1.1 Solving Simple Equations

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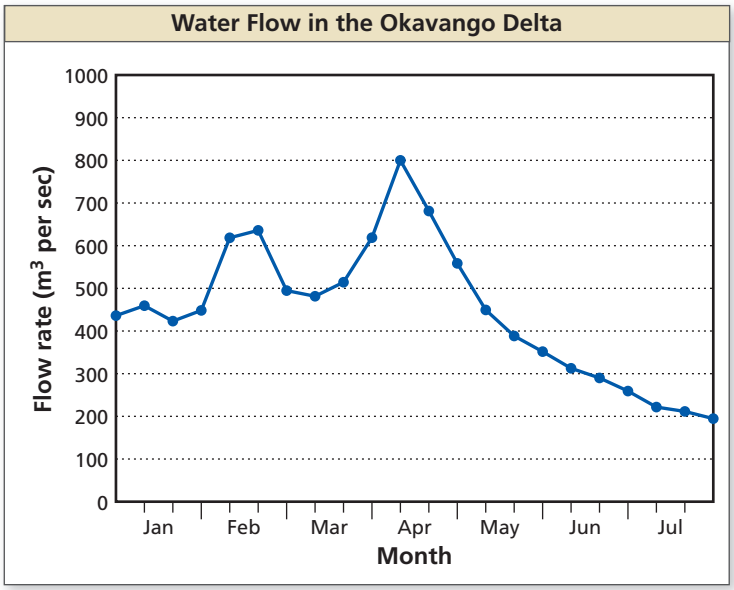
Learning Target Write and solve one-step linear equations.

Success Criteria

- I can apply properties of equality to produce equivalent equations.
- I can solve linear equations using addition, subtraction, multiplication, or division.
- I can write linear equations that model real-life situations.

EXPLORE IT! Modeling a Real-Life Problem

Work with a partner. The Okavango Delta is the largest freshwater wetland in southern Africa and is the main source of water for one million people.



Math Practice

Use a Graph

How can you use the graph to determine the quantities involved and the relationship between the quantities?

a. What does the graph show? Make several observations from the graph.

b. When the water flow was at its peak, about how long did it take 100,000 cubic meters of water to flow past a point in the Okavango Delta? Explain your reasoning.

c. Your friend uses an equation to answer part (b) as shown. Is your friend's reasoning valid? Explain.

$$f = 800t$$
$$100{,}000 = 800t$$
$$\frac{100{,}000}{800} = t$$
$$\frac{1000}{8} = t$$
$$125\ sec = t$$

$$m^3 \div \frac{m^3}{sec} = m^3 \times \frac{sec}{m^3} = sec$$

Solving Equations Using Addition or Subtraction

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Vocabulary

VOCAB

equation, *p. 4*
linear equation in one variable, *p. 4*
solution, *p. 4*
equivalent equations, *p. 4*

An **equation** is a statement that two expressions are equal. A **linear equation in one variable** is an equation that can be written in the form $ax + b = 0$, where a and b are constants and $a \neq 0$. When you *solve an equation*, you use properties of real numbers to find a **solution**, which is a value that makes the equation true.

Equivalent equations are equations that have the same solution(s). When you perform the same operation on each side of an equation, you produce an equivalent equation.

KEY IDEA

Addition, Subtraction, and Substitution Properties of Equality

Adding or subtracting the same number on each side of an equation produces an equivalent equation.

Addition Property of Equality	If $a = b$, then $a + c = b + c$.
Subtraction Property of Equality	If $a = b$, then $a - c = b - c$.
Substitution Property of Equality	If $a = b$, then a can be substituted for b (or b for a) in any equation or expression.

REMEMBER

Two operations that undo each other, such as addition and subtraction, are *inverse operations*. Use inverse operations to isolate the variable.

EXAMPLE 1 Solving Equations Using Addition or Subtraction

WATCH

Solve each equation. Justify each step. Check your solution.

a. $x - 3 = -5$ **b.** $0.9 = y + 2.8$

SOLUTION

a. $x - 3 = -5$ Write the equation.

Undo the subtraction. → $+ 3 \quad + 3$ Addition Property of Equality

$x = -2$ Simplify.

▶ The solution is $x = -2$.

Check

$x - 3 = -5$

$-2 - 3 \stackrel{?}{=} -5$

$-5 = -5$ ✓

b. $0.9 = y + 2.8$ Write the equation.

Undo the addition. → $-2.8 \quad -2.8$ Subtraction Property of Equality

$-1.9 = y$ Simplify.

▶ The solution is $y = -1.9$.

Check

$0.9 = y + 2.8$

$0.9 \stackrel{?}{=} -1.9 + 2.8$

$0.9 = 0.9$ ✓

SELF-ASSESSMENT

1 I do not understand. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

Solve the equation. Justify each step. Check your solution.

1. $n + 3 = -7$ **2.** $g - \frac{1}{3} = -\frac{2}{3}$ **3.** $-6.5 = p + 3.9$

4. VOCABULARY Are the equations $6x = -5$ and $-1 = 6x + 4$ equivalent? Explain your reasoning.

Solving Equations Using Multiplication or Division

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KEY IDEA

Multiplication and Division Properties of Equality

Multiplying or dividing each side of an equation by the same nonzero number produces an equivalent equation.

Multiplication Property of Equality If $a = b$, then $a \cdot c = b \cdot c$, $c \neq 0$.

Division Property of Equality If $a = b$, then $\frac{a}{c} = \frac{b}{c}$, $c \neq 0$.

REMEMBER
Multiplication and division are inverse operations.

EXAMPLE 2 Solving Equations Using Multiplication or Division

WATCH

Solve each equation. Justify each step. Check your solution.

a. $-\frac{n}{5} = -3$ **b.** $\pi x = -2\pi$ **c.** $1.3z = 5.2$

SOLUTION

a. $-\frac{n}{5} = -3$ Write the equation.

Undo the division. → $-5 \cdot \left(-\frac{n}{5}\right) = -5 \cdot (-3)$ Multiplication Property of Equality

$n = 15$ Simplify.

▶ The solution is $n = 15$.

Check

$-\frac{n}{5} = -3$

$-\frac{15}{3} \stackrel{?}{=} -3$

$-3 = -3$ ✓

b. $\pi x = -2\pi$ Write the equation.

Undo the multiplication. → $\frac{\pi x}{\pi} = \frac{-2\pi}{\pi}$ Division Property of Equality

$x = -2$ Simplify.

▶ The solution is $x = -2$.

Check

$\pi x = -2\pi$

$\pi(-2) \stackrel{?}{=} -2\pi$

$-2\pi = -2\pi$ ✓

c. $1.3z = 5.2$ Write the equation.

Undo the multiplication. → $\frac{1.3z}{1.3} = \frac{5.2}{1.3}$ Division Property of Equality

$z = 4$ Simplify.

▶ The solution is $z = 4$.

Check

$1.3z = 5.2$

$1.3(4) \stackrel{?}{=} 5.2$

$5.2 = 5.2$ ✓

SELF-ASSESSMENT

1 I do not understand. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

Solve the equation. Justify each step. Check your solution.

5. $\frac{y}{3} = -6$ **6.** $z \div 25 = -4.5$ **7.** $9\pi = \pi x$ **8.** $0.05w = 1.4$

9. WHICH ONE DOESN'T BELONG? Which equation does not belong with the other three? Explain your reasoning.

$8 = \frac{x}{2}$ $3 = x \div 4$ $x - 6 = 5$ $\frac{x}{3} = 9$

Solving Real-Life Problems

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KEY IDEA

Problem-Solving Plan

1. **Understand the Problem** What is the unknown? What information is given? What is being asked?
2. **Make a Plan** Decide how you will solve the problem. Your plan might involve one or more of the problem-solving strategies shown on the next page.
3. **Solve and Check** Carry out your plan. Examine your solution. Then check that your solution makes sense in the original statement of the problem.

WATCH

EXAMPLE 3 Modeling Real Life

In the 2016 Olympics, Usain Bolt won the 200-meter dash with a time of 19.78 seconds. Find his average speed to the nearest hundredth of a meter per second.

SOLUTION

1. **Understand the Problem** You know the winning time and the distance of the race. You are asked to find his average speed.
2. **Make a Plan** Use the Distance Formula to write an equation that represents the problem. Then solve the equation.
3. **Solve and Check**

REMEMBER
The formula that relates distance d, rate or speed r, and time t is
$d = rt$.

$$d = r \cdot t \qquad \text{Write the Distance Formula.}$$

$$200 = r \cdot 19.78 \qquad \text{Substitute 200 for } d \text{ and 19.78 for } t.$$

$$\frac{200}{19.78} = \frac{19.78r}{19.78} \qquad \text{Division Property of Equality}$$

$$10.11 \approx r \qquad \text{Simplify.}$$

REMEMBER
The symbol $\approx$ means "approximately equal to."

▶ Bolt's average speed was about 10.11 meters per second.

Check Reasonableness Round Bolt's average speed to 10 meters per second. At this speed, it would take

$$200 \text{ m} \div \frac{10 \text{ m}}{1 \text{ sec}} = 200 \cancel{\text{m}} \times \frac{1 \text{ sec}}{10 \cancel{\text{m}}} = 20 \text{ sec}$$

to run 200 meters. Because 20 is close to 19.78, your solution is reasonable.

SELF-ASSESSMENT

1 I do not understand. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

10. In 2015, an autonomous vehicle drove from the Golden Gate Bridge to New York City at an average speed of 15.7 miles per hour. The journey took 9 days. About how far did the vehicle travel?

11. In the 2012 Olympics, Usain Bolt ran the 200-meter dash at an average speed of about 10.35 meters per second. Was he faster in 2012 or in 2016? By how many seconds?

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KEY IDEA

Common Problem-Solving Strategies

Use a verbal model.	Guess, check, and revise.
Draw a diagram.	Sketch a graph or number line.
Write an equation.	Make a table.
Look for a pattern.	Make a list.
Work backward.	Break the problem into parts.

EXAMPLE 4 Modeling Real Life

WATCH INFO

On January 22, 1943, the temperature in Spearfish, South Dakota, fell from 54°F at 9:00 A.M. to −4°F at 9:27 A.M. How many degrees did the temperature fall?

SOLUTION

1. **Understand the Problem** You know the temperature before and after the temperature fell. You are asked to find how many degrees the temperature fell.
2. **Make a Plan** Use a verbal model to write an equation that represents the problem. Then solve the equation.
3. **Solve and Check**

Verbal Model

Temperature at 9:27 A.M. = Temperature at 9:00 A.M. − Number of degrees the temperature fell

Variable Let T be the number of degrees Fahrenheit the temperature fell.

Equation

$$-4 = 54 - T$$ Write the equation.

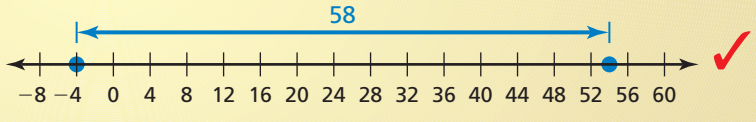
$$-4 - 54 = 54 - 54 - T$$ Subtraction Property of Equality

$$-58 = -T$$ Simplify.

$$58 = T$$ Divide each side by −1.

▶ The temperature fell 58°F.

Check The temperature fell from 54 degrees *above* 0 to 4 degrees *below* 0. You can use a number line to check your solution.



SELF-ASSESSMENT

1 I do not understand. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

12. You thought the balance in your savings account was $68.33, but you forgot to record a withdrawal. Your statement lists your balance as $26.33. How much was the withdrawal that you forgot to record?

13. In one year, a bluefin tuna releases 300% more eggs than an Atlantic sturgeon. The bluefin tuna releases about 10,000,000 eggs. About how many eggs does the Atlantic sturgeon release?

1.1 Practice WITH CalcChat® AND CalcView®

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In Exercises 1–10, solve the equation. Justify each step. Check your solution. *Example 1*

1. $x + 5 = 8$
2. $m + 9 = 2$
3. $y - 4 = 3$
4. $s - 2 = 1$
5. $w + 3 = -4$
6. $n - 6 = -7$
7. $5.2 = a - 0.4$
8. $1.7 = 3.1 + c$
9. $\frac{3}{2} + t = \frac{1}{2}$
10. $z - \frac{3}{4} = -\frac{1}{3}$

11. **MODELING REAL LIFE** An amusement park offers a ticket for \$12.95 off the original price p. Write and solve an equation to find the original price.

12. **MODELING REAL LIFE** You and a friend are playing a board game. Your final score x is 12 points less than your friend's final score. Write and solve an equation to find your final score.

	ROUND 9	ROUND 10	FINAL SCORE
Your Friend	22	12	195
You	9	25	?

In Exercises 13–22, solve the equation. Justify each step. Check your solution. *Example 2*

13. $5g = 20$
14. $4q = 52$
15. $p \div 5 = 3$
16. $y \div 7 = 1$
17. $-54 = 9s$
18. $\frac{w}{-3} = 6$
19. $-\frac{x}{6} = 1.4$
20. $-7.8 = -2.6t$
21. $-108\pi = 9\pi r$
22. $5 = \frac{h}{4\pi}$

In Exercises 23–32, solve the equation. Check your solution.

23. $-14 = p - 11$
24. $0 = 4 + q$
25. $-8r = 64$
26. $x \div (-2) = 8$
27. $\frac{3}{7}m = 6$
28. $-\frac{2}{5}y = 4$
29. $-3.8 = d \div 1.5$
30. $2a = \frac{1}{5}$
31. $f + 3\pi = 7\pi$
32. $-3\frac{1}{6} = k - \frac{2}{3}$

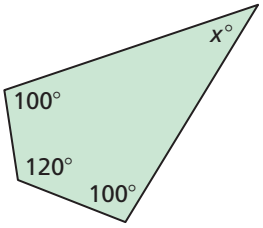
ERROR ANALYSIS **In Exercises 33 and 34, describe and correct the error in solving the equation.**

33. ✗
$$-0.8 + r = 12.6$$
$$r = 12.6 + (-0.8)$$
$$r = 11.8$$

34. ✗
$$-\frac{m}{3} = -4$$
$$3 \cdot \left(-\frac{m}{3}\right) = 3 \cdot (-4)$$
$$m = -12$$

MP USING TOOLS **The sum of the angle measures of a quadrilateral is 360°. In Exercises 35 and 36, write and solve an equation to find the value of x. Use a protractor to check the reasonableness of your answer.**

35.



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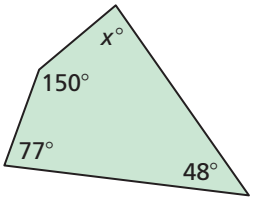


37. **COLLEGE PREP** A baker orders 162 eggs. Each carton contains 18 eggs. Which equation can you use to find the number x of cartons? Explain your reasoning and solve the equation.

Ⓐ $162x = 18$
Ⓑ $\frac{x}{18} = 162$
Ⓒ $18x = 162$
Ⓓ $x + 18 = 162$

38. MP **REASONING** Are the equations equivalent? Explain.

Equation 1	$x - \frac{1}{2} = \frac{x}{4} + 3$
Equation 2	$4x - 2 = x + 12$

MODELING REAL LIFE **In Exercises 39–42, write and solve an equation to answer the question.**

Examples 3 and 4

39. A swimmer wins the 50-yard freestyle with a time of 24.76 seconds. Find the swimmer's average speed to the nearest hundredth of a yard per second.

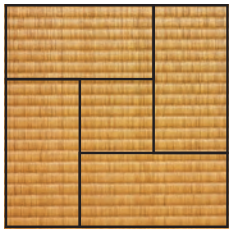
40. The length of an American flag is 1.9 times its width. What is the width of the flag?

41. The temperature at 5 P.M. is 20°F. The temperature at 10 P.M. is −5°F. How many degrees did the temperature fall?

42. The balance of an investment account is $308.32 greater than the balance 4 years ago. The current balance is $4708.57. What was the balance 4 years ago?

43. MP **PROBLEM SOLVING** You spend $8.64 on 12 cans of cat food. Each can costs the same amount and is on sale for 80% of the original price. The following week, the cans are no longer on sale. You have $10. Can you buy 12 more cans? Explain your reasoning.

44. DIG DEEPER Tatami mats are used as a floor covering in Japan. One possible layout uses four identical rectangular mats and one square mat, as shown. The area of the square mat is half the area of one of the rectangular mats. The length of a rectangular mat is twice the width. Find the dimensions of one rectangular mat. Justify your answer.



CONNECTING CONCEPTS **In Exercises 45–48, find the height h or the area B of the base of the solid.**

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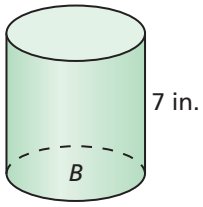
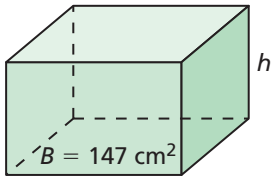


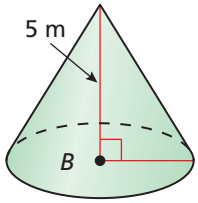
Volume = 84π in.^{3}

46.



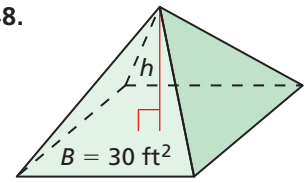
Volume = 1323 cm^3

47.



Volume = 15π m^3

48.



Volume = 35 ft^3

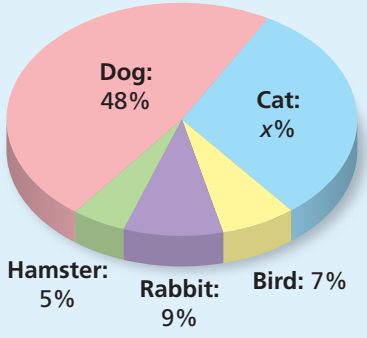
49. MP **STRUCTURE** Use the values −2, 5, 9, and 10 to complete each statement about the equation $ax = b - 5$.

a. When $a =$ ___ and $b =$ ___, x is a positive integer.

b. When $a =$ ___ and $b =$ ___, x is a negative integer.

50. **HOW DO YOU SEE IT?**

The circle graph shows the adoptions from a local animal shelter in 1 year. How does the equation $7 + 9 + 5 + 48 + x = 100$ relate to the circle graph? How can you use this equation to find the percent of adoptions that were cats?



51. MP **REASONING** One-sixth of the girls and two-sevenths of the boys in a school marching band are in the percussion section. The percussion section has 6 girls and 10 boys. How many students are in the marching band? Explain.

52. **ANALYZING RELATIONSHIPS** As c increases, does the value of x *increase, decrease,* or *stay the same* for each equation? Assume c is positive.

Equation	Value of x
$x - c = 0$	
$cx = 1$	
$cx = c$	
$\frac{x}{c} = 1$	

MP **REASONING** **In Exercises 53–56, the letters a, b, and c represent nonzero constants. Solve the equation for x. Then find values of a, b, and c for which the solution is positive.**

53. $bx = -7$

54. $x + a = \frac{3}{4}$

55. $-\frac{x}{c} = 6.5$

56. $\frac{c}{a}x = -b$

57. **MAKING AN ARGUMENT** In baseball, you calculate a player's batting average by dividing the number of hits by the number of at-bats.

a. How many hits does Player A have?

b. Player B has 33 fewer hits than Player A but has a greater batting average. Your friend concludes that Player B has more at-bats than Player A. Is your friend correct? Explain.

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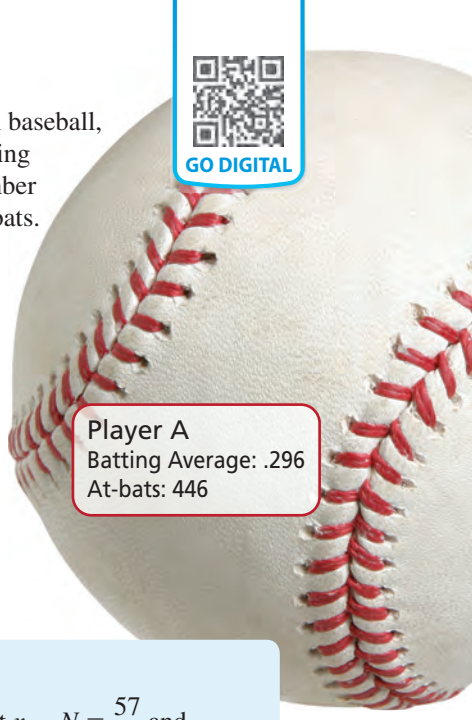


58. **THOUGHT PROVOKING**

Find the value of N such that $x - N = \frac{57}{10}$ and $\frac{x}{N} = -2.8$ are equivalent equations.

REVIEW & REFRESH

WATCH

In Exercises 59–62, multiply or divide.

59. $\frac{3}{5} \cdot \frac{4}{9}$

60. $2\frac{1}{8} \cdot \frac{2}{3}$

61. $\frac{3}{4} \div \frac{9}{10}$

62. $4\frac{1}{3} \div 1\frac{2}{5}$

63. Evaluate $15 - 6(7 + 5) \div 3^2$.

64. Find the missing values in the ratio table. Then write the equivalent ratios.

Calories	50		200	25
Servings	$\frac{1}{2}$	$\frac{3}{2}$		

In Exercises 65–67, simplify the expression.

65. $-5.9x - 4 + 2.3x - 6$

66. $4(-6m + 7)$

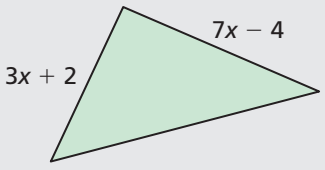
67. $-\frac{1}{3}(9y - 12) + 5y$

68. **MODELING REAL LIFE** You have 63 red roses and 45 white roses to make floral arrangements. Each arrangement must be identical. What is the greatest number of arrangements you can make using every flower?

69. Write $\frac{7}{9}$ as a decimal and a percent.

70. **MODELING REAL LIFE** A pizza shop charges \$10.99 for a large cheese pizza and \$1.50 for each topping. Write an expression that represents the cost (in dollars) of a large pizza with n toppings. How much does a large three-topping pizza cost?

71. The expression $14x + 3$ represents the perimeter of the triangle. What is the length of the third side?



In Exercises 72–75, solve the equation. Justify each step. Check your solution.

72. $7 + x = -5$

73. $-\frac{b}{9} = 3$

74. $-1.8t = -4.5$

75. $w - \frac{1}{4} = -\frac{5}{6}$

76. Find the mean of the data.

Data usage (gigabytes)			
2.5	1.7	3.6	5.4
3.2	1.5	1.8	2.8
4.8	3.5	3.1	4.5