### Lesson 2-5

#### Solving Literal Equations for a Variable

**Learning Targets:**
- Solve literal equations for a specified variable.
- Use a formula that has been solved for a specified variable to determine an unknown quantity.

**SUGGESTED LEARNING STRATEGIES:** Identify a Subtask, Close Reading, Work Backward, Create Representations, Discussion Groups

A **literal equation** has more than one variable, and the equation can be solved for a specific variable. Formulas are examples of literal equations. A **formula** is an equation written using symbols that describes the relationship between different quantities.

### Example A

Solve the equation $4x + b = 12$ for $x$.

**Step 1:** Isolate the term that contains $x$ by subtracting $b$ from both sides.

- $4x + b = 12$ (Original equation)
- $4x + b - b = 12 - b$ (Subtraction Property of Equality)
- $4x = 12 - b$ (Combine like terms).

**Step 2:** Isolate $x$ by dividing both sides by 4.

- $\frac{4x}{4} = \frac{12 - b}{4}$ (Division Property of Equality)
- $x = \frac{12 - b}{4}$ (Simplify).

**Solution:** $x = \frac{12 - b}{4}$, or $x = 3 - \frac{b}{4}$.

### Try These A

Solve each equation for $x$.

- **a.** $ax + 7 = 3$

- **b.** $cx - 10 = -5$

- **c.** $-3x + d = -9$

**Solution:**

- $x = \frac{3}{a}$
- $x = \frac{-1}{c}$
- $x = \frac{-9 - d}{-3}$
- $x = 3 + \frac{d}{3}$.
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Check Your Understanding
1. Is the equation $2x + 4 = 5x - 6$ a literal equation? Explain.
2. Describe the similarities and differences between solving an equation containing one variable and solving a literal equation for a variable.

Example B
The equation $v = v_0 + at$ gives the velocity in meters per second of an object after $t$ seconds, where $v_0$ is the object's initial velocity in meters per second and $a$ is its acceleration in meters per second squared.

a. Solve the equation for $a$.

b. Determine the acceleration for an object whose velocity after 15 seconds is 25 meters per second and whose initial velocity was 15 meters per second.

- $v = v_0 + at$  
  - Original equation
  - Subtraction Property of Equality: Subtract $v_0$ from both sides.
  - $v - v_0 = at$
  - Combine like terms.
  - Division Property of Equality: Divide both sides by $t$.
  - $a = \frac{v - v_0}{t}$
  - Symmetric Property of Equality

b. To determine the acceleration for an object whose velocity after 15 seconds is 25 meters per second and whose initial velocity was 15 meters per second, substitute 25 for $v$, 15 for $v_0$, and 15 for $t$.

$$a = \frac{25 - 15}{15} = \frac{10}{15} = \frac{2}{3} \text{ m/s}^2$$

Try These B
The equation $t = 13p + 108$ can be used to estimate the cooking time $t$ in minutes for a stuffed turkey that weighs $p$ pounds. Solve the equation for $p$. Then find the weight of a turkey that requires 285 minutes to cook.
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3. Reason abstractly. Solve for the indicated variable in each formula.

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Solve for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>( d = rt ), where ( d ) is the distance an object travels, ( r ) is the average rate of speed, and ( t ) is the time traveled</td>
<td>( r = \frac{d}{t} )</td>
</tr>
<tr>
<td>Pressure</td>
<td>( p = \frac{F}{A} ), where ( p ) is the pressure on a surface, ( F ) is the force applied, and ( A ) is the area of the surface</td>
<td>( r = \frac{pA}{A} )</td>
</tr>
<tr>
<td>Kinetic energy</td>
<td>( k = \frac{1}{2} mv^2 ), where ( k ) is the kinetic energy of an object, ( m ) is its mass, and ( v ) is its velocity</td>
<td>( m = \frac{2k}{v^2} )</td>
</tr>
<tr>
<td>Gravitational energy</td>
<td>( U = mgh ), where ( U ) is the gravitational energy of an object, ( m ) is its mass, ( g ) is the acceleration due to gravity, and ( h ) is the object's height</td>
<td>( h = \frac{U}{mg} )</td>
</tr>
<tr>
<td>Boyle's Law</td>
<td>( p_1V_1 = p_2V_2 ), where ( p_1 ) and ( V_1 ) are the initial pressure and volume of a gas and ( p_2 ) and ( V_2 ) are the final pressure and volume of the gas when the temperature is kept constant</td>
<td>( V_2 = \frac{p_1V_1}{p_2} )</td>
</tr>
</tbody>
</table>

Check Your Understanding

4. Solve the equation \( w + t = \frac{y}{z} \) for \( c \).
5. Why do you think being able to solve a literal equation for a variable would be useful in certain situations?

LESSON 2-5 PRACTICE

Solve each equation for the indicated variable.

6. \( W =Fd \), for \( d \)
7. \( P = \frac{W}{t} \), for \( W \)
8. \( P = \frac{W}{t} \), for \( t \)
9. \( ak - t = on \), for \( k \)

10. Reason quantitatively. In baseball, the equation \( E = \frac{3R}{I} \) gives a pitcher's earned run average \( E \), where \( R \) is the number of earned runs the player allowed and \( I \) is the number of innings pitched.
   a. Solve the equation for \( I \). State a property or provide an explanation for each step.
   b. Last season, a pitcher had an earned run average of 2.80 and allowed 70 earned runs. How many innings did the pitcher pitch last season?