2.4 Solve Multi-Step Equations

Before You solved one-step and two-step equations.

Now You will solve multi-step equations.

Why? So you can solve a problem about lifeguarding, as in Ex. 40.

Key Vocabulary

- **like terms**
- **distributive property**
- **reciprocal**

Solving a linear equation may take more than two steps. Start by simplifying one or both sides of the equation, if possible. Then use inverse operations to isolate the variable.

LESSON 2.4

Practice A

For use with the lesson "Solve Multi-Step Equations"

Check whether the given number is a solution of the equation.

1. $6x + 1 - 5x = 7; 2$ **2.** $7 + 2(m - 4) = 3; 1$ **3.** $\frac{1}{2}(8x - 6) = 1; 1$

$6x+1-5x=7$

$6\cdot2+1-5\cdot2=7$

$12+1-10=7$

$3=7$

NO

$\frac{1}{2}(8\cdot1-6)=1$

$\frac{1}{2}(8-6)=1$

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

$1=1$

YES

State the first step in solving the equation.

4. $13y + 7y - 6 = 11$

5. $5(a - 4) = 44$

6. $\frac{1}{3}(m - 4) = 5$

ADD Like TERMS

Distributive Property

7. $7 + 6(w - 3) = 31$

8. $8d - 4 - 6d = 22$

9. $7 - 3(p + 6) = 27$

Distributive Property

Solve the equation.

10. $3a + 2a + 7 = 12$ **11.** $9n - 4 + n = 16$ **12.** $7c + 3 - 5c = 15$

$9n + 4 + n = 16$

$4 \quad 10n + 4 = 16 + 4$

$\frac{1}{10} \quad 10n = 20 \quad \frac{1}{10}$

$n = 2$

13. $16 - 3y + 4y = 27$ **14.** $2 + 3(x + 1) = 17$ **15.** $15 + 4(m - 2) = 21$

$2+3(x+1)=17$

$2+3x+3=17$

$-5 \quad -5$

$3x+5=17$

$\frac{1}{3} \quad \frac{1}{3}$

$3x=12 \cdot \frac{1}{3}$

$x=4$

16. $2p + 3(p + 3) = 21$ **17.** $6w + 5(w - 2) = 23$ **18.** $7 - 3(x + 2) = 4$

$2p+3(p+3)=21$

$2p+3p+9=21$

$-9 \quad 5p+9=21 \quad -9$

$\frac{1}{5}5p=12\cdot\frac{1}{5}$

$p=\frac{12}{5}$

$7-3(x+2)=4$

$7-3x-6=4$

$-3x+1=4 \quad -1 \quad -1$

$-\frac{1}{3}\cdot -3x=3\cdot -\frac{1}{3}$

$x=-1$

19. $\frac{1}{4}(d-5)=1$ **20.** $\frac{1}{3}(m+6)=4$ **21.** $\frac{1}{8}(w-7)=5$

$4 \cdot \frac{1}{4}(D-5) = 1 \cdot 4$

$D-5 = 4$

$D = 9$

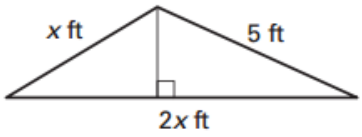
$8 \cdot \frac{1}{8}(w-7) = 5 \cdot 8$

$w-7 = 40$

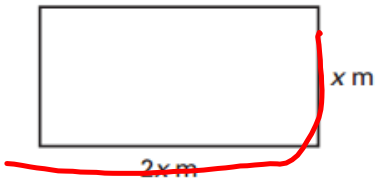
$w = 47$

Find the value of *x* for the triangle or rectangle.

22. Perimeter = 17 feet



23. Perimeter = 18 meters



$18 = 2(2x + x)$

$18 = 2(3x)$

$\frac{1}{2} \cdot 18 = 6x \cdot \frac{1}{2}$

$3 = x$

24. Target Heart Rate The target heart rate is the heartbeat rate during aerobic exercise that provides a benefit to your heart. The target heart rate for a person exercising at 70% intensity is given by the equation $y = 0.7(200 - x)$ where y is the target heart rate in beats per minute and x is the person's age in years.

a. How old is a person with a target heart rate of 133 beats per minute?

b. How old is a person with a target heart rate of 126 beats per minute?

25. Spare Change You have quarters and nickels saved in a piggy bank. There is a total of $3.45 in quarters and nickels and there are 9 more nickels than quarters.

a. Use the verbal model to write an equation that you can use to find the number of nickels and quarters in your piggy bank. Let q represent the number of quarters.

Number of quarters	·	Value of 1 quarter	+	Number of nickels	·	Value of 1 nickel	=	Total amount in piggy bank

$q \cdot .25 + (q+9)(.05) = 3.45$

$.25q + .05(q+9) = 3.45$

$.25q + .05q + .45 = 3.45$

$-.45 \quad -.45$

$.3q + .45 = 3.45$

$\frac{1}{.3}$ $.3q = 3$ $\frac{1}{.3}$

$q = 10$

b. How many nickels and quarters are in the piggy bank?

$n = q + 9$

$10 + 9$

$n = 19$

Practice Level A

1. no **2.** no **3.** yes **4.** Add $7y$ to $13y$.

5. Distribute 5 to $(a - 4)$. **6.** Multiply each side by 3. **7.** Distribute 6 to $(w - 3)$. **8.** Subtract $6d$ from $8d$. **9.** Distribute -3 to $(p + 6)$. **10.** $a = 1$

11. $n = 2$ **12.** $c = 6$ **13.** $y = 11$ **14.** $x = 4$

15. $m = \frac{7}{2}$ **16.** $p = \frac{12}{5}$ **17.** $w = 3$ **18.** $x = -1$

19. $d = 9$ **20.** $m = 6$ **21.** $w = 47$ **22.** $x = 4$

23. $x = 3$ **24. a.** 10 years old **b.** 20 years old

25. a. $q(0.25) + (q + 9)(0.05) = 3.45$
b. 10 quarters and 19 nickels

Name _____ Date _____

LESSON 2.4

Practice B

For use with the lesson "Solve Multi-Step Equations"

Solve the equation.

1. $16x - 15 - 9x = 13$

2. $15m + 4 - 9m = -32$

3. $3b - 9 - 8b = 11$

4. $-31 = 8 - 6p - 7p$

5. $9 + 4(x + 1) = 25$

6. $7(d - 5) + 12 = 5$

7. $10a + 5(a - 3) = 15$

8. $19a - 3(a - 6) = 66$

9. $\frac{1}{4}(x - 8) = 7$

10. $\frac{1}{3}(d + 9) = -12$

11. $\frac{3}{4}(n + 3) = 9$

12. $-\frac{5}{2}(w - 1) = 15$

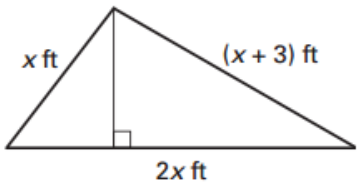
13. $6.4 + 2.1(z - 2) = 8.5$

14. $4.5 - 1.5(6m + 2) = 6$

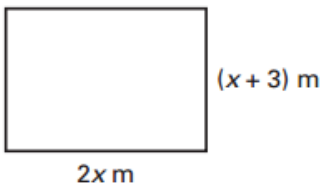
15. $15 = 4.3n - 2.1(n - 4)$

Find the value of *x* for the triangle or rectangle.

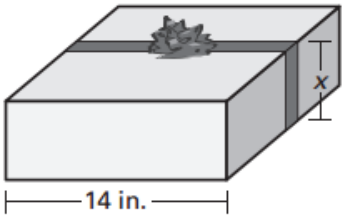
16. Perimeter = 23 feet



17. Perimeter = 24 meters



18. Wrapping a Package It takes 70 inches of ribbon to make a bow and wrap the ribbon around a box. The bow takes 32 inches of ribbon. The width of the box is 14 inches. What is the height of the box?



19. Vacation You are driving to a vacation spot that is 1500 miles away. Including rest stops, it takes you 42 hours to get to the vacation spot. You estimate that you drove at an average speed of 50 miles per hour. How many hours were you *not* driving?

20. Moving You helped a friend move a short distance recently. The friend rented a truck for $15 an hour and rented a dolly for $5. Your friend paid a total of $80 for the rental. For how long did your friend rent the truck?

21. Painting You and your friend are painting the walls in your apartment. You estimate that there is 1000 square feet of space to be painted. You paint at a rate of 4 square feet per minute and your friend paints at a rate of 3 square feet per minute. Your friend shows up to help you paint 45 minutes after you have already started painting.

a. Write an equation that gives the total number of square feet y as a function of the number of minutes x it takes to paint all of the walls.

b. How long will it take you and your friend to finish painting? Round your answer to the nearest minute.

Practice Level B

1. $x = 4$ **2.** $m = -6$ **3.** $b = -4$ **4.** $p = 3$

5. $x = 3$ **6.** $d = 4$ **7.** $a = 2$ **8.** $a = 3$

9. $x = 36$ **10.** $d = -45$ **11.** $n = 9$

12. $w = -5$ **13.** $z = 3$ **14.** $m = -0.5$

15. $n = 3$ **16.** $x = 5$ **17.** $x = 3$ **18.** 5 in.

19. 12 h **20.** 5 h **21. a.** $y = 4(x + 45) + 3x$ **b.** about 117 min

EXAMPLE 1 Solve an equation by combining like terms

Solve $8x - 3x - 10 = 20$.

$8x - 3x - 10 = 20$	Write original equation.
$5x - 10 = 20$	Combine like terms.
$5x - 10 + 10 = 20 + 10$	Add 10 to each side.
$5x = 30$	Simplify.
$\frac{5x}{5} = \frac{30}{5}$	Divide each side by 5.
$x = 6$	Simplify.

EXAMPLE 2 Solve an equation using the distributive property

Solve $7x + 2(x + 6) = 39$.

Solution

When solving an equation, you may feel comfortable doing some steps mentally. Method 2 shows a solution where some steps are done mentally.

METHOD 1 Show All Steps

$$7x + 2(x + 6) = 39$$
$$7x + 2x + 12 = 39$$
$$9x + 12 = 39$$
$$9x + 12 - 12 = 39 - 12$$
$$9x = 27$$
$$\frac{9x}{9} = \frac{27}{9}$$
$$x = 3$$

METHOD 2 Do Some Steps Mentally

$$7x + 2(x + 6) = 39$$
$$7x + 2x + 12 = 39$$
$$9x + 12 = 39$$
$$9x = 27$$
$$x = 3$$

EXAMPLE 3 Standardized Test Practice

Which equation represents Step 2 in the solution process?

Step 1 $5x - 4(x - 3) = 17$

Step 2 ☐

Step 3 $x + 12 = 17$

Step 4 $x = 5$

Ⓐ $5x - 4x - 12 = 17$ Ⓑ $5x - 4x - 3 = 17$

Ⓒ $5x - 4x + 3 = 17$ Ⓓ $5x - 4x + 12 = 17$

Solution

In Step 2, the distributive property is used to simplify the left side of the equation. Because $-4(x - 3) = -4x + 12$, Step 2 should be $5x - 4x + 12 = 17$.

▶ The correct answer is D. Ⓐ Ⓑ Ⓒ Ⓓ

GUIDED PRACTICE for Examples 1, 2, and 3

Solve the equation. Check your solution.

1. $9d - 2d + 4 = 32$ 4

2. $2w + 3(w + 4) = 27$ 3

3. $6x - 2(x - 5) = 46$ 9

GUIDED PRACTICE for Example 4

Solve the equation. Check your solution.

4. $\frac{3}{4}(z - 6) = 12$ **22**

5. $\frac{2}{5}(3r + 4) = 10$ **7**

6. $-\frac{4}{5}(4a - 1) = 28$ **−8.5**

SUMMER CAMP You are planning a scavenger hunt for 21 campers. You plan to have 5 teams. One camper from each team will be the recorder and the rest will be searchers. How many searchers will each team have?

Solution

Let s be the number of searchers on each team. Then $1 + s$ is the total number of campers on each team.

Number of campers	=	Number of teams	·	Number of campers on each team
21	**=**	**5**	**·**	**(1 + *s*)**

$21 = 5(1 + s)$ **Write equation.**

$21 = 5 + 5s$ **Distributive property**

$16 = 5s$ **Subtract 5 from each side.**

$3.2 = s$ **Divide each side by 5.**

▶ Because 4 searchers per team would require a total of $5(1 + 4) = 25$ campers, 4 teams will have 3 searchers and 1 team will have 4 searchers.

USING RECIPROCALS Although you can use the distributive property to solve an equation such as $\frac{3}{2}(3x + 5) = -24$, it is easier to multiply each side of the equation by the reciprocal of the fraction.

EXAMPLE 4 Multiply by a reciprocal to solve an equation

Solve $\frac{3}{2}(3x + 5) = -24$.

$\frac{3}{2}(3x + 5) = -24$	Write original equation.
$\frac{2}{3} \cdot \frac{3}{2}(3x + 5) = \frac{2}{3}(-24)$	Multiply each side by $\frac{2}{3}$, the reciprocal of $\frac{3}{2}$.
$3x + 5 = -16$	Simplify.
$3x = -21$	Subtract 5 from each side.
$x = -7$	Divide each side by 3.

GUIDED PRACTICE for Example 5

7. **WHAT IF?** In Example 5, suppose you decide to use only 4 teams. How many searchers should there be on each team?
5 searchers on one team and 4 searchers on the other teams