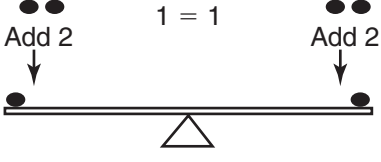# Properties of Equality
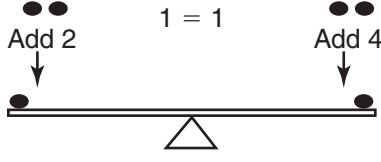
To keep an equation balanced, you must do the same thing to each side.

Balanced Equation	**Unbalanced Equation**
Add 2　1 = 1　Add 2	Add 2　1 = 1　Add 4
3 = 3	$3 \neq 5$
The scale is balanced because both sides **have the same value.** We added the same amount to each side of the equation.	The equation is not balanced. 3 does not equal 5. We did not add the same amount to both sides of the equation.

Use the Properties of Equality to balance equations.

Add the same number to each side.	$3c = 12$, so $3c + 5 = 12 + 5$
Subtract the same number from each side.	$3c = 12$, so $3c - 3 = 12 - 3$
Multiply each side by the same number.	$3c = 12$, so $3c \times 2 = 12 \times 2$
Divide each side by the same number.	$3c = 12$, so $3c \div 4 = 12 \div 4$

Evaluate the equations.

1. If $16 + 5 = 21$, does $16 + 5 - 4 = 21 - 4$? Why or why not?

Yes, because the same number, 4, is subtracted from each side.

2. If $3p = 27$, does $3p \times 2 = 27 \times 3$? Why or why not?

No, because each side is multiplied by a different number.

3. If $4s - 6 = 18$, does $(4s - 6) \div 2 = 18 \div 2$? Why or why not?

Yes, because each side is divided by the same number, 2.

4. Reasoning A pan balance shows $x + 2 = 10$. If you add 5 units to one side, can you balance the scale by adding x units to the other side? Explain.

No, to keep the scale and equation balanced, you have to add the same number of units, 5, to each side.

Properties of Equality

1. If $16 + 4 = 20$, does $16 + 4 - 4 = 20 - 4$? Why or why not?

Yes, the same number is subtracted from each side.

2. If $2d \div 4 = 5$, does $2d \div 4 + 6 = 5 + 4$? Why or why not?

No, because a different number is added to each side.

3. If $12 - 8 = 4$, does $(12 - 8) \div 2 = 4 \times 2$? Explain.

No, because one side is divided by 2 and the other side is multiplied by 2.

4. If $7t = 70$, does $12 \times 7t = 12 \times 70$? Explain.

Yes, because each side is multiplied by the same number.

5. **Critical Thinking** Emil and Jade have equal amounts of play money in two piles. Emil has $1 and a quarter in his pile. Jade has 5 quarters in her pile. If Emil gives Jade $1 and Jade gives Emil 4 quarters, will the two piles still be equal in value? Explain.

Sample answer: Yes, $1 = 4 quarters, so Emil and Jade subtracted $1 from each pile and then added $1 to each pile. Since they subtracted and added the same amounts to each pile, the piles are still equal in value.

6. Which equation shows the Multiplication Property of Equality if $n + 4 = 11$?

A $(n + 4) \times 2 = 11$ **B** $(n + 4) \times 2 = 11 \div 2$

C $(n + 4) \times 2 = 11 \times 4$ **(D)** $(n + 4) \times 2 = 11 \times 2$

7. **Writing to Explain** Bobbie wrote $y + 6 = 15$. Then she wrote $(y + 6) \div 3 = 15$. Explain why the second equation is not balanced and how to balance it.

To use the Division Property of Equality, you have to divide each side by the same number. Bobbie divided only one side of the second equation by 3. She needs to divide 15 by 3 to balance the equation.

Solving Addition and Subtraction Equations

You can use inverse relationships and the properties of equality to get the variable alone to solve an equation. Remember that you need to do the same thing to both sides of the equation to keep the equation equal.

Solve the equation $5 + c = 15$.

To get c alone, undo adding 5 by subtracting 5 from both sides.

$$5 + c = 15$$
$$5 + c - \mathbf{5} = 15 - \mathbf{5}$$
$$c = 10$$

Check your solution by substituting 10 for c in the equation.

$$5 + c = 15$$
$$5 + 10 = 15$$
$$15 = 15 \quad \text{It checks.}$$

Solve the equation $x - 20 = 16$.

To get x alone, undo subtracting 20 by adding 20 to both sides.

$$x - 20 = 16$$
$$x - 20 + \mathbf{20} = 16 + \mathbf{20}$$
$$x = 36$$

Check your solution by substituting 36 for x in the equation.

$$x - 20 = 16$$
$$36 - 20 = 16$$
$$16 = 16 \quad \text{It checks.}$$

Explain how to get the variable alone in each equation.

1. $x + 13 = 25$
$x + 13 - \mathbf{13} = 25 - \mathbf{13}$

Subtract 13 from both sides.

2. $n - 30 = 10$
$n - 30 + \mathbf{30} = 10 + \underline{\mathbf{?}}$

30; Add 30 to both sides.

Solve each equation and check your answer. Show your work.

3. $g - 100 = 150$

$g - 100 + \underline{\mathbf{100}} = 150 + \underline{\mathbf{100}}$

$g = \underline{\mathbf{250}}$

4. $y + 56 = 63$

y = 7

5. The Olympic triathlon is 51.5 km. A contestant has completed two of the three legs of the race and has traveled 41.5 km. Solve $41.5 + d = 51.5$ to find the distance of the third leg.

10 km

Solving Addition and Subtraction Equations

Explain how to get the variable alone in each equation.

1. $n + 10 = 100$
$n + 10 - 10 = 100 - 10$

Subtract 10 from both sides.

2. $x - 75 = 49$
$x - 75 + \underline{} = 49 + \underline{}$

Add 75 to both sides.

Solve each equation and check your answer.

3. $g - 8 = 25$

$g = 33$

4. $25 + y = 42$

$y = 17$

5. $r + 82 = 97$

$r = 15$

6. $30 = m - 18$

$m = 48$

7. $150 = e + 42$

$e = 108$

8. $a - 51 = 12$

$a = 63$

9. Jo loaned Al $15. She had $15 left. Solve the equation $15 = s - 15$ to find how much money Jo had before she made the loan.

A $0

B $15

(C) $30

D $60

10. Critical Thinking If $n + 10 = 40$, then what is the value of the expression $n - 25$?

(A) 5

B 25

C 30

D 50

11. Writing to Explain Explain how to solve the equation $35 + p = 92$. Then solve.

Subtract 35 from both sides; $p = 57$.

Practice **4-2**

Problem Solving: Draw a Picture and Write an Equation

Tico spent $37.51 at the computer store. Now he has $29.86 left. How much did Tico have before he went to the computer store?

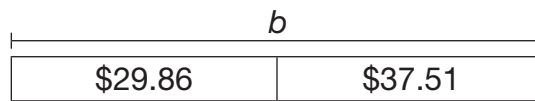|	
What do you know?	Tico has $29.86 now.
	He spent $37.51
What do you need to find out?	How much Tico had before.
1. Assign a variable.	b = how much Tico had before
2. Draw a picture.	

$$b$$

$29.86	$37.51

3. Write and solve an equation.	$29.86 + $37.51 = b
	$67.37 = b
4. Answer the question.	Tico had $67.37 before he went to the store.

Draw a picture and write an equation to solve each problem.

1. Gina's book has 349 fewer pages than Terri's. If Gina's book has 597 pages, how many pages does Terri's book have?

t pages

597	**349**

$; t = 597 + 349; 946$

2. Peter played a video game. Before dinner, he had collected 24,729 gold coins. At the end of the game he had collected 97,304 gold coins. How many coins did he collect after dinner?

97,304 coins

24,729	**c**

$; c + 24,729 = 97,304; 72,575$

3. SaveMart can store 840 cases of canned food in the big warehouse. This is 394 cases more than the number that can be displayed on the shelves. How many cases can be displayed?

840 cases

c	**394**

$; 394 + c = 840; 446$

Problem Solving: Draw a Picture and Write an Equation

Draw a picture and write an equation to solve each problem.

1. Mike has already driven 176 laps. The race is 250 laps long. How many more laps does he have to drive to finish the race?

250 laps

176	l

$; 176 + l = 250; 74$
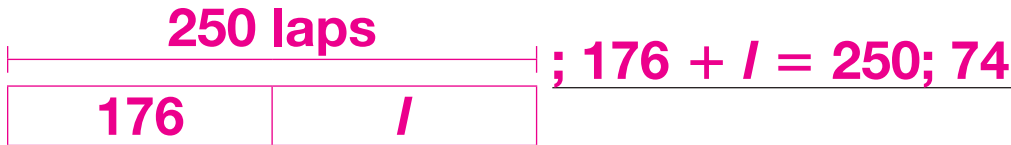
2. Antonio found 133 golf balls in the water. He picked up a total of 527 lost golf balls. How many golf balls did he find in the weeds and bushes?

527 lost golf balls

133	b

$; 133 + b = 527; 394$

3. A lumber company plants 840 trees. If the company cuts down 560 trees, how many more trees did it plant than it cut down?

840 trees

560	t

$; 560 + t = 840; 280$
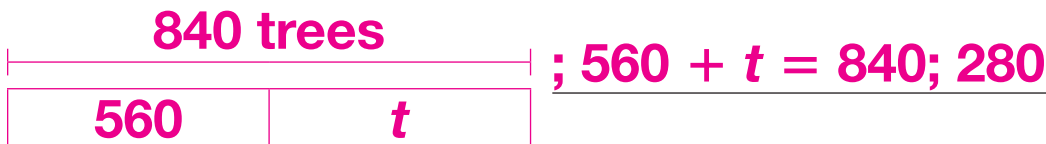
4. Writing to Explain What operation would you use to solve this problem? Why?

> Erik wants to buy a new stereo for $359. He has $288 saved already. How much more will he have to save to buy the stereo?

Sample answer: I would use subtraction. I know the whole and one part, so I could subtract to find the difference.

5. Reasonableness Write an estimate that will show if 77 is a reasonable solution to the equation $14 + m = 91$.

$90 - 15 = 75$; 75 is close to 77, so the answer is reasonable.

6. Juan brought 87 pounds of recyclables to the recycling center. He brought 54 pounds of glass, and the rest was plastic. Which equation could be used to find p, the number of pounds of plastic Juan recycled?

A $87 + p = 54$

C $p - 54 = 87$

B $54 + p = 87$

D $p + 87 = 54$

Solving Multiplication and Division Equations

To solve an equation, make the two sides of the equation equal with the variable alone on one side. You can use inverse operations and properties of equality.

Remember: **Inverse operations** "undo" each other. **Properties of Equality** say that you can multiply or divide both sides of an equation by the same number and the two sides of the equation remain equal.

Use division to "undo" multiplication.

With numbers:
$3 \times 6 = 18$
$3 \times 6 \div 6 = 18 \div 6$
$3 = 3$

In algebra:
$m \times 9 = 54$
$m \times 9 \div 9 = 54 \div 9$
$m = 6$

Use multiplication to "undo" division.

With numbers:
$24 \div 2 = 12$
$24 \div 2 \times 2 = 12 \times 2$
$24 = 24$

In algebra:
$p \div 8 = 7$
$p \div 8 \times 8 = 7 \times 8$
$p = 56$

For **1** through **3**, name the inverse operation you will use to get the variable alone on one side of the equation. In **2** and **3**, also fill in the blanks.

1. $5p = 50$
$5p \div 5 = 50 \div 5$

division

2. $n \div 16 = 4$
$n \div 16 \times 16 = 4 \times$ ___

16; multiplication

3. $15 = r \times 3$
$15 \div$ ___ $= r \times 3 \div$ ___

3; 3; division

For **4** through **6** solve the equation.

4. $w \div 5 = 8$

w = 40

5. $20y = 100$

y = 5

6. $3 = s \div 10$

s = 30

7. Writing to Explain Jason solved the equation $r \div 14 = 19$. He got 266. Is his answer correct? Explain how you know.

The answer is correct. When you substitute 266 for _r_ in the equation, 266 ÷ 14 = 19.

Solving Multiplication and Division Equations

For **1** through **3**, explain how to get the variable alone in each equation.

1. $r \times 7 = 42$
$r \times 7 \div 7 = 42 \div 7$

Divide both sides by 7.

2. $m \div 6 = 12$
$m \div 6 \times \_\_ = 12 \times \_\_$

Multiply both sides by 6.

3. $44 = 2k$

Divide both sides by 2.

For **4** through **9**, solve the equation. Check your answer.

4. $9n = 72$

n = 8

5. $y \times 5 = 60$

y = 12

6. $v \div 13 = 2$

v = 26

7. $w \div 7 = 15$

w = 105

8. $216 = 36p$

p = 6

9. $17 = t \div 3$

t= 51

10. Writing to Explain Tell how you would get the variable m alone on one side of the equation $15m = 45$.

15m means 15 times m. To undo multiplying m by 15, divide both sides of the equation by 15.

11. Write a Problem Write a problem that can be solved with the equation $r \div 6 = 14$.

Sample answer: Six friends shared the cost of a boat rental equally. Each friend paid $14. How much did the boat rental cost?

12. Number Sense Which equation can you use to solve this problem?

There are 12 muffins in a package. Will bought 84 muffins. How many packages did he buy?

A $12 \times p = 84$

B $84 \times 12 = p$

C $12 \div p = 84$

D $84 = 12 + p$

# Problem Solving: Draw a Picture and Write an Equation

Zoo keepers divided some land into 4 sections for the monkeys at the zoo. Each section has 23 monkeys. How many monkeys are at the zoo?

Read and Understand

Choose a variable for the unknown. The unknown is the total number of monkeys at the zoo.

Let m = the total number of monkeys.

Draw a picture to show that the total number of monkeys is divided into 4 equal sections of 23 monkeys.

	m		
23	23	23	23
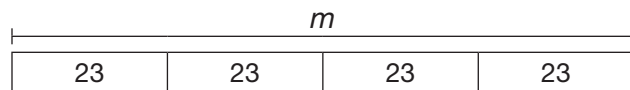
Plan and Solve
Write an equation using the variable and the picture.

$m \div 4 = 23 \leftarrow$ Use division.

Solve the equation.

$$m \div 4 = 23$$
$$m \div 4 \times 4 = 23 \times 4$$
$$m = 92$$

There are 92 monkeys at the zoo.

Write an equation for **1**. Solve each problem.

1. Juan has 6 times as many basketball cards as Nick. If Juan has 192 basketball cards, how many does Nick have?

		192			
x	x	x	x	x	x
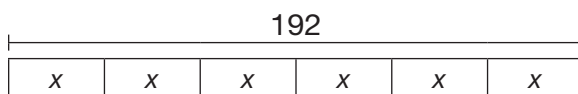
6x = 192; x = 32

2. Several sixth grade classes are going on a field trip to a planetarium. The teachers divided the classes into 19 groups. There are 7 students in each group. How many students are going to the planetarium? Use the equation $c \div 19 = 7$.

133 students

3. Each bus for a field trip can carry 27 students. If 216 students are going on the field trip, how many buses are needed? Use the equation $27n = 216$.

8 buses

Problem Solving: Draw a Picture and Write an Equation

Draw a picture and write an equation to solve each problem.

1. Mr. Conover bought 6 boxes of pastels for his art class. He paid $4.50 for each box. What was the total cost of the boxes?

c = total cost

| 4.50 | 4.50 | 4.50 | 4.50 | 4.50 | 4.50 |

; $27 _____

2. A company charters boats for whale watching. The company chartered 13 boats. There were a total of 325 passengers on the boats. What was the average number of passengers per boat?

325 passengers

| x | x | x | x | x | x | x | x | x | x | x | x | x |

;13x = 325; 25 _____

3. A store sells 5-gallon bottles of water for $8. The store made $288 on Monday selling the water. How many bottles were sold?

$288

| x | x | x | x | x | x | x | x |

; 36 _____

4. A sign at a recycling center states that 118 pounds of recycled newspapers saves one tree. How many pounds of newspapers will save 3 trees?

p = total pounds of newspapers

| 118 | 118 | 118 |

; p ÷118 = 3; 354 _____

5. Algebra Students mailed invitations to a play to 414 parents. Each student mailed 18 invitations. If s equals the number of students who mailed invitations, which equation best shows the number of invitations that were mailed?

A $s + 18 = 414$

B $s \div 18 = 414$

C $18 \div s = 414$

D $18s = 414$