdot 25$ *Use the Commutative Property.*
$\quad 9 \cdot (4 \cdot 25)$ *Use the Associative Property to make groups of compatible numbers.*
$\quad\quad 9 \cdot 100$
$\quad\quad\quad 900$

Helpful Hint

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

B $25 + 48 + 75$
$\quad 25 + 75 + 48$ *Use the Commutative Property.*
$\quad (25 + 75) + 48$ *Use the Associative Property to make groups of compatible numbers.*
$\quad\quad 100 + 48$
$\quad\quad\quad 148$

CHECK IT OUT! Simplify each expression.

1a. $15\frac{1}{3} + 4 + 1\frac{2}{3}$ **1b.** $410 + 58 + 90 + 2$ **1c.** $\frac{1}{2} \cdot 7 \cdot 8$
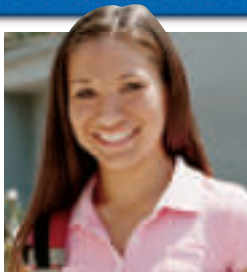
The Distributive Property is used with addition to simplify expressions.

Know it! Note

Distributive Property

WORDS	NUMBERS	ALGEBRA
You can multiply a number by a sum or multiply by each number in the sum 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.

E X A M P L E 2 **Using the Distributive Property with Mental Math**

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 *Add.*

Helpful Hint

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

CHECK IT OUT! 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.

Like terms   Constant

$4x - 3x + 2$

A **coefficient** is a number 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.

$$7x^2 - 4x^2 = (7 - 4)x^2 \qquad \textit{Factor out } x^2 \textit{ from both terms.}$$
$$= (3)x^2 \qquad \textit{Perform operations in parentheses.}$$
$$= 3x^2$$

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.*

> **Caution!**
> Add or subtract only the coefficients.
> $6.8y^2 - y^2 \neq 6.8$

B $6.8y^2 - y^2$

$6.8y^2 - y^2$ *A variable without a coefficient has a coefficient of 1.*

$6.8y^2 - \mathbf{1}y^2$ *$6.8y^2$ and $1y^2$ are like terms.*

$5.8y^2$ *Subtract the coefficients.*

C $4n + 11n^2$

$4n + 11n^2$ *4n and 11n² are not like terms.*

$4n + 11n^2$ *Do not combine the terms.*

CHECK IT OUT! 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
5.	$(2x + 3x) + 12$	Associative Property
6.	$5x + 12$	Combine like terms.

CHECK IT OUT! 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.

Associati e   Commutati e   Distributi e

1-7 Exercises
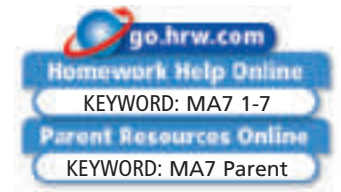
GUIDED PRACTICE

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

SEE EXAMPLE **1**
p. 46

Simplify each expression.

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**
p. 47

Write each product using the Distributive Property. Then simplify.

8. $14(1002)$ **9.** $16(19)$ **10.** $9(38)$

11. $8(57)$ **12.** $12(112)$ **13.** $7(109)$

SEE EXAMPLE **3**
p. 48

Simplify each expression by combining like terms.

14. $6x + 10x$ **15.** $35x - 15x$ **16.** $-3a + 9a$

17. $-8r - r$ **18.** $17x^2 + x$ **19.** $3.2x + 4.7x$

SEE EXAMPLE **4**
p. 48

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

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.** $6(53)$

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

a. Find the total time for each athlete. (*Hint:* 1 minute = 60 seconds)

b. 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. $x - 2 = -2 + x$
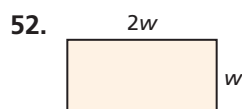
48. $2 + (3 + y) = (2 + 3) + y$

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.

52.

2w

w

53.

4p

8 − p

3p + 1

54.

2s + 3

2s + 3
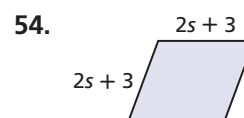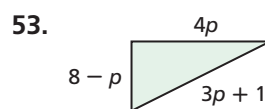
55. Critical Thinking Evaluate $a - (b - c)$ and $(a - b) - c$ for $a = 10$, $b = 7$, and $c = 3$. Based on your answers, explain whether there is an Associative Property of Subtraction.

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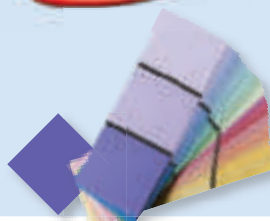
57. This problem will prepare you for the Multi-Step Test Prep on page 60.

a. The diagram shows a pattern of shapes that can be folded to make a cylinder. How is the length ℓ of the rectangle related to the circumference of (distance around) each circle?

b. An expression for the circumference of each circle is $2\pi r$. Write an expression for the area of the rectangle.

c. Use these expressions to write an expression for the total area of the figures. Leave the symbol π in your expression.
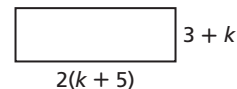

4 cm

12 cm

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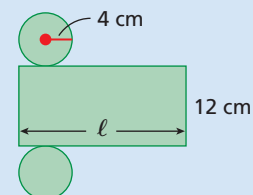
58. Ariel has 19 more CDs than her sister Tiffany has. Victor has 3 times as many CDs as Ariel has. Which expression can be used to show how many CDs the three have in total?

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

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

    Ⓕ $16k$ Ⓗ $3k + 13$

    Ⓖ $32k$ Ⓙ $6k + 26$

$3 + k$

$2(k + 5)$

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

    Ⓐ $(25 + 18) + 33 = 25 + (18 + 33)$ Ⓒ $33 \cdot 25 + 33 \cdot 18 = 33 \cdot (25 + 18)$

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

CHALLENGE AND EXTEND

Simplify.

61. $4\big[3\,(x + 9\,) + 2\big]$

62. $-3\big[(x - 2) + 5\,(x - 2)\big]$

63. $(2b + 5) - (8b + 6) + 3\,(b - 2)$

64. $\frac{1}{2}\big[(10 - g) + (-6 + 3g)\big]$

65. Fill in the missing justifications.

Procedure	Justification
$11e - 7 - 3e = 11e + (-7) + (-3)\,e$	Definition of subtraction
$= 11e + (-3)\,e + (-7)$	**a.** _____?_____
$= \big[11e + (-3)\,e\big] + (-7)$	**b.** _____?_____
$= \big[11 + (-3)\big]e + (-7)$	**c.** _____?_____
$= 8e + (-7)$	**d.** _____?_____
$= 8e - 7$	Definition of subtraction

66. Fill in the missing justifications.

Procedure	Justification
$\frac{a + b}{c} = \frac{1}{c}\,(a + b)$	Definition of division
$= \frac{1}{c}\,(a) + \frac{1}{c}\,(b)$	**a.** _____?_____
$= \frac{a}{c} + \frac{b}{c}$	**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

Evaluate 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.** $\dfrac{8^2 - 6^2}{8^2 + 6^2}$ **75.** $2 - \big[6 - 8 \div (3 + 1)\big]$

Geometry

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.

See Skills Bank page S60

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.**
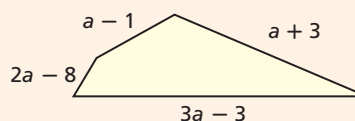
Add the lengths of the four sides.

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

Combine like terms to simplify.

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

$$= 7a - 9 \qquad \text{\textit{This is a general expression for the perimeter.}}$$

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

Substitute 5 for a.

$$P = 7(5) - 9 \qquad \text{\textit{Multiply; then subtract.}}$$

$$= 35 - 9$$

$$= 26 \qquad \text{\textit{This is the perimeter when } a = 5.}$$

Try This

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

1.
$x + 2$
$3x$
$2x + 1$

2. $b + 1$, $b - 1$, $2b$, $b + 3$

3. $m + 1$, $2m - 1$
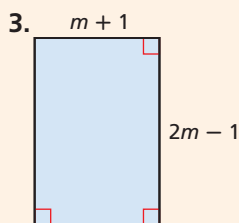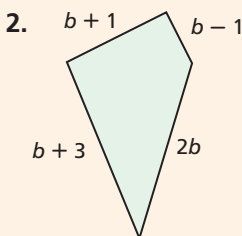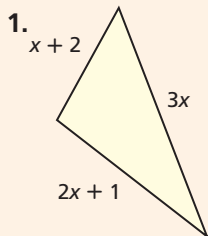
Find the perimeter of each figure for the given value of the variable.

4. $k = 3$
$k - 2$
$k - 1$
$k + 1$
$k - 1$
$k - 2$

5. $n = 10$
$3n - 1$
n
$3n - 1$

6. $y = 4$
$2y - 1$
$y + 1$
$y + 1$
$y + 1$
$y + 1$
$2y - 1$
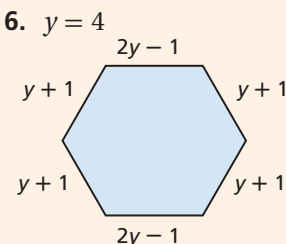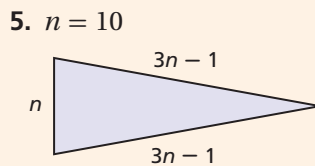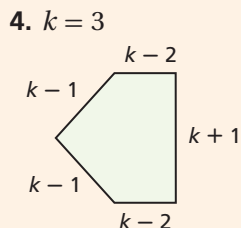
Combining like terms is one way to explore what happens to the perimeter when you double the sides of a triangle or other polygon.

Example 2

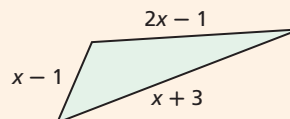**What happens to the perimeter of this triangle when you double the length of each side?**

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

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

$$(x + 2x + x) + (-1 - 1 + 3)$$
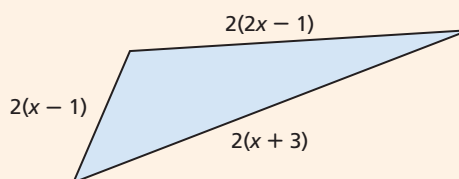
$4x + 1$ *Perimeter of small triangle*

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 Property 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.

11. Use the triangles in Example 2. Find the side lengths and perimeters for $x = 5$.

12. 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.

13. 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.
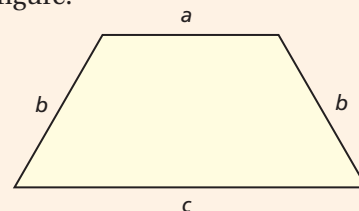
Objectives
Graph ordered pairs in the coordinate plane.

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.
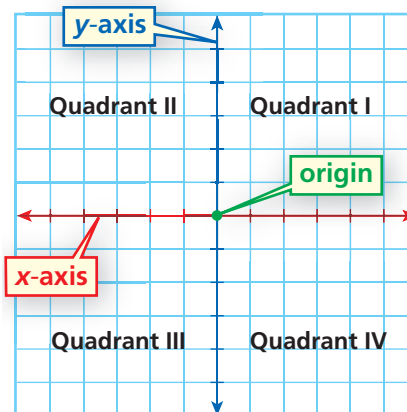
EXAMPLE **1** **Graphing Points in the Coordinate Plane**
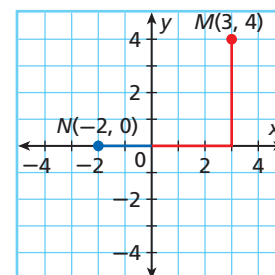
Graph each point.

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.

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.

CHECK IT OUT! 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**
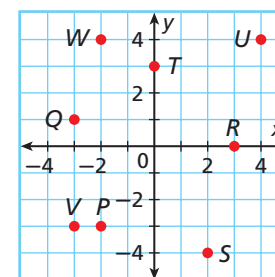
Name the quadrant in which each point lies.

A P
Quadrant III

B Q
Quadrant II

C R
no quadrant (*x*-axis)

D S
Quadrant IV

CHECK IT OUT! 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.

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	+	10	$\cdot$	x

$y = 5 + 10x$

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.

Number of People in Picture	Rule	Charges	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)

CHECK IT OUT!

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. Find the fee when there are 1, 2, 3, and 4 people.
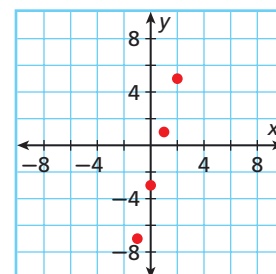
When you graph ordered pairs generated by a function, they may create a pattern.

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

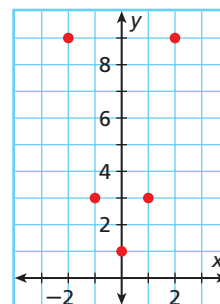| Input	Output	Ordered Pair
x	y	(x, y)
−1	$4(-1) - 3 = -7$	$(-1, -7)$
0	$4(0) - 3 = -3$	$(0, -3)$
1	$4(1) - 3 = 1$	$(1, 1)$
2	$4(2) - 3 = 5$	$(2, 5)$

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	$|-1 + 3| = |2| = 2$	$(-1, 2)$
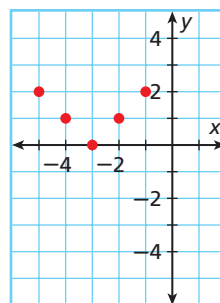
The points form a V shape.

CHECK IT OUT! 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

1. Describe how to graph the ordered pair $(-3, 6)$.

2. 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	Quadrant I
x is ? .	x is ? .
y is ? . The Coordinate Plane	y is ? .
x is ? .	x is ? .
y is ? .	y is ? .
Quadrant III	Quadrant IV

Know it! Note

1-8

Exercises

go.hrw.com
Homework Help Online
KEYWORD: MA7 1-8
Parent Resources Online
KEYWORD: MA7 Parent

GUIDED PRACTICE

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

SEE EXAMPLE 1
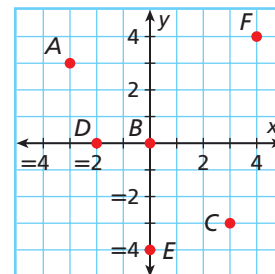p. 54

Graph each point.

2. $J(4, 5)$ **3.** $K(-3, 2)$ **4.** $L(6, 0)$ **5.** $M(1, -7)$

SEE EXAMPLE 2
p. 54

Name the quadrant in which each point lies.

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
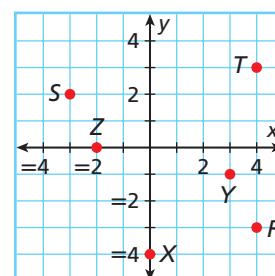Application Practice p. S28

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.**
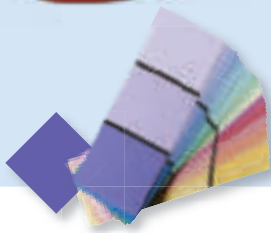
32. $(-1, 1), (4, 1), (4, -4), (-1, -4)$ **33.** $(-6, 3), (2, -2), (-7, -3)$

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. 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.

    b. Which variable is the input and which variable is the output?

    c. Make a table showing the cost of 1, 2, 3, 4, and 5 yards of fabric.

    d. 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; $x = -2, -1, 0, 1,$ and 2.

39. y is equal to the sum of one half of x and -3; $x = -4, -2, 0, 2,$ and 4.

40. y is equal to the sum of x squared and 1; $x = -5, -3, -1, 1, 3,$ 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.

    a. Write an equation for the number of water bottles the planner should buy.

    b. 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.

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?
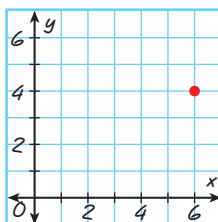
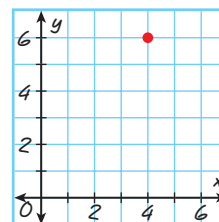**47.** **Write About It** Graph the point $(4, 2)$.

    a. How is graphing the point $(4, 2)$ different from graphing the point $(2, 4)$?

    b. 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.

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 $(6, 9)$?

    (A) $y = 9 - x$ (B) $y = \frac{3}{2}x^2 + 1$ (C) $y = \frac{1}{2}x + 6$ (D) $y = x + 5$

51. Which table of ordered pairs is generated when the values 1, 2, 3, and 4 are substituted for x in the equation $y = 2x - 4$?

(F)

x	y
1	−3
2	−2
3	−1
4	0

(G)

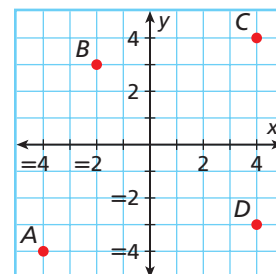| x	y
1	−2
2	0
3	2
4	4

(H)

x	y
1	−2
2	0
3	1
4	2

(J)

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) A   (C) C

    (B) B   (D) D

53. Which ordered pair describes the point $(2, 5)$ shifted 3 units right and 2 units down?

    (F) $(0, 8)$ (H) $(5, 3)$

    (G) $(2, 3)$ (J) $(5, 5)$

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)*

62.   **63.**   **64.**   **65.**
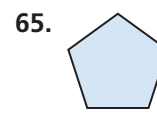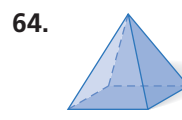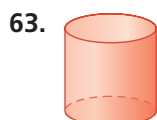
Classify each real number. Write all classifications that apply. *(Lesson 1-5)*

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.** $2a - b + a + 4b$

MULTI-STEP TEST PREP

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 it with yellow fabric on the top and the side. 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 π.

1 ft

2 ft
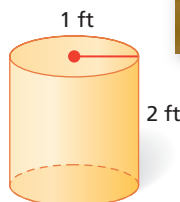
4. Lori will fill a vase with multicolored beads and place it on the bedside table. The vase is in the approximate shape of a cone. The height of the vase is 10 inches, and the radius of the vase at the top is 3 inches. Find the volume of the vase. Use 3.14 for π. (*Hint:* The formula for the volume 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.)

3 in.

1 in.

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?

READY To Go On?
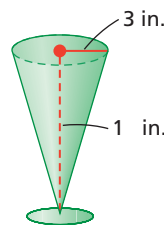
Quiz for Lessons 1-6 Through 1-8

✔ 1-6 Order of Operations

Simplify each expression.

1. $-6 + 12 \div (-3)$

2. $30 - 9 + 4$

3. $(6 - 8) \cdot (7 - 5)$
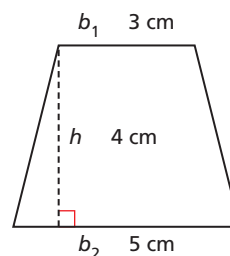
4. $8 \cdot \left[8 - (4 - 2)\right]$

5. $\dfrac{23 - 3 \cdot 5}{4}$

6. $|3 - 9| \div 2 + 5$

Translate each word phrase into a numerical expression.

7. the quotient of 16 and the difference of 9 and -7

8. the product of 5 and the sum of 6 and 4

9. The area of a trapezoid can be found using the expression $\frac{1}{2}\left(b_1 + b_2\right)h$. Find the area of the trapezoid shown.

✔ 1-7 Simplifying Expressions

Simplify each expression.

10. $75 + 32 + 25$

11. $5 \cdot 18 \cdot 20$

12. $\dfrac{1}{4} \cdot 19 \cdot 8$

Write each product using the Distributive Property. Then simplify.

13. $7(67)$

14. $9(29)$

15. $17(18)$

16. $8(106)$

Simplify each expression.

17. $4k + 15k$

18. $x^2 + 22x^2$

19. $-2g + 5g$

Simplify each expression. Justify each step.

20. $3(x + 2) - 3x$

21. $x - 6x^2 + 3x + 4x^2$

22. $-2(3x + 2y + 4x - 5y)$

✔ 1-8 Introduction to Functions

Graph each point.

23. $A(0, -3)$

24. $B(-2, -3)$

25. $C(1, 4)$

Name the quadrant in which each point lies.
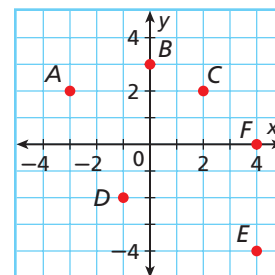
26. A

27. B

28. C

29. D

30. E

31. F

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

32. $y = x^2 + 1$

33. $y = x - 1$

34. $y = -|x|$

35. $y = 3x + 3$

36. 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. Find the amount of water in the pool when 30 minutes have gone by.

Study Guide: Review

Vocabulary

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.**

$65 - d$ *Think: d dollars less than the price of the sweater.*

■ **Evaluate $b - a$ for $a = 7$ and $b = 15$.**

$b - a = 15 - 7$ *Substitute the values for*
$\quad\quad = 8$ *the variables.*

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 **8.** $p \div q$ **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.*

- $-8 - (-3)$

  $-8 - (-3)$

  $-8 + 3$ *To subtract -3, add 3.*

  -5

EXERCISES

Add or subtract.

11. $-2 + (-12)$ **12.** $-6 + 1.4$ **13.** $9\frac{1}{4} + \left(-4\frac{3}{4}\right)$

14. $\frac{1}{2} - \frac{3}{2}$ **15.** $-8 - 16$ **16.** $6.7 - (-7.6)$

17. $3\frac{1}{3} - x$ when $x = -1\frac{2}{3}$

18. 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.

- $-12(9)$

  $-12(9) = -108$

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

  $-\frac{5}{6} \div \left(-\frac{3}{4}\right) = -\frac{5}{6}\left(-\frac{4}{3}\right)$

  $= \frac{(-5)(-4)}{6(3)}$

  $= \frac{20}{18} = \frac{10}{9}$

EXERCISES

Multiply or divide if possible.

19. $-5(-18)$ **20.** $0 \cdot 10$ **21.** $-4(3.8)$

22. $-56 \div 7$ **23.** $0 \div 0.75$ **24.** $9 \div 0$

Divide.

25. $4 \div \frac{4}{9}$ **26.** $-\frac{1}{2} \div \frac{3}{4}$ **27.** $\frac{6}{7} \div \frac{2}{5}$

28. 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.

29. 4^3 **30.** $(-3)^3$ **31.** $(-3)^4$

32. -5^2 **33.** $\left(\frac{2}{3}\right)^3$ **34.** $\left(-\frac{4}{5}\right)^2$

Write each number as a power of the given base.

35. 16; base 2   **36.** -1000; base -10

37. 64; base -8 **38.** 12; base 12

39. 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 Square Roots and Real Numbers (pp. 32–37)

EXAMPLES

Find each square root.

■ $-\sqrt{64}$ ■ $\sqrt{\dfrac{16}{81}}$

$8^2 = 64$ $\left(\dfrac{4}{9}\right)^2 = \dfrac{4}{9} \cdot \dfrac{4}{9} = \dfrac{16}{81}$

$-\sqrt{64} = -8$ $\sqrt{\dfrac{16}{81}} = \dfrac{4}{9}$

■ **Classify -7. Write all classifications that apply.**

$-7 = \dfrac{-7}{1} = -7.0$

rational number, terminating decimal, integer

EXERCISES

Find each square root.

40. $\sqrt{36}$ **41.** $\sqrt{196}$ **42.** $-\sqrt{49}$

43. $-\sqrt{144}$ **44.** $\sqrt{\dfrac{25}{36}}$ **45.** $\sqrt{\dfrac{1}{169}}$

Classify each real number. Write all the classifications that apply.

46. 21   **47.** 0   **48.** -13

49. 0.8   **50.** $\sqrt{3}$ **51.** $\dfrac{5}{6}$

52. 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 $18 - 3\left(\dfrac{15-7}{4}\right)^2$.**

$18 - 3\left(\dfrac{15-7}{4}\right)^2$

$18 - 3\left(\dfrac{8}{4}\right)^2$ *Simplify the numerator.*

$18 - 3(2)^2$ *Simplify inside parentheses.*

$18 - 3 \cdot 4$ *Evaluate powers.*

$18 - 12$ *Multiply.*

6 *Subtract.*

■ **Evaluate $-5\sqrt{40-x} + 12$ for $x = 4$.**

$-5\sqrt{40-4} + 12$ *Substitute the value for x.*

$-5\sqrt{36} + 12$ *Simplify inside the square root symbol.*

$-5(6) + 12$ *Evaluate the square root.*

$-30 + 12$ *Multiply.*

-18 *Add.*

EXERCISES

Simplify each expression.

53. $5 \cdot 4 + 3$ **54.** $17 + 3(-3)$

55. $[8 + (2-6)^2] \div 4$ **56.** $\dfrac{4^2 - 11}{10}$

57. $|12 - 3 \cdot 7| \cdot (-2)$ **58.** $\sqrt{4 \cdot 5 + 5} - 5$

Evaluate each expression for the given value of x.

59. $48 - x + 29$ for $x = 15$

60. $x + 4 \cdot 6 - 10$ for $x = -4$

61. $8(x - 8)^3$ for $x = 9$

62. $[(3-x)^2 + 4] \div 2$ for $x = 7$

Translate each word phrase into a numerical or algebraic expression.

63. the sum of 8 and the product of 7 and -2

64. the quotient of 12 and the sum of 8 and 3

65. 4 times the square root of x less than 20

66. 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. (*Note: This expression neglects air resistance.*)

1-7 Simplifying Expressions (pp. 46–51)

EXAMPLES

Simplify each expression.

- $-6f^2 - 8f + 3f^2$

  $-6f^2 + 3f^2 - 8f$ *Commutative Property*

  $-3f^2 - 8f$ *Combine like terms.*

- $3x - 4y$

  $3x - 4y$ *There are no like terms.*

             It cannot be simplified.

- $5x^2 - 3(x - 2) - x$

  $5x^2 - 3x - 3(-2) - x$ *Distributive Property*

  $5x^2 - 3x + 6 - x$ *Multiply.*

  $5x^2 - 3x - x + 6$ *Commutative Property*

  $5x^2 - 4x + 6$ *Combine like terms.*

EXERCISES

Simplify each expression.

67. $18 + 26 - 8 + 4$ **68.** $60 \cdot 27 \cdot \dfrac{1}{6}$

Write each product using the Distributive Property. Then simplify.

69. $13(103)$ **70.** $18(99)$

Simplify each expression.

71. $20x - 16x$ **72.** $2y^2 + 5y^2$

73. $6(x + 4) - 2x$ **74.** $-2(x^2 - 1) + 4x^2$

75. $-2y + 3y^2 - 3y + y$ **76.** $7y + 3y - a - 2y$

77. 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	$0 + 2 = 2$	$(0, 2)$
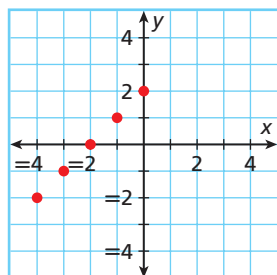
The points form a straight line.

EXERCISES

Graph each point.

78. $A(2, 3)$ **79.** $B(-1, 4)$

80. $C(0, 8)$ **81.** $D(5, -3)$

Name the quadrant in which each point lies.
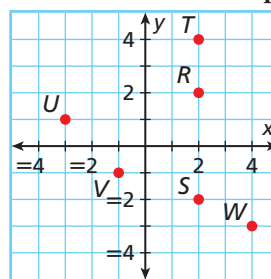
82. R

83. S

84. T

85. U

86. V

87. W

88. 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. Find the price with tax of items that cost $2, $15, $30, and $40.

89. Generate ordered pairs for the function $y = \frac{1}{4}x^2$ for $x = -4, -1, 0, 1,$ and 4. Graph the ordered pairs and describe the pattern.

CHAPTER TEST

Evaluate each expression for $a = 2$, $b = 3$, and $c = 6$.

1. $c - a$ 　　　　**2.** ab 　　　　**3.** $c \div a$ 　　　　**4.** $\dfrac{c}{b}$ 　　　　**5.** $b - a$

6. Write two verbal expressions for $n - 5$.

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.** $7 - x$ for $x = -2$

The table shows the lowest temperatures recorded in four states.

12. What is the difference between the lowest temperatures in Alaska and Hawaii?

13. What is the difference between the lowest temperatures in Nebraska and Texas?

Lowest Temperatures in Four States	
Location	Temperature (°F)
Prospect Creek, Alaska	−80
Camp Clarke, Nebraska	−47
Mauna Kea, Hawaii	12
Seminole, Texas	−23

Multiply or divide if possible.

14. $(-3)(-6)$ 　　　　**15.** $-\dfrac{1}{2} \div \dfrac{1}{4}$ 　　　　**16.** $12 \div (-3)$ 　　　　**17.** $x \div -4$ for $x = 0$

Simplify each expression.

18. 5^4 　　　　**19.** $\left(-\dfrac{4}{5}\right)^3$ 　　　　**20.** 2^5 　　　　**21.** -6^2

Classify each real number. Write all classifications that apply.

22. 30 　　　　**23.** $\sqrt{6}$ 　　　　**24.** -12 　　　　**25.** $\dfrac{1}{2}$

Evaluate each expression for the given value of x.

26. $\dfrac{-2 - 6}{x^2}$ for $x = 2$ 　　　　**27.** $8(x - 1)^2$ for $x = 11$ 　　　　**28.** $22 + \left[-2(19 - x)\right]$ 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. $5\dfrac{1}{4} + 7 + 2\dfrac{3}{4}$ 　　　　**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 a 3-hour test that 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.

You may want to time yourself as you take this practice test. It should take you about 8 minutes to complete.

HOT TIP!

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.

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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) 51

(B) 27

(C) 123

(D) 36

(E) 23

---

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) $3j > j$

(B) $3j$

(C) $j + 3$

(D) $3 - j$

(E) $\frac{1}{3}j$

---

4. Which of the following is equal to -3^4?

(A) -64

(B) 12

(C) -12

(D) 81

(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) $-\left(-\frac{2}{3} + 7\right)n$

(D) $-\left(\frac{n-2}{3} + 7\right)$

(E) $n - \frac{2}{3} + 7(-1)$

---

6. Which property is illustrated by the equation $8(7) + 8(6) = 8(7+6)$?

(A) Distributive Property

(B) Associative Property of Multiplication

(C) Commutative Property of Addition

(D) Commutative Property of Multiplication

(E) Associative Property of Addition

TEST TACKLER

Standardized Test Strategies

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		

$$12^2 - 3(10 + 4)$$
$$12^2 - 3(14)$$
$$144 - 3(14)$$
$$144 - 42$$
$$102$$

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		

$$ba \div c$$
$$(-7)(2) \div (-6)$$
$$-14 \div (-6)$$
$$\frac{7}{3} = 2\frac{1}{3} = 2.\overline{3}$$

The expression simplifies to $\frac{7}{3}$, $2\frac{1}{3}$, or $2.\overline{3}$.

- 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.

1. What error did the student make when filling out 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.

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.

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.

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, CHAPTER 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) $-45°C$ (H) $-25°C$

(G) $-39.2°C$ (J) $-10.6°C$

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) 16π in^3

(G) $\frac{64\pi}{3}$ in^3

(H) $\frac{256\pi}{3}$ in^3

(J) $\frac{4096\pi}{3}$ in^3

7. Which of the following real numbers is a terminating decimal?

(A) π

(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

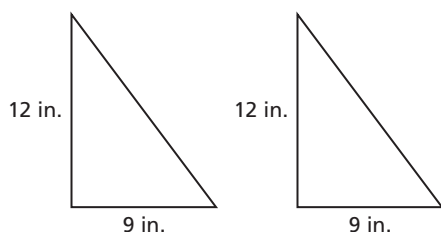(H) 27.32 pesos

(J) 181.12 pesos

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.

12 in.   12 in.

9 in.   9 in.

What was the area of the rectangle?

- **F** 42 in.
- **G** 54 in^2
- **H** 72 in.
- **J** 108 in^2

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 πr^2. What is the area in square meters of the robot sumo-wrestling ring shown below? Use 3.14 for π. Round to the nearest tenth.

0.76 m
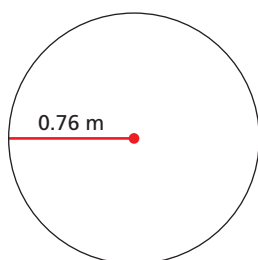
Short Response

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.
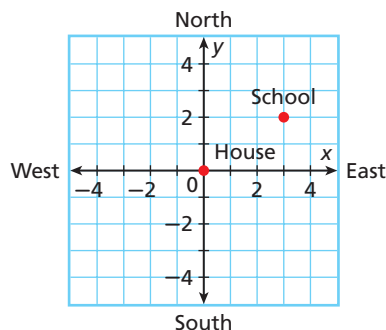
a. Write an ordered pair to show where Dee plotted the point for her school.

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 an expression 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?