

**Objective** To write equations that represent functions

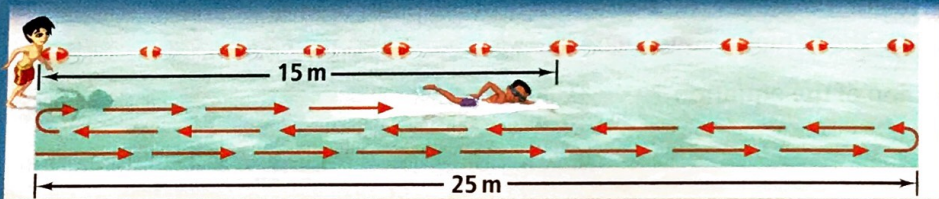
Start with a simple case—how far has your friend swum when you finish your first lap?



MATHEMATICAL PRACTICES

**Getting Ready!**

You and a friend are swimming 20 laps at the local pool. One lap is the distance across the pool and back. You both swim at the same rate. Your friend started first. The trail of arrows shows how far he has already swum. What equation gives the distance you have swum as a function of the number of laps your friend has swum? How far have you swum when your friend finishes? Explain your reasoning.



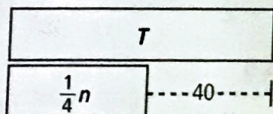
In the Solve It, you can see how the value of one variable depends on another. Once you see a pattern in a relationship, you can write a rule.

**Essential Understanding** Many real-world functional relationships can be represented by equations. You can use an equation to find the solution of a given real-world problem.

**Think**

How can a model help you visualize a real-world situation?

Use a model like the one below to represent the relationship that is described.

**Problem 1 Writing a Function Rule**

**Insects** You can estimate the temperature by counting the number of chirps of the snowy tree cricket. The outdoor temperature is about  $40^\circ\text{F}$  more than one fourth the number of chirps the cricket makes in one minute. What is a function rule that represents this situation?

**Relate** temperature is  $40^\circ\text{F}$  more than  $\frac{1}{4}$  of the number of chirps in 1 min

**Define** Let  $T$  = the temperature. Let  $n$  = the number of chirps in 1 min.

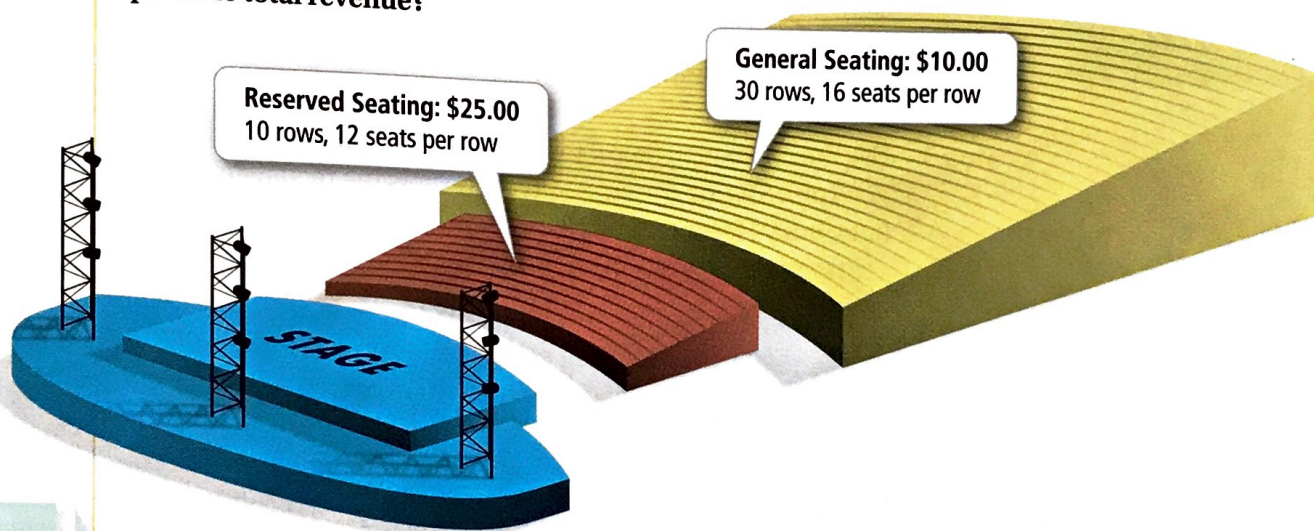
**Write**  $T = 40 + \frac{1}{4} \cdot n$

A function rule that represents this situation is  $T = 40 + \frac{1}{4}n$ .

- Got It?** 1. A landfill has 50,000 tons of waste in it. Each month it accumulates an average of 420 more tons of waste. What is a function rule that represents the total amount of waste after  $m$  months?

## Problem 2 Writing and Evaluating a Function Rule

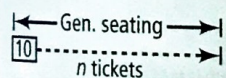
**Concert Revenue** A concert seating plan is shown below. Reserved seating is sold out. Total revenue from ticket sales will depend on the number of general-seating tickets sold. Write a function rule to represent this situation. What is the maximum possible total revenue?



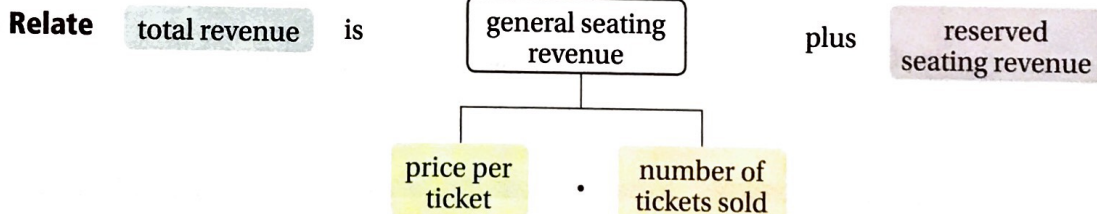
### Plan

How can a model help you write an equation?

A model like the one below can help you write an expression for the general-seating revenue.



Add the reserved-seating revenue to get the total revenue.



**Define** Let  $R$  = the total revenue.

Let  $n$  = the number of general-seating tickets sold.

**Write**

$$R = 10 \cdot n + (25 \cdot 10 \cdot 12)$$

$$R = 10n + 3000$$

The function rule  $R = 10n + 3000$  represents this situation. There are  $30 \cdot 16 = 480$  general-seating tickets. Substitute 480 for  $n$  to find the maximum possible revenue.

$$R = 10(480) + 3000 = 7800$$

The maximum possible revenue from ticket sales is \$7800.

- Got It?** 2. a. A kennel charges \$15 per day to board dogs. Upon arrival, each dog must have a flea bath that costs \$12. Write a function rule for the total cost for  $n$  days of boarding plus a bath. How much does a 10-day stay cost?  
 b. **Reasoning** Does a 5-day stay cost half as much as a 10-day stay? Explain.



### Problem 3 Writing a Nonlinear Function Rule

GRIDDED RESPONSE

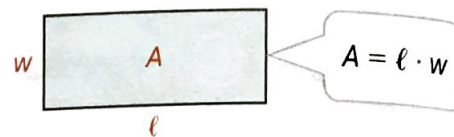
#### Think

**How can drawing a diagram help you to write a rule?**

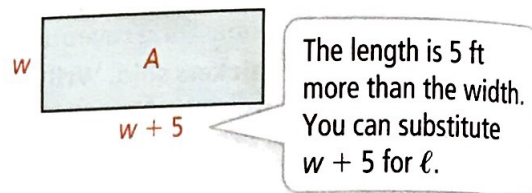
A diagram visually represents information in the problem. It can give you a clearer understanding of how variables are related.

**Geometry** Write a function rule for the area of a rectangle whose length is 5 ft more than its width. What is the area of the rectangle when its width is 9 ft?

**Step 1** Represent the general relationship first. The area  $A$  of a rectangle is the product of its length  $\ell$  and its width  $w$ .



**Step 2** Revise the model to show that the length is 5 ft more than the width.



**Step 3** Use the diagram in Step 2 to write the function rule. The function rule  $A = (w + 5)w$ , or  $A = w^2 + 5w$ , represents the rectangle's area. Substitute 9 for  $w$  to find the area when the width is 9 ft.

$$\begin{aligned} A &= 9^2 + 5(9) \\ &= 81 + 45 \\ &= 126 \end{aligned}$$

When the width of the rectangle is 9 ft, its area is 126 ft<sup>2</sup>.



- Got It?** 3. a. Write a function rule for the area of a triangle whose height is 4 in. more than twice the length of its base. What is the area of the triangle when the length of its base is 16 in.?
- b. **Reasoning** Graph the function rule from Problem 3. How do you know the rule is nonlinear?



### Lesson Check

#### Do you know HOW?

Write a function rule to represent each situation.

- the total cost  $C$  for  $p$  pounds of copper if each pound costs \$3.57
- the height  $f$ , in feet, of an object when you know the object's height  $h$  in inches
- the amount  $y$  of your friend's allowance if the amount she receives is \$2 more than the amount  $x$  you receive
- the volume  $V$  of a cube-shaped box whose edge lengths are 1 in. greater than the diameter  $d$  of the ball that the box will hold

#### Do you UNDERSTAND?



- Vocabulary** Suppose you write an equation that gives  $a$  as a function of  $b$ . Which is the dependent variable and which is the independent variable?
- Error Analysis** A worker has dug 3 holes for fence posts. It will take 15 min to dig each additional hole. Your friend writes the rule  $t = 15n + 3$  for the time  $t$ , in minutes, required to dig  $n$  additional holes. Describe and correct your friend's error.
- Reasoning** Is the graph of a function rule that relates a square's area to its side length *continuous* or *discrete*? Explain.

## A Practice

Write a function rule that represents each sentence.

8.  $y$  is 5 less than the product of 4 and  $x$ .
9.  $C$  is 8 more than half of  $n$ .
10. 7 less than three fifths of  $b$  is  $a$ .
11. 2.5 more than the quotient of  $h$  and 3 is  $w$ .

← See Problem 1.

Write a function rule that represents each situation.

12. **Wages** A worker's earnings  $e$  are a function of the number of hours  $n$  worked at a rate of \$8.75 per hour.
13. **Pizza** The price  $p$  of a pizza is \$6.95 plus \$.95 for each topping  $t$  on the pizza.
14. **Weight Loads** The load  $L$ , in pounds, of a wheelbarrow is the sum of its own 42-lb weight and the weight of the bricks that it carries, as shown at the right.
15. **Baking** The almond extract  $a$  remaining in an 8-oz bottle decreases by  $\frac{1}{6}$  oz for each batch  $b$  of waffle cookies made.

The wheelbarrow holds  $n$  4-lb bricks.



16. **Aviation** A helicopter hovers 40 ft above the ground. Then the helicopter climbs at a rate of 21 ft/s. Write a rule that represents the helicopter's height  $h$  above the ground as a function of time  $t$ . What is the helicopter's height after 45 s?
17. **Diving** A team of divers assembles at an elevation of  $-10$  ft relative to the surface of the water. Then the team dives at a rate of  $-50$  ft/min. Write a rule that represents the team's depth  $d$  as a function of time  $t$ . What is the team's depth after 3 min?
18. **Publishing** A new book is being planned. It will have 24 pages of introduction. Then it will have  $c$  12-page chapters and 48 more pages at the end. Write a rule that represents the total number of pages  $p$  in the book as a function of the number of chapters. Suppose the book has 25 chapters. How many pages will it have?

← See Problem 2.

19. Write a function rule for the area of a triangle with a base 3 cm greater than 5 times its height. What is the area of the triangle when its height is 6 cm?

← See Problem 3.

20. Write a function rule for the volume of the cylinder shown at the right with a height 3 in. more than 4 times the radius of the cylinder's base. What is the volume of the cylinder when it has a radius of 2 in.?

21. Write a function rule for the area of a rectangle with a length 2 ft less than three times its width. What is the area of the rectangle when its width is 2 ft?



$$V = \pi r^2 h$$

22. **Open-Ended** Write a function rule that models a real-world situation. Evaluate your function for an input value and explain what the output represents.

## B Apply

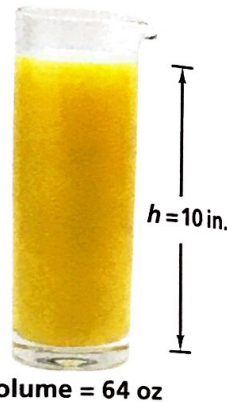
© 23. **Writing** What advantage(s) can you see of having a rule instead of a table of values to represent a function?

24. **History of Math** The golden ratio has been studied and used by mathematicians and artists for more than 2000 years. A golden rectangle, constructed using the golden ratio, has a length about 1.6 times its width. Write a rule for the area of a golden rectangle as a function of its width.

25. **Whales** From an elevation of 3.5 m below the surface of the water, a northern bottlenose whale dives at a rate of 1.8 m/s. Write a rule that gives the whale's depth  $d$  as a function of time in minutes. What is the whale's depth after 4 min?

© 26. **Think About a Plan** The height  $h$ , in inches, of the juice in the pitcher shown at the right is a function of the amount of juice  $j$ , in ounces, that has been poured out of the pitcher. Write a function rule that represents this situation. What is the height of the juice after 47 oz have been poured out?

- What is the height of the juice when half of it has been poured out?
- What fraction of the juice would you pour out to make the height decrease by 1 in.?



27. **Tips** You go to dinner and decide to leave a 15% tip for the server. You had \$55 when you entered the restaurant.

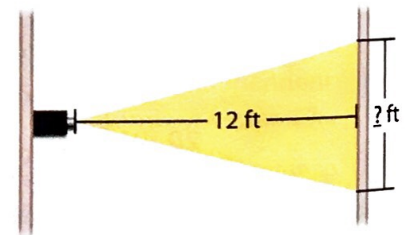
- Make a table showing how much money you would have left after buying a meal that costs \$15, \$21, \$24, or \$30.
- Write a function rule for the amount of money  $m$  you would have left if the meal costs  $c$  dollars before the tip.
- Graph the function rule.

28. **Car Rental** A car rental agency charges \$29 per day to rent a car and \$13.95 per day for a global positioning system (GPS). Customers are charged for their full tank of gas at \$3.80 per gallon.

- A car has a 12-gal tank and a GPS. Write a rule for the total bill  $b$  as a function of the number of days  $d$  the car is rented.
- What is the bill for a 9-day rental?

29. **Projectors** You consult your new projector's instruction manual before mounting it on the wall. The manual says to multiply the desired image width by 1.8 to find the correct distance of the projector lens from the wall.

- Write a rule to describe the distance of the lens from the wall as a function of desired image width.
- The diagram shows the room in which the projector will be installed. Will you be able to project an image 7 ft wide? Explain.
- What is the maximum image width you can project in the room?



© 30. **Reasoning** Write a rule that is an example of a nonlinear function that fits the following description.

When  $d$  is 4,  $r$  is 9, and  $r$  is a function of  $d$ .



Make a table and a graph of each set of ordered pairs  $(x, y)$ . Then write a function rule to represent the relationship between  $x$  and  $y$ .

31.  $(-4, 7), (-3, 6), (-2, 5), (-1, 4), (0, 3), (1, 2), (2, 1), (3, 0), (4, -1)$

32.  $(-4, 15), (-3, 8), (-2, 3), (-1, 0), (0, -1), (1, 0), (2, 3), (3, 8), (4, 15)$

## Standardized Test Prep

SAT/ACT

33. You buy  $x$  pounds of cherries for \$2.99/lb. What is a function rule for the amount of change  $C$  you receive from a \$50 bill?

(A)  $C = 2.99x - 50$

(C)  $C = 50x - 2.99$

(B)  $C = 50 - 2.99x$

(D)  $C = 2.99 - 50x$

34. What is the solution of  $-5 < h + 2 < 11$ ?

(F)  $-3 < h < 11$

(G)  $-7 < h < 9$

(H)  $-7 > h > 9$

(I)  $h < -7$  or  $h > 9$

35. Which equation do you get when you solve  $-ax + by^2 = c$  for  $b$ ?

(A)  $b = \frac{c - ax}{y^2}$

(B)  $b = y^2(c + ax)$

(C)  $b = \frac{c + ax}{y^2}$

(D)  $b = \frac{c}{y^2} + ax$

Extended Response

36. The recommended dosage  $D$ , in milligrams, of a certain medicine depends on a person's body mass  $m$ , in kilograms. The function rule  $D = 0.1m^2 + 5m$  represents this relationship.

a. What is the recommended dosage for a person whose mass is 60 kg? Show your work.

b. One pound is equivalent to approximately 0.45 kg. Explain how to find the recommended dosage for a 200-lb person. What is this dosage?

## Mixed Review

Graph each function rule.

37.  $y = 9 - x$

38.  $y = 4 + 3x$

39.  $y = x + 1.5$

40.  $y = 4x - 1$

41.  $y = 6x$

42.  $y = 12 - 3x$

Convert the given amount to the given unit.

43. 8.25 lb; ounces

44. 450 cm; meters

45. 17 yd; feet

46. 90 s; minutes

47. 216 h; days

48. 9.5 km; meters

**Get Ready!** To prepare for Lesson 4-6, do Exercises 49-56.

Find each product. Simplify if necessary.

49.  $-4(9)$

50.  $-3(-7)$

51.  $-7.2(-15.5)$

52.  $-6(1.5)$

53.  $-4\left(-\frac{7}{2}\right)$

54.  $-\frac{4}{9}\left(-\frac{9}{4}\right)$

55.  $\frac{25}{9}\left(\frac{3}{5}\right)$

56.  $\frac{7}{10}\left(\frac{15}{8}\right)$