Lesson 8-2
Solving Two-Step Equations

Interactive Study Guide
See pages 171–172 for:
- Getting Started
- Real-World Link
- Notes

Essential Question
How are equations and inequalities used to describe and solve multi-step problems?

Common Core State Standards
Content Standards
7.EE.4, 7.EE.4a, 8.EE.7, 8.EE.7b

Mathematical Practices
1, 3, 4, 7

Vocabulary
two-step equation

What You'll Learn
- Solve two-step equations.
- Solve real-world problems involving two-step equations.

Real-World Link
Cheerleading Cheerleaders on a middle school squad must purchase cheer shoes for $35, plus several pairs of white ankle socks. An equation involving two operations can be used to find the total cost.

Solve Two-Step Equations

A **two-step equation** contains two operations. To solve a two-step equation, use inverse operations to undo each operation in reverse order of the order of operations.

Example 1

Tutor

Solve $3a + 9 = 33$. Check your solution.

Method 1 The Vertical Method

$3a + 9 = 33$	Write the equation.
$3a + 9 = 33$	
$\quad -9 = -9$	Subtraction Property of Equality
$3a \quad = 24$	Simplify.
$\frac{3a}{3} = \frac{24}{3}$	Division Property of Equality
$a = 8$	Simplify.

Method 2 The Horizontal Method

$3a + 9 = 33$	Write the equation.
$3a + 9 - 9 = 33 - 9$	Subtraction Property of Equality
$3a = 24$	Simplify.
$\frac{3a}{3} = \frac{24}{3}$	Division Property of Equality
$a = 8$	Simplify.

Using either method, the solution is 8.

Check

$3a + 9 = 33$	Write the equation.
$3(8) + 9 \stackrel{?}{=} 33$	Replace a with 8.
$24 + 9 \stackrel{?}{=} 33$	Multiply.
$33 = 33$ ✓	The sentence is true.

$6x + 1 = 25$, $-1 \quad -1$, $\frac{6x}{6} = \frac{24}{6}$, $x = 4$

$4x - 5 = -33$, $+5 \quad +5$, $\frac{4x}{4} = \frac{-28}{4}$, $x = -7$

Got It? Do these problems to find out.

Solve each equation. Check your solution.

1a. $6x + 1 = 25$

1b. $4x - 5 = -33$

Image Source Pink/Getty Images

Example 2

Watch Tutor

Solve $\frac{1}{5}p - 12 = 20$.

$\frac{1}{5}p - 12 = 20$	Write the equation.
$\frac{1}{5}p - 12 + \mathbf{12} = 20 + \mathbf{12}$	Addition Property of Equality
$\frac{1}{5}p = 32$	Simplify.
$\mathbf{5} \cdot \frac{1}{5}p = \mathbf{5} \cdot 32$	Multiplication Property of Equality
$p = 160$	Simplify. Check your solution.

Properties of Equality
Recall that the Addition and Subtraction Properties of Equality state that the same number can be added to or subtracted from each side of an equation.

2a. $8 = 15 + \frac{1}{3}n$
$+(-15) \quad -15$
$3(-7) = \frac{3}{1}\left(\frac{1}{3}n\right)$
$-21 = n$

Got It? Do these problems to find out.

2a. $8 = 15 + \frac{1}{3}n$ **2b.** $-\frac{1}{6}x - 3 = 2$

$8 = 15 + \frac{1}{3}(-21)$
$8 = 15 + (-7)$
$8 = 8$ ✓

Example 3

Tutor

Solve $9 - t = -34$.

$9 - t = -34$	Write the equation.
$9 - \mathbf{1}t = -34$	Identity Property: $t = 1t$
$9 + (-1t) = -34$	Definition of Subtraction
$\mathbf{-9} + 9 + (-1t) = \mathbf{-9} + (-34)$	Addition Property of Equality
$-1t = -43$	Simplify.
$\frac{-1t}{\mathbf{-1}} = \frac{-43}{\mathbf{-1}}$	Division Property of Equality
$t = 43$	Simplify. Check your solution.

Got It? Do these problems to find out.

3a. $-15 - b = 44$ **3b.** $-6.5 = -4.3 - n$

Example 4

Tutor

Solve $2x + x - 27 = 3$.

$2x + x - 27 = 3$	Write the equation.
$2x + \mathbf{1}x - 27 = 3$	Identity Property; $x = 1x$
$3x - 27 = 3$	Distributive Property; $2x + 1x = (2 + 1)x$ or $3x$
$3x - 27 + \mathbf{27} = 3 + \mathbf{27}$	Addition Property of Equality
$3x = 30$	Simplify.
$\frac{3x}{\mathbf{3}} = \frac{30}{\mathbf{3}}$	Division Property of Equality
$x = 10$	Simplify. Check your solution.

Distributive Property
You use the Distributive Property to mentally simplify $2x + x$.
$2x + 1x = (2 + 1)x$
$= 3x$

Got It? Do these problems to find out.

4a. $4 - 9c + 3c = 58$ **4b.** $3.4 = 0.4m - 2 + 0.2m$

Solve Real-World Problems

You can write and solve two-step equations to solve many real-world problems.

Example 5

Deon wants to go on a camping trip with his hiking club. The trip costs $185.75. He paid a deposit of $45.75 and will save an additional $17.50 per week to pay for the trip. Solve $45.75 + 17.50w = 185.75$ to find the number of weeks Deon will need to save money for the trip.

$45.75 + 17.50w = 185.75$ — Write the equation.

$45.75 - \mathbf{45.75} + 17.50w = 185.75 - \mathbf{45.75}$ — Subtraction Property of Equality

$17.50w = 140$ — Simplify.

$\frac{17.50w}{\mathbf{17.50}} = \frac{140}{\mathbf{17.50}}$ — Division Property of Equality

$w = 8$ — Simplify. Check your solution.

Deon will need to save for 8 weeks.

Got It? Do this problem to find out.

5. Salvatore purchased a computer for $682.20. He paid $105.40 initially and will pay $20.60 per month until the computer is paid off. Solve $105.40 + 20.60x = 682.20$ to find the number of months Salvatore will make payments for the computer.

Guided Practice

Solve each equation. Check your solution. (Examples 1 and 2)

1. $4p + 9 = 25$ **2.** $-2x + 1 = 7$ **3.** $5y - 3 = -23$

4. $17 = 7x - 4$ **5.** $-4 = 8m - 12$ **6.** $-13 = 5 - 3z$

7. $\frac{1}{4}p - 6 = -8$ **8.** $-\frac{1}{6}t + 1 = 3$ **9.** $-\frac{1}{2}r - 12 = -27$

10. $\frac{1}{2}g + 6 = 4$ **11.** $-\frac{1}{8}x - 5 = -1$ **12.** $9 = 4 + \frac{1}{5}q$

Solve each equation. Check your solution. (Examples 3 and 4)

13. $-7 - 8d = 17$ **14.** $23 - 2c = 41$ **15.** $1 - 2k = -9$

16. $12 - m = -7$ **17.** $14 = 6 - x$ **18.** $-6 = 4 - 5b$

19. $-4 = 8y - 9y + 6$ **20.** $-1.3j + 0.4 = -1.16$ **21.** $1.1 - t + 2.2t = 5.9$

22. $5m + 4 - 7m = 10$ **23.** $\frac{1}{3}p + 6 - \frac{2}{3}p = 0$ **24.** $7.8 = 3 + 0.1n + 0.7n$

25. Kaleigh has $25. She plans to save $7.50 each week. Solve $25 + 7.50w = 250$ to find the number of weeks it will take Kaleigh to save $250. (Example 5)

26. A caterer is preparing a dinner for a party. She charges a flat fee of $16 plus $8.25 per person. Solve $16 + 8.25p = 131.50$ to find the number of people at a dinner that costs $131.50. (Example 5)

Independent Practice

Go online for Step-by-Step Solutions eHelp

Solve each equation. Check your solution. (Examples 1 and 2)

27. $5a + 3 = 28$

28. $3b + 15 = 27$

29 $4d - 18 = -34$

30. $25 = 2c - 9$

31. $\frac{1}{3}g + 4 = 2$

32. $\frac{1}{9}h - 3 = 2$

33. $-16 = \frac{1}{2}k - 7$

34. $20 = \frac{1}{5}m + 12$

35. $\frac{1}{4}n - 20 = -1$

36. $3.6 = 2x + 1.8$

37. $\frac{1}{8}y - \frac{1}{2} = \frac{7}{8}$

38. $\frac{1}{4}t + 1 = 2\frac{1}{4}$

Solve each equation. Check your solution. (Examples 3 and 4)

39. $46 - 8x = -18$

40. $y - 7y + 6 = 30$

41. $-7 = -\frac{1}{5}p - 1$

42. $14 = -\frac{1}{3}s - 8$

43. $x + 7 - 2x = 18$

44. $46 - 3n = -23$

45. $5.5 - 5x = 4$

46. $6 = 8.1 - 3x$

47. $8.4 - 3x - x = 2$

48. $m - 5 - 6m = 0$

49. $19 = 3 - 3d - 5d$

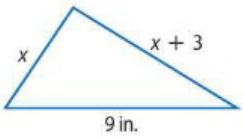
50. $0 = t + 4 - 9t$

51. **Financial Literacy** The cost of a family membership at a health club is shown at the right. The Johnson family budgets \$800 to use the health club. Solve $125 + 45f = 800$ to find the number of months the family can use the club. (Example 5)

52. The second book in a fantasy series is 112 pages longer than the first book. The total number of pages in both books is 524. Solve the equation $b + b + 112 = 524$ to find the number of pages b in the first book. (Example 5)

53. **STEM** Draven's computer downloads files at a rate of 220 kilobytes per second. The computer has already downloaded the first 550 kilobytes of a 2310-kilobyte file. Solve the equation $550 + 220s = 2310$ to find the number of seconds it will take to download the rest of the file. (Example 5)

54. The perimeter of the triangle in the figure is 22 inches. Solve the equation $x + x + 3 + 9 = 22$ to find the length x of the shortest side of the triangle. (Example 5)



55. Tenisha bought some gel pens that cost \$1.29 each. She also bought a notebook for \$3.59. She spent a total of \$10.04 on these items. Solve the equation $1.29g + 3.59 = 10.04$ to find the number of gel pens she bought. (Example 5)

56. Aaron has a piece of yarn that is 15 inches long. For an art project, he cut off 3 pieces of yarn of equal length. This left him with $4\frac{1}{2}$ inches of yarn. Solve the equation $3p + 4\frac{1}{2} = 15$ to find the length of each piece of yarn that Aaron will use in the art project. (Example 5)

Solve each equation. Check your solution.

57. $6.1e + 1.07 = 9$

58. $-2.5c + 6.7 = -1.3$

59. $\frac{2}{3} - 6y = -1\frac{5}{6}$

60. $\frac{3}{4}x + 1.5 = 2.7$

61. $-\frac{1}{4}f + 20.5 = 12.9$

62. $54.8 - \frac{1}{5}d = 60.1$

WORK ON THE NEXT TWO PAGES

(28) $3b + 15 = 27$

DIVISION ↑ SUBTRACTION

$36 + 15 = 27$
$-15 \quad -15$
$\frac{3b}{3} = \frac{12}{3}$
$b = 4$

$3(4) + 15 \stackrel{?}{=} 27$
$12 + 15$
$27 = 27$
✓

(32) ADDITION

$\frac{1}{9}h - 3 = 2$
$+3 \quad +3$
$\frac{1}{9}h = 5$

$\frac{\frac{1}{9}h}{\frac{1}{9}} = \frac{5}{\frac{1}{9}}$
$h = 45$

$5 \div \frac{1}{9} = 5 \cdot \frac{9}{1} = 45$

$\frac{9}{1} \cdot \frac{1}{9}h = 5 \cdot 9$
$h = 45$

$\frac{1}{9}\left(\frac{45}{1}\right) = 5$
$5 = 5$

(30)

$25 = 2c - 9$

$+9 \quad +9$

$\frac{34}{2} = \frac{2c}{2}$

$17 = c$

$25 \stackrel{?}{=} 2(17) - 9$

$34 - 9$

$25 = 25$:)

(34)

$20 = \frac{1}{5}m + 12$

$-12 \quad -12$

$\frac{5}{1} \cdot 8 = \frac{1}{5}m \cdot \frac{5}{1}$

$\frac{1}{5} \cdot \frac{5}{1} \cdot m$

$40 = m$

$20 \stackrel{?}{=} \frac{1}{5}(45) + 12$

$20 = 9 + 12$

$20 = 21$

63 Janelle and some of her friends went to the movies. Tickets cost $6 per person, and they each received a $1.50 student discount. Each girl also purchased a snack for $2.25. The total cost was $40.50. Solve the equation $6s - 1.5s + 2.25s = 40.50$ to find how many girls went to the movies.

65.
$40.77 = \frac{1y}{5} + 2.4y + \frac{1y}{10}$
$= \frac{2y}{10} + 2.4y + \frac{1y}{10}$
$= \frac{3y}{10} + 2.4y$
$= 0.3y + 2.4y$
$\frac{40.77}{2.7} = \frac{2.7y}{2.7}$
$15.1 = y$

Solve each equation. Check your solution.

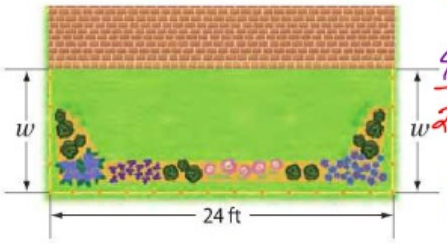
64. $\frac{3x}{2} + 4x = 22$

65. $40.77 = \frac{y}{5} + 2.4y + \frac{y}{10}$

66. $\frac{x}{2} + \frac{5x}{6} + \frac{x}{4} = 380$

67. $\frac{-2x + 5}{2} = 17$

68. CCSS **Multiple Representations** In this problem, you will investigate a function. Tia's family is installing a fence around three sides of her backyard as shown at the right. The equation $2w + 24 = f$ represents the relationship between the width of the fenced area and the total amount of fencing needed.



a. Table Make a function table to show the amount of fencing needed for widths of 12, 15, and 18 feet.

b. Symbols Find the width of the fenced area if Tia has 92 feet of fencing.

H.O.T. Problems Higher Order Thinking

69. CCSS **Model with Mathematics** Write a real-world example that could be solved by using the equation $2x + 7 = 15$. Then solve the equation.

70. CCSS **Persevere with Problems** The model at the right represents the equation $6y + 1 = 3x + 1$. What is the value of x?

71. CCSS **Identify Structure** Write a two-step equation that can be solved using the Subtraction Property of Equality and the Multiplication Property of Equality. Show how to use these properties to solve the equation.

72. CCSS **Find the Error** Toshiro is solving the equation $7 - 2x = -51$. Find his mistake and correct it.

$$7 - 2x = -51$$
$$7 + 7 - 2x = -51 + 7$$
$$2x = -44$$
$$\frac{2x}{2} = \frac{-44}{2}$$
$$x = -22$$

73. **Building on the Essential Question** Evaluate $3(2) + 5$. Then solve the equation $3x + 5 = 11$. How are the problems and solutions similar? How are they different?

Standardized Test Practice

74. The results of a student council fundraiser are shown in the table.

Purchase Price for 144 Pens	Profit for 144 Pens
$309.60	$50.40

Use the equation below to find the selling price p of one pen.

$$144p - 309.60 = 50.40$$

A $1.80 **C** $2.50
B $2.15 **D** $2.72

75. Ms. Fraser's total monthly cell phone bill b can be found using the equation $b = 45.60 + 0.10t$, where t represents the number of text messages she made. Find the number of text messages she made in a month in which the total charge was $56.70.

F 101 **H** 125
G 111 **J** 131

76. The distance d that Maxie can run in her first training run is represented by the equation $d = \frac{1}{2}m - 2$. What is the maximum distance m that she can run if her first training run is 3 miles?

A 10 miles
B 8 miles
C 6 miles
D 4 miles

77. **Short Response** Jody bought two pairs of jeans. The first pair costs $12 less than 3 times the cost c of the second pair. The first pair of jeans costs $45. The equation below can be used to find the cost of the second pair of jeans.

$$3c - 12 = 45$$

Solve the equation to find the cost in dollars of the second pair of jeans.

Common Core Review

Solve each equation. 8.EE.7

78. $36 = -12y$ **79.** $4 = \frac{x}{14}$ **80.** $5y = \frac{3}{2}$

81. $x - 13 = -45$ **82.** $\frac{2}{3} + p = 1$ **83.** $t + 12.4 = 16.23$

84. The difference between the record high and low temperatures in Columbus, Ohio, is 128° F. The record high temperature is 106° F. Write and solve an equation to find the record low temperature. 7.EE.4a

85. **Financial Literacy** You have saved some money. Your friend has saved $40 more than you. Write an expression in simplest form that represents the total amount of money you and your friend have saved. 6.EE.2a

86. Zane has a collection of CDs. Sage's collection has 24 more CDs than Zane's. Write an expression in simplest form that represents the total number of CDs Zane and Sage have altogether. 6.EE.2a

Evaluate each expression if $x = 4$, $y = -10$, and $z = 14$. 6.EE.2c

87. xy **88.** $y + z$ **89.** $2x - y$

90. $2z + 2y$ **91.** xyz **92.** $z - 3x + y$

93. $4z - x - y$ **94.** $\frac{1}{3}(x + y)$ **95.** $z(3 - x)$

96. $xy - y$ **97.** $z - (1 - y)$ **98.** $\frac{1}{2}x + y$