Chapter 10

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Chapter 10 Radical Functions and Equations

Dear Family,

Have you ever heard the sound of screeching tires on dry pavement as a vehicle is trying to stop? Skid marks are usually left behind on the road. Did you know that police can use math to determine approximately how fast the vehicle was traveling before coming to a stop?

Using the Internet, research the topic of vehicular accident reconstruction:

- Why would the police need to reconstruct an accident?
- What information is important for the police to gather about the accident?
- If there were no eyewitnesses, do you think the police could still determine what happened? Explain your reasoning.

Now do some specific research on skid marks:

- What is a skid mark?
- What tools would an accident reconstruction engineer use to determine a cause for an accident?
- What factors may affect a vehicle's ability to stop?

Accident reconstruction engineers use specific formulas to determine the speed of a vehicle prior to the accident by examining the skid marks. On dry pavement, the stopping distance of a skidding car can be determined by measuring the length of a skid mark. The initial speed of the car s (in miles per hour) is related to the length of the skid mark and is represented by the equation $s = \sqrt{22d}$, where d is the length of the skid mark (in feet) for the car to come to a complete stop.

- Using the above formula, determine how fast a vehicle was traveling before braking if the skid mark is 140 feet long?

$s = \sqrt{22 \cdot 140}$ Substitute 140 for d.

$= \sqrt{3080}$ Multiply.

≈ 55.5 mi/h Use a calculator to find the square root of the number.

Also consider how you could use the formula above to determine the length of a skid mark given the speed of a vehicle. In this chapter, your student will learn more about solving radical equations.

Always remember to drive carefully!

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Nombre _____ Fecha_____

Capítulo 10 Funciones y ecuaciones radical

Estimada familia:

¿Alguna vez han oído el sonido del chillido de las llantas sobre el pavimento seco cuando un vehículo trata de frenar? Suelen quedar marcas de desplazamiento en la carretera. ¿Sabían que la policía puede usar las matemáticas para determinar la velocidad aproximada del vehículo antes de frenar por completo?

Usen Internet para investigar la reconstrucción de accidentes automovilísticos:

- ¿Por qué la policía necesitaría reconstruir un accidente?
- ¿Qué información es importante que la policía reúna sobre el accidente?
- Si nadie presenció el hecho, ¿creen que la policía aún puede determinar qué sucedió? Expliquen su razonamiento.

Ahora, hagan una investigación específica sobre las marcas de desplazamiento:

- ¿Qué es una marca de desplazamiento?
- ¿Qué herramientas usaría un ingeniero especializado en reconstrucción de accidentes para determinar la causa de un accidente?
- ¿Qué factores podrían afectar la habilidad del vehículo para detenerse?

Los ingenieros especializados en reconstrucción de accidentes usan fórmulas específicas para determinar la velocidad de un vehículo antes del accidente mediante el estudio de las marcas de desplazamiento. En pavimento seco, la distancia de frenado de un carro que derrapa puede determinarse al medir la longitud de una marca de desplazamiento. La velocidad inicial del carros (en millas por hora) se relaciona con la longitud de la marca de desplazamiento y se representa con la ecuación $s = \sqrt{22d}$, donde d es la longitud de la marca de desplazamiento (en pies) del carro para que este frene completamente.

- Usen la fórmula mencionada para determinar la velocidad de un vehículo antes de frenar si la marca de desplazamiento mide 140 pies de largo.

$s = \sqrt{22 \cdot 140}$ Sustituyan 140 por d.

$= \sqrt{3080}$ Multipliquen.

≈ 55.5 mi/h Usen una calculadora para hallar la raíz cuadada del número.

Además, consideren cómo podrían usar la fórmula mencionada para determinar la longitud de una marca de desplazamiento dada la velocidad de un vehículo. En este capítulo, su hijo aprenderá más sobre cómo resolver ecuaciones radicales.

¡Siempre recuerden conducir con cuidado!

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10.1 Start Thinking

Use a graphing calculator to graph $y = \sqrt{x}$. Describe the domain and range of the function. Explain why you cannot use negative numbers in the domain.

Graph $y = \sqrt{-x}$. Explain why the calculator is able to graph this function, and relate your explanation to the domain for the graph of $y = \sqrt{x}$. How does the domain of $y = \sqrt{-x}$ differ from the domain of $y = \sqrt{x}$?

10.1 Warm Up

Graph the function.

1. $y = 3x + 2$

2. $y = -2x$

3. $y = 1$

4. $y = -\frac{2}{3}x - 4$

5. $y = \frac{2}{5}x + 2$

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

10.1 Cumulative Review Warm Up

Graph the function. Describe the domain and range.

1. $y = \begin{cases} x, & \text{if } x < 0 \\ x + 7, & \text{if } x > 0 \end{cases}$

2. $y = \begin{cases} x, & \text{if } x \leq -2 \\ -3x, & \text{if } x > -2 \end{cases}$

3. $y = \begin{cases} -2x + 1, & \text{if } x \leq 0 \\ x - 1, & \text{if } x > 0 \end{cases}$

4. $y = \begin{cases} 2x - 7, & \text{if } x < 5 \\ 3x + 5, & \text{if } x \geq 5 \end{cases}$

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10.1 Practice A

In Exercises 1–6, describe the domain of the function.

1. $y = 5\sqrt{x}$ **2.** $y = \sqrt{3x}$ **3.** $y = 6 + \sqrt{-x}$

4. $y = \sqrt{-4x} + 6$ **5.** $y = \sqrt{x - 8}$ **6.** $y = \sqrt{x + 6}$

In Exercises 7–12, graph the function. Describe the range.

7. $y = \sqrt{2x}$ **8.** $y = 3\sqrt{-x}$ **9.** $y = 4 + \sqrt{x}$

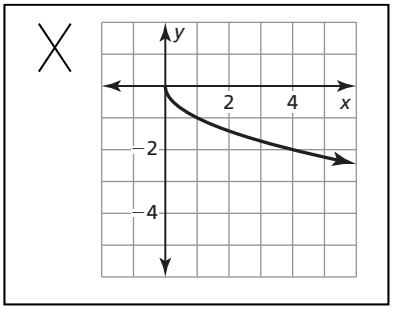
10. $y = \sqrt{x} - 1$ **11.** $y = \sqrt{x - 2}$ **12.** $y = -\sqrt{x + 5}$

In Exercises 13–18, graph the function. Compare the graph to the graph of $f(x) = \sqrt{x}$.

13. $g(x) = \frac{1}{3}\sqrt{x}$ **14.** $g(x) = \sqrt{\frac{1}{2}x}$ **15.** $g(x) = \sqrt{x - 1}$

16. $g(x) = \sqrt{x} + 6$ **17.** $g(x) = \sqrt{-2x}$ **18.** $g(x) = -3\sqrt{x}$

19. Describe and correct the error in graphing the function $y = \sqrt{-x}$.



20. Consider the graph of $y = \sqrt{x}$.

a. Write a function that is a horizontal translation of the graph of $y = \sqrt{x}$.

b. Write a function that is vertical shrink of the graph of $y = \sqrt{x}$.

c. Write a function that is reflection in the x-axis followed by a vertical translation of the graph of $y = \sqrt{x}$.

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10.1 Practice B

In Exercises 1–6, describe the domain of the function.

1. $y = \sqrt{7x}$

2. $y = 3 + \sqrt{-9x}$

3. $y = \sqrt{x - 8}$

4. $y = \sqrt{-x + 5}$

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

6. $y = \frac{1}{3}\sqrt{-x - 6}$

In Exercises 7–12, graph the function. Describe the range.

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

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

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

10. $y = \sqrt{x + 1}$

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

12. $y = -\sqrt{x + 2} + 1$

In Exercises 13–18, graph the function. Compare the graph to the graph of $f(x) = \sqrt{x}$.

13. $g(x) = \sqrt{\frac{1}{3}x}$

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

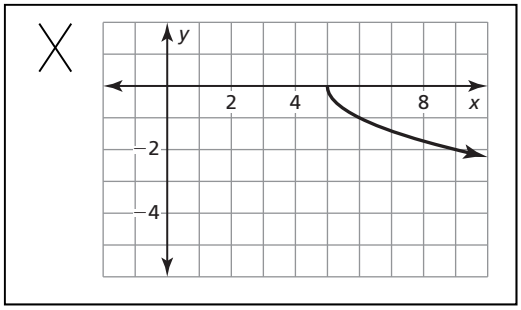
15. $g(x) = -1 + \sqrt{x}$

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

17. $g(x) = \sqrt{-4x}$

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

19. Describe and correct the error in graphing the function $y = -\sqrt{x + 5}$.



20. A right circular cylinder has a height of 2 centimeters. The radius r of the cylinder is given by $r = \sqrt{\frac{A}{2\pi}}$, where A is the cylinder's area.

a. Describe the domain of the function. Use a graphing calculator to graph the function.

b. Use the *trace* feature to approximate the area of the cylinder when the radius is 2.3 centimeters. Round your answer to the nearest tenth.

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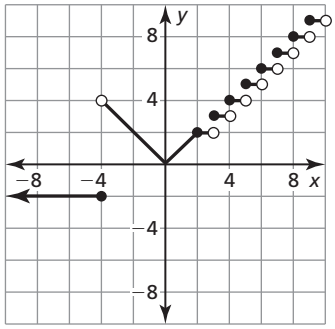
10.1 Enrichment and Extension

Graphing Functions Challenge

Use your knowledge of special functions, composition of functions, and linear, quadratic, and square root functions to complete the following challenge questions.

Example: Graph $y = \begin{cases} -2, & \text{if } x \le -4 \\ |x|, & \text{if } -4 < x \le 2. \\ [x], & \text{if } x > 2 \end{cases}$

Separate the graph into the three parts of the piecewise function. Using the bounds, graph each separate part in the appropriate place. From left to right, graph the constant function, the absolute value function, and then the step function.



Graph the function

1. $y = \left|2\sqrt{x+1} - 4\right|$

2. $y = -\left|(x-3)^2 - 4\right|$

3. $y = \begin{cases} -|x|, & \text{if } x \le 2 \\ 3\sqrt{x-2} - 2, & \text{if } x > 2 \end{cases}$

4. $y = \begin{cases} \sqrt{-x-2} + 1, & \text{if } x \le -2 \\ x^2 - 3, & \text{if } x > -2 \end{cases}$

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10.1 Puzzle Time

What's A Sign Of Old Age In A Computer?

Write the letter of each answer in the box containing the exercise number.

Describe the domain of the function.

1. $y = 9\sqrt{x}$

2. $g(x) = \sqrt{x + 6}$

3. $r(x) = \sqrt{-x - 2}$

4. $b(x) = \frac{1}{3}\sqrt{x + 8}$

Describe the range of the function.

5. $h(x) = 5\sqrt{-x}$

6. $c(x) = \sqrt{x} - 9$

7. $s(x) = -\sqrt{x + 5}$

8. $m(x) = \sqrt{x + 4} - 3$

Describe the transformation(s) from the graph of $f(x) = \sqrt{x}$ to the graph of h.

9. $h(x) = 5\sqrt{x - 3} + 2$

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

11. $h(x) = -8\sqrt{x + 2} - 7$

12. $h(x) = \frac{1}{8}\sqrt{x - 1} + 11$

Answers

O. $y \geq 0$

M. $y \geq -9$

F. $y \leq 0$

E. $y \geq -3$

O. $x \geq -8$

R. $x \leq -2$

S. $x \geq -6$

O. $x \geq 0$

M. vertical shrink by a factor of $\frac{1}{6}$; reflection in the y-axis; translation 4 units up

L. vertical shrink by a factor of $\frac{1}{8}$; translation 1 unit right and 11 units up

S. vertical stretch by a factor of 5; translation 3 units right and 2 units up

Y. reflection in the x-axis; translation 2 units left and 7 units down; vertical stretch by a factor of 8

12	4	2	9		1	7		10	8	6	5	3	11

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10.2 Start Thinking

Use a graphing calculator to graph $y = \sqrt[3]{x}$. Describe the shape of the graph. Compare the graph to that of $y = \sqrt{x}$.

Describe the domain and range of the function. Explain why the range differs from that of the function $y = \sqrt{x}$. Explain how you could use the graph of $y = \sqrt[3]{x}$ to find the side length of a cube when you know the volume.

10.2 Warm Up

Graph the function.

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

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

3. $p(x) = \sqrt{-\frac{1}{5}x}$

4. $m(x) = -\sqrt{x} + 5$

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

6. $v(x) = \sqrt{\frac{x}{12}}$

10.2 Cumulative Review Warm Up

Tell whether the ordered pair is a solution to the system of linear inequalities.

1. $(-4, 1)$; $y > 5$
$y < x - 2$

2. $(1, -1)$; $y \geq x - 8$
$y \leq x - 4$

3. $(0, 0)$; $y < -1$
$y < x + 4$

4. $(5, -4)$; $y \geq x - 1$
$y \geq 8x + 1$

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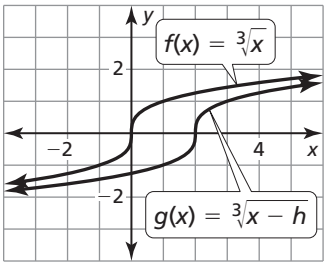
10.2 Practice A

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

1. $g(x) = \sqrt[3]{x - 3}$ **2.** $g(x) = \sqrt[3]{x} + 1$ **3.** $g(x) = 2\sqrt[3]{x}$

In Exercises 4 and 5, compare the graphs. Find the value of *h*, *k*, or *a*.

4.



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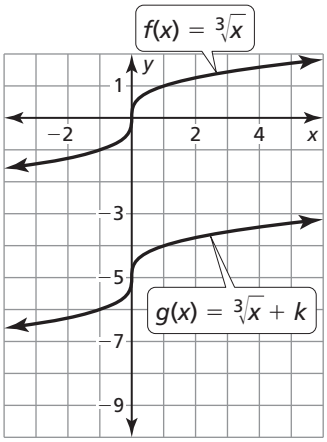


In Exercises 6–11, graph the function. Compare the graph to the graph of $f(x) = \sqrt[3]{x}$.

6. $g(x) = -\sqrt[3]{x + 1}$ **7.** $g(x) = -\sqrt[3]{x} - 2$ **8.** $g(x) = 4\sqrt[3]{x - 2}$

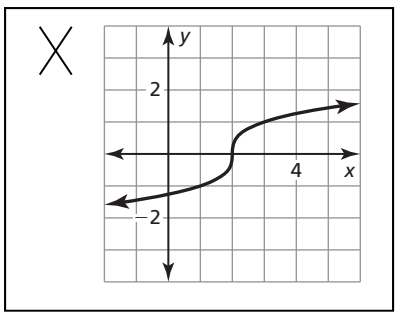
9. $g(x) = 0.1\sqrt[3]{x + 4}$ **10.** $g(x) = 2\sqrt[3]{x} + 1$ **11.** $g(x) = \sqrt[3]{-x} + 3$

In Exercises 12–15, describe the transformations from the graph of $f(x) = \sqrt[3]{x}$ to the graph of the given function. Then graph the function.

12. $g(x) = \sqrt[3]{x + 2} - 3$ **13.** $g(x) = \sqrt[3]{x - 3} + 1$

14. $g(x) = -4\sqrt[3]{x - 1} - 2$ **15.** $g(x) = 3\sqrt[3]{x + 6} + 2$

16. Describe and correct the error in graphing the function $f(x) = \sqrt[3]{x} - 2$.



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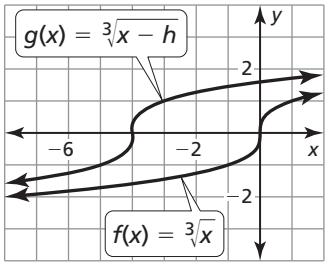
10.2 Practice B

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

1. $g(x) = \sqrt[3]{x + 4}$ **2.** $g(x) = \sqrt[3]{x} - 2$ **3.** $g(x) = \sqrt[3]{\frac{1}{3}x}$

In Exercises 4 and 5, compare the graphs. Find the value of *h*, *k*, or *a*.

4.



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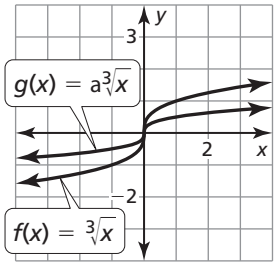


In Exercises 6–11, graph the function. Compare the graph to the graph of $f(x) = \sqrt[3]{x}$.

6. $g(x) = -\sqrt[3]{x - 3}$ **7.** $g(x) = 3\sqrt[3]{x + 2}$ **8.** $g(x) = 2\sqrt[3]{x} - 5$

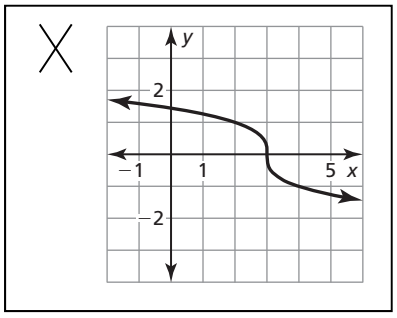
9. $g(x) = 0.2\sqrt[3]{x + 1}$ **10.** $g(x) = \sqrt[3]{-4x} + 1$ **11.** $g(x) = \sqrt[3]{2(x - 1)}$

In Exercises 12–15, describe the transformations from the graph of $f(x) = \sqrt[3]{x}$ to the graph of the given function. Then graph the function.

12. $g(x) = \sqrt[3]{x + 4} - 2$ **13.** $g(x) = 5\sqrt[3]{x - 2} + 3$

14. $g(x) = -\frac{1}{2}\sqrt[3]{x - 3} - 2$ **15.** $g(x) = \frac{4}{3}\sqrt[3]{x + 5} + 2$

16. Describe and correct the error in graphing the function $f(x) = -\sqrt[3]{x + 3}$.



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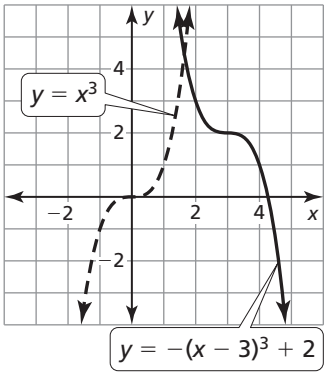
10.2 Enrichment and Extension

Graphing Cubic Functions

Example: Use transformations to graph the cubic function $y = -(x - 3)^3 + 2$.

Graph by reflecting the function $y = x^3$ in the x-axis and then shifting the graph right 3 units and up 2 units. The central point of the graph is now $(3, 2)$.



Graph the cubic function using the rules of transformations.

1. $y = -x^3$

2. $y = x^3 - 1$

3. $y = -x^3 - 5$

4. $y = \frac{1}{2}x^3 + 3$

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

6. $y = 3(x - 5)^3$

7. $y = -(x - 1)^3 + 3$

8. $y = (x + 5)^3 - 4$

9. $y = \frac{(x - 2)^3}{3} + 4$

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10.2 Puzzle Time

What Does A Dog Get When He Finishes Obedience School?

Write the letter of each answer in the box containing the exercise number.

Describe the transformation(s) from the graph of $f(x) = \sqrt[3]{x}$ to the graph of the given function.

1. $g(x) = \sqrt[3]{x + 5}$
2. $p(x) = \sqrt[3]{x} - 9$
3. $b(x) = \frac{1}{6}\sqrt[3]{x}$
4. $s(x) = \sqrt[3]{2x}$
5. $d(x) = \sqrt[3]{-x}$
6. $v(x) = -\sqrt[3]{x - 7}$
7. $j(x) = \sqrt[3]{-0.25x} - 6$
8. $h(x) = \frac{1}{3}\sqrt[3]{x} + 12$
9. $c(x) = -8\sqrt[3]{x} + 1$
10. $k(x) = \sqrt[3]{-\frac{1}{4}x} - 14$

Answers

E. horizontal shrink by a factor of $\frac{1}{2}$

A. translation 9 units down

R. reflection in the y-axis

E. translation 5 units left

T. vertical shrink by a factor of $\frac{1}{6}$

E. reflection in the x-axis; vertical stretch by a factor of 8; translation 1 unit up

G. reflection in the y-axis; horizontal stretch by a factor of 4; translation 6 units down

D. reflection in the y-axis; horizontal stretch by a factor of 4; translation 14 units down

P. vertical shrink by a factor of $\frac{1}{3}$ translation 12 units up

E. reflection in the x-axis; translation 7 units right

2		8	6	3		10	1	7	5	9	4

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10.3 Start Thinking

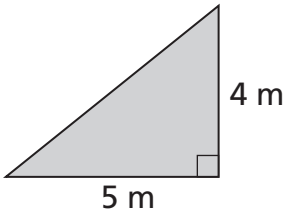
Draw a right triangle with leg lengths 3 centimeters and 4 centimeters. Find the length of the hypotenuse using the Pythagorean Theorem.

How can you use the Pythagorean Theorem if given the length of the hypotenuse and only one leg length of a right triangle? Use a hypotenuse length of 13 inches and a leg length of 5 inches to show how to rewrite the Pythagorean Theorem and solve for the other leg length.

10.3 Warm Up

Find the missing length. If necessary, round to the nearest tenth.

1.



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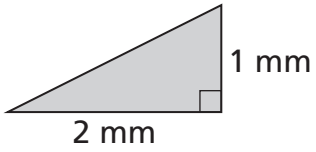

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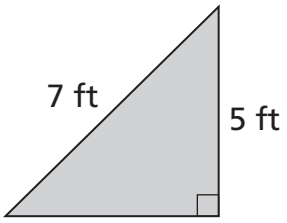

4.

10.3 Cumulative Review Warm Up

Write an explicit rule for the recursive rule.

1. $a_1 = -2, a_n = a_{n-1} - 2$

2. $a_1 = 9, a_n = a_{n-1} + 11$

3. $a_1 = 17, a_n = -1.6a_{n-1}$

4. $a_1 = -3, a_n = 10a_{n-1}$

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10.3 Practice A

In Exercises 1–6, solve the equation. Check your solution.

1. $\sqrt{x} = 7$

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

3. $\sqrt{t} - 4 = 2$

4. $\sqrt{h} + 10 = 21$

5. $5 - \sqrt{n} = 2$

6. $-6 = 4 - \sqrt{y}$

In Exercises 7–12, solve the equation. Check your solution.

7. $\sqrt{d + 2} + 3 = 7$

8. $\sqrt{m - 4} - 8 = -3$

9. $3\sqrt{x - 1} = 24$

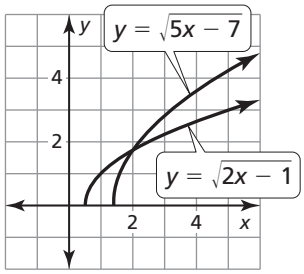
10. $7\sqrt{x + 6} = 14$

11. $-3 = \sqrt{2t + 5} - 4$

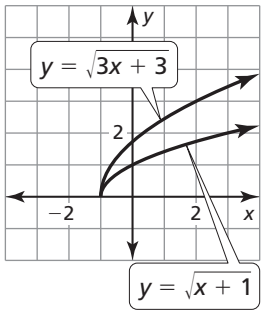
12. $5 = \sqrt{9p + 9} - 1$

In Exercises 13 and 14, use the graph to solve the equation.

13. $\sqrt{2x - 1} = \sqrt{5x - 7}$



14. $\sqrt{3x + 3} = \sqrt{x + 1}$



In Exercises 15–17, solve the equation. Check your solution.

15. $\sqrt[3]{x} = 3$

16. $10 = \sqrt[3]{8w}$

17. $\sqrt[3]{p + 10} = 4$

In Exercises 18 and 19, determine which solution, if any, is an extraneous solution.

18. $\sqrt{3x - 2} = x; x = 1, x = 2$

19. $\sqrt{x + 6} = x; x = 3, x = -2$

20. The radius r of a circle that goes through the point (x, y) is given by $r = \sqrt{x^2 + y^2}$.

a. Circle A has a radius of 5 centimeters and goes through the point $(x, 4)$. Find the x-coordinate of the point.

b. Circle B has a radius of 13 centimeters and goes through the point $(5, y)$. Find the y-coordinate of the point.

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10.3 Practice B

In Exercises 1–6, solve the equation. Check your solution.

1. $\sqrt{x} = 13$

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

3. $\sqrt{t} + 14 = 20$

4. $-16 = 4 - \sqrt{y}$

5. $5\sqrt{n} - 10 = 15$

6. $3\sqrt{h} + 7 = 19$

In Exercises 7–12, solve the equation. Check your solution.

7. $\sqrt{q - 4} - 10 = -7$

8. $5\sqrt{m + 3} = 20$

9. $-4 = \sqrt{3x + 2} - 8$

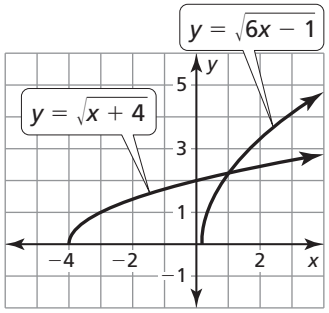
10. $3 = \sqrt{2x + 2} - 9$

11. $11 + 3\sqrt{2t + 5} = 23$

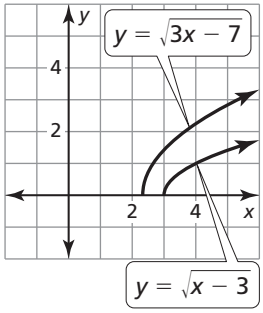
12. $5 - 2\sqrt{7p + 2} = 1$

In Exercises 13 and 14, use the graph to solve the equation.

13. $\sqrt{x + 4} - \sqrt{6x - 1} = 0$



14. $\sqrt{3x - 7} - \sqrt{x - 3} = 0$



In Exercises 15–17, solve the equation. Check your solution.

15. $\sqrt[3]{x - 9} = 2$

16. $-4 = \sqrt[3]{3w - 1}$

17. $\sqrt[3]{q - 3} = \sqrt{5q + 5}$

In Exercises 18 and 19, determine which solution, if any, is an extraneous solution.

18. $\sqrt{4t + 24} = -2t;\ t = 3,\ t = -2$

19. $\sqrt{36m - 36} = -3m;\ m = 2$

20. The radius r of a circle that goes through the point (x, y) is given by $r = \sqrt{x^2 + y^2}$. The y-coordinate of a point on the circle is 15 and the x-coordinate of the same point is 9 less than the radius.

a. Write an equation whose solution is the radius of the circle.

b. Find the radius of the circle.

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10.3 Enrichment and Extension

Solving Radical Inequalities

To solve radical inequalities, you must take a few factors into consideration, because square roots need to have a positive radicand, or value under the radical sign.

Example: Solve $3 + \sqrt{4x + 8} \leq 9$.

Step 1 Note that the radicand has to be greater than or equal to zero. So, set the expression under the radical sign greater than or equal to zero and solve for x.

$$4x + 8 \geq 0 \rightarrow 4x \geq -8 \rightarrow x \geq -2$$

Step 2 Solve the inequality by isolating the radical and squaring both sides.

$$3 + \sqrt{4x + 8} \leq 9 \rightarrow \sqrt{4x + 8} \leq 6 \rightarrow 4x + 8 \leq 36 \rightarrow 4x \leq 28 \rightarrow x \leq 7$$

Step 3 It appears that the solution is $-2 \leq x \leq 7$, but you must make sure by checking each interval. Choose numbers below, in the middle, and above the numbers in the solution and substitute the values into the original inequality.

$3 + \sqrt{4(-3) + 8} \leq 9 \rightarrow 3 + \sqrt{-4} \leq 9$ ✗

$3 + \sqrt{4(2) + 8} \leq 9 \rightarrow 3 + 4 \leq 9 \rightarrow 7 \leq 9$ ✓

$3 + \sqrt{4(8) + 8} \leq 9 \rightarrow 3 + 6.32 \leq 9 \rightarrow 9.32 \leq 9$ ✗

So, $-2 \leq x \leq 7$ is correct.

Solve the inequality.

1. $\sqrt{4x + 1} + 2 \leq 7$
2. $(14 - 2x)^{1/2} - 6 > 4$
3. $\sqrt{3x + 6} + 2 \leq 5$
4. $\sqrt{x + 4} \geq 2 + \sqrt{x}$
5. $-3 + \sqrt{8x + 1} \geq 4$

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10.3 Puzzle Time

Did You Hear About …

A	**B**	**C**	**D**	**E**	**F**
G	**H**	**I**	**J**	**K**	**L**
M	**N**	**O**	**P**		

Complete each exercise. Find the answer in the answer column. Write the word under the answer in the box containing the exercise letter.

43 **SO**	
343 **ALWAYS**	
24 **BROTHERS**	
2 **ME**	
16 **WHO**	
5 **GOT**	
34 **OLDER**	
36 **THE**	

Solve the equation.

A. $\sqrt{q} - 8 = -2$

B. $\sqrt{a} + 14 = 24$

C. $5 - \sqrt{s} = 1$

D. $6\sqrt{w} - 19 = -1$

E. $\sqrt{b - 7} + 8 = 14$

F. $3\sqrt{y + 5} = 18$

G. $-9 = \sqrt{6r + 21} - 24$

H. $10 + 4\sqrt{4p - 15} = 46$

I. $\sqrt{3x - 8} = \sqrt{x}$

J. $\sqrt{2c - 11} = \sqrt{\frac{c}{3} + 9}$

K. $\sqrt[3]{r} = 7$

L. $\sqrt[3]{17 - 5t} = -2$

M. $\sqrt[3]{z - 4} = \sqrt[3]{3z + 4}$

N. $d = \sqrt{7d - 6}$

O. $\sqrt{14 - 5u} = u$

P. The radius of a circle r (in inches) can be modeled by $\sqrt{12r + 13} = r$. What is the radius r of the circle?

100 **DUCK**	
4 **THAT**	
−4 **THE**	
31 **MANY**	
13 **DOWNS**	
1, 6 **HAND**	
12 **HE**	
9 **HAD**	

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10.4 Start Thinking

Write a function rule with the x-values as inputs and y-values as outputs. Create a table of values and a graph for the rule.

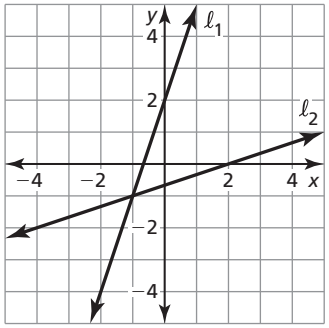
Follow the steps to create a new function rule:

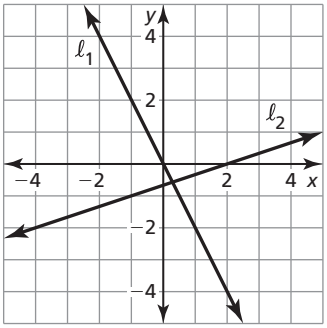
1. Replace $f(x)$ with y.
2. Switch x and y in the equation.
3. Solve for y.

Graph the new function rule on the same coordinate plane. What do you notice? Create a table of values for this function using the y-values in the original table as x-values in the new table. Compare the tables. What do you notice?

10.4 Warm Up

Determine whether ℓ_2 is a reflection in the line $y = x$ of ℓ_1.

1. 

2. 

10.4 Cumulative Review Warm Up

Factor the polynomial.

1. $x^2 - 9$
2. $y^2 - 1$
3. $9x^2 - 4$
4. $x^2 - 10x + 25$

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10.4 Practice A

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

1.

Input	−4	−2	0	0	2	4
Output	1	2	3	4	5	6

2.

Input	0	1	4	6	9	10
Output	−3	0	3	6	9	12

In Exercises 3–5, solve $y = f(x)$ for x. Then find the input when the output is 2.

3. $f(x) = x + 4$

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

5. $f(x) = \frac{1}{3}x + 2$

In Exercises 6–8, find the inverse of the function. Then graph the function and its inverse.

6. $f(x) = 5x - 3$

7. $f(x) = -3x + 1$

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

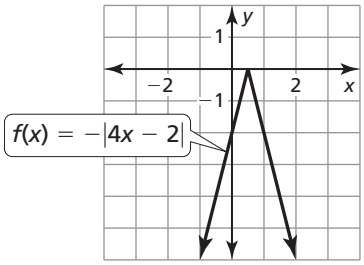
In Exercises 9 and 10, find the inverse of the function. Then graph the function and its inverse.

9. $f(x) = \frac{1}{4}x^2, x \geq 0$

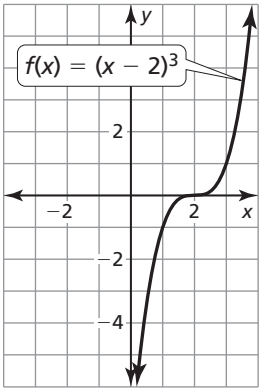
10. $f(x) = -x^2 + 3, x \leq 0$

In Exercises 11 and 12, use the Horizontal Line Test to determine whether the inverse of f is a function.

11.



12.



13. The temperature $-273.15°\text{C}$ is defined as being absolute zero. It is the basis for the Kelvin (K) temperature scale. The formula $C = K - 273.15$ converts a Kelvin temperature to a Celsius temperature.

a. Determine whether the inverse of the formula $C = K - 273.15$ is a function.

b. Using the formula $C = K - 273.15$, solve for K. Is this new formula the inverse of the formula $C = K - 273.15$? Explain.

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10.4 Practice B

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

1.

Input	−10	−5	0	5	10	15
Output	1	2	1	2	1	2

2.

Input	0	2	4	6	8	10
Output	7	2	−3	−8	−13	−18

In Exercises 3–5, solve $y = f(x)$ for x. Then find the input when the output is 2.

3. $f(x) = 4x + 5$

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

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

In Exercises 6–8, find the inverse of the function. Then graph the function and its inverse.

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

7. $f(x) = \frac{1}{2}x + 4$

8. $f(x) = -\frac{3}{4}x - \frac{1}{4}$

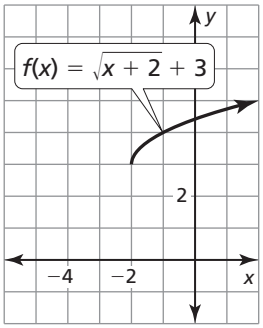
In Exercises 9 and 10, find the inverse of the function. Then graph the function and its inverse.

9. $f(x) = -2x^2 + 6, x \geq 0$

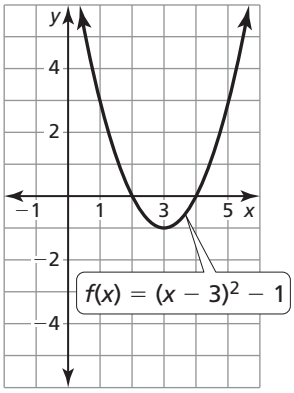
10. $f(x) = \frac{1}{4}x^2 - 1, x \leq 0$

In Exercises 11 and 12, use the Horizontal Line Test to determine whether the inverse of f is a function.

11.



12.



13. The formula $K = \frac{5}{9}(F - 32) + 273.15$ converts a Fahrenheit temperature to a Kelvin temperature. Solve the formula for F. Then find the Fahrenheit temperature for a Kelvin temperature of 310.15°K.

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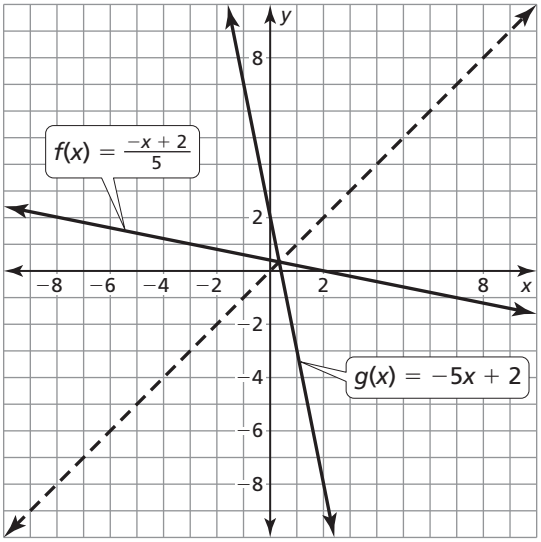
10.4 Enrichment and Extension

With inverse functions, the input and output are reversed. For instance, if $(-2, 5)$ is a point on the graph of a function, then $(5, -2)$ is a point on the graph of its inverse. That is, $f(-2) = 5$, and $f^{-1}(5) = -2$. If you substitute -2 into the first function, the output is 5. Similarly, when you substitute 5 into the inverse function, the output is -2. You end up back where you started. We use this same concept to prove that functions are inverses through composition. To prove inverse functions, you must compose two functions and show that the output reverts back to the original input value, x. This means that if $f(g(x)) = g(f(x)) = x$, where g composes with f to form an identity, the functions f and g are inverses.



Example: Prove $f(x) = \frac{-x + 2}{5}$ and $g(x) = -5x + 2$ are inverses through composition.

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

$$g(f(x)) = -5\left(\frac{-x + 2}{5}\right) + 2 = x - 2 + 2 = x$$

So, the functions are inverses.

Prove or disprove that the functions are inverses through composition.

1. $f(x) = 3x + 1$

$g(x) = \frac{x - 1}{3}$

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

$g(x) = \frac{x}{2}$

3. $f(x) = -\frac{1}{2}x + 3$

$g(x) = -2x + 6$

4. $f(x) = \frac{3}{2}x + 6$

$g(x) = \frac{2}{3}x - 4$

5. $f(x) = -x - 4$

$g(x) = x + 4$

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

$g(x) = \frac{x - 4}{3}$

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10.4 Puzzle Time

What Has Eight Flippers, Two Beach Balls, And Rides A Bicycle Built For Two?

Write the letter of each answer in the box containing the exercise number.

Solve $y = f(x)$ for x. Then find the input when the output is 6.

1. $f(x) = x + 9$

2. $f(x) = 4x - 10$

3. $f(x) = \frac{3}{5}x - 12$

4. $f(x) = 6x^2$

Find the inverse of the function.

5. $f(x) = 7x - 2$

6. $f(x) = -8x + 1$

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

8. $f(x) = \frac{2}{3}x + 6$

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

10. $f(x) = \frac{1}{36}x^2, x \geq 0$

11. $f(x) = \sqrt{x + 8}$

12. $f(x) = \sqrt{5x - 10}$

13. A cargo plane is flying at a height of 600 feet when it drops some packages. The height h (in feet) of the packages can be modeled by $h = -16t^2 + 600$, where t is the time (in seconds) since the cargo plane dropped them. Determine after how many seconds the packages will be 200 feet above the ground by solving the equation for t.

Answers

E. $-1, 1$

O. 4

S. 5

E. -3

L. 30

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

W. $g(x) = \frac{1}{5}x^2 + 2$

S. $g(x) = x^2 - 8$

L. $g(x) = \frac{1}{7}x + \frac{2}{7}$

N. $g(x) = \frac{1}{3}x + \frac{4}{3}$

H. $g(x) = \frac{3}{2}x - 9$

A. $g(x) = -\frac{1}{8}x + \frac{1}{8}$

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

11	4	6	3	9		2	7		12	8	1	10	5	13

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Chapter 10 Cumulative Review

Solve the equation, if possible.

1. $x + 3x + 4(x + 1) = 6(x - 1) + x$

2. $4|6y - 3| + 6 = 2$

Solve the inequality, if possible.

3. $|7h + 14| \geq 28$

4. $5 \geq -2(x + 1) - 3$

5. $4|3x + 9| + 2 > 14$

6. You have just been informed that your cell phone plan will be increasing in price. Your new pricing plan has a flat fee of $24.00 per month, plus a cost of $0.11 per minute of usage. Based on your budget, you have determined that you can only afford to use a maximum of 263 minutes per month. Based on this information, what is the highest amount you will pay for your cell phone per month?

7. Three times the quantity of a number x plus 4 is at least 20. Write this sentence as an inequality.

Graph the linear equation or linear inequality.

8. $y = -\frac{2}{5}x - 2$

9. $y < -4x + 2$

10. $y \geq -x$

Write the equation of the line in slope-intercept form that passes through the given point and is parallel to the given line.

11. $(-2, 4); y = 2x + 9$

12. $(8, 0); y + 2 = -\frac{1}{4}(x + 9)$

13. $(-8, -12); 18x - 9y = 27$

Solve the system of linear equations by graphing, substitution, or elimination.

14. $-x + 2y = 5$
$4x + 6y = -6$

15. $2x + 4y = -4$
$4x + 2y = 16$

16. $11x + 2y = 30$
$4x + y = 9$

17. You are planning a wedding. At Store A, the flowers cost $35.64 each bunch, and $62.00 for delivery. At Store B, the flowers cost $25.13 per bunch, and $120.00 for delivery. How many flower bunches should you purchase from Store B to get a better value?

Simplify the expression. Write your answer using only positive exponents.

18. $\frac{5^2 x^{-2} y^{-9} z^5}{10^2 x^7 y^{-8} z^6}$

19. $\frac{343m^{-10}}{49m^{-13}}$

20. $\frac{x^4 y^5 z^{-51}}{x^5 y^4 z^{-52}}$

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Chapter 10 Cumulative Review (continued)

Solve the equation. Check your solution.

21. $11^{2x+7} = 11^9$

22. $4^{3x+7} = 4^{x+9}$

23. $5^{9x} = 25^{4x+2}$

Find the sum or the difference.

24. $(-g - 12) + (g + 12)$

25. $(3y - 3) - (-3y - 3)$

Find the product.

26. $(x - 4)(x + 9)$

27. $(-2x - 8y)^2$

Factor the polynomial.

28. $m^2 - 8m - 20$

29. $z^2 + 11z - 42$

30. $3w^2 + 27w + 60$

31. A boulder is launched from the top of a tall cliff. The distance d (in feet) between the boulder and the ground t seconds after it is launched is given by $d = -16t^2 - 96t + 144$. Approximately how long after the boulder is launched does it hit the ground? Give your answer to two decimal places.

Solve the equation.

32. $z^2 - 1 = 0$

33. $y^2 + 20y + 100 = 0$

Factor the polynomial completely.

34. $2x^3 - 2x^2 - 5x + 5$

35. $10y^3 - 15y^2 - 4y + 6$

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

36. $h(x) = 0.25x^2$

37. $p(x) = 2x^2 - 5$

38. $q(x) = -6x^2 + 2$

39. The function $f(t) = -16t^2 + s_0$ represents the approximate height (in feet) of an object falling t seconds after it is dropped from an initial height s_0 (in feet). A tomato is dropped from a height of 1296 feet.

a. After how many seconds does the tomato hit the ground?

b. Suppose the initial height is adjusted by k feet. How will this affect the answer in part (a)?

Tell whether the function has a minimum value or a maximum value. Then find the value.

40. $f(x) = 2x^2 - 4x + 9$

41. $f(x) = -7x^2 + 28x - 9$

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Chapter 10 Cumulative Review (continued)

Find the vertex and the axis of symmetry of the graph of the function.

42. $f(x) = \frac{9}{2}(x + 7)^2$ **43.** $g(x) = 0.5(x - 9)^2$ **44.** $g(x) = 2(x - 1)^2 - 9$

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

45. $g(x) = \frac{7}{9}(x - 2)^2$ **46.** $g(x) = 5(x + 6)^2 + 1$

Simplify the expressions.

47. $\sqrt[3]{\frac{125x^7}{54y^4}}$ **48.** $\frac{8}{5 + \sqrt{7}}$ **49.** $-3\sqrt{3} - \sqrt{8} - 3\sqrt{3}$

Solve the equation by graphing.

50. $x^2 + 17x + 42 = 0$ **51.** $7x + 198 = x^2$

Solve the equation using square roots.

52. $2x^2 = 50$ **53.** $3x^2 = 3$ **54.** $2x^2 + 2 = 100$

Solve the equation by completing the square. Round your solutions to the nearest hundredth, if necessary.

55. $x^2 + 13x + 22 = 7$ **56.** $5y^2 - 21 = 10y$

57. You want to enclose a rectangular vegetable garden with 70 feet of fence, with one side of the garden being your garage. What should the dimensions of the garden be to maximize its area?

Solve the equation using the Quadratic Formula. Round your solutions to the nearest tenth, if necessary.

58. $9x^2 - 7x - 4 = 0$ **59.** $y^2 + 2y - 1 = 2$

Solve the system of equations by graphing, elimination, or substitution, if possible.

60. $y = x^2 - 5x + 7$
$y = 2x + 1$

61. $y - x^2 = 7 - 5x$
$4y - 8x = -21$

62. $y = x^2 - x - 6$
$y = 2x - 2$

63. A rectangle has an area of 40 square inches and a perimeter of 26 inches. Find the dimensions of the rectangle.

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Chapter 10 Cumulative Review (continued)

Describe the domain of the function.

64. $y = 2\sqrt{x}$

65. $y = \sqrt{x + 9}$

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

67. $y = \frac{1}{3}\sqrt{5x}$

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

69. $g(x) = \frac{3}{4}\sqrt{-x + 5}$

Graph the function. Describe the range.

70. $f(x) = \sqrt{x} + 2$

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

72. $h(x) = 2\sqrt{x}$

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

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

74. $g(x) = \sqrt[3]{x} + 4$

75. $p(x) = 7\sqrt[3]{x}$

76. $d(x) = 4\sqrt[3]{x + 2} - 1$

77. $c(x) = \frac{1}{2}\sqrt[3]{x - 1} + 2$

78. $j(x) = 0.25\sqrt[3]{x + 2}$

Solve the equation. Check your solution.

79. $\sqrt{x} = 5$

80. $\sqrt{x} - 4 = 2$

81. $5 - \sqrt{y} = -2$

82. $\sqrt{w - 2} + 4 = 7$

83. $2\sqrt{r - 2} = 20$

84. $-3 = \sqrt{4x + 12} - 7$

85. $\sqrt{5x - 8} = \sqrt{x}$

86. $\sqrt{7x + 5} = \sqrt{4x + 17}$

Find the inverse of each relation.

87.

Input	−2	−1	0	1	2	3	4
Output	6	5	4	3	2	1	0

88.

Input	5	2	−1	−4	−7	−10	−13
Output	−9	−5	−1	3	7	11	15

Find the inverse, $g(x)$ of the given function.

89. $f(x) = 3x + 10$

90. $f(x) = \frac{1}{5}x + 2$

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