5.3 Graphing Square Root Functions

Learning Target: Graph and describe square root functions.

Success Criteria:
- I can graph square root functions and describe the characteristics.
- I can graph and describe transformations of square root functions.
- I can use square root functions to solve real-life problems.

EXPLORE IT! Graphing Square Root Functions

4 MTR CONSTRUCT AN ARGUMENT

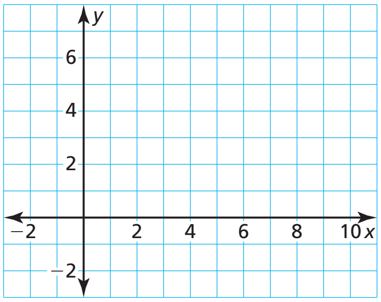
The expression $\sqrt{x}$ must be positive. Does this imply that the functions in part (b) do not have negative values? Explain.

Work with a partner.

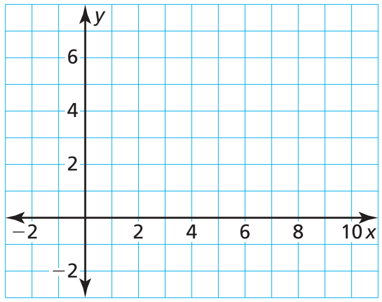
a. Graph $f(x) = \sqrt{x}$. Find the domain and range of the function. Then make several observations about the graph.

b. Describe what you expect the graph of g to look like. Then sketch the graph of g and find the domain and range of the function.

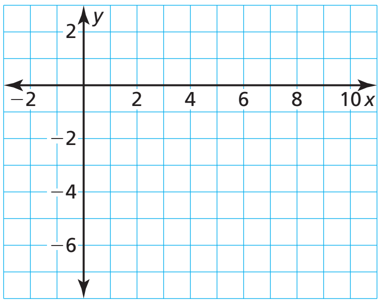
i. $g(x) = 2\sqrt{x}$



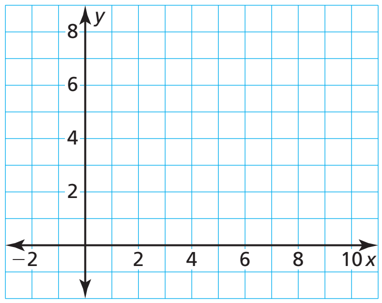
ii. $g(x) = \sqrt{x} - 2$



iii. $g(x) = -\sqrt{x}$



iv. $g(x) = \sqrt{x + 2}$



c. Without graphing, compare the graph of $g(x) = -\sqrt{x} - 3$ to the graph of $f(x) = \sqrt{x}$. Explain your reasoning.

d. How are graphs of square root functions similar to graphs of other types of functions you have studied in this course? How are they different?

Algebraic Reasoning

MA.912.AR.7.2 Given a table, equation or written description of a square root or cube root function, graph that function and determine its key features.

Functions

MA.912.F.2.2 Identify the effect on the graph of a given function of two or more transformations defined by adding a real number to the x- or y-values or multiplying the x- or y-values by a real number.

Also MA.912.AR.7.3, MA.912.F.2.3, MA.912.F.2.5

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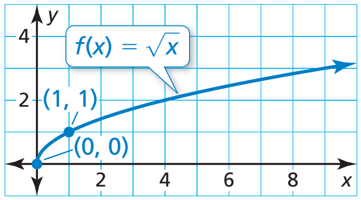
Describing and Graphing Square Root Functions

Vocabulary
square root function, *p. 256*
radical function, *p. 257*

KEY IDEA

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 $x \geq 0$, the range of f is $y \geq 0$, and the function increases over its entire domain.



The value of the radicand in a square root function cannot be negative. So, the domain of a square root function includes x-values for which the radicand is greater than or equal to 0.

EXAMPLE 1 Describing Characteristics

Graph $f(x) = \sqrt{x} - 2$. Determine when the function is positive, negative, increasing, or decreasing. Then describe the end behavior of the function.

SOLUTION

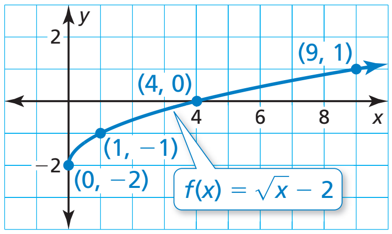
Step 1 Use the domain to make a table of values.

Because the radicand cannot be negative, the domain of f is $x \geq 0$.

x	0	1	4	9
$f(x)$	−2	−1	0	1

Step 2 Plot the ordered pairs.

Step 3 Draw a smooth curve through the points, starting at $(0, -2)$.



Positive and Negative: The x-intercept is 4. The function is negative over the interval $[0, 4)$ and positive over the interval $(4, \infty)$.

Increasing and Decreasing: The function increases over its entire domain, $x \geq 0$.

End Behavior: The function has a domain of $x \geq 0$, with a minimum value of -2 when $x = 0$. From the graph, you can see that $y \to +\infty$ as $x \to +\infty$.

1 MTR HELP A CLASSMATE
Help a classmate understand how you can use the domain and the end behavior of a radical function to find the range.

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.

1. **VOCABULARY** Is $y = 2x\sqrt{5}$ a square root function? Explain.
2. **REASONING** Can the domain of a square root function include negative numbers? Explain your reasoning.

Graph the function. Determine when the function is positive, negative, increasing, or decreasing. Then describe the end behavior of the function.

3. $h(x) = \sqrt{-x + 1}$
4. $g(x) = \sqrt{x} - 4$
5. $y = \sqrt{x + 5}$

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A **radical function** is a function that contains a radical expression with the independent variable in the radicand. A square root function is a radical function.

You can transform graphs of radical functions in the same way you transformed graphs of functions previously. In Example 1, notice that the graph of f is a vertical translation of the graph of the parent square root function.

KEY IDEAS

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 a line.	$f(-x)$ $-f(x)$	$g(x)=\sqrt{-x}$ $g(x)=-\sqrt{x}$	in the y-axis in the x-axis
Horizontal Stretch or Shrink Graph stretches away from or shrinks toward y-axis by a factor of $\frac{1}{a}$.	$f(ax)$	$g(x)=\sqrt{3x}$ $g(x)=\sqrt{\frac{1}{2}x}$	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 by a factor of a.	$a \bullet f(x)$	$g(x)=4\sqrt{x}$ $g(x)=\frac{1}{5}\sqrt{x}$	stretch by a factor of 4 shrink by a factor of $\frac{1}{5}$

EXAMPLE 2 Comparing Graphs of Square Root Functions

WATCH

Graph $g(x) = -\sqrt{x-2}$. Compare the graph to the graph of $f(x) = \sqrt{x}$.

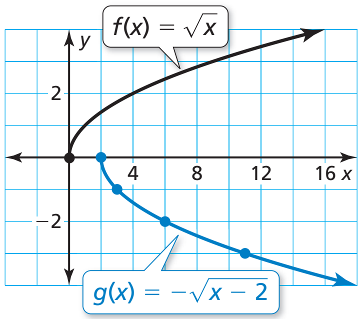
SOLUTION

Step 1 Use the domain of g, $x \geq 2$, to make a table of values.

x	2	3	6	11
$g(x)$	0	−1	−2	−3

Step 2 Plot the ordered pairs.

Step 3 Draw a smooth curve through the points, starting at (2, 0).



▶ The graph of g is a translation 2 units right and a reflection in the x-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.

Graph the function. Compare the graph to the graph of $f(x) = \sqrt{x}$.

6. $h(x) = \sqrt{\frac{1}{4}x}$

7. $g(x) = \sqrt{x} - 6$

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

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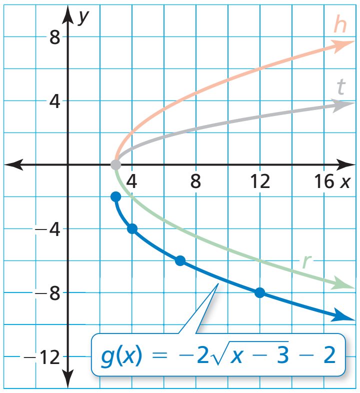
EXAMPLE 3 Graphing $y = a\sqrt{x - h} + k$

WATCH

Graph $g(x) = -2\sqrt{x - 3} - 2$. Describe the transformations from the graph of $f(x) = \sqrt{x}$ to the graph of g.

SOLUTION



Notice that you can rewrite g as $g(x) = -2f(x - 3) - 2$.

Step 1 Translate the graph of f horizontally 3 units right to get the graph of $t(x) = \sqrt{x - 3}$.

Step 2 Stretch the graph of t vertically by a factor of 2 to get the graph of $h(x) = 2\sqrt{x - 3}$.

Step 3 Reflect the graph of h in the x-axis to get the graph of $r(x) = -2\sqrt{x - 3}$.

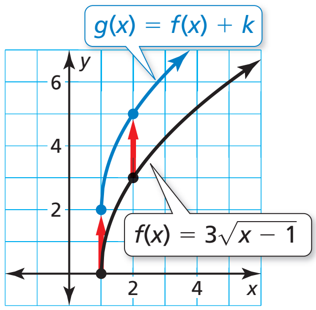
Step 4 Translate the graph of r vertically 2 units down to get the graph of $g(x) = -2\sqrt{x - 3} - 2$.

▶ The graph of g is a horizontal translation 3 units right, a vertical stretch by a factor of 2, a reflection in the x-axis, and a translation 2 units down of the graph of f.

EXAMPLE 4 Describing a Transformation

WATCH

Describe the transformation from the graph of f to the graph of g.



SOLUTION

The function $g(x) = f(x) + k$ indicates that the graph of g is a vertical translation of the graph of f. The graphs of f and g show that for any input, $g(x) = f(x) + 2$. For example, $g(1) = 2$ and $f(1) = 0$. So, $g(x) = f(x) + 2$ and $k = 2$.

▶ The graph of g is a translation 2 units up of the graph of f.

SELF-ASSESSMENT

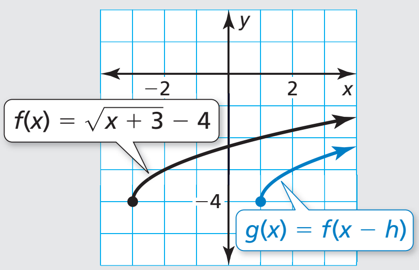
1 I don't understand yet. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

9. Graph $g(x) = \frac{1}{2}\sqrt{x + 4} + 1$. Describe the transformations from the graph of $f(x) = \sqrt{x}$ to the graph of g.

10. REASONING What is the domain of a function of the form $f(x) = a\sqrt{x - h} + k$? At what point does the graph of a function of this form start?

Describe the transformation from the graph of f to the graph of g.

11.



12.

x	0	1	4	9	16
$f(x)$	2	4	6	8	10
$g(x) = a \cdot f(x)$	1	2	3	4	5

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EXAMPLE 5 Representing a Transformation

The table of values represents a square root function. The graph of g is a reflection in the x-axis of the graph of f. Create a table of values for g.

x	−2	−1	2	7	14
$f(x)$	−1	1	3	5	7

SOLUTION

Because the graph of g is a reflection in the x-axis of the graph of f, $g(x) = -f(x)$. So, multiply the outputs of f by -1.

x	−2	−1	2	7	14
$f(x)$	−1	1	3	5	7
$g(x) = -f(x)$	1	−1	−3	−5	−7

$\times(-1)$

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.

The table of values represents a square root function. Create a table of values for *g*.

13. The graph of g is a translation 8 units down to the graph of f.

x	−12	−5	0	3	4
$f(x)$	6	5	4	3	2

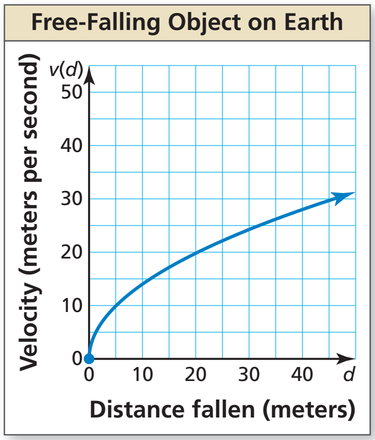
14. The graph of g is a vertical shrink by a factor of $\frac{1}{2}$ of the graph of f.

x	0	2	8	18	32
$f(x)$	2	0	−2	−4	−6

Comparing Average Rates of Change

EXAMPLE 6 Comparing Square Root Functions

The velocity (in meters per second) of an object after free-falling d meters on Earth is different from its velocity after free-falling d meters on the moon. Compare the velocities using their average rates of change over the interval [0, 10].



SOLUTION

To calculate the average rates of change, use points whose d-coordinates are 0 and 10.

Earth: Use the graph to estimate. Use (0, 0) and (10, 14).

$$\frac{v(10) - v(0)}{10 - 0} \approx \frac{14 - 0}{10} = \frac{1.4 \text{ m/sec}}{\text{m}}$$ Average rate of change on Earth

Moon: Find $v(d)$ when $d = 0$ and $d = 10$.

$$v(0) = \sqrt{3.2(0)} = 0 \quad \text{and} \quad v(10) = \sqrt{3.2(10)} = \sqrt{32}$$

Use (0, 0) and $(10, \sqrt{32})$.

$$\frac{v(10) - v(0)}{10 - 0} = \frac{\sqrt{32} - 0}{10} \approx \frac{0.57 \text{ m/sec}}{\text{m}}$$ Average rate of change on the moon

▶ Because 1.4 > 0.57, the velocity of an object free-falling from 0 to 10 meters increases at a greater average rate on Earth than on the moon.

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EXAMPLE 7 Modeling Real Life

7 MTR

WATCH STEM

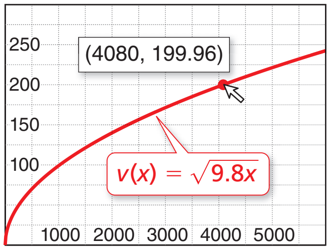
The velocity (in meters per second) of a tsunami can be modeled by the function $v(x) = \sqrt{9.8x}$, where x is the water depth (in meters).

a. At what depth is the velocity of the tsunami about 200 meters per second?

b. What happens to the average rate of change of the velocity as the water depth increases?

SOLUTION

1. **Understand the Problem** You are given a model that represents the velocity of a tsunami as a function of water depth. You are asked to find the depth for a given velocity and to describe the average rate of change of the velocity as the water depth increases.
2. **Make a Plan** Use technology to graph the function and find where $v(x) \approx 200$. Then calculate and compare average rates of change of the velocity over different intervals.
3. **Solve and Check**



a. Use technology to graph the function. Find the value of x for which $v(x) \approx 200$.

▶ The velocity is about 200 meters per second at a depth of about 4080 meters.

b. Calculate the average rates of change over the intervals [0, 1000], [1000, 2000], and [2000, 3000].

$$\frac{v(1000) - v(0)}{1000 - 0} = \frac{\sqrt{9800} - 0}{1000} \approx 0.099 \qquad \text{0 to 1000 meters}$$

$$\frac{v(2000) - v(1000)}{2000 - 1000} = \frac{\sqrt{19{,}600} - \sqrt{9800}}{1000} \approx 0.041 \qquad \text{1000 to 2000 meters}$$

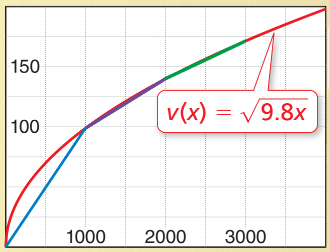
$$\frac{v(3000) - v(2000)}{3000 - 2000} = \frac{\sqrt{29{,}400} - \sqrt{19{,}600}}{1000} \approx 0.031 \qquad \text{2000 to 3000 meters}$$

▶ The average rate of change of the velocity decreases as the water depth increases.

Check To check the answer in part (a), find $v(x)$ when $x = 4080$.

$$v(4080) = \sqrt{9.8(4080)} \approx 200 \checkmark$$

In part (b), the slopes of the line segments that represent the average rates of change over the intervals are decreasing. So, the answer to part (b) is reasonable.



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.

15. In Example 6, compare the velocities using their average rates of change over the interval [30, 40].

16. **WHAT IF?** In Example 7(a), at what depth is the velocity of the tsunami about 100 meters per second? Does your answer in part (b) change when you compare the velocities using their average rates of change over the intervals [0, 2000], [2000, 4000], and [4000, 6000]?

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5.3 Practice WITH CalcChat® AND CalcView®

In Exercises 1–10, graph the function. Determine when the function is positive, negative, increasing, or decreasing. Then describe the end behavior of the function. *(See Example 1.)*

1. $y = 8\sqrt{x}$
2. $y = \sqrt{4x}$
3. $y = 4 + \sqrt{-x}$
4. $y = \sqrt{-\frac{1}{2}x} + 1$
5. $h(x) = \sqrt{x - 4}$
6. $p(x) = \sqrt{x + 7}$
7. $f(x) = \sqrt{-x + 8}$
8. $g(x) = \sqrt{-x - 1}$
9. $m(x) = 2\sqrt{x + 4}$
10. $n(x) = \frac{1}{2}\sqrt{-x - 2}$

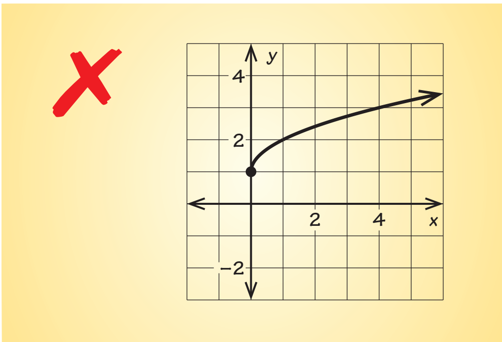
In Exercises 11–18, graph the function. Compare the graph to the graph of $f(x) = \sqrt{x}$. *(See Example 2.)*

11. $g(x) = \frac{1}{4}\sqrt{x}$
12. $r(x) = \sqrt{2x}$
13. $h(x) = \sqrt{x + 3}$
14. $q(x) = \sqrt{x} + 8$
15. $p(x) = \sqrt{-\frac{1}{3}x}$
16. $g(x) = -5\sqrt{x}$
17. $m(x) = -\sqrt{x} - 6$
18. $n(x) = -\sqrt{x - 4}$

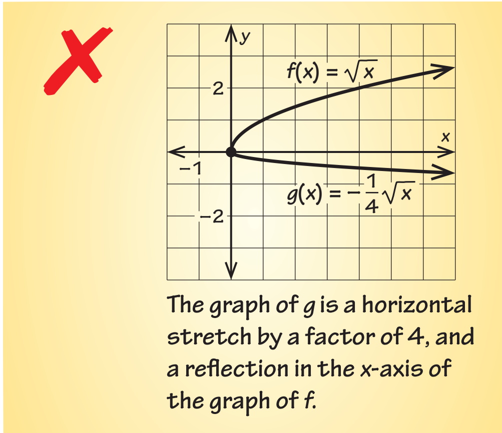
In Exercises 19–26, graph h. Describe the transformations from the graph of $f(x) = \sqrt{x}$ to the graph of h. *(See Example 3.)*

19. $h(x) = 4\sqrt{x + 2} - 1$
20. $h(x) = \frac{1}{2}\sqrt{x - 6} + 3$
21. $h(x) = 2\sqrt{-x} - 6$
22. $h(x) = -\sqrt{x - 3} - 2$
23. $h(x) = \frac{1}{3}\sqrt{x + 3} - 3$
24. $h(x) = 2\sqrt{x - 1} + 4$
25. $h(x) = -2\sqrt{x - 1} + 5$
26. $h(x) = -5\sqrt{x + 2} - 1$

27. **ERROR ANALYSIS** Describe and correct the error in graphing the function $y = \sqrt{x} + 1$.



28. **ERROR ANALYSIS** Describe and correct the error in comparing the graph of $g(x) = -\frac{1}{4}\sqrt{x}$ to the graph of $f(x) = \sqrt{x}$.



29. **REASONING** Is the graph of $g(x) = 1.25\sqrt{x}$ a vertical stretch or a vertical shrink of the graph of $f(x) = \sqrt{x}$? Explain.

30. **REASONING** Without graphing, determine which function's graph increases at a greater rate, $f(x) = 5\sqrt{x}$ or $g(x) = \sqrt{5x}$. Explain your reasoning.

31. **REASONING** Consider a function of the form $f(x) = a\sqrt{x - h} + k$. Describe when the function is increasing or decreasing when (a) $a > 0$ and (b) $a < 0$.

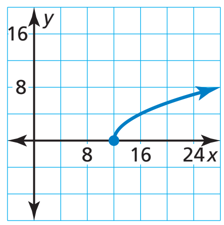
32. **COLLEGE PREP** The graph of which function is shown?

(A) $y = \sqrt{x - 12}$

(B) $y = \sqrt{x} - 12$

(C) $y = \sqrt{x + 12}$

(D) $y = \sqrt{-x + 12}$



In Exercises 33–36, write a rule for g described by the transformations of the graph of f.

33. Let the graph of g be a reflection in the x-axis of the graph of $f(x) = \sqrt{x - 5}$.

34. Let the graph of g be a translation 4 units down of the graph of $f(x) = \sqrt{x} + 7$.

35. Let g be a vertical stretch by a factor of 2, followed by a translation 2 units up of the graph of $f(x) = \sqrt{x} + 3$.

36. Let g be a horizontal shrink by a factor of $\frac{2}{3}$, followed by a translation 4 units left of the graph of $f(x) = \sqrt{6x}$.

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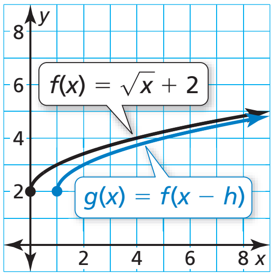
In Exercises 37–44, describe the transformation from the graph of *f* to the graph of *g*. *(See Example 4.)*

37.



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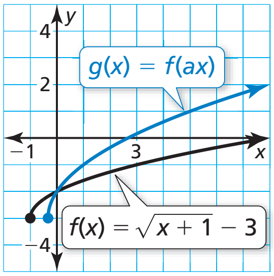


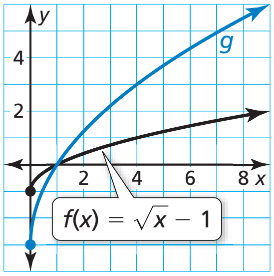
39.

x	−25	−16	−9	−4	−1
f(x)	11	9	7	5	3
g(x) = a • f(x)	22	18	14	10	6

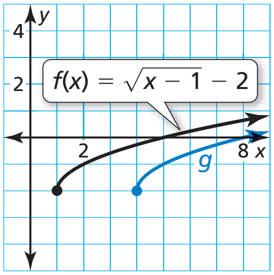
40.

x	0	1	4	9	16
f(x)	4	3	2	1	0
g(x) = f(x) + k	12	11	10	9	8

41.



42.



43.

x	2	3	6	11	18
f(x)	0	3	6	9	12
g(x)	−5	−2	1	4	7

44.

x	−3	−2	1	6	13
f(x)	−8	−4	0	4	8
g(x)	−2	−1	0	1	2

In Exercises 45 and 46, the table of values represents a square root function. Create a table of values for *g*. *(See Example 5.)*

45. The graph of g is a translation 4 units up of the graph of f.

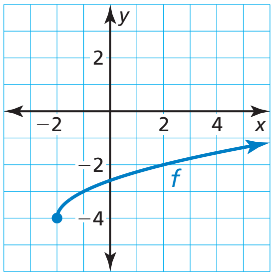
x	−5	−4	−1	4	11
f(x)	−1	0	1	2	3

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

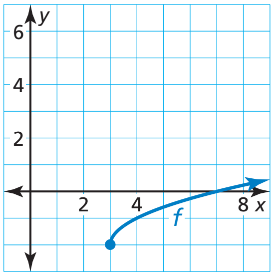
x	1	2	5	10	17
f(x)	−7	−3	1	5	9

In Exercises 47 and 48, graph *g*.

47. The graph of g is a translation 3 units left of the graph of f.



48. The graph of g is a vertical stretch by a factor of 3 of the graph of f.



In Exercises 49–52, describe the transformation of *f* represented by *g*. Then graph each function.

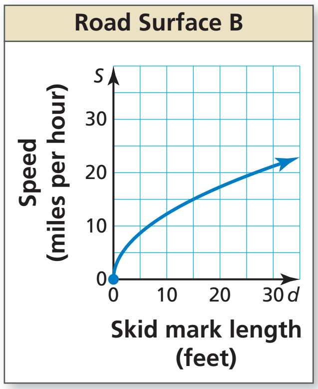
49. $f(x) = 2\sqrt{x}$, $g(x) = f(x + 3)$

50. $f(x) = \frac{1}{3}\sqrt{x - 1}$, $g(x) = -f(x) + 9$

51. $f(x) = \sqrt{x + 4} - 2$, $g(x) = f\left(\frac{1}{2}x\right) - 5$

52. $f(x) = 3\sqrt{x} + 6$, $g(x) = 4f(x - 1) + 2$

53. COMPARING FUNCTIONS The model $S(d) = \sqrt{30df}$ represents the speed (in miles per hour) of a van 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 A is 0.75. The graph shows the speed of the van on Road Surface B. Compare the speeds using their average rates of change over the interval [0, 15]. *(See Example 6.)*



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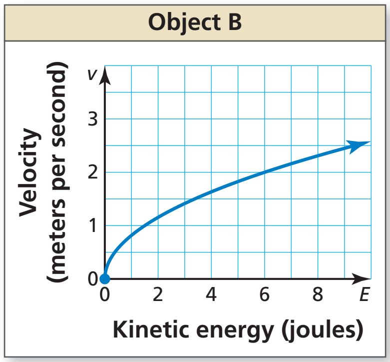
54. COMPARING FUNCTIONS The velocity (in meters per second) of an object in motion is given by $v(E) = \sqrt{\frac{2E}{m}}$, where E is the kinetic energy of the object (in joules) and m is the mass of the object (in kilograms). The mass of Object A is 4 kilograms. The graph shows the velocity of Object B. Compare the velocities of the objects using their average rates of change over the interval [0, 6].



55. MODELING REAL LIFE The nozzle pressure of a fire hose allows firefighters to control the amount of water they spray on a fire. The flow rate f (in gallons per minute) can be modeled by the function $f = 120\sqrt{p}$, where p is the nozzle pressure (in pounds per square inch). *(See Example 7.)*

a. Use technology to graph the function. At what pressure is the flow rate about 300 gallons per minute?

b. What happens to the average rate of change of the flow rate as the pressure increases?

56. MODELING REAL LIFE The speed s (in meters per second) of a long jumper before jumping can be modeled by the function $s = 10.9\sqrt{h}$, where h is the maximum height (in meters from the ground) reached by the jumper.

a. Use technology to graph the function. Estimate the maximum height reached by a jumper running 9.2 meters per second.

b. Suppose the runway and pit are raised on a platform slightly higher than the ground. How would the graph of the function be transformed?

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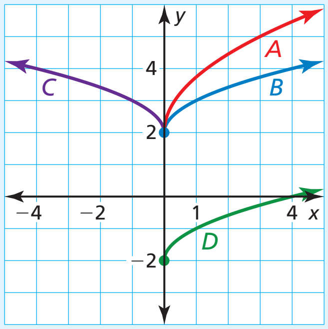
57. MAKING AN ARGUMENT Can a square root function have a minimum value? a maximum value? both? Explain your reasoning.

58. HOW DO YOU SEE IT?
Match each function with its graph. Explain your reasoning.

i. $f(x) = \sqrt{x} + 2$ **ii.** $m(x) = f(x) - 4$

iii. $n(x) = f(-x)$ **iv.** $p(x) = f(3x)$



59. JUSTIFYING STEPS The graph of g is a horizontal translation 2 units left and a reflection in the x-axis of the graph of f. Estimate $g(-2)$. Explain your reasoning.

x	−2	−1	2	7	14
$f(x)$	−2	−1	0	1	2

60. PERFORMANCE TASK When administering medication, it is critical for doctors to prescribe the correct dosage, especially for children. Body surface area (BSA) can be used to calculate appropriate dosages. Mosteller's Formula, shown below, estimates a person's body surface area (in square meters), where H is the height (in centimeters), and W is the weight (in kilograms) of the person. Use the heights and weights of at least two different children between the ages of 6 and 12 to calculate the correct dosage of each medication in the table. Research these medications and write a prescription for each child that includes how the medication should be administered, how often, and for how many days.

Mosteller's Formula: $BSA = \sqrt{\frac{H \cdot W}{3600}}$

Medication	Recommended daily dose
Mitoxantrone	18 mg/m^2
Cytarabine	100 mg/m^2
Cyclophosphamide	600 mg/m^2

61. REASONING The function below represents the cost C (in dollars) to hire a dog groomer, where x is the dog's weight (in pounds). Graph the function. Interpret the domain and range in this context. How much does the groomer charge when a dog weighs 200 pounds?

$$C(x) = \begin{cases} 40, & \text{if } 0 < x < 20 \\ x + 20, & \text{if } 20 \le x < 100 \\ 4\sqrt{x - 100} + 120, & \text{if } x \ge 100 \end{cases}$$

62. THOUGHT PROVOKING
Use a graphical approach to find the solutions of $x - 1 = \sqrt{5x - 9}$. Show your work. Verify your solutions algebraically.

REVIEW & REFRESH

WATCH

In Exercises 63–66, evaluate the expression.

63. $\sqrt[3]{343}$

64. $\sqrt[3]{-64}$

65. $-\sqrt[3]{-\frac{1}{27}}$

66. $\sqrt[3]{\frac{8}{125}}$

7 MTR **67. MODELING REAL LIFE** The table shows your daily usage time x (in minutes) and your cell phone's remaining battery percentage y.

x	24	40	55	67	79	92	107
y	88	83	80	76	68	63	54

a. Write a linear equation that models the battery percentage as a function of the usage time.

b. Interpret the slope and y-intercept of the line of fit.

In Exercises 68–70, factor the polynomial.

68. $x^2 + 7x + 6$

69. $d^2 - 11d + 28$

70. $y^2 - 3y - 40$

In Exercises 71–74, simplify the expression.

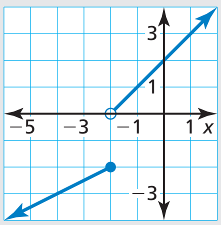
71. $\sqrt{108n^5}$

72. $6\sqrt{3} - \sqrt{7} + 8\sqrt{3}$

73. $\sqrt[3]{\frac{c}{-1000}}$

74. $\frac{20}{\sqrt{2} + \sqrt{6}}$

75. Write a piecewise function represented by the graph.



In Exercises 76–79, write the expression in simplest form. Assume all variables are positive.

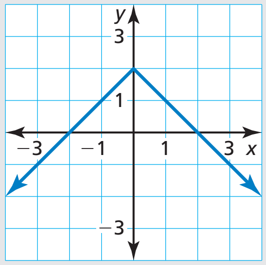
76. $\sqrt[3]{216p^9}$

77. $\frac{\sqrt[5]{32}}{\sqrt[5]{m^3}}$

78. $\sqrt[4]{n^4q} + 7n\sqrt[4]{q}$

79. $\frac{21ab^{3/2}}{3a^{1/3}b^{1/2}c^{-1/4}}$

80. Does the graph represent a *linear* or *nonlinear* function? Explain.



In Exercises 81 and 82, solve the equation using any method. Explain your choice of method.

81. $x^2 + 6x = 27$

82. $2x^2 - 11x + 13 = 0$

83. Graph $g(x) = \sqrt{x - 8} + 4$. Compare the graph to the graph of $f(x) = \sqrt{x}$.

84. OPEN-ENDED Write a quadratic function whose graph has a vertex of (1, 2).

85. Write the sentence as an inequality. Graph the inequality.

A number z is no less than 4 and fewer than 10.

In Exercises 86–89, solve the equation.

86. $|3x + 2| = 5$

87. $|4x + 9| = -7$

88. $|x - 9| = 2x$

89. $|x + 8| = |2x + 2|$

90. Use finite differences to determine the degree of the polynomial function that fits the data. Then use technology to find the polynomial function.

x	−3	−2	−1	0	1	2
$f(x)$	−7	−3	−2	−1	3	13

91. Evaluate $10^{2/3}$ using technology. Round your answer to two decimal places.

92. Graph $f(x) = -2\sqrt{x + 3}$. Determine when the function is positive, negative, increasing, or decreasing. Then describe the end behavior of the function.

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