Chapter 4

Rational Numbers

Essential Question
WHAT happens when you add, subtract, multiply, and divide fractions?

Common Core State Standards
Content Standards
7.NS.1, 7.NS.1b, 7.NS.1c, 7.NS.1d,
7.NS.2, 7.NS.2a, 7.NS.2b, 7.NS.2c,
7.NS.2d, 7.NS.3, 7.RP.3, 7.EE.3

Mathematical Practices
1, 3, 4, 5, 6, 7, 8

Math in the Real World
Tennis About 70,000 tennis balls are used at the U.S. Open tennis tournament each year. This is only a small fraction of the 300,000,000 tennis balls produced each year. Write a fraction in simplest form that compares the number of tennis balls used at the U.S. Open to the number produced per year.

Foldables Study Organizer
1. Cut out the Foldable on page FL9 of this book.
2. Place your Foldable on page 338.
3. Use the Foldable throughout this chapter to help you learn about rational numbers.
Vocabulary

bar notation
common denominator
least common denominator
like fractions
rational numbers
repeating decimal
terminating decimal
unlike fractions

Review Vocabulary

An improper fraction is a fraction in which the numerator is greater than or equal to the denominator, such as $\frac{21}{4}$. A mixed number is a number composed of a whole number and a fraction, such as $5\frac{1}{4}$.

In the organizer below, write each mixed number as an improper fraction and each improper fraction as a mixed number. The first one in each column is done for you.

<table>
<thead>
<tr>
<th>Change Mixed Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>$7\frac{1}{2}$ = $\frac{7}{2}$</td>
</tr>
<tr>
<td>$9\frac{1}{3}$ =</td>
</tr>
<tr>
<td>$8\frac{2}{5}$ =</td>
</tr>
<tr>
<td>$4\frac{4}{9}$ =</td>
</tr>
<tr>
<td>$10\frac{3}{8}$ =</td>
</tr>
<tr>
<td>$7\frac{3}{4}$ =</td>
</tr>
<tr>
<td>$15\frac{5}{2}$ =</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change Improper Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{41}{4}$ = $10\frac{1}{4}$</td>
</tr>
<tr>
<td>$\frac{16}{5}$ =</td>
</tr>
<tr>
<td>$\frac{23}{5}$ =</td>
</tr>
<tr>
<td>$\frac{90}{11}$ =</td>
</tr>
<tr>
<td>$\frac{64}{7}$ =</td>
</tr>
<tr>
<td>$\frac{101}{2}$ =</td>
</tr>
<tr>
<td>$\frac{87}{20}$ =</td>
</tr>
</tbody>
</table>

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What Do You Already Know?

List three things you already know about rational numbers in the first section. Then list three things you would like to learn about rational numbers in the second section.

Rational Numbers

<table>
<thead>
<tr>
<th>What I know...</th>
<th>What I want to find out...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When Will You Use This?

Here are a few examples of how rational numbers are used in the real world.

**Activity 1** Use a tape measure to find the width of a closet in your home. Do you think that a shelf that is $28\frac{3}{4}$ inches long would fit in the space that you measured? Is it too long or too short? What would you need to do to make the new shelf fit?

**Activity 2** Go online at connectED.mcgraw-hill.com to read the graphic novel Get Organized. What are the dimensions of each storage cube?
Example 1

Write $\frac{25}{100}$ in simplest form.

$$\frac{25}{100} = \frac{1}{4}$$

Divide the numerator and denominator by the GCF, 25.

Since the GCF of 1 and 4 is 1, the fraction $\frac{1}{4}$ is in simplest form.

Example 2

Graph $3\frac{2}{3}$ on a number line.

Find the two whole numbers between which $3\frac{2}{3}$ lies.

$3 < 3\frac{2}{3} < 4$

Since the denominator is 3, divide each space into 3 sections.

Draw a dot at $3\frac{2}{3}$.

Quick Check

Fractions Write each fraction in simplest form.

1. $\frac{24}{36} = \frac{2}{3}$
2. $\frac{45}{50} = \frac{9}{10}$
3. $\frac{88}{121} = \frac{8}{11}$

Graphing Graph each fraction or mixed number on the number line below.

4. $\frac{1}{2}$
5. $\frac{3}{4}$
6. $\frac{1}{4}$
7. $2\frac{1}{2}$

How Did You Do?
Which problems did you answer correctly in the Quick Check?
Shade those exercise numbers below.

1 2 3 4 5 6 7
**Inquiry Lab**

**Rational Numbers on the Number Line**

**Inquiry**

How can you graph negative fractions on the number line?

Water evaporates from Earth at an average of about $\frac{-3}{4}$ inch per week.

**Hands-On Activity**

Graph $\frac{-3}{4}$ on a number line.

**Step 1** Use the fraction strip below that is divided in fourths above a number line.

Mark a 0 on the right side and a $-1$ on the left side.

**Step 2** Starting from the right, shade three fourths. Label the number line with $\frac{-1}{4}$, $\frac{-2}{4}$, and $\frac{-3}{4}$.

**Step 3** Draw the number line portion of the model in Step 2.

Place a dot on the number line to represent $\frac{-3}{4}$.

So, on a number line, $\frac{-3}{4}$ is between $\_\_\_$ and $\_\_\_\_$ or $\_\_\_\_$.
Investigate

MP Model with Mathematics Work with a partner. Graph each fraction on a number line. Use a fraction strip if needed.

1. \(-\frac{3}{8}\)

2. \(-\frac{12}{5}\)

Analyze and Reflect

Work with a partner to complete each table. Use a number line if needed.

<table>
<thead>
<tr>
<th>(&lt;\text{ or }) &gt;</th>
<th>7/8</th>
<th>&gt;</th>
<th>3/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>9/8</td>
<td>&lt;</td>
<td>5/8</td>
</tr>
<tr>
<td>4.</td>
<td>13/8</td>
<td>&gt;</td>
<td>3/8</td>
</tr>
<tr>
<td>5.</td>
<td>15/8</td>
<td>&lt;</td>
<td>13/8</td>
</tr>
</tbody>
</table>

6. 7/8 < 3/8
7. 9/8 < 5/8
8. 13/8 > 3/8

9. MP Identify Repeated Reasoning Compare and contrast the information in the tables.

Create

10. MP Use Math Tools Graph \(-\frac{3}{4}\) and \(\frac{3}{4}\) on a number line. Then use the graph to explain how the representations of the two fractions differ.

11. Inquiry HOW can you graph negative fractions on the number line?
Terminating and Repeating Decimals

Vocabulary Start-Up

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

The decimal form of a fraction is called a **repeating decimal**. Repeating decimals can be represented using **bar notation**. In bar notation, a bar is drawn only over the digit(s) that repeat.

\[ 0.3333... = 0.\overline{3} \quad 0.1212... = 0.\overline{12} \quad 11.38585... = 11.\overline{385} \]

If the repeating digit is zero, the decimal is a **terminating decimal**. The terminating decimal 0.250 is typically written as 0.25.

**Match each repeating decimal to the correct bar notation.**

- 0.1111... = 0.\overline{1}
- 0.61111... = 0.6\overline{1}
- 0.616161... = 0.6\overline{1}

Real-World Link

Jamie had two hits on her first nine times at bat. To find her batting "average," she divided 2 by 9.

\[ 2 \div 9 = 0.2222... \]

Write 0.2222... using bar notation. \[ \text{[Blank]} \]

Round 0.2222... to the nearest thousandth. \[ \text{[Blank]} \]

Which **Mathematical Practices** did you use?

Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Write Fractions as Decimals

Our decimal system is based on powers of 10 such as 10, 100, and 1,000. If the denominator of a fraction is a power of 10, you can use place value to write the fraction as a decimal.

Complete the table below. Write fractions in simplest form.

<table>
<thead>
<tr>
<th>Words</th>
<th>Fraction</th>
<th>Decimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>seven tenths</td>
<td>(\frac{7}{10})</td>
<td>0.7</td>
</tr>
<tr>
<td>nineteen hundredths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>one-hundred five thousandths</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the denominator of a fraction is a factor of 10, 100, 1,000, or any greater power of ten, you can use mental math and place value.

Examples

Write each fraction or mixed number as a decimal.

1. \(\frac{74}{100}\)

   Use place value to write the equivalent decimal.

   \[\frac{74}{100} = 0.74\]  \(\text{Read } \frac{74}{100} \text{ as seventy-four hundredths.}\)

   So, \(\frac{74}{100} = 0.74\).

2. \(\frac{7}{20}\)

   \[\text{Think } \frac{7}{20} = \frac{35}{100} \times \frac{5}{5}\]

   So, \(\frac{7}{20} = 0.35\).

3. \(\frac{5\frac{3}{4}}{4}\)

   \[\frac{5\frac{3}{4}}{4} = \frac{5 + \frac{3}{4}}{4}\]

   Think of it as a sum.

   \[= 5 + 0.75\]

   You know that \(\frac{3}{4} = 0.75\)

   \[= 5.75\]

   Add mentally.

   \[\text{So, } \frac{5\frac{3}{4}}{4} = 5.75\]

Got it? Do these problems to find out.

a. \(\frac{3}{10}\)  

b. \(\frac{3}{25}\)  

c. \(-\frac{6\frac{1}{2}}{2}\)
Examples

4. Write $\frac{3}{8}$ as a decimal.

\[
\begin{align*}
0.375 \\
8) 3.000 \\
- 24 \\
60 \\
- 56 \\
40 \\
- 40 \\
0
\end{align*}
\]

Divide 3 by 8.

Division ends when the remainder is 0.
So, $\frac{3}{8} = 0.375$.

5. Write $-\frac{1}{40}$ as a decimal.

\[
\begin{align*}
0.025 \\
40) 1.000 \\
- 80 \\
200 \\
- 200 \\
0
\end{align*}
\]

Divide by 40.
So, $-\frac{1}{40} = -0.025$.

6. Write $\frac{7}{9}$ as a decimal.

\[
\begin{align*}
0.777... \\
9) 7.000 \\
- 63 \\
70 \\
- 63 \\
70 \\
- 63 \\
7
\end{align*}
\]

Divide 7 by 9.

Notice that the division will never terminate in zero.
So, $\frac{7}{9} = 0.777...$ or $0.\overline{7}$. 

Got it? Do these problems to find out.

Write each fraction or mixed number as a decimal. Use bar notation if needed.

d. $-\frac{7}{8}$
e. $2\frac{1}{8}$
f. $-\frac{3}{11}$
g. $8\frac{1}{3}$
Write Decimals as Fractions

Every terminating decimal can be written as a fraction with a denominator of 10, 100, 1,000, or a greater power of ten. Use the place value of the final digit as the denominator.

Example

7. Find the fraction of the fish in the aquarium that are goldfish. Write in simplest form.

\[
0.15 = \frac{15}{100} \quad \text{The digit 5 is in the hundredths place}
\]

\[
= \frac{3}{20} \quad \text{Simplify.}
\]

So, \( \frac{3}{20} \) of the fish are goldfish.

Got it? Do these problems to find out.

Determine the fraction of the aquarium made up by each fish. Write the answer in simplest form.

h. molly 

i. guppy 

j. angelfish

Guided Practice

Write each fraction or mixed number as a decimal. Use bar notation if needed. (Examples 1–6)

1. \( \frac{2}{5} \) = 

2. \( \frac{9}{10} \) = 

3. \( \frac{5}{9} \) = 

4. During a hockey game, an ice resurfacer travels 0.75 mile. What fraction represents this distance? (Example 7)

5. **Building on the Essential Question** How can you write a fraction as a decimal?

Rate Yourself!

Are you ready to move on? Shade the section that applies.

YES

NO

For more help, go online to access a Personal Tutor.
Write each fraction or mixed number as a decimal. Use bar notation if needed. (Examples 1–6)

1. \( \frac{1}{2} = \) 
2. \( -4 \frac{4}{25} = \) 
3. \( \frac{1}{8} = \) 
4. \( \frac{3}{16} = \) 

5. \( -\frac{33}{50} = \) 
6. \( -\frac{17}{40} = \) 
7. \( 5\frac{7}{8} = \) 
8. \( 9\frac{3}{8} = \)

9. \( -\frac{8}{9} = \) 
10. \( -\frac{1}{6} = \) 
11. \( -\frac{8}{11} = \) 
12. \( 2\frac{6}{11} = \)

Write each decimal as a fraction or mixed number in simplest form. (Example 7)

13. \( -0.2 = \) 
14. \( 0.55 = \) 
15. \( 5.96 = \)

16. The screen on Brianna’s new phone is 2.85 centimeters long. What mixed number represents the length of the phone screen? (Example 7)

17 STEM A praying mantis is an interesting insect that can rotate its head 180 degrees. Suppose the praying mantis at the right is 10.5 centimeters long. What mixed number represents this length? (Example 7)
18. **Persevere with Problems** Suppose you buy a 1.25-pound package of ham at $5.20 per pound.
   a. What fraction of a pound did you buy?

   b. How much money did you spend?

19. **H.O.T. Problems** Higher Order Thinking

   19. **Identify Structure** Write a fraction that is equivalent to a terminating decimal between 0.5 and 0.75.

20. **Persevere with Problems** Fractions in simplest form that have denominators of 2, 4, 8, 16, and 32 produce terminating decimals. Fractions with denominators of 6, 12, 18, and 24 produce repeating decimals. What causes the difference? Explain.

21. **Persevere with Problems** The value of π (pi) is 3.1415926... The mathematician Archimedes believed that π was between $3\frac{1}{7}$ and $3\frac{10}{71}$. Was Archimedes correct? Explain your reasoning.

22. **Reason Inductively** A unit fraction is a fraction that has 1 as its numerator. Write the four greatest unit fractions that are repeating decimals. Then write each fraction as a decimal.

23. **Model with Mathematics** Write a real-world scenario in which it would be appropriate to write a value in fractional form.
Write each fraction or mixed number as a decimal. Use bar notation if needed.

24. \( \frac{4}{5} = 0.8 \)  
25. \( -\frac{7}{20} = \)  
26. \( -\frac{4}{9} = \)  
27. \( 5\frac{1}{3} = \)

28. The fraction of a dime that is made up of copper is \( \frac{12}{16} \). Write this fraction as a decimal.

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

29. \(-0.9 = \)  
30. \(0.34 = \)  
31. \(2.66 = \)

Write each of the following as an improper fraction.

32. \(-13 = \)  
33. \(7\frac{1}{3} = \)  
34. \(-3.2 = \)

35. **Be Precise** Nicolás practiced playing the cello for 2 hours and 18 minutes. Write the time Nicolás spent practicing as a decimal.
36. The table shows the lengths of four hiking trails. Select the appropriate decimal equivalent of each trail length.

<table>
<thead>
<tr>
<th>Hiking Trail</th>
<th>Trail Length</th>
<th>Decimal Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lakeview</td>
<td>1\frac{1}{4}</td>
<td></td>
</tr>
<tr>
<td>Forest Lane</td>
<td>1\frac{1}{3}</td>
<td></td>
</tr>
<tr>
<td>Sparrow Stroll</td>
<td>1\frac{3}{10}</td>
<td></td>
</tr>
<tr>
<td>Mountain Climb</td>
<td>1\frac{2}{3}</td>
<td></td>
</tr>
</tbody>
</table>

37. Zoe went to lunch with a friend. After tax, her bill was $12.05. Which of the following rational numbers is equivalent to this amount? Select all that apply.

- $12\frac{1}{20}$
- $\frac{25}{2}$
- $\frac{241}{20}$
- $12\frac{5}{100}$

**Common Core Spiral Review**

Round each decimal to the tenths place. \(5.NBT.4\)

38. \(5.69 \approx \) 39. \(0.05 \approx \) 40. \(98.99 \approx \)

Graph and label each fraction on the number line below. \(6.NS.6\)

41. \(\frac{1}{2}\) 42. \(\frac{3}{4}\) 43. \(\frac{2}{3}\)

44. The table shows the discount on athletic shoes at two stores selling sporting equipment. Which store is offering the greater discount? Explain. \(6.NS.7\)

<table>
<thead>
<tr>
<th>Store</th>
<th>Discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Sports</td>
<td>(\frac{1}{3})</td>
</tr>
<tr>
<td>So Time</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Need more practice?** Download more Extra Practice at connectED.mheducation.com.
A **rational number** is a number that can be expressed as a ratio of two integers written as a fraction, in which the denominator is not zero. The Venn diagram below shows that the number 2 can be called many things. It is a whole number, integer, and rational number. The number $-1.4444...$ is only a rational number.

Common fractions, terminating and repeating decimals, percents, and integers are all rational numbers.

**Write the numbers from the number bank on the diagram.**

Not all numbers are rational numbers. The Greek letter $\pi$ (pi) represents the nonterminating and nonrepeating number whose first few digits are 3.14... . This number is an **irrational number**.

Use the Internet to search for the digits of $\pi$. Describe what you find.

**Which **Mathematical Practices** did you use? Shade the circle(s) that applies.**

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Compare Rational Numbers

A common denominator is a common multiple of the denominators of two or more fractions. The least common denominator or LCD is the LCM or least common multiple of the denominators. You can use the LCD to compare fractions. You can also use a number line.

Example

1. Fill in the circle with <, >, or = to make \(-\frac{5}{6} \bigcirc \frac{4}{6}\) a true sentence.

Graph each rational number on a number line.
Mark off equal-size increments of \(\frac{1}{6}\) between \(-2\) and \(-1\).

The number line shows that \(-\frac{5}{6} < -\frac{1}{6}\).

Got it? Do this problem to find out.

a. Use the number line to compare \(-\frac{5}{6}\) and \(-\frac{1}{6}\).

Example

2. Fill in the circle with <, >, or = to make \(\frac{7}{12} \bigcirc \frac{8}{18}\) a true sentence.

The LCD of the denominators 12 and 18 is 36.

\[
\frac{7}{12} = \frac{7 \times 3}{12 \times 3} = \frac{21}{36} \\
\frac{8}{18} = \frac{8 \times 2}{18 \times 2} = \frac{16}{36}
\]

Since \(\frac{21}{36} > \frac{16}{36}\), \(\frac{7}{12} > \frac{8}{18}\).

Got it? Do these problems to find out.

b. \(\frac{5}{6} \bigcirc \frac{7}{9}\)

c. \(\frac{1}{5} \bigcirc \frac{7}{50}\)

d. \(\frac{9}{16} \bigcirc \frac{7}{10}\)
Example

3. In Mr. Huang’s class, 20% of students own roller shoes. In Mrs. Trevino’s class, 5 out of 29 students own roller shoes. In which class does a greater fraction of students own roller shoes?

Express each number as a decimal and then compare.

$20\% = 0.2 \quad \frac{5}{29} = 5 \div 29$ or about $0.1724$

Since $0.2 > 0.1724$, $20\% > \frac{5}{29}$.

More students in Mr. Huang’s class own roller shoes.

Got it? Do this problem to find out.

e. In a second period class, 37.5% of students like to bowl. In a fifth period class, 12 out of 29 students like to bowl. In which class does a greater fraction of the students like to bowl?

Order Rational Numbers

You can order rational numbers using place value.

Example

4. Order the set $\{3.44, \pi, 3.14, 3.\bar{4}\}$ from least to greatest.

Line up the decimal points and compare using place value.

$3.140 \quad \text{Annex a zero.}$
$3.1415926... \quad \pi \approx 3.1415926...$
$\text{}$
$3.440 \quad \text{Annex a zero.}$
$3.444... \quad 3.\bar{4} = 3.444...$

Since $0 < 1$, $3.14 < \pi$.

So, the order of the numbers from least to greatest is $3.14, \pi, 3.44, \text{ and } 3.\bar{4}$.

Got it? Do this problem to find out.

f. Order the set $\{23\%, 0.21, \frac{1}{4}, \frac{1}{5}\}$ from least to greatest.
5. Nolan is the quarterback on the football team. He completed 67% of his passes in the first game. He completed 0.64, $\frac{3}{5}$, and 69% of his passes in the next three games. List Nolan's completed passing numbers from least to greatest.

Express each number as a decimal and then compare.

$67\% = 0.67 \quad 0.64 \quad \frac{3}{5} = 0.6 \quad 69\% = 0.69$

Nolan's completed passing numbers from least to greatest are $\frac{3}{5}$, 0.64, 67%, and 69%.

Guided Practice

Fill in each circle with $<$, $>$, or $=$ to make a true sentence. Use a number line if necessary. (Examples 1 and 2)

1. \(-\frac{4}{5}\) \(\circ\) \(-\frac{1}{5}\)

2. \(\frac{3}{4}\) \(\circ\) \(\frac{5}{8}\)

3. Elliot and Shanna are both soccer goalies. Elliot saves 3 goals out of 4. Shanna saves 7 goals out of 11. Who has the better average, Elliot or Shanna? Explain. (Example 3)

4. The lengths of four insects are 0.02 inch, $\frac{1}{8}$ inch, 0.1 inch, and $\frac{2}{3}$ inch. List the lengths in inches from least to greatest. (Examples 4 and 5)

5. **Building on the Essential Question** How can you compare two fractions?
Independent Practice

Fill in each circle with <, >, or = to make a true sentence. Use a number line if necessary. (Examples 1 and 2)

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

2. $-\frac{7}{5} \bigcirc -\frac{7}{8}$

3. $6\frac{2}{3} \bigcirc 6\frac{1}{x}$

4. $-\frac{17}{24} \bigcirc -\frac{11}{12}$

5. On her first quiz in social studies, Meg answered 92% of the questions correctly. On her second quiz, she answered 27 out of 30 questions correctly. On which quiz did Meg have the better score? (Example 3)

Order each set of numbers from least to greatest. (Example 4)

6. $[0.23, 19\%, \frac{1}{5}]$

7. $[-0.615, -\frac{5}{8}, -0.62]$ (Example 4)

8. Liberty Middle School is holding a fundraiser. The sixth-graders have raised 52% of their goal amount. The seventh- and eighth-graders have raised 0.57 and $\frac{2}{5}$ of their goal amounts, respectively. List the classes in order from least to greatest of their goal amounts. (Example 5)

Fill in each circle with <, >, or = to make a true sentence.

9. $7\frac{7}{12} \bigcirc 1\frac{5}{6}$ gallons

10. $2\frac{5}{6} \bigcirc 2.8$ hours
11. **Model with Mathematics** Refer to the graphic novel frame below. If the closet organizer has a total width of $69\frac{1}{8}$ inches and the closet is $69\frac{3}{4}$ inches wide, will the organizer fit? Explain.

![Image with characters discussing measurements]

We can do this! All we need to do is find a common denominator for all of the measurements before we add.

Caitlyn and Theresa are helping me install a new closet organizer.

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**H.O.T. Problems** Higher Order Thinking

12. **Justify Conclusions** Identify the ratio that does not have the same value as the other three. Explain your reasoning.

- $\frac{12}{15}$
- 0.08
- 80%
- $\frac{4}{5}$

---

13. **Persevere with Problems** Explain how you know which number, $\frac{15}{16}$, $\frac{17}{8}$, or $\frac{63}{32}$, is closest to 2.

---

14. **Reason Inductively** Are the fractions $\frac{5}{6}$, $\frac{5}{7}$, $\frac{5}{8}$, and $\frac{5}{9}$ arranged in order from least to greatest or from greatest to least? Explain.

---

15. **Model with Mathematics** Write a real-world problem in which you would compare and order rational numbers. Then solve the problem.

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Fill in each \( \bigcirc \) with \(<\), \(>\), or \(=\) to make a true sentence. Use a number line if necessary.

16. \( -\frac{5}{7} \bigcirc -\frac{2}{7} \)

Mark off equal-size increments of \(\frac{1}{7}\) between \(-1\) and \(0\).

17. \(-3\frac{2}{3} \bigcirc -3\frac{4}{6}\)

18. \(\frac{4}{7} \bigcirc \frac{5}{8}\)

The LCD of the denominators 7 and 8 is 56.

\[
\frac{4}{7} = \frac{4 \times 8}{7 \times 8} = \frac{32}{56}\quad \text{and}\quad \frac{5}{8} = \frac{5 \times 7}{8 \times 7} = \frac{35}{56}
\]

Since \(\frac{32}{56} < \frac{35}{56}\), \(\frac{4}{7} < \frac{5}{8}\).

19. \(2\frac{3}{4} \bigcirc 2\frac{2}{3}\)

20. Gracia and Jim were shooting free throws. Gracia made 4 out of 15 free throws. Jim missed 6 out of 16 free throws. Who made the free throw a greater fraction of the time?

Order each set of numbers from least to greatest.

21. \((7.49, 7\frac{49}{50}, 7.5\%\))

22. \((-1.4, -1\frac{1}{25}, -1.25\))

23. **STEM** Use the table that shows the lengths of small mammals.
   a. Which animal is the smallest mammal?

   b. Which animal is smaller than the European Mole but larger than the Spiny Pocket Mouse?

   c. Order the animals from greatest to least size.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Chipmunk</td>
<td>(\frac{1}{3})</td>
</tr>
<tr>
<td>European Mole</td>
<td>(\frac{5}{12})</td>
</tr>
<tr>
<td>Masked Shrew</td>
<td>(\frac{1}{6})</td>
</tr>
<tr>
<td>Spiny Pocket Mouse</td>
<td>0.25</td>
</tr>
</tbody>
</table>
24. The sales tax rates from 4 different counties are shown in the table. Convert each sales tax rate to a decimal. Then sort the counties from least to greatest tax rates.

<table>
<thead>
<tr>
<th>County</th>
<th>Sales Tax Rate (as a decimal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton</td>
<td>$\frac{9}{160}$</td>
</tr>
<tr>
<td>Oakland</td>
<td>5.75%</td>
</tr>
<tr>
<td>Green</td>
<td>$\frac{7}{8}$</td>
</tr>
<tr>
<td>Campbell</td>
<td>$\frac{11}{200}$</td>
</tr>
</tbody>
</table>

Which county has the lowest sales tax rate?  

25. The daily price changes for a stock are shown in the table. Determine if each statement is true or false.

a. The price increased by the greatest amount on Thursday.  
   - True  
   - False  

b. The price decreased by the greatest amount on Tuesday.  
   - True  
   - False  

c. The price decreased by the least amount on Monday.  
   - True  
   - False  

26. -2  
27. -4  
28. -20  

29. -7  
30. -10  
31. 50  

32. Victoria, Cooper, and Diego are reading the same book for their language arts class. The table shows the fraction of the book each student has read. Which student has read the least amount? Explain your reasoning.  

<table>
<thead>
<tr>
<th>Student</th>
<th>Amount Read</th>
</tr>
</thead>
</table>
| Victoria| $\frac{2}{5}$  
| Cooper  | $\frac{1}{5}$  
| Diego   | $\frac{2}{5}$  

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In eight times at bat, Max hit 2 doubles, 5 singles, and struck out 1 time. Find the fraction of the times that Max hit either a single or a double.

**Hands-On Activity 1**

**Step 1** Since there were 8 times at bat, create a vertical line that is divided into eighths.

**Step 2** Graph the fraction of doubles, $\frac{2}{8}$, on the number line.

**Step 3** From the $\frac{2}{8}$ point, count $\frac{5}{8}$ more on the number line.

So, $\frac{2}{8} + \frac{5}{8} = \boxed{\quad}$.

Max got a hit $\boxed{\quad}$ of the times he was at bat.
**Hands-On Activity 2**

Find \(\frac{3}{6} - \frac{4}{6}\).

**Step 1**  Divide a number line into sixths. Since we do not know if our answer is negative or positive, include fractions to the left and to the right of zero.

**Step 2**  Graph \(\frac{3}{6}\) on the number line.

**Step 3**  Move 4 units to the _____ to show taking away \(\frac{4}{6}\).

So, \(\frac{3}{6} - \frac{4}{6} = \frac{\_}{\_}\).

**Hands-On Activity 3**

Find \(\frac{4}{7} - \frac{2}{7}\). Fill in the missing numbers in the diagram below.

So, \(\frac{4}{7} - \frac{2}{7} = \frac{\_}{\_}\).
Investigate

Work with a partner. Use a number line to add or subtract. Write in simplest form.

1. \( \frac{1}{5} + \frac{2}{5} = \) __________

2. \( -\frac{3}{7} + \left(-\frac{1}{7}\right) = \) __________

3. \( -\frac{3}{8} + \frac{5}{8} = \) __________

4. \( \frac{8}{12} - \frac{4}{12} = \) __________

5. \( -\frac{4}{9} + \frac{5}{9} = \) __________

6. \( \frac{4}{7} - \frac{5}{7} = \) __________
### Analyze and Reflect

**Use Math Tools** Work with a partner to complete the table. The first one is done for you.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Use only the Numerators</th>
<th>Use a number line to add or subtract the fractions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-\frac{5}{6} - \left(\frac{1}{6}\right))</td>
<td>(-5 - (-1) = -4)</td>
<td></td>
</tr>
<tr>
<td>7. (-\frac{5}{6} - \frac{1}{6})</td>
<td>(-5 - \frac{1}{6} = -\frac{31}{6})</td>
<td></td>
</tr>
<tr>
<td>8. (\frac{5}{6} - \frac{1}{6})</td>
<td>(\frac{5}{6} - \frac{1}{6} = \frac{4}{6} = \frac{2}{3})</td>
<td></td>
</tr>
<tr>
<td>9. (-\frac{5}{6} + \frac{1}{6})</td>
<td>(-5 + \frac{1}{6} = -\frac{29}{6})</td>
<td></td>
</tr>
</tbody>
</table>

### Create

10. **Reason Inductively** Refer to the table above. Compare your results for using only the numerators with your results for using a number line. Write a rule for adding and subtracting like fractions.

11. **Inquiry** HOW can you use a number line to add and subtract like fractions?
Real-World Link

**Shoes** Sean surveyed ten classmates to find which type of tennis shoe they like to wear.

<table>
<thead>
<tr>
<th>Shoe Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Trainer</td>
<td>5</td>
</tr>
<tr>
<td>Running</td>
<td>3</td>
</tr>
<tr>
<td>High Top</td>
<td>2</td>
</tr>
</tbody>
</table>

1. What fraction of students liked to wear cross trainers?
   - Number of students that wear cross trainers. →
   - Total number of students surveyed. →

2. What fraction of students liked to wear high tops?
   - Number of students that wear high tops. →
   - Total number of students surveyed. →

3. What fraction of students liked to wear either cross trainers or high tops?
   - Fraction of students that wear cross trainers.
   - Fraction of students that wear high tops.
   - 
   - 
   - So, of the students liked to wear either cross trainers or high tops.

4. Explain how to find . Then find the sum.

Which **Mathematical Practices** did you use?
Shade the circle(s) that applies.

- Persevere with Problems
- Reason Abstractly
- Construct an Argument
- Model with Mathematics
- Use Math Tools
- Attend to Precision
- Make Use of Structure
- Use Repeated Reasoning

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Add and Subtract Like Fractions

Words
To add or subtract like fractions, add or subtract the numerators and write the result over the denominator.

Examples

<table>
<thead>
<tr>
<th>Numerator</th>
<th>Denominator</th>
<th>Algebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{5}{10} ) + ( \frac{2}{10} ) = ( \frac{5+2}{10} ) or ( \frac{7}{10} )</td>
<td>( \frac{5}{c} + \frac{2}{c} = \frac{a+b}{c} ), where ( c \neq 0 )</td>
<td></td>
</tr>
<tr>
<td>( \frac{11}{12} ) - ( \frac{4}{12} ) = ( \frac{11-4}{12} ) or ( \frac{7}{12} )</td>
<td>( \frac{a}{c} - \frac{b}{c} = \frac{a-b}{c} ), where ( c \neq 0 )</td>
<td></td>
</tr>
</tbody>
</table>

Fractions that have the same denominators are called like fractions.

Examples

Add. Write in simplest form.

1. \( \frac{5}{9} + \frac{2}{9} \)
   \[
   \frac{5}{9} + \frac{2}{9} = \frac{5+2}{9} \quad \text{Add the numerators.}
   \]
   \[
   = \frac{7}{9} \quad \text{Simplify.}
   \]

2. \( \frac{-3}{5} + \left( \frac{-1}{5} \right) \)
   \[
   \frac{-3}{5} + \left( \frac{-1}{5} \right) = \frac{-3+(-1)}{5} \quad \text{Add the numerators.}
   \]
   \[
   = \frac{-4}{5} \quad \text{or} \quad \frac{-4}{5} \quad \text{Use the rules for adding integers.}
   \]

Got it? Do these problems to find out.

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

3. Sofia ate $\frac{3}{5}$ of a cheese pizza. Jack ate $\frac{1}{5}$ of a cheese pizza and $\frac{2}{5}$ of a pepperoni pizza. How much pizza did Sofia and Jack eat altogether?

$$\frac{3}{5} + \left( \frac{1}{5} + \frac{2}{5} \right) = \frac{3}{5} + \left( \frac{2}{5} + \frac{1}{5} \right)$$

Commutative Property of Addition

$$= \left( \frac{3}{5} + \frac{2}{5} \right) + \frac{1}{5}$$

Associative Property of Addition

$$= 1 + \frac{1}{5} \text{ or } 1\frac{1}{5}$$

Simplify.

So, Sofia and Jack ate $1\frac{1}{5}$ pizzas altogether.

Got it? Do this problem to find out.

e. Eduardo used fabric to make three costumes. He used $\frac{1}{4}$ yard for the first, $\frac{2}{4}$ yard for the second, and $\frac{3}{4}$ yard for the third costume. How much fabric did Eduardo use altogether?

Examples

4. Find $\frac{5}{8} - \frac{3}{8}$.

$$\frac{5}{8} - \frac{3}{8} = \frac{5}{8} + \left( -\frac{3}{8} \right)$$

Add $\frac{3}{8}$.

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

Add the numerators.

$$= -\frac{8}{8} \text{ or } -1$$

Simplify.

5. Find $\frac{5}{8} - \frac{7}{8}$.

$$\frac{5}{8} - \frac{7}{8} = \frac{5 - 7}{8}$$

Subtract the numerators.

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

Simplify.

Got it? Do these problems to find out.

f. $\frac{5}{9} - \frac{2}{9}$

g. $\frac{5}{9} - \frac{2}{9}$

h. $\frac{11}{12} - \left( -\frac{5}{12} \right)$
Choose an Operation

You can add or subtract like fractions to solve real-world problems.

**Example**

6. About \( \frac{6}{100} \) of the population of the United States lives in Florida. Another \( \frac{4}{100} \) lives in Ohio. About what fraction more of the U.S. population lives in Florida than in Ohio?

\[
\begin{align*}
\frac{6}{100} - \frac{4}{100} &= \frac{6 - 4}{100} \\
&= \frac{2}{100} \quad \text{or} \quad \frac{1}{50}
\end{align*}
\]

Subtract the numerators. Simplify.

About \( \frac{1}{50} \) more of the U.S. population lives in Florida than in Ohio.

**Guided Practice**

Add or subtract. Write in simplest form. (Examples 1−5)

1. \( \frac{3}{5} + \frac{1}{5} = \) 

2. \( \frac{2}{7} + \frac{1}{7} = \) 

3. \( \frac{5}{6} + \frac{1}{8} + \frac{3}{8} = \) 

4. \( \frac{-4}{5} - \left( -\frac{1}{5} \right) = \) 

5. \( \frac{5}{14} - \left( -\frac{1}{14} \right) = \) 

6. \( \frac{2}{7} - \frac{6}{7} = \) 

7. Of the 50 states in the United States, 14 have an Atlantic Ocean coastline and 5 have a Pacific Ocean coastline. What fraction of U.S. states have either an Atlantic Ocean or Pacific Ocean coastline? (Example 6)

8. **Building on the Essential Question** What is a simple rule for adding and subtracting like fractions?

286 Chapter 4 Rational Numbers
Add or subtract. Write in simplest form. (Examples 1, 2, 4, and 5)

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

4. \( \frac{9}{10} - \frac{3}{10} = \)  
5. \( -\frac{3}{4} + \left( -\frac{3}{4} \right) = \)  
6. \( \frac{5}{9} - \frac{2}{9} = \)  

7. In Mr. Navarro’s first period class, \( \frac{17}{28} \) of the students got an A on their math test. In his second period class, \( \frac{11}{28} \) of the students got an A. What fraction more of the students got an A in Mr. Navarro’s first period class than in his second period class? Write in simplest form. (Example 6)

8. To make a greeting card, Bryce used \( \frac{1}{8} \) sheet of red paper, \( \frac{3}{8} \) sheet of green paper, and \( \frac{7}{8} \) sheet of white paper. How many sheets of paper did Bryce use? (Example 3)

9. The table shows the Instant Messenger abbreviations students at Hillside Middle School use the most.

<table>
<thead>
<tr>
<th>Instant Messenger Abbreviations</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBR (Later)</td>
<td>48/100</td>
</tr>
<tr>
<td>LOL (Laughing out loud)</td>
<td>25/100</td>
</tr>
<tr>
<td>BRB (Be right back)</td>
<td>19/100</td>
</tr>
<tr>
<td>CUL8R (See you later)</td>
<td>7/100</td>
</tr>
</tbody>
</table>

a. What fraction of these students uses LOL or CUL8R when using Instant Messenger?

b. What fraction of these students uses L8R or BRB when using Instant Messenger?

b. What fraction more of these students write L8R than CUL8R when using Instant Messenger?
10. **Model with Mathematics** Cross out the expression that does not belong. Explain your reasoning.

\[
\begin{array}{c}
\frac{2}{7} + \frac{3}{7} \\
\frac{4}{7} - \frac{1}{7} \\
\frac{8}{7} - \frac{3}{7} \\
\frac{10}{7} - \frac{2}{7}
\end{array}
\]

**H.O.T. Problems** Higher Order Thinking

11. **Justify Conclusions** Select two like fractions with a difference of \(
\frac{1}{3}
\) and with denominators that are not 3. Justify your selection.

12. **Persevere with Problems** Simplify the following expression.

\[
\frac{14}{15} + \frac{13}{15} - \frac{12}{15} + \frac{11}{15} - \frac{10}{15} + \cdots - \frac{4}{15} + \frac{3}{15} - \frac{2}{15} + \frac{1}{15}
\]

13. **Justify Conclusions** Is the difference between a positive like fraction and a negative like fraction always, sometimes, or never positive? Justify your answer with an example.

14. **Use Math Tools** Explain how you could use mental math to find the following sum. Then find the sum. Support your answer with a model.

\[
\frac{1}{4} + \frac{2}{3} + \frac{3}{2} + \frac{4}{1} + \frac{5}{1} + \frac{6}{4}
\]

15. **Persevere with Problems** A construction company is replacing a window in a house. The window is currently 3 feet wide by 4 feet tall. The homeowner wants to add 4\(\frac{1}{2}\) inches to each side of the window. What is the new perimeter of the window in feet? Justify your reasoning.

288 Chapter 4 Rational Numbers
Add or subtract. Write in simplest form.

16. \( \frac{4}{5} + \frac{3}{5} = \frac{7}{5} \)

17. \( \frac{5}{6} + \left( -\frac{5}{6} \right) = \)

18. \( -\frac{15}{16} + \left( -\frac{7}{16} \right) = \)

19. \( \frac{5}{8} - \frac{3}{8} = \)

20. \( \frac{7}{12} - \frac{2}{12} = \)

21. \( \frac{15}{18} - \frac{13}{18} = \)

22. Two nails are \( \frac{5}{16} \) inch and \( \frac{13}{16} \) inch long. How much shorter is the \( \frac{5}{16} \)-inch nail?

23. \( \left( \frac{81}{100} + \frac{47}{100} \right) + \frac{19}{100} = \)

24. \( \frac{1}{3} + \frac{2}{6} = \)

25. A recipe for Michigan blueberry pancakes calls for \( \frac{3}{4} \) cup flour, \( \frac{1}{4} \) cup milk, and \( \frac{1}{4} \) cup blueberries. How much more flour is needed than milk? Write in simplest form.

26. The graph shows the location of volcanic eruptions.
   a. What fraction represents the volcanic eruptions for both North and South America?

   b. How much larger is the section for Asia and South Pacific than for Europe? Write in simplest form.
27. A group of friends bought two large pizzas and ate only part of each pizza. The picture shows how much was left. How many pizzas did they eat?

28. The table shows the results of a survey on students' favorite kind of movie. Select the appropriate values to complete the model to find the fraction of students that prefer comedy or action movies.

\[
\begin{array}{c}
\text{Action} \\
\text{Comedy} \\
\text{Drama} \\
\text{Horror}
\end{array}
\begin{array}{c}
14 \\
50 \\
15 \\
60 \\
29 \\
80 \\
42 \\
100
\end{array}
\]

What fraction of the students who were surveyed prefers comedy or action movies?

29. Fill in each \( \bigcirc \) with <, >, or = to make a true sentence. 6.NS.7

\[
\begin{array}{c}
29. \frac{7}{8} \bigcirc \frac{3}{4} \\
30. \frac{1}{3} \bigcirc \frac{7}{9} \\
31. \frac{5}{7} \bigcirc \frac{4}{5} \\
32. \frac{6}{11} \bigcirc \frac{9}{14}
\end{array}
\]

Find the least common denominator for each pair of fractions. 6.NS.4

\[
\begin{array}{c}
33. \frac{1}{2} \text{ and } \frac{1}{3} \\
34. \frac{4}{7} \text{ and } \frac{3}{28} \\
35. \frac{1}{5} \text{ and } \frac{7}{6} \\
36. \frac{13}{15} \text{ and } \frac{7}{12}
\end{array}
\]

37. The results of a survey about favorite lunch choices are shown. Which lunch was chosen most often? 6.NS.7

<table>
<thead>
<tr>
<th>Favorite Lunch</th>
<th>Fraction of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pizza</td>
<td>39/50</td>
</tr>
<tr>
<td>Hot Dogs</td>
<td>3/25</td>
</tr>
<tr>
<td>Grilled Cheese</td>
<td>1/10</td>
</tr>
</tbody>
</table>

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Add and Subtract Unlike Fractions

Real-World Link:

**Time** The table shows the fractions of one hour for certain minutes.

1. What fraction of one hour is equal to the sum of 15 minutes and 20 minutes?

   
   \[
   \frac{15}{60} + \frac{20}{60} = \frac{35}{60}
   \]

2. Write each fraction of an hour in simplest form in the third column of the table.

<table>
<thead>
<tr>
<th>Number of Minutes</th>
<th>Fraction of One Hour</th>
<th>Simplified Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>(\frac{5}{60})</td>
<td>(\frac{1}{12})</td>
</tr>
<tr>
<td>10</td>
<td>(\frac{10}{60})</td>
<td>(\frac{1}{6})</td>
</tr>
<tr>
<td>15</td>
<td>(\frac{15}{60})</td>
<td>(\frac{1}{4})</td>
</tr>
<tr>
<td>20</td>
<td>(\frac{20}{60})</td>
<td>(\frac{1}{3})</td>
</tr>
<tr>
<td>30</td>
<td>(\frac{30}{60})</td>
<td>(\frac{1}{2})</td>
</tr>
</tbody>
</table>

3. Explain why \(\frac{1}{6}\) hour + \(\frac{1}{3}\) hour = \(\frac{1}{2}\) hour.

   
   [Explanation here]

4. Explain why \(\frac{1}{12}\) hour + \(\frac{1}{2}\) hour = \(\frac{7}{12}\) hour.

   
   [Explanation here]

Which **MP** Mathematical Practices did you use?

Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning

Lesson 4 Add and Subtract Unlike Fractions
**Key Concept**

**Add or Subtract Unlike Fractions**

To add or subtract fractions with different denominators,

- Rename the fractions using the least common denominator (LCD).
- Add or subtract as with like fractions.
- If necessary, simplify the sum or difference.

Before you can add two **unlike fractions**, or fractions with different denominators, rename one or both of the fractions so that they have a common denominator.

**Example**

1. Find $\frac{1}{2} + \frac{1}{4}$.

   **Method 1** Use a number line.

   ![Number line diagram]

   Divide the number line into fourths since the LCD is 4.

   **Method 2** Use the LCD.

   The least common denominator of $\frac{1}{2}$ and $\frac{1}{4}$ is 4.

   \[
   \frac{1}{2} + \frac{1}{4} = \frac{1 \times 2}{2 \times 2} + \frac{1 \times 1}{4 \times 1} = \frac{2}{4} + \frac{1}{4} = \frac{3}{4}
   \]

   Using either method, $\frac{1}{2} + \frac{1}{4} = \frac{3}{4}$.

**Got it?** Do these problems to find out.

Add. Write in simplest form.

a. $\frac{1}{6} + \frac{2}{3}$

b. $\frac{9}{10} + \left( -\frac{1}{2} \right)$

c. $\frac{1}{4} + \frac{3}{8}$

d. $-\frac{1}{3} + \left( -\frac{1}{4} \right)$
Example

2. Find \((-\frac{3}{4} + \frac{5}{9}) + \frac{7}{4}\).

\[
\left(-\frac{3}{4} + \frac{5}{9}\right) + \frac{7}{4} = \left(\frac{5}{9} + \left(-\frac{3}{4}\right)\right) + \frac{7}{4} \\
= \frac{5}{9} + \left(-\frac{3}{4} + \frac{7}{4}\right) \\
= \frac{5}{9} + 1 \text{ or } \frac{16}{9}
\]

Commutative Property of Addition

Associative Property of Addition

Simplify.

Got it? Do these problems to find out.

e. \(\frac{2}{5} + \left(\frac{4}{7} + \frac{3}{5}\right)\)

f. \((-\frac{3}{10} + \frac{5}{8}) + \frac{23}{10}\)

Example

3. Find \(-\frac{2}{3} - \frac{1}{2}\).

Method 1 Use a number line.

\[
\begin{array}{c}
\text{Method 2} \quad \text{Use the LCD.} \\
\frac{-2}{3} - \frac{1}{2} = \frac{-2 \times 2}{3 \times 2} - \frac{1 \times 3}{2 \times 3} \\
= \frac{-4}{6} - \frac{3}{6} \\
= \frac{-4 - 3}{6} \text{ or } \frac{-7}{6}
\end{array}
\]

Rename using the LCD, 6.

Simplify

Rewrite \(-\frac{4}{6}\) as \(-\frac{4}{6}\).

Subtract the numerators. Simplify.

Check by adding \(\frac{-7}{6} + \frac{1}{2} = \frac{-7}{6} + \frac{3}{6} = \frac{-4}{6}\) or \(\frac{2}{3}\).

Using either method, \(-\frac{2}{3} - \frac{1}{2} = \frac{-7}{6}\) or \(-\frac{11}{6}\).

Got it? Do these problems to find out.

Subtract. Write in simplest form.

g. \(\frac{5}{8} - \frac{1}{4}\)

h. \(\frac{3}{4} - \frac{1}{3}\)

i. \(\frac{1}{2} - \left(-\frac{2}{5}\right)\)
Choose an Operation

Add or subtract unlike fractions to solve real-world problems.

Example

4. **STEM** Use the table to find the fraction of the total population that has type A or type B blood.

<table>
<thead>
<tr>
<th>Blood Type Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABO Type</td>
</tr>
<tr>
<td>Fraction</td>
</tr>
</tbody>
</table>

To find the fraction of the total population, add \( \frac{21}{50} \) and \( \frac{1}{10} \).

\[
\frac{21}{50} + \frac{1}{10} = \frac{21 \times 1}{50 \times 1} + \frac{1 \times 5}{10 \times 5}
\]

\[
= \frac{21}{50} + \frac{5}{50}
\]

\[
= \frac{26}{50} \text{ or } \frac{13}{25}
\]

So, \( \frac{13}{25} \) of the population has type A or type B blood.

Guided Practice

Add or subtract. Write in simplest form. (Examples 1–3)

1. \( \frac{3}{5} + \frac{1}{10} = \) __________

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

3. \( \frac{7}{8} + \frac{3}{11} + \frac{1}{8} = \) __________

4. \( \frac{4}{5} - \frac{3}{10} = \) __________

5. \( \frac{3}{8} - \left( -\frac{1}{4} \right) = \) __________

6. \( \frac{3}{4} - \frac{1}{3} = \) __________

7. Cassandra cuts \( \frac{5}{16} \) inch off the top of a photo and \( \frac{3}{8} \) inch off the bottom. How much shorter is the total height of the photo now? Explain. (Example 4)

8. **Building on the Essential Question** Compare adding unlike fractions and adding like fractions.

Rate Yourself!

Are you ready to move on? Shade the section that applies.

YES ? NO

For more help, go online to access a Personal Tutor.

FOLDABLES Time to update your Foldable!
Add or subtract. Write in simplest form. (Examples 1–3)

1. \(\frac{1}{6} + \frac{3}{8} = \) 
2. \(-\frac{1}{15} + \left( -\frac{3}{5} \right) = \)
3. \(\left( \frac{15}{8} + \frac{2}{5} \right) + \left( -\frac{7}{8} \right) = \)
4. \(\left( -\frac{7}{10} \right) - \frac{2}{5} = \)
5. \(\frac{7}{9} - \frac{1}{3} = \)
6. \(\frac{-7}{12} + \frac{7}{10} = \)
7. \(-\frac{4}{9} - \frac{2}{15} = \)
8. \(\frac{5}{8} + \frac{11}{12} = \)
9. \(\frac{7}{9} + \frac{5}{6} = \)

**Justify Conclusions** Choose an operation to solve each problem. Explain your reasoning. Then solve the problem. Write in simplest form. (Example 4)

10. Mrs. Escalante was riding a bicycle on a bike path. After riding \(\frac{2}{3}\) of a mile, she discovered that she still needed to travel \(\frac{3}{4}\) of a mile to reach the end of the path. How long is the bike path?

11. Four students were scheduled to give book reports in 1 hour. After the first report, \(\frac{2}{3}\) hour remained. The next two reports took \(\frac{1}{6}\) hour and \(\frac{1}{4}\) hour. What fraction of the hour remained?

12. One hundred sixty cell phone owners were surveyed.
   a. What fraction of owners prefers using their cell phone for text messaging or playing games? Explain.
   b. What fraction of owners prefers using their phone to take pictures or text message?
13. Pepita and Francisco each spend an equal amount of time on homework. The table shows the fraction of time they spend on each subject. Complete the table by determining the missing fraction for each student.

<table>
<thead>
<tr>
<th>Homework</th>
<th>Fraction of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pepita</td>
</tr>
<tr>
<td>Math</td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>$\frac{2}{3}$</td>
</tr>
<tr>
<td>Science</td>
<td>$\frac{1}{6}$</td>
</tr>
</tbody>
</table>

14. Chelsie saves $\frac{1}{5}$ of her allowance and spends $\frac{2}{3}$ of her allowance at the mall. What fraction of her allowance remains? Explain.

---

**H.O.T. Problems** Higher Order Thinking

15. **Persevere with Problems** Fractions whose numerators are 1, such as $\frac{1}{2}$ or $\frac{1}{3}$, are called *unit fractions*. Describe a method you can use to add two unit fractions mentally.

---

16. **Use a Counterexample** Provide a counterexample to the following statement.

   *The sum of three fractions with odd numerators is never $\frac{1}{2}$."

---

17. **Reason Inductively** Suppose a bucket is placed under two faucets. If one faucet is turned on alone, the bucket will be filled in 6 minutes. If the other faucet is turned on alone, the bucket will be filled in 4 minutes. What fraction of the bucket will be filled in 1 minute if both faucets are turned on at the same time? Explain.
Add or subtract. Write in simplest form.

18. \( \frac{5}{8} + \frac{1}{4} = \frac{7}{8} \)

19. \( \frac{4}{5} - \frac{1}{6} = \) 

20. \( \frac{5}{6} - \left( -\frac{2}{3} \right) = \)

21. \( \frac{3}{10} - \left( -\frac{1}{4} \right) = \)

22. \( \frac{2}{3} + \left( \frac{3}{4} + \frac{5}{3} \right) = \)

23. \( \frac{7}{8} + \frac{1}{3} = \)

Choose an operation to solve each problem. Explain your reasoning. Then solve the problem. Write in simplest form.

24. Ebony is building a shelf to hold the two boxes shown. What is the least width she should make the shelf?

25. Makayla bought \( \frac{1}{4} \) pound of ham and \( \frac{5}{8} \) pound of turkey. How much more turkey did she buy?

26. **Persevere with Problems** Find the sum of \( \frac{3}{8} \) and \( \frac{1}{4} \). Write in simplest form.

27. **Find the Error** Theresa is finding \( \frac{1}{4} + \frac{3}{5} \). Find her mistake and correct it. Explain your answer.
28. The table shows the number of hours Orlando spent at football practice last week. Select the appropriate numbers below to complete the model to find the number of hours Orlando spent practicing on Tuesday and Friday.

\[
\begin{array}{c}
\boxed{1} + \boxed{3} = \boxed{4} + \boxed{5} = \boxed{9} \\
\boxed{10} \\
\boxed{12} \\
\boxed{16} \\
\boxed{19}
\end{array}
\]

How many hours did Orlando spend practicing on Tuesday and Friday?  

29. Brett has \(\frac{5}{6}\) of his monthly income left to spend. He has budgeted \(\frac{1}{8}\) of his income for a new video game and \(\frac{1}{3}\) of his income for savings. Determine if each statement is true or false.

a. Brett will have \(\frac{7}{8}\) of his income left if he only buys the video game.  
   - True  
   - False

b. Brett will have \(\frac{1}{2}\) of his income left if he only puts money in savings.  
   - True  
   - False

c. Brett will have \(\frac{3}{8}\) of his income left after buying the video game and putting money in savings.  
   - True  
   - False

---

**Common Core Spiral Review**

Write each improper fraction as a mixed number. 5.NF.3

30. \(\frac{7}{5} = \)  

31. \(\frac{14}{3} = \)  

32. \(\frac{101}{100} = \)  

33. \(\frac{22}{9} = \)  

34. \(\frac{77}{10} = \)  

35. \(\frac{23}{8} = \)
1. Use the expression $4\frac{5}{6} - 3\frac{2}{3}$ to find how much longer the adult hockey stick is than the junior hockey stick.

   Rename the fractions using the LCD, 6.
   Subtract the fractions.
   Then subtract the whole numbers.

   $\frac{4\frac{5}{6}}{-\frac{3\frac{2}{3}}{}} = \frac{}{\phantom{1}}$

2. Explain how to find $3\frac{7}{10} - 2\frac{2}{5}$. Then use your conjecture to find the difference.

Which **Mathematical Practices** did you use?
Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Add and Subtract Mixed Numbers

To add or subtract mixed numbers, first add or subtract the fractions. If necessary, rename them using the LCD. Then add or subtract the whole numbers and simplify if necessary.

Sometimes when you subtract mixed numbers, the fraction in the first mixed number is less than the fraction in the second mixed number. In this case, rename one or both fractions in order to subtract.

Examples

1. Find \(7\frac{4}{9} + 10\frac{2}{9}\). Write in simplest form.

   Estimate \(7 + 10 = 17\)

   \(\frac{4}{9} \quad \text{Add the whole numbers and fractions separately}\)

   \[\begin{array}{c}
   \frac{4}{9} \\
   \hline
   + 10\frac{2}{9} \\
   \hline
   17\frac{6}{9}
   \end{array}\]

   Simplify.

   \(17\frac{6}{9} \approx 17\)

2. Find \(8\frac{5}{6} - 2\frac{1}{3}\). Write in simplest form.

   Estimate \(9 - 2 = 7\)

   \(\frac{5}{6} \quad \text{ Rename the fraction using the LCD. Then subtract}\)

   \[\begin{array}{c}
   \frac{5}{6} \\
   \hline
   -2\frac{1}{3} \\
   \hline
   \frac{3}{6} \text{ or } \frac{1}{2}
   \end{array}\]

   Simplify.

   \(6\frac{1}{2} = 7\)

Got it? Do these problems to find out.

Add or subtract. Write in simplest form.

a. \(6\frac{1}{8} + 2\frac{5}{8}\)  
   b. \(5\frac{1}{5} + 2\frac{3}{10}\)  
   c. \(1\frac{5}{9} + 4\frac{1}{6}\)

d. \(5\frac{4}{5} - 1\frac{3}{10}\)  
   e. \(13\frac{7}{8} - 9\frac{3}{4}\)  
   f. \(8\frac{2}{3} - 2\frac{1}{2}\)
Example

3. Find \(2 \frac{1}{3} - 1 \frac{2}{3}\).

**Method 1** Rename Mixed Numbers

Estimate \(2 - 1 \frac{1}{2} = \frac{1}{2}\)

Since \(\frac{1}{3}\) is less than \(\frac{2}{3}\), rename \(2 \frac{1}{3}\) before subtracting.

\[
2 \frac{1}{3} = 1 \frac{3}{3} + \frac{1}{3} = 1 \frac{4}{3} \text{ or } 1 \frac{4}{3}
\]

\[
\begin{align*}
2 \frac{1}{3} & \quad \rightarrow \quad 1 \frac{4}{3} \\
-1 \frac{2}{3} & \quad \rightarrow \quad -1 \frac{2}{3}
\end{align*}
\]

Rename \(2 \frac{1}{3}\) as \(1 \frac{4}{3}\).

Subtract the whole numbers and then the fractions.

\[
\begin{align*}
\frac{2}{3} & \quad \text{Check for Reasonableness} \quad \frac{2}{3} = \frac{1}{2}\, \checkmark
\end{align*}
\]

**Method 2** Write as Improper Fractions

\[
\begin{align*}
2 \frac{1}{3} & \quad \rightarrow \quad \frac{7}{3} \\
-1 \frac{2}{3} & \quad \rightarrow \quad -\frac{5}{3}
\end{align*}
\]

Write \(2 \frac{1}{3}\) as \(\frac{7}{3}\).

Write \(1 \frac{2}{3}\) as \(\frac{5}{3}\).

Simplify.

So, \(2 \frac{1}{3} - 1 \frac{2}{3} = \frac{2}{3}\).

Using either method, the answer is \(\frac{2}{3}\).

Got it? Do these problems to find out.

Subtract. Write in simplest form.

\[
\begin{align*}
g. \quad 7 - 1 \frac{1}{2} & \quad \text{h. } 5 \frac{3}{8} - 4 \frac{11}{12} & \quad \text{i. } 11 \frac{2}{5} - 2 \frac{3}{5} \\
j. \quad 8 - 3 \frac{3}{4} & \quad \text{k. } 3 \frac{1}{4} - 1 \frac{3}{4} & \quad \text{l. } 16 - 5 \frac{5}{6}
\end{align*}
\]
Choose an Operation

Add or subtract unlike fractions to solve real-world problems.

Example

4. An urban planner is designing a skateboard park. The length of the skateboard park is $120\frac{1}{2}$ feet. The length of the parking lot is $40\frac{1}{3}$ feet. What will be the length of the park and the parking lot combined?

$$120\frac{1}{2} + 40\frac{1}{3} = 120\frac{3}{6} + 40\frac{2}{6}$$

$$= 160 + \frac{5}{6}$$

$$= 160\frac{5}{6}$$

The total length is $160\frac{5}{6}$ feet.

Guided Practice

Add or subtract. Write in simplest form. (Examples 1–3)

1. $8\frac{1}{2} + 3\frac{4}{5} =$

2. $7\frac{5}{6} - 3\frac{1}{6} =$

3. $11 - 6\frac{3}{8} =$

4. A hybrid car’s gas tank can hold $11\frac{9}{10}$ gallons of gasoline. It contains $8\frac{3}{4}$ gallons of gasoline. How much more gasoline is needed to fill the tank? (Example 4)

5. Building on the Essential Question  How can you subtract mixed numbers when the fraction in the first mixed number is less than the fraction in the second mixed number?

Rate Yourself!

How confident are you about adding and subtracting mixed numbers? Shade the ring on the target.

For more help, go online to access a Personal Tutor.
Add or subtract. Write in simplest form.  (Examples 1–3)

1. \(2\frac{1}{9} + 7\frac{4}{9} = \)  
2. \(8\frac{5}{12} + 11\frac{1}{4} = \)  
3. \(10\frac{4}{5} - 2\frac{1}{5} = \)  

4. \(9\frac{4}{5} - 2\frac{3}{10} = \)  
5. \(11\frac{3}{4} - 4\frac{1}{3} = \)  
6. \(9\frac{1}{5} - 2\frac{3}{5} = \)  

7. \(6\frac{3}{5} - 1\frac{2}{3} = \)  
8. \(14\frac{1}{6} - 7\frac{1}{3} = \)  
9. \(8 - 3\frac{2}{3} = \)  

**MP** Justify Conclusions For Exercises 10 and 11, choose an operation to solve. Explain your reasoning. Then solve the problem. Write your answer in simplest form.  (Example 4)

10. If Juliana and Brody hiked both of the trails listed in the table, how far did they hike?

<table>
<thead>
<tr>
<th>Trail</th>
<th>Length (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodland Park</td>
<td>3\frac{2}{3}</td>
</tr>
<tr>
<td>Mill Creek Way</td>
<td>5\frac{2}{15}</td>
</tr>
</tbody>
</table>

11. The length of Kasey's garden is 4\frac{5}{8} feet. Find the width of Kasey's garden if it is 2\frac{7}{8} feet shorter than the length.

12. Karen wakes up at 6:00 A.M. It takes her 1\frac{1}{4} hours to shower, get dressed, and comb her hair. It takes her 1\frac{1}{2} hour to eat breakfast, brush her teeth, and make her bed. At what time will she be ready for school?
Add or subtract. Write in simplest form.

13. \(-\frac{3}{4} + \left(-\frac{3}{4}\right) = \) ________

14. \(\frac{3}{5} + \frac{4}{2} = \) ________

15. \(6\frac{1}{3} + 1\frac{2}{3} + 5\frac{5}{9} = \) ________

16. \(\frac{3}{4} + 2\frac{5}{6} - 4\frac{1}{3} = \) ________

H.O.T. Problems Higher Order Thinking

17. **Model with Mathematics** Write a real-world problem that could be represented by the expression \(5\frac{1}{2} - 3\frac{7}{8}\). Then solve your problem.

[Blank space for student response]

18. **Persevere with Problems** A string is cut in half. One of the halves is thrown away. One fifth of the remaining half is cut away and the piece left is 8 feet long. How long was the string initially? Justify your answer.

[Blank space for student response]

19. **Model with Mathematics** Using three mixed numbers as side lengths, draw an equilateral triangle with a perimeter of \(8\frac{1}{4}\) feet.

[Blank space for student response]
Add or subtract. Write in simplest form.

20. \(6\frac{1}{4} - 2\frac{3}{4} = \frac{3}{2}\)  

21. \(8\frac{3}{8} + 10\frac{1}{3} = \)  

22. \(13 - 5\frac{5}{6} = \)

23. \(3\frac{2}{7} + 4\frac{3}{7} =\)  

24. \(4\frac{3}{10} - 1\frac{3}{4} =\)

25. \(12\frac{1}{2} - 6\frac{5}{8} = \)

**MP Justify Conclusions** Choose an operation to solve. Explain your reasoning. Then solve the problem. Write your answer in simplest form.

26. The length of Alana's hair was \(9\frac{3}{4}\) inches. After her haircut, the length was \(6\frac{1}{2}\) inches. How many inches did she have cut?

27. Emeril used a total of \(7\frac{1}{4}\) cups of flour to make three pastries. He used \(2\frac{1}{4}\) cups of flour for the first and \(2\frac{1}{3}\) cups for the second. How much flour did Emeril use for the third pastry?

28. Margarite made the jewelry shown. If the necklace is \(10\frac{5}{8}\) inches longer than the bracelet, how long is the necklace?

29. Find the perimeter of the figure. Write your answer in simplest form.

30. Suppose you want to place a shelf that is \(30\frac{1}{3}\) inches long in the center of a wall that is \(45\frac{3}{4}\) inches wide. About how far from each edge of the wall should you place the shelf?
31. A recipe for snack mix calls for $4\frac{3}{4}$ cups of cereal. The amount of peanuts needed is $1\frac{2}{3}$ cups less than the amount of cereal needed. Complete each box below to make a true statement.

The recipe calls for _____ cups of peanuts. A total of _____ cups of peanuts and cereal are needed in all.

32. Maria practiced the piano for $2\frac{1}{2}$ hours last week and $1\frac{3}{4}$ hours this week. Use the bar diagram sections to construct a bar diagram that represents how many hours Maria practiced in the past 2 weeks.

How many hours did Maria practice the piano in the past 2 weeks?

---

**Common Core Spiral Review**

Round each mixed number to its nearest whole number. Then estimate each product. 5.NF.4

33. $5\frac{1}{4} \times 7\frac{2}{3} \approx$ _____ $\times$ _____ $\approx$ _____

34. $1\frac{1}{14} \times 8\frac{14}{15} \approx$ _____ $\times$ _____ $\approx$ _____

35. Zoe's average running speed is about $6\frac{4}{5}$ miles per hour. Suppose Zoe runs for $1\frac{3}{4}$ hours. About how far will she have run? Explain. 5.NF.4

---

Need more practice? Download more Extra Practice at connectED.mcgraw-hill.com.
Case #1 Science Experiment
Casey drops a ball from a height of 12 feet. It hits the ground and bounces up half as high as it fell. This is true for each successive bounce.
What is the height the ball reaches after the fourth bounce?

1 Understand  What are the facts?
Casey dropped the ball from a height of 12 feet. It bounces up half as high for each successive bounce.

2 Plan  What is your strategy to solve this problem?
Draw a diagram to show the height of the ball after each bounce.

3 Solve  How can you apply the strategy?
The ball reaches a height of foot after the fourth bounce.

4 Check  Does the answer make sense?
Use division to check. \(12 \div 2 = 6\), \(6 \div 2 = 3\), \(3 \div 2 = 1.5\), \(1.5 \div 2 = 0.75\).

MP Be Precise If the ball is dropped from 12 feet and bounces up \(\frac{2}{3}\) as high on each successive bounce, what is the height of the fourth bounce?
Case #2 Travel
Mr. Garcia has driven 60 miles, which is \( \frac{2}{3} \) of the way to his sister's house.

How much farther does he have to drive to get to his sister's house?

1

Understand
Read the problem. What are you being asked to find?
I need to find
What information do you know?
Mr. Garcia has driven \( \frac{2}{3} \) of the way to his sister's house. This is equal to
Is there any information that you do not need to know?
I do not need to know

Plan
Choose a problem-solving strategy.
I will use the strategy.

2

Solve
Use your problem-solving strategy to solve the problem.
Use the bar diagram that represents the distance to his sister's house.
Fill in two of the sections to represent \( \frac{2}{3} \).

\[ \text{------------------- 60 miles -------------------} \]

\[ \square \] \[ \square \] \[ \square \]

Each part is \( \square \) miles. The distance to his sister's house is \( 60 + \square = \square \).

So, Mr. Garcia has \( \square \) miles left to drive.

3

Check
Use information from the problem to check your answer.
Work with a small group to solve the following cases. Show your work on a separate piece of paper.

**Case #3  Fractions**
Marta ate a quarter of a whole pie. Edwin ate \( \frac{1}{4} \) of what was left. Cristina then ate \( \frac{1}{3} \) of what was left.
What fraction of the pie remains?

**Case #4  Games**
Eight members of a chess club are having a tournament. In the first round, every player will play a chess game against every other player.
How many games will be in the first round of the tournament?

**Case #5  Distance**
Alejandro and Pedro are riding their bikes to school. After 1 mile, they are \( \frac{5}{8} \) of the way there.
How much farther do they have to go?

**Case #6  Seats**
The number of seats in the first row of a concert hall is 6. The second row has 9 seats, the third row has 12 seats, and the fourth row has 15 seats.
How many seats will be in the eighth row?
1. Define *rational number*. Give some examples of rational numbers written in different forms. (Lessons 3 and 4)

2. Fill in the blank in the sentence below with the correct term. (Lesson 1)
Repeating decimals can be represented using ________________________________.

**Skills Check and Problem Solving**

Add or subtract. Write in simplest form. (Lessons 3–5)

3. \( \frac{5}{8} + \frac{3}{8} = \) __________

4. \( -\frac{1}{9} + \frac{2}{9} = \) __________

5. \( -\frac{11}{15} - \frac{1}{15} = \) __________

6. \( 2\frac{5}{9} + 1\frac{2}{3} = \) __________

7. \( 8\frac{3}{4} - 2\frac{5}{12} = \) __________

8. \( 5\frac{1}{6} - 1\frac{1}{3} = \) __________

9. The table at the right shows the fraction of each state that is water. Order the states from least to greatest fraction of water. (Lesson 2)

<table>
<thead>
<tr>
<th>State</th>
<th>Fraction of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>( \frac{3}{41} )</td>
</tr>
<tr>
<td>Michigan</td>
<td>( \frac{40}{97} )</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>( \frac{1}{6} )</td>
</tr>
</tbody>
</table>

10. The maximum height of an Asian elephant is 9.8 feet. What mixed number represents this height? (Lesson 1) ________________________________

11. **Persevere with Problems** The table shows the weight of a newborn infant for its first year. During which three-month period was the infant’s weight gain the greatest? (Lesson 5) ________________________________

<table>
<thead>
<tr>
<th>Month</th>
<th>Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( 7\frac{1}{4} )</td>
</tr>
<tr>
<td>3</td>
<td>( 12\frac{1}{2} )</td>
</tr>
<tr>
<td>6</td>
<td>( 16\frac{5}{8} )</td>
</tr>
<tr>
<td>9</td>
<td>( 19\frac{4}{5} )</td>
</tr>
<tr>
<td>12</td>
<td>( 23\frac{3}{20} )</td>
</tr>
</tbody>
</table>
Lunch  There are 12 students at the lunch table. Two thirds of the
students ordered a hamburger for lunch. One half of those students
that ordered a hamburger put cheese on it.

Step 1  Draw an X through the students that
did not order a hamburger.

Step 2  Draw a C on the students that
ordered cheese on their hamburger.

1. What fraction of the students at the lunch table
ordered a cheeseburger? Write in simplest form.

2. What is \( \frac{1}{2} \) of \( \frac{2}{3} \)? Write in simplest form.

3. Write your own word problem that involves fractions that
can be solved using a diagram like the one above.

Which Mathematical Practices did you use?
Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Key Concept

Multiply Fractions

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

Examples

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Algebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{1}{2} \times \frac{2}{3} = \frac{1 \times 2}{2 \times 3} = \frac{2}{6} ) or ( \frac{3}{6} )</td>
<td>( \frac{a}{b} \cdot \frac{c}{d} = \frac{a \cdot c}{b \cdot d} ) or ( \frac{ac}{bd} ), where ( b, d \neq 0 )</td>
</tr>
</tbody>
</table>

When multiplying two fractions, write the product in simplest form. The numerator and denominator of either fraction may have common factors. If this is the case, you can simplify before multiplying.

Examples

Multiply. Write in simplest form.

1. \( \frac{1}{2} \times \frac{1}{3} \)
   \[ \frac{1}{2} \times \frac{1}{3} = \frac{1 \times 1}{2 \times 3} = \frac{1}{6} \]
   Multiply the numerators. Multiply the denominators. Simplify.

2. \( 2 \times \left( -\frac{3}{4} \right) \)
   \[ 2 \times \left( -\frac{3}{4} \right) = \frac{2}{1} \times \left( -\frac{3}{4} \right) = \frac{2 \times (-3)}{1 \times 4} = \frac{-6}{4} \text{ or } -\frac{3}{2} \]
   Write 2 as \( \frac{2}{1} \) and \( -\frac{3}{4} \) as \( -\frac{3}{4} \). Multiply the numerators. Multiply the denominators. Simplify.

3. \( \frac{2}{7} \times \left( -\frac{3}{8} \right) \)
   \[ \frac{2}{7} \times \left( -\frac{3}{8} \right) = \frac{1}{7} \times \left( -\frac{3}{8} \right) = \frac{1 \times (-3)}{7 \times 4} \text{ or } -\frac{3}{28} \]
   Divide 2 and 8 by their GCF, 2. Multiply.

Got it? Do these problems to find out.

Multiply. Write in simplest form.

a. \( \frac{3}{5} \times \frac{1}{2} \)

b. \( \frac{2}{3} \times (-4) \)

c. \( -\frac{1}{3} \times \left( -\frac{3}{7} \right) \)
Multiply Mixed Numbers

When multiplying by a mixed number, you can rename the mixed number as an improper fraction. You can also multiply mixed numbers using the Distributive Property and mental math.

Example

4. Find \( \frac{1}{2} \times 4 \frac{2}{5} \). Write in simplest form.

   Estimate \( \frac{1}{2} \times 4 = 2 \)

   **Method 1**  Rename the mixed number.
   \[
   \frac{1}{2} \times 4 \frac{2}{5} = \frac{1}{2} \times \frac{22}{5}
   \]
   Rename \( 4 \frac{2}{5} \) as an improper fraction, \( \frac{22}{5} \).
   Divide 2 and 22 by their GCF, 2.
   \[
   = \frac{1}{2} \times \frac{11}{5}
   \]
   Multiply.
   \[
   = \frac{11}{5}
   \]
   Simplify.
   \[
   = 2 \frac{1}{5}
   \]
   Simplify.

   **Method 2**  Use mental math.

   The mixed number \( 4 \frac{2}{5} \) is equal to \( 4 + \frac{2}{5} \).
   So, \( \frac{1}{2} \times 4 \frac{2}{5} = \frac{1}{2} \times (4 + \frac{2}{5}) \).
   Use the Distributive Property to multiply, then add mentally.
   \[
   \frac{1}{2}(4 + \frac{2}{5}) = 2 + \frac{1}{5}
   \]
   Think: Half of 4 is 2 and half of 2 fifths is 1 fifth.
   \[
   = 2 \frac{1}{5}
   \]
   Rewrite the sum as a mixed number.

Check for Reasonableness \( 2 \frac{1}{5} \approx 2 \)

So, \( \frac{1}{2} \times 4 \frac{2}{5} = 2 \frac{1}{5} \).

Using either method, the answer is \( 2 \frac{1}{5} \).

**Got it?** Do these problems to find out.

Multiply. Write in simplest form.

- d. \( \frac{1}{4} \times 8\frac{4}{9} \)
- e. \( 5\frac{1}{3} \times 3 \)
- f. \( -1\frac{7}{8} \times (-2\frac{2}{5}) \)

**Simplifying**

If you forget to simplify before multiplying, you can always simplify the final answer. However, it is usually easier to simplify before multiplying.
Example

5. Humans sleep about \( \frac{1}{3} \) of each day. Let each year equal \( 365 \frac{1}{4} \) days. Determine the number of days in a year the average human sleeps.

Find \( \frac{1}{3} \times 365 \frac{1}{4} \).

Estimate \( \frac{1}{3} \times 360 = 120 \)

\[
\frac{1}{3} \times 365 \frac{1}{4} = \frac{1}{3} \times \frac{1461}{4} = \frac{487}{4} \text{ or } 121 \frac{3}{4}
\]

Check for Reasonableness \( 121 \frac{3}{4} \approx 120 \) ✓

The average human sleeps \( 121 \frac{3}{4} \) days each year.

Guided Practice

Multiply. Write in simplest form. (Examples 1–4)

1. \( \frac{2}{3} \times \frac{1}{3} = \)

2. \( -\frac{1}{4} \times \left( -\frac{8}{9} \right) = \)

3. \( \frac{3}{4} \times \frac{2}{3} = \)

4. STEM The weight of an object on Mars is about \( \frac{2}{5} \) its weight on Earth. How much would an \( 80 \frac{1}{2} \)-pound dog weigh on Mars? (Example 5)

5. Building on the Essential Question How is the process of multiplying fractions different from the process of adding fractions?

Rate Yourself!

How well do you understand multiplying fractions? Circle the image that applies.

Clear Somewhat Clear Not So Clear

For more help, go online to access a Personal Tutor.
Multiply. Write in simplest form. (Examples 1–4)

1. \( \frac{3}{4} \times \frac{1}{6} = \) ________
2. \( \frac{2}{5} \times \frac{2}{3} = \) ________
3. \( -9 \times \frac{1}{2} = \) ________
4. \( -\frac{1}{5} \times \left( -\frac{5}{6} \right) = \) ________
5. \( \frac{2}{3} \times \frac{1}{4} = \) ________
6. \( -\frac{1}{12} \times \frac{2}{5} = \) ________

7. \( \frac{2}{5} \times \frac{15}{16} = \) ________
8. \( \frac{4}{7} \times \frac{7}{8} = \) ________
9. \( \left( -\frac{1}{2} \right) \times \frac{2}{3} = \) ________

10. The width of a vegetable garden is \( \frac{1}{3} \) times its length. If the length of the garden is \( 7\frac{3}{4} \) feet, what is the width in simplest form? (Example 5)

11. One evening, \( \frac{2}{3} \) of the students in Rick’s class watched television. Of those students, \( \frac{3}{8} \) watched a reality show. Of the students that watched the show, \( \frac{1}{4} \) of them recorded the show. What fraction of the students in Rick’s class watched and recorded a reality TV show?

Write each numerical expression. Then evaluate the expression.

12. one half of negative five eighths

13. one third of eleven sixteenths
14. Model with Mathematics Refer to the graphic novel frame below.

The height of the closet is 96 inches. How many rows of cube organizers did you want?

Four rows... if they will fit.

With a little thinking, you can help us organize this closet.

a. The height of the closet is 96 inches, and Aisha would like to have 4 rows of cube organizers. What is the most the height of each cube organizer can be?

b. Aisha would like to stack 3 shoe boxes on top of each other at the bottom of the closet. The height of each shoe box is $4\frac{1}{2}$ inches. What is the total height of the 3 boxes?

H.O.T. Problems Higher Order Thinking

15. Model with Mathematics Write a real-world problem that involves finding the product of $\frac{3}{4}$ and $\frac{1}{8}$.

16. Persevere with Problems Two positive improper fractions are multiplied. Is the product sometimes, always, or never less than 1? Explain.

17. Reason Inductively Find two fractions that satisfy each of the following.
   a. each greater than $\frac{2}{5}$ with a product less than $\frac{2}{5}$
   b. each greater than $\frac{1}{2}$ with a product greater than $\frac{1}{2}$
Multiply. Write in simplest form.

18. \(\frac{4}{5} \times (-6) = -\frac{24}{5}\)

19. \(-\frac{4}{9} \times \left(-\frac{1}{4}\right) = \frac{1}{9}\)

20. \(3\frac{1}{3} \times \left(-\frac{1}{5}\right) = -\frac{14}{15}\)

21. \(\frac{1}{3} \times \frac{3}{4} = \frac{1}{4}\)

22. \(\frac{4}{9} \times \left(-\frac{1}{8}\right) = -\frac{1}{18}\)

23. \(\frac{5}{6} \times \frac{2}{5} = \frac{1}{3}\)

24. Each DVD storage case is about \(\frac{1}{5}\) inch thick. What will be the height in simplest form of 12 cases sold together?

25. Mark left \(\frac{3}{8}\) of a pizza in the refrigerator. On Friday, he ate \(\frac{1}{2}\) of what was left of the pizza. What fraction of the entire pizza did he eat on Friday?

Multiply. Write in simplest form.

26. \(\left(\frac{1}{4}\right)^2 = \frac{1}{16}\)

27. \(\left(-\frac{2}{3}\right)^3 = -\frac{8}{27}\)

28. \(\frac{1}{3} \times \frac{2}{1} = \frac{2}{3}\)

29. **Justify Conclusions**  Alano wants to make one and a half batches of the pasta salad recipe shown at the right. How much of each ingredient will Alano need? Explain how you solved the problem.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>(\frac{1}{4}) c</td>
</tr>
<tr>
<td>Cooked pasta</td>
<td>(3\frac{3}{4}) c</td>
</tr>
<tr>
<td>Salad dressing</td>
<td>(\frac{2}{3}) c</td>
</tr>
<tr>
<td>Cheese</td>
<td>(\frac{1}{3}) c</td>
</tr>
</tbody>
</table>

30. Philip rode his bicycle at \(9\frac{1}{2}\) miles per hour. If he rode for \(\frac{3}{4}\) of an hour, how many miles in simplest form did he cover?
31. Of the dolls in Marjorie’s doll collection, \( \frac{2}{5} \) have red hair. Of these, \( \frac{1}{4} \) have green eyes, \( \frac{2}{3} \) have blue eyes, and \( \frac{1}{12} \) have brown eyes. Determine if each statement is true or false.
   a. \( \frac{1}{10} \) of Marjorie’s doll collection has red hair and green eyes.  
      □ True □ False
   b. \( \frac{4}{10} \) of Marjorie’s doll collection has red hair and blue eyes.  
      □ True □ False
   c. \( \frac{29}{60} \) of Marjorie’s doll collection has red hair and brown eyes.  
      □ True □ False

32. The table shows the number of teaspoons of vanilla needed to make different batches of cookies. Select one box from each row to describe how to find the number of teaspoons of vanilla needed to make \( n \) batches of cookies.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batches</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>( n )</td>
</tr>
<tr>
<td>Vanilla (tsp)</td>
<td>( \frac{1}{4} )</td>
<td>( \frac{1}{2} )</td>
<td>( \frac{3}{4} )</td>
<td>1</td>
<td>( \frac{1}{4} )</td>
<td></td>
</tr>
</tbody>
</table>

Row 1: Subtract | Add | Multiply | Divide
Row 2: \( 4 \) | \( n \) | \( \frac{1}{4} \)
Row 3: to | by | from
Row 4: \( 4 \) | \( n \) | \( \frac{1}{4} \)

How many teaspoons of vanilla are needed to make \( 6 \frac{1}{2} \) batches of cookies?

---

**Common Core Spiral Review**

For each multiplication sentence, write two related division sentences. 5.NBT.5

33. \( 3 \times 4 = 12 \)

34. \( \frac{1}{6} \times \frac{1}{3} = \frac{1}{18} \)

35. \( 2\frac{2}{5} \times 4\frac{1}{2} = 10\frac{4}{5} \)

36. \( 5\frac{5}{8} \times \frac{1}{5} = 6\frac{3}{4} \)

---

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**Real-World Link**

**5K Race** To raise money for a health organization, the Matthews family is participating in a 5K race. A 5K race is 5 kilometers.

1. How many meters long is the race?
   
   5 kilometers = ____ meters

2. One mile is approximately 1.6 kilometers. About how many miles is the race?
   
   5 kilometers ≈ ____ miles

3. A kilometer is a unit of length in the metric measurement system. A mile is a measure of length in the customary measurement system. Write the following units of length under the correct measurement system.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Customary</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilometer</td>
<td>mile</td>
</tr>
</tbody>
</table>

**Which **MP** Mathematical Practices did you use?**

Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Convert Between Measurement Systems

You can multiply by fractions to convert between customary and metric units. The table below lists common customary and metric relationships.

<table>
<thead>
<tr>
<th>Type of Measure</th>
<th>Customary</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1 inch (in.)</td>
<td>≈ 2.54 centimeters (cm)</td>
</tr>
<tr>
<td></td>
<td>1 foot (ft)</td>
<td>≈ 0.30 meter (m)</td>
</tr>
<tr>
<td></td>
<td>1 yard (yd)</td>
<td>≈ 0.91 meter (m)</td>
</tr>
<tr>
<td></td>
<td>1 mile (mi)</td>
<td>≈ 1.61 kilometers (km)</td>
</tr>
<tr>
<td>Weight/Mass</td>
<td>1 pound (lb)</td>
<td>≈ 453.6 grams (g)</td>
</tr>
<tr>
<td></td>
<td>1 pound (lb)</td>
<td>≈ 0.4536 kilogram (kg)</td>
</tr>
<tr>
<td></td>
<td>1 ton (T)</td>
<td>≈ 907.2 kilograms (kg)</td>
</tr>
<tr>
<td>Capacity</td>
<td>1 cup (c)</td>
<td>≈ 236.59 milliliters (mL)</td>
</tr>
<tr>
<td></td>
<td>1 pint (pt)</td>
<td>≈ 473.18 milliliters (mL)</td>
</tr>
<tr>
<td></td>
<td>1 quart (qt)</td>
<td>≈ 946.35 milliliters (mL)</td>
</tr>
<tr>
<td></td>
<td>1 gallon (gal)</td>
<td>≈ 3.79 liters (L)</td>
</tr>
</tbody>
</table>

Examples

1. Convert 17.22 inches to centimeters. Round to the nearest hundredth if necessary.

Since 2.54 centimeters ≈ 1 inch, multiply by \( \frac{2.54 \text{ cm}}{1 \text{ in.}} \).

\[
17.22 \text{ in.} \cdot \frac{2.54 \text{ cm}}{1 \text{ in.}} = 43.7388 \text{ cm}
\]

So, 17.22 inches is approximately 43.74 centimeters.

2. Convert 5 kilometers to miles. Round to the nearest hundredth if necessary.

Since 1 mile ≈ 1.61 kilometers, multiply by \( \frac{1 \text{ mi}}{1.61 \text{ km}} \).

\[
5 \text{ km} \cdot \frac{1 \text{ mi}}{1.61 \text{ km}} = 3.0958974359 \text{ mi}
\]

So, 5 kilometers is approximately 3.10 miles.

Got it? Do these problems to find out.

Complete. Round to the nearest hundredth if necessary.

a. 6 yd ≈ ___ m
b. 1.6 cm ≈ ___ in.
   c. 17 m ≈ ___ yd
Examples

3. Convert 828.5 milliliters to cups. Round to the nearest hundredth if necessary.

Since 1 cup ≈ 236.59 milliliters, multiply by \( \frac{1 \text{ c}}{236.59 \text{ mL}} \).

\[
828.5 \text{ mL} \approx 828.5 \text{ mL} \cdot \frac{1 \text{ c}}{236.59 \text{ mL}}
\]

\[
\approx \frac{828.5 \text{ c}}{236.59} \text{ or } 3.50 \text{ c}
\]

So, 828.5 milliliters is approximately 3.50 cups.

4. Convert 3.4 quarts to milliliters. Round to the nearest hundredth if necessary.

Since 946.35 milliliters ≈ 1 quart, multiply by \( \frac{946.35 \text{ mL}}{1 \text{ qt}} \).

\[
3.4 \text{ qt} \approx 3.4 \text{ qt} \cdot \frac{946.35 \text{ mL}}{1 \text{ qt}}
\]

\[
\approx 3,217.59 \text{ mL}
\]

So, 3.4 quarts is approximately 3,217.59 milliliters.

5. Convert 4.25 kilograms to pounds. Round to the nearest hundredth if necessary.

Since 1 pound ≈ 0.4536 kilogram, multiply by \( \frac{1 \text{ lb}}{0.4536 \text{ kg}} \).

\[
4.25 \text{ kg} \approx 4.25 \text{ kg} \cdot \frac{1 \text{ lb}}{0.4536 \text{ kg}}
\]

\[
\approx \frac{4.25 \text{ lb}}{0.4536} \text{ or } 9.37 \text{ lb}
\]

So, 4.25 kilograms is approximately 9.37 pounds.

Got it? Do these problems to find out.

Complete. Round to the nearest hundredth if necessary.

d. 7.44 c ≈ \( \_ \) mL

e. 22.09 lb ≈ \( \_ \) kg

f. 35.85 L ≈ \( \_ \) gal
Example

6. An Olympic-size swimming pool is 50 meters long. About how many feet long is the pool?

Since 1 foot ≈ 0.30 meter, use the ratio \( \frac{1 \text{ ft}}{0.30 \text{ m}} \).

\[
50 \text{ m} \approx 50 \text{ m} \cdot \frac{1 \text{ ft}}{0.30 \text{ m}}
\]

Multiply by \( \frac{1 \text{ ft}}{0.30 \text{ m}} \).

\[
\approx 50 \text{ ft} \cdot \frac{1 \text{ ft}}{0.30 \text{ m}}
\]

Divide out common units, leaving the desired unit, feet.

\[
\approx 50 \text{ ft} \div 0.30 \text{ ft} 
\]

Divide.

An Olympic-size swimming pool is about 166.67 feet long.

Guided Practice

Complete. Round to the nearest hundredth if necessary. (Examples 1–5)

1. 3.7 yd ≈ _______ m
2. 11.07 pt ≈ _______ mL
3. 650 lb ≈ _______ kg

4. About how many feet does a team of athletes run in a 1,600-meter relay race? (Example 6)

5. Raheem bought 3 pounds of bananas. About how many kilograms did he buy? (Example 6)

6. Building on the Essential Question How can you use dimensional analysis to convert between measurement systems?

Rate Yourself!

Are you ready to move on? Shade the section that applies.

YES ? NO

For more help, go online to access a Personal Tutor.
Independent Practice

Complete. Round to the nearest hundredth if necessary. (Examples 1–5)

1. 5 in. ≈ _______ cm
2. 2 qt ≈ _______ mL
3. 58.14 kg ≈ _______ lb

4. 4 L ≈ _______ gal
5. 10 mL ≈ _______ c
6. 63.5 T ≈ _______ kg

7. 4.725 m ≈ _______ ft
8. 3 T ≈ _______ kg
9. 680.4 g ≈ _______ lb

10. A notebook computer has a mass of 2.25 kilograms. About how many pounds does the notebook weigh? (Example 6)

11. A glass bottle holds 3.75 cups of water. About how many milliliters of water can the bottle hold? (Example 6)

12. A Cabbage Palmetto has a height of 80 feet. What is the approximate height of the tree in meters? (Example 5)
**MP Persevere with Problems** Determine the greater amount for each situation.

13. Which box is greater, a 1.5-pound box of raisins or a 650-gram box of raisins?

14. Which is greater a 2.75-gallon container of juice or a 12-liter container of juice?

---

**H.O.T. Problems** Higher Order Thinking

15. **MP Reason Inductively** One gram of water has a volume of 1 milliliter. What is the volume of the water if it has a mass of 1 kilogram?

16. **MP Persevere with Problems** The distance from Earth to the Sun is approximately 93 million miles. About how many gigameters is this? Round to the nearest hundredth. *(Hint: In 1 gigameter there are about 621,371,000 miles.)*

---

**MP Be Precise** Order each set of measures from greatest to least.

17. 1.2 cm, 0.6 in., 0.031 m, 0.1 ft

18. 2 lb, 891 g, 1 kg, 0.02 T

19. 1 1/4 c, 0.4 L, 950 ml, 0.7 gal

20. 4.5 ft, 48 in., 1.3 m, 120 cm

21. **MP Model with Mathematics** Convert 2 1/8 inches and 2 5/8 inches to centimeters. Round to the nearest tenth. Then draw a segment whose length is between those two measures.

*Solve your work.*
Complete. Round to the nearest hundredth if necessary.

22. 15 cm ≈ 5.91 in.
   \[ 15 \text{ cm} = 15 \text{ cm} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \]
   \[ \approx 15 \text{ in} \times \frac{1 \text{ in}}{2.54 \text{ cm}} \]
   \[ \approx 5.91 \text{ in.} \]

23. 350 lb ≈ 158.76 kg
   \[ 350 \text{ lb} = 350 \text{ lb} \times \frac{0.4536 \text{ kg}}{1 \text{ lb}} \]
   \[ \approx 350 \text{ lb} \times \frac{0.4536 \text{ kg}}{1 \text{ lb}} \]
   \[ \approx 158.76 \text{ kg} \]

24. 17 mi ≈ _____ km

25. 32 gal ≈ _____ L

26. 50 ml = _____ fl oz

27. 19 kg ≈ _____ lb

28. The Willis Tower has a height of 1,451 feet. What is the estimated height of the building in meters?

29. Which is greater, a bottle containing 64 fluid ounces or a bottle containing 2 liters of water?

30. **Use Math Tools** A bakery uses 900 grams of peaches in a cobbler. About how many pounds of peaches does the bakery use in a cobbler?

Determine which quantity is greater.

31. 3 gal, 10 L

32. 14 oz, 0.4 kg

33. 4 mi, 6.2 km

34. Velocity is a rate usually expressed in feet per second or meters per second. How can the units help you calculate velocity using the distance a car traveled and the time recorded?
35. The diagram shows the length of a fork from the cafeteria. Which measurements are approximately equal to the length of the fork? Select all that apply.

- 15.2 cm  
- 0.152 m  
- 152 cm  
- 1.52 m

36. The masses of 4 different animals from a zoo are shown in the table. Convert each measure to pounds. Then sort the animals from least to greatest weight.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown Bear</td>
<td>272.15</td>
</tr>
<tr>
<td>Giraffe</td>
<td>1,134.0</td>
</tr>
<tr>
<td>Lion</td>
<td>226.8</td>
</tr>
<tr>
<td>Rhinoceros</td>
<td>1,587.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Animal</th>
<th>Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least</td>
<td></td>
</tr>
<tr>
<td>Greatest</td>
<td></td>
</tr>
</tbody>
</table>

How many pounds greater is the heaviest animal than the lightest animal?

Explain how you can use units to be sure you are multiplying by the correct fraction when converting between measurement systems. Give an example.

---

**Common Core Spiral Review**

Convert. Round to the nearest tenth if necessary. 5.MD.1

37. 17 ft = _______ yd

38. 82 in. = _______ ft

39. 3 mi = _______ ft

40. A skyscraper is 0.484 kilometer tall. What is the height of the skyscraper in meters? 5.MD.1
**Real-World Link**

**Oranges** Deandre has three oranges and each orange is divided evenly into fourths. Complete the steps below to find $3 \div \frac{1}{4}$.

**Step 1** Draw three oranges. The first one is drawn for you.

![Image of oranges]

**Step 2** Imagine you cut each orange into fourths. Draw the slices for each orange.

So $3 \div \frac{1}{4} = 12$. Deandre will have [ ] orange slices.

1. Find $3 \div \frac{1}{2}$. Use a diagram.

2. What is true about $3 \div \frac{1}{2}$ and $3 \times 2$?

---

**Which **Mathematical Practices** did you use? Shade the circle(s) that applies.**

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning
Divide Fractions

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

**Examples**

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Algebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \frac{7}{8} ÷ \frac{3}{4} = \frac{7}{8} \cdot \frac{4}{3} ]</td>
<td>[ \frac{a}{b} ÷ \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}, \text{ where } b, c, d \neq 0 ]</td>
</tr>
</tbody>
</table>

Dividing 3 by \( \frac{1}{4} \) is the same as multiplying 3 by the reciprocal of \( \frac{1}{4} \), which is 4.

\[3 ÷ \frac{1}{4} = 12 \quad 3 \cdot 4 = 12\]

Is this pattern true for any division expression?

Consider \[ \frac{7}{8} ÷ \frac{3}{4} \], which can be rewritten as \[ \frac{7}{8} ÷ \frac{3}{4} \] or \[ \frac{7}{8} ÷ \frac{3}{4} \] or \[ \frac{7}{8} ÷ \frac{3}{4} \].

Multiply the numerator and denominator by the reciprocal of \( \frac{3}{4} \), which is \( \frac{4}{3} \).

\[ \frac{7}{8} ÷ \frac{3}{4} = \frac{7}{8} \cdot \frac{4}{3} \]

\[ = \frac{7}{8} \cdot \frac{4}{3} \]

\[ = \frac{7}{8} \cdot \frac{4}{3} \]

So, \[ \frac{7}{8} ÷ \frac{3}{4} = \frac{7}{8} \cdot \frac{4}{3} \]. The pattern is true in this case.

**Examples**

1. Find \( \frac{1}{3} ÷ 5 \).

\[ \frac{1}{3} ÷ 5 = \frac{1}{3} ÷ \frac{5}{1} \]  

A whole number can be written as a fraction over 1.

\[ = \frac{1}{3} \cdot \frac{1}{5} \]  

Multiply by the reciprocal of \( \frac{5}{1} \), which is \( \frac{1}{5} \).

\[ = \frac{1}{15} \]  

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

Estimate $1 \div \left( -\frac{1}{2} \right) = \underline{\text{}}$

$\frac{3}{4} \div \left( -\frac{1}{2} \right) = \frac{3}{4} \cdot \left( -\frac{2}{1} \right)$  Multiply by the reciprocal of $-\frac{1}{2}$, which is $-\frac{2}{1}$.

$= \frac{3}{4} \cdot \left( -\frac{2}{1} \right)$  Divide 4 and 2 by their GCF, 2.

$= -\frac{3}{2}$ or $-1\frac{1}{2}$  Multiply.

Check for Reasonableness $-1\frac{1}{2} \approx -2$  ✓

Got it? Do these problems to find out.

Divide. Write in simplest form.

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

b. $-\frac{4}{5} \div \frac{8}{9}$

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

d. $\underline{\text{}}$

e. $\underline{\text{}}$

Divide Mixed Numbers

To divide by a mixed number, first rename the mixed number as a fraction greater than one. Then multiply the first fraction by the reciprocal, or multiplicative inverse, of the second fraction.

Example

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

$\frac{2}{3} \div 3\frac{1}{3} = \frac{2}{3} \div \frac{10}{3}$  Rename $3\frac{1}{3}$ a fraction greater than one.

$= \frac{2}{3} \cdot \frac{3}{10}$  Multiply by the reciprocal of $\frac{10}{3}$, which is $\frac{3}{10}$.

$= \frac{2}{3} \cdot \frac{3}{10}$  Divide out common factors.

$= \frac{1}{5}$  Multiply

d. $\underline{\text{}}$

e. $\underline{\text{}}$

Got it? Do these problems to find out.

Divide. Write in simplest form.

d. $5 \div 1\frac{1}{3}$  

e. $-\frac{3}{4} \div 1\frac{1}{2}$

f. $2\frac{1}{3} \div 5$
Example

4. The side pieces of a butterfly house are 8\(\frac{1}{2}\) inches long. How many side pieces can be cut from a board measuring 49\(\frac{1}{2}\) inches long?

To find how many side pieces can be cut, divide 49\(\frac{1}{2}\) by 8\(\frac{1}{4}\).

**Estimate** Use compatible numbers. 48 ÷ 8 = 6

\[
49\frac{1}{2} \div 8\frac{1}{4} = \frac{99}{2} \div \frac{33}{4}
\]

Rename the mixed numbers as fractions greater than one.

\[
= \frac{99}{2} \times \frac{4}{33} = \frac{33}{2} \times \frac{4}{33}
\]

Multiply by the reciprocal of \(\frac{33}{4}\), which is \(\frac{4}{33}\).

\[
= \frac{33}{2} \times \frac{4}{33} = \frac{33}{1} \times \frac{1}{1}
\]

Divide out common factors.

\[
= \frac{33}{1} \div \frac{1}{1} = \frac{33}{1} \times \frac{1}{1}
\]

Multiply.

\[
= \frac{33}{1} \div \frac{1}{1} = \frac{6}{1} \text{ or } 6
\]

So, 6 side pieces can be cut.

**Check for Reasonableness** Compare to the estimate. 6 = 6 ✔

Guided Practice

Divide. Write in simplest form. (Examples 1 – 3)

1. \(\frac{1}{8} + \frac{1}{3} = \)

2. \(-3 ÷ (-\frac{6}{7}) = \)

3. \(-\frac{7}{8} ÷ \frac{3}{4} = \)

4. On Saturday, Lindsay walked 3\(\frac{1}{2}\) miles in 1\(\frac{2}{5}\) hours. What was her walking pace in miles per hour? Write in simplest form. (Example 4)

5. **Building on the Essential Question** How is dividing fractions related to multiplying?
Divide. Write in simplest form. (Examples 1–3)

1. \( \frac{3}{8} \div \frac{5}{7} = \)  
2. \( -\frac{2}{3} \div \left(-\frac{1}{2}\right) = \)  
3. \( \frac{1}{2} \div 7\frac{1}{2} = \)

4. \( 6 \div \left(-\frac{1}{2}\right) = \)  
5. \( -\frac{4}{9} \div (-2) = \)  
6. \( \frac{2}{3} \div 2\frac{1}{2} = \)

Cheryl is organizing her movie collection. If each movie case is \( \frac{3}{4} \) inch wide, how many movies can fit on a shelf \( 5\frac{1}{4} \) feet wide? (Example 4)

8. Use the table to solve. Write your answers in simplest form.
   a. How many times as heavy is the Golden Eagle as the Red-Tailed Hawk?
   b. How many times as heavy is the Golden Eagle as the Northern Bald Eagle?

<table>
<thead>
<tr>
<th>Bird</th>
<th>Maximum Weight (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Eagle</td>
<td>13(\frac{9}{10})</td>
</tr>
<tr>
<td>Northern Bald Eagle</td>
<td>9(\frac{9}{10})</td>
</tr>
<tr>
<td>Red-Tailed Hawk</td>
<td>3(\frac{1}{2})</td>
</tr>
</tbody>
</table>

9. **Model with Mathematics** Draw a model of the verbal expression below and then evaluate the expression. Explain how the model shows the division process.

   \( \text{one half divided by two fifths} \)
Copy and Solve  For Exercises 10 and 11, show your work on a separate piece of paper.

10. **Multiple Representations** Jorge recorded the distance that five of his friends live from his house in the table shown.

   a. **Numbers** Tye lives about how many times farther away than Jamal?

   b. **Algebra** The mean is the sum of the data divided by the number of items in the data set. Write and solve an equation to find the mean number of miles that Jorge's friends live from his house. Write your answer in simplest form.

   c. **Model** Draw a bar diagram that can be used to find how many more miles Lon travels than Lucia to get to Jorge's house.

<table>
<thead>
<tr>
<th>Student</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucia</td>
<td>5 1/2</td>
</tr>
<tr>
<td>Lon</td>
<td>3 2/3</td>
</tr>
<tr>
<td>Sam</td>
<td>12 5/6</td>
</tr>
<tr>
<td>Jamal</td>
<td>2 7/9</td>
</tr>
<tr>
<td>Tye</td>
<td>17 13/18</td>
</tr>
</tbody>
</table>

11. Tara bought a dozen folders. She took \( \frac{1}{3} \) of the dozen and then divided the remaining folders equally among her four friends. What fraction of the dozen did each of her four friends receive? How many folders was this per person?

**H.O.T. Problems**

12. **Find the Error** Blake is finding \( \frac{4}{5} \div \frac{6}{7} \). Find his mistake and correct it.

\[ \frac{4}{5} \div \frac{6}{7} = \frac{5}{4} \times \frac{7}{6} = \frac{30}{28} \text{ or } 1 \frac{1}{14} \]

13. **Persevere with Problems** If \( \frac{5}{6} \) is divided by a certain fraction \( \frac{a}{b} \), the result is \( \frac{1}{4} \). What is the fraction \( \frac{a}{b} \)?

14. **Reason Inductively** So far, the Rabun family has traveled 30 miles in \( \frac{1}{2} \) hour. If it is currently 3:00 P.M. and their destination is 75 miles away from them, at what time will the Rabun family reach their destination? Explain how you solved the problem.
15. \( \frac{5}{9} + \frac{5}{6} = \frac{2}{3} \)
\[
\begin{align*}
\frac{5}{9} + \frac{5}{6} &= \frac{5}{9} \times \frac{6}{6} \\
&= \frac{5 \times 2}{9 \times 1} \\
&= \frac{10}{9} \\
&= \frac{2}{3} 
\end{align*}
\]

16. \(-5\frac{2}{7} \div (-2\frac{1}{7}) = \)

17. \(-5\frac{1}{5} \div \frac{2}{3} = \)

18. Vinh bought 4\(\frac{1}{2}\) gallons of ice cream to serve. If a pint is \(\frac{1}{8}\) of a gallon, how many pint-sized servings can be made?

19. William has 8\(\frac{1}{4}\) cups of fruit juice. If he divides the juice into \(\frac{3}{4}\)-cup servings, how many servings will he have?

20. **MP Justify Conclusions** So far, a storm has traveled 35 miles in \(\frac{1}{2}\) hour. If it is currently 5:00 P.M. and the storm is 105 miles away from you, at what time will the storm reach you? Explain how you solved the problem.

21. Find \(\frac{1\frac{2}{9}}{1\frac{1}{3}}\). Write in simplest form.

22. **MP Use Math Tools** Write the letter of each statement below in the section of any operation to which the statement applies.

- **Addition**
- **Multiplication**
- **Subtraction**
- **Division**

Operations on Rational Numbers

A. Use a common denominator.
B. Multiply by the multiplicative inverse.
C. Write the result in simplest form.
23. Tracy has $94\frac{1}{4}$ inches of string that she uses for making bracelets. She uses $7\frac{1}{4}$ inches of string to make each bracelet. How many bracelets can Tracy make?

24. A grocery store offers 4 different size boxes of peanuts as shown below.

![Box sizes]

Write large, medium, or small in each box to make a true statement.

The [ ] box is 3 times larger than the [ ] box.

The [ ] box is 6 times larger than the [ ] box.

The [ ] box is 2 times larger than the [ ] box.

---

**Common Core Spiral Review**

Add or subtract. Write in simplest form. 5.NF.2

25. $\frac{1}{5} + \frac{1}{4} =$  

26. $\frac{1}{3} - \frac{1}{6} =$  

27. $\frac{4}{9} + \frac{2}{7} =$  

28. $\frac{11}{15} - \frac{3}{20} =$

29. The cheerleaders made spirit buttons for the basketball team. They used blue and red ribbons. How much total ribbon did they use? 5.NF.2

<table>
<thead>
<tr>
<th>Ribbon</th>
<th>Blue</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\frac{3}{8}$ ft</td>
<td>$\frac{3}{8}$ ft</td>
</tr>
</tbody>
</table>

30. How much longer is a $2\frac{1}{2}$-inch-long piece of string than a $\frac{2}{5}$-inch-long piece of string? 5.NF.2

334 Need more practice? Download more Extra Practice at connectED.mcgraw-hill.com.
Fashion Designer

Do you enjoy reading fashion magazines, keeping up with the latest trends, and creating your own unique sense of style? You might want to consider a career in fashion design. Fashion designers create new designs for clothing, accessories, and shoes. In addition to being creative and knowledgeable about current fashion trends, fashion designers need to be able to take accurate measurements and calculate fit by adding, subtracting, and dividing measurements.

Is This the Career for You?

Are you interested in a career as a fashion designer? Take some of the following courses in high school.

- Algebra
- Art
- Digital Design
- Geometry

Find out how math relates to a career in Fashion Design.
A Flair for Fashion!

Use the information in the table to solve each problem. Write in simplest form.

1. For size 8, does Dress Style A or B require more fabric? Explain.

2. How many yards of fabric are needed to make Style A in sizes 8 and 14?

3. Estimate how many yards of fabric are needed to make Style B in each of the sizes shown. Then find the actual amount of fabric.

4. For Style B, how much more fabric is required for size 14 than for size 12?

5. A designer has half the amount of fabric needed to make Style A in size 10. How much fabric does she have?

6. A bolt has $12\frac{1}{8}$ yards of fabric left on it. How many dresses in Style B size 12 could be made? How much fabric is left over?

<table>
<thead>
<tr>
<th>Dress Style</th>
<th>Size 8</th>
<th>Size 10</th>
<th>Size 12</th>
<th>Size 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$3\frac{3}{8}$</td>
<td>$3\frac{1}{2}$</td>
<td>$3\frac{3}{4}$</td>
<td>$3\frac{7}{8}$</td>
</tr>
<tr>
<td>B</td>
<td>$3\frac{1}{4}$</td>
<td>$3\frac{1}{2}$</td>
<td>$3\frac{7}{8}$</td>
<td>4</td>
</tr>
</tbody>
</table>

Career Project

It's time to update your career portfolio! Use blogs and webpages of fashion designers to answer some of these questions: Where did they go to school? What was their first job? What do they say is the most difficult part about being a fashion designer? What inspires them to create their designs? What advice do they have for new designers?

Suppose you are an employer hiring a fashion designer. What questions would you ask a potential employee?

•

•

336 Chapter 4 Rational Numbers
Unscramble each of the clue words. After unscrambling each of the terms, use the numbered letters to find a vocabulary term that relates to all of the other terms.

RAB TONNOTIA

1

7

TAMTINRINGE

3

GIEPEATNR

4

KIEL STAFCOIRN

5

LIJKIEN

6

8

NOMMOC

NIOAREOMNDT

2

Complete each sentence using one of the unscrambled words above.

1. The process of using a line over the repeating digits of a decimal is called ____________________.

2. Fractions with different denominators are called ____________________ fractions.

3. The least common multiple of the denominators is called the least ____________________.

4. The decimal form of a fraction is a(n) ________________ decimal.

5. A ____________________ decimal is a decimal in which the repeating digit is zero.

6. Fractions with the same denominator are called ____________________.
Got it?

Circle the correct term or number to complete each sentence.

1. $\frac{1}{5}$ and $\left(\frac{1}{3}, \frac{3}{5}\right)$ are like fractions.

2. To add like fractions, add the (numerators, denominators).

3. To add unlike fractions, rename the fractions using the least common (numerator, denominator).

4. The reciprocal of $\frac{1}{3}$ is (−3, 3).

5. To divide by a fraction, (multiply, divide) by its reciprocal.

6. The least common denominator of $\frac{1}{5}$ and $\frac{1}{10}$ is (10, 50).
Managing Money

Tamiko has recently started managing her own finances. She tracks her debts and income, as well as any gifts that she receives from her family members. Some of her recent transactions are listed below.

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowed money from a friend</td>
<td>43.75</td>
</tr>
<tr>
<td>Received a gift from Dad</td>
<td>50.00</td>
</tr>
<tr>
<td>Spent money on lunches</td>
<td>62.50</td>
</tr>
<tr>
<td>Received allowance</td>
<td>20.00</td>
</tr>
</tbody>
</table>

Write your answers on another piece of paper. Show all of your work to receive full credit.

**Part A**

What rational number represents the net result of the transactions shown in the table? Explain what your answer represents.

**Part B**

The following week, Tamiko receives a check for $109.60 for working at a local fast food restaurant and a small bonus check for $34.15. Determine the net result of her transactions using the result from Part A. She wants to save \( \frac{3}{5} \) of this amount. How much will she save?

**Part C**

The next month, Tamiko develops a budget for her income. One-fourth of her income is budgeted for car insurance, \( \frac{1}{10} \) of her income is budgeted for gasoline, \( \frac{2}{5} \) of her income is budgeted for savings, and the remainder is budgeted for spending money. She earns $234.80 for working at the fast food restaurant, $64 for baby sitting, and $20 in allowance. According to her budget, how much of her total monthly income is allotted for spending money?
Answering the Essential Question

Use what you learned about operations with rational numbers to complete the graphic organizer. Describe a process to perform each operation.

Essential Question
WHAT happens when you add, subtract, multiply, and divide fractions?

Answer the Essential Question. WHAT happens when you add, subtract, multiply, and divide fractions?
UNIT PROJECT

Explore the Ocean Depths For this project, imagine that your dream job is to become an oceanographer. In this project you will:

- **Collaborate** with your classmates as you research information about the ocean.
- **Share** the results of your research in a creative way.
- **Reflect** on how mathematical ideas can be represented.

**Go Online** Work with your group to research and complete each activity. You will use your results in the Share section on the following page.

1. About \( \frac{2}{3} \) of Earth is covered by ocean. Research the five oceans of the world and create a table that shows about what fraction each ocean is of that \( \frac{2}{3} \).

2. What is the greatest ocean depth? Find out and then display it on a vertical number line along with other facts about what you can find at different ocean depths.

3. Coral reefs are the home of many ocean creatures. Look up some facts about the state of coral reefs in the world today and display them in a creative way.

4. Choose three different types of whales that live in the ocean. Compare their size, the amount of food they eat, or the climate in which they live. Organize the information in a table or graph.

5. Research one of the larger icebergs in the Arctic Ocean. Sketch an image of the iceberg next to a vertical number line that shows the approximate top and bottom of the iceberg. Remember, about \( \frac{7}{8} \) of an iceberg is underwater.
Share

With your group, decide on a way to share what you have learned about ocean depths. Some suggestions are listed below, but you could also think of other creative ways to present your information. Remember to show how you used mathematics in your project!

- Use presentation software to organize what you have learned in this project. Share your presentation with the class.
- Imagine you need to apply for funds to go on a deep sea exploration. Write a persuasive letter or speech that highlights the importance of studying ocean depths.

Check out the note on the right to connect this project with other subjects.

Reflect

6. Answer the Essential Question How can mathematical ideas be represented?

a. How were mathematical ideas involving integers represented in the information you discovered about oceans?

b. How were mathematical ideas involving rational numbers represented in the information you discovered about oceans?