

10-5

Graphing Square Root Functions

Content Standards

F.IF.7.b Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.

Also **A.CED.2**

Objectives To graph square root functions
To translate graphs of square root functions



Look at your graph. How is it similar to and different from a parabola?



MATHEMATICAL PRACTICES




Dynamic Activity

Square Root Functions




Lesson Vocabulary

- square root function




SOLVE IT!

Getting Ready!



A landscaper is planning to build a square yard with a wall on one side. The size of the yard will determine the project's cost. Graph the length of the wall as a function of the area of the yard. What is an equation of this graph? Explain your reasoning.



The Solve It involves a *square root function*. Square root functions are examples of radical functions.

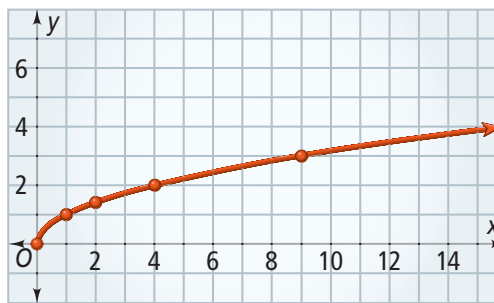
Take note

Key Concept Square Root Functions

A **square root function** is a function containing a square root with the independent variable in the radicand. The parent square root function is $y = \sqrt{x}$.

The table and graph below show the parent square root function.

x	y
0	0
1	1
2	1.4
4	2
9	3



Essential Understanding You can graph a square root function by plotting points or using a translation of the parent square root function.

For real numbers, the value of the radicand cannot be negative. So the domain of a square root function is limited to values of x for which the radicand is greater than or equal to 0.

Problem 1 Finding the Domain of a Square Root Function

What is the domain of the function $y = 2\sqrt{3x - 9}$?

Think

The radicand cannot be negative.

Solve for x .

Write

$$3x - 9 \geq 0$$

$$3x \geq 9$$

$$x \geq 3$$

The domain of the function is the set of real numbers greater than or equal to 3.

Got It? 1. What is the domain of $y = \sqrt{-2x + 5}$?

Problem 2 Graphing a Square Root Function STEM

Engineering Graph the function $I = \frac{1}{5}\sqrt{P}$, which gives the current I in amperes for a certain circuit with P watts of power. When will the current exceed 2 amperes?

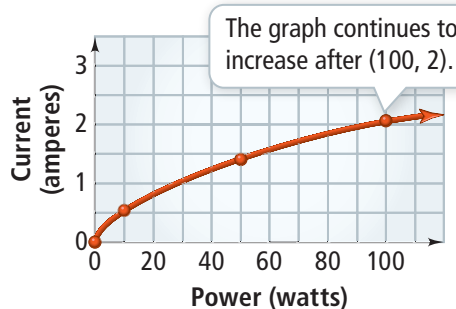
Step 1 Make a table.

Current in Circuit

Power (watts)	Current (amperes)
0	0
10	0.6
50	1.4
100	2

Step 2 Plot the points on a graph.

Current in Circuit



The current will exceed 2 amperes when the power is more than 100 watts.

Got It? 2. a. When will the current in Problem 2 exceed 1.5 amperes?
 b. **Reasoning** By how many times must you increase the power to double the current?

Plan

How can you solve this problem?
 Make a chart of ordered pairs that satisfy the equation. Then plot the ordered pairs on a graph.

For any positive number k , graphing $y = \sqrt{x} + k$ translates the graph of $y = \sqrt{x}$ up k units. Graphing $y = \sqrt{x} - k$ translates the graph of $y = \sqrt{x}$ down k units.

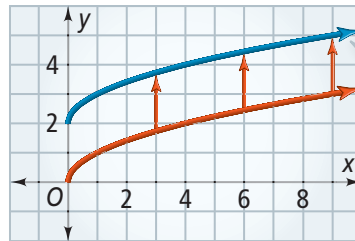
Think

Is this similar to a problem you've seen before?

Yes. You have graphed functions of the form $y = |x| + k$ by translating the graph of $y = |x|$.

Problem 3 Graphing a Vertical Translation

What is the graph of $y = \sqrt{x} + 2$?



For the graph of $y = \sqrt{x} + 2$, the graph of $y = \sqrt{x}$ is shifted 2 units up.

Got It? 3. What is the graph of $y = \sqrt{x} - 3$?

For any positive number h , graphing $y = \sqrt{x+h}$ translates the graph of $y = \sqrt{x}$ to the left h units. Graphing $y = \sqrt{x-h}$ translates the graph of $y = \sqrt{x}$ to the right h units.

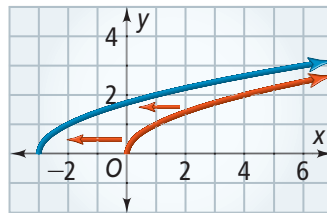
Think

Is there another way to solve this problem?

Yes. You could make a table of ordered pairs that satisfy the equation and then plot them.

Problem 4 Graphing a Horizontal Translation

What is the graph of $y = \sqrt{x+3}$?



For the graph of $y = \sqrt{x+3}$, the graph of $y = \sqrt{x}$ is shifted 3 units to the left.

Got It? 4. What is the graph of $y = \sqrt{x-3}$?

Lesson Check

Do you know HOW?

1. What is the domain of the function $y = \sqrt{x+3}$?

Graph each function.

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

Do you UNDERSTAND?



4. **Vocabulary** Is $y = x\sqrt{5}$ a square root function? Explain.
5. **Writing** Explain how the graph of $y = \sqrt{x-1}$ is related to the graph of $y = \sqrt{x}$.
6. **Reasoning** Can the domain of a square root function include negative numbers? Explain.



Practice and Problem-Solving Exercises



A Practice

Find the domain of each function.

◀ See Problem 1.

- | | | |
|------------------------------------|--------------------------------|---------------------------|
| 7. $y = \frac{1}{2}\sqrt{x}$ | 8. $y = \sqrt{x} + 2$ | 9. $y = \sqrt{x - 7}$ |
| 10. $y = 3\sqrt{\frac{x}{3}}$ | 11. $y = 2.7\sqrt{x + 2} + 11$ | 12. $y = \sqrt{4x - 13}$ |
| 13. $y = \frac{4}{7}\sqrt{18 - x}$ | 14. $y = \sqrt{3x + 9} - 6$ | 15. $y = \sqrt{3(x - 4)}$ |

Make a table of values and graph each function.

◀ See Problem 2.

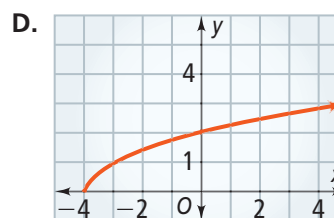
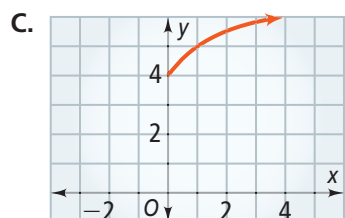
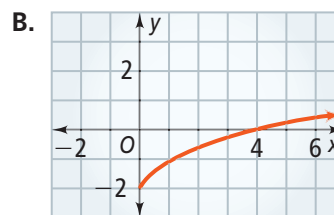
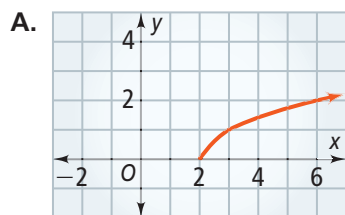
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|----------------------------------|------------------------------|-------------------------|
| 16. $y = \sqrt{2x}$ | 17. $f(x) = 4\sqrt{x}$ | 18. $y = \sqrt{4x - 8}$ |
| 19. $y = \sqrt{3x}$ | 20. $f(x) = 3\sqrt{x}$ | 21. $y = -3\sqrt{x}$ |
| 22. $f(x) = \frac{1}{3}\sqrt{x}$ | 23. $y = \sqrt{\frac{x}{2}}$ | 24. $y = 2\sqrt{x - 3}$ |

- STEM** 25. **Physics** The function $v = \sqrt{19.6h}$ models an object's velocity v in meters per second after it has fallen h meters, ignoring the effects of air resistance. Make a table and graph the function. For what values of h will the object's velocity be more than 10 m/s?

Match each function with its graph.

◀ See Problems 3 and 4.

- | | | | |
|------------------------|------------------------|------------------------|------------------------|
| 26. $y = \sqrt{x + 4}$ | 27. $y = \sqrt{x - 2}$ | 28. $y = \sqrt{x} + 4$ | 29. $y = \sqrt{x} - 2$ |
|------------------------|------------------------|------------------------|------------------------|



Graph each function by translating the graph of $y = \sqrt{x}$.

- | | | |
|------------------------|---------------------------|---------------------------|
| 30. $y = \sqrt{x} + 5$ | 31. $y = \sqrt{x} - 5$ | 32. $y = \sqrt{x} - 1$ |
| 33. $y = \sqrt{x + 2}$ | 34. $f(x) = \sqrt{x - 5}$ | 35. $f(x) = \sqrt{x - 4}$ |
| 36. $y = \sqrt{x} + 1$ | 37. $y = \sqrt{x + 1}$ | 38. $y = \sqrt{x - 1}$ |

B Apply

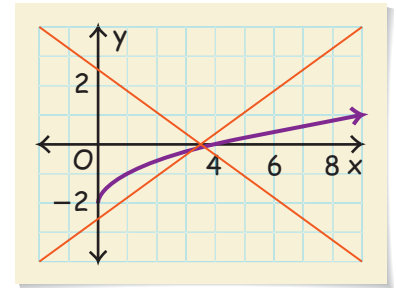
39. What are the domain and the range of the function $y = \sqrt{2x - 8}$?
40. What are the domain and the range of the function $y = \sqrt{8 - 2x}$?

41. **Firefighting** When firefighters are trying to put out a fire, the rate at which they can spray water on the fire depends on the nozzle pressure. You can find the flow rate f in gallons per minute using the function $f = 120\sqrt{p}$, where p is the nozzle pressure in pounds per square inch.

- Graph the function.
- What nozzle pressure gives a flow rate of 800 gal/min?

42. **Error Analysis** A student graphed the function $y = \sqrt{x - 2}$ at the right. What mistake did the student make? Draw the correct graph.

43. **Think About a Plan** The velocity v in meters per second of a 2,000,000-kg rocket is given by the function $v = \sqrt{E}$, where E is the rocket's kinetic energy in megajoules (MJ). When the rocket's kinetic energy is 8,000,000 MJ, what is its velocity?
- How can you use a graph to solve the problem?
 - How can you check your answer?



Make a table of values and graph each function.

44. $y = \sqrt{x - 2.5}$

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

46. $y = \sqrt{x + 6}$

47. $y = \sqrt{0.5x}$

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

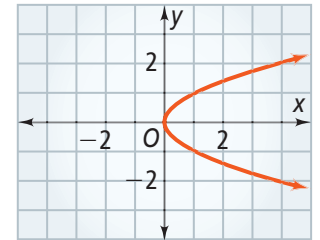
49. $f(x) = \sqrt{x + 2} - 4$

50. $y = \sqrt{2x} + 3$

51. $y = \sqrt{2x + 6} + 1$

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

53. The graph of $x = y^2$ is shown at the right.
- Is this the graph of a function?
 - How does $x = y^2$ relate to the square root function $y = \sqrt{x}$?
 - Reasoning** What is a function for the part of the graph that is shown in Quadrant IV? Explain.
54. **Reasoning** Without graphing, determine which graph rises more steeply, $y = \sqrt{3x}$ or $y = 3\sqrt{x}$. Explain your answer.



Graph each function by translating the graph of $y = \sqrt{x}$.

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

56. $y = \sqrt{x + 1} + 5$

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

58. $y = \sqrt{x - 6} + 3$

59. $y = \sqrt{x + 2.5} - 1$

60. $y = \sqrt{x - 4.5} + 1.5$

Challenge


61.
 - Graph $y = \sqrt{x^2} + 5$.
 - Write a function for the graph you drew that does not require a radical.
62. In parts (a)–(d), graph each function.
- $y = \sqrt{4x}$
 - $y = \sqrt{5x}$
 - $y = \sqrt{6x}$
 - $y = \sqrt{-6x}$
 - Reasoning** Describe how the graph of $y = \sqrt{nx}$ changes as the value of n varies.

63. **Data Collection** Mark at least 6 places on a ramp that is at least 6 ft long. For each mark, measure the distance d from the mark to the bottom of the ramp. Measure the time t it takes a ball to roll from each mark to the bottom of the ramp.
- Graph the data points (d, t) . Connect the points with a smooth curve.
 - Describe your graph. What function does it resemble?
 - Is the graph linear? Why or why not?

Standardized Test Prep

GRIDDED RESPONSE

SAT/ACT

64. What is the positive solution of the equation $5.2x^2 + 3.4x - 7.3 = 0$? Use a graphing calculator. Round your answer to the nearest thousandth.
65. What is the value of the expression $\sqrt{12} \cdot \frac{5}{\sqrt{2}}$? Round your answer to the nearest tenth.
66. A scientist graphs the results of a chemical reaction as a linear function that passes through the points $(4, 1)$ and $(-3, 0)$. What is the slope of the line?
67. The diagram at the right shows the distance between a new building and its nearest neighbor. The diagram has a scale of 1 in. : 100 ft. What is the actual distance between the buildings, in feet?
- 
68. What is the value of the expression $|-4^7| \div \left(\frac{3^3}{4^{-2}} + \frac{4^3}{\sqrt{16}}\right)$? Round your answer to the nearest tenth.

Mixed Review

Solve each radical equation. Check your solutions.

See Lesson 10-4.

69. $\sqrt{2s + 8} = s$

70. $\sqrt{f} = \sqrt{3f + 6}$

71. $\sqrt{2r - 3} = r$

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

73. $2x = \sqrt{x - 3}$

74. $2t = \sqrt{2t + 56}$

Simplify each expression.

See Lesson 8-1.

75. $3m + 5 + 2m + 7$

76. $(8h^3 + 3h) + (4h^3 + 5h)$

77. $(9b + 2) - (12b + 8)$

78. $(4a^2 + 3a + 1) - (3a^2 - 6a)$

79. $(24p + 13) + (9p^2 - 12)$

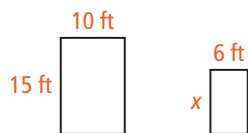
80. $(7c^5 + 5c^3 - 1) - (c^5 - 3c^3)$

Get Ready! To prepare for Lesson 10-6, do Exercises 81-83.

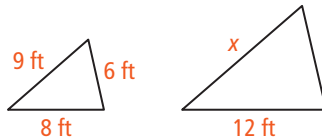
The figures in each pair are similar. Find the value of x .

See Lesson 2-8.

81.



82.



83.

