

# Solve Two-Step Equations

## Vocabulary Start-Up



Recall that in mathematics, **properties** are statements that are true for any number.

Complete the graphic organizer by matching the Property of Equality with the correct example.

Addition Property of Equality

$$\frac{1}{2}x = 10$$

$$2 \cdot \frac{1}{2}x = 10 \cdot 2$$

Division Property of Equality

$$3x = 9$$

$$\frac{3x}{3} = \frac{9}{3}$$

Multiplication Property of Equality

$$x + 3 = 1$$

$$x + 3 - 3 = 1 - 3$$

Subtraction Property of Equality

$$x - 5 = 6$$

$$x - 5 + 5 = 6 + 5$$



### Essential Question

WHAT is equivalence?

ANSWER KEY



### Vocabulary

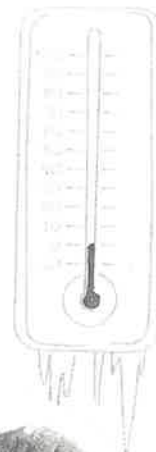
properties  
two-step equation



### Common Core State Standards

Content Standards  
8.EE.7, 8.EE.7a, 8.EE.7b

MP Mathematical Practices  
1, 2, 3, 4



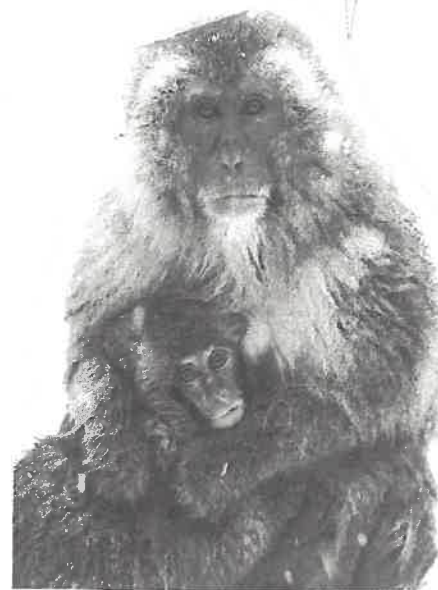
## Real-World Link

A property in science is a trait of matter that is always true under a given set of conditions. For example, pure water freezes at 0°C. How is the definition of *property* similar in science and math? \_\_\_\_\_

Which **MP** Mathematical Practices did you use?

Shade the circle(s) that applies.

- ① Persevere with Problems
- ② Reason Abstractly
- ③ Construct an Argument
- ④ Model with Mathematics
- ⑤ Use Math Tools
- ⑥ Attend to Precision
- ⑦ Make Use of Structure
- ⑧ Use Repeated Reasoning



# Solve Two-Step Equations

A **two-step equation** contains two operations. In the equation  $2x + 3 = 7$ ,  $x$  is multiplied by 2 and then 3 is added. To solve two-step equations, undo each operation in reverse order.

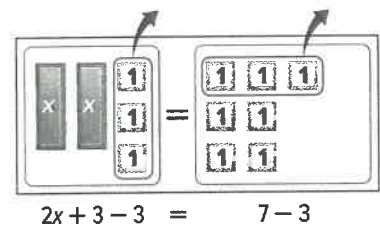
## Example



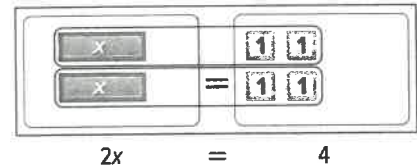
### 1. Solve $2x + 3 = 7$ .

#### Method 1 Use a model.

Remove three 1-tiles from each mat.



Separate the remaining tiles into 2 equal groups.



There are two 1-tiles in each group, so  $x = 2$ .

#### Method 2 Use symbols.

$2x + 3 = 7$	Write the equation.
$\underline{-3 = -3}$	Subtraction Property of Equality
$2x = 4$	
$\underline{\frac{2x}{2} = \frac{4}{2}}$	Division Property of Equality
$x = 2$	Simplify.

Using either method, the solution is 2.

a.  $x = 6$

b.  $n = -3$

### Got it? Do these problems to find out.

a.  $3x + 2 = 20$

$$\begin{aligned} & -2 \quad -2 \\ 3x + 2 &= 20 \\ \underline{-2} & \\ 3x &= 18 \\ \underline{\div 3} & \\ x &= 6 \end{aligned}$$

b.  $5 + 2n = -1$

$$\begin{aligned} & -5 \quad -5 \\ 5 + 2n &= -1 \\ \underline{-5} & \\ 2n &= -6 \\ \underline{\div 2} & \\ n &= -3 \end{aligned}$$

**Example**



2. Solve  $25 = \frac{1}{4}n - 3$ .

$25 = \frac{1}{4}n - 3$  Write the equation.

$+ 3 = + 3$  Addition Property of Equality

$28 = \frac{1}{4}n$  Simplify.

$4 \cdot 28 = 4 \cdot \frac{1}{4}n$  Multiplication Property of Equality

$112 = n$

The solution is 112.

**Got it?** Do these problems to find out.

c.  $-1 = \frac{1}{2}a + 9$   
 $-9 \quad -9$

d.  $\frac{2}{5}r - 5 = 7$   
 $+5 \quad +5$

$\frac{2}{1} \cdot -10 = \frac{1}{2}a \cdot \frac{2}{1}$   
 $-20 = a$

$\frac{5}{2} \cdot \frac{2}{5}r = 12 \cdot \frac{5}{2} = \frac{60}{2} = 30$

**Example**



3. Solve  $6 - 3x = 21$ .

$6 - 3x = 21$  Write the equation.

$6 + (-3x) = 21$  Rewrite the left side as addition.

$-6 \quad = -6$  Subtraction Property of Equality

$-3x = 15$  Simplify.

$\frac{-3x}{-3} = \frac{15}{-3}$  Division Property of Equality

$x = -5$  Simplify.

The solution is  $-5$ .

**Check**  $6 - 3x = 21$  Write the equation.

$6 - 3(-5) \stackrel{?}{=} 21$  Replace  $x$  with  $-5$ .

$6 - (-15) \stackrel{?}{=} 21$  Multiply.

$6 + 15 \stackrel{?}{=} 21$  To subtract a negative number, add its opposite.

$21 = 21 \checkmark$  The sentence is true.

**Got it?** Do these problems to find out.

e.  $10 - \frac{2}{3}p = 52$   
 $-10 \quad -10$

f.  $-19 = -3x + 2$   
 $-2 \quad -2$

g.  $\frac{n}{-3} - 2 = -18$   
 $+2 \quad +2$

$-3 \cdot \frac{2}{3}p = 42 \cdot \frac{-3}{2}$   
 $-2p = -63$   
 $p = -63$

$-21 = -3x$   
 $\frac{-21}{-3} = \frac{-3x}{-3}$   
 $7 = x$

$-3 \cdot \frac{n}{-3} = -16 \cdot -3$   
 $n = 48$

Show your work.

c.  $a = -20$

d.  $r = 30$

**Common Error**

A common mistake when solving the equation in Example 3 is to divide each side by 3 instead of  $-3$ . Since  $6 - 3x = 6 + (-3x)$ , the coefficient is  $-3$ .

e.  $p = -63$

f.  $x = 7$

g.  $n = 48$



## Example



4. **STEM** Chicago's lowest recorded temperature in degrees Fahrenheit is  $-27^\circ$ . Solve the equation  $-27 = 1.8C + 32$  to convert to degrees Celsius.

$$\begin{array}{ll} -27 = 1.8C + 32 & \text{Write the equation.} \\ -32 = & -32 & \text{Subtraction Property of Equality} \\ -59 = 1.8C & \text{Simplify.} \\ \frac{-59}{1.8} = \frac{1.8C}{1.8} & \text{Division Property of Equality} \\ -32.8 \approx C & \text{Simplify. Check the solution.} \end{array}$$

So, Chicago's lowest recorded temperature is about  $-32.8$  degrees Celsius.

## Guided Practice



Solve each equation. Check your solution. (Examples 1–3)

1.  $6x + 5 = 29$

Show your work.

$$\begin{array}{l} -5 \quad -5 \\ 6x = 24 \\ \frac{6x}{6} = \frac{24}{6} \\ x = 4 \end{array}$$

2.  $3 - 5y = -37$

$$\begin{array}{l} -3 \quad -3 \\ -5y = -40 \\ \frac{-5y}{-5} = \frac{-40}{-5} \\ y = 8 \end{array}$$

3.  $\frac{2}{3}x - 5 = 7$

$$\begin{array}{l} +5 \quad +5 \\ \frac{2}{3}x = 12 \\ \frac{3}{2} \cdot \frac{2}{3}x = \frac{3}{2} \cdot \frac{12}{1} \\ x = 18 \end{array}$$

4. Cassidy went to the movies with some of her friends. The tickets cost \$6.50 each, and they spent \$17.50 on snacks. The total amount paid was \$63.00. Solve the equation  $63 = 6.50p + 17.50$  to determine how many people went to the movies. (Example 4)

$$\begin{array}{l} 63 = 6.50p + 17.50 \\ -17.50 \quad -17.50 \\ 45.50 = 6.50p \end{array}$$

$$\begin{array}{l} \frac{45.50}{6.50} = \frac{6.50p}{6.50} \\ 7 = p \end{array}$$

7 people

5. **Building on the Essential Question** How can you use the *work backward* problem-solving strategy to solve a two-step equation?

You identify the order in which operations would be performed on the variable, then you undo each operation using its inverse operation in reverse order.

### Rate Yourself!

How confident are you about solving equations? Check the box square that applies.



For more help, go online to access a Personal Tutor.



# Independent Practice

Go online for Step-by-Step Solutions

eHelp



Solve each equation. Check your solution. (Examples 1–3)

$$1. \begin{array}{r} 5 = 4a - 7 \\ +7 \quad +7 \end{array}$$

Show your work.

$$\frac{12}{4} = \frac{4a}{4}$$

$$3 = a$$

$$2. \begin{array}{r} 16 = 5x - 9 \\ +9 \quad +9 \end{array}$$

$$\frac{25}{5} = \frac{5x}{5}$$

$$5 = x$$

$$3. \begin{array}{r} 3 - 8c = 35 \\ -3 \quad -3 \end{array}$$

$$\frac{-8c}{-8} = \frac{32}{-8}$$

$$c = -4$$

$$4. \begin{array}{r} -\frac{1}{2}x - 7 = -11 \\ +7 \quad +7 \end{array}$$

$$-\frac{2}{1} \cdot -\frac{1}{2}x = -4 \cdot -\frac{2}{1}$$

$$x = 8$$

$$5. \begin{array}{r} 15 - \frac{w}{4} = 28 \\ -15 \quad -15 \end{array}$$

$$-4 \cdot \frac{-w}{4} = 13 \cdot -4$$

$$w = -52$$

$$6. \begin{array}{r} -3 - 6x = 9 \\ +3 \quad +3 \end{array}$$

$$\frac{-6x}{-6} = \frac{12}{-6}$$

$$x = -2$$

7. Larina received a \$50 gift card to an online store. She wants to purchase some bracelets that cost \$8 each. There will be a \$10 overnight delivery fee. Solve  $8n + 10 = 50$  to find the number of bracelets she can purchase. (Example 4)

$$\begin{array}{r} 8n + 10 = 50 \\ -10 \quad -10 \end{array}$$

$$\frac{8n}{8} = \frac{40}{8}$$

$$n = 5$$

5 bracelets

8. LaTasha paid \$75 to join a summer golf program. The course where she plays charges \$30 per round. Since she is a student, she receives a \$10 discount per round. If LaTasha spent \$375, use the equation  $375 = 20g + 75$  to find how many rounds of golf LaTasha played.

(Example 4)

15 rounds of golf

$$\begin{array}{r} 375 = 20g + 75 \\ -75 \quad -75 \end{array}$$

$$\frac{300}{20} = \frac{20g}{20}$$

$$15 = g$$

Copy and Solve Solve each equation. Show your work on a separate piece of paper.

$$9. \begin{array}{r} a - 4 = 12 \\ +4 \quad +4 \end{array}$$

$$a - 4 = 12$$

$$+4 \quad +4$$

$$a = 16$$

$$10. \begin{array}{r} \frac{n+3}{8} = -4 \\ \cdot 8 \quad \cdot 8 \end{array}$$

$$\frac{n+3}{8} = -4$$

$$\cdot 8 \quad \cdot 8$$

$$n+3 = -32$$

$$-3 \quad -3$$

$$n = -35$$

$$11. \begin{array}{r} \frac{6+z}{10} = -2 \\ \cdot 10 \quad \cdot 10 \end{array}$$

$$\frac{6+z}{10} = -2$$

$$\cdot 10 \quad \cdot 10$$

$$6+z = -20$$

$$-6 \quad -6$$

$$z = -26$$

12. **MP Reason Abstractly** If Mr. Arenth wants to put new carpeting in the room shown, how many square feet should he order?

$$\begin{array}{r} 5 + 3c = 14 \\ -5 \quad -5 \end{array}$$

$$\frac{3c}{3} = \frac{9}{3}$$

$$c = 3$$

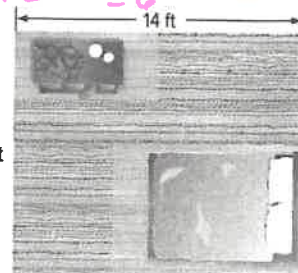
$$6(3) - 8$$

$$18 - 8$$

$$10$$

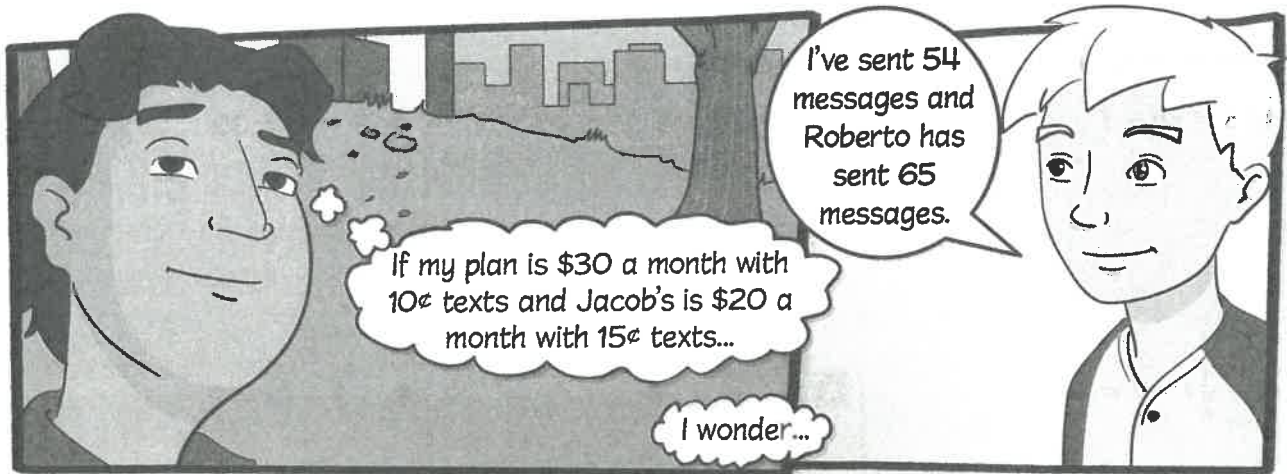
$$140 \text{ ft}^2$$

$$\begin{array}{r} 6c - 8 \text{ ft} \\ 10 \end{array}$$



5 + 3c ft

13. **MP Model with Mathematics** Refer to the graphic novel frame below for Exercises a–b.



- a. The equation  $50 = 28.10 + 0.15m$  represents the additional number of messages Jacob can send with a budget of \$50. Solve the equation to find the number of messages he has left to send.

146 messages

$$\begin{array}{r} 50 = 28.10 + 0.15m \\ -28.10 \quad -28.10 \\ \hline 21.90 = 0.15m \\ \frac{0.15}{0.15} \quad \frac{0.15}{0.15} \end{array}$$

$$146 = m$$

- b. The equation  $50 = 36.50 + 0.10m$  represents the additional number of messages Roberto can send with a budget of \$50. Solve the equation to find the number of messages he has left to send.

135 messages

$$\begin{array}{r} 50 = 36.50 + 0.10m \\ -36.50 \quad -36.50 \\ \hline 13.50 = 0.10m \\ \frac{0.10}{0.10} \quad \frac{0.10}{0.10} \end{array}$$

$$135 = m$$

### **H.O.T. Problems** Higher Order Thinking

14. **MP Persevere with Problems** Solve  $(x + 5)(x + 5) = 49$ .  
(Hint: There are two solutions.)

-12 and 2

15. **MP Model with Mathematics** Write a real-world problem that could be solved by using the equation  $3x - 25 = 125$ . Then solve the equation.

Ex: Andrea saved  $x$  dollars each week for 3 weeks. She spent \$25 and had \$125 left. How much did she save each week? (\$50)

16. **MP Use a Counterexample** Determine if the following statement is true or false. If false, provide a counterexample.

An equation with an integer coefficient will always have an integer solution.

False. Ex:  $-3x + 1 = 8$

$$\begin{array}{r} -3x + 1 = 8 \\ -3x = 7 \\ \frac{-3x}{-3} = \frac{7}{-3} \end{array}$$

$$x = -\frac{7}{3}$$

# Extra Practice

Solve each equation. Check your solution.

17.  $2h + 9 = 21$

$$\begin{aligned} 2h + 9 &= 21 \\ -9 &= -9 \\ \hline 2h &= 12 \\ \hline h &= 6 \end{aligned}$$

Homework Help

18.  $12 - \frac{3}{5}p = -27$

$$\begin{aligned} 12 - \frac{3}{5}p &= -27 \\ -12 &= -12 \\ \hline -\frac{3}{5}p &= -39 \\ \left(-\frac{5}{3}\right)\left(-\frac{3}{5}p\right) &= -39\left(-\frac{5}{3}\right) \\ p &= 65 \end{aligned}$$

19.  $11 = 2b + 17$

$$\begin{aligned} -17 &= -17 \\ \hline -6 &= 2b \\ \frac{-6}{2} &= \frac{2b}{2} \\ -3 &= b \end{aligned}$$

20.  $-17 = 6p - 5$

$$\begin{aligned} +5 &= +5 \\ \hline -12 &= 6p \\ \frac{-12}{6} &= \frac{6p}{6} \\ -2 &= p \end{aligned}$$

21.  $2g - 3 = -19$

$$\begin{aligned} +3 &= +3 \\ \hline 2g &= -16 \\ \frac{2g}{2} &= \frac{-16}{2} \\ g &= -8 \end{aligned}$$

22.  $13 = \frac{g}{3} + 4$

$$\begin{aligned} -4 &= -4 \\ \hline 9 &= \frac{g}{3} \cdot 3 \\ 27 &= g \end{aligned}$$

23.  $13 - 3d = -8$

$$\begin{aligned} -13 &= -13 \\ \hline -3d &= -21 \\ \frac{-3d}{-3} &= \frac{-21}{-3} \\ d &= 7 \end{aligned}$$

24.  $-\frac{2}{3}m - 4 = 10$

$$\begin{aligned} +4 &= +4 \\ \hline -\frac{2}{3}m &= 14 \\ \frac{-3}{2} \cdot -\frac{2}{3}m &= \frac{14}{1} \cdot \frac{-3}{2} \\ m &= -21 \end{aligned}$$

25.  $-5y - 25 = 25$

$$\begin{aligned} +25 &= +25 \\ \hline -5y &= 50 \\ \frac{-5y}{-5} &= \frac{50}{-5} \\ y &= -10 \end{aligned}$$

26. Some friends decide to go to the aquarium together. Each person pays \$7.50 to get in. They spend a total of \$40 for the shark exhibit. The total cost is \$70. Solve  $7.5x + 40 = 70$  to find how many people went to the aquarium.

$$\begin{aligned} 7.5x + 40 &= 70 \\ -40 &= -40 \\ \hline 7.5x &= 30 \end{aligned}$$

$$\frac{7.5x}{7.5} = \frac{30}{7.5}$$

$$x = 4$$

4 people

27. **MP Identify Structure** Brent had \$26 when he went to the fair. After playing 7 games, he had \$15.50 left. Solve  $15.50 = 26 - 7p$  to find the price for each game. Then list the Properties of Equality you used to solve the equation.

$$\begin{aligned} 15.50 &= 26 - 7p \\ -26 &= -26 \end{aligned}$$

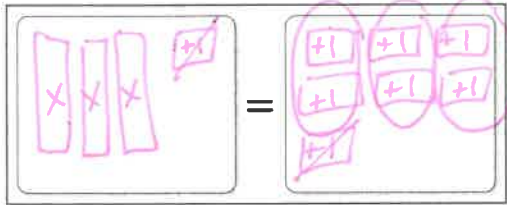
$$\begin{aligned} -10.50 &= -7p \\ -7 &= -7 \end{aligned}$$

$$1.5 = p$$

\$1.50 per game



28. Use the algebra tiles to model the equation  $3x + 1 = 7$  on the equation mat below. Then solve the equation.



(b)  $\frac{3}{4}(8) + 4 = 10$   
 $\frac{3}{4}(8) = 6$   
 $6 = 6 \checkmark$

$x = \boxed{2}$

29. Determine if the value of the variable is a solution of each equation. Select yes or no.

a.  $5x - 4 = 31, x = 5.4$

yes  no

(a)  $5(5.4) - 4 = 31$   
 $27 + 4 = 31$

b.  $\frac{3}{4}n + 4 = 10, n = 8$

yes  no

$5(5.4) = 35$   
 $27 \neq 35$

c.  $-3 + 4y = 7, y = 2.5$

yes  no

(c)  $-3 + 4(2.5) = 7$   
 $+3$   
 $4(2.5) = 10$   
 $10 = 10 \checkmark$



## Common Core Spiral Review

Solve each equation. Check your solution. 6.EE.7

30.  $t - 17 = 5$

$+17 +17$   
 $t = 22$

31.  $a - 5 = 14$

$+5 +5$   
 $a = 19$

32.  $9 = 5 + x$

$-5 -5$   
 $4 = x$

Write and solve an equation for each of the following. 6.EE.7

33. Solomon is 9 years younger than his brother. His brother is 21. How old is Solomon?

$s + 9 = 21$   
 $-9 -9$   
 $s = 12$   
 12 years old

34. Kelly spent \$45 more on boots than she did on a pair of jeans. She spent \$79.50 on the boots. How much did she spend on the jeans?

$j + 45 = 79.50$   
 $-45 -45$   
 $j = 34.50$   
 \$34.50 for jeans

35. The product of two integers is 72. If one integer is 18, what is the other integer?

$18 \cdot x = 72$   
 $\frac{18}{18} \frac{72}{18}$   
 $x = 4$   
 4