# 3.1 Solving Equations Using Addition and Subtraction

*What you should learn*

GOAL 1 Solve linear equations using addition and subtraction.

GOAL 2 Use linear equations to solve **real-life** problems such as finding a record temperature change in **Example 3**.

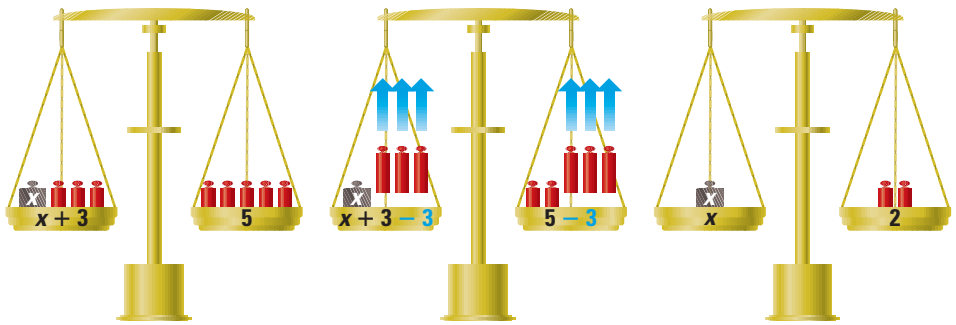
*Why you should learn it*

▼ To model **real-life** situations, such as comparing the sizes of city parks in **Exs. 52 and 53**.


## GOAL 1 ADDITION AND SUBTRACTION EQUATIONS

You can solve an equation by using the *transformations* below and on page 138 to isolate the variable on one side of the equation. When you rewrite an equation using these transformations, you produce an equation with the same solutions as the original equation. These equations are called **equivalent** equations. For example, $x + 3 = 5$ and $x = 2$ are equivalent because $x + 3 = 5$ can be transformed into $x = 2$ and each equation has 2 as its only solution.

To change, or *transform*, an equation into an equivalent equation, think of an equation as having two sides that are "in balance."




Original equation: $x + 3 = 5$

Subtract 3 from both sides to isolate $x$ on the left. Scale stays in balance.

Simplify both sides. Equivalent equation: $x = 2$

Any transformation you apply to an equation must keep the equation in balance. For instance, if you subtract 3 from one side of the equation, you must also subtract 3 from the other side of the equation. Simplifying one side of the equation does not affect the balance, so you don't have to change the other side.

### TRANSFORMATIONS THAT PRODUCE EQUIVALENT EQUATIONS

| | ORIGINAL EQUATION | | EQUIVALENT EQUATION |
|---|---|---|---|
| • Add the same number to *each* side. | $x - 3 = 5$ | Add 3. → | $x = 8$ |
| • Subtract the same number from *each* side. | $x + 6 = 10$ | Subtract 6. → | $x = 4$ |
| • Simplify one or both sides. | $x = 8 - 3$ | Simplify. → | $x = 5$ |
| • Interchange the sides. | $7 = x$ | Interchange. → | $x = 7$ |

**Inverse operations** are operations that undo each other, such as addition and subtraction. Inverse operations help you to *isolate the variable* in an equation.

**STUDENT HELP**

**Look Back**
For help with checking whether a number is a solution, see p. 24.

**INTERNET HOMEWORK HELP**
Visit our Web site www.mcdougallittell.com for extra examples.

## EXAMPLE 1 Adding to Each Side

Solve $x - 5 = -13$.

**SOLUTION**

On the left side of the equation, 5 is subtracted from $x$. To isolate $x$, you need to undo the subtraction by applying the inverse operation of adding 5. Remember, to keep the balance you must add 5 to *each* side.

$x - 5 = -13$ — Write original equation.

$x - 5 + 5 = -13 + 5$ — Add 5 to each side.

$x = -8$ — Simplify.

▶ The solution is $-8$. Check by substituting $-8$ for $x$ in the original equation.

**✓CHECK**

$x - 5 = -13$ — Write original equation.

$-8 - 5 \stackrel{?}{=} -13$ — Substitute $-8$ for $x$.

$-13 = -13$ — Solution is correct.

. . . . . .

Each time you apply a transformation to an equation, you are writing a **solution step**. Solution steps are written one below the other with the equals signs aligned.

## EXAMPLE 2 Simplifying First

Solve $-8 = n - (-4)$.

**STUDENT HELP**

**Study Tip**
After you solve an equation, check by substituting into the *original* equation. To check Example 2, substitute $-12$ for $n$ in the equation $-8 = n - (-4)$, not in the simplified equation $-8 = n + 4$.

**SOLUTION**

$-8 = n - (-4)$ — Write original equation.

$-8 = n + 4$ — Simplify.

$-8 - 4 = n + 4 - 4$ — Subtract 4 from each side.

$-12 = n$ — Simplify.

. . . . . .

The equations in this chapter are called *linear equations*. In a **linear equation** the variable is raised to the *first* power and does not occur in a denominator, inside a square root symbol, or inside absolute value symbols.

| LINEAR EQUATION | NOT A LINEAR EQUATION |
|---|---|
| $x + 5 = 9$ | $x^2 + 5 = 9$ |
| $-4 + n = 2n - 6$ | $\lvert x + 3 \rvert = 7$ |

In Chapter 4 you will see that *linear equations* get their name from the fact that their graphs are straight lines.

## GOAL 2 USING LINEAR EQUATIONS IN REAL-LIFE PROBLEMS

REAL LIFE *Temperature*

### EXAMPLE 3 *Modeling a Real-Life Problem*

Several record temperature changes have taken place in Spearfish, South Dakota. On January 22, 1943, the temperature in Spearfish fell from 54°F at 9:00 A.M. to −4°F at 9:27 A.M. By how many degrees did the temperature fall?

**SOLUTION**

PROBLEM SOLVING STRATEGY

**VERBAL MODEL**

Temperature at 9:27 A.M. = Temperature at 9:00 A.M. − Degrees fallen

**LABELS**

Temperature at 9:27 A.M. $= -4$ (degrees Fahrenheit)

Temperature at 9:00 A.M. $= 54$ (degrees Fahrenheit)

Degrees fallen $= T$ (degrees Fahrenheit)

**ALGEBRAIC MODEL**

$-4 = 54 - T$ Write algebraic model.

$-4 - 54 = 54 - T - 54$ Subtract 54 from each side.

$-58 = -T$ Simplify.

$58 = T$ $T$ is the opposite of −58.

▶ The temperature fell by 58°. Check this in the original statement of the problem.

STUDENT HELP

**Study Tip**

When you solve an equation, if you get a solution such as $-x = 9$, remember that this is the same as saying "the opposite of $x$ is 9" or "$x$ is the opposite of 9," which you can write as $x = -9$.

### EXAMPLE 4 *Translating Verbal Statements*

Match the real-life problem with an equation.

$x - 4 = 16$ $x + 16 = 4$ $16 - x = 4$

**a.** You owe $16 to your cousin. You paid $x$ dollars back and you now owe $4. How much did you pay back?

**b.** The temperature was $x$°F. It rose 16°F and is now 4°F. What was the original temperature?

**c.** A telephone pole extends 4 feet below ground and 16 feet above ground. What is the total length $x$ of the pole?

**SOLUTION**

**a.** Original amount owed (16) − Amount paid back ($x$) = Amount now owed (4)

**b.** Original temperature ($x$) + Degrees risen (16) = Temperature now (4)

**c.** Total length ($x$) − Length below ground (4) = Length above ground (16)

# GUIDED PRACTICE

**Vocabulary Check** ✓

1. Two equations that have the same solutions are called ? equations.

**Concept Check** ✓

2. Show how to check the solution found in Example 3.
3. Explain each solution step for the equation $-3 - x = 1$. Use the Study Tip and Example 3 on page 134 to help.

**Skill Check** ✓

**Solve the equation.**

4. $r + 3 = 2$
5. $9 = x - 4$
6. $7 + c = -10$
7. $-3 = b - 6$
8. $8 - x = 4$
9. $r - (-2) = 5$

**SPENDING MONEY** **You started with some money in your pocket. All you spent was $4.65 on lunch. You ended up with $7.39 in your pocket.**

10. Write an equation to find how much money you started with.
11. Describe the transformation you would use to solve the equation.
12. Solve the equation. What does the solution mean?

# PRACTICE AND APPLICATIONS

STUDENT HELP

**Extra Practice** to help you master skills is on p. 799.

**STATING THE INVERSE** **State the inverse operation.**

13. Add 28.
14. Add 17.
15. Subtract 15.
16. Subtract 3.
17. Add $-3$.
18. Add $-12$.
19. Subtract $-45$.
20. Subtract $-2\frac{1}{2}$.

**SOLVING EQUATIONS** **Solve the equation.**

21. $x = 4 - 7$
22. $x + 5 = 10$
23. $t - 2 = 6$
24. $11 = r - 4$
25. $-9 = 2 + y$
26. $n - 5 = -9$
27. $-3 + x = 7$
28. $\frac{2}{5} = a - \frac{1}{5}$
29. $r + 3\frac{1}{4} = 2\frac{1}{2}$
30. $t - (-4) = 4$
31. $|-6| + y = 11$
32. $|-8| + x = -3$
33. $19 - (-y) = 25$
34. $|2| - (-b) = 6$
35. $x + 4 - 3 = 6 \cdot 5$
36. $-b = 8$
37. $12 - 6 = -n$
38. $3 - a = 0$
39. $4 = -b - 12$
40. $-3 = -a + (-4)$
41. $-r - (-7) = 16$

**MATCHING AN EQUATION** **In Exercises 42–44, match the real-life problem with an equation. Then solve the problem.**

**A.** $x + 15 = 7$ **B.** $15 - x = 7$ **C.** $15 + 7 = x$ **D.** $x + 15 = -7$

42. You own 15 CDs. You buy 7 more. How many CDs do you own now?
43. There are 15 members of a high school band brass section. After graduation there are only 7 members. How many members graduated?
44. The temperature rose 15 degrees to 7°F. What was the original temperature?

STUDENT HELP

HOMEWORK HELP

**Example 1:** Exs. 13–29
**Example 2:** Exs. 30–35
**Example 3:** Exs. 36–49
**Example 4:** Exs. 42–49

**SOLVING EQUATIONS** **Write and solve an equation to answer the question.**

**45.** **VIDEO PRICES** The selling price of a certain video is $7 more than the price the store paid. If the selling price is $24, find the price the store paid.

**46.** **TRACK** Jackie Joyner-Kersee won a gold medal in the Olympic Heptathlon in 1988 and in 1992. Her 1992 score was 7044 points. This was 247 fewer points than her 1988 score. What was her 1988 score?

**47.** **BASEBALL STADIUMS** Turner Field in Atlanta, GA, has 49,831 seats. Jacobs Field in Cleveland, OH, has 43,368 seats. How many seats would need to be added to Jacobs Field for it to have as many seats as Turner Field?

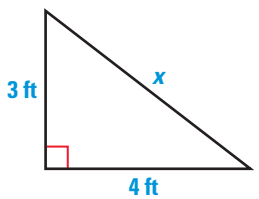
**48.** **TEST SCORES** The last math test that you took had 100 regular points and 10 bonus points. You received a total score of 87, which included 9 bonus points. What would your score have been without any bonus points?

**49.** **COMPUTER TIME** The average 12-to-17-year-old spends 645 minutes per month on a personal computer. This is 732 fewer minutes per month than the average 18-to-24-year-old spends. How many minutes per month does the average 18-to-24-year-old spend on a personal computer?

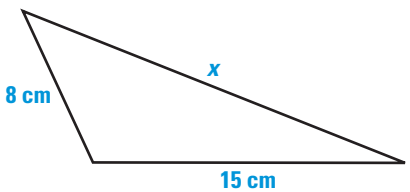
▶ Source: Media Matrix

**GEOMETRY CONNECTION** **Find the length of the side marked *x*.**

**50.** The perimeter is 12 feet.




**51.** The perimeter is 43 centimeters.




**CITY PARKS** **In Exercises 52 and 53, use the table that shows the sizes (in acres) of the largest city parks in the United States.**

| Park (location) | Size (in acres) |
|---|---|
| Cullen Park (Houston, TX) | ? |
| Fairmount Park (Philadelphia, PA) | 8700 |
| Griffith Park (Los Angeles, CA) | 4218 |
| Eagle Creek Park (Indianapolis, IN) | ? |
| Pelham Bay Park (Bronx, NY) | 2764 |

▶ Source: The Trust for Public Land

**52.** You are researching United States city parks. You note that Griffith Park is only 418 acres larger than Eagle Creek Park. Write an equation that models the size of Eagle Creek Park. Solve the equation.

**53.** You note that the largest city park, Cullen Park, is only 248 acres smaller than the sum of the sizes of Griffith Park, Eagle Creek Park, and Pelham Bay Park. Write an equation that models the size of Cullen Park. Solve the equation. (*Hint:* Use the result of Exercise 52.)

**FOCUS ON CAREERS**

**REAL LIFE** **PARK RANGER** Possible duties of a park ranger include gathering and presenting historical or scientific information, managing resources, guiding tours, and maintaining order and safety.

**INTERNET CAREER LINK**
www.mcdougallittell.com

## Test Preparation

**54. MULTI-STEP PROBLEM** The table shows the number of Digital Versatile Disc (DVD) players sold in the first ten months after their release in 1997.

| Month | Cumulative sales | Sales equation | Monthly sales |
|---|---|---|---|
| March | 5,828 | —— | 5,828 |
| April | 13,198 | $5{,}828 + x = 13{,}198$ | 7,370 |
| May | 22,254 | ? | ? |
| June | 31,580 | ? | ? |
| July | 40,972 | ? | ? |
| Aug. | 51,401 | ? | ? |
| Sept. | 68,702 | ? | ? |
| Oct. | 83,494 | ? | ? |
| Nov. | 108,897 | ? | ? |
| Dec. | 158,068 | ? | ? |

▶ Source: INTELECT ASW

**a.** Copy the table. For each month, write a sales equation relating cumulative and monthly sales. Let $x$ represent the number of players sold that month.

**b.** Solve your sales equations to fill in the monthly sales column.

**c.** *Writing* Suppose a DVD player manufacturer started an advertising campaign in September. Use your table to judge the campaign's effect on sales. Write a report explaining whether the campaign was successful.

## ★ Challenge

**55. LOGICAL REASONING** You decide to see if you can ride the elevator to street level (Floor 0) without pushing any buttons. The elevator takes you up 4 floors, down 6 floors, up 1 floor, down 8 floors, down 3 floors, up 1 floor, and then down 6 floors to street level. Write and solve an equation to find your starting floor.

# MIXED REVIEW

**TRANSLATING VERBAL SENTENCES** **Write the verbal sentence as an equation.** (Review 1.5 for 3.2)

**56.** Five times a number is 160.

**57.** A number divided by 6 is 32.

**58.** One fourth of a number is 36.

**59.** A number multiplied by $\frac{2}{3}$ is 8.

**SIMPLIFYING EXPRESSIONS** **Simplify the expression.** (Review 2.5 and 2.7 for 3.2)

**60.** $8\left(\frac{x}{8}\right)$ **61.** $\frac{1}{8}y \cdot 8$ **62.** $-\frac{3}{5}\left(-\frac{5}{3}x\right)$ **63.** $-4x \div (-4)$

**64.** $6\left(-\frac{1}{6}x\right)$ **65.** $\frac{7}{12}y \cdot \frac{12}{7}$ **66.** $\frac{t}{-4}(-4)$ **67.** $-19a \div 19$

**DISTRIBUTIVE PROPERTY** **Apply the distributive property.** (Review 2.6)

**68.** $4(x + 2)$ **69.** $7(3 - 2y)$ **70.** $-5(-y - 7)$ **71.** $(3x + 8)(-2)$

**72.** $-x(x - 6)$ **73.** $-5x(y + 3)$ **74.** $2y(8 - 7y)$ **75.** $(-3x - 9y)(-6y)$