3.7 Transformations of Linear Functions

Learning Target: Graph transformations of linear functions.

Success Criteria:
- I can identify a transformation of a linear graph.
- I can graph transformations of linear functions.
- I can explain how translations, reflections, stretches, and shrinks affect graphs of functions.

EXPLORE IT! Comparing Graphs of Functions

Work with a partner.

a. The graph of \( f(x) = x \) is shown. Graph \( f \) and \( g \) on the same set of coordinate axes. Compare the graphs of \( f \) and \( g \).

- \( g(x) = x + 4 \)
- \( g(x) = 2x \)
- \( g(x) = -x \)

b. Write any linear function \( m \) in terms of \( x \). Compare the graphs of \( m \) and \( n \). Explain your reasoning.

- \( n(x) = m(x) + 3 \)
- \( n(x) = \frac{1}{3} \cdot m(x) \)
- \( n(x) = 3 \cdot m(x) \)
- \( n(x) = -m(x) \)
- \( n(x) = m(-x) \)

Use Structure

How can you use the right side of each equation in part (b) to compare the values of \( n(x) \) and \( m(x) \)? What does this tell you about the graph of \( n \)?

c. Discuss your results in part (b) with other students. What do you notice?

d. How does the graph of a function \( p \) compare to the graph of each of the following functions? Explain your reasoning.

- \( q(x) = p(x) + k \)
- \( q(x) = k \cdot p(x) \), where \( k > 0 \)
- \( q(x) = -p(x) \)
- \( q(x) = p(-x) \)

Algebraic Reasoning

MA.912.F.2.1 Identify the effect on the graph or table of a given function after replacing \( f(x) \) by \( f(x) + k \), \( kf(x) \), \( f(kx) \) and \( f(x + k) \) for specific values of \( k \).

MA.912.F.2.3 Given the graph or table of \( f(x) \) and the graph or table of \( f(x) + k \), \( kf(x) \), \( f(kx) \) and \( f(x + k) \), state the type of transformation and find the value of the real number \( k \).

Also MA.912.AR.2.4, MA.912.AR.2.5

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**Translations and Reflections**

A **family of functions** is a group of functions with similar characteristics. The most basic function in a family of functions is the **parent function**. For nonconstant linear functions, the parent function is \( f(x) = x \). The graphs of all other nonconstant linear functions are **transformations** of the graph of the parent function.

A **transformation** changes the size, shape, position, or orientation of a graph.

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**KEY IDEAS**

A **translation** is a transformation that shifts a graph horizontally or vertically.

**Horizontal Translations**

The graph of \( y = f(x - h) \) is a horizontal translation of the graph of \( y = f(x) \), where \( h \neq 0 \).

**Vertical Translations**

The graph of \( y = f(x) + k \) is a vertical translation of the graph of \( y = f(x) \), where \( k \neq 0 \).

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**EXAMPLE 1** Describing Horizontal and Vertical Translations

Let \( f(x) = 2x - 1 \). Graph (a) \( g(x) = f(x) + 3 \) and (b) \( t(x) = f(x + 3) \).

Describe the transformations from the graph of \( f \) to the graphs of \( g \) and \( t \).

**SOLUTION**

a. The function \( g \) is of the form \( y = f(x + h) \), where \( h = 3 \). So, the graph of \( g \) is a vertical translation 3 units up of the graph of \( f \).

b. The function \( t \) is of the form \( y = f(x - h) \), where \( h = 3 \). So, the graph of \( t \) is a horizontal translation 3 units left of the graph of \( f \).

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**SELF-ASSESSMENT**

Using \( f \), graph (a) \( g \) and (b) \( h \). Describe the transformations from the graph of \( f \) to the graphs of \( g \) and \( h \).

1. \( f(x) = 3x + 1; g(x) = f(x) - 2; h(x) = f(x) - 2 \)  
2. \( f(x) = -2x; g(x) = f(x) + 1; h(x) = f(x + 1) \)
KEY IDEAS

A **reflection** is a transformation that flips a graph over a line called the **line of reflection**.

**Reflections in the x-Axis**
The graph of $y = -f(x)$ is a reflection in the x-axis of the graph of $y = f(x)$.

**Reflections in the y-Axis**
The graph of $y = f(-x)$ is a reflection in the y-axis of the graph of $y = f(x)$.

- Multiplying the outputs by $-1$ changes their signs.
- Multiplying the inputs by $-1$ changes their signs.

**EXAMPLE 2** Describing Reflections in the x-Axis and the y-Axis

Let $f(x) = \frac{1}{2}x + 1$. Graph (a) $g(x) = -f(x)$ and (b) $t(x) = f(-x)$. Describe the transformations from the graph of $f$ to the graphs of $g$ and $t$.

**SOLUTION**

a. To find the outputs of $g$, multiply the outputs of $f$ by $-1$. The graph of $g$ consists of the points $(x, -f(x))$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$f(x)$</th>
<th>$-f(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>-2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>-1</td>
</tr>
</tbody>
</table>

The graph of $g$ is a reflection in the x-axis of the graph of $f$.

b. To find the outputs of $t$, multiply the inputs by $-1$ and then evaluate $f$. The graph of $t$ consists of the points $(x, f(-x))$.

<table>
<thead>
<tr>
<th>$x$</th>
<th>$f(x)$</th>
<th>$f(-x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>-x</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>-2</td>
</tr>
</tbody>
</table>

The graph of $t$ is a reflection in the y-axis of the graph of $f$.

**SELF-ASSESSMENT**

1. I don’t understand yet. 2. I can do it with help. 3. I can do it on my own. 4. I can teach someone else.

Using $f$, graph $g$. Describe the transformation from the graph of $f$ to the graph of $g$.

3. $f(x) = \frac{3}{2}x + 2; g(x) = -f(x)$

4. $f(x) = -4x - 2; g(x) = f(-x)$

5. **OPEN-ENDED** Write a linear function for which a reflection in the x-axis has the same graph as a reflection in the y-axis.

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**Stretches and Shrinks**

You can transform a function by multiplying all the inputs (x-coordinates) by the same factor \( a \). When \( a > 1 \), the transformation is a **horizontal shrink** because the graph shrinks toward the y-axis. When \( 0 < a < 1 \), the transformation is a **horizontal stretch** because the graph stretches away from the y-axis. In each case, the y-intercept stays the same.

You can also transform a function by multiplying all the outputs (y-coordinates) by the same factor \( a \). When \( a > 1 \), the transformation is a **vertical stretch** because the graph stretches away from the x-axis. When \( 0 < a < 1 \), the transformation is a **vertical shrink** because the graph shrinks toward the x-axis. In each case, the x-intercept stays the same.

**KEY IDEAS**

**Horizontal Stretches and Shrinks**

The graph of \( y = f(ax) \) is a horizontal **stretch** or **shrink** by a factor of \( \frac{1}{a} \) of the graph of \( y = f(x) \), where \( a > 0 \) and \( a \neq 1 \).

**Vertical Stretches and Shrinks**

The graph of \( y = a \cdot f(x) \) is a vertical **stretch** or **shrink** by a factor of \( a \) of the graph of \( y = f(x) \), where \( a > 0 \) and \( a \neq 1 \).

**EXAMPLE 3** Describing Horizontal and Vertical Stretches

Let \( f(x) = x - 1 \). Graph (a) \( g(x) = f \left( \frac{1}{3}x \right) \) and (b) \( h(x) = 3f(x) \). Describe the transformations from the graph of \( f \) to the graphs of \( g \) and \( h \).

**SOLUTION**

**a.** To find the outputs of \( g \), multiply the inputs by \( \frac{1}{3} \). Then evaluate \( f \). The graph of \( g \) consists of the points \((x, f \left( \frac{1}{3}x \right))\).

The graph of \( g \) is a horizontal stretch of the graph of \( f \) by a factor of \( 1 \div \frac{1}{3} = 3 \).

**b.** To find the outputs of \( h \), multiply the outputs of \( f \) by \( 3 \). The graph of \( h \) consists of the points \((x, 3f(x))\).

The graph of \( h \) is a vertical stretch of the graph of \( f \) by a factor of \( 3 \).
EXAMPLE 4 Describing Horizontal and Vertical Shrinks

Let \( f(x) = x + 2 \). Graph (a) \( g(x) = f(2x) \) and (b) \( h(x) = \frac{1}{4}f(x) \). Describe the transformations from the graph of \( f \) to the graphs of \( g \) and \( h \).

SOLUTION

a. To find the outputs of \( g \), multiply the inputs by 2. Then evaluate \( f \). The graph of \( g \) consists of the points \((x, f(2x))\).

<table>
<thead>
<tr>
<th>( x )</th>
<th>(-1)</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2x )</td>
<td>(-2)</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>( f(2x) )</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

\[ \text{The graph of } g \text{ is a horizontal shrink of the graph of } f \text{ by a factor of } \frac{1}{2}. \]

b. To find the outputs of \( h \), multiply the outputs of \( f \) by \( \frac{1}{4} \). The graph of \( h \) consists of the points \((x, \frac{1}{4}f(x))\).

<table>
<thead>
<tr>
<th>( x )</th>
<th>(-2)</th>
<th>0</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>( \frac{1}{4}f(x) )</td>
<td>0</td>
<td>( \frac{1}{2} )</td>
<td>1</td>
</tr>
</tbody>
</table>

\[ \text{The graph of } h \text{ is a vertical shrink of the graph of } f \text{ by a factor of } \frac{1}{4}. \]

SELF-ASSESSMENT

Using \( f \), graph (a) \( g \) and (b) \( h \). Describe the transformations from the graph of \( f \) to the graphs of \( g \) and \( h \).

6. \( f(x) = 4x - 2 \); \( g(x) = f\left(\frac{1}{2}x\right) \); \( h(x) = 2f(x) \)

7. \( f(x) = -3x + 4 \); \( g(x) = f(3x) \); \( h(x) = \frac{1}{2}f(x) \)

8. WRITING How does the value of \( a \) in the equation \( y = h(ax) \) affect the graph of \( y = h(x) \)? How does the value of \( a \) in the equation \( y = a \cdot h(x) \) affect the graph of \( y = h(x) \)?

9. REASONING The functions \( f \) and \( g \) are linear functions. The graph of \( g \) is a vertical shrink of the graph of \( f \). What can you say about the intercepts of the graphs of \( f \) and \( g \)? Is this always true? Explain.
Describing Transformations

EXAMPLE 5  Describing a Transformation

The table represents two linear functions \( f \) and \( g \). Describe the transformation from the graph of \( f \) to the graph of \( g \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( -1 )</th>
<th>( 0 )</th>
<th>( 1 )</th>
<th>( 2 )</th>
<th>( 3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td>( -4 )</td>
<td>( -1 )</td>
<td>( 2 )</td>
<td>( 5 )</td>
<td>( 8 )</td>
</tr>
<tr>
<td>( g(x) )</td>
<td>( -2 )</td>
<td>( 1 )</td>
<td>( 4 )</td>
<td>( 7 )</td>
<td>( 10 )</td>
</tr>
</tbody>
</table>

\[ \text{For each input, } g(x) \text{ is 2 more than } f(x). \text{ So, } g(x) = f(x) + 2. \]

The graph of \( g \) is a translation 2 units up of the graph of \( f \).

EXAMPLE 6  Modeling Real Life

The cost (in dollars) of cable service for \( m \) months is represented by the function \( f \). To attract new customers, the cable company multiplies the monthly fee by a factor of \( c \). Use the graph to find and interpret the value of \( c \).

\[ \frac{g(m)}{f(m)} = c \]

\[ g(m) = c \cdot f(m) \]

For any number of months, the new cost is one-half of the original cost. For example, the cost for two months (\( m = 2 \)) decreases from $120 to $60. So, \( c = \frac{1}{2} \).

The factor \( c = \frac{1}{2} \) indicates that the monthly price is halved.

SELF-ASSESSMENT 1 I don't understand yet. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else

10. The table represents two linear functions \( f \) and \( g \). Describe the transformation from the graph of \( f \) to the graph of \( g \).

<table>
<thead>
<tr>
<th>( x )</th>
<th>( 0 )</th>
<th>( 2 )</th>
<th>( 4 )</th>
<th>( 6 )</th>
<th>( 8 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td>( -8 )</td>
<td>( -4 )</td>
<td>( 0 )</td>
<td>( 4 )</td>
<td>( 8 )</td>
</tr>
<tr>
<td>( g(x) )</td>
<td>( -2 )</td>
<td>( -1 )</td>
<td>( 0 )</td>
<td>( 1 )</td>
<td>( 2 )</td>
</tr>
</tbody>
</table>

11. A company pays \( x \) dollars per unit for a product. The selling price is represented by the function \( p \).

a. What does \( f(x) = x \) represent in this situation? Describe a transformation of the graph of \( f \) that results in the graph of \( p \).

b. How does the company determine the selling price of a product?
In Exercises 1–6, use the graphs of \( f \) and \( g \) to describe the transformation from the graph of \( f \) to the graph of \( g \). (See Example 1.)

1. \( g(x) = f(x) + 2 \)

2. \( g(x) = f(x + 4) \)

3. \( f(x) = \frac{1}{3}x + 3; \ g(x) = f(x) - 3 \)

4. \( f(x) = -3x + 4; \ g(x) = f(x) + 1 \)

5. \( f(x) = -x - 2; \ g(x) = f(x + 5) \)

6. \( f(x) = \frac{1}{2}x - 5; \ g(x) = f(x) - 3 \)

7. **MODELING REAL LIFE** You and your friend start biking from the same location. Your distance (in miles) after \( t \) minutes is represented by \( d(t) = \frac{1}{2}t \). Your friend starts biking 5 minutes after you. Her distance is represented by \( f(t) = d(t - 5) \). Describe the transformation from the graph of \( d \) to the graph of \( f \).

8. **MODELING REAL LIFE** The total cost (in dollars) to bowl \( n \) games is represented by \( C(n) = 4.5n + 2.5 \). The shoe rental price increases \$0.50. The new total cost is represented by \( T(n) = C(n) + 0.5 \). Describe the transformation from the graph of \( C \) to the graph of \( T \).

In Exercises 9–12, use the graphs of \( f \) and \( h \) to describe the transformation from the graph of \( f \) to the graph of \( h \). (See Example 2.)

9. \( h(x) = f(x) \)

10. \( h(x) = f(x) - 2 \)

11. \( f(x) = -5 - x; \ h(x) = f(-x) \)

12. \( f(x) = \frac{1}{2}x - 2; \ h(x) = -f(x) \)

In Exercises 13–18, use the graphs of \( f \) and \( r \) to describe the transformation from the graph of \( f \) to the graph of \( r \). (See Example 3.)

13. \( f(x) = \frac{2}{3}x - 1 \)

14. \( f(x) = -x \)

15. \( f(x) = -2x - 4; \ r(x) = f\left(\frac{1}{2}x\right) \)

16. \( f(x) = 3x + 5; \ r(x) = f\left(\frac{1}{3}x\right) \)

17. \( f(x) = \frac{1}{2}x + 1; \ r(x) = 3f(x) \)

18. \( f(x) = -\frac{1}{2}x - 2; \ r(x) = 4f(x) \)

In Exercises 19–24, use the graphs of \( f \) and \( h \) to describe the transformation from the graph of \( f \) to the graph of \( h \). (See Example 4.)

19.

20.

21. \( f(x) = 3x - 12; \ h(x) = \frac{1}{6}f(x) \)

22. \( f(x) = -x + 1; \ h(x) = f(2x) \)

23. \( f(x) = -2x - 2; \ h(x) = f(5x) \)

24. \( f(x) = 4x + 8; \ h(x) = \frac{3}{2}f(x) \)

25. **MODELING REAL LIFE** The temperature (in degrees Fahrenheit) \( x \) hours after 5 p.m. is represented by \( t(x) = -4x + 72 \). The temperature \( x \) hours after 10 a.m. is represented by \( d(x) = 4x + 72 \). Describe the transformation from the graph of \( t \) to the graph of \( d \).
26. **MODELING REAL LIFE** The cost (in dollars) of a basic music streaming service for \( m \) months is represented by \( B(m) = 5m \). The cost of the premium service is represented by \( P(m) = 10m \). Describe the transformation from the graph of \( B \) to the graph of \( P \).

In Exercises 27–32, use the graphs of \( f \) and \( g \) to describe the transformation from the graph of \( f \) to the graph of \( g \).

27. \( f(x) = x - 2 \); \( g(x) = f(x + 4) \)
28. \( f(x) = -4x + 8 \); \( g(x) = -f(x) \)
29. \( f(x) = -2x - 7 \); \( g(x) = f(x - 2) \)
30. \( f(x) = 3x + 8 \); \( g(x) = f\left(\frac{2}{3}x\right) \)
31. \( f(x) = x - 6 \); \( g(x) = 6f(x) \)
32. \( f(x) = -x \); \( g(x) = f(x) - 3 \)

In Exercises 33–36, write a function \( g \) in terms of \( f \) so that the statement is true.

33. The graph of \( g \) is a horizontal translation 2 units right of the graph of \( f \).
34. The graph of \( g \) is a reflection in the \( y \)-axis of the graph of \( f \).
35. The graph of \( g \) is a vertical translation 4 units up of the graph of \( f \).
36. The graph of \( g \) is a horizontal shrink by a factor of \( \frac{1}{3} \) of the graph of \( f \).

**ERROR ANALYSIS** In Exercises 37 and 38, describe and correct the error in graphing \( g \).

37. [Graph with error]
38. [Graph with error]

In Exercises 39–46, describe the transformation from the graph of \( f \) to the graph of \( g \). (See Example 5.)

39. \[
\begin{array}{c|ccccc}
\hline
x & -2 & -1 & 0 & 1 & 2 \\
\hline
f(x) & 14 & 11 & 8 & 5 & 2 \\
g(x) = f(x + k) & 11 & 8 & 5 & 2 & -1 \\
\hline
\end{array}
\]
40. \[
\begin{array}{c|ccccc}
\hline
x & -3 & -2 & -1 & 0 & 1 \\
\hline
f(x) & -10 & -6 & -2 & 2 & 6 \\
g(x) = f(x + k) & -5 & -1 & 3 & 7 & 11 \\
\hline
\end{array}
\]
41. \( g(x) = af(x) \)
42. \( g(x) = f(ax) \)
43. \[
\begin{array}{c|ccc}
\hline
x & -1 & 0 & 1 \\
\hline
f(x) & 6 & 7 & 8 \\
g(x) & -6 & -7 & -8 \\
\hline
\end{array}
\]
44. \[
\begin{array}{c|cccc}
\hline
x & 3 & 5 & 7 & 9 \\
\hline
f(x) & 2 & 0 & -2 & -4 \\
g(x) & -2 & -4 & -6 & -8 \\
\hline
\end{array}
\]
45. [Graph]
46. [Graph]
47. **MODELING REAL LIFE** The cost (in dollars) of a gym membership for \( m \) months is represented by the function \( g \). In January, the gym multiplies the monthly fee by a factor of \( a \). Use the graph to find and interpret the value of \( a \). (See Example 6.)

![Gym Membership Graph](image)

48. **MODELING REAL LIFE** The function \( m(x) = 360x \) represents the amount of money (in dollars) you make at your job after \( x \) weeks. You earn a bonus of \( c \) dollars. Use the graph to find and interpret the value of \( c \).

![Job Earnings Graph](image)

49. **B.E.S.T. TEST PREP** Which of the graphs are related by only a translation? Explain.

50. **WRITING** How does the value of \( p \) in the equation \( y = g(x) + p \) affect the graph of \( y = g(x) \)? How does the value of \( p \) in the equation \( y = g(x) + p \) affect the graph of \( y = g(x) \)?

51. **STRUCTURE** The graph of \( g(x) = a \cdot f(x - b) + c \) is a transformation of the graph of the linear function \( f \). Complete each statement.

   a. The graph of \( g \) is a vertical _____ of the graph of \( f \) when \( a = 4 \), \( b = 0 \), and \( c = 0 \).
   
   b. The graph of \( g \) is a vertical translation 1 unit up of the graph of \( f \) when \( a = 1 \), \( b = 0 \), and \( c = ____ \).
   
   c. The graph of \( g \) is a reflection in the _____ of the graph of \( f \) when \( a = -1 \), \( b = 0 \), and \( c = 0 \).

52. **HOW DO YOU SEE IT?**

   Match each function with its graph. Explain.

   ![Graphs](image)

   a. \( a(x) = f(-x) \)  
   b. \( g(x) = f(x) - 4 \)
   
   c. \( h(x) = f(x) + 2 \)  
   d. \( k(x) = f(3x) \)

53. **OPEN-ENDED** In Exercises 53 and 54, write a function whose graph passes through the given point and is a transformation of the graph of \( f(x) = x \).

   53. \((4, 2)\)
   
   In Exercises 55–58, graph \( f \) and \( g \). Write \( g \) in terms of \( f \). Describe the transformation from the graph of \( f \) to the graph of \( g \).

   55. \( f(x) = 2x - 5; g(x) = 2x - 8 \)
   
   56. \( f(x) = 3x + 9; g(x) = 3x + 15 \)
   
   57. \( f(x) = -x - 4; g(x) = x - 4 \)
   
   58. \( f(x) = x - 1; g(x) = 3x - 3 \)

59. **REASONING** The graph of \( f(x) = x + 5 \) is a vertical translation 5 units up of the graph of \( f(x) = x \). How can you obtain the graph of \( f(x) = x + 5 \) from the graph of \( f(x) = x \) using a horizontal translation?
60. **REASONING** A swimming pool is filled with water by a hose at a rate of 1020 gallons per hour. The amount (in gallons) of water in the pool after \( t \) hours is represented by the function \( v(t) = 1020t \). How does the graph of \( v \) change in each situation?

a. A larger hose is found. Then the pool is filled at a rate of 1360 gallons per hour.

b. Before filling up the pool with a hose, a water truck adds 2000 gallons of water to the pool.

61. **MAKING AN ARGUMENT** Is it true that for all linear functions, a horizontal stretch by a factor of \( c \) produces the same result as a vertical shrink by a factor of \( \frac{1}{c} \)? Explain.

62. **THOUGHT PROVOKING** When is the graph of \( y = f(x) + w \) the same as the graph of \( y = f(x + w) \) for linear functions? Explain your reasoning.

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**REVIEW & REFRESH**

63. The red figure is similar to the blue figure. Describe a similarity transformation between the figures.

64. \( 5|x + 7| < 25 \)

65. \( -2|x + 1| \geq 18 \)

66. **REASONING** Complete the inequality \( -\frac{1}{6}x \geq \frac{2}{3} \) with \( <, \leq, >, \) or \( \geq \) so that the solution is \( n \leq -4 \).

67. Evaluate \( p(x) = \frac{1}{2}x^2 - 5 \) when \( x = 12 \) and when \( x = -2 \).

68. **MODELING REAL LIFE** An elevator on the top floor of a building begins to descend to the ground floor. The function \( h(t) = -8t + 250 \) models the situation, where \( h(t) \) is the height (in meters) of the elevator \( t \) seconds after it begins to descend.

a. Graph the function, and find its domain and range.

b. Interpret the terms and coefficient in the equation, and the \( x \)-intercept of its graph.

In Exercises 69–72, solve the equation. Check your solution.

69. \( 2.5b = 10 \)

70. \( \frac{c}{5} + 1 = -2 \)

71. \( 14 - 3q = 4q - 14 + q \)

72. \( |-4r + 6| - 5 = 13 \)

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63. The red figure is similar to the blue figure. Describe a similarity transformation between the figures.

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73. **MODELING REAL LIFE** The linear function \( m = 55 - 8.5b \) represents the amount \( m \) (in dollars) of money that you have after buying \( b \) books.

a. Find the domain of the function. Is the domain discrete or continuous? Explain.

b. Graph the function using its domain.

In Exercises 74 and 75, graph \( f \) and \( h \). Describe the transformation from the graph of \( f \) to the graph of \( h \).

74. \( f(x) = x; h(x) = \frac{1}{3}x \)

75. \( f(x) = x; h(x) = x - 4 \)

76. **STRUCTURE** The graph of the equation \( Ax + By = 15 \) is shown. Find the values of \( A \) and \( B \).

77. Determine whether the relation is a function. Explain.

\((-10, 2), (-8, 3), (-6, 5), (-8, 8), (-10, 6)\)

78. Solve the formula for \( h \).

\[ V = \pi r^2 h \]

79. Write an inequality that represents the graph.