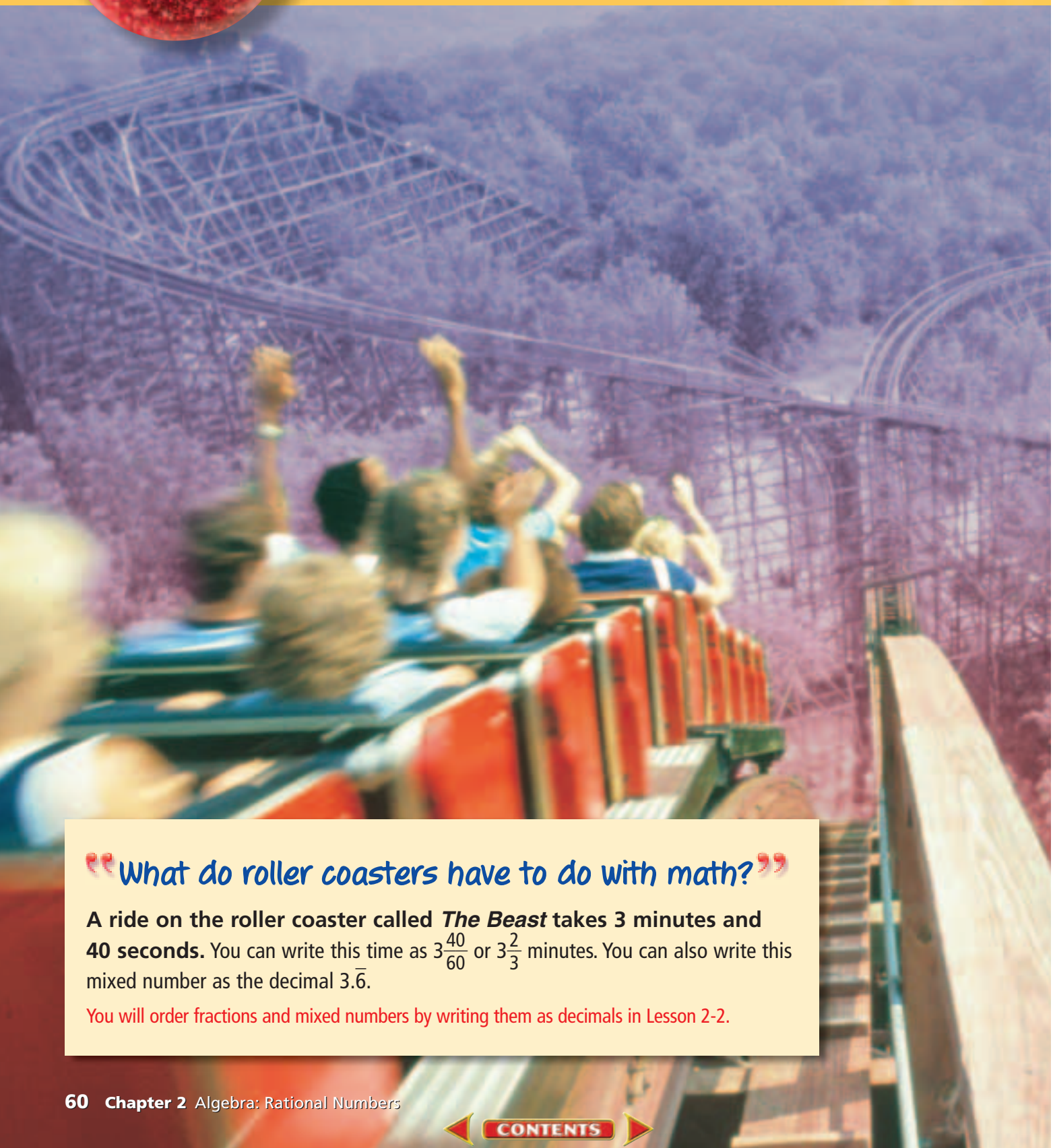
CHAPTER 2

Algebra: Rational Numbers

Courtesy Paramount's Kings Island, 60–61



"What do roller coasters have to do with math?"

A ride on the roller coaster called *The Beast* takes 3 minutes and 40 seconds. You can write this time as $3\frac{40}{60}$ or $3\frac{2}{3}$ minutes. You can also write this mixed number as the decimal $3.\overline{6}$.

You will order fractions and mixed numbers by writing them as decimals in Lesson 2-2.

GETTING STARTED

Diagnose Readiness

Take this quiz to see if you are ready to begin Chapter 2. Refer to the lesson or page number in parentheses for review.

Vocabulary Review

Complete each sentence.

1. Two numbers with the same absolute value but different signs are called ___?___ or ___?___ ___?___. (Lesson 1-4)
2. The value of a variable that makes an equation true is called the ___?___ of the equation. (Lesson 1-8)

Prerequisite Skills

Add. (Lesson 1-4)

3. $-13 + 4$
4. $28 + (-9)$
5. $-18 + 21$
6. $4 + (-16)$

Subtract. (Lesson 1-5)

7. $-8 - 6$
8. $23 - (-15)$
9. $-17 - 11$
10. $-5 - (-10)$

Multiply or divide. (Lesson 1-6)

11. $6(-14)$
12. $36 \div (-4)$
13. $-86 \div (-2)$
14. $-3(-9)$

Solve each equation. (Lessons 1-8 and 1-9)

15. $-12x = 144$
16. $a + 9 = 37$
17. $-18 = y - 42$
18. $25 = \frac{n}{5}$

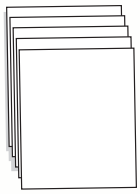
Find the least common multiple (LCM) of each set of numbers. (Page 612)

19. 10, 5, 6
20. 3, 7, 9
21. 12, 16
22. 24, 9

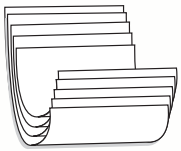
FOLDABLES Study Organizer

Rational Numbers Make this Foldable to organize your notes. Begin with five sheets of $8\frac{1}{2}$" by 11" paper.

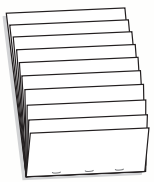
STEP 1 **Stack Pages**
Place 5 sheets of paper $\frac{3}{4}$ inch apart.



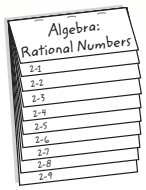
STEP 2 **Roll Up Bottom Edges**
All tabs should be the same size.



STEP 3 **Crease and Staple**
Staple along the fold.



STEP 4 **Label**
Label the tabs with the lesson numbers.



Noteables™ **Chapter Notes** Each time you find this logo throughout the chapter, use your *Noteables™: Interactive Study Notebook with Foldables™* or your own notebook to take notes. Begin your chapter notes with this Foldable activity.

Math Online **Readiness** To prepare yourself for this chapter with another quiz, visit **msmath3.net/chapter_readiness**

2-1 Fractions and Decimals

What You'll LEARN

Express rational numbers as decimals and decimals as fractions.

NEW Vocabulary

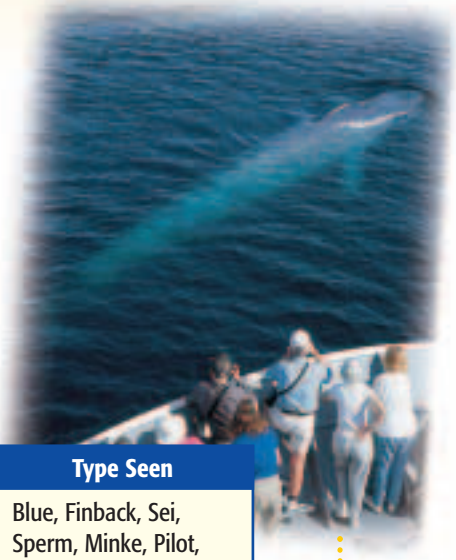
rational number
terminating decimal
repeating decimal
bar notation

Link to READING

Everyday Meaning of Terminate: to bring to an end

WHEN am I ever going to use this?

WHALE WATCHING The top ten places in the Northern Hemisphere to watch whales are listed below.



Viewing Site	Location	Type Seen
Sea of Cortez	Baja California, Mexico	Blue, Finback, Sei, Sperm, Minke, Pilot, Orca, Humpback, Gray
Dana Point	California	Gray
Monterey Bay	California	Gray
San Ignacio Lagoon	Baja California, Mexico	Gray
Churchill River Estuary	Manitoba, Canada	Beluga
Stellwagen Bank National Marine Sanctuary	Massachusetts	Humpback, Finback, Minke
Lahaina	Hawaii	Humpback
Silver Bank	Dominican Republic	Humpback
Mingan Island	Quebec, Canada	Blue
Friday Harbor	Washington	Orca, Minke

1. What fraction of the sites are in the United States?
2. What fraction of the sites are in Canada?
3. At what fraction of the sites might you see gray whales?
4. What fraction of the humpback viewing sites are in Mexico?

Numbers such as $\frac{1}{2}$, $\frac{1}{5}$, $\frac{2}{5}$, and $\frac{1}{10}$ are called **rational numbers**.

Noteables™ Key Concept: Rational Numbers

Words A rational number is any number that can be expressed in the form $\frac{a}{b}$, where a and b are integers and $b \neq 0$.

READING in the Content Area

For strategies in reading this lesson, visit **msmath3.net/reading**.

Since -7 can be written as $\frac{-7}{1}$ and $2\frac{2}{3}$ can be written as $\frac{8}{3}$, -7 and $2\frac{2}{3}$ are rational numbers. All integers, fractions, and mixed numbers are rational numbers.

Bud Lehnhausen/Photo Researchers

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Any fraction can be expressed as a decimal by dividing the numerator by the denominator.

EXAMPLE Write a Fraction as a Decimal

1 **Write $\frac{5}{8}$ as a decimal.**

$\frac{5}{8}$ means $5 \div 8$.

$$\begin{array}{r} 0.625 \\ 8\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \\ 0 \end{array}$$

Add a decimal point and zeros to the dividend: $5 = 5.000$

Division ends when the remainder is 0.

You can also use a calculator. 5 ÷ 8 ENTER **0.625**

The fraction $\frac{5}{8}$ can be written as 0.625.

A decimal like 0.625 is called a **terminating decimal** because the division ends, or terminates, when the remainder is 0.

EXAMPLE Write a Mixed Number as a Decimal

2 **Write $1\frac{2}{3}$ as a decimal.**

$1\frac{2}{3}$ means $1 + \frac{2}{3}$. To change $\frac{2}{3}$ to a decimal, divide 2 by 3.

$$\begin{array}{r} 0.666\ldots \\ 3\overline{)2.000} \\ \underline{1\,8} \\ 20 \\ \underline{18} \\ 20 \\ \underline{18} \\ 2 \end{array}$$

The three dots means the six keeps repeating.

The remainder after each step is 2.

You can also use a calculator. 2 ÷ 3 ENTER **0.666666667**

The mixed number $1\frac{2}{3}$ can be written as $1 + 0.666\ldots$ or $1.666\ldots$.

Your Turn **Write each fraction or mixed number as a decimal.**

a. $\frac{3}{4}$ **b.** $-\frac{3}{5}$ **c.** $2\frac{1}{9}$ **d.** $5\frac{1}{6}$

A decimal like 1.666... is called a **repeating decimal**. Since it is not possible to write all of the digits, you can use **bar notation** to show that the 6 repeats.

$$1.666\ldots = 1.\overline{6}$$

STUDY TIP

Mental Math It is helpful to memorize these commonly used fraction-decimal equivalencies.

$\frac{1}{2} = 0.5$ $\frac{1}{3} = 0.\overline{3}$

$\frac{1}{4} = 0.25$ $\frac{1}{5} = 0.2$

$\frac{1}{8} = 0.125$

$\frac{1}{10} = 0.1$

STUDY TIP

Bar Notation The bar is placed above the repeating part. To write 8.636363... in bar notation, write $8.\overline{63}$, not $8.\overline{6}$ or $8.\overline{636}$. To write 0.3444... in bar notation, write $0.3\overline{4}$, not $0.\overline{34}$.

REAL LIFE CAREERS

How Does a Sports Statistician Use Math?

A baseball statistician uses decimal equivalents to determine batting averages and winning averages. A batting average is the number of hits divided by the number of times at bat.

Research

For information about a career as a sports statistician, visit: msmath3.net/careers

Repeating decimals often occur in real-life situations. However, they are usually rounded to a certain place-value position.

EXAMPLE Round a Repeating Decimal

3 **BASEBALL** **In a recent season, Kansas City pitcher Kris Wilson won 6 of the 11 games he started. To the nearest thousandth, find his winning average.**

To find his winning average, divide the number of wins, 6, by the number of games, 11.

6 ÷ 11 ENTER 0.5454545

Look at the digit to the right of the thousandths place. Round down since $4 < 5$.

Kris Wilson's winning average was 0.545.

Terminating and repeating decimals are also rational numbers because you can write them as fractions.

EXAMPLE Write a Terminating Decimal as a Fraction

4 **Write 0.45 as a fraction.**

$$0.45 = \frac{45}{100}$$ 0.45 is 45 hundredths.

$$= \frac{9}{20}$$ Simplify. Divide by the greatest common factor of 45 and 100, 5.

The decimal 0.45 can be written as $\frac{9}{20}$.

You can use algebra to change repeating decimals to fractions.

READING Math

Repeating Decimals
Read $0.\overline{5}$ as *point five repeating*.

EXAMPLE Write a Repeating Decimal as a Fraction

5 **ALGEBRA** **Write $0.\overline{5}$ as a fraction in simplest form.**

Let $N = 0.\overline{5}$ or 0.555... . Then $10N = 5.555...$.

Multiply N by 10 because 1 digit repeats.

Subtract $N = 0.555...$ to eliminate the repeating part, 0.555... .

$10N = 5.555...$

$-1N = 0.555...$ $N = 1N$

$9N = 5$ $10N - 1N = 9N$

$\frac{9N}{9} = \frac{5}{9}$ Divide each side by 9.

$N = \frac{5}{9}$ Simplify.

The decimal $0.\overline{5}$ can be written as $\frac{5}{9}$.

Your Turn **Write each decimal as a fraction or mixed number in simplest form.**

e. -0.14 **f.** 8.75 **g.** $0.\overline{3}$ **h.** $-1.\overline{4}$

Aaron Haupt

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Skill and Concept Check

1. **OPEN ENDED** Give an example of a repeating decimal where two digits repeat. Explain why your number is a rational number.

2. **Write** 5.321321321... using bar notation.

3. **Which One Doesn't Belong?** Identify the fraction that cannot be expressed as the same type of decimal as the other three. Explain.

$\frac{4}{11}$ $\frac{1}{2}$ $\frac{1}{9}$ $\frac{1}{3}$

GUIDED PRACTICE

Write each fraction or mixed number as a decimal.

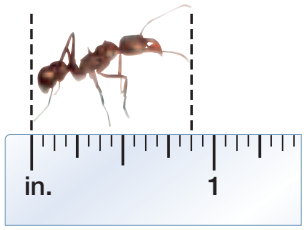
4. $\frac{4}{5}$ 5. $4\frac{3}{8}$ 6. $-\frac{1}{3}$ 7. $7\frac{5}{33}$

Write each decimal as a fraction or mixed number in simplest form.

8. 0.6 9. -1.55 10. $-0.\overline{5}$ 11. $2.\overline{1}$

BIOLOGY **For Exercises 12 and 13, use the figure at the right.**

12. Write the length of the ant as a fraction.
13. Write the length of the ant as a decimal.



Practice and Applications

Write each fraction or mixed number as a decimal.

14. $\frac{1}{4}$ 15. $\frac{1}{5}$ 16. $-\frac{13}{25}$ 17. $-\frac{11}{50}$
18. $2\frac{1}{8}$ 19. $5\frac{5}{16}$ 20. $-\frac{5}{6}$ 21. $-\frac{2}{9}$
22. $-\frac{4}{33}$ 23. $-\frac{6}{11}$ 24. $6\frac{4}{11}$ 25. $7\frac{8}{33}$

HOMEWORK HELP

For Exercises	See Examples
14–27	1, 2
28–33, 41–44	4
34–39	5
40	3

Extra Practice
See pages 619, 649.

26. Write $\frac{10}{33}$ as a decimal using bar notation.
27. Write $\frac{2}{45}$ as a decimal using bar notation.

Write each decimal as a fraction or mixed number in simplest form.

28. 0.4 29. 0.5 30. -0.16 31. -0.35
32. 5.55 33. 7.32 34. $-0.\overline{2}$ 35. $-0.\overline{4}$
36. $3.\overline{6}$ 37. $2.\overline{7}$ 38. $-4.\overline{21}$ 39. $-3.\overline{72}$

40. **BASEBALL** In a recent season, Sammy Sosa had 189 hits during his 577 at-bats. What was Sammy Sosa's batting average? Round to the nearest thousandth.

41. Write 0.38 and 0.383838 as fractions.

BIOLOGY **For Exercises 42–44, use the information at the right.**

42. Write the weight of a queen bee as a fraction.
43. Write the weight of a hummingbird as a fraction.
44. Write the weight of a hamster as a mixed number.

Animal	Weight (ounces)
Queen Bee	0.004
Hummingbird	0.11
Hamster	3.5

Source: *Animals as Our Companions*

THEATER **For Exercises 45 and 46, use the following information.**
The Tony Award is given to exceptional plays and people involved in making them. The award weighs 1 pound 10 ounces.

45. Write the weight of the Tony Award in pounds using a mixed number in simplest form.
46. Write the weight of the Tony Award in pounds using decimals.

47. **CRITICAL THINKING** A *unit fraction* is a fraction that has 1 as its numerator.
    a. Write the four greatest unit fractions that are terminating decimals. Write each fraction as a decimal.
    b. Write the four greatest unit fractions that are repeating decimals. Write each fraction as a decimal.

Spiral Review with Standardized Test Practice

48. **MULTIPLE CHOICE** Janeth Arcain of the Houston Comets in the WNBA made 0.84 of her free throws in the 2003 season. Write this decimal as a fraction in simplest form.

(A) $\frac{17}{20}$ (B) $\frac{21}{25}$ (C) $\frac{8}{10}$ (D) $\frac{41}{50}$

49. **MULTIPLE CHOICE** A survey asked Americans to name the biggest problem with home improvement. The results are shown in the table. What decimal represents the fraction of people surveyed who chose procrastination?

(F) 0.15 (G) 0.32
(H) 0.11 (I) 0.42

Reason	Fraction of Respondents
Lack of Time	$\frac{21}{50}$
Procrastination	$\frac{8}{25}$
Lack of Know-How	$\frac{3}{20}$
Lack of Tools	$\frac{11}{100}$

Source: Impulse Research for Ace Hardware

50. The product of two integers is 72. If one integer is -18, what is the other integer? (Lesson 1-9)

Solve each equation. Check your solution. (Lesson 1-8)

51. $t + 17 = -5$ 52. $a - 5 = 14$ 53. $5 = 9 + x$ 54. $m - 5 = -14$

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Find the least common multiple for each pair of numbers.** (Page 612)

55. 15, 5 56. 6, 9 57. 8, 6 58. 3, 5

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2-2 Comparing and Ordering Rational Numbers

What You'll LEARN

Compare and order rational numbers.

MATH Symbols

< less than
> greater than

WHEN am I ever going to use this?

RECYCLING The table shows the portion of some common materials and products that are recycled.

Material	Fraction Recycled
Paper	$\frac{5}{11}$
Aluminum Cans	$\frac{5}{8}$
Glass	$\frac{2}{5}$
Scrap Tires	$\frac{3}{4}$

Source: http://envirosystemsinc.com

1. Do we recycle more or less than half of the paper we produce? Explain.
2. Do we recycle more or less than half of the aluminum cans? Explain.
3. Which items have a recycle rate less than one half?
4. Which items have a recycle rate greater than one half?
5. Using this estimation method, can you order the rates from least to greatest?

Sometimes you can use estimation to compare rational numbers. Another method is to compare two fractions with common denominators. Or you can also compare decimals.

EXAMPLE 1 Compare Rational Numbers

Replace ● with <, >, or = to make $\frac{5}{8}$ ● $\frac{3}{4}$ a true sentence.

Method 1 Write as fractions with the same denominator.

For $\frac{5}{8}$ and $\frac{3}{4}$, the least common denominator is 8.

$\frac{5}{8} = \frac{5 \cdot 1}{8 \cdot 1}$ or $\frac{5}{8}$

$\frac{3}{4} = \frac{3 \cdot 2}{4 \cdot 2}$ or $\frac{6}{8}$

Since $\frac{5}{8} < \frac{6}{8}$, $\frac{5}{8} < \frac{3}{4}$.

Method 2 Write as decimals.

Write $\frac{5}{8}$ and $\frac{3}{4}$ as decimals. Use a calculator.

5 ÷ 8 ENTER 0.625

$\frac{5}{8} = 0.625$

3 ÷ 4 ENTER 0.75

$\frac{3}{4} = 0.75$

Since $0.625 < 0.75$, $\frac{5}{8} < \frac{3}{4}$.

Matt Meadows

EXAMPLE Compare Negative Rational Numbers

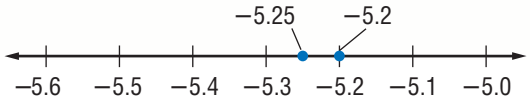
2 **Replace ● with <, >, or = to make -5.2 ● $-5\frac{1}{4}$ a true sentence.**

Write $-5\frac{1}{4}$ as a decimal.

$\frac{1}{4} = 0.25$, so $-5\frac{1}{4} = -5.25$.

Since $-5.2 > -5.25$, $-5.2 > -5\frac{1}{4}$.

Check Use a number line to check the answer.



The answer is correct.

STUDY TIP

Number Lines A number to the left is always less than a number to the right.

Your Turn **Replace each ● with <, >, or = to make a true sentence.**

a. $\frac{5}{6}$ ● $\frac{7}{9}$ **b.** $-\frac{5}{7}$ ● -0.7 **c.** $2\frac{3}{5}$ ● $2.\overline{6}$

You can order rational numbers by writing any fractions as decimals. Then order the decimals.

EXAMPLE Order Rational Numbers

REAL-LIFE MATH

ROLLER COASTERS The *Dragon Fire* is a double looping coaster with a corkscrew. The track is 2,160 feet long.

Source: Paramount

3 **ROLLER COASTERS** **The ride times for nine roller coasters are shown in the table. Order the times from least to greatest.**

Coaster	Ride Time (min)
Dragon Fire	$2\frac{1}{6}$
Mighty Canadian Minebuster	$2.\overline{6}$
Wilde Beast	2.5
Ghoster Coaster	$1\frac{5}{6}$
SkyRider	$2\frac{5}{12}$
Thunder Run	1.75
The Bat	$1\frac{5}{6}$
Vortex	1.75
Top Gun	$2\frac{5}{12}$

Source: Paramount

$2\frac{1}{6} = 2.1\overline{6}$ $1\frac{5}{6} = 1.8\overline{3}$ $2\frac{5}{12} = 2.41\overline{6}$

From least to greatest, the times are 1.75, 1.75, $1\frac{5}{6}$, $1\frac{5}{6}$, $2\frac{1}{6}$, $2\frac{5}{12}$, $2\frac{5}{12}$, 2.5, and $2.\overline{6}$. So, Vortex and Thunder Run have the shortest ride times, and Mighty Canadian Minebuster has the longest ride time.

Courtesy Paramount Canada's Wonderland, Paramount Parks, Inc.

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Skill and Concept Check

1. Writing Math Explain why 0.28 is less than $0.\overline{28}$.

2. **OPEN ENDED** Name two fractions that are less than $\frac{1}{2}$ and two fractions that are greater than $\frac{1}{2}$.

3. **NUMBER SENSE** Are the fractions $\frac{5}{11}$, $\frac{5}{12}$, $\frac{5}{13}$, and $\frac{5}{14}$ arranged in order from least to greatest or from greatest to least? Explain.

GUIDED PRACTICE

Replace each ● with <, >, or = to make a true sentence.

4. $\frac{3}{4}$ ● $\frac{7}{12}$ 5. $-\frac{4}{5}$ ● $-\frac{7}{9}$ 6. $3\frac{5}{8}$ ● 3.625 7. $-2\frac{4}{9}$ ● -2.42

Order each set of rational numbers from least to greatest.

8. $\frac{4}{5}, 0.5, \frac{1}{3}, 0.65$ 9. $-\frac{2}{3}, 0.7, -0.68, \frac{3}{4}$ 10. $-1\frac{2}{3}, -1.23, -1.45, -1\frac{1}{2}$

11. **CARPENTRY** Rondell has some drill bits marked $\frac{7}{16}$, $\frac{3}{8}$, $\frac{5}{32}$, $\frac{9}{16}$, and $\frac{1}{4}$. If these are all measurements in inches, how should he arrange them if he wants them from least to greatest?

Practice and Applications

HOMEWORK HELP

For Exercises	See Examples
12–23, 33	1, 2
24–32, 34–35	3

Extra Practice See pages 619, 649.

Replace each ● with <, >, or = to make a true sentence.

12. $\frac{2}{3}$ ● $\frac{7}{9}$ 13. $\frac{3}{5}$ ● $\frac{5}{8}$ 14. $-\frac{3}{11}$ ● $-\frac{1}{3}$

15. $-\frac{8}{11}$ ● $-\frac{7}{9}$ 16. -2.3125 ● $-2\frac{5}{16}$ 17. -5.2 ● $-5\frac{3}{11}$

18. $0.\overline{38}$ ● $\frac{4}{11}$ 19. $0.\overline{26}$ ● $\frac{4}{15}$ 20. $-4.\overline{37}$ ● -4.37

21. $-3.1\overline{6}$ ● $-3.\overline{16}$ 22. $\frac{3}{7}$ ● $0.\overline{42}$ 23. $12\frac{5}{6}$ ● $12.8\overline{3}$

Order each set of rational numbers from least to greatest.

24. $1.8, 1.07, 1\frac{8}{9}, 1\frac{1}{2}$ 25. $7\frac{1}{5}, 6.8, 7.6, 6\frac{3}{4}$ 26. $\frac{1}{9}, 0.1, -\frac{1}{3}, -0.25$

27. $-\frac{3}{5}, 0.45, -0.5, \frac{4}{7}$ 28. $-3\frac{2}{5}, -3.68, -3.97, -4\frac{3}{4}$ 29. $-2.9, -2.95, -2\frac{9}{11}, -2\frac{13}{14}$

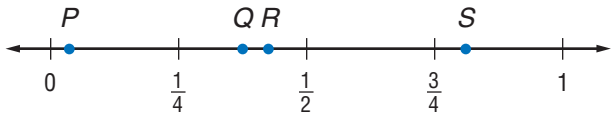
30. Which is least: $\frac{7}{11}$, 0.6, $\frac{2}{3}$, $0.6\overline{3}$, or $\frac{8}{13}$?

31. Which is greatest: $\frac{3}{8}$, 0.376, 0.367, $\frac{2}{5}$, or $0.\overline{37}$?

32. **STATISTICS** If you order a set of numbers from least to greatest, the middle number is the *median*. Find the median of 23.2, 22.45, 21.63, $22\frac{5}{8}$, and $21\frac{3}{5}$.

33. **PHOTOGRAPHY** The shutter time on Diego's camera is set at $\frac{1}{250}$ second. If Diego wants to increase the shutter time, should he set the time at $\frac{1}{500}$ second or $\frac{1}{125}$ second?

34. Match each number with a point on the number line.



a. 0.425 b. $\frac{3}{8}$ c. $\frac{13}{16}$ d. $0.\overline{15}$

35. **MULTI STEP** The table shows the regular season records of five college baseball teams during a recent season. Which team had the best record?

Team	Games Won	Games Played
University of Alabama	48	61
University of Notre Dame	44	59
University of Southern California	34	56
Florida State University	56	68
Rice University	47	58

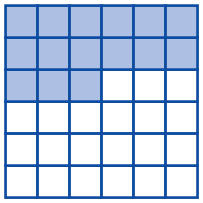
36. **CRITICAL THINKING** Are there any rational numbers between $0.\overline{2}$ and $\frac{2}{9}$? Explain.

Spiral Review with Standardized Test Practice

37. **MULTIPLE CHOICE** Determine which statement is *not* true.

(A) $\frac{3}{4} < 0.\overline{7}$ (B) $-\frac{2}{3} = -0.\overline{6}$ (C) $0.81 > \frac{4}{5}$ (D) $-0.58 > -\frac{5}{12}$

38. **SHORT RESPONSE** Is the fraction represented by the shaded part of the square at the right greater than, equal to, or less than 0.41?



39. **HISTORY** During the fourteenth and fifteenth centuries, printing presses used type cut from wood blocks. Each block was $\frac{7}{8}$ inch thick. Write this fraction as a decimal. (Lesson 2-1)

Solve each equation. Check your solution. (Lesson 1-9)

40. $\frac{y}{7} = 22$ 41. $4p = -60$ 42. $20 = \frac{t}{15}$ 43. $81 = -3d$

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Multiply.** (Lesson 1-6)

44. $-4(-7)$ 45. $8(-12)$ 46. $17(-3)$ 47. $-23(-5)$

AP/Wide World Photos

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2-3 Multiplying Rational Numbers

What You'll LEARN

Multiply fractions.

NEW Vocabulary

dimensional analysis

REVIEW Vocabulary

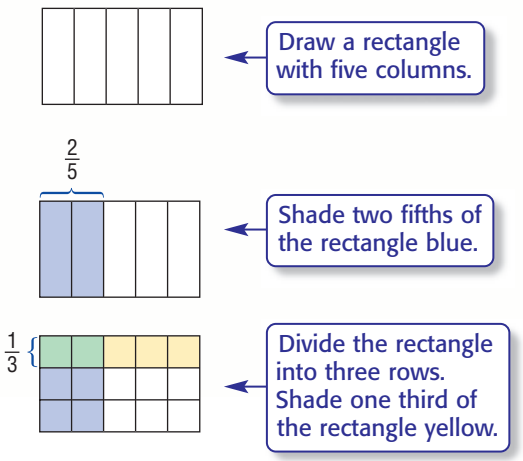
greatest common factor (GCF): the greatest of the common factors of two or more numbers
(Page 610)

HANDS-ON Mini Lab

Materials
- paper
- colored pencils

Work with a partner.

To multiply $\frac{1}{3}$ and $\frac{2}{5}$, you can use an area model to find $\frac{1}{3}$ of $\frac{2}{5}$.



The overlapping green area represents the product of $\frac{1}{3}$ and $\frac{2}{5}$.

1. What is the product of $\frac{1}{3}$ and $\frac{2}{5}$?
2. Use an area model to find each product.
   a. $\frac{3}{4} \cdot \frac{1}{2}$ b. $\frac{2}{5} \cdot \frac{2}{3}$ c. $\frac{1}{4} \cdot \frac{3}{5}$ d. $\frac{2}{3} \cdot \frac{4}{5}$
3. What is the relationship between the numerators of the factors and the numerator of the product?
4. What is the relationship between the denominators of the factors and the denominator of the product?

The Mini Lab suggests the rule for multiplying fractions.

Noteables™

Key Concept: Multiply Fractions

Words To multiply fractions, multiply the numerators and multiply the denominators.

Symbols

Arithmetic	Algebra
$\frac{2}{3} \cdot \frac{4}{5} = \frac{8}{15}$	$\frac{a}{b} \cdot \frac{c}{d} = \frac{ac}{bd}$, where $b \neq 0, d \neq 0$

EXAMPLE 1 Multiply Fractions

Find $\frac{4}{9} \cdot \frac{3}{5}$. Write in simplest form.

$$\frac{4}{9} \cdot \frac{3}{5} = \frac{4}{\cancel{9}_{3}} \cdot \frac{\overset{1}{\cancel{3}}}{5}$$ Divide 9 and 3 by their GCF, 3.

$$= \frac{4 \cdot 1}{3 \cdot 5}$$ ← Multiply the numerators. ← Multiply the denominators.

$$= \frac{4}{15}$$ Simplify.

Use the rules for multiplying integers to determine the sign of the product.

EXAMPLE 2 Multiply Negative Fractions

Find $-\frac{5}{6} \cdot \frac{3}{8}$. Write in simplest form.

$$-\frac{5}{6} \cdot \frac{3}{8} = \frac{-5}{\cancel{6}_{2}} \cdot \frac{\overset{1}{\cancel{3}}}{8}$$ Divide 6 and 3 by their GCF, 3.

$$= \frac{-5 \cdot 1}{2 \cdot 8}$$ ← Multiply the numerators. ← Multiply the denominators.

$$= -\frac{5}{16}$$ The fractions have different signs, so the product is negative.

Your Turn **Multiply. Write in simplest form.**

a. $\frac{8}{9} \cdot \frac{3}{4}$ b. $-\frac{3}{5} \cdot \frac{7}{9}$ c. $\left(-\frac{1}{2}\right)\left(-\frac{6}{7}\right)$

STUDY TIP

Negative Fractions

$-\frac{5}{6}$ can be written as $\frac{-5}{6}$ or as $\frac{5}{-6}$.

To multiply mixed numbers, first rename them as improper fractions.

EXAMPLE 3 Multiply Mixed Numbers

Find $4\frac{1}{2} \cdot 2\frac{2}{3}$. Write in simplest form.

$$4\frac{1}{2} \cdot 2\frac{2}{3} = \frac{9}{2} \cdot \frac{8}{3}$$ $4\frac{1}{2} = \frac{9}{2}$, $2\frac{2}{3} = \frac{8}{3}$

$$= \frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{2}}} \cdot \frac{\overset{4}{\cancel{8}}}{\underset{1}{\cancel{3}}}$$ Divide out common factors.

$$= \frac{3 \cdot 4}{1 \cdot 1}$$ ← Multiply the numerators. ← Multiply the denominators.

$$= \frac{12}{1} \text{ or } 12$$ Simplify.

Check $4\frac{1}{2}$ is less than 5, and $2\frac{2}{3}$ is less than 3. Therefore, $4\frac{1}{2} \cdot 2\frac{2}{3}$ is less than $5 \cdot 3$ or 15. The answer is reasonable.

Your Turn **Multiply. Write in simplest form.**

d. $1\frac{1}{2} \cdot 1\frac{2}{3}$ e. $\frac{5}{7} \cdot 1\frac{3}{5}$ f. $\left(-2\frac{1}{6}\right)\left(-1\frac{1}{5}\right)$

EXAMPLE 4 Evaluate an Algebraic Expression

ALGEBRA Evaluate abc if $a = -\frac{1}{2}$, $b = \frac{3}{5}$, and $c = \frac{5}{9}$.

$abc = -\frac{1}{2} \cdot \frac{3}{5} \cdot \frac{5}{9}$ Replace a with $-\frac{1}{2}$, b with $\frac{3}{5}$, and c with $\frac{5}{9}$.

$= -\frac{1}{2} \cdot \frac{\cancel{3}^{1}}{\cancel{5}_{1}} \cdot \frac{\cancel{5}^{1}}{\cancel{9}_{3}}$ Divide out common factors.

$= -\frac{1 \cdot 1 \cdot 1}{2 \cdot 1 \cdot 3}$ or $-\frac{1}{6}$ Simplify.

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

g. ac h. ab i. abc

REAL-LIFE MATH

AIRCRAFT A 757 aircraft has a capacity of 242 passengers and a wingspan of 165 feet 4 inches.

Source: *Continental Traveler*

Dimensional analysis is the process of including units of measurement when you compute. You can use dimensional analysis to check whether your answers are reasonable.

EXAMPLE 5 Use Dimensional Analysis

AIRCRAFT Suppose a 757 aircraft is traveling at its cruise speed. How far will it travel in $1\frac{1}{3}$ hours?

Aircraft	Cruise Speed (mph)
MD-80	505
DC-10	550
757	540
ATR-42	328

Source: *Continental Traveler*

Words	Distance equals the rate multiplied by the time.
Variables	$d = r \cdot t$
Equation	$d = 540$ miles per hour $\cdot\ 1\frac{1}{3}$ hours

$d = \frac{540 \text{ miles}}{1 \text{ hour}} \cdot 1\frac{1}{3} \text{ hours}$ Write the equation.

$d = \frac{540 \text{ miles}}{1 \text{ hour}} \cdot \frac{4}{3} \text{ hours}$ $1\frac{1}{3} = \frac{4}{3}$

$d = \frac{\cancel{540}^{180} \text{ miles}}{1 \text{ } \cancel{\text{hour}}} \cdot \frac{4}{\cancel{3}_{1}} \cancel{\text{hours}}$ Divide by common factors and units.

$d = 720$ miles

At its cruising speed, a 757 will travel 720 miles in $1\frac{1}{3}$ hours.

Check The problem asks for the distance. When you divide the common units, the answer is expressed in miles. So, the answer is reasonable.

STUDY TIP

Mental Math

$\frac{1}{3}$ of 540 is 180.

Using the Distributive Property, $1\frac{1}{3}$ of 540 should equal 540 + 180, or 720.

Skill and Concept Check

1. Writing Math Explain why the product of $\frac{1}{2}$ and $\frac{7}{8}$ is less than $\frac{1}{2}$.

2. **OPEN ENDED** Name two fractions whose product is greater than $\frac{1}{2}$ and less than 1.

3. **FIND THE ERROR** Matt and Enrique are multiplying $2\frac{1}{2}$ and $3\frac{1}{4}$. Who is correct? Explain.

Matt

$$2\tfrac{1}{2} \cdot 3\tfrac{1}{4} = 2 \cdot 3 + \tfrac{1}{2} \cdot \tfrac{1}{4}$$
$$= 6 + \tfrac{1}{8}$$
$$= 6\tfrac{1}{8}$$

Enrique

$$2\tfrac{1}{2} \cdot 3\tfrac{1}{4} = \tfrac{5}{2} \cdot \tfrac{13}{4}$$
$$= \tfrac{65}{8}$$
$$= 8\tfrac{1}{8}$$

GUIDED PRACTICE

Multiply. Write in simplest form.

4. $\frac{3}{5} \cdot \frac{5}{7}$

5. $-\frac{1}{8} \cdot \frac{4}{9}$

6. $1\frac{1}{3} \cdot 5\frac{1}{2}$

7. $\left(-\frac{4}{5}\right)\left(-\frac{4}{5}\right)$

8. **FOOD** The nutrition label is from a can of green beans. How many cups of green beans does the can contain?

9. **ALGEBRA** Evaluate xy if $x = \frac{4}{5}$ and $y = \frac{1}{2}$.

Practice and Applications

Multiply. Write in simplest form.

10. $\frac{3}{8} \cdot \frac{4}{5}$

11. $\frac{1}{12} \cdot \frac{4}{7}$

12. $-\frac{3}{8} \cdot \frac{4}{9}$

13. $-\frac{9}{10} \cdot \frac{2}{3}$

14. $-3\frac{3}{8} \cdot \left(-\frac{2}{3}\right)$

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

16. $3\frac{1}{3} \cdot 1\frac{1}{2}$

17. $2\frac{1}{2} \cdot 1\frac{2}{5}$

18. $-3\frac{1}{3} \cdot 2\frac{1}{4}$

19. $-4\frac{1}{4} \cdot 3\frac{1}{3}$

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

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

HOMEWORK HELP

For Exercises	See Examples
10–23	1–3
24–27	4
28–29	5

Extra Practice
See pages 619, 649.

22. Find the product of $\frac{1}{3}$, $-\frac{3}{8}$, and $\frac{4}{5}$.

23. What is one half of the product of $\frac{2}{5}$ and $\frac{3}{4}$?

ALGEBRA **Evaluate each expression if $r = -\frac{1}{4}$, $s = \frac{2}{5}$, $t = \frac{8}{9}$, and $v = -\frac{2}{3}$.**

24. rs

25. rt

26. stv

27. rtv

Matt Meadows

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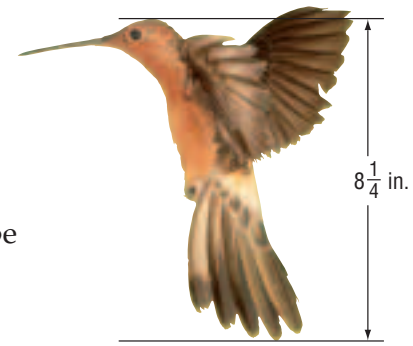
28. **PHOTOGRAPHY** Minh-Thu has a square photograph that measures $3\frac{1}{2}$ inches on each side. She reduces it to $\frac{2}{3}$ of its size. What is the length of a side of the new photograph?

29. **BIOLOGY** The bee hummingbird of Cuba is the smallest hummingbird in the world. It is $\frac{1}{4}$ the length of the giant hummingbird. Use the information at the right to find the length of a bee hummingbird.

Giant Hummingbird



30. **RESEARCH** Use the Internet or other resource to find a recipe for spaghetti sauce. Change the recipe to make $\frac{2}{3}$ of the amount. Then, change the recipe to make $1\frac{1}{2}$ of the amount.

31. **CRITICAL THINKING** Find the missing fraction. $\frac{3}{4} \cdot ? = \frac{9}{14}$

EXTENDING THE LESSON

MENTAL MATH You can use number properties to simplify computations.

Example: $\frac{3}{4} \cdot \frac{3}{7} \cdot \frac{4}{3} = \left(\frac{3}{4} \cdot \frac{4}{3}\right) \cdot \frac{3}{7}$ Commutative and Associative Properties

$= 1 \cdot \frac{3}{7}$ or $\frac{3}{7}$ Identity Property of Multiplication

Use mental math to find each product.

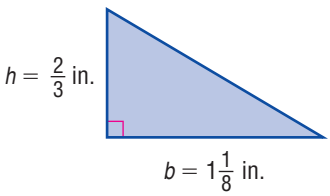
32. $\frac{2}{5} \cdot \frac{1}{6} \cdot \frac{5}{2}$

33. $5 \cdot 3.78 \cdot \frac{1}{5}$

34. $\frac{2}{7} \cdot \frac{4}{9} \cdot \frac{3}{5} \cdot 0$

Spiral Review with Standardized Test Practice

35. **MULTIPLE CHOICE** Find the area of the triangle. Use the formula $A = \frac{1}{2}bh$.



(A) $\frac{3}{4}$ in^2 (B) $\frac{5}{8}$ in^2 (C) $\frac{3}{8}$ in^2 (D) $\frac{1}{6}$ in^2

36. **MULTIPLE CHOICE** What number will make $\frac{3}{4} \cdot \frac{7}{8} = \frac{7}{8} \cdot n$ true?

(F) $\frac{4}{8}$ (G) $\frac{3}{4}$ (H) $\frac{10}{12}$ (I) $\frac{7}{8}$

Replace each ● with <, >, or = to make a true sentence. (Lesson 2-2)

37. $\frac{1}{2}$ ● $\frac{4}{7}$

38. $\frac{2}{7}$ ● $0.\overline{28}$

39. -0.753 ● $-\frac{3}{4}$

40. $-\frac{4}{9}$ ● $-0.\overline{4}$

41. **HISTORY** In 1864, Abraham Lincoln won the presidential election with about 0.55 of the popular vote. Write this as a fraction in simplest form. (Lesson 2-1)

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Divide.** (Lesson 1-6)

42. $51 \div (-17)$

43. $-81 \div (-3)$

44. $-92 \div 4$

45. $-105 \div (-7)$

2-4 Dividing Rational Numbers

What You'll LEARN

Divide fractions.

NEW Vocabulary

multiplicative inverses
reciprocals

REVIEW Vocabulary

additive inverse: the sum of any number and its additive inverse is zero, $a + (-a) = 0$ (Lesson 1-5)

WHEN am I ever going to use this?

ANIMALS The world's longest snake is the reticulated python. It is approximately one-fourth the length of the blue whale.

World's Largest Animals		
Largest Animal	Blue Whale	110 feet long
Largest Reptile	Saltwater Crocodile	16 feet long
Largest Bird	Ostrich	9 feet tall
Largest Insect	Stick Insect	15 inches long

Source: *The World Almanac for Kids*

1. Find the value of $110 \div 4$.
2. Find the value of $110 \cdot \frac{1}{4}$.
3. Compare the values of $110 \div 4$ and $110 \cdot \frac{1}{4}$.
4. What can you conclude about the relationship between dividing by 4 and multiplying by $\frac{1}{4}$?

In Chapter 1, you learned about additive inverses. A similar property applies to multiplication. Two numbers whose product is 1 are **multiplicative inverses**, or **reciprocals**, of each other. For example, 4 and $\frac{1}{4}$ are multiplicative inverses because $4 \cdot \frac{1}{4} = 1$.

Noteables™ **Key Concept: Inverse Property of Multiplication**

Words The product of a rational number and its multiplicative inverse is 1.

Symbols

Arithmetic	Algebra
$\frac{3}{4} \cdot \frac{4}{3} = 1$	$\frac{a}{b} \cdot \frac{b}{a} = 1$, where $a, b \neq 0$

EXAMPLE 1 Find a Multiplicative Inverse

Write the multiplicative inverse of $-5\frac{2}{3}$.

$-5\frac{2}{3} = -\frac{17}{3}$ Write $-5\frac{2}{3}$ as an improper fraction.

Since $-\frac{17}{3}\left(-\frac{3}{17}\right) = 1$, the multiplicative inverse of $-5\frac{2}{3}$ is $-\frac{3}{17}$.

Your Turn **Write the multiplicative inverse of each number.**

a. $-2\frac{1}{3}$ b. $-\frac{5}{8}$ c. 7

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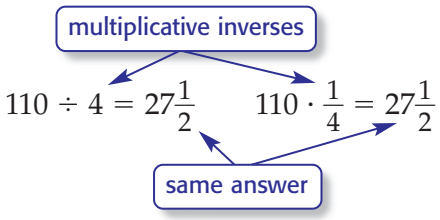
Dividing by 4 is the same as multiplying by $\frac{1}{4}$, its multiplicative inverse. This is true for any rational number.



Noteables

Key Concept: Divide Fractions

Words To divide by a fraction, multiply by its multiplicative inverse.

Symbols

Arithmetic	Algebra
$\frac{2}{5} \div \frac{3}{4} = \frac{2}{5} \cdot \frac{4}{3}$ or $\frac{8}{15}$	$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$, where $b, c, d \neq 0$

EXAMPLE 2 Divide Fractions

Find $\frac{7}{8} \div \frac{3}{4}$. Write in simplest form.

$\frac{7}{8} \div \frac{3}{4} = \frac{7}{8} \cdot \frac{4}{3}$ Multiply by the multiplicative inverse of $\frac{3}{4}$, which is $\frac{4}{3}$.

$= \frac{7}{\cancel{8}_{2}} \cdot \frac{\cancel{4}^{1}}{3}$ Divide 8 and 4 by their GCF, 4.

$= \frac{7}{6}$ or $1\frac{1}{6}$ Simplify.

EXAMPLE 3 Divide by a Whole Number

Find $\frac{2}{5} \div 5$. Write in simplest form.

$\frac{2}{5} \div 5 = \frac{2}{5} \div \frac{5}{1}$ Write 5 as $\frac{5}{1}$.

$= \frac{2}{5} \cdot \frac{1}{5}$ Multiply by the multiplicative inverse of 5, which is $\frac{1}{5}$.

$= \frac{2}{25}$ Simplify.

STUDY TIP

Dividing By a Whole Number When dividing by a whole number, always rename it as an improper fraction. Then multiply by its reciprocal.

EXAMPLE 4 Divide Negative Fractions

Find $-\frac{4}{5} \div \frac{6}{7}$. Write in simplest form.

$-\frac{4}{5} \div \frac{6}{7} = -\frac{4}{5} \cdot \frac{7}{6}$ Multiply by the multiplicative inverse of $\frac{6}{7}$, which is $\frac{7}{6}$.

$= \frac{-\cancel{4}^{2}}{5} \cdot \frac{7}{\cancel{6}}$ Divide -4 and 6 by their GCF, 2.

$= -\frac{14}{15}$ The fractions have different signs, so the quotient is negative.

Your Turn **Divide. Write in simplest form.**

d. $\frac{3}{4} \div \frac{1}{2}$ e. $\frac{3}{5} \div (6)$ f. $-\frac{2}{3} \div \left(-\frac{3}{5}\right)$

EXAMPLE 5 Divide Mixed Numbers

Find $4\frac{2}{3} \div \left(-3\frac{1}{2}\right)$. Write in simplest form.

$$4\frac{2}{3} \div \left(-3\frac{1}{2}\right) = \frac{14}{3} \div \left(-\frac{7}{2}\right) \qquad 4\frac{2}{3} = \frac{14}{3},\ -3\frac{1}{2} = -\frac{7}{2}$$

$$= \frac{14}{3} \cdot \left(-\frac{2}{7}\right) \qquad \text{The multiplicative inverse of } -\frac{7}{2} \text{ is } -\frac{2}{7}.$$

$$= \frac{\overset{2}{\cancel{14}}}{3} \cdot \left(-\frac{2}{\underset{1}{\cancel{7}}}\right) \qquad \text{Divide 14 and 7 by their GCF, 7.}$$

$$= -\frac{4}{3} \text{ or } -1\frac{1}{3} \qquad \text{Simplify.}$$

Check Since $4\frac{2}{3}$ is about 5 and $-3\frac{1}{2}$ is about -4, you can estimate the answer to be about $5 \div (-4)$, which is $\frac{5}{-4}$ or $-1\frac{1}{4}$. The answer seems reasonable because $-1\frac{1}{3}$ is about $-1\frac{1}{4}$.

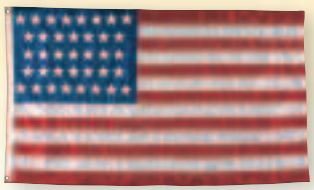
Your Turn **Divide. Write in simplest form.**

g. $2\frac{3}{4} \div \left(-2\frac{1}{5}\right)$ h. $1\frac{1}{2} \div 2\frac{1}{3}$ i. $-3\frac{1}{2} \div \left(-1\frac{1}{4}\right)$

REAL-LIFE MATH

HOLIDAYS The first Flag Day was celebrated in 1877. It was the 100th anniversary of the day the Continental Congress adopted the Stars and Stripes as the official flag.

Source: *World Book*



You can use dimensional analysis to check for reasonable answers in division problems as well as multiplication problems.

EXAMPLE 6 Use Dimensional Analysis

HOLIDAYS Isabel and her friends are making ribbons to give to other campers at their day camp on Flag Day. They have a roll with 20 feet of ribbon. How many Flag Day ribbons as shown at the right can they make?

Since 4 inches equals $\frac{4}{12}$ or $\frac{1}{3}$ foot, divide 20 by $\frac{1}{3}$.

$$20 \div \frac{1}{3} = \frac{20}{1} \div \frac{1}{3} \qquad \text{Write 20 as } \frac{20}{1}.$$

$$= \frac{20}{1} \cdot \frac{3}{1} \qquad \text{Multiply by the multiplicative inverse of } \frac{1}{3}, \text{ which is 3.}$$

$$= \frac{60}{1} \text{ or } 60 \qquad \text{Simplify.}$$

Isabel and her friends can make 60 Flag Day ribbons.

STUDY TIP

Mental Math
Isabel can make 3 ribbons for each foot. Since 3×20 is 60, Isabel can make 60 ribbons.

Check Use dimensional analysis to examine the units.

$$\text{feet} \div \frac{\text{feet}}{\text{ribbon}} = \cancel{\text{feet}} \times \frac{\text{ribbon}}{\cancel{\text{feet}}} \qquad \text{Divide out the units.}$$

$$= \text{ribbon} \qquad \text{Simplify.}$$

The result is expressed as ribbons. This agrees with your answer of 60 ribbons.

Aaron Haupt

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Skill and Concept Check

1. Writing Math Explain how you know if two numbers are multiplicative inverses.

2. **Give a counterexample** to the statement *the quotient of two fractions between 0 and 1 is never a whole number*.

3. **OPEN ENDED** Write a division problem that can be solved by multiplying a rational number by $\frac{6}{5}$.

4. **NUMBER SENSE** Which is greater: $30 \cdot \frac{3}{4}$ or $30 \div \frac{3}{4}$? Explain.

GUIDED PRACTICE

Write the multiplicative inverse of each number.

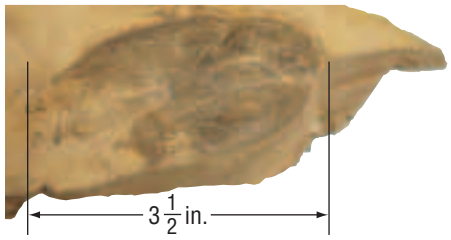
5. $\frac{5}{7}$ 6. -12 7. $-2\frac{3}{4}$

Divide. Write in simplest form.

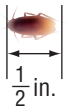
8. $\frac{2}{3} \div \frac{3}{4}$ 9. $-5\frac{5}{6} \div 4\frac{2}{3}$ 10. $-\frac{4}{5} \div (-8)$

11. **BIOLOGY** The 300-million-year-old fossil of a cockroach was recently found in eastern Ohio. The ancient cockroach is shown next to the common German cockroach found today. How many times longer is the ancient cockroach than the German cockroach?

300-Million-Year-Old Cockroach



Common German Cockroach



Practice and Applications

Write the multiplicative inverse of each number.

12. $-\frac{7}{9}$ 13. $-\frac{5}{8}$ 14. 15 15. 18

16. $\frac{6}{11}$ 17. $\frac{7}{15}$ 18. $3\frac{2}{5}$ 19. $4\frac{1}{8}$

Divide. Write in simplest form.

20. $\frac{2}{5} \div \frac{3}{4}$ 21. $\frac{3}{8} \div \frac{2}{3}$ 22. $-\frac{3}{8} \div \frac{9}{10}$ 23. $-\frac{2}{3} \div \frac{5}{6}$

24. $-5\frac{2}{5} \div \left(-2\frac{1}{10}\right)$ 25. $-3\frac{1}{4} \div \left(-8\frac{2}{3}\right)$ 26. $3\frac{3}{4} \div 2\frac{1}{2}$ 27. $7\frac{1}{2} \div 2\frac{1}{10}$

28. $\frac{4}{5} \div (-6)$ 29. $\frac{6}{7} \div (-4)$ 30. $-12\frac{1}{4} \div 4\frac{2}{3}$ 31. $-10\frac{1}{5} \div 3\frac{3}{15}$

32. What is $\frac{7}{12}$ divided by $\frac{5}{6}$?

33. Divide $\frac{5}{6}$ by $\frac{15}{16}$.

34. **ALGEBRA** Evaluate $x \div y$ if $x = -\frac{5}{12}$ and $y = \frac{5}{8}$.

35. **ALGEBRA** Evaluate $a \div b$ if $a = \frac{3}{4}$ and $b = \frac{5}{6}$.

HOMEWORK HELP

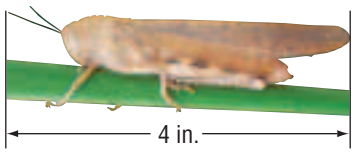
For Exercises	See Examples
12–19	1
20–35	2–5
36–39	6

Extra Practice
See pages 620, 649.

36. **BIOLOGY** Use the information at the right. How many of the smallest grasshoppers need to be laid end-to-end to have the same length as the largest grasshoppers?

Smallest grasshopper

Largest grasshopper



37. **ENERGY** Electricity costs $6\frac{1}{2}$¢ per kilowatt-hour. Of that cost, $3\frac{1}{4}$¢ goes toward the cost of the fuel. What fraction of the cost goes toward the fuel?

GEOGRAPHY **For Exercises 38 and 39, use the information at the right.**

Continent	Fraction of Earth's Landmass
North America	$\frac{1}{6}$
South America	$\frac{1}{8}$
Asia	$\frac{3}{10}$

Source: *The World Almanac*

38. About how many times larger is North America than South America?

39. About how many times larger is Asia than North America?

40. **WRITE A PROBLEM** Write a real-life situation that can be solved by dividing fractions or mixed numbers. Solve the problem.

41. **CRITICAL THINKING** Use mental math to find each value.

a. $\frac{43}{594} \cdot \frac{641}{76} \div \frac{641}{594}$ b. $\frac{783}{241} \cdot \frac{241}{783} \div \frac{72}{53}$

Spiral Review with Standardized Test Practice

42. **MULTIPLE CHOICE** A submarine sandwich that is $26\frac{1}{2}$ inches long is cut into $4\frac{5}{12}$-inch mini-subs. How many mini-subs are there?

(A) 4 (B) 5 (C) 6 (D) 7

43. **SHORT RESPONSE** What is the multiplicative inverse of $-\frac{1}{a}$?

Multiply. Write in simplest form. (Lesson 2-3)

44. $\frac{1}{2} \cdot \frac{3}{4}$ 45. $\frac{7}{12} \cdot \frac{4}{7}$ 46. $1\frac{2}{3} \cdot 4\frac{1}{5}$ 47. $\frac{2}{3} \cdot 3\frac{1}{4}$

48. **SCHOOL** In a survey of students at Centerburg Middle School, $\frac{13}{20}$ of the boys and $\frac{17}{25}$ of the girls said they rode the bus to school. Of those surveyed, do a greater fraction of boys or girls ride the bus? (Lesson 2-2)

49. **ALGEBRA** Write an algebraic expression to represent *eight million less than four times the population of Africa*. (Lesson 1-7)

50. Write an integer to describe *10 candy bars short of his goal*. (Lesson 1-3)

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Add or subtract.** (Lessons 1-4 and 1-5)

51. $-7 + 15$ 52. $-9 + (-4)$ 53. $-3 - 15$ 54. $12 - (-17)$

CONTENTS

Study Skill

Use Two-Column Notes

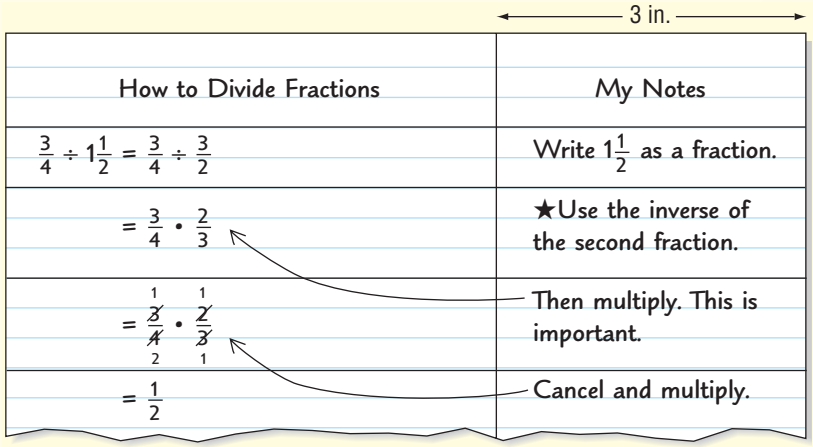
Taking Good Notes

Have you ever written a step-by-step solution to a problem, but couldn't follow the steps later? Try using two-column notes. You may like this method of taking notes so well, you'll want to use it for your other classes.

To take two-column notes, first fold your paper lengthwise into two columns. Make the right-hand column about 3 inches wide.

When your teacher solves a problem in class, write all of the steps in the left-hand column. In the right-hand column, add notes in your own words that will help you remember how to solve the problem. Add a ★ by any step that you especially want to remember.

Here's a sample.



SKILL PRACTICE

Use the method above to write notes for each step-by-step solution.

1. $\frac{3}{4} \div 3 = \frac{3}{4} \div \frac{3}{1}$

$= \frac{3}{4} \cdot \frac{1}{3}$

$= \frac{\overset{1}{\cancel{3}}}{4} \cdot \frac{1}{\underset{1}{\cancel{3}}}$

$= \frac{1}{4}$

2. $1\frac{1}{2} \cdot 1\frac{2}{3} = \frac{3}{2} \cdot \frac{5}{3}$

$= \frac{3}{2} \cdot \frac{5}{3}$

$= \frac{5}{2}$

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

3. $x + 8 = -6$

$\quad -8 = -8$

$x = -14$

4. $5 - 12 = 5 + (-12)$

$= -7$

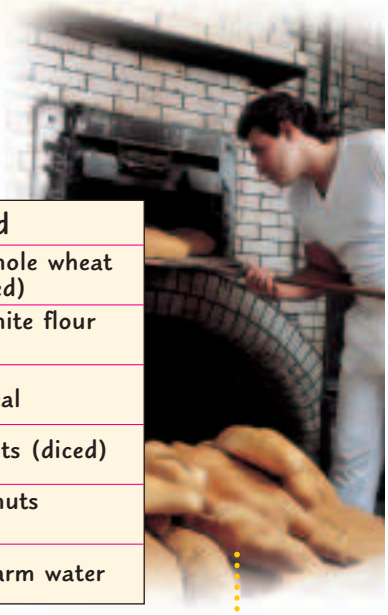
2-5 Adding and Subtracting Like Fractions

What You'll LEARN

Add and subtract fractions with like denominators.

NEW Vocabulary

like fractions



WHEN am I ever going to use this?

BAKING A bread recipe calls for the ingredients at the right together with small amounts of sugar, oil, yeast, and salt.

Bread
$1\frac{1}{3}$ cups of whole wheat flour (sifted)
$2\frac{1}{3}$ cups of white flour (sifted)
$\frac{1}{3}$ cup oatmeal
$\frac{1}{3}$ cup apricots (diced)
$\frac{1}{3}$ cup hazelnuts (chopped)
$1\frac{1}{3}$ cups of warm water

1. What is the sum of the whole-number parts of the amounts?
2. How many $\frac{1}{3}$ cups are there?
3. Since $\frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1$, how many cups do all the $\frac{1}{3}$ cups make?
4. What is the total number of cups of the ingredients listed?

The fractions above have like denominators. Fractions with like denominators are called **like fractions**.

Noteables™ **Key Concept: Add Like Fractions**

Words To add fractions with like denominators, add the numerators and write the sum over the denominator.

Symbols

Arithmetic	Algebra
$\frac{1}{3} + \frac{1}{3} = \frac{2}{3}$	$\frac{a}{c} + \frac{b}{c} = \frac{a+b}{c}$, where $c \neq 0$

You can use the rules for adding integers to determine the sign of the sum of fractions.

EXAMPLE 1 Add Like Fractions

Find $\frac{5}{8} + \left(-\frac{7}{8}\right)$. Write in simplest form.

$$\frac{5}{8} + \left(-\frac{7}{8}\right) = \frac{5 + (-7)}{8}$$ ← Add the numerators. ← The denominators are the same.

$$= \frac{-2}{8} \text{ or } -\frac{1}{4}$$ Simplify.

STUDY TIP

Look Back You can review **adding integers** in Lesson 1-4.

Your Turn **Add. Write in simplest form.**

a. $\frac{5}{9} + \frac{7}{9}$ b. $-\frac{5}{6} + \frac{1}{6}$ c. $-\frac{1}{6} + \left(-\frac{5}{6}\right)$

Julie Houck/Stock Boston

CONTENTS

Subtracting like fractions is similar to adding them.

Noteables **Key Concept: Subtract Like Fractions**

Words To subtract fractions with like denominators, subtract the numerators and write the difference over the denominator.

Symbols

Arithmetic	Algebra
$\frac{5}{7} - \frac{3}{7} = \frac{5-3}{7}$ or $\frac{2}{7}$	$\frac{a}{c} - \frac{b}{c} = \frac{a-b}{c}$, where $c \neq 0$

EXAMPLE 2 Subtract Like Fractions

Find $-\frac{8}{9} - \frac{7}{9}$. Write in simplest form.

$-\frac{8}{9} - \frac{7}{9} = \frac{-8-7}{9}$ ← Subtract the numerators. ← The denominators are the same.

$= \frac{-15}{9}$ or $-1\frac{2}{3}$ Rename $\frac{-15}{9}$ as $-1\frac{6}{9}$ or $-1\frac{2}{3}$.

To add mixed numbers, add the whole numbers and the fractions separately. Then simplify.

EXAMPLE 3 Add Mixed Numbers

Find $5\frac{7}{9} + 8\frac{4}{9}$. Write in simplest form.

$5\frac{7}{9} + 8\frac{4}{9} = (5+8) + \left(\frac{7}{9} + \frac{4}{9}\right)$ Add the whole numbers and fractions separately.

$= 13 + \frac{7+4}{9}$ Add the numerators.

$= 13\frac{11}{9}$ or $14\frac{2}{9}$ $\frac{11}{9} = 1\frac{2}{9}$

STUDY TIP

Alternative Method
You can also add the mixed numbers vertically.

$$\begin{array}{r} 5\frac{7}{9} \\ +\ 8\frac{4}{9} \\ \hline 13\frac{11}{9} \text{ or } 14\frac{2}{9} \end{array}$$

One way to subtract mixed numbers is to write the mixed numbers as improper fractions.

EXAMPLE 4 Subtract Mixed Numbers

HEIGHTS Jasmine is $60\frac{1}{4}$ inches tall. Amber is $58\frac{3}{4}$ inches tall. How much taller is Jasmine than Amber? **Estimate** $60 - 59 = 1$

$60\frac{1}{4} - 58\frac{3}{4} = \frac{241}{4} - \frac{235}{4}$ Write the mixed numbers as improper fractions.

$= \frac{241-235}{4}$ ← Subtract the numerators. ← The denominators are the same.

$= \frac{6}{4}$ or $1\frac{1}{2}$ Rename $\frac{6}{4}$ as $1\frac{2}{4}$ or $1\frac{1}{2}$.

Jasmine is $1\frac{1}{2}$ inches taller than Amber.

Skill and Concept Check

1. **Draw** a model to show the sum of $\frac{1}{5}$ and $\frac{3}{5}$.

2. **OPEN ENDED** Write a subtraction problem with a difference of $\frac{2}{9}$.

3. **FIND THE ERROR** Allison and Wesley are adding $\frac{1}{7}$ and $\frac{3}{7}$. Who is correct? Explain.

Allison

$\frac{1}{7} + \frac{3}{7} = \frac{1+3}{7}$

$= \frac{4}{7}$

Wesley

$\frac{1}{7} + \frac{3}{7} = \frac{1+3}{7+7}$

$= \frac{4}{14}$ or $\frac{2}{7}$

GUIDED PRACTICE

Add or subtract. Write in simplest form.

4. $\frac{2}{5} + \frac{2}{5}$

5. $-\frac{3}{4} + \frac{1}{4}$

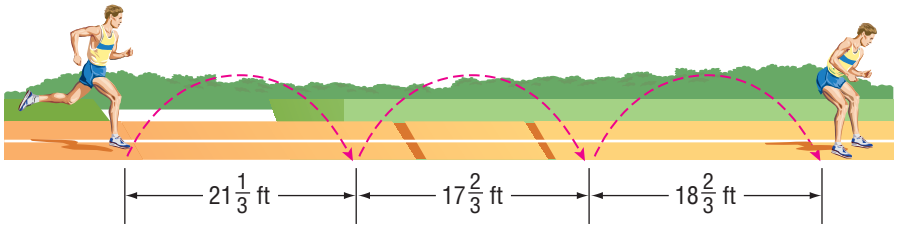
6. $-5\frac{4}{9} + \left(-2\frac{2}{9}\right)$

7. $\frac{3}{8} - \frac{7}{8}$

8. $8 - 6\frac{1}{6}$

9. $-1\frac{3}{7} - \left(-2\frac{2}{7}\right)$

10. **SPORTS** One of the track and field events is the triple jump. In this event, the athlete takes a running start and makes three jumps without stopping. Find the total length of the 3 jumps for the athlete below.



Practice and Applications

Add or subtract. Write in simplest form.

11. $\frac{3}{7} + \frac{3}{7}$

12. $\frac{1}{9} + \frac{1}{9}$

13. $-\frac{5}{12} + \frac{7}{12}$

14. $-\frac{8}{9} + \frac{5}{9}$

15. $-\frac{7}{8} + \left(-\frac{7}{8}\right)$

16. $-\frac{5}{9} + \left(-\frac{7}{9}\right)$

17. $\frac{1}{12} - \frac{7}{12}$

18. $\frac{2}{9} - \frac{8}{9}$

19. $-\frac{4}{5} - \frac{3}{5}$

20. $-\frac{2}{3} - \frac{2}{3}$

21. $3\frac{5}{8} + 7\frac{5}{8}$

22. $9\frac{5}{9} + 4\frac{7}{9}$

23. $8\frac{1}{10} - 2\frac{9}{10}$

24. $8\frac{5}{12} - 5\frac{11}{12}$

25. $-1\frac{5}{6} - 3\frac{5}{6}$

26. $-3\frac{3}{4} - 7\frac{3}{4}$

27. $7 - 5\frac{2}{5}$

28. $9 - 6\frac{3}{7}$

29. $-8 - \left(-3\frac{5}{8}\right)$

30. $-7 - \left(-2\frac{3}{5}\right)$

31. **ALGEBRA** Find $a - b$ if $a = 5\frac{1}{3}$ and $b = -2\frac{1}{3}$.

HOMEWORK HELP

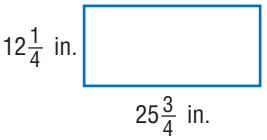
For Exercises	See Examples
11–20, 32	1, 2
21–31, 34–36	3, 4

Extra Practice
See pages 620, 649.

32. **ALGEBRA** Find $x + y$ if $x = -\frac{5}{12}$ and $y = -\frac{1}{12}$.

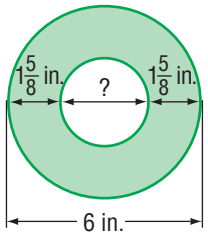
33. **MENTAL MATH** Explain how to use the Distributive Property to find $\frac{1}{2} \cdot \frac{3}{4} + \frac{1}{2} \cdot \frac{1}{4}$.

34. **GEOMETRY** Find the perimeter of the rectangle at the right.



35. **CLOTHING** Hat sizes are determined by the distance across a person's head. How much wider is a person's head who wears a hat size of $7\frac{3}{4}$ inches than someone who wears a hat size of $6\frac{1}{4}$ inches?

36. **MULTI STEP** Quoits was one of five original games in the ancient Greek Pentathlon. Find the distance across the hole of the quoit shown at the right.



37. **CRITICAL THINKING** Explain how to use mental math to find the following sum. Then find the sum.

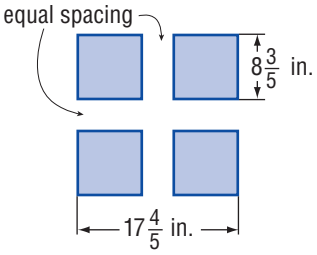
$$3\frac{2}{3} + 4\frac{2}{5} + 2\frac{1}{6} + 2\frac{5}{6} + 1\frac{1}{3} + \frac{3}{5}$$

Spiral Review with Standardized Test Practice

38. **MULTIPLE CHOICE** Find $\frac{7}{8} - \left(-\frac{3}{8}\right)$.

(A) $-1\frac{1}{4}$ (B) $-\frac{1}{2}$ (C) $\frac{1}{2}$ (D) $1\frac{1}{4}$

39. **MULTIPLE CHOICE** The equal-sized square tiles on a bathroom floor are set as shown. What is the width of the space between the tiles?



(F) $\frac{3}{5}$ in. (G) $\frac{1}{5}$ in.

(H) $\frac{3}{10}$ in. (I) $\frac{2}{5}$ in.

Divide. Write in simplest form. (Lesson 2-4)

40. $\frac{3}{5} \div \frac{6}{7}$ 41. $\frac{7}{8} \div 2\frac{4}{5}$ 42. $-3\frac{1}{4} \div 2\frac{1}{2}$

43. Find the product of $-\frac{7}{8}$ and $-\frac{6}{7}$. (Lesson 2-3)

44. **FOOD** On a typical day, 2 million gallons of ice cream are produced in the United States. About how many gallons are produced each year? (Lesson 1-1)

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Find the least common multiple (LCM) of each set of numbers.** (Page 612)

45. 14, 21 46. 18, 9, 6 47. 6, 4, 9 48. 5, 10, 20

CHAPTER 2

Mid-Chapter Practice Test

Vocabulary and Concepts

1. **Name** three numbers that are between $\frac{1}{2}$ and $\frac{3}{4}$. (Lesson 2-2)

2. **Define** reciprocals and give the reciprocal of $\frac{2}{3}$. (Lesson 2-4)

3. **OPEN ENDED** Write an addition problem with a sum of $2\frac{2}{3}$. (Lesson 2-5)

Skills and Applications

4. Write $-\frac{2}{9}$ as a decimal. (Lesson 2-1)

5. Write -2.65 as a mixed number in simplest form. (Lesson 2-1)

6. Write $0.\overline{5}$ as a fraction in simplest form. (Lesson 2-1)

Replace each ● with <, >, or = to make a true sentence. (Lesson 2-2)

7. $\frac{1}{3}$ ● $\frac{1}{4}$

8. $-\frac{2}{5}$ ● $-\frac{3}{10}$

9. $0.\overline{12}$ ● $\frac{4}{33}$

10. $-\frac{5}{6}$ ● $-\frac{4}{5}$

Multiply, divide, add, or subtract. Write in simplest form. (Lessons 2-3, 2-4, and 2-5)

11. $-\frac{1}{3} \cdot \frac{2}{3}$

12. $\frac{1}{2} \div \frac{3}{4}$

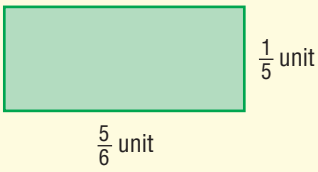
13. $-1\frac{1}{3} \div \left(-\frac{1}{4}\right)$

14. $2\frac{3}{4} \cdot \frac{1}{5}$

15. $\frac{3}{10} + \left(-\frac{7}{10}\right)$

16. $-\frac{7}{9} - \frac{8}{9}$

17. **GEOMETRY** Find the area of the rectangle at the right. Use the formula $A = \ell w$. (Lesson 2-3)



18. **CARPENTRY** A board that is $25\frac{1}{2}$ feet long is cut into equal pieces that are each $1\frac{1}{2}$ feet long. Into how many pieces is the board cut? (Lesson 2-4)

Standardized Test Practice

19. **MULTIPLE CHOICE** One centimeter is about 0.392 inch. What fraction of an inch is this? (Lesson 2-1)

(A) $\frac{49}{500}$ in. (B) $\frac{49}{125}$ in. (C) $\frac{98}{125}$ in. (D) $\frac{392}{100}$ in.

20. **SHORT RESPONSE** A bag of candy weighs 12 ounces. Each individual piece of candy weighs $\frac{1}{6}$ ounce. Write a division problem that you could use to determine the number of candies in the bag. How many candies are in the bag? (Lesson 2-4)

The Game Zone

A Place To Practice Your Math Skills

Plug It In

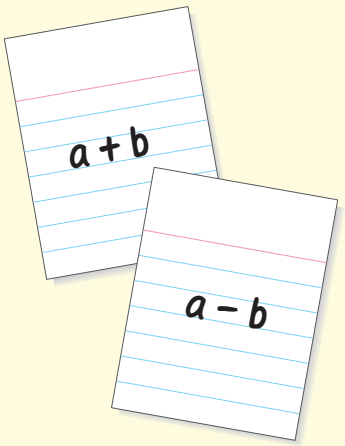
GET READY!

Players: two
Materials: 1 piece of paper, 9 index cards, scissors, marker

GET SET!

- Write the following fractions on a piece of paper.
  $-\frac{8}{9}, -\frac{7}{9}, -\frac{5}{9}, -\frac{4}{9}, -\frac{2}{9}, -\frac{1}{9}, \frac{1}{9}, \frac{2}{9}, \frac{4}{9}, \frac{5}{9}, \frac{7}{9}, \frac{8}{9}$
- Cut the index cards in half, making 18 cards.
- Write one of the following expressions on each of the cards.

$a + b$	$a - b$	$b - a$	ab	$\frac{1}{2}a$
$a \div b$	$b \div a$	$a + 1$	$b + 1$	$\frac{1}{2}b$
$1 - a$	$1 - b$	$a - 1$	$b - 1$	
a	b	$1 \div a$	$1 \div b$	



GO!

- The cards are shuffled and dealt facedown to each player.
- One player chooses the value for a from the list of fractions on the paper. The other player chooses the value for b from the same list.
- Each player turns over the top card from his or her pile and evaluates the expression. The person whose expression has the greatest value wins a point. If the values are equal, no points are awarded.
- The players choose new values for a and b. Each player turns over a new card. The play continues until all the cards are used.
- **Who Wins?** The person with the most points wins the game.

2-6 Adding and Subtracting Unlike Fractions

What You'll LEARN

Add and subtract fractions with unlike denominators.

NEW Vocabulary

unlike fractions

REVIEW Vocabulary

least common denominator (LCD): the least common multiple (LCM) of the denominators (Page 612)

WHEN am I ever going to use this?

FOOD Marta and Brooke are sharing a pizza. Marta eats $\frac{1}{4}$ of the pizza and Brooke eats $\frac{3}{8}$ of the pizza.

1. What are the denominators of the fractions?
2. What is the least common multiple of the denominators?
3. Find the missing value in $\frac{1}{4} = \frac{?}{8}$.
4. What fraction of the pizza did the two girls eat?

The fractions $\frac{1}{4}$ and $\frac{3}{8}$ have different or unlike denominators. Fractions with unlike denominators are called **unlike fractions**. To add or subtract unlike fractions, you must use a common denominator.

Noteables™ **Key Concept: Add and Subtract Unlike Fractions**

Words To find the sum or difference of two fractions with unlike denominators, rename the fractions with a common denominator. Then add or subtract and simplify, if necessary.

Examples

$$\frac{1}{4} + \frac{1}{6} = \frac{1}{4} \cdot \frac{3}{3} + \frac{1}{6} \cdot \frac{2}{2}$$
$$= \frac{3}{12} + \frac{2}{12} \text{ or } \frac{5}{12}$$

$$\frac{2}{3} - \frac{4}{9} = \frac{2}{3} \cdot \frac{3}{3} - \frac{4}{9}$$
$$= \frac{6}{9} - \frac{4}{9} \text{ or } \frac{2}{9}$$

EXAMPLE **Subtract Unlike Fractions**

1 **Find $-\frac{2}{3} - \left(-\frac{3}{8}\right)$. Write in simplest form.**

$$-\frac{2}{3} - \left(-\frac{3}{8}\right) = -\frac{2}{3} \cdot \frac{8}{8} - \left(-\frac{3}{8}\right) \cdot \frac{3}{3}$$ The LCD is $3 \cdot 2 \cdot 2 \cdot 2$ or 24.

$$= -\frac{16}{24} - \left(-\frac{9}{24}\right)$$ Rename each fraction using the LCD.

$$= -\frac{16}{24} + \frac{9}{24}$$ Subtract $-\frac{9}{24}$ by adding its inverse, $\frac{9}{24}$.

$$= \frac{-16 + 9}{24}$$ Add the numerators.

$$= -\frac{7}{24}$$ Simplify.

CONTENTS

STUDY TIP

Estimation Think: $-6\frac{2}{9}$ is about -6 and $4\frac{5}{6}$ is about 5. Since $-6 + 5$ is about -1, the answer is about -1. The answer seems reasonable.

EXAMPLE 2 Add Mixed Numbers

Find $-6\frac{2}{9} + 4\frac{5}{6}$. Write in simplest form.

$$-6\frac{2}{9} + 4\frac{5}{6} = -\frac{56}{9} + \frac{29}{6}$$ Write the mixed numbers as fractions.

$$= -\frac{56}{9} \cdot \frac{2}{2} + \frac{29}{6} \cdot \frac{3}{3}$$ The LCD is $3 \cdot 3 \cdot 2$ or 18.

$$= -\frac{112}{18} + \frac{87}{18}$$ Rename each fraction using the LCD.

$$= \frac{-112 + 87}{18}$$ Add the numerators.

$$= \frac{-25}{18} \text{ or } -1\frac{7}{18}$$ Simplify.

Your Turn **Add or subtract. Write in simplest form.**

a. $-\frac{1}{3} - \left(-\frac{3}{4}\right)$ b. $-\frac{5}{6} + \left(-\frac{1}{2}\right)$ c. $-\frac{1}{2} + \frac{7}{8}$

d. $-3\frac{1}{2} + 8\frac{1}{3}$ e. $-1\frac{2}{5} + \left(-3\frac{1}{3}\right)$ f. $2\frac{3}{4} - 6\frac{1}{3}$

Standardized Test Practice

EXAMPLE 3 Estimate the Sum of Mixed Numbers

MULTIPLE-CHOICE TEST ITEM Four telephone books are $2\frac{1}{8}$, $1\frac{15}{16}$, $1\frac{3}{4}$, and $2\frac{3}{8}$ inches thick. If these books were stacked one on top of another, what is the total height of the books?

(A) $5\frac{3}{16}$ in. (B) $8\frac{3}{16}$ in. (C) $11\frac{3}{16}$ in. (D) $15\frac{3}{16}$ in.

Read the Test Item You need to find the sum of four mixed numbers.

Solve the Test Item It would take some time to change each of the fractions to ones with a common denominator. However, notice that all four of the numbers are about 2. Since 2×4 equals 8, the answer will be about 8. Notice that only one of the choices is close to 8. The answer is B.

Test-Taking Tip

Use Estimation If the test question would take an excessive amount of time to work, try estimating the answer. Then look for the appropriate answer choice.

EXAMPLE 4 Evaluate Expressions

ALGEBRA Find the value of $a - b$ if $a = \frac{5}{7}$ and $b = -\frac{3}{5}$.

$$a - b = \frac{5}{7} - \left(-\frac{3}{5}\right)$$ Replace a with $\frac{5}{7}$ and b with $-\frac{3}{5}$.

$$= \frac{25}{35} - \left(-\frac{21}{35}\right)$$ Rename each fraction using the LCD, 35.

$$= \frac{25 - (-21)}{35}$$ Subtract the numerators.

$$= \frac{46}{35} \text{ or } 1\frac{11}{35}$$ Simplify.

Skill and Concept Check

1. Writing Math Describe the first step in adding unlike fractions.

2. **OPEN ENDED** Write a subtraction problem with unlike fractions with a least common denominator of 12. Find the answer.

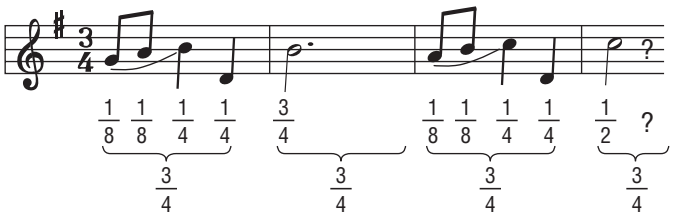
3. **NUMBER SENSE** Without doing the computation, determine whether $\frac{4}{7} + \frac{5}{9}$ is greater than, less than, or equal to 1. Explain.

GUIDED PRACTICE

Add or subtract. Write in simplest form.

4. $\frac{3}{4} + \frac{1}{6}$
5. $\frac{7}{8} - \frac{3}{4}$
6. $-\frac{1}{7} - \left(-\frac{4}{5}\right)$
7. $-\frac{2}{5} + \left(-\frac{5}{6}\right)$
8. $3\frac{5}{8} - 1\frac{1}{3}$
9. $-4\frac{2}{3} - \left(-3\frac{4}{5}\right)$

10. **MUSIC** A waltz is written in $\frac{3}{4}$ time. This means the quarter note gets one beat and the total value of each measure is $\frac{3}{4}$. What type of note must be used to finish the last measure of the waltz below?



Practice and Applications

HOMEWORK HELP

For Exercises	See Examples
11–32, 35	1–3
33–34	4

Extra Practice See pages 620, 649.

Add or subtract. Write in simplest form.

11. $\frac{3}{8} + \frac{5}{6}$
12. $\frac{7}{8} + \frac{3}{12}$
13. $\frac{3}{4} - \frac{1}{6}$
14. $\frac{4}{5} - \frac{2}{15}$
15. $-\frac{6}{7} - \left(-\frac{1}{3}\right)$
16. $-\frac{4}{5} - \left(-\frac{2}{3}\right)$
17. $8\frac{3}{7} - \left(-6\frac{1}{2}\right)$
18. $7\frac{3}{4} - \left(-1\frac{1}{8}\right)$
19. $-4\frac{3}{4} - 5\frac{5}{8}$
20. $-8\frac{1}{3} - 4\frac{5}{6}$
21. $9\frac{1}{6} - 4\frac{1}{2}$
22. $9\frac{1}{3} - 2\frac{1}{2}$
23. $3\frac{1}{5} + \left(-8\frac{1}{2}\right)$
24. $1\frac{1}{6} + \left(-6\frac{2}{3}\right)$
25. $-15\frac{5}{8} + 11\frac{2}{3}$
26. $-22\frac{2}{5} + 15\frac{5}{6}$
27. $\frac{65}{187} - \frac{9}{136}$
28. $\frac{45}{152} - \frac{13}{209}$

29. Subtract $-6\frac{1}{4}$ from 9.
30. What is $2\frac{3}{8}$ less than $-8\frac{1}{5}$?
31. What is the sum of $-\frac{5}{8}$ and $-\frac{1}{2}$?
32. Find the sum of $-\frac{4}{9}$ and $-\frac{2}{3}$.
33. **ALGEBRA** Evaluate $c - d$ if $c = -\frac{3}{4}$ and $d = -12\frac{7}{8}$.
34. **ALGEBRA** Evaluate $r - s$ if $r = -\frac{5}{8}$ and $s = 2\frac{5}{6}$.

35. **HISTORY** In the 1824 presidential election, Andrew Jackson, John Quincy Adams, Henry Clay, and William H. Crawford received electoral votes. Use the information at the right to determine what fraction of the votes William H. Crawford received.

Candidate	Fraction of Vote
Andrew Jackson	$\frac{3}{8}$
John Quincy Adams	$\frac{1}{3}$
Henry Clay	$\frac{1}{7}$

Source: *The World Almanac*

WATER MANAGEMENT **For Exercises 36–40, use the following information.**

Suppose a bucket is placed under two faucets.

36. If one faucet is turned on alone, the bucket will be filled in 5 minutes. Write the fraction of the bucket that will be filled in 1 minute.

37. If the other faucet is turned on alone, the bucket will be filled in 3 minutes. Write the fraction of the bucket that will be filled in 1 minute.

38. Write the fraction of the bucket that will be filled in 1 minute if both faucets are turned on.

39. Divide 1 by the sum in Exercise 38 to determine the number of minutes it will take to fill the bucket if both faucets are turned on.

40. How many seconds will it take to fill the bucket if both faucets are turned on?

41. **CRITICAL THINKING** Write an expression for each statement. Then find the answer.

a. $\frac{3}{4}$ of $\frac{2}{3}$

b. $\frac{3}{4}$ more than $\frac{2}{3}$

c. $\frac{3}{4}$ less than $\frac{2}{3}$

d. $\frac{3}{4}$ divided into $\frac{2}{3}$

Spiral Review with Standardized Test Practice

42. **MULTIPLE CHOICE** Teresa worked on homework $\frac{2}{3}$ of an hour on Monday and $1\frac{1}{2}$ hours on Tuesday. How much more time did she spend working on homework on Tuesday than on Monday?

(A) $\frac{1}{6}$ h (B) $\frac{1}{4}$ h (C) $\frac{5}{6}$ h (D) $\frac{13}{6}$ h

43. **SHORT RESPONSE** Show each step in finding $5\frac{1}{6} + 4\frac{2}{9}$.

Add or subtract. Write in simplest form. (Lesson 2-5)

44. $-\frac{7}{11} + \frac{5}{11}$

45. $-\frac{7}{15} - \frac{4}{15}$

46. $5\frac{4}{5} - 7\frac{1}{5}$

47. **ALGEBRA** Find $a \div b$ if $a = 3\frac{1}{2}$ and $b = -\frac{7}{8}$. (Lesson 2-4)

GETTING READY FOR THE NEXT LESSON

PREREQUISITE SKILL **Solve each equation. Check your solution.** (Lessons 1-8 and 1-9)

48. $d - 13 = -44$

49. $-18t = 270$

50. $-34 = y + 22$

51. $-5 = \frac{a}{16}$

2-7 Solving Equations with Rational Numbers

What You'll LEARN

Solve equations involving rational numbers.

REVIEW Vocabulary

equation: a mathematical sentence that contains an equals sign (Lesson 1-8)

WHEN am I ever going to use this?

BIOLOGY An elephant, which can run at a speed of 25 miles per hour, runs $\frac{5}{6}$ as fast as a grizzly bear. If s represents the speed of a grizzly bear, you can write the equation $25 = \frac{5}{6}s$.

1. Multiply each side of the equation by 6. Write the result.
2. Divide each side of the equation in Exercise 1 by 5. Write the result.
3. Multiply each side of the original equation $25 = \frac{5}{6}s$ by the multiplicative inverse of $\frac{5}{6}$. Write the result.
4. What is the speed of a grizzly bear?
5. Which method of solving the equation seems most efficient?

You used the Multiplication and Division Properties of Equality to solve $25 = \frac{5}{6}s$. You can also use the Addition and Subtraction Properties of Equality to solve equations with rational numbers.

EXAMPLES Solve by Using Addition or Subtraction

1 **Solve $p - 7.36 = -2.84$. Check your solution.**

$p - 7.36 = -2.84$	Write the equation.
$p - 7.36 + 7.36 = -2.84 + 7.36$	Add 7.36 to each side.
$p = 4.52$	Simplify.

2 **Solve $\frac{1}{2} = t + \frac{3}{4}$.**

$\frac{1}{2} = t + \frac{3}{4}$	Write the equation.
$\frac{1}{2} - \frac{3}{4} = t + \frac{3}{4} - \frac{3}{4}$	Subtract $\frac{3}{4}$ from each side.
$\frac{1}{2} - \frac{3}{4} = t$	Simplify.
$\frac{2}{4} - \frac{3}{4} = t$	Rename $\frac{1}{2}$.
$-\frac{1}{4} = t$	Simplify.

Tom Brakefield/CORBIS

CONTENTS

EXAMPLES Solve by Using Multiplication or Division

3 **Solve $\frac{4}{7}b = 16$. Check your solution.**

$\frac{4}{7}b = 16$ Write the equation.

$\frac{7}{4}\left(\frac{4}{7}b\right) = \frac{7}{4}(16)$ Multiply each side by $\frac{7}{4}$.

$b = 28$ Simplify.

Check $\frac{4}{7}b = 16$ Write the original equation.

$\frac{4}{7}(28) \stackrel{?}{=} 16$ Replace b with 28.

$16 = 16$ ✔ Simplify.

4 **Solve $58.4 = -7.3m$.**

$58.4 = -7.3m$ Write the equation.

$\frac{58.4}{-7.3} = \frac{-7.3m}{-7.3}$ Divide each side by -7.3.

$-8 = m$ Simplify. Check the solution.

Your Turn **Solve each equation. Check your solution.**

a. $r - 7.81 = 4.32$ **b.** $7.2v = -36$ **c.** $-\frac{2}{3}n = -\frac{3}{5}$

REAL-LIFE MATH

BASKETBALL During her rookie season for the WNBA, Sue Bird's field goal average was 0.379, and she made 232 field goal attempts.

Source: WNBA.com

You can write equations with rational numbers to solve real-life problems.

EXAMPLE Write an Equation to Solve a Problem

5 **BASKETBALL** **In basketball, a player's field goal average is determined by dividing the number of field goals made by the number of field goals attempted. Use the information at the left to determine the number of field goals Sue Bird made in her rookie season.**

Words	Field goal average equals goals divided by attempts.		
Variables	f	$=$	$\frac{g}{a}$
Equation	0.379	$=$	$\frac{g}{232}$

$0.379 = \frac{g}{232}$ Write the equation.

$232(0.379) = 232\left(\frac{g}{232}\right)$ Multiply each side by 232.

$87.928 = h$ Simplify.

Sue Bird made 88 field goals during her rookie season.

Elaine Thompson/AP/Wide World Photos

Skill and Concept Check

1. **OPEN ENDED** Write an equation with rational numbers that has a solution of $\frac{1}{4}$.

2. **Which One Doesn't Belong?** Identify the expression that does not have the same value as the other three. Explain your reasoning.

$\frac{4}{3}\left(\frac{3}{4}x\right)$ | $-\frac{3}{2}\left(-\frac{2}{3}x\right)$ | $2\left(\frac{1}{2}x\right)$ | $-\frac{1}{3}\left(\frac{1}{3}x\right)$

GUIDED PRACTICE

Solve each equation. Check your solution.

3. $t + 0.25 = -4.12$
4. $a - \frac{3}{4} = -\frac{3}{8}$
5. $-45 = \frac{5}{6}d$
6. $-26.5 = -5.3w$
7. $\frac{5}{8}z = \frac{2}{9}$
8. $p - (-0.03) = 3.2$

SPACE **For Exercises 9 and 10, use the following information.**
The planet Jupiter takes 11.9 years to make one revolution around the Sun.

9. Write a multiplication equation you can use to determine the number of revolutions Jupiter makes in 59.5 years. Let r represent the number of revolutions.
10. How many revolutions does Jupiter make in 59.5 years?

Practice and Applications

HOMEWORK HELP

For Exercises	See Examples
11–30	1–4
31–33	5

Extra Practice
See pages 621, 649.

Solve each equation. Check your solution.

11. $q + 0.45 = 1.29$
12. $a - 1.72 = 5.81$
13. $-\frac{1}{2} = m - \frac{2}{3}$
14. $-\frac{5}{9} = f + \frac{1}{3}$
15. $-\frac{4}{7}b = 16$
16. $-\frac{2}{9}p = -8$
17. $-1.92 = -0.32s$
18. $-8.4 = 1.2t$
19. $\frac{3}{4}z = -\frac{5}{6}$
20. $-\frac{2}{5}d = \frac{4}{9}$
21. $g - (-1.5) = 2.35$
22. $-1.3 = n - (-6.12)$
23. $\frac{t}{3.2} = -4.5$
24. $-\frac{a}{1.6} = 7.5$
25. $-5\frac{3}{4} = -2\frac{1}{2}x$
26. $4\frac{1}{6} = -3\frac{1}{3}c$
27. $3.5g = -\frac{7}{8}$
28. $-7.5r = -3\frac{1}{3}$

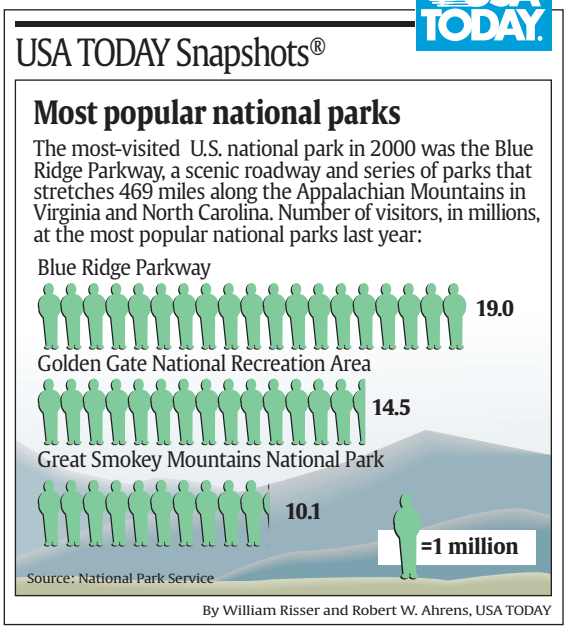
29. Find the solution of $v - \frac{2}{5} = -2$.
30. What is the solution of $-4.2 = \frac{c}{7}$?

31. **MONEY** The currency of Egypt is called a pound. The equation $3\frac{3}{4}d = 21$ can be used to determine how many U.S. dollars d equal 21 Egyptian pounds. Solve the equation.

RECREATION **For Exercises 32 and 33, use the graph.**

32. Let v equal the number of additional visitors that the Golden Gate National Recreation Area needed in the year 2000 to equal the number of visitors to the Blue Ridge Parkway. Write an addition equation to represent the situation.

33. How many more visitors did the Golden Gate National Recreation Area need to equal the number of visitors to the Blue Ridge Parkway?



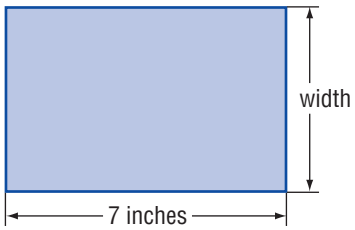
34. **CRITICAL THINKING** What is the solution of $\frac{1}{2}y + 3 = 15$? Check your solution.

Spiral Review with Standardized Test Practice

35. **MULTIPLE CHOICE** Find the value of t in $t - (-4.36) = 7.2$.

Ⓐ 2.84 Ⓑ 11.56 Ⓒ -2.84 Ⓓ -11.56

36. **MULTIPLE CHOICE** If the area of the rectangle at the right is $22\frac{3}{4}$ square inches, what is the width of the rectangle?



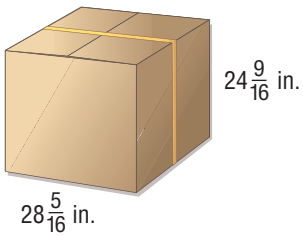
Ⓕ $\frac{4}{13}$ in. Ⓖ $2\frac{1}{2}$ in.

Ⓗ $3\frac{1}{4}$ in. Ⓘ $3\frac{3}{4}$ in.

Add or subtract. Write in simplest form. (Lesson 2-6)

37. $\frac{1}{6} + \frac{1}{7}$ 38. $\frac{7}{8} - \frac{1}{6}$ 39. $-5\frac{1}{2} - 6\frac{4}{5}$ 40. $2\frac{1}{2} + 5\frac{2}{3}$

41. **SHIPPING** Plastic straps are often wound around large cardboard boxes to reinforce them during shipping. Suppose the end of the strap must overlap $\frac{7}{16}$ inch to fasten. How long is the plastic strap around the box at the right? (Lesson 2-5)



42. **ALGEBRA** The sum of two integers is 13. One of the integers is -5. Write an equation and solve to find the other integer. (Lesson 1-8)

43. **ALGEBRA** Write an expression for *17 more than p*. (Lesson 1-7)

GETTING READY FOR THE NEXT LESSON

BASIC SKILL **Multiply.**

44. $4 \cdot 4 \cdot 4$ 45. $2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$ 46. $3 \cdot 3 \cdot 3 \cdot 3$ 47. $5 \cdot 5 \cdot 5$

2-8a Problem-Solving Strategy

A Preview of Lesson 2-8

Look for a Pattern

What You'll LEARN

Solve problems using the look for a pattern strategy.

In science class, we dropped a ball from 48 inches above the ground. Each time it hit the ground, it bounced back up $\frac{1}{2}$ of the previous height.

How many bounces occurred before the ball reached a height less than 5 inches?

Explore	We know the original height of the ball. Each time the ball bounced, its height was $\frac{1}{2}$ of the previous height. We want to know the number of bounces before the ball reaches a height less than 5 inches.
Plan	Use a pattern to determine when the ball will reach a height of less than 5 inches.
Solve	

Bounce	Height (inches)
1	$\frac{1}{2} \cdot 48 = 24$
2	$\frac{1}{2} \cdot 24 = 12$
3	$\frac{1}{2} \cdot 12 = 6$
4	$\frac{1}{2} \cdot 6 = 3$

After the fourth bounce, the ball will reach a height less than 5 inches.

Examine	Check your pattern to make sure the answer is correct.

Analyze the Strategy

1. **Explain** how Jerome and Haley determined the numbers in the first column.
2. **Describe** how to continue the pattern in the second column. Find the fraction of the height after 7 bounces.
3. **Write** a problem that can be solved by finding a pattern. Describe the pattern.

Matt Meadows

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Apply the Strategy

Solve. Use the look for a pattern strategy.

4. **WATER MANAGEMENT** A tank is draining at a rate of 8 gallons every 3 minutes. If there are 70 gallons in the tank, when will the tank have just 22 gallons left?

5. **MUSIC** The names of musical notes form a pattern. Name the next three notes in the following pattern. whole note, half note, quarter note

Mixed Problem Solving

Solve. Use any strategy.

6. **TRAVEL** Rafael is taking a vacation. His plane is scheduled to leave at 2:20 P.M. He must arrive at the airport at least 2 hours before his flight. It will take him 45 minutes to drive from his house to the airport. When is the latest he should plan to leave for the airport?

7. **GEOMETRY** What is the total number of rectangles, of any size, in the figure below?

8. **TECHNOLOGY** The price of calculators has been decreasing. A calculator sold for $12.50 in 1990. A similar calculator sold for $8.90 in 2000. If the price decrease continues at the same rate, what would be the price in 2020?

9. **FUND-RAISING** Marissa is collecting donations for her 15-mile bike-a-thon. She is asking for pledges between $1.50 and $2.50 per mile. If she has 12 pledges, about how much could she expect to collect?

10. **SCHOOL** Lawanda was assigned some math exercises for homework. She answered half of them in study period. After school, she answered 7 more exercises. If she still has 11 exercises to do, how many exercises were assigned?

11. **SCIENCE** The Italian scientist Galileo discovered a relationship between the time of the back and forth swing of a pendulum and its length. How long is a pendulum with a swing of 5 seconds?

Time of Swing	Length of Pendulum
1 second	1 unit
2 seconds	4 units
3 seconds	9 units
4 seconds	16 units

12. **MULTI STEP** Hiroshi is planning a party. He plans to order 4 pizzas, which cost $12.75 each. If he has a coupon for $1.50 off each pizza, find the total cost of the pizzas.

13. **GEOMETRY** Draw the next two geometric figures in the pattern.

14. **STANDARDIZED TEST PRACTICE**

Madeline rode her bicycle $\frac{1}{3}$ mile in 2 minutes. If she continues riding at the same rate, how far will she ride in 10 minutes?

(A) $1\frac{2}{3}$ mi (B) $2\frac{1}{3}$ mi

(C) $2\frac{2}{3}$ mi (D) $3\frac{1}{3}$ mi

2-8 Powers and Exponents

What You'll LEARN

Use powers and exponents in expressions.

NEW Vocabulary

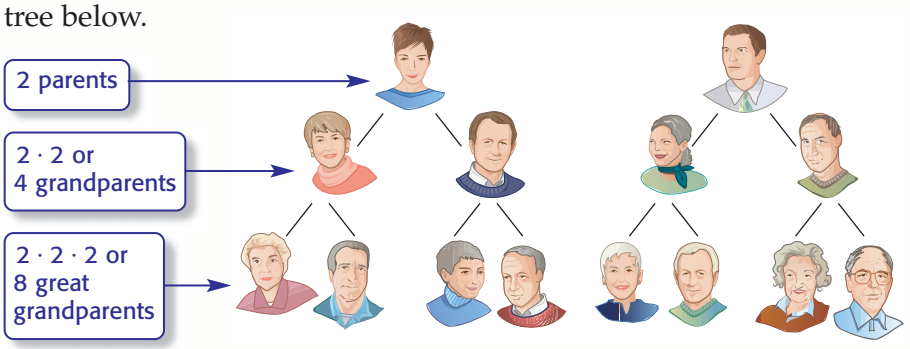
base
exponent
power

REVIEW Vocabulary

evaluate: to find the value of an expression (Lesson 1-2)

WHEN am I ever going to use this?

FAMILY Every person has 2 biological parents. Study the family tree below.



1. How many 2s are multiplied to determine the number of great grandparents?
2. How many 2s would you multiply to determine the number of great-great grandparents?

An expression like $2 \cdot 2 \cdot 2 \cdot 2$ can be written as the power 2^4.

The **base** is the number that is multiplied. 2^4 The **exponent** tells how many times the base is used as a factor.

The number that is expressed using an exponent is called a **power**.

The table below shows how to write and read powers.

Powers	Words	Repeated Factors
2^1	2 to the first power	2
2^2	2 to the second power or 2 squared	$2 \cdot 2$
2^3	2 to the third power or 2 cubed	$2 \cdot 2 \cdot 2$
2^4	2 to the fourth power	$2 \cdot 2 \cdot 2 \cdot 2$
⋮	⋮	⋮
2^n	2 to the nth power	$2 \cdot 2 \cdot 2 \cdot \ldots \cdot 2$ (n factors)

EXAMPLE 1 Write an Expression Using Powers

Write $a \cdot b \cdot b \cdot a \cdot b$ using exponents.

$a \cdot b \cdot b \cdot a \cdot b = a \cdot a \cdot b \cdot b \cdot b$ Commutative Property

$= (a \cdot a) \cdot (b \cdot b \cdot b)$ Associative Property

$= a^2 \cdot b^3$ Definition of exponents

You can also use powers to name numbers that are less than 1. Consider the pattern in the powers of 10.

$10^3 = 10 \cdot 10 \cdot 10$ or 1,000 → $1{,}000 \div 10 = 100$

$10^2 = 10 \cdot 10$ or 100 → $100 \div 10 = 10$

$10^1 = 10$ → $10 \div 10 = 1$

$10^0 = 1$ → $1 \div 10 = \frac{1}{10}$

$10^{-1} = \frac{1}{10}$ → $\frac{1}{10} \div 10 = \frac{1}{10^2}$ or $\frac{1}{100}$

$10^{-2} = \frac{1}{100}$

STUDY TIP

Negative Exponents
Remember that 10^{-2} equals $\frac{1}{10^2}$, *not* -20 or -100.

The pattern above suggests the following definitions for zero exponents and negative exponents.

Noteables **Key Concept: Zero and Negative Exponents**

Words Any nonzero number to the zero power is 1. Any nonzero number to the negative n power is 1 divided by the number to the nth power.

Symbols

Arithmetic	Algebra
$5^0 = 1$	$x^0 = 1, x \neq 0$
$7^{-3} = \frac{1}{7^3}$	$x^{-n} = \frac{1}{x^n}, x \neq 0$

EXAMPLES Evaluate Powers

2 **Evaluate 5^4.**

$5^4 = 5 \cdot 5 \cdot 5 \cdot 5$ Definition of exponents

$= 625$ Simplify.

Check using a calculator. 5 ^ 4 ENTER 625

3 **Evaluate 4^{-3}.**

$4^{-3} = \frac{1}{4^3}$ Definition of negative exponents

$= \frac{1}{64}$ Simplify.

4 **ALGEBRA Evaluate $a^2 \cdot b^4$ if $a = 3$ and $b = 5$.**

$a^2 \cdot b^4 = 3^2 \cdot 5^4$ Replace a with 3 and b with 5.

$= (3 \cdot 3) \cdot (5 \cdot 5 \cdot 5 \cdot 5)$ Definition of exponents

$= 9 \cdot 625$ Simplify.

$= 5{,}625$ Simplify.

Your Turn **Evaluate each expression.**

a. 15^3 b. $2^5 \cdot 5^2$ c. 5^{-4}

Skill and Concept Check

1. **OPEN ENDED** Write an expression with a negative exponent and explain what it means.

2. **NUMBER SENSE** Without evaluating the powers, order 6^{-3}, 6^2, and 6^0 from least to greatest.

GUIDED PRACTICE

Write each expression using exponents.

3. $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$
4. $2 \cdot 2 \cdot 2 \cdot 3 \cdot 3 \cdot 3$
5. $r \cdot s \cdot r \cdot r \cdot s \cdot s \cdot r \cdot r$

Evaluate each expression.

6. 7^3
7. $2^3 \cdot 6^2$
8. $4^2 \cdot 5^3$
9. 6^{-3}

10. **ALGEBRA** Evaluate $x^2 \cdot y^4$ if $x = 2$ and $y = 10$.

For Exercises 11–14, use the information at the right.

11. How many stars can be seen with unaided eyes in an urban area?
12. How many stars can be seen with unaided eyes in a rural area?
13. How many stars can be seen with binoculars?
14. How many stars can be seen with a small telescope?

How Many Stars Can You See?	
Unaided Eye in Urban Area	$3 \cdot 10^2$ stars
Unaided Eye in Rural Area	$2 \cdot 10^3$ stars
With Binoculars	$3 \cdot 10^4$ stars
With Small Telescope	$2 \cdot 10^6$ stars

Source: *Kids Discover*

Practice and Applications

HOMEWORK HELP

For Exercises	See Examples
15–26	1
27–38	2, 3
39–40	4

Extra Practice See pages 621, 649.

Write each expression using exponents.

15. $8 \cdot 8 \cdot 8$
16. $5 \cdot 5 \cdot 5 \cdot 5$
17. $p \cdot p \cdot p \cdot p \cdot p \cdot p$
18. $d \cdot d \cdot d \cdot d \cdot d$
19. $3 \cdot 3 \cdot 4 \cdot 4 \cdot 4$
20. $2 \cdot 2 \cdot 2 \cdot 5 \cdot 5$
21. $4 \cdot 7 \cdot 4 \cdot 4 \cdot 7 \cdot 7 \cdot 7 \cdot 7$
22. $5 \cdot 5 \cdot 8 \cdot 8 \cdot 5 \cdot 8 \cdot 8$
23. $a \cdot a \cdot b \cdot b \cdot a \cdot b \cdot b \cdot a$
24. $x \cdot y \cdot y \cdot y \cdot x \cdot y \cdot y \cdot y$

25. Write the product $7 \cdot 7 \cdot 7 \cdot 15 \cdot 15 \cdot 7$ using exponents.
26. Write the product $5 \cdot 12 \cdot 12 \cdot 12 \cdot 5 \cdot 5 \cdot 5 \cdot 5$ using exponents.

Evaluate each expression.

27. 2^3
28. 3^4
29. 3^5
30. 9^3
31. $3^2 \cdot 5^2$
32. $3^3 \cdot 4^2$
33. $2^5 \cdot 5^3$
34. $3^2 \cdot 7^3$
35. 5^{-4}
36. 9^{-3}
37. $2^3 \cdot 7^{-2}$
38. $5^2 \cdot 2^{-7}$

39. **ALGEBRA** Evaluate $g^5 \cdot h$ if $g = 2$ and $h = 7$.

40. **ALGEBRA** Evaluate $x^3 \cdot y^4$ if $x = 1$ and $y = 3$.

41. **BIOLOGY** Suppose a bacterium splits into two bacteria every 20 minutes. How many bacteria will there be in 2 hours?

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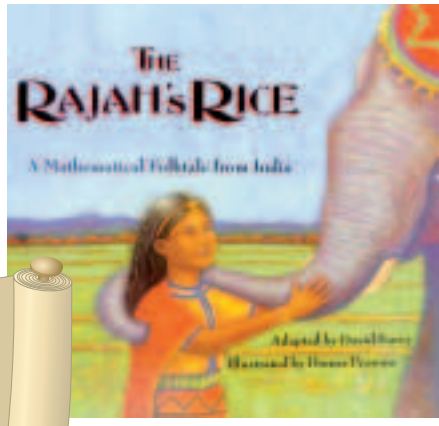


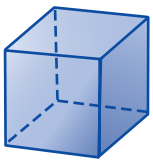
42. LITERATURE *The Rajah's Rice* is the story of a young girl named Chandra. She loved elephants and helped take care of the Rajah's elephants. The Rajah was pleased and wanted to reward her. She asked for the following reward.

> "If Your Majesty pleases, place two grains of rice on the first square of this chessboard. Place four grains on the second square, eight on the next, and so on, doubling each pile of rice till the last square."

Write the number of grains of rice the Rajah should put on the last square using an exponent.

43. GEOMETRY To find the volume of a cube, multiply its length, its width, and its depth. Find the volume of each cube.


2 in.


6 in.

44. Continue the following pattern.

$3^4 = 81, 3^3 = 27, 3^2 = 9, 3^1 = 3,$
$3^0 = ?, 3^{-1} = ?, 3^{-2} = ?, 3^{-3} = ?$

45. CRITICAL THINKING Write each of the following as a power of 10 or the product of a whole number between 1 and 10 and a power of 10.

a. 100,000

b. fifty million

c. 3,000,000,000

d. sixty thousand

Spiral Review with Standardized Test Practice

46. MULTIPLE CHOICE Write $5 \cdot 5 \cdot 7 \cdot 7 \cdot 7 \cdot q \cdot q$ using exponents.

(A) $5 \cdot 12^2 \cdot q^2$ (B) $5^2 \cdot 7^3 \cdot q^2$ (C) $35^2 \cdot q^2$ (D) $70\,q^2$

47. SHORT RESPONSE Write $2^3 \cdot 6^2$ in expanded form. Then find its value.

48. FOOD Suppose hamburgers are cut in the shape of a square that is $2\frac{1}{2}$ inches on a side. Write a multiplication equation to determine how many hamburgers can fit across a grill that is 30 inches wide. Solve the equation. (Lesson 2-7)

Add or subtract. Write in simplest form. (Lesson 2-6)

49. $\frac{1}{6} + \frac{4}{9}$ **50.** $\frac{2}{5} - \frac{1}{4}$ **51.** $1\frac{1}{2} - \left(-\frac{7}{9}\right)$ **52.** $-\frac{1}{8} + \frac{5}{6}$

53. ALGEBRA Write an algebraic expression for *12 more than a number.* (Lesson 1-7)

GETTING READY FOR THE NEXT LESSON

BASIC SKILL Write each number.

54. two million **55.** three hundred twenty **56.** twenty-six hundred

2-8b HANDS-ON LAB

A Follow-Up of Lesson 2-8

Binary Numbers

What You'll LEARN

Use binary numbers.

Materials

- paper and pencil
- grid paper

Computers have a language of their own. The digits 0 and 1, also called bits, translate into OFF and ON within the computer's electronic switches system. Numbers that use only the digits 0 and 1 are called **base two numbers** or **binary numbers**. For example, 101001_2 is a binary number. The small 2 after 101001_2 means the number is in base two.

INVESTIGATE

1. Copy and complete the table for the powers of 2.

Power of Two	2^5	2^4	2^3	2^2	2^1
Value	32				

2. Use the pattern in the table to determine the value of 2^0.

Find the value of each expression.

3. $2^3 + 2^2 + 2^0$
4. $2^4 + 2^2$
5. $2^5 + 2^3 + 2^2$
6. $2^5 + 2^2 + 2^0$
7. $2^4 + 2^3 + 2^2 + 2^1$
8. $2^5 + 2^4 + 2^1 + 2^0$

When using binary numbers, use the following rules.

- The digits 0 and 1 are the only digits used in base two.
- The digit 1 represents that the power of two is ON. The digit 0 represents the power is OFF.

Binary numbers can be written in our standard base ten system.

ACTIVITY *Work with a partner.*

1 **Write 10011_2 in base ten.**

10011_2 is in base two. Each place value represents a power of 2.

1	0	0	1	1
ON	OFF	OFF	ON	ON
2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1

$$\begin{aligned} 10011_2 &= (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= (1 \times 16) + (0 \times 8) + (0 \times 4) + (1 \times 2) + (1 \times 1) \\ &= 16 + 0 + 0 + 2 + 1 \text{ or } 19 \end{aligned}$$

Therefore, 10011_2 is 19 in base ten.

Your Turn **Write each number in base ten.**

a. 10101_2 b. 1001_2 c. 110110_2

You can also reverse the process and write base ten numbers in base two.

ACTIVITY *Work with a partner.*

2 **Write 38 in base two.**

STEP 1 Make a base two place-value chart.

2^6 or 64	2^5 or 32	2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1

STEP 2 Find the greatest power of 2 that is less than or equal to 38. Place a 1 in that place value.

2^6 or 64	2^5 or 32	2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1
	1					

STEP 3 Since $38 - 32 = 6$, find the greatest power of 2 that is less than or equal to 6. Place a 1 in that place value.

2^6 or 64	2^5 or 32	2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1
	1			1		

STEP 4 Since $6 - 4 = 2$, find the greatest power of 2 that is less than or equal to 2. Place a 1 in that place value.

2^6 or 64	2^5 or 32	2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1
	1			1	1	

STEP 5 Since $2 - 2 = 0$, place a 0 in any unfilled spaces.

2^6 or 64	2^5 or 32	2^4 or 16	2^3 or 8	2^2 or 4	2^1 or 2	2^0 or 1
0	1	0	0	1	1	0

The zero at the far left is not needed as a placeholder. Therefore, 38 in base ten is equal to 100110 in base two. Or, $38 = 100110_2$.

Your Turn **Write each number in base two.**

d. 46 **e.** 70 **f.** 15

Writing Math

1. **Explain** how to determine the place value of each digit in base two.
2. **Make** a place-value chart of the first four digits in base five.
3. **Identify** the digits you would use in base five.
4. **MAKE A CONJECTURE** Explain how to determine the place values for base n. What digits would you use for base n?

2-9 Scientific Notation

What You'll LEARN

Express numbers in scientific notation.

NEW Vocabulary

scientific notation

WHEN am I ever going to use this?

LANGUAGES The most frequently spoken languages are listed in the table.

1. All of the values contain 10^8. What is the value of 10^8?
2. How many people speak Mandarin as their native language?
3. How many people speak English as their native language?

Top Five Languages of the World

Language	Where Spoken	Number of Native Speakers
Mandarin	China, Taiwan	8.74×10^8
Hindi	India	3.66×10^8
English	U.S.A., Canada, Britain	3.41×10^8
Spanish	Spain, Latin America	3.22×10^8
Arabic	Arabian Peninsula	2.07×10^8

Source: *The World Almanac for Kids*

The number 8.74×10^8 is written in **scientific notation**. Scientific notation is often used to express very large or very small numbers.

Noteables™

Key Concept: Scientific Notation

A number is expressed in scientific notation when it is written as the product of a factor and a power of 10. The factor must be greater than or equal to 1 and less than 10.

Multiplying by a positive power of 10 moves the decimal point right. Multiplying by a negative power of 10 moves the decimal point left.

EXAMPLES Express Numbers in Standard Form

1 **Write 5.34×10^4 in standard form.**

$5.34 \times 10^4 = 5.34 \times 10{,}000$ $10^4 = 10 \cdot 10 \cdot 10 \cdot 10$ or 10,000

$= 53{,}400$ The decimal point moves 4 places to the right.

2 **Write 3.27×10^{-3} in standard form.**

$3.27 \times 10^{-3} = 3.27 \times \frac{1}{10^3}$ $10^{-3} = \frac{1}{10^3}$

$= 3.27 \times 0.001$ $\frac{1}{10^3} = \frac{1}{1{,}000}$ or 0.001

$= 0.00327$ The decimal point moves 3 places to the left.

Your Turn **Write each number in standard form.**

a. 7.42×10^5 b. 6.1×10^{-2} c. 3.714×10^2

Flash! Light/Stock Boston

CONTENTS

To write a number in scientific notation, place the decimal point after the first nonzero digit. Then find the power of 10. If a number is between 0 and 1, the power of ten is negative. Otherwise, the power of ten is positive.

STUDY TIP

Scientific Notation and Calculators
To enter 3.725×10^6, use the following keystrokes.
3.725 EE 6
The screen will display **3.725E6**. This means 3.725×10^6.

EXAMPLES Write Numbers in Scientific Notation

3 **Write 3,725,000 in scientific notation.**

$3{,}725{,}000 = 3.725 \times 1{,}000{,}000$ The decimal point moves 6 places.

$= 3.725 \times 10^6$ The exponent is positive.

4 **Write 0.000316 in scientific notation.**

$0.000316 = 3.16 \times 0.0001$ The decimal point moves 4 places.

$= 3.16 \times 10^{-4}$ The exponent is negative.

Your Turn **Write each number in scientific notation.**

d. 14,140,000 **e.** 0.00876 **f.** 0.114

EXAMPLE Compare Numbers in Scientific Notation

REAL-LIFE MATH

TRAVEL In 2002, 5.455×10^{11} dollars were spent on travel expenditures in the United States.
Source: www.tia.org

5 **TRAVEL** **The number of visitors from various countries to the United States in a recent year are listed in the table. Order the countries according to the number of visitors from greatest to least.**

International Visitors to the U.S.A.

Country	Number of Visitors
Canada	1.46×10^7
France	1.1×10^6
Germany	1.8×10^6
Japan	5.1×10^6
Mexico	1.03×10^7
United Kingdom	4.7×10^6

Source: International Trade Association

First, order the number according to their exponents. Then order the number with the same exponents by comparing the factors.

Canada and Mexico | France, Germany, Japan, and United Kingdom

Step 1

1.46×10^7 $>$ 1.1×10^6

1.03×10^7 1.8×10^6

5.1×10^6

4.7×10^6

Step 2 $1.46 > 1.03$ $5.1 > 4.7 > 1.8 > 1.1$

Canada, Mexico, Japan, United Kingdom, Germany, France

The countries in order are Canada, Mexico, Japan, United Kingdom, Germany, and France.

Skill and Concept Check

1. Writing Math Determine whether a decimal times a power of 10 is *sometimes*, *always*, or *never* scientific notation. Explain.

2. **OPEN ENDED** Write a number in scientific notation that is less than 1 and greater than 0. Then write the number in standard form.

3. **NUMBER SENSE** Is 1.2×10^5 or 1.2×10^6 closer to one million? Explain.

GUIDED PRACTICE

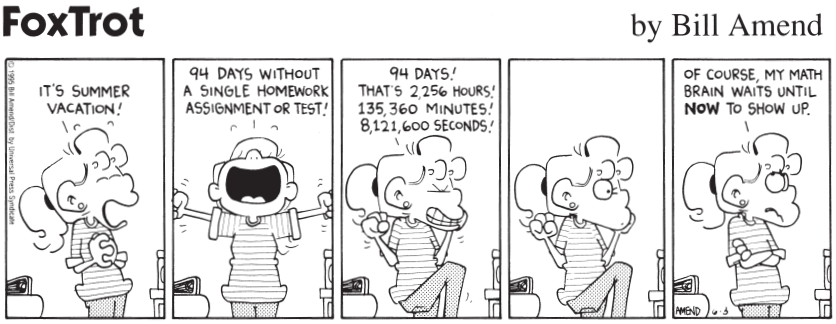
Write each number in standard form.

4. 7.32×10^4 5. 9.931×10^5 6. 4.55×10^{-1} 7. 6.02×10^{-4}

Write each number in scientific notation.

8. 277,000 9. 8,785,000,000 10. 0.00004955 11. 0.524

12. **CARTOONS** Use scientific notation to write the number of seconds in summer vacation according to the cartoon.



Practice and Applications

Write each number in standard form.

13. 2.08×10^2 14. 3.16×10^3 15. 7.113×10^7
16. 4.265×10^6 17. 7.8×10^{-3} 18. 1.1×10^{-4}
19. 8.73×10^{-4} 20. 2.52×10^{-5} 21. 1.046×10^6
22. 2.051×10^5 23. 6.299×10^{-6} 24. 5.022×10^{-7}

HOMEWORK HELP

For Exercises	See Examples
13–26	1, 2
27–28, 41	5
29–39	3, 4

Extra Practice
See pages 621, 649.

25. **DINOSAURS** The Giganotosaurus weighed 1.4×10^4 pounds. Write this number in standard form.

26. **HEALTH** The diameter of a red blood cell is about 7.4×10^{-4} centimeter. Write this number using standard form.

27. Which is greater: 6.3×10^5 or 7.1×10^4? 28. Which is less: 4.1×10^3 or 3.2×10^7?

Write each number in scientific notation.

29. 6,700 30. 43,000 31. 52,300,000 32. 147,000,000
33. 0.037 34. 0.0072 35. 0.00000707 36. 0.0000901

CONTENTS

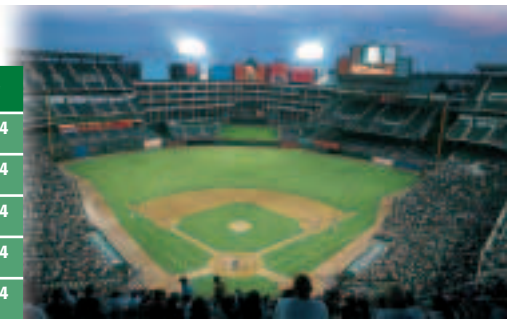
37. **TIME** The smallest unit of time is the *yoctosecond*, which equals 0.000000000000000000000001 second. Write this number in scientific notation.

38. **SPACE** The temperature of the Sun varies from 10,900°F on the surface to 27,000,000,000°F at its core. Write these temperatures in scientific notation.

39. **NUMBERS** A googol is a number written as a 1 followed by 100 zeros. Write a googol in scientific notation.

40. **SCIENCE** An oxygen atom has a mass of 2.66×10^{-23} gram. Explain how to enter this number into a calculator.

41. **BASEBALL** The following table lists five Major League Ballparks. List the ballparks from least capacity to greatest capacity.



Ballpark	Team	Capacity
H.H.H. Metrodome	Minnesota Twins	4.8×10^4
Network Associates Coliseum	Oakland Athletics	4.7×10^4
The Ballpark in Arlington	Texas Rangers	4.9×10^4
Wrigley Field	Chicago Cubs	3.9×10^4
Yankee Stadium	New York Yankees	5.5×10^4

Source: www.users.bestweb.net

Data Update What is the capacity of your favorite ballpark? Visit msmath3.net/data_update to learn more.

CRITICAL THINKING **Compute and express each value in scientific notation.**

42. $\dfrac{(130{,}000)(0.0057)}{0.0004}$

43. $\dfrac{(90{,}000)(0.0016)}{(200{,}000)(30{,}000)(0.00012)}$

Spiral Review with Standardized Test Practice

44. **MULTIPLE CHOICE** The distance from Milford to Loveland is 326 kilometers. If there are 1,000 meters in a kilometer, use scientific notation to write the distance from Milford to Loveland in meters.

A 3.26×10^6 m B 32.6×10^5 m

C 326×10^5 m D 3.26×10^5 m

45. **SHORT RESPONSE** Name the Great Lake with the second greatest area.

Great Lakes	
Lake	Area (square miles)
Erie	9.91×10^3
Huron	2.3×10^4
Michigan	2.23×10^4
Ontario	7.32×10^3
Superior	3.17×10^4

Source: *World Book*

46. **ALGEBRA** Evaluate $a^5 \cdot b^2$ if $a = 2$ and $b = 3$. (Lesson 2-8)

ALGEBRA **Solve each equation. Check your solution.** (Lesson 2-7)

47. $t + 3\frac{1}{3} = 2\frac{1}{2}$

48. $-\frac{2}{3}y = 14$

49. $\frac{p}{1.3} = 2.4$

50. $-1\frac{3}{4} = n - 4\frac{1}{6}$

msmath3.net/self_check_quiz

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CHAPTER 2

Study Guide and Review

Vocabulary and Concept Check

bar notation (p. 63)
base (p. 98)
dimensional analysis (p. 73)
exponent (p. 98)
like fractions (p. 82)
multiplicative inverses (p. 76)
power (p. 98)
rational number (p. 62)
reciprocals (p. 76)
repeating decimal (p. 63)
scientific notation (p. 104)
terminating decimal (p. 63)
unlike fractions (p. 88)

Choose the correct term to complete each sentence.

1. The (base, exponent) tells how many times a number is used as a factor.
2. Two numbers whose product is one are called (multiplicative inverses, rational numbers).
3. (Unlike fractions, Like fractions) have the same denominator.
4. A number that is expressed using an exponent is called a (power, base).
5. The (base, exponent) is the number that is multiplied.
6. The number 3.51×10^{-3} is written in (dimensional analysis, scientific notation).
7. The number $\frac{3}{4}$ is a (power, rational number).
8. Bar notation is used to represent a (terminating decimal, repeating decimal).

Lesson-by-Lesson Exercises and Examples

2-1 Fractions and Decimals (pp. 62–66)

Write each fraction or mixed number as a decimal.

9. $1\frac{1}{3}$
10. $-\frac{5}{8}$
11. $5\frac{13}{50}$
12. $-\frac{5}{6}$
13. $-2\frac{3}{10}$
14. $\frac{5}{9}$

Write each decimal as a fraction or mixed number in simplest form.

15. 0.3
16. 3.56
17. -2.75
18. -7.14
19. $4.\overline{3}$
20. $-5.\overline{7}$

Example 1 **Write $\frac{3}{5}$ as a decimal.**

$\frac{3}{5}$ means $3 \div 5$.

$$5\overline{)3.0}\quad 0.6$$
$$3\,0$$
$$0$$

The fraction $\frac{3}{5}$ can be written as 0.6.

Example 2 **Write 0.25 as a fraction in simplest form.**

$0.25 = \frac{25}{100}$ 0.25 is 25 hundredths.

$= \frac{1}{4}$ Simplify.

The decimal 0.25 can be written as $\frac{1}{4}$.

msmath3.net/vocabulary_review

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2-2 Comparing and Ordering Rational Numbers (pp. 67–70)

Replace each ● with <, >, or = to make a true sentence.

21. $\frac{2}{3}$ ● $\frac{8}{9}$

22. $-0.\overline{24}$ ● $-\frac{8}{33}$

23. $-\frac{1}{2}$ ● $-\frac{55}{110}$

24. $\frac{5}{6}$ ● $\frac{3}{4}$

25. Order $-\frac{1}{2}$, 0.75, $-\frac{3}{4}$, 0 from least to greatest.

Example 3 **Replace ● with <, >, or = to make $\frac{2}{5}$ ● 0.34 a true sentence.**

$\frac{2}{5} = 0.4$

Since $0.4 > 0.34$, $\frac{2}{5} > 0.34$.

2-3 Multiplying Rational Numbers (pp. 71–75)

Multiply. Write in simplest form.

26. $\frac{3}{5} \cdot 1\frac{2}{3}$

27. $-\frac{2}{3} \cdot \left(-\frac{2}{3}\right)$

28. $\frac{5}{6} \cdot \frac{3}{5}$

29. $\frac{1}{2} \cdot \frac{10}{11}$

30. COOKING Crystal is making $1\frac{1}{2}$ times a recipe. The original recipe calls for $3\frac{1}{2}$ cups of milk. How many cups of milk does she need?

Example 4 **Find $\frac{2}{3} \cdot \frac{5}{7}$. Write in simplest form.**

$\frac{2}{3} \cdot \frac{5}{7} = \frac{2 \cdot 5}{3 \cdot 7}$ ← Multiply the numerators. ← Multiply the denominators.

$= \frac{10}{21}$ Simplify.

2-4 Dividing Rational Numbers (pp. 76–80)

Divide. Write in simplest form.

31. $\frac{7}{9} \div \frac{1}{3}$

32. $\frac{7}{12} \div \left(-\frac{2}{3}\right)$

33. $-4\frac{2}{5} \div (-2)$

34. $6\frac{1}{6} \div \left(-1\frac{2}{3}\right)$

Example 5 **Find $-\frac{5}{6} \div \frac{3}{5}$. Write in simplest form.**

$-\frac{5}{6} \div \frac{3}{5} = -\frac{5}{6} \cdot \frac{5}{3}$ Multiply by the multiplicative inverse.

$= -\frac{25}{18}$ or $-1\frac{7}{18}$ Simplify.

2-5 Adding and Subtracting Like Fractions (pp. 82–85)

Add or subtract. Write in simplest form.

35. $\frac{5}{11} + \frac{6}{11}$

36. $\frac{1}{8} + \left(-\frac{3}{8}\right)$

37. $\frac{1}{8} - \frac{7}{8}$

38. $12\frac{4}{5} - 5\frac{3}{5}$

Example 6 **Find $\frac{1}{5} - \frac{3}{5}$. Write in simplest form.**

$\frac{1}{5} - \frac{3}{5} = \frac{1 - 3}{5}$ ← Subtract the numerators. ← The denominators are the same.

$= \frac{-2}{5}$ or $-\frac{2}{5}$ Simplify.

Mixed Problem Solving
For mixed problem-solving practice, see page 649.

2-6 Adding and Subtracting Unlike Fractions (pp. 88–91)

Add or subtract. Write in simplest form.

39. $-\frac{2}{3} + \frac{3}{5}$
40. $\frac{2}{3} + \frac{3}{4}$
41. $-4\frac{1}{2} - 6\frac{2}{3}$
42. $5 - 1\frac{2}{5}$
43. $7\frac{3}{4} + 3\frac{4}{5}$
44. $5\frac{3}{5} - 12\frac{1}{2}$

Example 7 Find $\frac{3}{4} + \frac{1}{3}$. Write in simplest form.

$\frac{3}{4} + \frac{1}{3} = \frac{9}{12} + \frac{4}{12}$ Rename the fractions.

$= \frac{9+4}{12}$ Add the numerators.

$= \frac{13}{12}$ or $1\frac{1}{12}$ Simplify.

2-7 Solving Equations with Rational Numbers (pp. 92–95)

Solve each equation. Check your solution.

45. $d - (-0.8) = 4$
46. $\frac{x}{4} = -2.2$
47. $\frac{3}{4}n = \frac{7}{8}$
48. $-7.2 = \frac{r}{1.6}$
49. **AGE** Trevor is $\frac{3}{8}$ of Maria's age. If Trevor is 15, how old is Maria?

Example 8 Solve $t + \frac{1}{3} = \frac{5}{6}$.

$t + \frac{1}{3} = \frac{5}{6}$ Write the equation.

$t + \frac{1}{3} - \frac{1}{3} = \frac{5}{6} - \frac{1}{3}$ Subtract $\frac{1}{3}$ from each side.

$t = \frac{1}{2}$ Simplify.

2-8 Powers and Exponents (pp. 98–101)

Write each expression using exponents.

50. $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$
51. $2 \cdot 2 \cdot 5 \cdot 5 \cdot 5$
52. $x \cdot x \cdot x \cdot x \cdot y$
53. $4 \cdot 4 \cdot 9 \cdot 9$

Evaluate each expression.

54. 5^4
55. $4^2 \cdot 3^3$
56. 5^{-3}
57. $4^2 \cdot 2^3$

Example 9

Write $3 \cdot 3 \cdot 3 \cdot 7 \cdot 7$ using exponents.

$3 \cdot 3 \cdot 3 \cdot 7 \cdot 7 = 3^3 \cdot 7^2$

Example 10

Evaluate 7^3.

$7^3 = 7 \cdot 7 \cdot 7$ or 343

2-9 Scientific Notation (pp. 104–107)

Write each number in standard form.

58. 3.2×10^{-3}
59. 6.71×10^4
60. 1.72×10^5
61. 1.5×10^{-2}

Write each number in scientific notation.

62. 0.000064
63. 0.000351
64. 87,500,000
65. 7,410,000

Example 11

Write 3.21×10^{-6} in standard form.

$3.21 \times 10^{-6} = 0.00000321$ Move the decimal point six places to the left.

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CHAPTER 2

Practice Test

Vocabulary and Concepts

1. **Explain** how to write a number in scientific notation.
2. **Write** $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$ using exponents.

Skills and Applications

Write each fraction or mixed number as a decimal.

3. $1\frac{2}{3}$
4. $\frac{1}{8}$
5. $-\frac{7}{20}$

Write each decimal as a fraction or mixed number in simplest form.

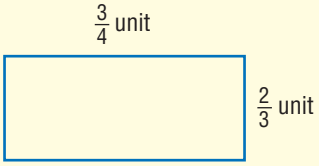
6. 0.78
7. $0.\overline{1}$
8. 2.04

Multiply, divide, add, or subtract. Write in simplest form.

9. $-\frac{2}{3} \cdot \frac{7}{8}$
10. $-6 \div \frac{2}{3}$
11. $-5\frac{1}{4} \cdot \left(-2\frac{1}{3}\right)$
12. $\frac{1}{8} \div \frac{5}{6}$
13. $-\frac{5}{7} + \frac{3}{7}$
14. $1\frac{1}{2} + \frac{2}{3}$
15. $\frac{5}{6} - \frac{1}{2}$
16. $-\frac{7}{8} - \left(-\frac{1}{4}\right)$

17. **BAKING** Madison needs $2\frac{3}{4}$ cups of flour. She has only $1\frac{1}{3}$ cups. How much does she need to borrow from her neighbor Raul?

18. **GEOMETRY** Find the perimeter of the rectangle.



Solve each equation. Check your solution.

19. $x - \frac{5}{6} = \frac{1}{3}$
20. $16 = \frac{2}{3}y$

Write each expression using exponents.

21. $4 \cdot 4 \cdot 4 \cdot 4 \cdot 4 \cdot 5 \cdot 5 \cdot 5$
22. $a \cdot a \cdot a \cdot a \cdot b \cdot b$

23. Write 8.83×10^{-7} in standard form.
24. Write 25,000 in scientific notation.

Standardized Test Practice

25. **MULTIPLE CHOICE** The table lists four movies and their running times. Which movie is the longest?

Movie	Length (h)
Movie A	$2\frac{1}{4}$
Movie B	$2.11\overline{6}$
Movie C	$2\frac{1}{6}$
Movie D	$2.18\overline{3}$

(A) Movie A (B) Movie B
(C) Movie C (D) Movie D

CHAPTER 2

Standardized Test Practice

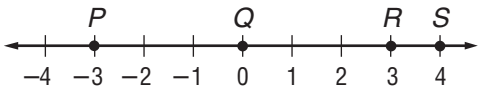
PART 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. Sonia pours 8 ounces of water into a 12-ounce glass. Which of the following fractions represents how full the glass is? (Prerequisite Skill, p. 611)

   (A) $\frac{3}{12}$ (B) $\frac{2}{3}$ (C) $\frac{8}{1}$ (D) $\frac{12}{1}$

2. Which point is graphed at $|-3|$? (Lesson 1-3)



   (F) P (G) Q (H) R (I) S

3. Which of the following is *not* equivalent to $(12)(-9)(-7)(5)$? (Lesson 1-6)

   (A) $12[(-9)(-7)]5$

   (B) $[(12)(-9)](-7)(5)$

   (C) $[(12 - 9)](-7)(5)$

   (D) $[(12)(-9)][(-7)(5)]$

4. Which decimal can be written as the fraction $\frac{5}{9}$? (Lesson 2-1)

   (F) $0.\overline{5}$ (G) $0.\overline{59}$

   (H) 1.8 (I) 9.500

5. If a whole number greater than one is multiplied by a fraction less than zero, which of the following describes the product? (Lesson 2-3)

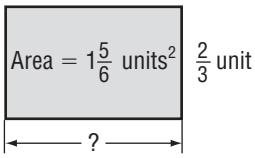
   (A) a number greater than the whole number

   (B) a negative number less than the fraction

   (C) a negative number greater than the fraction

   (D) zero

6. What is the length of the rectangle? (Lesson 2-7)



   (F) $\frac{4}{33}$ unit (G) $\frac{4}{11}$ unit

   (H) $\frac{13}{9}$ units (I) $\frac{11}{4}$ units

7. Which of the following represents the expression $12y^4$? (Lesson 2-8)

   (A) $12 \cdot y \cdot 4$

   (B) $12 \cdot 12 \cdot y \cdot y$

   (C) $12 \cdot 12 \cdot 12 \cdot 12 \cdot y$

   (D) $12 \cdot y \cdot y \cdot y \cdot y$

8. What is the same as $(2 \cdot 2 \cdot 2)^3$? (Lesson 2-8)

   (F) 3^2 (G) 2^6 (H) 8^3 (I) 222^3

9. The populations of the three largest countries in the world in 2003 are given below.

Country	Population
China	1,304,000,000
India	1,065,000,000
United States	294,000,000

Source: *The World Almanac*

   Which of the following does *not* express the population of the United States in another way? (Lesson 2-9)

   (A) 2.94×10^8 (B) 29.4×10^7

   (C) 29.4 million (D) 294 million

10. What is the standard form of 4.673×10^{-5}? (Lesson 2-9)

    (F) 0.00004673 (G) 0.004673

    (H) 46,730 (I) 467,300

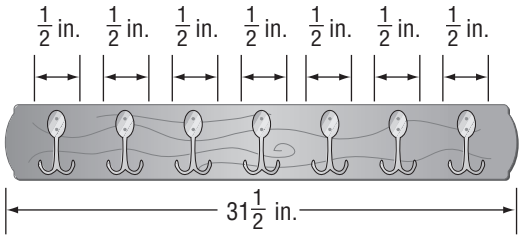
PART 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

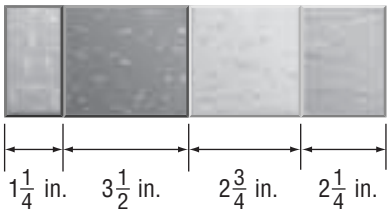
11. Salvador has finished 28 of the 40 assigned math problems. Write this ratio in a different way. (Prerequisite Skill, p. 611)

12. At a golf tournament, a player scored 3, −4, −7, and −5. What was his total score? (Lesson 1-4)

13. Olivia made a coat rack with seven hooks. She found a board that was $31\frac{1}{2}$ inches long. She divided the board evenly, making the space at the ends of the rack the same as the space between the hooks. Each hook was $\frac{1}{2}$-inch in width. What was the space between each hook? (Lesson 2-5)



14. Logan was using 4 tiles of different lengths to make a mosaic. What is the length of the mosaic shown below? (Lesson 2-6)



TEST-TAKING TIP

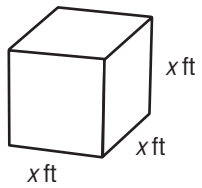
Questions 13 and 14 You cannot write mixed numbers, such as $2\frac{1}{2}$, on an answer grid. Answers such as these need to be written as improper fractions, such as 5/2, or as decimals, such as 2.5. Choose the method that you like best, so that you will avoid making unnecessary mistakes.

15. During one week, Ms. Ito biked $1\frac{3}{8}$ miles, $1\frac{3}{4}$ miles, and $1\frac{1}{2}$ miles. What was the total distance she biked that week? (Lesson 2-6)

16. Lindsey made $3\frac{3}{4}$ cups of chocolate milk. She poured $1\frac{1}{2}$ cups for her brother. How much did she have left? (Lesson 2-6)

17. Find the value of the expression $4^3 - 3^3$. (Lesson 2-8)

18. Write an expression for the volume of the cube. (Lesson 2-8)



PART 3 Extended Response

Record your answers on a sheet of paper. Show your work.

19. Leo found the value of x in the equation $\frac{5x}{6} - 7 = 3$ to be 30. Is Leo correct or incorrect? Explain. (Lesson 2-7)

20. Masons are making large bricks. The container they are using is 9 inches by 9 inches by 9 inches. They have several boxes measuring 3 inches by 3 inches by 3 inches of cement that they will use to fill the large container. (Lesson 2-8)

a. Describe how to determine the number of boxes of cement required to fill the container.

b. Write and simplify an expression to solve the problem.

c. How many boxes it will take?