

THINK AND DISCUSS

1. Explain how to determine the parent function for a given equation.
2. Explain why recognizing parent functions is useful for graphing.
3. **GET ORGANIZED** Copy and complete the graphic organizer. In each box, give the appropriate information for a translation of the parent function 3 units up.



Transformed Parent Functions			
Family	Linear	Quadratic	Square root
Rule			
Graph			
Domain			
Range			
Intersects y-axis			

1-2

Exercises



GUIDED PRACTICE

1. **Vocabulary** Explain how transformations, families of functions, and *parent functions* are related.

SEE EXAMPLE 1

Identify the parent function for g from its function rule. Then graph g on your calculator and describe what transformation of the parent function it represents.

2. $g(x) = (x - 1)^3$
3. $g(x) = (x + 1)^2$
4. $g(x) = -x$
5. $g(x) = \sqrt{x + 3}$
6. $g(x) = x^2 + 4$
7. $g(x) = x - \sqrt{2}$

SEE EXAMPLE 2

Graph the data from the table. Describe the parent function and the transformation that best approximates the data set.

8.

x	-3	-1	0	1	3
y	-15	-5	0	5	15

9.

x	-3	-1	0	1	3
y	-1	$-\frac{1}{27}$	0	$\frac{1}{27}$	1

SEE EXAMPLE 3

10. **Physics** The time it takes a pendulum to make one complete swing back and forth depends on its string length.
 - a. Graph the relationship from string length to time.
 - b. Identify which parent function best describes the data.
 - c. Use your graph to estimate the string length of a pendulum that takes 4.5 seconds to make one complete swing.
 - d. Use your graph to estimate the time it takes to make a complete swing for a string of length 14 meters.

Pendulum Swing	
String Length (m)	Time (s)
2	2.8
4	4.0
6	4.9
8	5.7
10	6.3

PRACTICE AND PROBLEM SOLVING

Independent Practice

For Exercises	See Example
11–13	1
14–15	2
16	3

Extra Practice

See Extra Practice for more Skills Practice and Applications Practice exercises.

Identify the parent function for g from its function rule. Then graph g on your calculator and describe what transformation of the parent function it represents.

11. $g(x) = x^2 - 1$

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

13. $g(x) = x^3 + 3$

Graph the data from the table. Describe the parent function and the transformation that best approximates the data set.

14.

x	-3	-1	0	1	3
y	3	$\frac{1}{3}$	0	$\frac{1}{3}$	3

15.

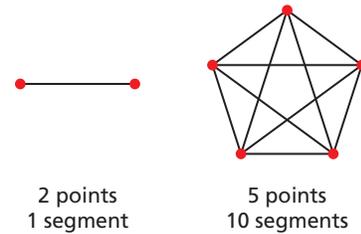
x	0	1	4	9	16
y	0	2	4	6	8



16. **Geometry** The number of segments required to connect a given number of points is shown in the table.

- Graph the relationship from the number of points to the number of segments.
- Identify which parent function best describes the data.
- Use your graph to estimate the number of points if there are 45 segments.
- Use your graph to estimate the number of segments if there are 7 points.

Connecting Points				
Number of Points	2	5	8	11
Number of Segments	1	10	28	55



Graphing Calculator Graph each function with a graphing calculator. Identify the domain and range of the function, and describe the transformation from its parent function.

17. $g(x) = 3\sqrt{x}$

18. $g(x) = \frac{2}{3}x$

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

20. $g(x) = -(x - 2)^2$

21. $g(x) = -x^2 + 1$

22. $g(x) = -\frac{1}{2}x^3$

23. **Sports** Based on the information in the table, what is the total cost of 15 tickets to the hockey game? Explain how you determined your answer.

Hockey Tickets				
Number of Tickets	1	5	8	12
Total Cost (\$)	13	65	104	156

Graph each function. Identify the parent function that best describes the set of points, and describe the transformation from the parent function.

24. $\{(-2, 8), (-1, 1), (0, 0), (1, -1), (2, -8)\}$

25. $\{(5, 4), (7, 0), (9, 4), (10, 9), (11, 16)\}$

26. $\{(0, 0), (-1, 1), (-4, 2), (-9, 3), (-16, 4)\}$

27. $\{(-4, 3), (-2, 1), (0, -1), (2, -3), (4, -5)\}$

MULTI-STEP TEST PREP



- One function used in the Multi-Step Test Prep in the lesson *Exploring Transformations* was $f(x) = 20 + 1.25x$. What is its parent function?
- The graph for a given function has a U shape. What could be the parent function?
- Plot the data set $\{(0, 0), (1, 2), (4, 4), (9, 6), (16, 8), (25, 10)\}$. Which parent function best models the data set?

Photography When resizing a digital photo, it is often important to preserve its *aspect ratio*, the ratio of its width to its height. Use the table for Exercises 29–31.



Digital Photos with Aspect Ratio 3:2

Width (pixels)	Height (pixels)	File Size (KB)
640	427	220
800	533	254
1024	683	413
1280	853	750

29. Graph the relationship from width to height and identify which parent function best describes the data. Use the graph to estimate the width of a photo with a height of 1000 pixels.
30. Graph the relationship from height to width and identify which parent function best describes the data. Use the graph to estimate the height of a photo with a width of 500 pixels.
31. Resizing a photo changes the file size. Graph the relationship from width to file size and identify which parent function best describes the data. Use the graph to estimate the width of a photo with a file size of 1000 KB.

Sketch a graph for each situation and identify the related parent function. Then explain what the reasonable domain and range for the function is and compare it with the domain and range of the parent function.

32. distance traveled after h hours at a speed of 55 mi/h
33. volume of a cube with side length ℓ
34. area of a room with width w and a length of 15 feet
35. cost to wash n loads of laundry at \$1.00 per load
36. cost of an item with original price p after a 15% discount
37. side length of a square with area A

LINK
Chemistry

Aerogel has been called the world's lowest density solid. It is 99.8% air and is an excellent heat insulator. As shown above, a layer of aerogel can prevent a flame from melting crayons.

38. **Chemistry** The table shows properties of aerogel. Graph the relationship from mass to volume, and then estimate the volume of 1 gram of aerogel.

Aerogel Properties				
Mass (mg)	30	90	300	450
Volume (cm ³)	10	30	100	150

39. **What if...?** Use the set of points $\{(-1, -1), (0, 0), (1, 1)\}$ to answer each question.
 - a. What parent function best describes the set of points?
 - b. If the points $(-2, 8)$ and $(2, 8)$ were added, what parent function would best describe the set?
 - c. If the point $(1, 1)$ were replaced with $(1, -1)$, what parent function would best describe the set?
 - d. If the point $(-1, -1)$ were replaced with $(4, 2)$, what parent function would best describe the set?
 - e. **Multi-Step** If the x -coordinate of each point were doubled and 3 were added to each y -coordinate, what parent function would best describe the set? What transformation of the parent function would the set represent?
40. **Critical Thinking** Explain any relationship you have noticed between the quadratic parent function and a function rule that represents a horizontal translation, a vertical translation, or a reflection across the x -axis.

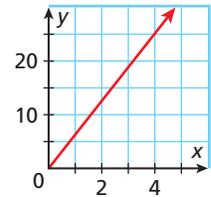


41. **Write About It** Order the parent functions covered in this lesson from least to greatest by the rate at which $f(x)$ increases as x increases for $x > 1$. Explain your answer.

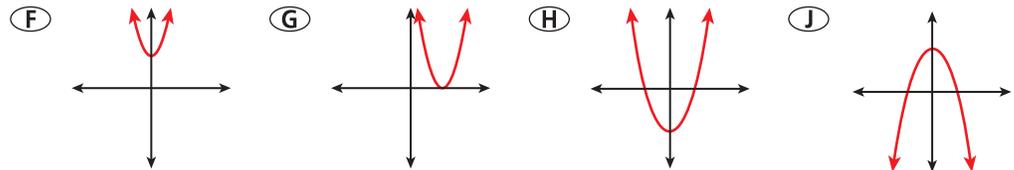


42. Which situation could be represented by the graph?

- (A) The area of a circle based on its radius
 (B) The volume of a sphere based on its radius
 (C) The surface area of a sphere based on its radius
 (D) The circumference of a circle based on its radius



43. Which graph best represents the function $f(x) = 2x^2 - 2$?



44. Which equation describes a relationship in which every nonzero real number x corresponds to a negative real number y ?

- (A) $y = -x^3$ (B) $y = -x^2$ (C) $y = (-x)^2$ (D) $y = -x$

45. For which function is -1 NOT an element of the range?

- (F) $y = -1$ (G) $y = (-x)^2$ (H) $y = -x$ (J) $y = x^3$

46. What type of function can be used to determine the side length of a square if the independent variable is the square's area?

- (A) Cubic (B) Linear (C) Quadratic (D) Square root

CHALLENGE AND EXTEND

Identify the parent function for each function.

47. $g(x) = 3(x - 1)^2 - 6$ 48. $h(x) = (4x^3)^0 + 2$ 49. $g(x) = 5(3x - 2) - 11x$

50. Another parent function is an exponential function of the form $f(x) = a^x$.

- Graph $f(x) = 2^x$.
- Find the domain and range of the function.
- Identify the point where the function crosses the y -axis.
- Predict where $f(x) = 3^x$ crosses the y -axis and explain your answer.