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HOMEWORK ANSWER KEYS – STARTS AT PAGE 59
Chapter 4–1 – Relations and Functions (Day 1)

SWBAT: Identify the domain and range of relations and functions

A set of ordered pairs is called a ________________.

- Ex: \{(1, 2) \ (3, 5) \ (6, 9) \ (10, 28)\}

Study the different representations of the same relation below.

The **domain** of a relation is the set of all _____ values

The **range** of a relation is the set of all _______ values.

**Notation**
- Use \{ \} if the D/R has only a few values
- Use Set Notation otherwise
  - \{x \mid -2 \leq x \leq 5\}
  - \{y \mid -1 \leq y \leq 10\}
For each relation below, state the domain and range.

Example 1:

Example 2:

(a) Determine the minimum and maximum x-values represented on this graph.

(b) Determine the minimum and maximum y-values represented on this graph.

(c) State the domain and range of this function using set builder notation.

---

**Functions**

A **function** is a relation where each x goes to only one y

- **No x values are repeated** among ordered pairs
- A graph would pass the **Vertical Line Test**
- Any vertical line only crosses graph once
- It is OK if the y-values are repeated
One-to-One Functions

A one-to-one function (1-1) is function relation in which each member of the range also corresponds to **one and only one** member of the domain.

- No y values are repeated among ordered pairs
- A graph would pass the Horizontal Line Test

For each function below, determine if it is One-to-One.

Example 3:

\[ f(x) = 3x - 4 \]

Example 4:

\[ g(x) = x^2 - 2 \]
Am I a function? Am I One-to-One?
If your answer to “Is it a function” or “is it a 1-1 function” is “no” explain why not.

a. Domain =
Range =
Function?
1-1 Function?

b. \{(-1, 5), (2, 5), (2, 4), (-3, 1)\}
Domain =
Range =
Function?
1-1 Function?

c.

Domain =
Range =
Function?
1-1 Function?

d.

Domain =
Range =
Function?
1-1 Function?

e. \(y = -(x + 2)^2 + 8\)
Domain =
Range =
Function?
1-1 Function?

f. \(y = |x - 3|\)
Domain =
Range =
Function?
1-1 Function?
SUMMARY
Determining if a Relation is a Function

Examples:
(a) Is \((1, 2), (1, 3)\) a function?
No, the relation is not a function.
An \(x\) value has more than one \(y\) value.

(c) Is \((1, 4), (3, 2), (5, 4)\) a function?
Yes, the relation is a function.
Each \(x\) value has only one \(y\) value.

(b)
No, the relation is not a function.
An \(x\) value has more than one \(y\) value.

(d)

Exit Ticket
Which graph represents a relation that is \textit{not} a function?

(1) 

(3) 

(2) 

(4)
(Day 2)

SWBAT: Evaluate Functions

Warm – Up:
Determine the domain and range of the relation below. Determine if the relation is a function and if it is a one-to-one function.

Function Notation

- x is an **independent variable**
- Y is the **dependent variable** because its value depends on the given x-value
- Y = f(x)
  - Means y is a function of x (dependant on x)
  - Read “f of x”
  - F is the name of the function
  - X is the independent variable
If you want to evaluate a function at, for example, the x-value of 3, we write “determine $f(3)$.” Simply substitute $x$ in the equation and evaluate:

**Example:** If $f(x) = 4x^2 + 2$, find $f(2)$.

$$f(2) = 4(2)^2 + 2$$

$$f(2) = 18$$

Example 1: If $f(x) = x^2 - 6$, find

a. $f(2)$

b. $f(n - 2)$

c. $f(3x)$

d. If the domain of $f(x) = x^2 - 6$ is $\{x \mid -2 \leq x \leq 2\}$, find the range of the function.
Example 2: The graph of function f is shown below. Find:

a. f(-1)

b. f(0)

c. f(1)

d. f(3)

Practice Section: Evaluating Functions

1. If \( f(x) = 3x^2 - 2 \), find \( f(-1) \).

2. If \( f(x) = \frac{3x}{\sqrt{6x}} \), find \( f(6) \).

3. If \( f(x) = 3\sqrt{-x} \), find \( f(8) \).

4. If \( f(x) = |4x - 5| \), find \( f(-2) \).

5. If \( f(x) = x^2 - 4x \), find \( f(-2) \).

6. If \( g(x) = 3x + 4 \) and the domain is \( \{x|-1 \leq x < 7\} \), find the range.
7. The graph of function g is shown at the right.
   a. Find \( g(-1) \).  
   b. Find \( g(1) \).
   c. Find \( g(2) \).  
   d. Find \( g(0) \).
   e. Find \( g(1 \frac{1}{2}) \).  
   f. Find \( g(-1 \frac{1}{2}) \).
   g. For what value(s) of \( x \) will \( g(x) = 2 \frac{1}{2} \)?
   h. State the domain of function g.
   i. State the range of function g.

Answers:

<table>
<thead>
<tr>
<th>a.</th>
<th>b.</th>
</tr>
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<tbody>
<tr>
<td>c.</td>
<td>d.</td>
</tr>
<tr>
<td>e.</td>
<td>f.</td>
</tr>
<tr>
<td>g.</td>
<td>h.</td>
</tr>
<tr>
<td>i.</td>
<td></td>
</tr>
</tbody>
</table>
Challenge

If \( f \) is a one-to-one function, \( f(g(4)) = 8 \) and \( f(4) = 8 \), then \( g(4) \) equals

Summary/Closure

Evaluating Functions:

To evaluate a function, simply replace (substitute) the function's variable with the indicated number or expression.

1. A function is represented by \( f(x) = 2x + 5 \). Find \( f(3) \).

   To find \( f(3) \), replace the \( x \)-value with 3. \( f(3) = 2(3) + 5 = 11 \).
   The answer, 11, is called the image of 3 under \( f(x) \).

Exit Ticket:

If \( f(x) = \frac{x}{x^2 - 16} \), what is the value of \( f(-10) \)?

(1) \( -\frac{5}{2} \)  
(2) \( -\frac{5}{42} \)  
(3) \( \frac{5}{58} \)  
(4) \( \frac{5}{18} \)
Chapter 4 – Functions with Restricted Domains
(Day 3)

SWBAT: Calculate restricted domains of functions

Warm – Up:

The graph of function f is shown at the right.

a. Find f(-1).
   b. Find f(0).
   c. Find f(1).
   d. Find f(3).

Functions with Restricted Domains

Any equation that can be written as “y =” with no ± symbol is a function. Almost every function we study this year has the domain “All Real Numbers” (\(\mathbb{R}\)) which means that you are allowed to use ANY VALUE OF X you want, and there will be some value of y that corresponds to it.

Functions with Restricted Domains have some value(s) of x which cannot be used, because it results in some undefined values of y.

Functions that have no domain restriction:

\[
f(x) = 2x + 5
\]

\[
k(x) = x^2
\]

\[
m(x) = |x|
\]
These are the three functions with restricted domains we will explore this year:

<table>
<thead>
<tr>
<th>Rational Functions</th>
<th>Square Root Functions</th>
<th>Combination of the two… (a composition of a rational function and a square root function)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A rational function is defined as</strong> $f(x) = \frac{p(x)}{q(x)}$, where $p(x)$ and $q(x) \neq 0$ are also functions of $x$.</td>
<td><strong>A square root function has a square root in it!</strong> $f(x) = \sqrt{p(x)}$</td>
<td>Put the two together and you have…a rational function with a square root in the denominator.</td>
</tr>
<tr>
<td>Example: $g(x) = \frac{1}{x^2-9}$ try the value $x = 3$.</td>
<td>Example: $f(x) = \sqrt{3x + 4}$ try the value $x = -10$.</td>
<td>Example: $h(x) = \frac{1}{\sqrt{2x+1}}$ try the value $x = -4$.</td>
</tr>
</tbody>
</table>

**Rational Fractions are undefined when the denominator is equal to 0**

$$f(x) = \frac{x - 3}{x^2 + 5x}$$

To restrict the domain:
(1) Set the den. $\neq 0$
(2) Solve.

These are the restricted values.

**Square Root functions are undefined when the radicand is less than 0**

$$f(x) = \sqrt{x^2 + 9x}$$

To restrict the domain:
(1) Set the radicand $\geq 0$.
(2) Solve.

These are the restricted values.

**These functions are undefined when the radicand in the denominator less than or equal to 0**

$$f(x) = \frac{3}{\sqrt{4x+8}}$$

To restrict the domain:
(1) Set the radicand $> 0$.
(2) Solve.

These are the restricted values.
Determine the domain of each of the following rational functions:

a) \( f(x) = \frac{1}{x+6} \)  

b) \( f(x) = \frac{x-3}{x^2 + 9} \)  

c) \( f(x) = \frac{x^2-7x+6}{x^2 - 6x + 5} \) 

d) \( f(x) = \frac{2}{x^2-4} \)  

e) \( f(x) = \frac{x-3}{x^2-5x+6} \)  

f) \( f(x) = \frac{x}{x^2 + 4} \)
Determine the domain of each of the following square root function:

\[ g) \quad f(x) = \sqrt{x} \quad h) \quad f(x) = \sqrt{x-3} \quad i) \quad f(x) = 3\sqrt{x-4} + 8 \]

Determine the domain of each of the following compositions of square root and rational functions

\[ j) \quad f(x) = \frac{3}{\sqrt{4x+8}} \quad k) \quad f(x) = \frac{x}{\sqrt{x^2+16}} \quad l) \quad f(x) = \frac{x}{\sqrt{10-5x}} \]
### Summary/Closure:

<table>
<thead>
<tr>
<th>Type of Function</th>
<th>Example</th>
<th>Domain</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td></td>
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<tr>
<td>Quadratic</td>
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<tr>
<td>Absolute Value</td>
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<td></td>
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<tr>
<td>Square Root</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Rational Function</td>
<td></td>
<td></td>
<td>Do Not Determine</td>
</tr>
<tr>
<td>Composition of Rational Function and Square Root Function</td>
<td></td>
<td></td>
<td>Do Not Determine</td>
</tr>
</tbody>
</table>

### Exit Ticket:

What is the domain of \( h(x) = \sqrt{x^2 - 4x - 5} \)?

[A] \( \{x| x \geq 1 \text{ or } x \leq -5\} \)

[B] \( \{x| -5 \leq x \leq 1\} \)

[C] \( \{x| x \geq 5 \text{ or } x \leq -1\} \)

[D] \( \{x| -1 \leq x \leq 5\} \)
In 1–9:  a. Identify the function as being a linear, constant, quadratic, absolute-value, or step function. b. Find \( f(3) \). c. Find \( f \left( \frac{1}{2} \right) \).

1. \( f(x) = 2 \)  
2. \( f(x) = x \)  
3. \( f(x) = [x] \)  
4. \( f(x) = 2x^2 \)  
5. \( f(x) = 2 - x \)  
6. \( f(x) = |2 - x| \)  
7. \( f(x) = [2 - x] \)  
8. \( f(x) = x^2 - x \)  
9. \( f(x) = \pi \)

In 10–12, for the given function and its domain, find the range.

10. \( \{(x, y) | y = 3x - 2 \}; \ domain = \{x | -2 \leq x \leq 2 \} \)
11. \( f(x) = 5 - \frac{1}{2}x; \ domain = \{x | 0 \leq x \leq 16 \} \)
12. \( g: x \rightarrow 6 - x; \ domain = \{x | x \geq 0 \} \)

13. If the domain of \( y = 4x - 3 \) is \( \{x | 2 \leq x \leq 5 \} \), what is the greatest value in its range?
14. The domain of \( f(x) = 9 - 2x \) is \( 4 \leq x \leq 10 \). What is the greatest value in the range of \( f \)?
15. Let the domain of the quadratic function \( y = 1 + 4x - x^2 \) be \( 0 \leq x \leq 4 \). a. Graph the function, including all points whose \( x \)-coordinates are 0, 1, 2, 3, 4. b. What is the greatest value in the range of this function?

In 16–24, state the largest possible domain such that the given relation is a function.

16. \( f(x) = \frac{2}{x - 2} \)  
17. \( g(x) = \frac{x - 3}{x - 9} \)  
18. \( h(x) = \frac{x}{x + 7} \)
19. \( m(x) = \frac{6}{x^2 - 16} \)  
20. \( k: x \to \frac{1}{x^2 - 5x} \)  
21. \( r: x \to 3x - 6 \)

22. \( x \xrightarrow{f} \sqrt{x - 1} \)  
23. \( x \xrightarrow{g} \frac{1}{\sqrt{x - 1}} \)  
24. \( y = \frac{1}{x^2 + 1} \)

In 25–30, for the given function: a. State the domain. b. State the range.

25. \( y = 2x \)  
26. \( y = x^2 \)  
27. \( y = \sqrt{x} \)

28. \( h(x) = |x - 5| \)  
29. \( f(x) = 10 \)  
30. \( x \xrightarrow{g} x + 10 \)

31. Given the function \( f(x) = \frac{2x - 6}{x - 3} \):
   a. State the domain of the function.
   b. Find \( f(5) \).
   c. Find \( f(38) \).
   d. Find \( f(0) \).
   e. Find \( f(-2) \).
   f. True or False: For every \( x \) in the domain stated in part a, \( f(x) = 2 \). Explain why.
   g. State the range of the function.

32. Evaluate each expression, finding the greatest integer.
   a. \([17]\)  
b. \([27\frac{1}{2}]\)  
c. \([1.23]\)  
d. \([0.8]\)
   e. \([-5\frac{1}{2}]\)  
f. \([-0.1]\)  
g. \([\frac{15}{4}]\)  
h. \([-\frac{15}{4}]\)

In 33–35, select the numeral preceding the expression that best answers the question.

33. If \( k(x) = \frac{x - 2}{x - 1} \), for what value of \( x \) will \( k(x) = 0 \)?
   (1) 1  
   (2) 2  
   (3) both 1 and 2  
   (4) neither 1 nor 2

34. Which of the following ordered pairs is not an element of the greatest integer function, \( y = [x] \)?
   (1) \((8, 8)\)  
   (2) \((2.76, 2)\)  
   (3) \((-3.6, -3)\)  
   (4) \((-4.6, -5)\)

35. Which of the following is not a function?
   (1) the line \( y = 5x - 4 \)  
   (2) the parabola \( y = x^2 - 3x \)  
   (3) the line \( y = 2 \)  
   (4) the circle \( x^2 + y^2 = 16 \)

In 36–41: a. Graph the given function for the domain \(-3 \leq x \leq 3\).  
b. Using this domain, what is the range of the function?

36. \( y = |x| \)  
37. \( f(x) = |3x| \)  
38. \( y = |x| + 2 \)

39. \( f(x) = |x + 2| \)  
40. \( y = 3 - |x| \)  
41. \( f(x) = x + |x| \)
GRAPHING ABSOLUTE VALUE FUNCTIONS (Day 4)

SWBAT: Graph Absolute Value functions

Warm – Up:
Identify the domain and range of each.

\[ y = \sqrt{x + 3} \]

A) Domain: \( x \geq 0 \) \hspace{1cm} B) Domain: \( x \geq 3 \)
Range: \( y \geq -1 \) \hspace{1cm} Range: \( y \geq 0 \)
C) Domain: \( x \leq 1 \) \hspace{1cm} D) Domain: \( x \geq -3 \)
Range: \( y \geq -3 \) \hspace{1cm} Range: \( y \geq 0 \)

Identify the domain of each.

\[ f(x) = \frac{1}{-3x^2 - 3x + 18} \]

A) Domain: All reals except 3, 0
B) Domain: All real numbers
C) Domain: All reals except 2, -3
D) Domain: All reals except 1, -3

In Unit 2, we talked about absolute value in terms of the distance a number is away from zero on a number line. We will now investigate the graph of the absolute value function.

**Graph: \( y = |x| \)**

| \( x \) | \( y = |x| \) | \((x, y)\) |
|-------|-----------|---------|
| -5    |           |         |
| -4    |           |         |
| -3    |           |         |
| -2    |           |         |
| -1    |           |         |
| 0     |           |         |
| 1     |           |         |
| 2     |           |         |
| 3     |           |         |
| 4     |           |         |
| 5     |           |         |

**VERTEX**
The vertex of the absolute value function is the point where the function changes direction.
Which coordinates are the turning points (vertex) of the graph above? (___, ___)
Exercise #2: Graph the following functions using a graphing calculator.

\[ y = |x + 3| \]

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
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</tbody>
</table>

\[ y = |x - 3| \]

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
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</table>

**SUMMARY**

When \( y = |x - h| \) the graph is shifted ________________________________

When \( y = |x + h| \) the graph is shifted ________________________________
**Exercise #3:** Consider the function: \( y = |x| + 2 \), and \( y = |x| - 3 \)

(a) Using your graphing calculator to generate an \( xy \)-table, graph this function on the given grid.

\[
y = |x| + 2, \\
\begin{array}{|c|c|}
\hline
x & y \\
\hline
\end{array}
\]

\[
y = |x| - 3 \\
\begin{array}{|c|c|}
\hline
x & y \\
\hline
\end{array}
\]

**SUMMARY**

Compare the graphs for problem 4. Make a conjecture about functions that come in the form:
\[ y = |x| + k. \]

When \( y = |x| + k \) the graph is shifted __________________________

When \( y = |x| - k \) the graph is shifted __________________________
A translation is a shift of a graph vertically, horizontally, or both. The resulting graph is the same size and shape as the original but is in a different position in the plane.

<table>
<thead>
<tr>
<th>Graphs of Absolute Value Functions</th>
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</thead>
<tbody>
<tr>
<td>$y =</td>
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<td>$y =</td>
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</tbody>
</table>

Practice: Writing equations of an absolute value function from its graph. Write an equation for each translation of $y = |x|$ shown below.
Vertical and Horizontal Translations

Identify the vertex and graph each.

g) \( y = |x| + 5 \)

Vertex: (__, __)

h) \( y = |x - 4| \)

Vertex: (__, __)

i) \( y = |x - 6| - 2 \)

Vertex: (__, __)

j) \( y = |x + 8| + 3 \)

Vertex: (__, __)
Lastly, let’s observe what happens when the coefficient changes in front of the absolute value of $x$.

$$y = |x|$$

$$y = -|x|$$

Compare the graphs from above. Make a conjecture about functions that come in the form:

$$y = \pm |x|$$

When $y = + |x|$ the graph opens __________________________

When $y = - |x|$ the graph is opens __________________________

(which means its reflected over the ___ axis)

$$y = 3|x|$$

$$y = \frac{1}{3} |x|$$

Compare the graphs from above. Make a conjecture about functions that come in the form:

$$y = a|x| \quad \text{and} \quad y = \frac{1}{a} |x|$$

When $y = a|x|$ the graph is __________ than $y=|x|$.  

When $y = \frac{1}{a} |x|$ the graph is __________ than $y=|x|$.  

23
**SUMMARY**

*A translation* is a shift of a graph vertically, horizontally, or both. The resulting graph is the same size and shape as the original but is in a different position in the plane.

<table>
<thead>
<tr>
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</tbody>
</table>

$y = a|x-h| + k$; *Vertex* = $(h, k)$

**Exit Ticket**

1. What happens to the graph of $y = a|x|$ if $a$ changes from 1 to $\frac{1}{2}$?
   
   (1) The graph will become narrower.  
   (2) The graph will become wider.  
   (3) The graph will move right $\frac{1}{2}$ units.  
   (4) The graph will move down $\frac{1}{2}$ units.

2. The graph most accurately represents which of the following functions?

   A $y = |x + 3| + 2$  
   B $y = |x - 3| + 2$  
   C $y = |x - 2| + 3$  
   D $y = |x + 2| + 3$
Homework – Writing and Graphing Functions – Day 4

1. Which equation describes the graph shown below?

   (1) \( y = |x + 2| - 5 \)  
   (2) \( y = |x + 5| + 2 \)  
   (3) \( y = |x - 2| - 5 \)  
   (4) \( y = |x - 5| - 2 \)

2. Which equation describes the graph shown below?

   (1) \( y = |x + 3| - 2 \)  
   (2) \( y = |x - 2| - 3 \)  
   (3) \( y = |x - 3| - 2 \)  
   (4) \( y = |x + 2| + 3 \)

3. Lorraine entered an absolute value function in her graphing calculator and produced the table shown below. What are the coordinates of the turning point of this absolute value function?

   (1) (1, 1)  
   (2) (7, -1)  
   (3) (-3, 5)  
   (4) (5, -3)

4. The graph of \( y = |x + 2| \) is shown below.

Which graph represents \( y = -|x + 2| \)?
In examples 5 – 13, write an equation for each translation of \( y = |x| \).

5. 9 units up ____________________________
6. 6 units down ____________________________
7. right 4 units ____________________________
8. left 12 units ____________________________
9. 8 units up, 10 units left ____________________________
10. 3 units down, 5 units right ____________________________

11. ____________________________
12. ____________________________
13. ____________________________
In examples 14 and 15, identify the vertex and graph each.

14) \( y = |x - 1| \)

Vertex: (___, ___)

15) \( y = |x + 2| - 7 \)

Vertex: (___, ___)

16) On the set of axes below, graph and label the equations \( y = |x| \) and \( y = 2|x| \).

Explain how changing the coefficient of the absolute value from 1 to 2 affects the graph.

17) On the set of axes below, graph and label the equations \( y = |x| \) and \( y = \frac{1}{2}|x| \).

Explain how changing the coefficient of the absolute value from 1 to \( \frac{1}{2} \) affects the graph.
SWBAT: Transform Quadratic and Other functions

Warm Up:
1. Which graph best represents the following equation?

\[ y = |x - 4| \]

2. The vertex of \( y = |x + 2| - 3 \) is

(1) (2, 3)
(2) (-2, 3)
(3) (-2, -3)
(4) (2, -3)
<table>
<thead>
<tr>
<th>Type</th>
<th>Quadratic</th>
<th>Absolute Value</th>
<th>Cubic</th>
<th>Square Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Function</td>
<td>$y = x^2$</td>
<td>$y =</td>
<td>x</td>
<td>$</td>
</tr>
<tr>
<td>Sketch of basic function</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
<td><img src="image3" alt="Graph" /></td>
<td><img src="image4" alt="Graph" /></td>
</tr>
<tr>
<td>Vertex Form</td>
<td>$y = a(x - h)^2 + k$</td>
<td>$y = a</td>
<td>x - h</td>
<td>+ k$</td>
</tr>
</tbody>
</table>

Knowing how a function can be transformed makes it easier to graph the function. There are **three** types of transformations that can be done to a function.

<table>
<thead>
<tr>
<th>Function</th>
<th>Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f(x) + c$</td>
<td></td>
</tr>
<tr>
<td>$f(x) - c$</td>
<td></td>
</tr>
<tr>
<td>$f(x + c)$</td>
<td></td>
</tr>
<tr>
<td>$f(x - c)$</td>
<td></td>
</tr>
<tr>
<td>$f(-x)$</td>
<td></td>
</tr>
<tr>
<td>$-f(x)$</td>
<td></td>
</tr>
<tr>
<td>$\frac{a}{b} f(x)$</td>
<td>$\frac{a}{b} &lt; 1 \text{ and } b \neq 0$</td>
</tr>
<tr>
<td>$a f(x)$</td>
<td>$a &gt; 1$</td>
</tr>
<tr>
<td>$f\left(\frac{a}{b} x\right)$</td>
<td>$\frac{a}{b} &lt; 1 \text{ and } b \neq 0$</td>
</tr>
<tr>
<td>$f(ax)$</td>
<td>$a &gt; 1$</td>
</tr>
</tbody>
</table>
Describe the transformation for each function.

<table>
<thead>
<tr>
<th>Function</th>
<th>Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y =</td>
<td>x + 6</td>
</tr>
<tr>
<td>( y = \sqrt{x} - 2 )</td>
<td></td>
</tr>
<tr>
<td>( y = (x - 3)^2 + 7 )</td>
<td></td>
</tr>
<tr>
<td>( y = -3\sqrt{x + 7} - 10 )</td>
<td></td>
</tr>
<tr>
<td>( y = \frac{1}{2}x + 2 )</td>
<td></td>
</tr>
</tbody>
</table>

**Exercise #1:** The function \( y = x^2 \) is shown already graphed on the grid below. For parts (a) and (b), graph the function given and describe how the graph of \( y = x^2 \) has been shifted in order to produce the new graph.

(a) \( y = (x - 4)^2 + 2 \)

(b) \( y = (x + 3)^2 - 5 \)

[Graph of \( y = x^2 \) shifted]

**Exercise #2:** If the parabola \( y = x^2 \) were shifted 6 units left and 2 units down, its resulting equation would be which of the following? Verify by graphing your answer and seeing if its turning point is at \((-6, -2)\).

1. \( y = (x + 6)^2 + 2 \)
2. \( y = (x + 6)^2 - 2 \)
3. \( y = (x - 6)^2 - 2 \)
4. \( y = (x - 6)^2 + 2 \)

**Exercise #3:** Which of the following represents the turning point of the function \( f(x) = (x - 8)^2 - 4 \)?

1. \((-8, -4)\)
2. \((8, 4)\)
3. \((-8, 4)\)
4. \((8, -4)\)
4. Which of the following equations would result from shifting $y = x^2$ five units right and four units up?

(1) $y = (x - 5)^2 + 4$  
(2) $y = (x + 5)^2 + 4$  
(3) $y = (x - 4)^2 - 5$  
(4) $y = (x + 4)^2 - 5$

5. The quadratic function shown graphed to the right has the form $y = x^2 + bx + c$. Determine its equation first in vertex form and then determine the values of $b$ and $c$.

Consider the two functions $f(x) = \sqrt{x}$ and $g(x) = \sqrt{x + 3} - 2$.

6. Graph each function. Describe the transformation.
Example 7: Which of the following equations would represent the graph shown below?

(1) \( y = -\sqrt{x + 4} \)
(2) \( y = 4 - \sqrt{x} \)
(3) \( y = \sqrt{x - 4} \)
(4) \( y = -\sqrt{x - 4} \)

Example 8:
Which of the following represents the domain and range of \( y = \sqrt{x - 5} + 7 \). Solve this either by considering the shifting that has occurred to \( y = \sqrt{x} \) or by producing a graph on your calculator.

(1) Domain: \([-5, \infty)\)  
   Range: \([7, \infty)\)
(2) Domain: \([5, \infty)\)  
   Range: \([7, \infty)\)
(3) Domain: \((-7, \infty)\)  
   Range: \((5, \infty)\)
(4) Domain: \([7, \infty)\)  
   Range: \([5, \infty)\)

9: Which of the following equations describes the graph shown below?

(1) \( y = \sqrt{x} + 4 + 1 \)
(2) \( y = \sqrt{x} - 4 - 1 \)
(3) \( y = \sqrt{x} + 4 - 1 \)
(4) \( y = \sqrt{x} - 4 + 1 \)

10: Which equation below represents the graph shown?

(1) \( y = \sqrt{x - 2} - 5 \)
(2) \( y = -\sqrt{x + 2} + 5 \)
(3) \( y = -\sqrt{x - 2} + 5 \)
(4) \( y = \sqrt{x + 2} + 5 \)
SUMMARY

Reflection in x-axis \( y = -f(x) \)  \quad \text{Reflection in the y-axis} \quad y = f(-x)
Translate up c units \( y = f(x) + c \)  \quad \text{Translate down c units} \quad y = f(x) - c
Translate left c units \( y = f(x + c) \)  \quad \text{Translate right c units} \quad y = f(x - c)
Stretch vertically \( y = cf(x), c > 1 \)  \quad \text{Shrink vertically} \quad y = cf(x), 0 < c < 1
Shrink horizontally \( y = f(cx), c > 1 \)  \quad \text{Stretch horizontally} \quad y = f(cx), 0 < c < 1

For multiples shifts, use the order of operations to determine what to do first

Example: Describe the transformations on \( f(x) = x^2 \) to get the graph of the equation

\[
f(x) = -2(x - 3)^2 + 5
\]

Transformations of Functions—Vertex Form of a Function

| Quadratic Function: \( f(x) = a(x - h)^2 + k \) | Absolute Value Function: \( f(x) = a|x - h|^2 + k \) |
|-----------------------------------------------|-------------------------------------------------|
| Cubic Function: \( f(x) = a(x - h)^3 + k \)  | Square Root Function: \( f(x) = a\sqrt{x - h} + k \) |

The vertex is \( (h, k) \).

Exit Ticket

The graph of \( y = 10 - x^2 \) represents the graph of \( y = x^2 \) after

(1) a vertical shift of 10 units followed by a reflection in the x-axis.
(2) a reflection in the x-axis followed by a vertical shift of 10 units.
(3) a leftward shift of 10 units followed by a reflection in the y-axis.
(4) a reflection across the x-axis followed by a rightward shift of 10 units.
Day 5 – HW
Transformation of Functions

Part I: Short Answer

1) Explain how \( y = |x + 3| - 6 \) is translated from \( y = |x| \).

2) Explain how \( y = \sqrt{x - 5} + 3 \) is translated from \( y = \sqrt{x} \).

3) Explain how \( y = f(x - 4) - 2 \) is translated from \( y = f(x) \).

4) Explain how \( y = g(x + 9) \) is translated from \( y = g(x) \).

5) Let the graph of \( y = f(x) \) have the following points: \((4, -3), (-2, 0), (-10, -15)\).
   List the points on the graph of
   a) \( y = f(x - 2) \)
   b) \( y = f(x) + 9 \)
   c) \( y = f(x + 3) - 1 \)

6) If the graph of \( y = \sqrt{x} \) is translated up four units and left five units, write the new equation for this function.

7) If the graph of \( y = x^2 \) is translated right seven units and down two units, write the new equation for this function.
Part II: Graphing - If the scale on the axes is not 1 unit, you will need to label the axes with numbers. You must show at least five exact points or five steps on each graph, if possible.

6) \( y = (x - 2)^2 \)  

8) \( f(x) = -|x + 2| + 1 \)  

10) \( y = (x + 1)^3 \)  

7) \( y = 2\sqrt{x} \)  

9) \( f(x) = 2x^2 - 5 \)  

11) \( f(x) = \sqrt{x + 3} - 2 \)
12) \( y = 2|x + 2| - 5 \)  

13) \( y = |x + 1| + 1 \)  

14) \( y = \sqrt{x + 3} - 1 \)  

15) \( y = (x + 3)^2 - 6 \)  

16) \( y = \frac{2}{3}x - 1 \)  

17) \( f(x) = \sqrt{x - 2} - 4 \)
Part III: Use the graph of \( f(x) \) to sketch the graphs of the following.

18) \( y = f(x) - 3 \)

19) \( y = f(x + 3) - 1 \)

20) \( y = f(2x) \)

21) \( y = \frac{1}{2} f(x) \)

22) \( y = f(x - 1) + 2 \)
Day 6: Chapter 4–7/Composition of Functions

SWBAT: Add, Subtract, Multiply and Divide Functions

Warm – Up:

Let the graph of \( y = f(x) \) have the following points: \((-2, 4), (0, -3), (6, -1)\).
List the points on the graph of

\[
\begin{align*}
\text{a) } y &= f(x + 1) \\
\text{b) } y &= f(x) - 4 \\
\text{c) } y &= f(x - 5) + 3
\end{align*}
\]

Operations on Functions

- Given 2 functions \( f \) and \( g \):

<table>
<thead>
<tr>
<th>Notation</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>((f + g)(x))</td>
<td></td>
</tr>
<tr>
<td>((f - g)(x))</td>
<td></td>
</tr>
<tr>
<td>((fg)(x))</td>
<td></td>
</tr>
<tr>
<td>((\frac{f}{g})(x))</td>
<td></td>
</tr>
</tbody>
</table>

Domain of Functions

- First find domain of \( f \) and \( g \)
- The domain of +, -, or \(*\) is the intersection of the domains of \( f \) and \( g \)
- The domain of \( ÷ \) must exclude values that make denominator = 0.
Find: a) \((f + g)(x)\)  

b) \((f - g)(x)\)  
c) \((f \cdot g)(x)\)  
d) \((\frac{f}{g})(x)\)

1) \(f(x) = 3x + 4\)  
\(g(x) = 2x - 3\)

---

**Composition of Functions**

A **composition** of two or more functions is when a function is performed on the result of another evaluated function.

There are two ways to represent the composition of a function: \(f(g(x))\) or \((f \circ g)(x)\) both are read “f of g of x”, and mean that you are taking the result of g(x) and applying that result to the function f.

**Example:** \(f(x) = x + 2\) and \(g(x) = 5x - 4\). Find \(f(g(3))\).

\(F(g(3))\) means determine \(g(3)\), then find \(f\text{ result}\).

\[
\begin{align*}
g & \quad 3 \rightarrow 5(3) - 4 = 11 \rightarrow (11) + 2 = 13 \\
(f \circ g)(3) & \quad \text{(f \circ g)(3)}
\end{align*}
\]

So, \(f(g(3)) = 13\). **This is also \((f \circ g)(3)\).**

Composition of functions is generally not commutative, meaning the order matters!
Given: \( f(x) = 3x - 2 \) \quad g(x) = x^2 + 1 \quad h(x) = \sqrt{x + 3} \quad j(x) = (x + 2)^2

Determine:
1. \((g \circ f)(-3)\)  
2. \((f \circ g)(-3)\)  
3. \((g \circ h)(4)\)

4. \((h \circ g)(-6)\)  
5. \((f \circ h \circ g)(2)\)  
6. \((g \circ h \circ f)(1)\)

Finding a general formula for \( f(g(x)) \) or \( g(f(x)) \) requires you to go the same thing \textit{without actual values of } x.\textit{.}

Example: \( f(x) = x + 2 \) and \( g(x) = 5x - 4 \). Find \( f(g(x)) \) and \( g(f(x)) \).

\( f(g(x)) \) means do \( g(x) \) first, then do \( f(\text{result}) \).

- \( f( g(x) ) = \)
  \[ f(5x - 4) = (5x - 4) + 2 \]
  \[ = 5x - 4 + 2 \]
  \[ = 5x - 2. \]

So, \( f(g(x)) = 5x - 2 \)

- \( g( f(x) ) = \)
  \[ g( x + 2 ) = 5(x + 2) - 4 \]
  \[ = 5x + 10 - 4 \]

So, \( g(f(x)) = 5x + 6 \)
Given: \( f(x) = 3x - 2 \) \quad g(x) = x^2 + 1 \quad h(x) = \sqrt{x+3} \quad j(x) = (x + 2)^2 

Determine the general formulas for:

7. \((f \circ g)(x)\)  
8. \((g \circ f)(x)\)  
9. \((g \circ h)(x)\)  
10. \((h \circ g)(x)\)  
11. \((f \circ h)(x)\)  
12. \((h \circ f)(x)\)
Summary

Let $h(x) = x^2$ and $r(x) = x + 3$. a. Evaluate $(h \circ r)(5)$. b. Find the rule of the function $(h \circ r)(x)$.

Solution

a. To evaluate $(h \circ r)(5)$, apply $r$ first. Under $r$, $5 \rightarrow 8$. Under $h$, $8$ is squared.

$$5 \xrightarrow{r} 8 \xrightarrow{h} 64$$

$(h \circ r)(5) = 64 \text{ Ans.}$

b. Use the same process with $(h \circ r)(x)$.

Under $r$, $x \rightarrow x + 3$. Under $h$, $x + 3$ is squared.

$$x \xrightarrow{r} x + 3 \xrightarrow{h} (x + 3)^2 = x^2 + 6x + 9$$

$(h \circ r)(x) = x^2 + 6x + 9 \text{ Ans.}$

Note: By substituting $x = 5$ in the rule $(h \circ r)(x) = x^2 + 6x + 9$, we can show again that $(h \circ r)(5) = (5)^2 + 6(5) + 9 = 25 + 30 + 9 = 64$.

Exit Ticket

If $f(x) = 3x$ and $g(x) = 5x + 1$, what is $g(f(4))$?

(A) 61 \hspace{1cm} (B) 63 \hspace{1cm} (C) 83

(D) 241 \hspace{1cm} (E) 252
Day 6: HW

Work on Problems #2-42 Every Other Even

In 1–8, using \( f(x) = x + 5 \) and \( g(x) = 4x \), evaluate the composition.

1. \( f(g(2)) \)  
2. \( g(f(2)) \)  
3. \( f(g(-1)) \)  
4. \( g(f(-1)) \)  
5. \( f(g(0)) \)  
6. \( g(f(0)) \)  
7. \( g(f(\frac{1}{2})) \)  
8. \( f(g(\frac{1}{2})) \)  

In 9–16, using \( f(x) = 3x \) and \( g(x) = x - 2 \), evaluate the composition.

9. \( (f \circ g)(4) \)  
10. \( (g \circ f)(4) \)  
11. \( (f \circ g)(-2) \)  
12. \( (g \circ f)(-2) \)  
13. \( (g \circ f)(0) \)  
14. \( (f \circ g)(0) \)  
15. \( (g \circ f)(\frac{2}{3}) \)  
16. \( (f \circ g)(\frac{2}{3}) \)  

In 17–24, using \( h(x) = x^2 \) and \( p(x) = 2x - 3 \), evaluate the composition.

17. \( (h \circ p)(2) \)  
18. \( (p \circ h)(2) \)  
19. \( (p \circ h)(1) \)  
20. \( (h \circ p)(1) \)  
21. \( (p \circ h)(-3) \)  
22. \( (h \circ p)(-3) \)  
23. \( (h \circ p)(1.5) \)  
24. \( (p \circ h)(1.5) \)  

25. Let \( f(x) = x + 6 \) and \( g(x) = 3x \). a. Find the rule of the function \( (f \circ g)(x) \). b. Find the rule of the function \( (g \circ f)(x) \). c. Does \( (f \circ g)(x) = (g \circ f)(x) \)?

26. Let \( r(x) = x - 8 \) and \( t(x) = x^2 \). a. Find the rule of the function \( (r \circ t)(x) \). b. Find the rule of the function \( (t \circ r)(x) \). c. Does \( (r \circ t)(x) = (t \circ r)(x) \)?

27. Let \( d(x) = 2x + 3 \) and \( c(x) = x - 3 \). a. Evaluate \( (d \circ c)(2) \). b. Find the rule of the function \( (d \circ c)(x) \). c. Use the rule from part b to find the value of \( (d \circ c)(2) \). d. Do the answers from parts a and c agree?
In 28–37, for the given functions \( f(x) \) and \( g(x) \), find the rule of the composition \( (f \circ g)(x) \).

28. \( f(x) = 6x; \ g(x) = x - 2 \)  
29. \( f(x) = x - 10; \ g(x) = 4x \)  
30. \( f(x) = x; \ g(x) = 2x + 5 \)  
31. \( f(x) = x - 3; \ g(x) = x - 5 \)  
32. \( f(x) = 2x; \ g(x) = 5x \)  
33. \( f(x) = 3x + 2; \ g(x) = x - 3 \)  
34. \( f(x) = \frac{1}{2}x - 3; \ g(x) = 4x + 6 \)  
35. \( f(x) = 5 - x; \ g(x) = x + 2 \)  
36. \( f(x) = x^2; \ g(x) = x - 5 \)  
37. \( f(x) = 4 - x^2; \ g(x) = x - 2 \)

38. If \( f(x) = x + 8 \), then the rule of the composition \( (f \circ f)(x) \) is:
   (1) \( x + 8 \)  
   (2) \( x + 16 \)  
   (3) \( 2x + 8 \)  
   (4) \( 2x + 16 \)

39. If \( g(x) = 2x + 5 \), what is the rule of the composition \( (g \circ g)(x) \)?

40. Let \( h(x) = x^2 + 2x \), and \( g(x) = x - 3 \). In a to e, evaluate the composition.
   a. \( (h \circ g)(4) \)  
   b. \( (h \circ g)(3) \)  
   c. \( (h \circ g)(2) \)  
   d. \( (h \circ g)(1) \)  
   e. \( (h \circ g)(-2) \)  
   f. Find the rule of the function \( (h \circ g)(x) \).

41. Let \( f(x) = x + 5 \), \( g(x) = 2x \), and \( h(x) = x - 2 \).
   a. If \( k(x) = (f \circ g)(x) \), find the rule of the function \( k(x) \).
   b. Find the rule of \( ((f \circ g) \circ h)(x) \), that is, the rule of \( ((k) \circ h)(x) \).
   c. If \( r(x) = (g \circ h)(x) \), find the rule of the function \( r(x) \).
   d. Find the rule of \( (f \circ (g \circ h))(x) \), that is, the rule of \( (f \circ (r))(x) \).
   e. Using parts b and d, does \( ((f \circ g) \circ h)(x) = (f \circ (g \circ h))(x) \)? If yes, what group property is demonstrated? If no, explain why.

42. Let \( b(x) = |x| \), \( d(x) = [x] \), \( f(x) = \frac{1}{x} \), \( g(x) = x - 3 \), and \( h(x) = 2x \).

   Find the rule of the given composition:
   a. \( (f \circ b)(x) \)  
   b. \( (d \circ g)(x) \)  
   c. \( (b \circ g)(x) \)  
   d. \( (g \circ d)(x) \)  
   e. \( (g \circ f)(x) \)  
   f. \( (h \circ g)(x) \)  
   g. \( (f \circ (g \circ h))(x) \)  
   h. \( (d \circ (h \circ f))(x) \)  
   i. \( (g \circ (h \circ b))(x) \)  
   j. \( (b \circ (f \circ h))(x) \)
Day 7: Chapter 4–8/Inverse Function

Warm – Up

Perform the indicated operation.

1. \( h(a) = -4a - 2 \)
   \( g(a) = 3a - 2 \)
   Find \((h \circ g)(2)\)
   
   A) \(-18\)  B) \(78\)  C) \(16\)  D) \(-32\)

2. \( h(a) = 3a + 3 \)
   \( g(a) = a^2 + 3 \)
   Find \((h \circ g)(6)\)
   
   A) \(120\)  B) \(24\)  C) \(87\)  D) \(159\)

Inverse Function

The **inverse** of a function is found by switching the x and y values.

Example:

Function \( f \):

\[
\begin{array}{ccc}
1 & 6 \\
2 & 7 \\
3 & 8 \\
\end{array}
\]

Function \( f = \{(1, 6), (2, 7), (3, 8)\}\)

This function is said to be **one-to-one** since no two ordered pairs have the same second element. We already know that the x values cannot repeat. In a **one-to-one function**, no y value will repeat either.

A function has an **inverse function** if and only if it is a **one-to-one** function.

If we switch the domain and range, we notice that the relation is still a function, since no elements of the domain repeat.

\[
\begin{array}{ccc}
6 & 1 \\
7 & 2 \\
8 & 3 \\
\end{array}
\]

Inverse function \( f^{-1} = \{(6, 1), (7, 2), (8, 3)\}\)

Because the original function is one-to-one, the inverse will also be a function.
There are 3 ways to find the inverse of a function:

- Ordered Pairs
- Coordinate Graph
- Algebraically

1. Ordered Pairs

Example 1: Given \( f(x) = \{(3, 7), (5, 1), (7, 1)\} \), find the inverse.

Is the inverse a function? Explain your reasoning.

2. Coordinate Plane

In Geometry last year, you learned that \((x, y) \rightarrow (y, x)\) is a reflection in the line \(y = x\). The inverse of a composition of a 1-1 function \(f\) is graphed by reflecting the function \(f\) in the line \(y = x\), that is, the line whose equation is the identity function \(i\).

Example 2:

On the accompanying set of axes, graph the function \(f(x) = 2x + 4\) and its inverse, \(f^{-1}(x)\).
3. Algebraically

The rule of the inverse function \( f^{-1} \) can be found by interchanging \( x \) and \( y \) in the rule of the given function \( f \).

Example 3: Find \( f^{-1}(x) \) if \( f(x) = 2x + 3 \)

1. Rewrite \( f(x) = 2x + 3 \) as \( y = 2x + 3 \)
2. Switch \( x \) and \( y \)
3. Solve for \( y \)

Practice Section:
Find the inverse of each function.

1. \( A: \{(8, 5), (6, 8), (4, 11), (2, 14)\} \)

2. \( f(x) = \frac{2}{3}x + 4 \)
**Practice Section:**
Find the inverse of each function.

3. \( f(x) = \sqrt[3]{2x - 1} \)

4. \( f(x) = 2x^2 - 1 \)

(a) Using the same axes, sketch the graph of \( f^{-1} \).
(b) State the domain and range of \( f \).
(c) State the domain and range of \( f^{-1} \).
Regents Questions

If \( g(x) = \sqrt[3]{2x + 3} \), \( g^{-1}(2) \) equals

(1) \( -\frac{1}{2} \)  
(2) \( \sqrt[3]{7} \)  
(3) \( \frac{5}{2} \)  
(4) \( \frac{11}{2} \)

If \( h(x) = 2 - \frac{x}{2} \), find \( (h \circ h^{-1})(2) \).

(1) \( x \)  
(2) \( 2 \)  
(3) \( \frac{1}{2} \)  
(4) \( 0 \)

If \( f(x) = \sqrt[3]{\frac{2x}{3} - 1} \), then \( f^{-1}(-5) \) is

(1) an imaginary number
(2) 39
(3) 36
(4) \( \frac{52}{3} \)
Challenge

If \( f(x) = x + 1 \), then \( f(f(f(x))) \) equals

Summary

1. What is the inverse of the function \( y = 3x + 5 \)?

   \[ y = 3x + 5 \]
   \[ x = 3y + 5 \]
   \[ x - 5 = 3y \]
   \[ \frac{x - 5}{3} = y \]
   
   \[ Answer: \ y = \frac{x - 5}{3} \quad \text{OR} \quad y = \frac{1}{3}x - \frac{5}{3} \]

2. What is the inverse of the function \( f(x) = (3, 7), (2, 1), (5, -4) \)?

   \[ Solution: \] Interchange the \( x \)-coordinate and \( y \)-coordinate of each pair in the given function to find its inverse under composition.

   \[ Answer: \ (7, 3), (1, 2), (-4, 5) \]

Exit Ticket

What is the inverse of the function \( y = 3x + 2 \)?

1) \( 3y = x + 2 \)
2) \( x = 3y + 2 \)
3) \( y = \frac{1}{3}x - 2 \)
4) \( x = \frac{1}{3}y + \frac{2}{3} \)
Day 7 Homework: Inverse Function
Evens Only!

EXERCISES

In 1–4, write the inverse of the given function.
1. \{(1, 5), (2, 7), (3, -2), (4, -3)\}
2. \{(0, 6), (4, 2), (-1, 7), (-2, 8)\}
3. \{(1, 1), (2, 2), (3, 3), (4, 4)\}
4. \{(1, k), (2, k + 1), (3, k + 2)\}

5. Let \(f = \{(3, -2), (4, -2), (5, -1)\}\). a. Write the relation formed by interchanging the \(x\)-coordinate and \(y\)-coordinate of \(f\). b. Is this new relation a function? If not, explain why.

6. True or False: The relation formed by interchanging \(x\) and \(y\) in each pair of a function is also a function.

7. True or False: The relation formed by interchanging \(x\) and \(y\) in each pair of a one-to-one function is also a one-to-one function.

In 8–16, write the equation of the inverse of the given function, solved for \(y\).
8. \(y = 3x\)
9. \(y = x - 6\)
10. \(y = \frac{1}{4}x\)
11. \(y = \frac{1}{3}x + 1\)
12. \(y = 4x - 8\)
13. \(y = 5 - x\)
14. \(y = \sqrt{x}\)
15. \(y - 12 = 3x\)
16. \(y + 7 = x^3\)

In 17–19 and 23, select the numeral preceding the expression that best completes the sentence or answers the question.

17. If \(f(x) = 6x - 2\), then the inverse function \(f^{-1}(x)\) is:
   (1) \(\frac{x + 2}{6}\)
   (2) \(\frac{x}{6} + 2\)
   (3) \(\frac{x + 1}{3}\)
   (4) \(\frac{x}{3} + 1\)

18. If \(m(x) = 2x - 1\), then \(m^{-1}(x)\) is:
   (1) \(\frac{1}{2}x + 1\)
   (2) \(\frac{1}{2}x + \frac{1}{2}\)
   (3) \(2x + 1\)
   (4) \(-2x + 1\)

19. The inverse of the function \(y = -2x\) is:
   (1) \(y = 2x\)
   (2) \(x = 2y\)
   (3) \(x = -2y\)
   (4) \(y = x - 2\)
20. If \( f(x) = 3x - 7 \), evaluate:  
   a. \( f(2) \)  
   b. \( f^{-1}(-1) \)  
21. If \( g(x) = \frac{2}{3}x + 4 \), evaluate:  
   a. \( g(-3) \)  
   b. \( g^{-1}(2) \)  
22. If \( h(x) = 5x - 2 \), find the value of \( (h^{-1} \circ h)(123) \).  

23. What is the inverse of the function \( \{(3, 1), (4, -1), (-2, 6)\} \)?  
   (1) \( \{(-3, -1), (4, 1), (-2, -6)\} \)  
   (2) \( \{(-1, 3), (1, 4), (-6, -2)\} \)  
   (3) \( \{(-3, -1), (-4, 1), (2, -6)\} \)  
   (4) \( \{(1, 3), (-1, 4), (6, -2)\} \)  

In 24–26:  
   a. On graph paper, copy the function \( f \).  
   b. Using the same axes, sketch the graph of \( f^{-1} \), the inverse under composition.  
   c. State the domain and range of \( f \).  
   d. State the domain and range of \( f^{-1} \).

24. 

25. 

26.
Day 8: Inverse Variation

Warm-Up

If the function $j(x)$ is defined by $j(x) = \sqrt{x - 4}$, for $x \geq 4$, which of the following represents $j^{-1}(x)$, when $x \geq 0$?

(1) $\sqrt{4 + x}$

(2) $\frac{1}{\sqrt{x - 4}}$

(3) $x^2 + 4$

(4) $4 - x^2$

In Algebra, you learned about Direct Variations.

Direct variation: the ratio of 2 variables is a constant. We say the variables are directly proportional or that they vary directly. It is of the form $\frac{x}{y} = k$ or $\frac{y}{x} = k$

All direct variations are linear functions that intersect the origin. They are always one to one.
Inverse variation: the product of 2 variables is a constant. We say the variables are inversely proportional or that they vary inversely. It is of the form $xy = k$.

We use this equation to solve problems:

The graph of an inverse variation function is a hyperbola, a two-branched curved shape.

The graph of an inverse variation function is a hyperbola, a two-branched curved shape.

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<thead>
<tr>
<th>$k&gt;0$</th>
<th>$k&lt;0$</th>
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Asymptote- An asymptote is a line in which a graph gets infinitely close to but never touches. In inverse variation graphs, the asymptotes are the axes.
The Hyperbola

Example 1: Graph $xy = 4$

Example 2: Graph $y = \frac{-6}{x}$

Example 3: Write the equation of the hyperbola below.
Example 4: The speed of a laundry truck varies inversely with the time it takes to reach its destination. If the truck takes 3 hours to reach its destination traveling at a constant speed of 50 miles per hour, how long will it take to reach the same location when it travels at a constant speed of 60 miles per hour?

Example 5: The time it takes to travel a fixed distance varies inversely with the speed traveled. If it takes Pam 40 minutes to bike to the secret fishing spot at 9 miles per hour, what is the equation that represents this situation? How long will it take if she rides 12 miles per hour?

Example 6: The volume $V$ of a gas kept at a constant temperature varies inversely as the pressure $p$. If the pressure is 24 pounds per square inch, the volume is 15 cubic feet. What will be the volume when the pressure is 30 pounds per square inch?
**Challenge**

To build a sound wall along the highway, the amount of time $t$ needed varies **directly** with the number of cement blocks $c$ needed and **inversely** with the number of workers $w$. A sound wall made of 2400 blocks, using six workers takes 18 hours to complete. How long would it take to build a wall of 4500 blocks with 10 workers?

**SUMMARY**

The time it takes to travel a fixed distance varies inversely with the speed traveled. If it takes Pam 40 minutes to bike to the secret fishing spot at 9 miles per hour, what is the equation that represents this situation? How long will it take if she rides 12 miles per hour?

Since the units are not the same first change 40 minutes into hours: $\frac{40}{60} = \frac{2}{3}$ hour.

Letting $y = \text{time}$ and $x = \text{speed}$, use the equation: 

$$y = \frac{k}{x} \quad \text{(time varies inversely with speed)}$$

Substitute the values and solve for $k$.

$$\frac{2}{3} = \frac{k}{9}, \text{ so } k = 6.$$ 

The equation of this inverse variation is: 

$$y = \frac{6}{x}$$

If she rides 12 miles per hour the time is: 

$$y = \frac{6}{12} = \frac{1}{2} \text{ hour or 30 minutes}$$

**Exit Ticket**

Every year a band is paid $350 to play at the county fair. Let $a$ represent the amount each member receives and let $n$ represent the number of members in the band. The inverse variation relationship between $a$ and $n$ is best represented as

A) $a + n = 350$

B) $\frac{n}{a} = 350$

C) $\frac{350}{a} = \frac{1}{n}$

D) $an = 350$
Day 8 Homework: Inverse Variation

Work on Odds Only!

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<th>EXERCISES</th>
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In 1–8, draw the graph of the equation.

1. \( xy = 6 \)

2. \( xy = 15 \)

3. \( xy = -4 \)

4. \( xy = -2 \)

5. \( y = \frac{10}{x} \)

6. \( y = \frac{8}{x} \)

7. \( y = \frac{1}{x} \)

8. \( y = \frac{1}{x} \)

9. If 4 typists can complete the typing of a manuscript in 9 days, how long would it take 12 typists to complete the manuscript?

10. If 4 typists can complete the typing of a manuscript in 9 days, how many typists are needed to complete the typing in 6 days?

11. If a man can drive from his home to Albany in 5 hours at 45 mph, how long would it take him if he drove at 50 mph?

12. If a man can drive from his home to Albany in 6 hours at 45 mph, how fast did he drive if he made the trip in 5 hours?

13. Let \( S \) be the set of all rectangles that have an area of 600 cm\(^2\). The length varies inversely as the width.

a. What is the length of a rectangle from the set \( S \) whose width is 20 cm?

b. What is the width of a rectangle from the set \( S \) whose length is 100 cm?
Chapter 4. Relations and Functions

4-1 Relations and Functions
(pages 126–127)

Writing About Mathematics
1. \( \{ (x, y) : x = y^2 \} \) is not a function because for all values of \( x > 0 \) there are two distinct \( y \)-values, whereas \( \{ (x, y) : \sqrt{x} = y \} \) is a function because for every value of \( x \geq 0 \) there is exactly one real number that is the square root. No two pairs have the same first element.
2. No, because not every positive integer has an integral square root. The range contains non-integer values.

Developing Skills
3. a. function; no two pairs have the same first element
   b. \([1, 2, 3, 4] \)
   c. \([1, 4, 9, 16] \)
4. a. not a function; points \((1, -1)\) and \((1, 1)\) have the same first element
   b. \([0, 1] \)
   c. \([-1, 0, 1] \)
5. a. function; no two pairs have the same first element
   b. \([-2, -1, 0, 1, 2] \)
   c. \([0] \)
6. a. function
   b. \([all real numbers] \)
   c. \([y : y \geq -1] \)
7. a. not a function
   b. \([all real numbers] \)
   c. \([y : y \leq -1 or y \geq 1] \)
8. a. not a function
   b. \([x : x \geq -2] \)
   c. \([all real numbers] \)
9. a. function
   b. \([all real numbers] \)
   c. range: \( y = 2 \)
10. a. function
    b. \([x : -3 \leq x \leq 3] \)
    c. \([y : 0 \leq y \leq 4] \)
11. a. function
    b. \([x : 1 \leq x \leq 6] \)
    c. \([y : 0 \leq y \leq 2.5] \)
12. a. \([all real numbers] \)
    b. The function is not onto since the range is \([-183]\).
13. a. \([all real numbers] \)
    b. The function is onto since the range is equal to the domain.

14. a. \([all real numbers] \)
    b. The function is not onto since the range is \([y : y \neq 0]\).
15. a. \([all real numbers] \)
    b. The function is not onto since the range is \([y : y \neq 1]\).
16. a. \([x : x \geq 0] \)
    b. The function is onto since the range is equal to the domain.
17. a. \([all real numbers] \)
    b. The function is not onto since the range is \([y : y \neq 0]\).
18. a. \([x : x \neq 0]\)
    b. The function is onto since the range is equal to the domain.
19. a. \([x : x \leq 3]\)
    b. The function is onto since the range is equal to the domain.
20. a. \([x : x > -1]\)
    b. The function is not onto since the range is \([y : y > 0]\).
21. a. \([all real numbers] \)
    b. The function is not onto since the range is \([y : 0 < y < 1]\).
22. a. \([x : x \neq 2]\)
    b. The function is onto since the range is equal to the domain.
23. a. \([x : x \neq 3]\)
    b. The function is not onto since the range is \([y : y < 1]\).

Applying Skills

24. a. \([x, y] : y = x(6 - x)\)

b. 

```
\begin{array}{|c|c|c|c|c|c|c|c|c|c|c|}
\hline
x & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \\
\hline
y & 0 & 5 & 8 & 9 & 8 & 5 & 0 & -7 & -16 & -27 & -40 \\
\hline
\end{array}
```

c. \([x : 0 < x < 6]\)

25. a. \([x, y] : y = 10x\)
    b. \((0, 0), (1, 10), (2, 20), (3, 30), (4, 40), (5, 50), (6, 60), (7, 70), (8, 80)\)
    c. \([0, 1, 2, 3, 4, 5, 6, 7, 8]\)
    d. \([0, 10, 20, 30, 40, 50, 60, 70, 80]\)
4-2 Function Notation (pages 128–129)

Writing About Mathematics
1. f and g are the same function, since evaluating g at x yields the same value as f.
2. f and g are not the same function. For example, note that f(3) = 9, while g(3) = g(1 + 2) = 3.

Developing Skills
3. a. f(x) = x – 2  
   b. 3
4. a. f(x) = x^2  
   b. 25
5. a. f(x) = |3x – 7|  
   b. 8
6. a. f(x) = 5x  
   b. 25
7. a. f(x) = \sqrt{x – 1}  
   b. 2
8. a. f(x) = \frac{2}{x}  
   b. \frac{2}{5}
9. 10  
   10. 10
11. 12
12. 4  
   13. 2
14. 1
15. a. 2  
   b. –3  
   c. –2  
   d. 2

Applying Skills
16. a. t(a) = 0.08a  
   b. \{a : a \geq 0\}
   c. $0.40
   d. $1.32

Day 3 - HW Answers for Pages 15 – 16 in Packet

1. a. constant  
   b. 2  
   c. 2
2. a. linear  
   b. 3  
   c. \frac{1}{2}
3. a. step  
   b. 3  
   c. 0
4. a. quadratic  
   b. 18  
   c. \frac{1}{2}
5. a. linear  
   b. –1  
   c. 1\frac{1}{2}
6. a. absolute-value  
   b. 1  
   c. 1\frac{1}{2}
7. a. step  
   b. –1  
   c. 1
8. a. quadratic  
   b. 6  
   c. –\frac{1}{4}
9. a. constant  
   b. \pi  
   c. \pi
10. \( y \leq 4 \) \( y \leq 8 \) \( y \leq 5 \)

11. \( y \leq 6 \)

12. \( y \leq 6 \)

13. 17 14. 1

15. a. 

\[ y = \begin{cases} 
\sqrt{x} & \text{if } x \geq 0 \\
-\sqrt{x} & \text{if } x < 0 
\end{cases} \]

b. 5

16. \( x \in \text{Reals} \{/2\} \)

17. \( x \in \text{Reals} \{/9\} \)

18. \( x \in \text{Reals} \{/7\} \)

19. \( x \in \text{Reals} \{/4, 4\} \)

20. \( x \in \text{Reals} \{/0, 5\} \)

21. \( x \in \text{Reals} \)

22. \( x \in \text{Reals} \)

23. \( x \geq 1 \)

24. \( x \in \text{Reals} \)

25. a. \( \{x | x \in \text{Reals}\} \)

b. \( \{y | y \in \text{Reals}\} \)

26. a. \( \{x | x \in \text{Reals}\} \)

b. \( \{y | y \geq 0\} \)

27. a. \( \{x | x \geq 0\} \)

b. \( \{y | y \geq 0\} \)

28. a. \( \{x | x \in \text{Reals}\} \)

b. \( \{y | y \geq 0\} \)

29. a. \( \{x | x \in \text{Reals}\} \)

b. \( \{y | y = 10\} \)

30. a. \( \{x | x \in \text{Reals}\} \)

b. \( \{y | y \in \text{Reals}\} \)

31. a. \( \{x | x \in \text{Reals} \{/3\} \}

b. 2

c. 2
d. 2
e. 2

f. true, since \( 2x - 6 = 2(x - 3) \)
g. \{2\}

32. a. 17

b. 27
c. 1
d. 0
e. -6

f. -1

g. 3

h. -4

33. (2)

34. (3)

35. (4)

36. b. \( \{y | 0 \leq y \leq 3\} \)

37. b. \( \{y | 0 \leq y \leq 9\} \)

38. b. \( \{y | 2 \leq y \leq 5\} \)

39. b. \( \{y | 0 \leq y \leq 5\} \)

40. b. \( \{y | 0 \leq y \leq 3\} \)

41. b. \( \{y | 0 \leq y \leq 6\} \)

42. b. \( \{0, 1, 2, 3, 4, 5\} \)

43. b. \( \{-2, -1, 0, 1, 2, 3\} \)

44. b. \( \{-3, -2, -1, 0, 1, 2, 3\} \)

45. b. \( \{0, 1, 2\} \)

46. b. \( \{0, 1\} \)

47. b. \( \{y | 0 \leq y < 1\} \)

48. a. \$1.40

b. \$1.05

c. \$2.24

d. \$3.99
e. 38

49. a. \$0.04

b. \$0.07

c. \$0.03

d. none

e. \$0.80

f. true
g. false

50. a. \$7.95

b. \$8.95

c. \$7.45

d. \$13.20

e. 27

51. a. \$3.90

b. \$5.15

c. \$7.65

d. \$6.40

e. 250

f. 201

52. a. 16

b. 64

c. 144

d. 256

e. 784 feet

53. a. true

b. \$70.00
c. The maximum weekly rental is \$100.
d. \{$50, \$70, \$90, \$100\}

54. b. \$4.00

c. \$6.00

d. \$7.00

e. \$7.00

55. b. true

c. (1) \$10

(2) \$14

(3) \$63

56. b. \$1.60

c. \$1.80

d. \$1.40

e. \$2.00

f. \$7.10
1. Which equation describes the graph shown below?
   (1) \( y = |x + 2| - 5 \)  (3) \( y = |x - 2| - 5 \)
   (2) \( y = |x + 5| + 2 \)  (4) \( y = |x - 5| - 2 \)

2. Which equation describes the graph shown below?
   (1) \( y = |x + 2| - 2 \)  (3) \( y = |x - 2| - 2 \)
   (2) \( y = |x - 2| - 3 \)  (4) \( y = |x + 2| + 3 \)

3. Lorraine entered an absolute value function in her graphing calculator and produced the table shown below. What are the coordinates of the turning point of this absolute value function?
   (1) \((1, 1)\)  (3) \((-3, 5)\)
   (2) \((7, -1)\)  (4) \((5, -3)\)

4. The graph of \( y = |x + 2| \) is shown below.

   Which graph represents \( y = -|x + 2| \)?
   1)  
   2)  
   3)  
   4)
In examples 5 – 13, write an equation for each translation of \( y = |x| \).

5. 9 units up
6. 6 units down
7. right 4 units
8. left 12 units
9. 8 units up, 10 units left
10. 3 units down, 5 units right

In examples 14 and 15, identify the vertex and graph each.

14) \( y = |x - 1| \)
   \[ y = |x| - 1 \]
   **Vertex:** \((-1, 0)\)
   **Shift:** 1 right

15) \( y = |x + 2| - 7 \)
   \[ y = |x| + 2 \]
   **Vertex:** \((-2, -7)\)
   **Shift:** 2 left + 1 down

16) On the set of axes below, graph and label the equations \( y = |x| \) and \( y = 2|x| \).

17) On the set of axes below, graph and label the equations \( y = |x| \) and \( y = \frac{1}{2}|x| \).

Explain how changing the coefficient of the absolute value from 1 to 2 affects the graph.

Explain how changing the coefficient of the absolute value from 1 to \( \frac{1}{2} \) affects the graph.
Day 5 – HW
Transformation of Functions

Part I: Short Answer

1) Explain how \( y = |x + 3| - 6 \) is translated from \( y = |x| \).
\[
\text{graph is shifted left 3 units and 6 units down}
\]

2) Explain how \( y = \sqrt{x - 5} + 3 \) is translated from \( y = \sqrt{x} \).
\[
\text{graph is shifted right 5 units and 3 units up}
\]

3) Explain how \( y = f(x - 4) - 2 \) is translated from \( y = f(x) \).
\[
\text{graph is shifted right 4 units and 2 units down}
\]

4) Explain how \( y = g(x + 9) \) is translated from \( y = g(x) \).
\[
\text{graph is shifted left 9 units}
\]

5) Let the graph of \( y = f(x) \) have the following points: \((4, -3), (-2, 0), (-10, -15)\).
List the points on the graph of
\[
\begin{align*}
\text{a)} & \quad y = f(x - 2) \quad \text{(shift \( x \) 2 units to the right)} \\
& \quad (6, -3), (0, 0), (-8, -15) \\
\text{b)} & \quad y = f(x) + 9 \quad \text{(shift \( y \) 9 units up)} \\
& \quad (4, 6), (-2, 9), (-10, -6) \\
\text{c)} & \quad y = f(x + 3) - 1 \quad \text{(shift \( x \) 3 units left and 1 unit down)} \\
& \quad (1, -4), (-5, -1), (-13, -6)
\end{align*}
\]

6) If the graph of \( y = \sqrt{x} \) is translated up four units and left five units, write the new equation for this function.
\[
y = \sqrt{x + 5} + 4
\]

7) If the graph of \( y = x^2 \) is translated right seven units and down two units, write the new equation for this function.
\[
y = (x - 7)^2 - 2
\]
Part II: Graphing - If the scale on the axes is not 1 unit, you will need to label the axes with numbers. You must show at least five exact points or five steps on each graph, if possible.

6) \( y = (x - 2)^2 \)

7) \( y = 2\sqrt{x} \)

8) \( f(x) = -|x+2|+1 \)

9) \( f(x) = 2x^2 - 5 \)

10) \( y = (x+1)^3 \)

11) \( f(x) = \sqrt{x+3} - 2 \)
12) $y = 2|x + 2| - 5$

13) $y = |x + 1| + 1$

14) $y = \sqrt{x + 3} - 1$

15) $y = (x + 3)^2 - 6$

16) $y = \frac{2}{3}x - 1$

17) $f(x) = \sqrt{x - 2} - 4$
Part III: Use the graph of $f(x)$ to sketch the graphs of the following.

18) $y = f(x) - 3$

19) $y = f(x + 3) - 1$

20) $y = f(2x)$

21) $y = \frac{1}{2} f(x)$

22) $y = f(x - 1) + 2$
### HW Answers for Day 6

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<td>13.</td>
<td>-2</td>
<td>14.</td>
<td>-6</td>
<td>15.</td>
<td>0</td>
<td>16.</td>
</tr>
<tr>
<td>17.</td>
<td>1</td>
<td>18.</td>
<td>5</td>
<td>19.</td>
<td>-1</td>
<td>20.</td>
</tr>
<tr>
<td>21.</td>
<td>15</td>
<td>22.</td>
<td>81</td>
<td>23.</td>
<td>0</td>
<td>24.</td>
</tr>
</tbody>
</table>

25. a. \(x \xrightarrow{g} 3x \xrightarrow{f} (3x + 6)\)
   b. \(x \xrightarrow{f} (x + 6) \xrightarrow{g} (x + 6) = (3x + 18)\)
   c. no

26. a. \(x \xrightarrow{t} x^2 \xrightarrow{r} (x^2 - 8)\)
   b. \(x \xrightarrow{r} (x - 8) \xrightarrow{t} (x - 8)^2 = (x^2 - 16x + 64)\)
   c. no

27. a. 1  b. \(x \xrightarrow{c} (x - 3) \xrightarrow{d} (2x - 3)\)  c. 1  d. yes

28. \(x \xrightarrow{g} (x - 2) \xrightarrow{f} (6x - 12)\)

29. \(x \xrightarrow{g} 4x \xrightarrow{f} (4x - 10)\)

30. \(x \xrightarrow{g} (2x + 5) \xrightarrow{f} (2x + 5)\)

31. \(x \xrightarrow{g} (x - 5) \xrightarrow{f} (x - 8)\)

32. \(x \xrightarrow{g} 5x \xrightarrow{f} (10x)\)

33. \(x \xrightarrow{g} (x - 3) \xrightarrow{f} (3x - 7)\)

34. \(x \xrightarrow{g} (4x + 6) \xrightarrow{f} (2x)\)

35. \(x \xrightarrow{g} (x + 2) \xrightarrow{f} (3 - x)\)

36. \(x \xrightarrow{g} (x - 5) \xrightarrow{f} (x^2 - 10x + 25)\)

37. \(x \xrightarrow{g} (x - 2) \xrightarrow{f} (4x - x^2)\)

38. (2)

39. \(x \xrightarrow{g} (2x + 5) \xrightarrow{f} (4x + 15)\)

40. a. 3  b. 0  c. -1  d. 0  e. 15

41. a. \(k(x) = 2x + 5\)  b. \(x \xrightarrow{h} (x - 2) \xrightarrow{k} (2x + 1)\)  c. \(r(x) = 2x - 4\)
   d. \(x \xrightarrow{r} (2x - 4) \xrightarrow{f} (2x + 1)\)  e. yes; associative property

42. a. \(x \xrightarrow{b} |x| \xrightarrow{f} \left( \frac{1}{|x|} \right)\)
   b. \(x \xrightarrow{g} (x - 3) \xrightarrow{d} [x - 3]\)
   c. \(x \xrightarrow{g} (x - 3) \xrightarrow{b} |x - 3|\)
   d. \(x \xrightarrow{d} [x] \xrightarrow{g} [x] - 3\)
   e. \(x \xrightarrow{f} \frac{1}{x - 3}\)  f. \(x \xrightarrow{f} 2x - 6\)
   g. \(x \xrightarrow{f} \frac{1}{2x - 3}\)
   h. \(x \xrightarrow{f} \frac{1}{x} \xrightarrow{h} \frac{2}{x} \xrightarrow{d} \left[ \frac{2}{x} \right]\)
   i. \(x \xrightarrow{h} 2|x| - 3\)
   j. \(x \xrightarrow{h} (2x) \xrightarrow{f} \frac{1}{2x} \xrightarrow{b} \left| \frac{1}{2x} \right|\)

43. a. true  b. $0.08  c. $1.01  d. true  e. $3.34  f. $21.15
HW Answers for Day 7

1. \{ (5, 1), (7, 2), (-2, 3), (-3, 4) \}  
2. \{ (6, 0), (2, 4), (7, -1), (8, -2) \}  
3. \{ (1, 1), (2, 2), (3, 3), (4, 4) \}  
4. \{ (k, 1), (k + 1, 2), (k + 2, 3) \}  
5. a. \( f^{-1} = \{ (-2, 3), (-2, 4), (-1, 5) \} \)  
   b. no; the element -2 in the domain corresponds to more than one element of the range.

6. false  
7. true  
8. \( y = \frac{1}{3}x \)  
9. \( y = x + 6 \)

10. \( y = 4x \)  
11. \( y = 3x - 3 \)  
12. \( y = \frac{1}{4}x + 2 \)  
13. \( y = 5 - x \)  
14. \( y = x^2 \)  
15. \( y = \frac{1}{3}x - 4 \)  
16. \( y = \sqrt{x + 7} \)  
17. (1)

18. (2)  
19. (3)  
20. a. -1  
   b. 2  
21. a. 2  
   b. -3  
22. 123  
23. (4)

24. a.  
   b.  

25. a.  
   b.  
   c. Domain: Real numbers  
      Range: Real numbers  
   d. Domain: Real numbers  
      Range: Real numbers

26. a.  
   b.  
   c. Domain: \(-1 \leq x \leq 4\)  
      Range: \(-2 \leq y \leq 3\)  
   d. Domain: \(-2 \leq x \leq 3\)  
      Range: \(-1 \leq y \leq 4\)
Answers to Day 8

1. 

3. 

For Exercises 2, 5, 7, see the graph of Exercise 1. For Exercises 4, 6, 8, see the graph of Exercise 3.

9. 3 days  
10. 6 typists  
11. 4 1/2 hr.

12. 54 mph  
13. a. 30 cm  
b. 6 cm