1.7 Exercises

VOCABULARY CHECK:
In Exercises 1–5, fill in the blanks.

1. Horizontal shifts, vertical shifts, and reflections are called rigid transformations.

2. A reflection in the x-axis of y = f(x) is represented by h(x) = -f(x), while a reflection in the y-axis of y = f(x) is represented by h(x) = f(-x).

3. Transformations that cause a distortion in the shape of the graph of y = f(x) are called nonrigid transformations.

4. A nonrigid transformation of y = f(x) represented by h(x) = f(cx) is a horizontal stretch if c > 1 and a horizontal shrink if 0 < c < 1.

5. A nonrigid transformation of y = f(x) represented by g(x) = cf(x) is a vertical stretch if c > 1 and a vertical shrink if 0 < c < 1.

6. Match the rigid transformation of y = f(x) with the correct representation of the graph of h, where c > 0.

(a) h(x) = f(x) + c
   (i) A horizontal shift of f, c units to the right
(b) h(x) = f(x) - c
   (ii) A vertical shift of f, c units downward
(c) h(x) = f(x + c)
   (iii) A horizontal shift of f, c units to the left
(d) h(x) = f(x - c)
   (iv) A vertical shift of f, c units upward

1–4. See margin.

1. For each function, sketch (on the same set of coordinate axes) a graph of each function for c = -1, 1, and 3.

(a) f(x) = |x| + c
(b) f(x) = |x - c|
(c) f(x) = |x + 4| + c

2. For each function, sketch (on the same set of coordinate axes) a graph of each function for c = -3, -1, 1, and 3.

(a) f(x) = \sqrt{x} + c
(b) f(x) = \sqrt{x - c}
(c) f(x) = \sqrt{x - 3} + c

3. For each function, sketch (on the same set of coordinate axes) a graph of each function for c = -2, 0, and 2.

(a) f(x) = |x| + c
(b) f(x) = |x + c|
(c) f(x) = |x - 1| + c

4. For each function, sketch (on the same set of coordinate axes) a graph of each function for c = -3, -1, 1, and 3.

(a) f(x) = \begin{cases} x^2 + c, & x < 0 \\ -x^2 + c, & x \geq 0 \end{cases}
(b) f(x) = \begin{cases} (x + c)^2, & x < 0 \\ -(x + c)^2, & x \geq 0 \end{cases}

In Exercises 5–8, use the graph of f to sketch each graph. To print an enlarged copy of the graph go to the website www.mathgraphs.com.

5. (a) y = f(x) + \frac{1}{2}
   (b) y = f(x - 2)
   (c) y = f(x)
   (d) y = f(x + 3)
   (f) y = f(-x)
   (g) y = f(\frac{1}{3}x)

6. (a) y = f(-x)
   (b) y = f(x + 4)
   (c) y = 2f(x)
   (d) y = -f(x - 4)
   (e) y = f(x - 3)
   (f) y = -f(x - 1)
   (g) y = f(2x)

7. (a) y = f(x) - 1
   (b) y = f(x - 1)
   (c) y = f(-x)
   (d) y = f(x + 1)
   (e) y = -f(x - 2)
   (f) y = \frac{1}{2}f(x)
   (g) y = f(2x)

8. (a) y = f(x - 5)
   (b) y = -f(x) + 3
   (c) y = \frac{1}{2}f(x)
   (d) y = -f(x + 1)
   (e) y = f(-x)
   (f) y = f(x) - 10
   (g) y = f(\frac{1}{3}x)
9. Use the graph of \( f(x) = x^3 \) to write an equation for each function whose graph is shown. See margin.

(a) \[ \text{Graph} \]
(b) \[ \text{Graph} \]

10. Use the graph of \( f(x) = x^3 \) to write an equation for each function whose graph is shown. See margin.

(a) \[ \text{Graph} \]
(b) \[ \text{Graph} \]

12. Use the graph of \( f(x) = \sqrt{x} \) to write an equation for each function whose graph is shown. See margin.

(a) \[ \text{Graph} \]
(b) \[ \text{Graph} \]

In Exercises 13–18, identify the parent function and the transformation shown in the graph. Write an equation for the function shown in the graph.

13. \[ \text{Graph} \]
Horizontal shift of \( y = x^3; \)
\( y = (x - 2)^3 \)

14. \[ \text{Graph} \]
Vertical shrink of \( y = x; \)
\( y = \frac{1}{2}x \)
15–18. See margin.

19. \( g(x) = 12 - x^2 \)
20. \( g(x) = (x - 8)^2 \)
21. \( g(x) = x^3 + 7 \)
22. \( g(x) = -x^3 - 1 \)
23. \( g(x) = \frac{3}{2}x^2 + 4 \)
24. \( g(x) = 2(x-7)^2 \)
25. \( g(x) = 2 - (x + 5)^2 \)
26. \( g(x) = -(x+10)^2 + 5 \)
27. \( g(x) = \sqrt[3]{x} \)
28. \( g(x) = \frac{1}{\sqrt[3]{x}} \)
29. \( g(x) = (x - 1)^3 + 2 \)
30. \( g(x) = (x + 3)^3 - 10 \)
31. \( g(x) = -|x| - 2 \)
32. \( g(x) = 6 - |x + 5| \)
33. \( g(x) = -|x + 4| + 8 \)
34. \( g(x) = |x - 3| + 9 \)
35. \( g(x) = 3 - [x] \)
36. \( g(x) = 2[x + 5] \)
37. \( g(x) = \sqrt{x} - 9 \)
38. \( g(x) = \sqrt{x} + 4 + 8 \)
39. \( g(x) = \sqrt[3]{7-x} - 2 \)
40. \( g(x) = -\sqrt[3]{x} + 1 - 6 \)
41. \( g(x) = \sqrt[3]{x} - 4 \)
42. \( g(x) = \sqrt[3]{x^4} + 1 \)

In Exercises 43–50, write an equation for the function that is described by the given characteristics.

43. The shape of \( f(x) = x^2 \), but moved two units to the right and eight units downward
44. The shape of \( f(x) = x^3 \), but moved three units to the left, seven units upward, and reflected in the \( x \)-axis
45. The shape of \( f(x) = x^3 \), but moved 13 units to the right
46. The shape of \( f(x) = x^3 \), but moved six units to the left, six units downward, and reflected in the \( y \)-axis
47. The shape of \( f(x) = |x| \), but moved 10 units upward and reflected in the \( x \)-axis
48. The shape of \( f(x) = |x| \), but moved one unit to the left and seven units downward

49. The shape of \( f(x) = \sqrt{x} \), but moved six units to the left and reflected in both the \( x \)-axis and the \( y \)-axis
50. The shape of \( f(x) = \sqrt{x} \), but moved nine units downward and reflected in both the \( x \)-axis and the \( y \)-axis
51. Use the graph of \( f(x) = x^2 \) to write an equation for each function whose graph is shown.

52. Use the graph of \( f(x) = x^2 \) to write an equation for each function whose graph is shown.

53. Use the graph of \( f(x) = |x| \) to write an equation for each function whose graph is shown.

54. Use the graph of \( f(x) = \sqrt{x} \) to write an equation for each function whose graph is shown.
Graphical Analysis  In Exercises 61–64, use the viewing window shown to write a possible equation for the transformation of the parent function.

61. \( y = -(x - 2)^3 + 2 \)  
62. \( y = |x + 4| - 2 \)

63. \( y = -\sqrt{x} - 3 \)  
64. \( y = (x - 2)^2 + 4 \)

Model It

67. Fuel Use  The amounts of fuel \( F \) (in billions of gallons) used by trucks from 1980 through 2002 can be approximated by the function \( F = f(t) = 20.6 + 0.035t^2 \) \( 0 \leq t \leq 22 \) where \( t \) represents the year, with \( t = 0 \) corresponding to 1980. (Source: U.S. Federal Highway Administration)

(a) Describe the transformation of the parent function \( f(x) = x^2 \). Then sketch the graph over the specified domain.

(b) Find the average rate of change of the function from 1980 to 2002. Interpret your answer in the context of the problem.

(c) Rewrite the function so that \( t = 0 \) represents 1990. Explain how you got your answer.

(d) Use the model from part (c) to predict the amount of fuel used by trucks in 2010. Does your answer seem reasonable? Explain.
1.8 Exercises

VOCABULARY CHECK: Fill in the blanks.

1. Two functions \( f \) and \( g \) can be combined by the arithmetic operations of _______, _______, _______, and _______ to create new functions. addition; subtraction; multiplication; division

2. The _______ of the function \( f \) with \( g \) is \((f \circ g)(x) = f(g(x))\). composition

3. The domain of \((f \circ g)\) is all \( x \) in the domain of \( g \) such that \( g(x) \) is in the domain of \( f \).

4. To decompose a composite function, look for an _______ function and an _______ function.

In Exercises 1–4, use the graphs of \( f \) and \( g \) to graph \( h(x) = (f + g)(x) \). To print an enlarged copy of the graph, go to the website www.mathgraphs.com. 1–4. See margin.

1. 

2. 

3. 

4. 

5–12. See margin.

In Exercises 5–12, find (a) \((f + g)(x)\), (b) \((f - g)(x)\), (c) \((fg)(x)\), and (d) \((f/g)(x)\). What is the domain of \(f/g\)?

5. \( f(x) = x + 2 \), \( g(x) = x - 2 \)
6. \( f(x) = 2x - 5 \), \( g(x) = 2 - x \)
7. \( f(x) = x^2 \), \( g(x) = 4x - 5 \)
8. \( f(x) = 2x - 5 \), \( g(x) = 4 \)
9. \( f(x) = x^2 + 6 \), \( g(x) = \sqrt{1 - x} \)
10. \( f(x) = \sqrt{x^2 - 4} \), \( g(x) = \frac{x^2}{x^2 + 1} \)
11. \( f(x) = \frac{1}{x} \), \( g(x) = \frac{1}{x^2} \)
12. \( f(x) = \frac{x}{x + 1} \), \( g(x) = x^3 \)

In Exercises 13–24, evaluate the indicated function for \( f(x) = x^2 + 1 \) and \( g(x) = x - 4 \).

13. \((f + g)(2)\) 14. \((f - g)(-1)\) 15. \((f - g)(0)\) 16. \((f + g)(1)\) 17. \((f - g)(3)\) 18. \((f + g)(-2)\) 19. \((f/g)(6)\) 20. \((fg)(-6)\) 21. \((f/g)(5)\) 22. \((fg)(0)\) 23. \((f/g)(-1) - g(3)\) 24. \((f/g)(5) + f(4)\)

In Exercises 25–28, graph the functions \(f, g\), and \(f + g\) on the same set of coordinate axes. 25–28. See margin.

25. \( f(x) = \frac{1}{3}x \), \( g(x) = x - 1 \)
26. \( f(x) = \frac{1}{3}x \), \( g(x) = -x + 4 \)
27. \( f(x) = x^2 \), \( g(x) = -2x \)
28. \( f(x) = 4 - x^2 \), \( g(x) = x \)

Graphical Reasoning In Exercises 29 and 30, use a graphing utility to graph \(f, g\), and \(f + g\) in the same viewing window. Which function contributes most to the magnitude of the sum when \(0 \leq x \leq 27\) Which function contributes most to the magnitude of the sum when \(x > 67\)? 29–30. See margin.

29. \( f(x) = 3x \), \( g(x) = -\frac{x^3}{10} \)
30. \( f(x) = \frac{x}{2} \), \( g(x) = \sqrt{x} \)

In Exercises 31–34, find (a) \(f \circ g\), (b) \(g \circ f\), and (c) \(f \circ f\).

31. \( f(x) = x^3 \), \( g(x) = x - 1 \)
32. \( f(x) = 3x + 5 \), \( g(x) = 5 - x \)
33. \( f(x) = \sqrt{x - 1} \), \( g(x) = x^3 + 1 \)
34. \( f(x) = x^3 \), \( g(x) = \frac{1}{x} \)

5. (a) \( 2x \) (b) \( 4 \) (c) \( x^2 - 4 \) (d) \( \frac{1}{x} \) (all real numbers) 8. (a) \( 2x - 1 \) (b) \( 2x - 9 \) (c) \( 8x - 20 \) (d) \( \frac{1}{x} \) (all real numbers)
64. **Physics** A pebble is dropped into a calm pond, causing ripples in the form of concentric circles (see figure). The radius \( r \) (in feet) of the outer ripple is \( r(t) = 0.6t \), where \( t \) is the time in seconds after the pebble strikes the water. The area \( A \) of the circle is given by the function \( A(r) = \pi r^2 \). Find and interpret \((A \circ r)(t)\).

65. **Bacteria Count** The number \( N \) of bacteria in a refrigerated food is given by

\[
N(T) = 10T^2 - 20T + 600, \quad 1 \leq T \leq 20
\]

where \( T \) is the temperature of the food in degrees Celsius. When the food is removed from refrigeration, the temperature of the food is given by

\[
T(t) = 3t + 2, \quad 0 \leq t \leq 6
\]

where \( t \) is the time in hours.

(a) Find the composition \( N(T(t)) \) and interpret its meaning in context.

(b) Find the time when the bacterial count reaches 1500.

66. **Cost** The weekly cost \( C \) of producing \( x \) units in a manufacturing process is given by

\[
C(x) = 60x + 750.
\]

The number of units \( x \) produced in \( t \) hours is given by \( x(t) = 50t \).

(a) Find and interpret \((C \circ x)(t)\).

(b) Find the time that must elapse in order for the cost to increase to $15,000.

67. **Salary** You are a sales representative for a clothing manufacturer. You are paid an annual salary, plus a bonus of 3% of your sales over $500,000. Consider the two functions given by

\[
f(x) = x - 500,000 \quad \text{and} \quad g(x) = 0.03x.
\]

If \( x \) is greater than $500,000, which of the following represents your bonus? Explain your reasoning.

(a) \( f(g(x)) \)  
(b) \( g(f(x)) \)

68. **Consumer Awareness** The suggested retail price of a new hybrid car is \( p \) dollars. The dealership advertises a factory rebate of $2000 and a 10% discount. See margin.

(a) Write a function \( R \) in terms of \( p \) giving the cost of the hybrid car after receiving the rebate from the factory.

(b) Write a function \( S \) in terms of \( p \) giving the cost of the hybrid car after receiving the dealership discount.

(c) Form the composite functions \((R \circ S)(p)\) and \((S \circ R)(p)\) and interpret each.

(d) Find \((R \circ S)(20,500)\) and \((S \circ R)(20,500)\). Which yields the lower cost for the hybrid car? Explain.

**Synthesis**

**True or False?** In Exercises 69 and 70, determine whether the statement is true or false. Justify your answer.

69. If \( f(x) = x + 1 \) and \( g(x) = 6x \), then

\[
(f \circ g)(x) = (g \circ f)(x).
\]

60. If you are given two functions \( f(x) \) and \( g(x) \), you can calculate \((f \circ g)(x)\) if and only if the range of \( g \) is a subset of the domain of \( f \). See margin.

71. **Proof** Prove that the product of two odd functions is an even function, and that the product of two even functions is an even function. Answers will vary.

72. **Conjecture** Use examples to hypothesize whether the product of an odd function and an even function is even or odd. Then prove your hypothesis. Proofs will vary.

**Skills Review**

**Average Rate of Change** In Exercises 73–76, find the difference quotient

\[
\frac{f(x + h) - f(x)}{h}
\]

and simplify your answer.

73. \( f(x) = 3x - 4 \)

74. \( f(x) = 1 - x^2 \)

75. \( f(x) = \frac{4}{x} \)

76. \( f(x) = \sqrt{2x + 1} \)

In Exercises 77–80, find an equation of the line that passes through the given point and has the indicated slope. Sketch the line.

77. \((2, -4), m = 3\)

78. \((-6, 3), m = -1\)

79. \((8, -1), m = -\frac{3}{2}\)

80. \((7, 0), m = \frac{5}{3}\)
1.9 Exercises

VOCABULARY CHECK: Fill in the blanks.
1. If the composite functions \( f(g(x)) = x \) and \( g(f(x)) = x \) then the function \( g \) is the \underline{inverse} function of \( f \), inverse; \( f \)-inverse.
2. The domain of \( f \) is the \underline{range} of \( f^{-1} \), and the \underline{domain} of \( f^{-1} \) is the range of \( f \).
3. The graphs of \( f \) and \( f^{-1} \) are reflections of each other in the line \( y = x \).
4. A function \( f \) is \underline{one-to-one} if each value of the independent variable corresponds to exactly one value of the dependent variable.
5. A graphical test for the existence of an inverse function of \( f \) is called the \underline{Line} Test. horizontal

In Exercises 1–8, find the inverse function of \( f \) informally. Verify that \( f(f^{-1}(x)) = x \) and \( f^{-1}(f(x)) = x \). 1–8. See margin.

1. \( f(x) = 6x \)
2. \( f(x) = \frac{1}{2}x \)
3. \( f(x) = x + 9 \)
4. \( f(x) = x - 4 \)
5. \( f(x) = 3x + 1 \)
6. \( f(x) = \frac{x - 1}{5} \)
7. \( f(x) = \frac{3}{x} \)
8. \( f(x) = x^2 \)

In Exercises 9–12, match the graph of the function with the graph of its inverse function. [The graphs of the inverse functions are labeled (a), (b), (c), and (d).]

11. \( y = a \)
12. \( y = d \)

In Exercises 13–24, show that \( f \) and \( g \) are inverse functions (a) algebraically and (b) graphically. 13–24. See margin.

13. \( f(x) = 2x \)
14. \( f(x) = x - 5 \)
15. \( f(x) = 7x + 1 \)
16. \( f(x) = 3 - 4x \)
17. \( f(x) = \frac{x^3}{8} \)
18. \( f(x) = \frac{1}{x} \)
19. \( f(x) = \sqrt{x - 4} \)
20. \( f(x) = 1 - x^3 \)
21. \( f(x) = 9 - x^2, \ x \geq 0 \)
22. \( f(x) = \frac{1}{1 + x}, \ x \geq 0 \)
23. \( f(x) = \frac{x - 1}{x + 5}, \ x \leq 0 \)
24. \( f(x) = \frac{x + 3}{x - 2} \)

14. (a) \( f(g(x)) = f(x + 5) = (x + 5) - 5 = x \)
(b) \( g(f(x)) = g(x - 5) = (x - 5) + 5 = x \)

15. (a) \( f(g(x)) = f\left(\frac{x - 1}{7}\right) = \frac{x - 1}{7} + 1 = x \)
(b) \( g(f(x)) = g(7x + 1) = \frac{(7x + 1) - 1}{7} = x \)
In Exercises 25 and 26, does the function have an inverse function?

25. \[
\begin{array}{c|cccccc}
  x & -1 & 0 & 1 & 2 & 3 & 4 \\
f(x) & -2 & 1 & 2 & 1 & -2 & -6 \\
\end{array}
\] Yes

26. \[
\begin{array}{c|cccc}
  x & -3 & -2 & -1 & 0 \\
f(x) & 10 & 6 & 4 & 1 \\
\end{array}
\] Yes

In Exercises 27 and 28, use the table of values for \( y = f(x) \) to complete a table for \( y = f^{-1}(x) \). 27–28. See margin.

27. \[
\begin{array}{c|cccc}
  x & -2 & -1 & 0 & 1 \\
f(x) & -2 & 0 & 2 & 4 \\
\end{array}
\] 3, 6, 8

28. \[
\begin{array}{c|cccc}
  x & -3 & -2 & -1 & 0 \\
f(x) & -10 & -7 & -4 & -1 \\
\end{array}
\] 2, 5

In Exercises 29–32, does the function have an inverse function?

29. Yes

30. No

31. No

32. Yes

In Exercises 33–38, use a graphing utility to graph the function, and use the Horizontal Line Test to determine whether the function is one-to-one and so has an inverse function. 33–38. See margin.

33. \( g(x) = \frac{4 - x}{6} \)

34. \( f(x) = 10 \)

35. \( h(x) = |x + 4| - |x - 4| \)

36. \( g(x) = (x + 5)^2 \)

37. \( f(x) = -2x - \sqrt{16 - x^2} \)

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

In Exercises 39–54, (a) find the inverse function of \( f \), (b) graph both \( f \) and \( f^{-1} \) on the same set of coordinate axes, (c) describe the relationship between the graphs of \( f \) and \( f^{-1} \), and (d) state the domain and range of \( f \) and \( f^{-1} \). 39–54. See margin.

39. \( f(x) = 2x - 3 \)

40. \( f(x) = 3x + 1 \)

41. \( f(x) = x^3 - 2 \)

42. \( f(x) = x^3 + 1 \)

43. \( f(x) = \sqrt{x} \)

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

45. \( f(x) = \sqrt{4 - x^2}, \ 0 \leq x \leq 2 \)

46. \( f(x) = x^2 - 2, \ x \leq 0 \)

47. \( f(x) = \frac{4}{x} \)

48. \( f(x) = \frac{2}{x} \)

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

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

51. \( f(x) = \sqrt{x - 1} \)

52. \( f(x) = x^{1/2} \)

53. \( f(x) = \frac{6x + 4}{4x + 5} \)

54. \( f(x) = \frac{8x - 4}{2x + 6} \)

In Exercises 55–68, determine whether the function has an inverse function. If it does, find the inverse function.

55. \( f(x) = x^2 \) No inverse

56. \( f(x) = \frac{1}{x^2} \) No inverse

57. \( g(x) = \frac{x}{8} \) \( g^{-1}(x) = 8x \)

58. \( f(x) = 3x + 5 \)

59. \( p(x) = -4 \) No inverse

60. \( f(x) = \frac{x - 5}{x + 4} \)

61. \( f^{-1}(x) = \sqrt{x - 3} \)

62. No inverse

63. \( f(x) = \begin{cases} x + 3, & x < 0 \\ -x, & x \geq 0 \end{cases} \)

64. No inverse

65. \( h(x) = -\frac{4}{x^2} \)

66. No inverse

67. \( f(x) = \sqrt{2x + 3} \) No inverse

68. \( f(x) = -\sqrt{x - 2} \)

(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).

(d) The domain of \( f \) is the range of \( f^{-1} \).

(e) The range of \( f \) is the domain of \( f^{-1} \).
In Exercises 69–74, use the functions given by \( f(x) = \frac{1}{4}x - 3 \) and \( g(x) = x^2 \) to find the indicated value or function.

69. \((g \circ f)^{-1}(1)\) 32

70. \((g \circ f^{-1})(-3)\) 0

71. \((f \circ g)^{-1}(6)\) 600

72. \((g^{-1} \circ f^{-1})(-4)\) \(\sqrt{2}\)

73. \((f \circ g)^{-1}\left(\frac{3}{2}\right)\) \(\frac{2}{3}\)

74. \((g^{-1} \circ f^{-1})(2)\) \(\frac{3}{2}\)

In Exercises 75–78, use the functions given by \( f(x) = x + 4 \) and \( g(x) = 2x - 5 \) to find the specified function.

75. \((g^{-1} \circ f^{-1})(2)\) \(\frac{3}{2}\)

76. \((f^{-1} \circ g^{-1})(x - 3)\) \(x + 1\)

77. \((f \circ g)^{-1}\left(\frac{3}{2}\right)\) \(x + 1\)

78. \((g \circ f)^{-1}(x - 3)\) \(x + 1\)

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**Model It**

**79. U.S. Households** The numbers of households \( f \) (in thousands) in the United States from 1995 to 2003 are shown in the table. The time (in years) is given by \( t \), with \( t = 5 \) corresponding to 1995. (Source: U.S. Census Bureau) See margin.

<table>
<thead>
<tr>
<th>Year, ( t )</th>
<th>Households, ( f(t) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>98,990</td>
</tr>
<tr>
<td>6</td>
<td>99,627</td>
</tr>
<tr>
<td>7</td>
<td>101,018</td>
</tr>
<tr>
<td>8</td>
<td>102,528</td>
</tr>
<tr>
<td>9</td>
<td>103,874</td>
</tr>
<tr>
<td>10</td>
<td>104,705</td>
</tr>
<tr>
<td>11</td>
<td>108,209</td>
</tr>
<tr>
<td>12</td>
<td>109,297</td>
</tr>
<tr>
<td>13</td>
<td>111,278</td>
</tr>
</tbody>
</table>

(a) Find \( f^{-1}(108,209) \).
(b) What does \( f^{-1} \) mean in the context of the problem?
(c) Use the regression feature of a graphing utility to find a linear model for the data, \( y = mx + b \). (Round \( m \) and \( b \) to two decimal places.)
(d) Algebraically find the inverse function of the linear model in part (c).
(e) Use the inverse function of the linear model you found in part (d) to approximate \( f^{-1}(110,022) \).
(f) Use the inverse function of the linear model you found in part (d) to approximate \( f^{-1}(108,209) \). How does this value compare with the original data shown in the table?

---

(a) Does \( f^{-1} \) exist? Yes
(b) If \( f^{-1} \) exists, what does it represent in the context of the problem? See margin.
(c) If \( f^{-1} \) exists, find \( f^{-1}(1825) \). \( f^{-1}(1825) = 10 \)
(d) If the table was extended to 2004 and if the factory sales of digital cameras for that year was \$2794 million, would \( f^{-1} \) exist? Explain. See margin.

---

**80. Digital Camera Sales** The factory sales \( f \) (in millions of dollars) of digital cameras in the United States from 1998 through 2003 are shown in the table. The time (in years) is given by \( t \), with \( t = 8 \) corresponding to 1998. (Source: Consumer Electronics Association)

<table>
<thead>
<tr>
<th>Year, ( t )</th>
<th>Sales, ( f(t) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>519</td>
</tr>
<tr>
<td>9</td>
<td>1209</td>
</tr>
<tr>
<td>10</td>
<td>1825</td>
</tr>
<tr>
<td>11</td>
<td>1972</td>
</tr>
<tr>
<td>12</td>
<td>2794</td>
</tr>
<tr>
<td>13</td>
<td>3421</td>
</tr>
</tbody>
</table>

(a) Does \( f^{-1} \) exist? Yes
(b) If \( f^{-1} \) exists, what does \( f^{-1} \) represent in the context of the problem?
(c) If \( f^{-1} \) exists, find \( f^{-1}(1825) \). \( f^{-1}(1825) = 10 \)
(d) If the table was extended to 2004 and if the factory sales of digital cameras for that year was \$2794 million, would \( f^{-1} \) exist? Explain. See margin.

---

**81. Miles Traveled** The total numbers \( f \) (in billions) of miles traveled by motor vehicles in the United States from 1995 through 2002 are shown in the table. The time (in years) is given by \( t \), with \( t = 5 \) corresponding to 1995. (Source: U.S. Federal Highway Administration)

<table>
<thead>
<tr>
<th>Year, ( t )</th>
<th>Miles traveled, ( f(t) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2423</td>
</tr>
<tr>
<td>6</td>
<td>2486</td>
</tr>
<tr>
<td>7</td>
<td>2562</td>
</tr>
<tr>
<td>8</td>
<td>2632</td>
</tr>
<tr>
<td>9</td>
<td>2691</td>
</tr>
<tr>
<td>10</td>
<td>2747</td>
</tr>
<tr>
<td>11</td>
<td>2797</td>
</tr>
<tr>
<td>12</td>
<td>2856</td>
</tr>
</tbody>
</table>

(a) Does \( f^{-1} \) exist? Yes
(b) If \( f^{-1} \) exists, what does \( f^{-1} \) represent in the context of the problem?
(c) If \( f^{-1} \) exists, find \( f^{-1}(2632) \). \( f^{-1}(2632) = 8 \)
(d) No. \( f(t) \) would not pass the Horizontal Line Test.

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44. (a) \( f^{-1}(x) = \sqrt{x} \)
(b) All \( x \geq 0 \)

79. (a) \( f^{-1}(108,209) = 11 \)
(b) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers such that \( x \geq 0 \).

(f) \( f^{-1}(108,209) = 11,418 \); the results are similar.

80. (b) \( f^{-1} \) represents the time in years for a given sales level.