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Chapter 10 Maintaining Mathematical Proficiency

Evaluate the expression.

1. $6\sqrt{36} + 4$

2. $-7 - \sqrt{\frac{49}{4}}$

3. $4\left(\frac{\sqrt{25}}{4} - 6\right)$

4. $-3\left(4\sqrt{16} + 24\right)$

5. $9 - 4\sqrt{81}$

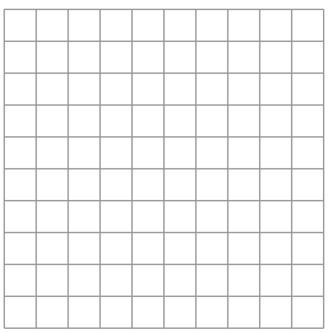
6. $-\sqrt{\frac{225}{9}} + 35$

7. $4\left(3 - \frac{\sqrt{36}}{6}\right)$

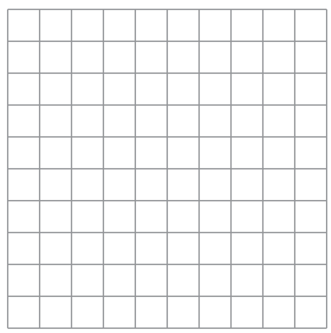
8. $2\left(2\sqrt{100} + 12\right)$

Graph *f* and *g*. Describe the transformations from the graph of *f* to the graph of *g*.

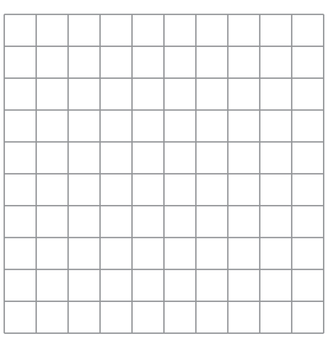
9. $f(x) = x;\ g(x) = 3x - 1$



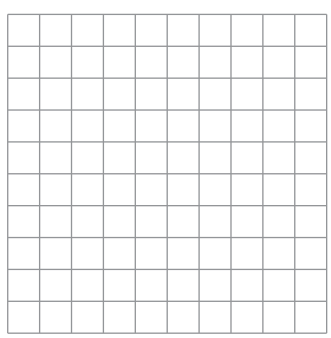
10. $f(x) = x;\ g(x) = \frac{1}{2}x + 3$



11. $f(x) = x;\ g(x) = -x - 2$



12. $f(x) = x;\ g(x) = -\frac{1}{4}x + 3$



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10.1 Graphing Square Root Functions
For use with Exploration 10.1

Essential Question What are some of the characteristics of the graph of a square root function?

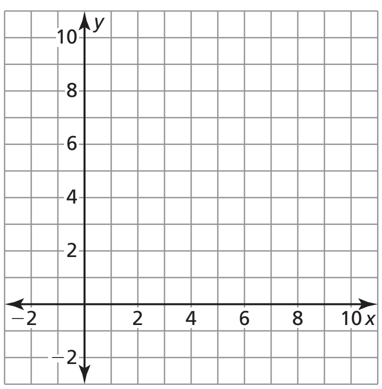
1 EXPLORATION: Graphing Square Root Functions

Work with a partner.

- Make a table of values for each function.
- Use the table to sketch the graph of each function.
- Describe the domain of each function.
- Describe the range of each function.

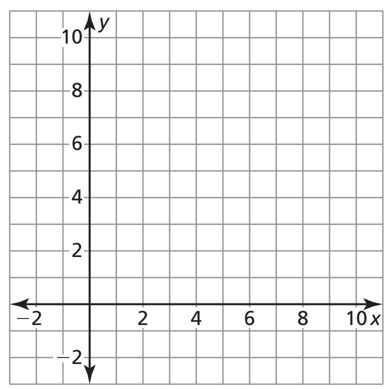
a. $y = \sqrt{x}$

x						
y						



b. $y = \sqrt{x + 2}$

x						
y						



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10.1 Graphing Square Root Functions (continued)

2 EXPLORATION: Writing Square Root Functions

Work with a partner. Write a square root function, $y = f(x)$, that has the given values. Then use the function to complete the table.

a.

x	$f(x)$
–4	0
–3	
–2	
–1	$\sqrt{3}$
0	2
1	

b.

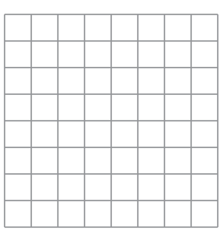
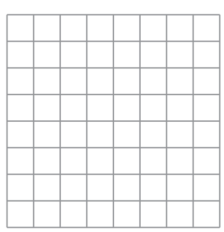
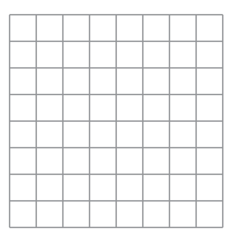
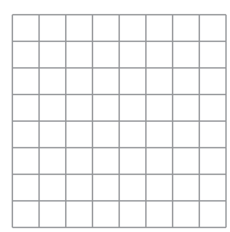
x	$f(x)$
–4	0
–3	
–2	
–1	$1 + \sqrt{3}$
0	3
1	

Communicate Your Answer

3. What are some of the characteristics of the graph of a square root function?

4. Graph each function. Then compare the graph to the graph of $f(x) = \sqrt{x}$.

a. $g(x) = \sqrt{x - 1}$ **b.** $g(x) = \sqrt{x} - 1$ **c.** $g(x) = 2\sqrt{x}$ **d.** $g(x) = -2\sqrt{x}$

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10.1 Notetaking with Vocabulary

For use after Lesson 10.1

In your own words, write the meaning of each vocabulary term.

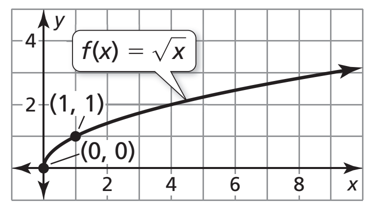
square root function

radical function

Core Concepts

Square Root Functions

A **square root function** is a function that contains a square root with the independent variable in the radicand. The parent function for the family of square root functions is $f(x) = \sqrt{x}$. The domain of f is $x \geq 0$, and the range of f is $y \geq 0$.



Notes:

Transformation	*f*(*x*) Notation	Examples	
Horizontal Translation Graph shifts left or right.	$f(x - h)$	$g(x) = \sqrt{x - 2}$ $g(x) = \sqrt{x + 3}$	**2 units right** **3 units left**
Vertical Translation Graph shifts up or down.	$f(x) + k$	$g(x) = \sqrt{x} + 7$ $g(x) = \sqrt{x} - 1$	**7 units up** **1 unit down**
Reflection Graph flips over x- or y-axis.	$f(-x)$ $-f(x)$	$g(x) = \sqrt{-x}$ $g(x) = -\sqrt{x}$	**in the y-axis** **in the x-axis**
Horizontal Stretch or Shrink Graph stretches away from or shrinks toward y-axis.	$f(ax)$	$g(x) = \sqrt{3x}$ $g(x) = \sqrt{\frac{1}{2}x}$	**shrink by a factor of $\frac{1}{3}$** **stretch by a factor of 2**
Vertical Stretch or Shrink Graph stretches away from or shrinks toward x-axis.	$a \bullet f(x)$	$g(x) = 4\sqrt{x}$ $g(x) = \frac{1}{5}\sqrt{x}$	**stretch by a factor of 4** **shrink by a factor of $\frac{1}{5}$**

Notes:

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Extra Practice

In Exercises 1–3, describe the domain of the function.

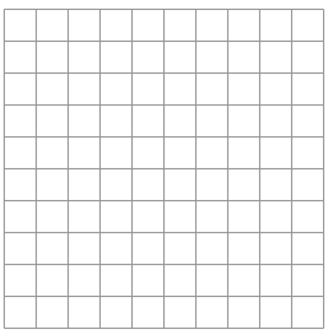
1. $y = 4\sqrt{-x}$

2. $y = \sqrt{x - 3}$

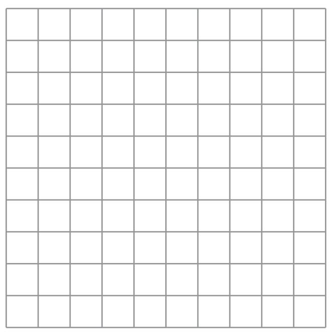
3. $f(x) = \sqrt{\frac{1}{3}x} + 4$

In Exercises 4–6, graph the function. Describe the range.

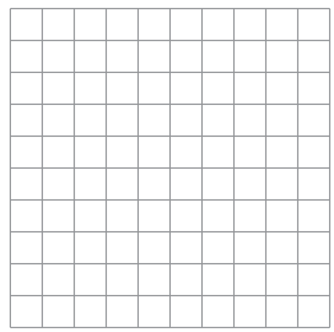
4. $y = \sqrt{3x}$



5. $y = 2\sqrt{-x}$

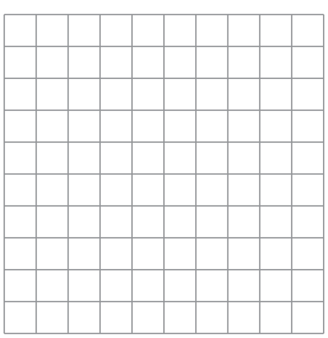


6. $g(x) = \sqrt{x + 3} - 1$

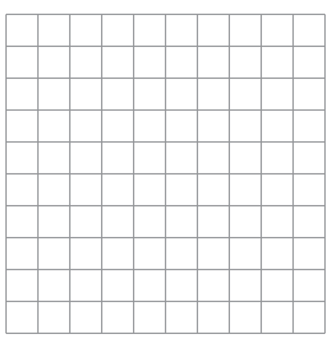


In Exercises 7–9, graph the function. Compare the graph to the graph of $f(x) = \sqrt{x}$.

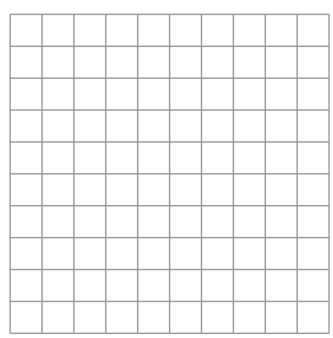
7. $r(x) = \sqrt{-\frac{1}{2}x}$



8. $s(x) = -\sqrt{x} - 2$



9. $t(x) = \sqrt{x + 4}$



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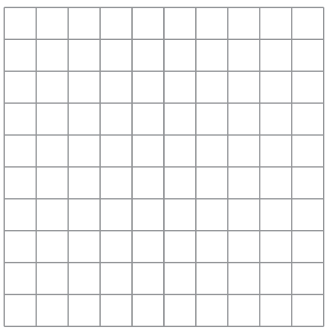
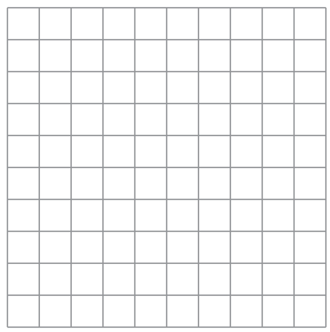
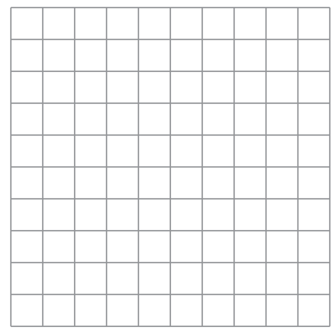
10.1 Notetaking with Vocabulary (continued)

In Exercises 10–12, describe the transformations from the graph of $f(x) = \sqrt{x}$ to the graph the of *h*. Then graph *h*.

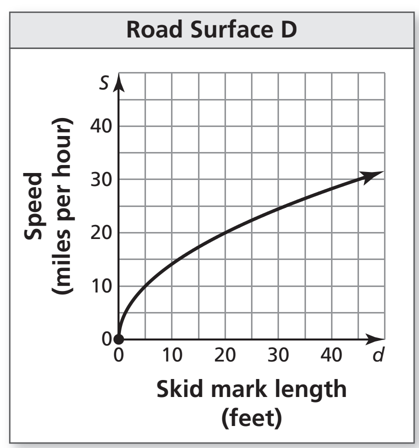
10. $h(x) = \frac{1}{2}\sqrt{x + 2} - 2$ **11.** $h(x) = 2\sqrt{x - 3} + 1$ **12.** $h(x) = -\sqrt{x + 4} - 4$







13. The model $S(d) = \sqrt{30df}$ represents the speed S (in miles per hour) of a car before it skids to a stop, where f is the drag factor of the road surface and d is the length (in feet) of the skid marks. The drag factor of Road Surface C is 0.8. The graph shows the speed of the car on Road Surface D. Compare the speeds by finding and interpreting their average rates of change over the interval $d = 0$ to $d = 20$.



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10.2 Graphing Cube Root Functions
For use with Exploration 10.2

Essential Question What are some of the characteristics of the graph of a cube root function?

1 EXPLORATION: Graphing Cube Root Functions

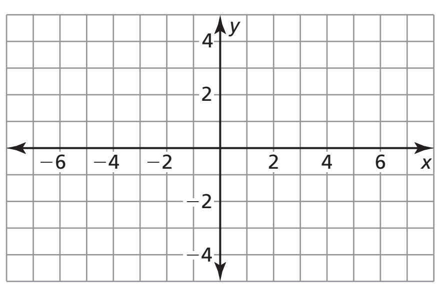
Work with a partner.

- Make a table of values for each function. Use positive and negative values of x.
- Use the table to sketch the graph of each function.
- Describe the domain of each function.
- Describe the range of each function.

a. $y = \sqrt[3]{x}$

x					
y					

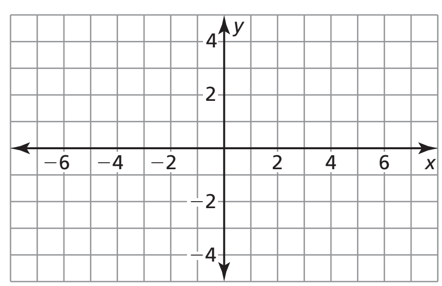
x					
y					



b. $y = \sqrt[3]{x + 3}$

x					
y					

x					
y					



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2 EXPLORATION: Writing Cube Root Functions

Work with a partner. Write a cube root function, $y = f(x)$, that has the given values. Then use the function to complete the table.

a.

x	*f*(*x*)
–4	0
–3	
–2	
–1	$\sqrt[3]{3}$
0	

x	*f*(*x*)
1	
2	
3	
4	2
5	

b.

x	*f*(*x*)
–4	1
–3	
–2	
–1	$1 + \sqrt[3]{3}$
0	

x	*f*(*x*)
1	
2	
3	
4	3
5	

Communicate Your Answer

3. What are some of the characteristics of the graph of a cube root function?

4. Graph each function. Then compare the graph to the graph of $f(x) = \sqrt[3]{x}$.

a. $g(x) = \sqrt[3]{x - 1}$ **b.** $g(x) = \sqrt[3]{x} - 1$ **c.** $g(x) = 2\sqrt[3]{x}$ **d.** $g(x) = -2\sqrt[3]{x}$

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10.2 Notetaking with Vocabulary

For use after Lesson 10.2

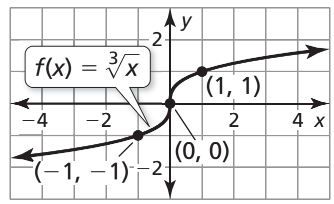
In your own words, write the meaning of each vocabulary term.

cube root function

Core Concepts

Cube Root Functions

A **cube root function** is a radical function with an index of 3. The parent function for the family of cube root functions is $f(x) = \sqrt[3]{x}$. The domain and range of f are all real numbers.



Notes:

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10.2 Notetaking with Vocabulary (continued)

Extra Practice

In Exercises 1–6, graph the function. Compare the graph to the graph of $f(x) = \sqrt[3]{x}$.

1. $h(x) = \sqrt[3]{x - 3}$

2. $g(x) = \sqrt[3]{x} + 2$

3. $j(x) = 4\sqrt[3]{x}$

4. $r(x) = -\sqrt[3]{x - 3}$

5. $s(x) = 2\sqrt[3]{x} - 1$

6. $t(x) = \sqrt[3]{-6x} - 2$

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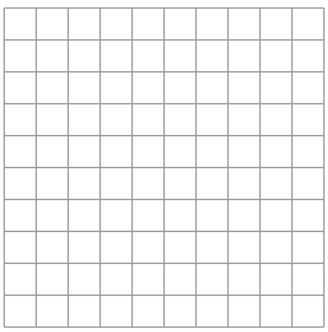
10.2 Notetaking with Vocabulary (continued)

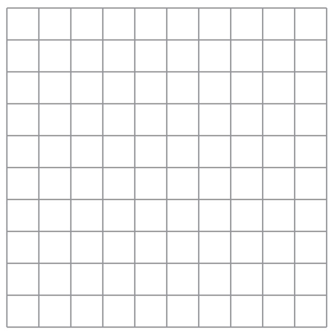
In Exercises 7–9, describe the transformations from the graph of $f(x) = \sqrt[3]{x}$ to the graph of the given function. Then graph the given function.

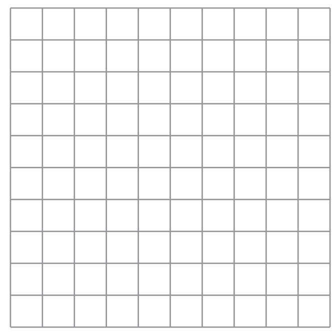
7. $p(x) = \sqrt[3]{x - 1} + 1$

8. $q(x) = -4\sqrt[3]{x + 2} + 3$

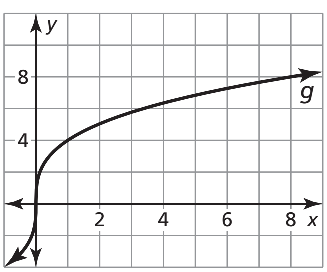
9. $r(x) = \frac{1}{2}\sqrt[3]{x + 1} + 4$







10. The graph of cube root function g is shown. Compare the average rate of change of g to the average rate of change of $h(x) = 2\sqrt[3]{x}$ over the interval $x = 0$ to $x = 8$.



11. The edge length s of a regular tetrahedron is approximately given by $s = \sqrt[3]{8.49V}$, where V is the volume of the tetrahedron. Use a graphing calculator to graph the function. Estimate the volume of a regular tetrahedron with an edge length of 24 inches.

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10.3 Solving Radical Equations
For use with Exploration 10.3

Essential Question How can you solve an equation that contains square roots?

1 EXPLORATION: Analyzing a Free-Falling Object

Go to *BigIdeasMath.com* for an interactive tool to investigate this exploration.

Work with a partner. The table shows the time t (in seconds) that it takes a free-falling object (with no air resistance) to fall d feet.

d (feet)	t (seconds)
0	0.00
32	1.41
64	2.00
96	2.45
128	2.83
160	3.16
192	3.46
224	3.74
256	4.00
288	4.24
320	4.47

a. Use the data in the table to sketch the graph of t as a function of d. Use the coordinate plane below.

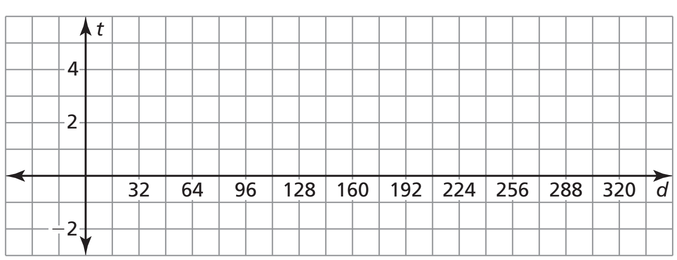
b. Use your graph to estimate the time it takes the object to fall 240 feet.

c. The relationship between d and t is given by the function

$$r = \sqrt{\frac{d}{16}}.$$

Use this function to check you estimate in part (b).

d. It takes 5 seconds for the object to hit the ground. How far did it fall? Explain your reasoning.



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2 EXPLORATION: Solving a Square Root Equation

Work with a partner. The speed s (in feet per second) of the free-falling object in Exploration 1 is given by the function

$$s = \sqrt{64d}.$$

Find the distance the object has fallen when it reaches each speed.

a. $s = 8$ ft/sec **b.** $s = 16$ ft/sec **c.** $s = 24$ ft/sec

Communicate Your Answer

3. How can you solve an equation that contains square roots?

4. Use your answer to Question 3 to solve each equation.

a. $5 = \sqrt{x + 20}$ **b.** $4 = \sqrt{x - 18}$

c. $\sqrt{x} + 2 = 3$ **d.** $-3 = -2\sqrt{x}$

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10.3 Notetaking with Vocabulary
For use after Lesson 10.3

In your own words, write the meaning of each vocabulary term.

radical equation

Core Concepts

Squaring Each Side of an Equation

Words If two expressions are equal, then their squares are also equal.

Algebra If $a = b$, then $a^2 = b^2$.

Notes:

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Extra Practice

In Exercises 1–21, solve the equation. Check your solution(s).

1. $\sqrt{x} = 4$

2. $8 = \sqrt{n} - 3$

3. $3\sqrt{a} - 15 = -6$

4. $\sqrt{s - 3} + 7 = 11$

5. $6\sqrt{t - 2} = 12$

6. $3\sqrt{3x - 6} + 2 = 20$

7. $\sqrt{d} = \sqrt{5d - 8}$

8. $\sqrt{3c - 2} = \sqrt{4c - 6}$

9. $\sqrt{4b - 4} = \sqrt{2b + 4}$

10. $\sqrt{z - 12} = \sqrt{\frac{z}{3} - 3}$

11. $\sqrt{\frac{2v}{3} + 10} = \sqrt{4v - 10}$

12. $\sqrt{3w + 1} - \sqrt{6w} = 0$

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10.3 Notetaking with Vocabulary (continued)

13. $5 = \sqrt[3]{x}$

14. $-3 = \sqrt[3]{x + 2}$

15. $\sqrt[3]{7m - 3} = \sqrt[3]{m + 9}$

16. $k + 6 = \sqrt{2k + 15}$

17. $\sqrt{-1 - 2b} = b$

18. $\sqrt{3p + 19} = p - 3$

19. $r - 1 = \sqrt{r + 5}$

20. $\sqrt{2x - 1} + 6 = 3$

21. $k - 1 = \sqrt{5k - 9}$

22. The period P (in seconds) of a pendulum is given by the function $P = 2\pi\sqrt{\frac{L}{32}}$, where L is the pendulum length (in feet). A pendulum has a period of 16 seconds. Is this pendulum 16 times as long as a pendulum with a period of 4 seconds? Explain your reasoning.

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10.4 Inverse of a Function

For use with Exploration 10.4

Essential Question How are a function and its inverse related?

1 EXPLORATION: Exploring Inverse Functions

Work with a partner. The functions *f* and *g* are *inverses* of each other. Compare the tables of values of the two functions. How are the functions related?

x	0	0.5	1	1.5	2	2.5	3	3.5
$f(x)$	0	0.25	1	2.25	4	6.25	9	12.25

x	0	0.25	1	2.25	4	6.25	9	12.25
$g(x)$	0	0.5	1	1.5	2	2.5	3	3.5

2 EXPLORATION: Exploring Inverse Functions

Go to *BigIdeasMath.com* for an interactive tool to investigate this exploration.

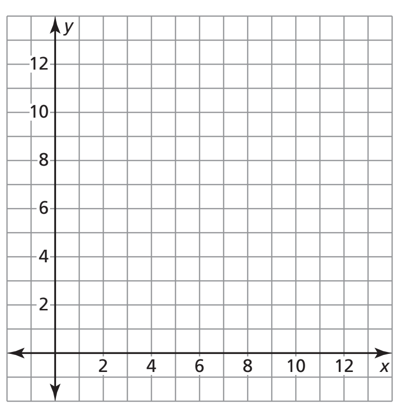
Work with a partner.

a. Plot the two sets of points represented by the tables in Exploration 1. Use the coordinate plane below.

b. Connect each set of points with a smooth curve.

c. Describe the relationship between the two graphs.

d. Write an equation for each function.



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Communicate Your Answer

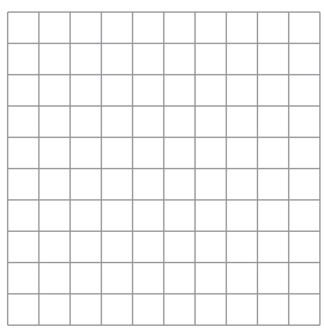
3. How are a function and its inverse related?

4. A table of values for a function *f* is given. Create a table of values for a function *g*, the inverse of *f*.

x	0	1	2	3	4	5	6	7
***f*(*x*)**	1	2	3	4	5	6	7	8

x								
***g*(*x*)**								

5. Sketch the graphs of $f(x) = x + 4$ and its inverse in the same coordinate plane. Then write an equation of the inverse of *f*. Explain your reasoning.



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10.4 Notetaking with Vocabulary

For use after Lesson 10.4

In your own words, write the meaning of each vocabulary term.

inverse relation

inverse function

Core Concepts

Inverse Relation

When a relation contains (a, b), the inverse relation contains (b, a).

Notes:

Finding Inverses of Functions Algebraically

Step 1 Set y equal to $f(x)$.

Step 2 Switch x and y in the equation.

Step 3 Solve the equation for y.

Notes:

Horizontal Line Test

The inverse of a function f is also a function if and only if no horizontal line intersects the graph of f more than once.

Notes:

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10.4 Notetaking with Vocabulary (continued)

Extra Practice

In Exercises 1 and 2, find the inverse of the relation.

1. $(1, -1), (2, 5), (4, -2), (6, 8), (8, 9)$

2.

Input	-3	-1	0	1	3
Output	4	2	2	5	3

Input					
Output					

In Exercises 3–5, solve $y = f(x)$ for x. Then find the input when the output is 3.

3. $f(x) = x + 3$

4. $f(x) = 3x - 2$

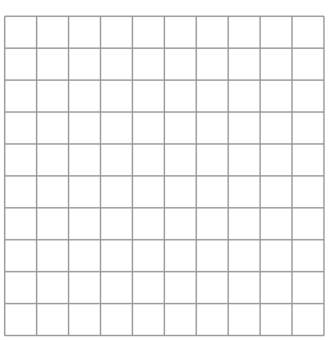
5. $f(x) = 4x^2$

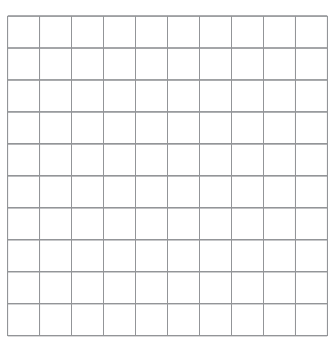
In Exercises 6–11, find the inverse of the function. Then graph the function and its inverse.

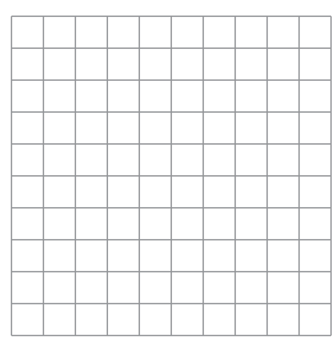
6. $f(x) = 3x - 1$

7. $f(x) = -3x + 2$

8. $f(x) = \frac{1}{2}x + 2$







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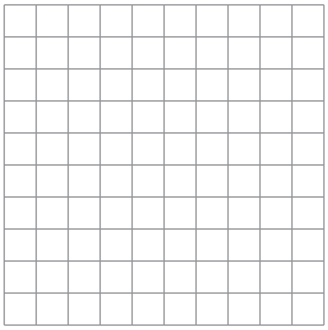
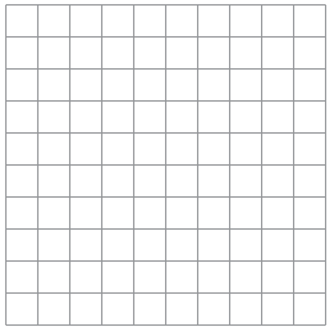
10.4 Notetaking with Vocabulary (continued)

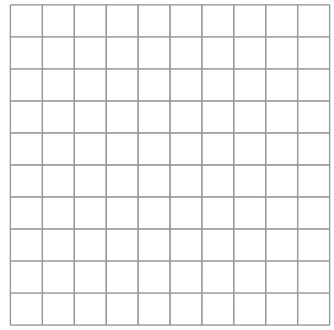
9. $f(x) = 2x^2, x \geq 0$



10. $f(x) = -x^2 + 5, x \leq 0$



11. $f(x) = 16x^2 + 3, x \geq 0$



In Exercises 12–17, determine whether the inverse of *f* is a function. Then find the inverse.

12. $f(x) = \sqrt{x + 4}$

13. $f(x) = \sqrt{3x - 9}$

14. $f(x) = 2\sqrt{x - 4}$

15. $f(x) = 3x^2$

16. $f(x) = 5x^2 - 1$

17. $f(x) = -\sqrt{2x + 3} - 5$

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