

## 5.2 Proportions

**Essential Question** How can proportions help you decide when things are “fair”?

### The Meaning of a Word ● Proportional

When you work toward a goal, your success is usually **proportional** to the amount of work you put in.

An equation stating that two ratios are equal is a **proportion**.



### 1 ACTIVITY: Determining Proportions

Work with a partner. Tell whether the two ratios are equivalent. If they are not equivalent, change the next day to make the ratios equivalent. Explain your reasoning.

- a. On the first day, you pay \$5 for 2 boxes of popcorn. The next day, you pay \$7.50 for 3 boxes.



First Day		Next Day
\$5.00	?	\$7.50
2 boxes	=	3 boxes



- b. On the first day, it takes you  $3\frac{1}{2}$  hours to drive 175 miles. The next day, it takes you 5 hours to drive 200 miles.

First Day		Next Day
$3\frac{1}{2}$ h	?	5 h
175 mi	=	200 mi

- c. On the first day, you walk 4 miles and burn 300 calories. The next day, you walk  $3\frac{1}{3}$  miles and burn 250 calories.



First Day		Next Day
4 mi	?	$3\frac{1}{3}$ mi
300 cal	=	250 cal

#### Proportions

In this lesson, you will

- use equivalent ratios to determine whether two ratios form a proportion.
- use the Cross Products Property to determine whether two ratios form a proportion.



- d. On the first day, you paint 150 square feet in  $2\frac{1}{2}$  hours. The next day, you paint 200 square feet in 4 hours.

First Day		Next Day
150 ft <sup>2</sup>	?	200 ft <sup>2</sup>
$2\frac{1}{2}$ h	=	4 h

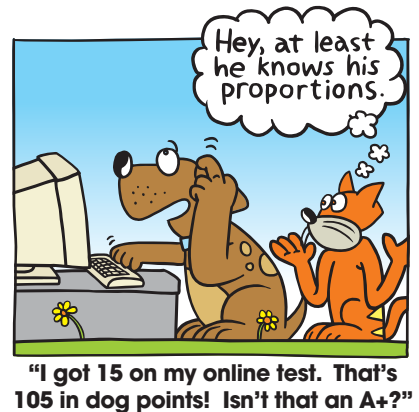
## 2 ACTIVITY: Checking a Proportion

Work with a partner.

- a. It is said that “one year in a dog’s life is equivalent to seven years in a human’s life.” Explain why Newton thinks he has a score of 105 points. Did he solve the proportion correctly?

$$\frac{1 \text{ year}}{7 \text{ years}} \stackrel{?}{=} \frac{15 \text{ points}}{105 \text{ points}}$$

- b. If Newton thinks his score is 98 points, how many points does he actually have? Explain your reasoning.



## 3 ACTIVITY: Determining Fairness

### Math Practice

#### Justify Conclusions

What information can you use to justify your conclusion?

Work with a partner. Write a ratio for each sentence. Compare the ratios. If they are equal, then the answer is “It is fair.” If they are not equal, then the answer is “It is not fair.” Explain your reasoning.

- |    |                                                         |   |                                                       |   |               |
|----|---------------------------------------------------------|---|-------------------------------------------------------|---|---------------|
| a. | You pay \$184 for 2 tickets to a concert.               | & | I pay \$266 for 3 tickets to the same concert.        | ➔ | Is this fair? |
| b. | You get 75 points for answering 15 questions correctly. | & | I get 70 points for answering 14 questions correctly. | ➔ | Is this fair? |
| c. | You trade 24 football cards for 15 baseball cards.      | & | I trade 20 football cards for 32 baseball cards.      | ➔ | Is this fair? |

## What Is Your Answer?

- Find a recipe for something you like to eat. Then show how two of the ingredient amounts are proportional when you double or triple the recipe.
- IN YOUR OWN WORDS** How can proportions help you decide when things are “fair”? Give an example.

### Practice

Use what you discovered about proportions to complete Exercises 15–20 on page 174.

### Key Vocabulary

proportion, p. 172  
proportional, p. 172  
cross products, p. 173

## Key Idea

### Proportions

**Words** A **proportion** is an equation stating that two ratios are equivalent. Two quantities that form a proportion are **proportional**.

**Numbers**  $\frac{2}{3} = \frac{4}{6}$  The proportion is read "2 is to 3 as 4 is to 6."

## EXAMPLE 1 Determining Whether Ratios Form a Proportion

Tell whether  $\frac{6}{4}$  and  $\frac{8}{12}$  form a proportion.

Compare the ratios in simplest form.

$$\frac{6}{4} = \frac{6 \div 2}{4 \div 2} = \frac{3}{2}$$

$$\frac{8}{12} = \frac{8 \div 4}{12 \div 4} = \frac{2}{3}$$

The ratios are *not* equivalent.

So,  $\frac{6}{4}$  and  $\frac{8}{12}$  do *not* form a proportion.

## EXAMPLE 2 Determining Whether Two Quantities Are Proportional

Tell whether  $x$  and  $y$  are proportional.

Compare each ratio  $x$  to  $y$  in simplest form.

$$\frac{\frac{1}{2}}{3} = \frac{1}{6} \quad \frac{1}{6} \quad \frac{\frac{3}{2}}{9} = \frac{1}{6} \quad \frac{2}{12} = \frac{1}{6}$$

The ratios are equivalent.

So,  $x$  and  $y$  are proportional.

$x$	$y$
$\frac{1}{2}$	3
1	6
$\frac{3}{2}$	9
2	12

### Reading

Two quantities that are proportional are in a *proportional relationship*.

## On Your Own

Tell whether the ratios form a proportion.

- $\frac{1}{2}, \frac{5}{10}$
- $\frac{4}{6}, \frac{18}{24}$
- $\frac{10}{3}, \frac{5}{6}$
- $\frac{25}{20}, \frac{15}{12}$

5. Tell whether  $x$  and  $y$  are proportional.

Birdhouses Built, $x$	1	2	4	6
Nails Used, $y$	12	24	48	72

Now You're Ready  
Exercises 5–14

## Key Ideas

### Study Tip

You can use the Multiplication Property of Equality to show that the cross products are equal.

$$\frac{a}{b} = \frac{c}{d}$$

$$bd \cdot \frac{a}{b} = bd \cdot \frac{c}{d}$$

$$ad = bc$$

### Cross Products

In the proportion  $\frac{a}{b} = \frac{c}{d}$ , the products  $a \cdot d$  and  $b \cdot c$  are called **cross products**.

### Cross Products Property

**Words** The cross products of a proportion are equal.

#### Numbers

$$\frac{2}{3} = \frac{4}{6}$$

$$2 \cdot 6 = 3 \cdot 4$$

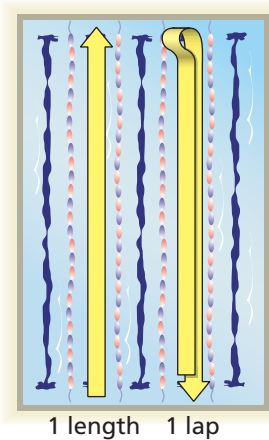
#### Algebra

$$\frac{a}{b} = \frac{c}{d}$$

$$ad = bc,$$

where  $b \neq 0$  and  $d \neq 0$

## EXAMPLE 3 Identifying Proportional Relationships



You swim your first 4 laps in 2.4 minutes. You complete 16 laps in 12 minutes. Is the number of laps proportional to your time?

**Method 1:** Compare unit rates.

$$\frac{2.4 \text{ min}}{4 \text{ laps}} = \frac{0.6 \text{ min}}{1 \text{ lap}}$$

$$\frac{12 \text{ min}}{16 \text{ laps}} = \frac{0.75 \text{ min}}{1 \text{ lap}}$$

The unit rates are *not* equivalent.

So, the number of laps is *not* proportional to the time.

**Method 2:** Use the Cross Products Property.

$$\frac{2.4 \text{ min}}{4 \text{ laps}} \stackrel{?}{=} \frac{12 \text{ min}}{16 \text{ laps}}$$

Test to see if the rates are equivalent.

$$2.4 \cdot 16 \stackrel{?}{=} 4 \cdot 12$$

Find the cross products.

$$38.4 \neq 48$$

The cross products are *not* equal.

So, the number of laps is *not* proportional to the time.

## On Your Own

6. You read the first 20 pages of a book in 25 minutes. You read 36 pages in 45 minutes. Is the number of pages read proportional to your time?

## Vocabulary and Concept Check

- VOCABULARY** What does it mean for two ratios to form a proportion?
- VOCABULARY** What are two ways you can tell that two ratios form a proportion?
- OPEN-ENDED** Write two ratios that are equivalent to  $\frac{3}{5}$ .
- WHICH ONE DOESN'T BELONG?** Which ratio does *not* belong with the other three? Explain your reasoning.

$\frac{4}{10}$	$\frac{2}{5}$	$\frac{3}{5}$	$\frac{6}{15}$
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## Practice and Problem Solving

Tell whether the ratios form a proportion.

- |                                  |                                    |                                 |                                    |
|----------------------------------|------------------------------------|---------------------------------|------------------------------------|
| 1 5. $\frac{1}{3}, \frac{7}{21}$ | 6. $\frac{1}{5}, \frac{6}{30}$     | 7. $\frac{3}{4}, \frac{24}{18}$ | 8. $\frac{2}{5}, \frac{40}{16}$    |
| 9. $\frac{48}{9}, \frac{16}{3}$  | 10. $\frac{18}{27}, \frac{33}{44}$ | 11. $\frac{7}{2}, \frac{16}{6}$ | 12. $\frac{12}{10}, \frac{14}{12}$ |

Tell whether  $x$  and  $y$  are proportional.

- |                                                                                                                                                                                                                                                                                                                |   |    |    |    |   |   |   |   |   |    |                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |   |   |    |    |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|----|----|----|---|---|---|---|---|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|----|----|----|
| 2 13. <table border="1" style="display: inline-table; border-collapse: collapse; text-align: center;"> <tr><td style="background-color: #d9ead3;">x</td><td>1</td><td>2</td><td>3</td><td>4</td></tr> <tr><td style="background-color: #d9ead3;">y</td><td>7</td><td>8</td><td>9</td><td>10</td></tr> </table> | x | 1  | 2  | 3  | 4 | y | 7 | 8 | 9 | 10 | 14. <table border="1" style="display: inline-table; border-collapse: collapse; text-align: center;"> <tr><td style="background-color: #d9ead3;">x</td><td>2</td><td>4</td><td>6</td><td>8</td></tr> <tr><td style="background-color: #d9ead3;">y</td><td>5</td><td>10</td><td>15</td><td>20</td></tr> </table> | x | 2 | 4 | 6 | 8 | y | 5 | 10 | 15 | 20 |
| x                                                                                                                                                                                                                                                                                                              | 1 | 2  | 3  | 4  |   |   |   |   |   |    |                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |   |   |    |    |    |
| y                                                                                                                                                                                                                                                                                                              | 7 | 8  | 9  | 10 |   |   |   |   |   |    |                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |   |   |    |    |    |
| x                                                                                                                                                                                                                                                                                                              | 2 | 4  | 6  | 8  |   |   |   |   |   |    |                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |   |   |    |    |    |
| y                                                                                                                                                                                                                                                                                                              | 5 | 10 | 15 | 20 |   |   |   |   |   |    |                                                                                                                                                                                                                                                                                                                |   |   |   |   |   |   |   |    |    |    |

Tell whether the two rates form a proportion.

15. 7 inches in 9 hours; 42 inches in 54 hours
16. 12 players from 21 teams; 15 players from 24 teams
17. 440 calories in 4 servings; 300 calories in 3 servings
18. 120 units made in 5 days; 88 units made in 4 days
19. 66 wins in 82 games; 99 wins in 123 games
20. 68 hits in 172 at bats; 43 hits in 123 at bats



21. **FITNESS** You can do 90 sit-ups in 2 minutes. Your friend can do 135 sit-ups in 3 minutes. Do these rates form a proportion? Explain.
22. **HEART RATES** Find the heart rates of you and your friend. Do these rates form a proportion? Explain.

	Heartbeats	Seconds
You	22	20
Friend	18	15

**Tell whether the ratios form a proportion.**

23.  $\frac{2.5}{4}, \frac{7}{11.2}$

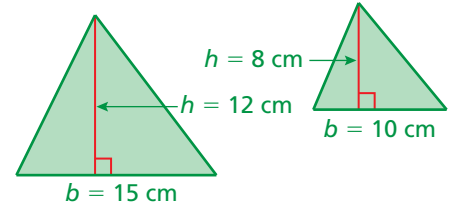
24. 2 to 4, 11 to  $\frac{11}{2}$

25.  $2 : \frac{4}{5}, \frac{3}{4} : \frac{3}{10}$

26. **PAY RATE** You earn \$56 walking your neighbor's dog for 8 hours. Your friend earns \$36 painting your neighbor's fence for 4 hours.

- What is your pay rate?
- What is your friend's pay rate?
- Are the pay rates equivalent? Explain.

27. **GEOMETRY** Are the heights and bases of the two triangles proportional? Explain.



28. **BASEBALL** A pitcher coming back from an injury limits the number of pitches thrown in bull pen sessions as shown.

- Which quantities are proportional?
- How many pitches that are not curveballs do you think the pitcher will throw in Session 5?

Session Number, $x$	Pitches, $y$	Curveballs, $z$
1	10	4
2	20	8
3	30	12
4	40	16



29. **NAIL POLISH** A specific shade of red nail polish requires 7 parts red to 2 parts yellow. A mixture contains 35 quarts of red and 8 quarts of yellow. How can you fix the mixture to make the correct shade of red?

30. **COIN COLLECTION** The ratio of quarters to dimes in a coin collection is 5 : 3. You add the same number of new quarters as dimes to the collection.

- Is the ratio of quarters to dimes still 5 : 3?
- If so, illustrate your answer with an example. If not, show why with a "counterexample."

31. **AGE** You are 13 years old, and your cousin is 19 years old. As you grow older, is your age proportional to your cousin's age? Explain your reasoning.

32. **Critical Thinking** Ratio  $A$  is equivalent to Ratio  $B$ . Ratio  $B$  is equivalent to Ratio  $C$ . Is Ratio  $A$  equivalent to Ratio  $C$ ? Explain.



## Fair Game Review what you learned in previous grades & lessons

**Add or subtract.** (Section 1.2 and Section 1.3)

33.  $-28 + 15$

34.  $-6 + (-11)$

35.  $-10 - 8$

36.  $-17 - (-14)$

37. **MULTIPLE CHOICE** Which fraction is not equivalent to  $\frac{2}{6}$ ? (Skills Review Handbook)

(A)  $\frac{1}{3}$

(B)  $\frac{12}{36}$

(C)  $\frac{4}{12}$

(D)  $\frac{6}{9}$