Chapter 1
Section 1.1 (page 9)
Vocabulary Check (page 9)
1. (a) v (b) vi (c) i (d) iv (e) iii (f) ii
2. Cartesian 3. Distance Formula
4. Midpoint Formula

1. A: (2, 6), B: (−6, −2), C: (4, −4), D: (−3, 2)
2. A: (−3, −4), B: (0, −2), C: (−3, −2), D: (−6, 0)
3. 4.

5.

6.

7. (−3, 4) 8. (4, −8) 9. (−5, −5)
10. (−12, 0) 11. Quadrant IV 12. Quadrant III
13. Quadrant II 14. Quadrant I
15. Quadrant III or IV 16. Quadrant I or IV
17. Quadrant III 18. Quadrant III
19. Quadrant I or III 20. Quadrant II or IV
21.
22.

23. 8 24. 7 25. 5 26. 10
27. (a) 4, 3, 5 (b) $4^2 + 3^2 = 5^2$
28. (a) 5, 12, 13 (b) $5^2 + 12^2 = 13^2$
29. (a) 10, 3, $\sqrt{109}$ (b) $10^2 + 3^2 = (\sqrt{109})^2$
30. (a) 4, 7, $\sqrt{65}$ (b) $4^2 + 7^2 = (\sqrt{65})^2$
31. (a) (b) 10 (c) (5, 4)
32. (a) (b) 13 (c) $\left(\frac{1}{2}, 6\right)$
33. (a) (b) 17 (c) $\left(0, \frac{5}{2}\right)$
34. (a) (b) 15 (c) $\left(-\frac{5}{2}, 2\right)$
(Continued)

35. (a) (b) \(2\sqrt{10}\)
(c) \((2, 3)\)

36. (a)
(b) \(8\sqrt{2}\)
(c) \((6, 6)\)

37. (a)
(b) \(\frac{5\sqrt{3}}{3}\)
(c) \((-1, \frac{2}{3})\)

38. (a)
(b) \(\frac{\sqrt{3}}{6}\)
(c) \((-\frac{1}{2}, -\frac{5}{12})\)

39. (a)
(b) \(\sqrt{110.97}\)
(c) \((1.25, 3.6)\)

40. (a)
(b) \(\sqrt{566.52}\)
(c) \((-5.6, 8.6)\)

41. \((\sqrt{3})^2 + (\sqrt{45})^2 = (\sqrt{50})^2\)

42. Distances between the points: \(\sqrt{29}, \sqrt{58}, \sqrt{29}\)

43. \((2x - x_1, 2y - y_1)\)

44. (a) \((7, 0)\) (b) \((9, -3)\)

45. \(\left(\frac{3x_1 + x_2}{4}, \frac{3y_1 + y_2}{4}\right),\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)\)

46. (a) \((\frac{5}{4}, -\frac{3}{2}), (\frac{5}{4}, -\frac{9}{2})\)
(b) \((-\frac{3}{2}, -\frac{1}{2}), (-1, -\frac{3}{2}), (-\frac{1}{2}, -\frac{5}{2})\)

47. \(2\sqrt{505} \approx 45\) yards

48. \(30\sqrt{11} \approx 192\) kilometers

49. \$3803.5 million

50. \$2393.5 million

51. \((0, 1), (4, 2), (1, 4)\)

52. \((3, 3), (1, 0), (3, -3), (5, 0)\)

53. \((-3, 6), (2, 10), (2, 4), (-3, 4)\)

54. \((-5, 2), (-7, 0), (-3, 0), (-5, -4)\)

55. \$3.31 per pound; 2001

56. \(\approx 91\%\)

57. \(\approx 250\%\)

58. (a) \(\approx 25\%\) (b) \(\approx 147\%\)

59. (a) The number of artists elected each year seems to be nearly steady except for the first few years. From six to eight artists will be elected in 2008.
(b) The Rock and Roll Hall of Fame was opened in 1986.

60. (a) 1990s (b) 26.5%; 21.2% (c) $6.24
(d) Answers will vary.

61. 1998: \$19,384.5 million; 2000: \$20,223.0 million; 2002: \$21,061.5 million

62. (a)
(b) \(65\)

63. (c) No. There are many variables that will affect the final exam score.
(Continued)

63. \( 3 \sqrt{\frac{4.47}{\pi}} \approx 1.12 \text{ inches} \)

64. \( \frac{603.2}{4\pi} \approx 48 \text{ feet} \)

65. Length of side = 43 centimeters; area = 800.64 square centimeters

66. 34 centimeters

67. (a) \( l = 1.5w; \ p = 5w \)
   (b) 7.5 meters \times 5 \text{ meters}
   (c) Answers will vary. Sample answer: Technology now enables us to transport information in many ways other than by mail. The Internet is one example.

68. (a) \( w = 1.25h; \ V = (20 \text{ inches})h^2 \)
   (b) 10 inches, \( w = 12.5 \text{ inches}, \ l = 16 \text{ inches} \)
   (c) Answers will vary. Sample answer: Technology now enables us to transport information in many ways other than by mail. The Internet is one example.

69. (a) Answers will vary. Sample answer: Technology now enables us to transport information in many ways other than by mail. The Internet is one example.

70. (a) Answers will vary. Sample answer: Technology now enables us to transport information in many ways other than by mail. The Internet is one example.

72. (a) First Set Second Set
   Distance A to B 3 \( \sqrt{10} \)
   Distance B to C 5 \( \sqrt{10} \)
   Distance A to C 4 \( \sqrt{16} \)
   Right triangle Isosceles triangle

(b) The first set of points is not collinear. The second set of points is collinear.

(c) Answers will vary. Sample answer: Technology now enables us to transport information in many ways other than by mail. The Internet is one example.

73. False. The Midpoint Formula would be used 15 times.

74. True. Two sides of the triangle have lengths of \( \sqrt{149} \), and the third side has a length of \( \sqrt{18} \).

75. No. It depends on the magnitudes of the quantities measured.

76. Use the Midpoint Formula to prove that the diagonals of the parallelogram bisect each other.
   \[ \left(\frac{b+a}{2}, \frac{c+0}{2}\right) = \left(\frac{a+b}{2}, \frac{c}{2}\right) \]
   \[ \left(\frac{a+b+0}{2}, \frac{c+0}{2}\right) = \left(\frac{a+b}{2}, \frac{c}{2}\right) \]

77. b

78. c

79. d

80. a

81. \( x = 1 \)

82. \( x = 6 \)

83. \( x = 2 \pm \sqrt{11} \)

84. \( x = \frac{-3 \pm \sqrt{73}}{4} \)

85. \( x < \frac{3}{5} \)

86. \( x \leq -\frac{23}{4} \)

87. \( 14 < x < 22 \)

88. \( x \leq -13 \) or \( x \geq -2 \)
Section 1.2 (page 22)

Vocabulary Check (page 22)

1. solution or solution point
2. graph
3. intercepts
4. y-axis
5. circle: \((h, k); r\)
6. numerical

1. (a) Yes (b) Yes
2. (a) Yes (b) No
3. (a) No (b) Yes
4. (a) Yes (b) No
5. 

<table>
<thead>
<tr>
<th>(x)</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>(\frac{5}{2})</th>
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<tbody>
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<td>7</td>
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6.

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<td>-1</td>
<td>(-\frac{1}{3})</td>
<td>0</td>
<td>(\frac{1}{2})</td>
</tr>
</tbody>
</table>

| \(x, y\) | (-2, \(-\frac{3}{2}\)) | (0, -1) | (1, \(-\frac{1}{3}\)) | \(\left(\frac{2}{3}, 0\right)\) | (2, \(\frac{1}{2}\)) |

7.

<table>
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<tr>
<th>(x)</th>
<th>-1</th>
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<th>2</th>
<th>3</th>
</tr>
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<td>0</td>
<td>-2</td>
<td>-2</td>
<td>0</td>
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| \(x, y\) | (-1, 4) | (0, 0) | (1, -2) | (2, -2) | (3, 0) |

8. 

<table>
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<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
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<tbody>
<tr>
<td>(y)</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

| \(x, y\) | (-2, 1) | (-1, 4) | (0, 5) | (1, 4) | (2, 1) |

9. \(x\)-intercepts: \((\pm 2, 0)\)
   \(y\)-intercept: \((0, 16)\)

10. \(x\)-intercept: \((-3, 0)\)
    \(y\)-intercept: \((0, 9)\)

11. \(x\)-intercept: \(\left(\frac{5}{2}, 0\right)\)
    \(y\)-intercept: \((0, -6)\)

12. \(x\)-intercept: \(\left(\frac{7}{2}, 0\right)\)
    \(y\)-intercept: \((0, 8)\)

13. \(x\)-intercept: \((-4, 0)\)
    \(y\)-intercept: \((0, 2)\)

14. \(x\)-intercept: \(\left(\frac{11}{2}, 0\right)\)

15. \(x\)-intercept: \(\left(\frac{15}{2}, 0\right)\)
    \(y\)-intercept: \((0, 7)\)

16. \(x\)-intercept: \((-10, 0)\)
    \(y\)-intercept: \((0, -10)\)

17. \(x\)-intercepts: \((0, 0), (2, 0)\)
    \(y\)-intercept: \((0, 0)\)

18. \(x\)-intercepts: \(\left(\pm \sqrt{5}, 0\right)\)
    \(y\)-intercept: \((0, -25)\)

19. \(x\)-intercept: \((6, 0)\)
    \(y\)-intercepts: \((0, \pm \sqrt{6})\)

20. \(x\)-intercept: \((-1, 0)\)
    \(y\)-intercepts: \((0, \pm 1)\)

21. 

22. 

23. 

24. 

25. \(y\)-axis symmetry
26. \(x\)-axis symmetry
27. Origin symmetry
28. \(y\)-axis symmetry
29. Origin symmetry
30. \(y\)-axis symmetry
31. \(x\)-axis symmetry
32. Origin symmetry
(Continued)

33. 34.

35. 36.

37. 38.

39. 40.

41. 42.

43. 44.

45. 46.

47. 48.

49. 50.

51. 52.

53. 54.

Intercepts: 

Intercepts: 

Intercepts: 

Intercepts: 

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Intercepts: 

Intercepts:
Intercepts: \((-3, 0), (0, 3)\)
\[57. \quad x^2 + y^2 = 16\]
Intercepts: \((\pm 2, 0), (0, 2)\)
\[58. \quad x^2 + y^2 = 25\]
\[59. \quad (x - 2)^2 + (y + 1)^2 = 16\]
\[60. \quad (x + 7)^2 + (y + 4)^2 = 49\]
\[61. \quad (x + 1)^2 + (y - 2)^2 = 5\]
\[62. \quad (x - 3)^2 + (y + 2)^2 = 25\]
\[63. \quad (x - 3)^2 + (y - 4)^2 = 25\]
\[64. \quad x^2 + y^2 = 17\]

55. Center: \((0, 0)\); Radius: 5

56. Center: \((0, 0)\); Radius: 4

65. Center: \((0, 0)\)

66. Center: \((0, 0)\)

69. Center: \((\frac{1}{2}, \frac{-1}{3})\); Radius: \(\frac{3}{7}\)

70. Center: \((2, -3)\); Radius: \(\frac{4}{5}\)

71. 

72. 

73. (a)

(b) Answers will vary.

(c)

(d) \(x = 86\frac{3}{5}, y = 86\frac{3}{5}\)

(e) A regulation NFL playing field is 120 yards long and 53\frac{1}{3} yards wide. The actual area is 6400 square yards.

74. (a)

(b) Answers will vary.

(c)

(d) \(x = 90, y = 90\)

(e) Answers will vary.

Sample answer: There are no fixed dimensions for a regulation major league soccer field, but they are generally 110 to 115 yards (100.6 to 105.2 meters) long and 75 yards (68.6 meters) wide. This makes the area about 8250 square yards (6901.2 square meters).

75. (a) and (b)
Precalculus with Limits, Answers to Section 1.2

(Continued)

(c) 66.0 years  (d) 2005: 77.0 years; 2010: 77.1 years
(e) Answers will vary.

76. (a) 

<table>
<thead>
<tr>
<th>x</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
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<tbody>
<tr>
<td>y</td>
<td>430.43</td>
<td>107.33</td>
<td>26.56</td>
<td>11.60</td>
<td>6.36</td>
<td>3.94</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
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<tbody>
<tr>
<td>y</td>
<td>2.62</td>
<td>1.83</td>
<td>1.31</td>
<td>0.96</td>
<td>0.71</td>
</tr>
</tbody>
</table>

(b) When $x = 85.5$, the resistance is 1.1 ohms.

(c) Answers will vary.

(d) As the diameter of the copper wire increases, the resistance decreases.

77. False. A graph is symmetric with respect to the $x$-axis if, whenever $(x, y)$ is on the graph $(x, -y)$ is also on the graph.

78. True. It is possible for a graph to have no intercepts, one intercept, or several intercepts, as shown in Figure 1.5.

79. The viewing window is incorrect. Change the viewing window. Answers will vary.

80. (a) $a = 1, b = 0$  (b) $a = 0, b = 1$

81. $9x^5, 4x^3, -7$  82. $-7^4$  83. $2\sqrt{2x}$  84. $|x|\sqrt{x}$

85. $\frac{10\sqrt{7x}}{x}$  86. $5(2\sqrt{5} + 3)$  87. $\sqrt{|r|}$  88. $\sqrt[3]{y}$
Section 1.3 (page 34)

Vocabulary Check (page 34)
1. linear  2. slope  3. parallel  4. perpendicular  5. rate or rate of change  6. linear extrapolation  7. a. iii  b. i  c. v  d. ii  e. iv

1. (a) $L_2$  (b) $L_3$  (c) $L_1$
2. (a) $L_2$  (b) $L_1$  (c) $L_3$
3. 
4. 
5. $\frac{3}{7}$  
6. $\frac{5}{7}$
7. $-4$
8. $-1$  
9. $m = 5$; y-intercept: $(0, 3)$
10. $m = 1$; y-intercept: $(0, -10)$
11. $m = -\frac{1}{2}$; y-intercept: $(0, 4)$
12. $m = -\frac{3}{2}$; y-intercept: $(0, 6)$
13. $m$ is undefined. There is no $y$-intercept.
14. $m = 0$; y-intercept: $(0, -\frac{5}{7})$
15. $m = -\frac{2}{6}$; $y$-intercept: $(0, 5)$
16. $m = -\frac{2}{3}$; $y$-intercept: $(0, 3)$
17. $m = 0$; $y$-intercept: $(0, 3)$
18. $m = 0$; $y$-intercept: $(0, -4)$
19. $m$ is undefined. There is no $y$-intercept.
20. $m$ is undefined. There is no $y$-intercept.
21. 
22. 
23. $m = 2$
24. $m = -4$
25. $m$ is undefined.
26. $m = -\frac{5}{2}$
Pre calculus with Limits, Answers to Section 1.3

(Continued)

25.

\[
\begin{align*}
&\text{Graph of } y = -\frac{1}{7}x + \frac{2}{3} \\
&m = -\frac{1}{7}
\end{align*}
\]

26.

\[
\begin{align*}
&\text{Graph of } y = \frac{1}{2}x + \frac{1}{2} \\
&m = -\frac{8}{3}
\end{align*}
\]

27.

\[
\begin{align*}
&\text{Graph of } y = -0.15x + 4.8 \\
&m = 0.15
\end{align*}
\]

28.

\[
\begin{align*}
&\text{Graph of } y = \frac{5}{2}x - \frac{3}{4} \\
&m = 1.425
\end{align*}
\]

29. (0, 1), (3, 1), (−1, 1)

30. (−4, 0), (−4, 3), (−4, 5)

31. (6, −5), (7, −4), (8, −3)

32. (0, 4), (9, −5), (11, −7)

33. (−8, 0), (−8, 2), (−8, 3)

34. (−4, −1), (−2, −1), (0, −1)

35. (−4, 6), (−3, 8), (−2, 10)

36. (−2, −5), (1, −11), (3, −15)

37. (9, −1), (10, 0), (13, 1)

38. (−3, −5), (1, −7), (5, −9)

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

40. \( y = -x + 10 \)

41. \( y = -2x \)

42. \( y = 4x \)

43. \( y = -\frac{1}{3}x + \frac{4}{3} \)

44. \( y = \frac{2}{3}x - \frac{7}{2} \)

45. \( x = 6 \)

46. \( x = -10 \)

47. \( y = \frac{5}{2}x \)

48. \( y = \frac{3}{2} \)

49. \( y = 5x + 27.3 \)

50. \( y = -2.5x - 2.75 \)

51. \( y = -\frac{3}{2}x + 2 \)

52. \( y = \frac{2}{3}x - \frac{7}{2} \)
(Continued)

53. \( x = -8 \)  
54. \( y = 4 \)

55. \( y = -\frac{1}{2}x + \frac{3}{2} \)  
56. \( y = -\frac{1}{5}x + \frac{4}{5} \)

57. \( y = -\frac{5}{2}x - \frac{18}{5} \)  
58. \( y = -\frac{3}{5}x + \frac{150}{50} \)

59. \( y = 0.4x + 0.2 \)  
60. \( y = -0.3x - 1.8 \)

61. \( y = -1 \)  
62. \( y = -2 \)

63. \( x = \frac{y}{2} \)  
64. \( x = 1.5 \)

65. Perpendicular  
66. Neither parallel nor perpendicular

67. Parallel  
68. Perpendicular

69. (a) \( y = 2x - 3 \)  
   (b) \( y = -\frac{1}{2}x + 2 \)

70. (a) \( y = -x - 1 \)  
   (b) \( y = x + 5 \)

71. (a) \( y = -\frac{2}{3}x + \frac{8}{3} \)  
   (b) \( y = \frac{2}{3}x + \frac{177}{22} \)

72. (a) \( y = -\frac{3}{5}x + \frac{83}{24} \)  
   (b) \( y = \frac{3}{5}x + \frac{9}{20} \)

73. (a) \( y = 0 \)  
   (b) \( x = -1 \)

74. (a) \( y = -2 \)  
   (b) \( x = 4 \)

75. (a) \( x = 2 \)  
   (b) \( y = 5 \)

76. (a) \( x = -5 \)  
   (b) \( y = 1 \)

77. (a) \( y = x + 4.3 \)  
   (b) \( y = -x + 9.3 \)

78. (a) \( y = -3x - 13.1 \)  
   (b) \( y = \frac{1}{3}x - 0.1 \)

79. \( 3x + 2y - 6 = 0 \)  
80. \( 4x - 3y + 12 = 0 \)

81. \( 12x + 3y + 2 = 0 \)  
82. \( 3x - y - 2 = 0 \)

83. \( x + y - 3 = 0 \)  
84. \( x + y - 1 = 0 \)

85. Line (b) is perpendicular to line (c).

86. Line (a) is parallel to line (c). Line (b) is perpendicular to line (a) and line (c).

87. Line (a) is parallel to line (b). Line (c) is perpendicular to line (a) and line (b).
88. Line (a) is parallel to line (b). Line (c) is perpendicular to line (a) and line (b).

89. \(3x - 2y - 1 = 0\)
90. \(5x + 13y + 2 = 0\)
91. \(80x + 12y + 139 = 0\)
92. \(128x + 168y + 39 = 0\)

93. (a) Sales increasing 135 units per year
   (b) No change in sales
   (c) Sales decreasing 40 units per year

94. (a) Revenues increasing $400 per day.
   (b) Revenues increasing $100 per day.
   (c) No change in revenues.

95. (a) Salary increased greatest from 1990 to 1992; Least from 1992 to 1994
   (b) Slope of line from 1990 to 2002 is about 2351.83
   (c) Salary increased an average of $2351.83 over the 12 years between 1990 and 2002

96. (a) Net profit showed largest increase in years 2002–2003; Least increase in years 2000–2001
   (b) Slope of line connecting 1994 and 2003 is about 9.18
   (c) Annual profits increased a factor of about 9.18 over those years

97. 12 feet
98. (a) and (b)
     \[
     \begin{array}{c|c c c c c}
     \text{Horizontal measurements} & 600 & 1200 & 1800 & 2400 \\
     \text{Vertical measurements} & 0 & -50 & -100 & -150 \\
     \end{array}
     \]
   (c) \(y = -\frac{1}{12}x\)
   (d) For every 12 horizontal measurements, the vertical measurement decreases by 1.
   (e) “8.3% grade”

99. \(V(t) = 3165 - 125t\)
100. \(V(t) = 4.5t + 133.5\)

101. (b) The slope is -20, which represents the decrease in the amount of the loan each week. The y-intercept is (0, 200) which represents the original amount of the loan.

102. (c) The slope is 2, which represents the hourly wage per unit produced. The y-intercept is (0, 8.50) which represents the initial hourly wage.

103. (a) The slope is 0.32, which represents the increase in travel cost for each mile driven. The y-intercept is (0, 30) which represents the amount per day for food.

104. (d) The slope is -100, which represents the decrease in the value of the word processor each year. The y-intercept is (0, 750) which represents the initial purchase price of the computer.

105. \(y = 0.4825t - 2.2325; y(18) \approx$6.45, $y(20) \approx$7.42
106. \(y(t) = -749.5t + 10,821.5; y(18) = -2669.5; y(20) = -4168.5; \) Answers will vary.

107. \(V = -175t + 875\)
108. \(V = 25,000 - 2300t\)

109. (a) \(y(t) = 179.5t + 40,571\)
    (b) \(y(8) = 42,007; y(10) = 42,366\)
    (c) \(m = 179.5\)

110. (a) Average annual change from 1990 to 2003 was 934.
    (b) 1994: 40,267; 1998: 44,003; 2002: 47,739
    (c) \(y(t) = 934t + 36,531; m = 934\)
    (d) Answers will vary.

111. \(S = 0.85L\)
112. \(W = 0.75x + 11.50\)

113. (a) \(C = 16.75t + 36,500\)
    (b) \(R = 27t\)
    (c) \(P = 10.25t - 36,500\)
    (d) \(t \approx 3561\) hours

114. (a) \(x = \frac{1}{12}p + \frac{36}{2}\)
    (b) \(y = 8x + 50\)
    (c) \(y = \frac{1}{12}x + 5\)
    (d) \(m = 8, 8\) meters

116. \(W = 0.07S + 2500\)
117. \(C = 0.38x + 120\)

118. Answers will vary. Sample answer: \(y = 327.3t - 1854\)

119. (a) and (b)

120. (c) Answers will vary. Sample answer:
    \(y = 11.72x - 14.1\)
Precalculus with Limits, Answers to Section 1.3

(Continued)

(d) Answers will vary. Sample answer: The y-intercept indicates that initially there were \(-14.1\) million subscribers which doesn’t make sense in the context of this problem. Each year, the number of cellular phone subscribers increases by \(11.72\) million.

(e) The model is accurate.

(f) Answers will vary. Sample answer: \(196.9\) million

120. (a) and (b)  
   \[
   y = 4x + 19
   \]
   
   (c) \(y = 4x + 19\)  
   (d) \(87\)

(e) Vertical shift four units upward

121. False. The slope with the greatest magnitude corresponds to the steepest line.

122. False. The slope of the first line is \(\frac{2}{7}\) and the slope of the second line is \(-\frac{1}{4}\).

123. Find the distance between each two points and use the Pythagorean Theorem.

124. The slope of a vertical line is undefined because division by zero is undefined.

125. No. The slope cannot be determined without knowing the scale on the y-axis. The slopes could be the same.

126. The line with a slope of \(-4\) is steeper. The slope with the greatest magnitude corresponds to the steepest line.

127. V-intercept: initial cost; Slope: annual depreciation

128. No. The slopes of two perpendicular lines have opposite signs (assume that neither line is vertical or horizontal).

129. d  
130. c  
131. a

132. b  
133. \(-1\)  
134. \(\frac{5}{2}\)

135. \(\frac{7}{2}, 7\)  
136. \(4 \pm \sqrt{3}\)  
137. No solution

138. \(\frac{1}{6}, 25\)  
139. Answers will vary.
Section 1.4  (page 48)

Vocabulary Check  (page 48)
1. domain; range; function
2. verbally; numerically; graphically; algebraically
3. independent; dependent  4. piecewise-defined
5. implied domain  6. difference quotient

1. Yes  2. No  3. No  4. Yes
5. Yes, each input value has exactly one output value.
6. No, the input values of 0 and 1 each have two different output values.
7. No, the input values of 7 and 10 each have two different output values.
8. Yes, it does not matter that each input value has the same output value.
9. (a) Function
   (b) Not a function, because the element 1 in A corresponds to two elements, –2 and 1, in B.
   (c) Function
   (d) Not a function, because not every element in A is matched with an element in B.
10. (a) Not a function, because the element c in A corresponds to two elements, 2 and 3, in B.
    (b) Function
    (c) Not a function from A to B. (It is instead a function from B to A.)
    (d) Function
11. Each is a function. For each year there corresponds one and only one circulation.
24. Function  25. (a) –1 (b) –9 (c) 2x – 5
26. (a) 7  (b) 0  (c) 1 – 3x
27. (a) 36π  (b) 9π  (c) 32πx3
28. (a) 0  (b) –0.75  (c) x2 + 2x
29. (a) 1  (b) 2.5  (c) 3 – 2|x|
30. (a) 2  (b) 5  (c) √x + 2
31. (a) 1/9  (b) Undefined  (c) 1/3x² + 6y
32. (a) 11/4  (b) Undefined  (c) 2x² + 3x²
33. (a) 1  (b) –1  (c) [x – 1]/x – 1
34. (a) 6  (b) 6  (c) x² + 4
35. (a) –1  (b) 2  (c) 6
36. (a) 6  (b) 3  (c) 10
37. (a) –7  (b) 4  (c) 9
38. (a) 19  (b) 17  (c) 0
39. x  -2  -1  0  1  2
   f(x)  1  -2  -3  -2  1
40. x  3  4  5  6  7
   g(x)  0  1  √2  √3  2
41. t  -5  -4  -3  -2  -1
   h(t)  1  3/2  0  1/2  1
42. s  0  1  3/2  5/2  4
   f(s)  -1  -1  -1  1  1
43. x  -2  -1  0  1  2
   f(x)  5  9/7  4  1  0
44. x  1  2  3  4  5
   f(x)  8  5  0  1  2
45. 5  46. -5/3  47. 5  48. ±2√3  49. ±3
50. 3, 5  51. 0, ±1  52. 1, ±2  53. 2, –1  54. 0, ±2  55. 3, 0  56. 4  57. All real numbers  58. All real numbers  59. All real numbers t except t = 0  60. All real numbers y except y = –5  61. All real numbers y such that y ≥ 0  62. All real numbers  63. All real numbers x such that –1 ≤ x ≤ 1  64. All real numbers x such that x ≤ –3 and x ≥ 0  65. All real numbers x except x = 0, –2  66. All real numbers x except x = 0, 2  67. All real numbers x such that 1 ≤ x ≤ 4  68. All real numbers x such that x > –6  69. All real numbers x such that x > 0  70. All real numbers x such that x < –3, x > 3  71. {(–2, 4), (–1, 1), (0, 0), (1, 1), (2, 4)}  72. {(–2, 1), (–1, –2), (0, –3), (1, –2), (2, 1)}  73. {(–2, 4), (–1, 3), (0, 2), (1, 3), (2, 4)}  74. {(–2, 1), (–1, 0), (0, 1), (1, 2), (2, 3)}  75. g(x) = cx²; c = –2  76. f(x) = cx; c = 1/4  77. r(x) = c/x; c = 32  78. h(x) = c√|x|; c = 3  79. 3 + h, h ≠ 0  80. (5 + h), h ≠ 0  81. 3x² + 3x + h² + 3, h ≠ 0  82. 8x + 4h – 2, h ≠ 0
83. \( \frac{x + 3}{9x^2}, x \neq 3 \)  
84. \( \frac{1}{t - 2}, t \neq 1 \)  
85. \( \sqrt{5x - 5} \) \( \frac{x - 5}{x} \)

86. \( \frac{x^{2/3} - 4}{x - 8} \)  
87. \( A = \frac{P^2}{16} \)  
88. \( A = \frac{C^2}{4\pi} \)

89. (a) The maximum volume is 1024 cubic centimeters. 
(b) 

Yes, \( V \) is a function of \( x \). 
(c) \( V = x(24 - 2x)^2, 0 < x < 12 \)

90. (a) The maximum profit is $3375. 
(b) 

Yes, \( P \) is a function of \( x \). 
(c) \( P = 45x - 0.15x^2, x > 100 \)

91. \( A = \frac{x^2}{2(x - 2)} \), \( x > 2 \)

92. \( A = 2xy = 2x\sqrt{36 - x^2}, 0 < x < 6 \)

93. Yes, the ball will be at a height of 6 feet.

94. 1991: $42 billion  
1992: $47 billion  
1993: $52 billion  
1994: $57 billion  
1995: $62 billion  
1996: $67 billion  
1997: $72 billion  
1998: $85.6 billion  
1999: $104.3 billion  
2000: $123 billion  
2001: $141.7 billion  
2002: $160.4 billion  
2003: $181 billion  
2004: $200 billion

95. 1990: $27,300  
1991: $28,052  
1992: $29,168  
1993: $30,648  
1994: $32,492  
1995: $34,700  
1996: $37,272  
1997: $40,208  
1998: $43,800  
1999: $46,300  
2000: $48,800  
2001: $51,300

96. (a) \( V = x^2y = x^2(108 - 4x) \)  
= \( 108x^2 - 4x^3, 0 < x < 27 \)

97. (a) \( C = 12.30x + 98,000 \)  
(b) \( R = 17.98x \)

98. (a) \( C = 6000 + 0.95x \)  
(b) \( \mathcal{C} = \frac{6000}{x} + 0.95 \)

99. (a) \( R = \frac{240n - n^2}{20}, n \geq 80 \)

The revenue is maximum when 120 people take the trip.

100. (a) 

\[ \begin{array}{ccc}
\quad & 5 & 10 & 20 \\
F(y) & 26,474.08 & 149,760.00 & 847,170.49 \\
\end{array} \]

(b) The deeper the water, the greater the force.

101. (a) 

(b) \( h = \sqrt{d^2 - 300^2}, d \geq 3000 \)

102. (a) 1.428. Approximately 1.428 species of fish became threatened and/or endangered each year between 1996 and 2003.

(b) \( N = \begin{cases} 
2x + 104, & 6 \leq x \leq 7 \\
2x + 103, & 8 \leq x \leq 11 \\
126, & 12 \leq x \leq 13 
\end{cases} \)

(c) 

\[ \begin{array}{ccccccccccc}
x & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 \\
N & 116 & 118 & 119 & 121 & 123 & 125 & 126 & 126 \\
\end{array} \]

(d) The algebraic model is a good fit to the actual data.

(e) \( N = 1.5x + 107 \); The model found in part (b) is a better model than the model given by the graphing utility.
Precalculus with Limits, Answers to Section 1.4

(Continued)

103. False. The range is \([-1, \infty)\).
104. True. Each x-value corresponds to one y-value.
105. The domain is the set of inputs of the function, and the range is the set of outputs.
106. Domain of \(f(x)\): all real numbers \(x\) such that \(x \geq -2\)
    Domain of \(g(x)\): all real numbers \(x\)
107. (a) Yes. The amount you pay in sales tax will increase as the price of the item purchased increases.
    (b) No. The length of time that you study will not necessarily determine how well you do on an exam.
108. (a) No, not necessarily. It depends on how you manage your money.
    (b) Yes. The speed of the baseball will increase as the height from which it was dropped increases.
109. \(\frac{15}{8}\)  110. 8
111. \(-\frac{1}{5}\)  112. \(\frac{2}{5}\)
113. \(2x - 3y - 11 = 0\)  114. \(x + y - 10 = 0\)
115. \(10x + 9y + 15 = 0\)  116. \(10x + 18y - 49 = 0\)
Section 1.5 (page 61)

Vocabulary Check (page 61)

1. ordered pairs  2. Vertical Line Test
3. zeros  4. decreasing
5. maximum  6. average rate of change; secant
7. odd  8. even

1. Domain: (−∞, −1], [1, ∞)  2. Domain: (−∞, ∞)
   Range: [0, ∞)  Range: [0, ∞)
3. Domain: [−4, 4]  4. Domain: (−∞, 1), (1, ∞)
   Range: [0, 4]  Range: −1, 1
5. (a) 0 (b) −1 (c) 0 (d) −2
6. (a) 4 (b) 4 (c) 2 (d) 0
7. (a) −3 (b) 0 (c) 1 (d) −3
8. (a) 0 (b) 1 (c) 2 (d) 3
15. −5/2, 6  16. −8, 2  17. 0  18. 2, 7
19. 0, ±√2  20. ±3, 4  21. ±1/4, 6  22. 0, ±5
23. 1/2  24. −3/2

12. Increasing on (−∞, 1)
38. Increasing on (−∞, −2), (0, ∞)
   Decreasing on (−2, −1), (−1, 0)
39.  
40.  

Constant on (−∞, ∞)

41.  
42.  

Decreasing on (−∞, 0)  Increasing on (0, ∞)

43.  

44. Increasing on (−1, 0), (1, ∞)
   Decreasing on (−∞, −1), (0, 1)

45.  
46.  

Decreasing on (−∞, 1)  Increasing on (−2, ∞)

47.  
48.  

Increasing on (0, ∞)  Decreasing on (−∞, 0)

49.  

Relative minimum: (1, −9)
Precalculus with Limits, Answers to Section 1.5

(Continued)

50. Relative minimum: \( \left( \frac{1}{3}, -\frac{16}{9} \right) \)

51. Relative maximum: \((1.5, 0.25)\)

52. Relative maximum: \((2.25, 10.125)\)

53. Relative maximum: \((-1.79, 8.21)\)
Relative minimum: \((1.12, -4.06)\)

54. Relative maximum: \((-0.15, 1.08)\)
Relative minimum: \((2.15, -5.08)\)

55.\( f(x) < 0 \) for all \( x \)

56.\( \infty, 4 \)

57.\( (-\infty, -1], [0, \infty) \)

58.\( (-\infty, 0], [4, \infty) \)

59. Even; \( y \)-axis symmetry

60. Neither even nor odd; no symmetry

61. Odd; origin symmetry

62. Odd; origin symmetry

63. The average rate of change from \( x_1 = 0 \) to \( x_2 = 3 \) is \( -2 \).

64. The average rate of change from \( x_1 = 0 \) to \( x_2 = 3 \) is \( 3 \).

65. The average rate of change from \( x_1 = 1 \) to \( x_2 = 5 \) is \( 18 \).

66. The average rate of change from \( x_1 = 1 \) to \( x_2 = 5 \) is \( 4 \).

67. The average rate of change from \( x_1 = 1 \) to \( x_2 = 3 \) is \( 0 \).

68. The average rate of change from \( x_1 = 1 \) to \( x_2 = 6 \) is \( 0 \).

69. The average rate of change from \( x_1 = 3 \) to \( x_2 = 11 \) is \(-\frac{1}{2}\).

70. The average rate of change from \( x_1 = 3 \) to \( x_2 = 8 \) is \( -\frac{1}{5} \).

71. Even; \( y \)-axis symmetry

72. Neither even nor odd; no symmetry

73. Odd; origin symmetry

74. Odd; origin symmetry

75. Neither even nor odd; no symmetry

76. Even; \( y \)-axis symmetry

77. \( h = -x^2 + 4x - 3 \)

78. \( h = 3 - 4x + x^2 \)

79. \( h = 2x - x^2 \)

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

81. \( L = \frac{1}{2} y^2 \)

82. \( L = 2 - \sqrt{2} y \)

83. \( L = 4 - y^2 \)

84. \( L = \frac{2}{y} \)
Precalculus with Limits, Answers to Section 1.5

(Continued)

85. (a) 6000  (b) 30 watts

86. (a) 70

(b) The model fits the data very well.
(c) The temperature was increasing from 6 A.M. \( (x = 0) \) to noon \( (x = 6) \), and again from 2 A.M. \( (x = 20) \) to 6 A.M. \( (x = 24) \). The temperature was decreasing from noon to 2 A.M.
(d) The maximum temperature was 63.93°F and the minimum temperature was 33.98°F.
(e) Answers will vary.

87. (a) Ten thousands  (b) Ten millions  (c) Percents

88. (a) \( A = 64 - 2x^2, \ 0 \leq x \leq 4 \)
(b) 32 \( \leq A \leq 64 \)

(c) Square with sides of \( 4\sqrt{2} \) meters

89. (a)

(b) The average rate of change from 2002 to 2007 is 408.56. The estimated revenue is increasing each year at a fast pace.

90. (a)

(b) The average rate of change of the model from 1992 to 2002 is 14.73. This shows that the number of students enrolling in college increased at a fairly steady rate.
(c) The five-year time period when the rate of change was the least was from 1992 to 1997 with a 6.05 average rate, and the greatest from 1997 to 2002 with a 23.41 average rate.

91. (a) \( s = -16t^2 + 64t + 6 \)
(b) \( \quad \) 

(c) Average rate of change = 16
(d) The slope of the secant line is positive.
(e) Secant line: \( 16t + 6 \)
(f)

92. (a) \( s = -16t^2 + 72t + 6.5 \)
(b) \( \quad \) 

(c) Average rate of change = 8
(d) The slope of the secant line is positive.
(e) Secant line: \( 8t + 6.5 \)
(f)

93. (a) \( s = -16t^2 + 120t \)
(b) \( \quad \) 

(c) Average rate of change = -8
(d) The slope of the secant line is negative.
(e) Secant line: \( -8t + 240 \)
(f)
94. (a) \( s = -16t^2 + 96t \)

(b) 

(c) Average rate of change = -16

(d) The slope of the secant line is negative.

(e) Secant line: \(-16t + 160\)

(f) 

95. (a) \( s = -16t^2 + 120 \)

(b) 

(c) Average rate of change = -32

(d) The slope of the secant line is negative.

(e) Secant line: \(-32t + 120\)

(f) 

96. (a) \( s = -16t^2 + 80 \)

(b) 

(c) Average rate of change = -48

(d) The slope of the secant line is negative.

(e) Secant line: \(-48t + 112\)

(f) 

97. False. The function \( f(x) = \sqrt{x^2 + 1} \) has a domain of all real numbers.

98. False. An odd function is symmetric with respect to the origin, so its domain must include negative values.

99. (a) Even. The graph is a reflection in the x-axis.

(b) Even. The graph is a reflection in the y-axis.

(c) Even. The graph is a vertical translation of \( f \).

(d) Neither. The graph is a horizontal translation of \( f \).

100. Yes. For each value of \( y \) there corresponds one and only one value of \( x \).

101. (a) \( \left( \frac{2}{3}, 4 \right) \)

(b) \( \left( \frac{2}{3}, -4 \right) \)

102. (a) \( \left( \frac{5}{3}, -7 \right) \)

(b) \( \left( \frac{5}{3}, 7 \right) \)

103. (a) \( (-4, 9) \)

(b) \( (-4, -9) \)

104. (a) \( (-5, -1) \)

(b) \( (-5, 1) \)

105. 

106. All the graphs pass through the origin. The graphs of the odd powers of \( x \) are symmetric with respect to the origin, and the graphs of the even powers are symmetric with respect to the y-axis. As the powers increase, the graphs become flatter in the interval \(-1 < x < 1\).

107. \( 0, 10 \)

108. \(-5, 15 \)

109. \( 0, \pm 1 \)

110. \( \frac{5}{4} \)

111. (a) \( 37 \)

(b) \( -28 \)

(c) \( 5x - 43 \)

112. (a) \(-24 \)

(b) \( 144 \)

(c) \( x^2 - 18x + 56 \)

113. (a) \(-9 \)

(b) \( 2\sqrt{7} - 9 \)

(c) The given value is not in the domain of the function.

114. (a) \(-3 \)

(b) \( -\frac{12}{16} \)

(c) \( 139 - 2\sqrt{3} \)

115. \( h + 4, h \neq 0 \)

116. \(-6 - h, h \neq 0 \)
Section 1.6 (page 71)

Vocabulary Check (page 71)

1. g  2. i  3. h  4. a  5. b
6. c  7. f  8. c  9. d

1. (a) \( f(x) = -2x + 6 \)
   (b) [Graph of \( f(x) = -2x + 6 \)]

2. (a) \( f(x) = \frac{5}{2}x - \frac{1}{2} \)
   (b) [Graph of \( f(x) = \frac{5}{2}x - \frac{1}{2} \)]

3. (a) \( f(x) = -3x + 11 \)
   (b) [Graph of \( f(x) = -3x + 11 \)]

4. (a) \( f(x) = 5x - 6 \)
   (b) [Graph of \( f(x) = 5x - 6 \)]

5. (a) \( f(x) = -1 \)
   (b) [Graph of \( f(x) = -1 \)]

6. (a) \( f(x) = -\frac{1}{2}x + 7 \)
   (b) [Graph of \( f(x) = -\frac{1}{2}x + 7 \)]

7. (a) \( f(x) = \frac{6}{7}x - \frac{45}{7} \)
   (b) [Graph of \( f(x) = \frac{6}{7}x - \frac{45}{7} \)]

8. (a) \( f(x) = \frac{3}{4}x - 8 \)
   (b) [Graph of \( f(x) = \frac{3}{4}x - 8 \)]

9. [Graph of \( f(x) = -2x + 6 \)]
10. [Graph of \( f(x) = \frac{5}{2}x - \frac{1}{2} \)]
11. [Graph of \( f(x) = -3x + 11 \)]
12. [Graph of \( f(x) = 5x - 6 \)]
13. [Graph of \( f(x) = -1 \)]
14. [Graph of \( f(x) = -\frac{1}{2}x + 7 \)]
15. [Graph of \( f(x) = \frac{6}{7}x - \frac{45}{7} \)]
16. [Graph of \( f(x) = \frac{3}{4}x - 8 \)]
25. 
26. 
27. 
28. 
29. (a) 2  (b) 2  (c) -4  (d) 3  
30. (a) -6  (b) 0  (c) 18  (d) 6  
31. (a) 1  (b) 3  (c) 7  (d) -19  
32. (a) 7  (b) -1  (c) 31  (d) 11  
33. (a) 6  (b) -11  (c) 6  (d) -22  
34. (a) 8  (b) 2  (c) 6  (d) 13  
35. (a) -10  (b) -4  (c) -1  (d) 41  
36. (a) -22  (b) -85  (c) 6  (d) -29  
37.  
38.  
39.  
40.  
41.  
42.  
43.  
44.  
45.  
46.  
47.  
48.  
49.  
50.  
51. (a)  
(b) Domain: (-\infty, \infty);  
Range: [0, 2]  
(c) Sawtooth pattern  
52. (a)  
(b) Domain: (-\infty, \infty);  
Range: [0, 2]  
(c) Sawtooth pattern  
53. (a) f(x) = |x|  (b) g(x) = |x + 2| - 1  
54. (a) f(x) = \sqrt{x}  (b) g(x) = 1 + \sqrt{x} + 2  
55. (a) f(x) = x^3  (b) g(x) = (x - 1)^3 - 2  
56. (a) f(x) = \frac{1}{x}  (b) g(x) = \frac{1}{x} - 2
(Continued)

57. (a) \( f(x) = 2 \)  
     (b) \( g(x) = 2 \)

58. (a) \( f(x) = x^2 \)  
     (b) \( g(x) = 1 - (x + 2)^2 \)

59. (a) \( f(x) = x \)  
     (b) \( g(x) = x - 2 \)

60. (a) \( f(x) = \lfloor x \rfloor \)  
     (b) \( g(x) = \lceil x - 1 \rceil \)

61. (a) 

\[
\begin{array}{|c|c|}
\hline
\text{Time (in minutes)} & \text{Cost (in dollars)} \\
\hline
1 & 1 \\
2 & 2 \\
3 & 3 \\
4 & 4 \\
5 & 5 \\
\hline
\end{array}
\]

(b) $5.64

62. (a) \( C_2 \) is the appropriate model, because the cost does not increase until after the next minute of conversation has started.

(b)

\[
\begin{array}{|c|c|}
\hline
\text{Time (in minutes)} & \text{Cost (in dollars)} \\
\hline
1 & 1 \\
2 & 2 \\
3 & 3 \\
4 & 4 \\
5 & 5 \\
\hline
\end{array}
\]

$7.89

63. (a) 

\[
\begin{array}{|c|c|}
\hline
\text{Weight (in pounds)} & \text{Cost of overnight delivery} \\
\hline
1 & 2 \\
2 & 4 \\
3 & 6 \\
4 & 8 \\
5 & 10 \\
\hline
\end{array}
\]

(b) $50.25

64. (a) \( C = 9.8 + 2.5 \lfloor x \rfloor \)

(b) 

\[
\begin{array}{|c|c|}
\hline
\text{Weight (in pounds)} & \text{Cost of overnight delivery} \\
\hline
10 & 12.8 \\
20 & 15.8 \\
30 & 18.8 \\
40 & 21.8 \\
50 & 24.8 \\
\hline
\end{array}
\]

65. (a) \( W(30) = 360; W(40) = 480; \)  
     \( W(45) = 570; W(50) = 660 \)

(b) \( W(h) = \begin{cases} 
12h, & 0 < h \leq 45 \\
18(h - 45) + 540, & h > 45 
\end{cases} \)

66. \( f(t) = \begin{cases} 
t, & 0 \leq t \leq 2 \\
2t - 2, & 2 < t \leq 8 \\
\frac{1}{9}t + 10, & 8 < t \leq 9 
\end{cases} \)

Total accumulation = 14.5 inches

67. (a) \( f(x) = \begin{cases} 
0.505x^2 - 1.47x + 6.3, & 1 \leq x \leq 6 \\
-1.97x + 26.3, & 6 < x \leq 12 
\end{cases} \)

Answers will vary. Sample answer: The domain is determined by inspection of a graph of the data with the two models.

(b)

\[
\begin{array}{|c|c|}
\hline
\text{Month (1 ↔ January)} & \text{Revenue (in thousands of dollars)} \\
\hline
1 & 10 \\
2 & 15 \\
3 & 20 \\
4 & 25 \\
5 & 30 \\
\hline
\end{array}
\]

(c) \( f(5) = 11.575; f(11) = 4.63 \); These values represent the revenue for the months of May and November, respectively.

(d) These values are quite close to the actual data values.

68. \( \begin{array}{|c|c|c|c|}
\hline
\text{Interval} & \text{Input Pipe} & \text{Drainpipe 1} & \text{Drainpipe 2} \\
\hline
[0, 5] & \text{Open} & \text{Closed} & \text{Closed} \\
[5, 10] & \text{Open} & \text{Open} & \text{Closed} \\
[10, 20] & \text{Closed} & \text{Open} & \text{Closed} \\
[20, 30] & \text{Closed} & \text{Closed} & \text{Open} \\
[30, 40] & \text{Open} & \text{Open} & \text{Open} \\
[40, 45] & \text{Open} & \text{Closed} & \text{Open} \\
[45, 50] & \text{Open} & \text{Open} & \text{Open} \\
[50, 60] & \text{Open} & \text{Open} & \text{Closed} \\
\hline
\end{array} \)

69. False. A piecewise-defined function is a function that is defined by two or more equations over a specified domain. That domain may or may not include x- and y-intercepts.

70. True. The solution sets are the same.

71. \( f(x) = \begin{cases} 
-\frac{x}{2} + 6, & 0 \leq x \leq 3 \\
-\frac{x}{2} + \frac{16}{x}, & 3 < x \leq 8 
\end{cases} \)

72. \( f(x) = \begin{cases} 
x^2, & x \leq 2 \\
7 - x, & x > 2 
\end{cases} \)

73. \( x \leq 1 \)

74. \( x < \frac{5}{2} \)

75. Neither

76. Neither
Section 1.7 (page 79)

Vocabulary Check (page 79)
1. rigid  2. \(-f(x); f(-x)\)  3. nonrigid
4. horizontal shrink; horizontal stretch
5. vertical stretch; vertical shrink
6. (a) iv  (b) ii  (c) iii  (d) i

1. (a)  
   ![Graph 1a](image)
   ![Graph 1b](image)

2. (a)  
   ![Graph 2a](image)
   ![Graph 2b](image)

3. (a)  
   ![Graph 3a](image)
   ![Graph 3b](image)

4. (a)  
   ![Graph 4a](image)
   ![Graph 4b](image)

5. (a)  
   ![Graph 5a](image)
   ![Graph 5b](image)

6. (a)  
   ![Graph 6a](image)
   ![Graph 6b](image)
   ![Graph 6c](image)
   ![Graph 6d](image)
(Continued)

6. (a) (b) (c) (d) (e) (f) (g)

7. (a) (b) (c) (d) (e) (f) (g)
18. Horizontal shift of \( y = |x|; y = |x + 2| \\
19. (a) \( f(x) = x^2 \)
(b) Reflection in the \( x \)-axis, and vertical shift 12 units upward, of \( f(x) = x^2 \)

(c)

(d) \( g(x) = 12 - f(x) \)

20. (a) \( f(x) = x^2 \)
(b) Horizontal shift eight units to the right, of \( f(x) = x^2 \)

(c)

(d) \( g(x) = f(x - 8) \)

21. (a) \( f(x) = x^3 \)
(b) Vertical shift seven units upward, of \( f(x) = x^3 \)

(c)

(d) \( g(x) = f(x) + 7 \)

22. (a) \( f(x) = x^3 \)
(b) Reflection in the \( x \)-axis, and a vertical shift of one unit downward, of \( f(x) = x^3 \)

(c)

(d) \( g(x) = -f(x) - 1 \)
23. (a) \( f(x) = x^2 \)
(b) Vertical shrink of two-thirds, and vertical shift four units upward, of \( f(x) = x^2 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^2 \\
\text{Vertical shrink of two-thirds, vertical shift four units upward}
\end{array}
\]
(d) \( g(x) = \frac{2}{3}f(x) + 4 \)

24. (a) \( f(x) = x^2 \)
(b) Vertical stretch of two, and horizontal shift seven units to the right, of \( f(x) = x^2 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^2 \\
\text{Vertical stretch of two, horizontal shift seven units to the right}
\end{array}
\]
(d) \( g(x) = 2f(x - 7) \)

25. (a) \( f(x) = x^2 \)
(b) Reflection in the \( x \)-axis, horizontal shift five units to the left, and vertical shift two units upward, of \( f(x) = x^2 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^2 \\
\text{Reflection in the } x\text{-axis, horizontal shift five units to the left, vertical shift two units upward}
\end{array}
\]
(d) \( g(x) = 2 - f(x + 5) \)

26. (a) \( f(x) = x^2 \)
(b) Reflection in the \( x \)-axis, horizontal shift 10 units to the left, and vertical shift five units upward, of \( f(x) = x^2 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^2 \\
\text{Reflection in the } x\text{-axis, horizontal shift 10 units to the left, vertical shift five units upward}
\end{array}
\]
(d) \( g(x) = -f(x + 10) + 5 \)

27. (a) \( f(x) = \sqrt{x} \)
(b) Horizontal shrink of \( \frac{1}{2} \), of \( f(x) = \sqrt{x} \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = \sqrt{x} \\
\text{Horizontal shrink of } \frac{1}{2}
\end{array}
\]
(d) \( g(x) = f(3x) \)

28. (a) \( f(x) = \sqrt{x} \)
(b) Horizontal stretch of four, of \( f(x) = \sqrt{x} \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = \sqrt{x} \\
\text{Horizontal stretch of four}
\end{array}
\]
(d) \( g(x) = f\left(\frac{1}{4}x\right) \)

29. (a) \( f(x) = x^3 \)
(b) Vertical shift two units upward, and horizontal shift one unit to the right, of \( f(x) = x^3 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^3 \\
\text{Vertical shift two units upward, horizontal shift one unit to the right}
\end{array}
\]
(d) \( g(x) = f(x - 1) + 2 \)

30. (a) \( f(x) = x^3 \)
(b) Vertical shift 10 units downward, and horizontal shift three units to the left, of \( f(x) = x^3 \)
(c) 
\[
\begin{array}{c}
\text{Graph of } f(x) = x^3 \\
\text{Vertical shift 10 units downward, horizontal shift three units to the left}
\end{array}
\]
(d) \( g(x) = f(x + 3) - 10 \)

31. (a) \( f(x) = |x| \)
(b) Reflection in the \( x \)-axis, and vertical shift two units downward, of \( f(x) = |x| \)
(Continued)

32. (a) \( f(x) = |x| \)
   (b) Reflection in the x-axis, horizontal shift five units to the left, and vertical shift six units upward, of \( f(x) = |x| \)
   (c) \( g(x) = \frac{3}{2} - 3 \)
   (d) \( g(x) = -f(x) - 2 \)

33. (a) \( f(x) = |x| \)
   (b) Reflection in the x-axis, horizontal shift four units to the left, and vertical shift eight units upward, of \( f(x) = |x| \)
   (c) \( g(x) = 6 - f(x + 5) \)

34. (a) \( f(x) = |x| \)
   (b) Reflection in the y-axis, horizontal shift three units to the right, and vertical shift nine units upward, of \( f(x) = |x| \)
   (c) \( g(x) = -f(x + 4) + 8 \)

35. (a) \( f(x) = \lfloor x \rfloor \)
   (b) Reflection in the x-axis, and vertical shift three units upward, of \( f(x) = \lfloor x \rfloor \)
   (c) \( g(x) = f(- (x - 3)) + 9 \)

36. (a) \( f(x) = \|x\| \)
   (b) Horizontal shift five units to the left, and vertical stretch of two, of \( f(x) = \|x\| \)
   (c) \( g(x) = 2f(x + 5) \)

37. (a) \( f(x) = \sqrt{x} \)
   (b) Horizontal shift of nine units to the right, of \( f(x) = \sqrt{x} \)
   (c) \( g(x) = f(x - 9) \)

38. (a) \( f(x) = \sqrt{x} \)
   (b) Horizontal shift of four units to the left, and vertical shift eight units upward, of \( f(x) = \sqrt{x} \)
   (c) \( g(x) = f(x + 4) + 8 \)

39. (a) \( f(x) = \sqrt{x} \)
   (b) Reflection in the y-axis, horizontal shift of seven units to the right, and vertical shift two units downward, of \( f(x) = \sqrt{x} \)
40. (a) \( f(x) = \sqrt{x} \)
(b) Reflection in the x-axis, horizontal shift of one unit to the left, and vertical shift six units downward, of \( f(x) = \sqrt{x} \)

(c) \[ g(x) = f(7 - x) - 2 \]

41. (a) \( f(x) = \sqrt{x} \)
(b) Horizontal stretch, and vertical shift four units downward, of \( f(x) = \sqrt{x} \)

(c) \[ g(x) = -f(x + 1) - 6 \]

42. (a) \( f(x) = \sqrt{x} \)
(b) Horizontal shrink of \( \frac{1}{2} \), and vertical shift one unit upward, of \( f(x) = \sqrt{x} \)

(c) \[ g(x) = f(\frac{1}{2}x) - 4 \]

43. \( f(x) = (x - 2)^2 - 8 \)
44. \( f(x) = -(x + 3)^2 - 7 \)
45. \( f(x) = (x - 13)^3 \)
46. \( f(x) = -(x + 6)^3 - 6 \)
47. \( f(x) = -|x| - 10 \)
48. \( f(x) = |x + 1| - 7 \)
49. \( f(x) = -\sqrt{-x} + 6 \)
50. \( f(x) = -\sqrt{-x} + 9 \)
51. (a) \( y = -3x^2 \) (b) \( y = 4x^2 + 3 \)
52. (a) \( y = \frac{1}{3}x^3 \) (b) \( y = -2x^3 \)
53. (a) \( y = -\frac{1}{2}|x| \) (b) \( y = 3|x| - 3 \)
54. (a) \( y = 8\sqrt{x} \) (b) \( y = -\frac{1}{2}\sqrt{x} \)
55. Vertical stretch of \( y = x^3; y = 2x^3 \)
56. Vertical stretch of \( y = |x; y = 6|x| \)
57. Reflection in the x-axis and vertical shrink of \( y = x^2; y = \frac{1}{2}x^2 \)
58. Horizontal stretch of \( y = \lfloor x \rfloor; y = \lfloor \frac{1}{2}x \rfloor \)
59. Reflection in the y-axis and vertical shrink of \( y = \sqrt{x}; y = \frac{1}{2}\sqrt{x} \)
60. Reflection in the x-axis, vertical stretch, and vertical shift two units downward, of \( y = |x; y = -2|x| - 2 \)
61. \( y = -(x - 2)^3 + 2 \)
62. \( y = |x + 4| - 2 \)
63. \( y = -\sqrt{x} - 3 \)
64. \( y = (x - 2)^2 + 4 \)
65. (a)
66. (a) Horizontal stretch of 0.035 and a vertical shift of 20.6 units upward.
   (b) 0.77-billion-gallon increase in fuel usage by trucks each year.

(c) \( f(t) = 20.6 + 0.035(t + 10)^2 \). The graph is shifted 10 units to the left.
(d) 52.1 billion gallons. Yes.

68. (a) Horizontal shift of 20.396 units to the left and vertical shrink of 0.0054.
(b) \( f(t) = 0.0054(t + 30.396)^2 \). The graph is shifted 10 units to the left.

69. True. \( |−x| = |x| \).
70. False. The point \((-2, -67)\) will lie on the transformation.
71. (a) \( g(t) = \frac{3}{t} f(t) \) (b) \( g(t) = f(t) + 10,000 \) (c) \( g(t) = f(t - 2) \)
72. If you consider the -axis to be a mirror, the graph of \( y = −f(x) \) is the mirror image of the graph of \( y = f(x) \).
73. \((-2, 0), (-1, 1), (0, 2)\)
74. Answers will vary.
75. \( \frac{4}{x(1-x)} \) \( \frac{-20}{(x+5)(x-5)} \) \( \frac{3x-2}{x(x-1)} \)
76. \( \frac{3x-5}{2(x-5)} \) \( \frac{(x-4)\sqrt{x^2-4}}{x^2-4} \)
77. \( \frac{80}{x(x+2)}, x \neq 2 \) \( 81. 5(x-3), x \neq -3 \)
78. \( \frac{x+1}{(x-7)(x+3)} x \neq 0, -1, -4 \)
79. \( (a) 38 \) \( (b) \frac{52}{7} \) \( (c) x^2 - 12x + 38 \)
80. \( 82. (a) -3 \) \( (b) 3 \) \( (c) \sqrt{x} - 3 \)
81. All real numbers \( x \) except \( x = 1 \)
82. All real numbers \( x \) such that \( x \geq 3 \), except \( x = 8 \)
83. All real numbers \( x \) such that \( -9 \leq x \leq 9 \)
84. All real numbers \( x \)
Section 1.8  (page 89)

Vocabulary Check  (page 89)
1. addition; subtraction; multiplication; division
2. composition   3. g(x)   4. inner; outer

1. [Graphs and diagrams are shown here.]
2. [Graphs and diagrams are shown here.]
3. [Graphs and diagrams are shown here.]
4. [Graphs and diagrams are shown here.]

5. (a) 2x  (b) 4  (c) x^2 - 4  
   (d) \( \frac{x + 2}{x - 2} \); all real numbers except x = 2
6. (a) x - 3  (b) 3x - 7  (c) -2x^2 + 9x - 10  
   (d) \( \frac{2x - 5}{2 - x} \); all real numbers except x = 2
7. (a) x^2 + 4x - 5  (b) x^2 - 4x + 5  (c) 4x^3 - 5x^2  
   (d) \( \frac{x^2}{4x - 5} \); all real numbers except x = 5/4
8. (a) 2x - 1  (b) 2x - 9  (c) 8x - 20  
   (d) \( \frac{1}{2}x - \frac{5}{2} \); all real numbers x
9. (a) x^2 + 6 + \sqrt{1 - x}  (b) x^2 + 6 - \sqrt{1 - x}  
   (c) \( (x^2 + 6) \sqrt{1 - x} \)  
   (d) \( \frac{(x^2 + 6) \sqrt{1 - x}}{1 - x} \); all real numbers x such that x < 1
10. (a) \( \sqrt{x^2 - 4} + \frac{x^2}{x^2 + 1} \)  (b) \( \sqrt{x^2 - 4} - \frac{x^2}{x^2 + 1} \)  
    (c) \( \frac{x^2 \sqrt{x^2 - 4}}{x^2 + 1} \)  
    (d) \( \frac{(x^2 + 1) \sqrt{x^2 - 4}}{x^2} \); all real numbers x such that |x| \geq 2
11. (a) \( \frac{x + 1}{x^2} \)  (b) \( \frac{x - 1}{x^2} \)  (c) \( \frac{1}{x^3} \)  
    (d) x; all real numbers x except x = 0

12. (a) \( \frac{x^4 + x^3 + x}{x + 1} \)  (b) \( \frac{-x^4 - x^3 + x}{x + 1} \)  (c) \( \frac{x^4}{x + 1} \)  
    (d) \( \frac{1}{x^2(x + 1)} \); all real numbers x except x = 0, -1
13. 3  14. 7  15. 5  16. -1
17. 9r^2 - 3r + 5  18. r^2 - 3r - 1  19. 74
20. -370  21. 26  22. -\frac{1}{2}  23. \frac{3}{2}  24. 43
25. [Graphs and diagrams are shown here.]
26. [Graphs and diagrams are shown here.]
27. [Graphs and diagrams are shown here.]
28. [Graphs and diagrams are shown here.]
29. [Graphs and diagrams are shown here.]
30. [Graphs and diagrams are shown here.]

31. (a) (x - 1)^2  (b) x^2 - 1  (c) x^4
32. (a) 20 - 3x  (b) -3x  (c) 9x + 20
33. (a) x  (b) x  (c) \( \sqrt[3]{x^2 - 1} \)
34. (a) \( \frac{1}{x^3} \)  (b) \( \frac{1}{x^2} \)  (c) x^9
35. (a) \( \sqrt{x^2 + 4} \)  (b) x + 4  
    Domains of f and g \( f \cdot g \); x \geq -4
    Domains of g and f \( f \cdot g \); all real numbers
36. (a) \( \frac{1}{\sqrt{x^3 - 4}} \)  (b) x - 4  
    Domains of f, g, \( f \cdot g \), and \( g \cdot f \); all real numbers
37. (a) x + 1  (b) \( \sqrt{x^2 + 1} \)  
    Domains of f and g \( f \cdot g \); all real numbers
    Domains of g and f \( f \cdot g \); all real numbers x such that x \geq 0
38. (a) x^4  (b) x^4  
    Domains of f, g, \( f \cdot g \), and \( g \cdot f \); all real numbers
39. (a) \( |x + 6| \)  (b) |x| + 6  
    Domains of f, g, \( f \cdot g \), and \( g \cdot f \); all real numbers
40. (a) |1 - x|  (b) 3 - |x - 4|  
    Domains of f, g, \( f \cdot g \), and \( g \cdot f \); all real numbers
(Continued)

41. (a) \frac{1}{x + 3}  \hspace{1cm} (b) \frac{1}{x + 3}

Domains of \( f \) and \( g \cdot f \): all real numbers \( x \) except \( x = 0 \)
Domains of \( g \): all real numbers
Domains of \( f \cdot g \): all real numbers \( x \) except \( x = -3 \)

42. (a) \frac{3}{x^2 + 2x}  \hspace{1cm} (b) \frac{x^2 + 2}{x^2 - 1}

Domains of \( f \) and \( g \cdot f \): all real numbers \( x \) except \( x = 0 \)
Domains of \( g \): all real numbers
Domains of \( f \cdot g \): all real numbers \( x \) except \( x = 0, -2 \)

43. (a) 3  \hspace{1cm} (b) 0

44. (a) -1  \hspace{1cm} (b) 0

45. (a) 0  \hspace{1cm} (b) 4

46. (a) 2  \hspace{1cm} (b) 2

47. \( f(x) = x^2 \), \( g(x) = 2x + 1 \)

48. \( f(x) = x^3 \), \( g(x) = 1 - x \)

49. \( f(x) = \sqrt{x} \), \( g(x) = x^2 - 4 \)

50. \( f(x) = \sqrt{x} \), \( g(x) = 9 - x \)

51. \( f(x) = \frac{1}{x} \), \( g(x) = x + 2 \)

52. \( f(x) = \frac{4}{x^2} \), \( g(x) = 5x + 2 \)

53. \( f(x) = \frac{x + 3}{4 + x} \), \( g(x) = -x^2 \)

54. \( f(x) = \frac{27x + 6\sqrt{x}}{10 - 27x} \), \( g(x) = x^3 \)

55. \( T = \frac{3x}{2} + \frac{1}{15}x^2 \)

56. (a) \( R_3 = 734 - 7.22t - 0.8t^2 \)  \hspace{1cm} (b) \[ \text{Distance Traveled (in feet)} \]

\[ \text{Speed (in miles per hour)} \]

57. (a) \( c(t) = \frac{p(t) + b(t) - d(t)}{p(t)} \times 100 \)

(b) \( c(5) \) is the population change in the year 2005.

58. (a) \( p(t) = d(t) + c(t) \)

(b) \( p(5) \) = Number of dogs and cats in the year 2005.

(c) The function \( h(t) \) represents the number of dogs and cats per capita.

59. (a) \( (A + N)(t) = 5.31t^2 - 102.0t + 1338 \)

(b) \( (A + N)(4) = 101.46 \)

(c) \( (A + N)(8) = 861.84 \)

(d) \( (A + N)(12) = 878.64 \)

60. (a) \( h(t) = \frac{25.95t^2 - 231.2t + 3356}{3.02t + 252.0} \), which represents the number of dollars spent on exercise equipment compared with the millions of people in the United States.

(b) \( h(7) = 11.02; h(10) = 12.90; h(12) = 14.98 \)

61. (a) \( y_1 = 10.20t + 92.7 \)

(b) \( y_2 = 3.357t^2 - 26.46t + 379.5 \)

(c) \( y_3 = -0.465t^2 + 9.71t + 7.4 \)

(d) \( y_1 + y_2 + y_3 = 2.892t^2 - 6.55t + 479.6 \); this amount represents the amount spent on health care in the United States.

62. (a) For each time \( t \) there corresponds one and only one temperature \( T \).

(b) \( 60^\circ, 72^\circ \)

(c) All the temperature changes occur 1 hour later.

(d) The temperature is decreased by 1 degree.

\[ T(t) = \begin{cases} 
60, & 0 \leq t < 6 \\
12t - 12, & 6 \leq t < 7 \\
72, & 7 \leq t < 20 \\
-12t + 312, & 20 \leq t < 21 \\
60, & 21 \leq t \leq 24 
\end{cases} \]

63. (a) \( r(x) = \frac{x}{2} \)  \hspace{1cm} (b) \( A(r) = \pi r^2 \)

(c) \( A + r(x) = \pi \left( \frac{x^2}{2} \right) \); \( A + r(x) \) represents the area of the circular base of the tank on the square foundation with side length \( x \).

64. \( A + r(t) = 0.36 \pi r^2 \); \( A + r(t) \) represents the area of the circle at time \( t \).

65. \( N(T(t)) = 30(3r^2 + 2r + 20) \) This represents the number of bacteria in the food as a function of time.

(b) \( t = 2.846 \) hours

66. (a) \( C \cdot x(t) = 3000 + 750; C \cdot x(t) \) represents the cost of \( t \) hours of production.

(b) \( t = 4.75 \) hours
(Continued)

67. \( g(f(x)) \) represents 3 percent of an amount over $500,000.

68. (a) \( R(p) = p - 2000 \)
   (b) \( S(p) = 0.9p \)
   (c) \( (R \cdot S)(p) = 0.9p - 2000; (R \cdot S)(p) \) represents the dealership discount after the factory discount.
   \( (S \cdot R)(p) = 0.9(p - 2000); (S \cdot R)(p) \) represents the dealership discount after the factory discount.
   (d) \( (R \cdot S)(p) = $16,450 \)
   \( (S \cdot R)(p) = $16,650 \)
   $16,450 is the lower cost because 10% of the price of the car is larger than $2000.

69. False. \((f \cdot g)(x) = 6x + 1 \) and \((g \cdot f)(x) = 6x + 6 \)

70. True. The range of \( g \) must be a subset of the domain of \( f \) for \((f \cdot g)(x)\) to be defined.

71. Answers will vary.  
72. Proofs will vary.

73. 3  
74. \(-2x - h\)  
75. \(-\frac{4}{x(x + h)}\)

76. 
\[
\frac{\sqrt{2(x + h)} + 1 - \sqrt{2x + 1}}{h} = \frac{2}{\sqrt{2(x + h)} + 1 + \sqrt{2x + 1}}
\]

77. \(3x - y - 10 = 0\)  
78. \(x + y + 3 = 0\)  
79. \(3x + 2y - 22 = 0\)  
80. \(5x - 7y - 35 = 0\)
**Section 1.9 (page 99)**

**Vocabulary Check (page 99)**
1. inverse; f-inverse  
2. range; domain  
3. y = x  
4. one-to-one  
5. horizontal

1. \( f^{-1}(x) = \frac{1}{3}x \)  
2. \( f^{-1}(x) = 3x \)  
3. \( f^{-1}(x) = x - 9 \)  
4. \( f^{-1}(x) = x + 4 \)  
5. \( f^{-1}(x) = \frac{x - 1}{3} \)  
6. \( f^{-1}(x) = 5x + 1 \)  
7. \( f^{-1}(x) = x^3 \)  
8. \( f^{-1}(x) = \sqrt[3]{x} \)  
9. c  
10. b  
11. a  
12. d  
13. (a) \( f(g(x)) = f\left(\frac{x}{2}\right) = 2\left(\frac{x}{2}\right) = x \)  
   \( g(f(x)) = g(2x) = \frac{2x}{2} = x \)  
   (b)  
14. (a) \( f(g(x)) = f(x + 5) = (x + 5) - 5 = x \)  
   \( g(f(x)) = g(x - 5) = (x - 5) + 5 = x \)  
   (b)  
15. (a) \( f(g(x)) = f\left(\frac{x - 1}{7}\right) = 7\left(\frac{x - 1}{7}\right) + 1 = x \)  
   \( g(f(x)) = g(7x + 1) = \frac{(7x + 1) - 1}{7} = x \)  
   (b)  
16. (a) \( f(g(x)) = f\left(\frac{3 - x^4}{4}\right) = 3 - 4\left(\frac{3 - x^4}{4}\right) = x \)  
   \( g(f(x)) = g\left(\frac{3 - (3 - 4x)}{4}\right) = x \)  
   (b)  
17. (a) \( f(g(x)) = f\left(\frac{\sqrt[3]{8x}}{8}\right) = x \)  
   \( g(f(x)) = g\left(\frac{x^3}{8}\right) = \sqrt[3]{x^3} = x \)  
   (b)  
18. (a) \( f(g(x)) = f\left(\frac{1}{x}\right) = \frac{1}{\frac{1}{x}} = x \)  
   \( g(f(x)) = g\left(\frac{1}{x}\right) = \frac{1}{\frac{1}{x}} = x \)  
   (b)  
19. (a) \( f(g(x)) = f(x^2 + 4), \ x \geq 0 \)  
   \( = \sqrt{(x^2 + 4) - 4} = x \)  
   \( g(f(x)) = g\left(\sqrt{x - 4}\right) \)  
   \( = \left(\sqrt{x - 4}\right)^2 + 4 = x \)  
   (b)
(Continued)

20. (a) \( f(g(x)) = f(\sqrt{T - x}) \)
\[ = 1 - \left(\sqrt{T - x}\right)^3 = x \]
g\( (f(x)) = g(1 - x^2) \)
\[ = \sqrt{1 - (1 - x^2)} = x \]

(b) \[ f \quad \quad g \]
\[ -6 \quad 0 \quad 6 \]
\[ -6 \quad 0 \quad 6 \]

21. (a) \( f(g(x)) = f(\sqrt{9 - x}), \ x \leq 9 \)
\[ = 9 - (\sqrt{9 - x})^2 = x \]
g\( (f(x)) = g(9 - x^2), \ x \geq 0 \)
\[ = \sqrt{9 - (9 - x^2)} = x \]

(b) \[ f \quad \quad g \]
\[ -12 \ -8 \ -4 \ 0 \ 4 \ 8 \ 12 \]
\[ -12 \ -8 \ -4 \ 0 \ 4 \ 8 \ 12 \]

22. (a) \( f(g(x)) = f\left(\frac{1-x}{x}\right), \ 0 < x \leq 1 \)
\[ = \frac{1}{1 + (1-x)/x} = \frac{x}{x + 1 - x} = x \]
g\( (f(x)) = g\left(\frac{1}{1+x}\right), \ x \geq 0 \)
\[ = 1 - 1/(1+x) = \frac{1 + x - 1}{1} = x \]

(b) \[ f \quad \quad g \]
\[ 1 \ 2 \ 3 \ 4 \ 5 \]
\[ 1 \ 2 \ 3 \ 4 \ 5 \]

23. (a) \( f(g(x)) = f\left(\frac{5x + 1}{x - 1}\right) = \frac{5x + 1}{x - 1} - 1 \)
\[ = \frac{5x + 1 - (5x + 1)}{x - 1} + 5 \]
\[ = -\frac{5x - 1 - x + 1}{-5x - 1 + 5x - 5} = x \]

(b) \[ f \quad \quad g \]
\[ -4 \ -2 \ 0 \ 2 \ 4 \ 6 \]
\[ -4 \ -2 \ 0 \ 2 \ 4 \ 6 \]

\[ g(f(x)) = g\left(\frac{x - 1}{x + 5}\right) = -\frac{5\left(\frac{x - 1}{x + 5}\right) - 1}{x - 1 - \left(\frac{x - 1}{x + 5}\right)} = x \]

24. (a) \( f(g(x)) = f\left(\frac{2x + 3}{x - 1}\right) = \frac{2x + 3}{x - 1} + 3 \)
\[ = \frac{2x + 3 - 2x + 2}{x - 1} = x \]

(b) \[ g(f(x)) = g\left(\frac{x + 3}{x - 2}\right) = \frac{x + 3}{x - 2} + 3 \]
\[ = \frac{2x + 6 + 3x - 6}{x - 1 - x + 1} = x \]

25. No 26. Yes

27. \[ x \quad -2 \ 0 \ 2 \ 4 \ 6 \ 8 \]
\[ f^{-1}(x) \quad -2 \ -1 \ 0 \ 1 \ 2 \ 3 \]

28. \[ x \quad -10 \ -7 \ -4 \ -1 \ 2 \ 5 \]
\[ f^{-1}(x) \quad -3 \ -2 \ -1 \ 0 \ 1 \ 2 \]


33. \[ \text{The function has an inverse.} \]

34. \[ \text{The function does not have an inverse.} \]
(Continued)

35. The function does not have an inverse.

36. The function has an inverse.

37. The function does not have an inverse.

38. The function does not have an inverse.

39. (a) \( f^{-1}(x) = \frac{x + 3}{2} \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

40. (a) \( f^{-1}(x) = \frac{x - 1}{3} \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

41. (a) \( f^{-1}(x) = \sqrt[3]{x + 2} \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

42. (a) \( f^{-1}(x) = \sqrt{x - 1} \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

43. (a) \( f^{-1}(x) = x^2, \ x \geq 0 \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

44. (a) \( f^{-1}(x) = \sqrt{x} \)
   (b) 
   (c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
   (d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers such that \( x \geq 0 \).
(Continued)

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

(d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers such that \( x \geq 0 \).

45. (a) \( f^{-1}(x) = \sqrt{4 - x^2}, \ 0 \leq x \leq 2 \)

(b)

(c) The graph of \( f^{-1} \) is the same as the graph of \( f \).

46. (a) \( f^{-1}(x) = -\sqrt{x + 2} \)

(b)

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

(d) The domain of \( f \) and the range of \( f^{-1} \) are all real numbers \( x \) such that \( x \leq 0 \). The domain of \( f^{-1} \) and the range of \( f \) are all real numbers \( x \) such that \( x \geq -2 \).

47. (a) \( f^{-1}(x) = \frac{4}{x} \)

(b)

(c) The graph of \( f^{-1} \) is the same as the graph of \( f \).

48. (a) \( f^{-1}(x) = -\frac{2}{x} \)

(b)

(c) The graph of \( f^{-1} \) is the same as the graph of \( f \).

(d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers \( x \) except \( x = 0 \).

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

(b)

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

(d) The domain of \( f \) and the range of \( f^{-1} \) are all real numbers \( x \) except \( x = 2 \). The domain of \( f^{-1} \) and the range of \( f \) are all real numbers \( x \) except \( x = 1 \).

50. (a) \( f^{-1}(x) = -\frac{2x - 3}{x - 1} \)

(b)

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

(d) The domain of \( f \) and the range of \( f^{-1} \) are all real numbers \( x \) except \( x = -2 \). The domain of \( f^{-1} \) and the range of \( f \) are all real numbers \( x \) except \( x = 1 \).
(Continued)

51. (a) \( f^{-1}(x) = x^3 + 1 \)
   
   (b) \[ f^{-1} \]

(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

52. (a) \( f^{-1}(x) = x^{5/3} \)
   
   (b) \[ f^{-1} \]

(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) The domains and ranges of \( f \) and \( f^{-1} \) are all real numbers.

53. (a) \( f^{-1}(x) = \frac{5x - 4}{6 - 4x} \)
   
   (b) \[ f^{-1} \]

(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) The domain of \( f \) and the range of \( f^{-1} \) are all real numbers except \( x = \frac{3}{2} \). The domain of \( f^{-1} \) and the range of \( f \) are all real numbers except \( x = \frac{3}{2} \).

54. (a) \( f^{-1}(x) = \frac{-6x - 4}{2x - 8} \)
   
   (b) \[ f^{-1} \]

(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) The domain of \( f \) and the range of \( f^{-1} \) are all real numbers except \( x = -3 \). The domain of \( f^{-1} \) and the range of \( f \) are all real numbers except \( x = -4 \).

55. No inverse \hspace{1cm} 56. No inverse \hspace{1cm} 57. \( g^{-1}(x) = 8x \)

58. \( f^{-1}(x) = \frac{x - 5}{3} \)

59. No inverse

60. \( f^{-1}(x) = \frac{5x - 4}{3} \)

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

62. No inverse

63. No inverse

64. No inverse

65. No inverse

66. \( f^{-1}(x) = 2 - x, \ x \geq 0 \)

67. \( f^{-1}(x) = \frac{x^2 - 3}{2}, \ x \geq 0 \)

68. \( f^{-1}(x) = x^2 + 2, \ x \geq 0 \)

69. 32

70. 0

71. 600

72. \( \sqrt[2]{4} \)

73. 2 \( \sqrt[3]{x + 3} \)

74. 2 \( \sqrt[2]{x + 3} \)

75. \( \frac{x + 1}{2} \)

76. \( \frac{x - 3}{2} \)

77. \( \frac{x + 1}{2} \)

78. \( \frac{x - 3}{2} \)

79. (a) \( f^{-1}(108,209) = 11 \)
   
   (b) \( f^{-1} \) represents the year for a given number of households in the United States.
   
   (c) \( y = 1578.68t + 90,183.63 \)
   
   (d) \( f^{-1} = \frac{t - 90,183.63}{1578.68} \)
   
   (e) \( f^{-1}(117,022) = 17 \)
   
   (f) \( f^{-1}(108,209) = 11.418; \ the \ results \ are \ similar. \)

80. (a) Yes
   
   (b) \( f^{-1} \) represents the time in years for a given sales level.
   
   (c) \( f^{-1}(1825) = 10 \)
   
   (d) No, it wouldn’t exist because \( f(12) = 2794. \)

81. (a) Yes
   
   (b) \( f^{-1} \) yields the year for a given number of miles traveled by motor vehicles.
   
   (c) \( f^{-1}(2632) = 8 \)
   
   (d) No, \( f(t) \) would not pass the Horizontal Line Test.
(Continued)

82. (a) \( y = \frac{x - 8}{0.75} \)

(b) \( y = \) number of units produced; \( x = \) hourly wage

(c) 19 units

83. (a) \( y = \frac{\sqrt{x - 245.50}}{0.03}, \) \( 245.5 < x < 545.5 \)

\( x = \) degrees Fahrenheit; \( y = \% \) load

(b) \( 0 \leq x \leq 92.11 \)

84. (a) \( y = \frac{80 - x}{0.35} \)

\( x = \) total cost; \( y = \) number of pounds of the less expensive ground beef

(b) \( 62.5 \leq x \leq 80 \)

(c) 20 pounds

85. False. \( f(x) = x^2 \) has no inverse.

86. True. If \( f(x) = x - 6 \) and \( f^{-1}(x) = x + 6 \), then the \( y \)-intercept of \( f \) is \((0, -6)\) and the \( x \)-intercept of \( f^{-1} \) is \((-6, 0)\).

87–88. Answers will vary.

89.

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89.

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90.

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<td>4</td>
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The graph of \( f \) does not pass the Horizontal Line Test, so \( f^{-1}(x) \) does not exist.

91.

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91.

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92.

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93. \( k = \frac{1}{4} \)

94. \( k = -\frac{1}{2} \)

95. \( \pm 8 \)

96. \( 5 \pm 2\sqrt{2} \)

97. \( \frac{3}{4} \)

98. \( -1, -\frac{1}{4} \)

99. \( 3 \pm \sqrt{5} \)

100. \(-1, 3\)

101. 5, \(-\frac{10}{3}\)

102. \( \frac{11}{8} \)

103. 16, 18

104. \( b = \sqrt{10} \) feet, \( h = 2\sqrt{10} \) feet
Section 1.10  (page 109)

Vocabulary Check  (page 109)

1. variation; regression  2. sum of square differences
3. correlation coefficient  4. directly proportional
5. constant of variation  6. directly proportional
7. inverse  8. combined  9. jointly proportional

1. \[
\begin{array}{c}
\text{Number of employees (in thousands)} \\
\text{Year (2 ↔ 1992)}
\end{array}
\]

The model is a good fit for the actual data.

2. \[
\begin{array}{c}
\text{Winning time (in minutes)} \\
\text{Year (0 ↔ 1950)}
\end{array}
\]

The model is not a good fit. Answers will vary.

3. \[
y = \frac{1}{2}x + 3
\]

4. \[
y = -\frac{5}{2}x + 8
\]

5. \[
y = -\frac{1}{2}x + 3
\]

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

7. (a) and (b)

(c) \[y = 1.03t + 130.27\]

(d) The models are similar.

(e) Part (b): 238 feet; Part (c): 241.51 feet

(f) Answers will vary.

8. (a) and (b)

(c) \[y = 251.5t - 608.9\]

(d) The models are similar.

(e) Part (b): $3163.6$ million; Part (c): $3164.6$ million

(f) Answers will vary.

9. (a) \[S = 38.4t + 224\]

(c) \[
\begin{array}{c}
\text{Number of employees (in thousands)} \\
\text{Year (2 ↔ 1992)}
\end{array}
\]

(d) 2005: $800$ million; 2007: $876.8$ million

(e) Each year the annual gross ticket sales for Broadway shows in New York City increase by $38.4$ million.

10. (a) \[y = 0.43x + 67.7\]
(Continued)

(b) 106.4 million

d) For every million households with cable TV, there is a
0.43 million increase in the number of households with
color TV.

11. Inversely
12. Directly

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</table>
31. Model: \( y = \frac{13}{17} x \); 25.4 centimeters, 50.8 centimeters
32. Model: \( y = \frac{13}{17} x \); 18.9 liters, 94.6 liters
33. \( y = 0.0368x; 7360 \quad 34. y = 0.07x; 37.84 \)
35. (a) 0.05 meter \( \quad \text{(b) 1765} \text{ newtons} \)
36. 293 \text{ newtons} \quad 37. 39.47 pounds
38. Combined lifting force \( = 2F = 120 \text{ pounds} \)
39. \( A = kr^2 \quad 40. V = ke^3 \quad 41. y = \frac{k}{x^2} \)
42. \( h = \frac{k}{\sqrt{r}} \quad 43. F = \frac{kx}{r^2} \quad 44. z = kx^2y^3 \)
45. \( P = \frac{k}{V} \quad 46. R = k(T - T_e) \quad 47. F = \frac{km_1m_2}{r^2} \)
48. \( R = kS(L - S) \)
49. The area of a triangle is jointly proportional to its base and height.
50. The surface area of a sphere varies directly as the square of its radius.
51. The volume of a sphere varies directly as the cube of its radius.
52. The volume of a right circular cylinder is jointly proportional to the product of its height and the square of its radius.
53. Average speed is directly proportional to the distance and inversely proportional to the time.
54. \( \omega \) varies directly as the square root of \( g \) and inversely as the square root of \( W \).
55. \( A = \pi r^2 \quad 56. y = \frac{75}{x} \quad 57. y = \frac{28}{x} \)
58. \( z = 2xy \quad 59. F = 14rs^3 \quad 60. P = \frac{18x}{y^3} \)
61. \( z = \frac{2x^2}{3y} \quad 62. v = \frac{24pq}{287s^2} \quad 63. \approx 0.61 \text{ mile per hour} \)
64. \( \frac{k(2v)^2}{kv^2} = 4 \quad 65. 506 \text{ feet} \)
66. Diameter = \( 2r = 0.054 \text{ inch} \quad 67. 1470 \text{ joules} \)
68. No. The 15-inch pizza is the best buy.
69. The velocity is increased by one-third.
70. (a) The safe load is unchanged.
    (b) The safe load is eight times as great.
    (c) The safe load is four times as great.
    (d) The safe load is one-fourth as great.
71. (a) \( \quad \text{(b) Yes, } k_1 = 4200, k_2 = 3800, k_3 = 4200, k_4 = 4800, k_5 = 4500 \)
    (c) \( C = \frac{4300}{d} \)
    (d) \( e \approx 1433 \text{ meters} \)
72. (a) \( \quad \text{(b) Yes, } k = 0.575 \quad \text{(c) 15.7 pounds} \)
73. (a) \( \quad \text{(b) 0.2857 microwatt per square centimeter} \)
74. The illumination is reduced to one-fourth of its original value. Explanations will vary.
75. False. \( y \) will increase if \( k \) is positive and \( y \) will decrease if \( k \) is negative.
76. False. \( E \) is jointly proportional to the mass of an object and the square of its velocity.
77. True. The closer the value of \( |r| \) is to 1, the better the fit.
78. (a) Good approximation  (b) Poor approximation  
(c) Poor approximation  (d) Good approximation  
79. The accuracy is questionable when based on such limited data.  
80. Answers will vary.  
81. $x > 5$  
82. $x \geq \frac{11}{3}$  
83. $-4 < x < 5$  
84. $x \geq 3, x \leq -\frac{1}{3}$  
85. (a) $-\frac{5}{3}$  (b) $-\frac{7}{3}$  (c) 21  
86. (a) 6  (b) 9  (c) 383  
87. Answers will vary.
Review Exercises  (page 117)

1. [Graph of a point in Quadrant II]

2. [Graph of a point in Quadrant III]

3. Quadrant IV

4. Quadrant I or II

5. (a) $(-3, 8)$
   (b) $5$
   (c) $(-1, \frac{13}{2})$

6. (a) $(-2, 6)$
   (b) $3\sqrt{3}$
   (c) $(1, \frac{3}{2})$

7. (a) $(0, 8.2)$
   (b) $9.9$
   (c) $(2.8, 4.1)$

8. (a) $(-3.6, 0)$
   (b) $\sqrt{14.4}$
   (c) $(-1.8, -0.6)$

9. $(2, 5), (4, 5), (2, 0), (4, 0)$

10. $(-4, 6), (-1, 8), (-4, 10), (-7, 8)$

11. $\$656.45$ million

12. (a) [Graph of a function with points]
   (b) $80^\circ F$

13. Radius $\approx 22.5$ centimeters

14. (a) [Diagram of a rectangular prism]
   (b) $l = 24$ inches, $w = 8$ inches, $h = 12$ inches

15. | $x$ | $-2$ | $-1$ | $0$ | $1$ | $2$ |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$y$</td>
<td>$-11$</td>
<td>$-8$</td>
<td>$-5$</td>
<td>$-2$</td>
</tr>
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</table>

16. | $x$ | $-4$ | $-2$ | $0$ | $2$ | $4$ |
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<tr>
<td>$y$</td>
<td>$4$</td>
<td>$3$</td>
<td>$2$</td>
<td>$1$</td>
</tr>
</tbody>
</table>

17. | $x$ | $-1$ | $0$ | $1$ | $2$ | $3$ | $4$ |
<table>
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</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>$4$</td>
<td>$0$</td>
<td>$-2$</td>
<td>$-2$</td>
<td>$0$</td>
</tr>
</tbody>
</table>
18. | $x$ | $-2$ | $-1$ | $0$ | $1$ | $2$ | $3$ |
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>$1$</td>
<td>$-6$</td>
<td>$-9$</td>
<td>$-8$</td>
<td>$-3$</td>
<td>$6$</td>
</tr>
</tbody>
</table>

25. $x$-intercept: $\left(-\frac{7}{2}, 0\right)$  
   $y$-intercept: $(0, 7)$
26. $x$-intercepts: $(2, 0), (-4, 0)$  
   $y$-intercept: $(0, -2)$
27. $x$-intercepts: $(1, 0), (5, 0)$  
   $y$-intercept: $(0, 5)$
28. $x$-intercepts: $(2, 0), (-2, 0), (0, 0)$  
   $y$-intercept: $(0, 0)$
29. No symmetry
30. No symmetry
31. $y$-axis symmetry
32. $y$-axis symmetry
33. No symmetry
34. No symmetry
35. No symmetry
36. $y$-axis symmetry
(Continued)

37. Center: (0, 0); Radius: 3

38. Center: (0, 0); Radius: 2

39. Center: (−2, 0); Radius: 4

40. Center: (0, 8); Radius: 9

41. Center: \( \left( \frac{1}{2}, -1 \right) \); Radius: 6

42. Center: \( (−4, \frac{3}{2}) \); Radius: 10

43. \((x - 2)^2 + (y + 3)^2 = 13\)

44. \((x - 1)^2 + \left( y + \frac{13}{2} \right)^2 = \frac{85}{4}\)

45. (a)

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
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<tbody>
<tr>
<td>F</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

(b) 1999

46. (a) \[\begin{array}{cc}
0 & 4 \\
8 & 12 \\
16 & 20 \\
24 & 30 \\
\end{array}\]

(c) 12.5 pounds

47. slope: 0

48. slope: undefined

49. slope: 3

50. slope: −10

51.

52.

53. \(m = -\frac{1}{2}\)

54. \(m = 0\)
All real numbers

55. \( y = \frac{1}{2}x - 5 \)  
56. \( y = 6 \)

57. \( y = -\frac{1}{2}x + 2 \)  
58. \( x = -8 \)

59. \( x = 0 \)  
60. \( y = \frac{3}{2}x + 2 \)

61. \( y = -\frac{1}{2}x + \frac{3}{2} \)  
62. \( y = -\frac{1}{2}x + \frac{7}{2} \)

63. (a) \( y = \frac{2}{3}x - \frac{23}{3} \)  
(b) \( y = -\frac{4}{5}x + \frac{2}{5} \)

64. (a) \( y = -\frac{1}{3}x - \frac{2}{3} \)  
(b) \( y = \frac{2}{3}x + 15 \)

65. \( V = 850t + 7400, \quad 6 \leq t \leq 11 \)  
66. \( V = 5.15t + 42.05, \quad 6 \leq t \leq 11 \)

67. No  
68. Yes  
69. Yes  
70. No

71. (a) 5  
(b) 17  
(c) \( t^4 + 1 \)  
(d) \( t^2 + 2t + 2 \)

72. (a) -3  
(b) -1  
(c) 2  
(d) 6

73. All real numbers \( x \) such that \(-5 \leq x \leq 5\)

74. All real numbers

75. All real numbers \( x \) except \( x = 3, -2 \)

76. All real numbers

77. (a) 16 feet per second  
(b) 1.5 seconds  
(c) -16 feet per second

78. (a) \( f(x) = 0.4(50 - x) + x = 20 + 0.6x \)  
(b) Domain: \( 0 \leq x \leq 50 \); Range: \( 20 \leq y \leq 50 \)  
(c) \( \frac{82}{5} \) liters

79. \( 4x + 2h + 3, \quad h \neq 0 \)

80. \( 3x^2 + 3xh + h^2 - 10x - 5h + 1, \quad h \neq 0 \)

81. Function  
82. Function  
83. Not a function

84. Not a function  
85. \( \frac{7}{3}, 3 \)  
86. \( -1, \frac{1}{3} \)

87. \( -\frac{3}{5} \)  
88. \( 1, \pm 5 \)

89. Increasing on \((0, \infty)\)  
Decreasing on \((-\infty, -1)\)  
Constant on \((-1, 0)\)

90. Increasing on \((-2, 0)\) and \((2, \infty)\)  
Decreasing on \((-\infty, -2)\) and \((0, 2)\)

91.  
92.  
93.  
94.  
95. 4  
96. 28  
97. \( 1 - \frac{\sqrt{2}}{2} \)

98. -0.2  
99. Neither even nor odd

100. Even  
101. Odd  
102. Even
103. \( f(x) = -3x \)

104. \( f(x) = -\frac{3}{2}x - 5 \)

107.

108.

113.

114.

115. \( y = x^3 \)

116. \( y = \sqrt{x} \)

117. (a) \( f(x) = x^2 \)

(b) Vertical shift of nine units downward

(c) \( h(x) = f(x) - 9 \)

118. (a) \( f(x) = x^3 \)

(b) Horizontal shift of two units to the right and vertical shift of two units upward

(c) \( h(x) = f(x - 2) + 2 \)

119. (a) \( f(x) = \sqrt{x} \)

(b) Horizontal shift of seven units to the right

(c) \( h(x) = f(x - 7) \)

(d) \( h(x) = f(x - 7) \)

120. (a) \( f(x) = |x| \)

(b) Horizontal shift of three units to the left and vertical shift of five units downward
121. (a) \( f(x) = x^2 \)
(b) Reflection in the x-axis, horizontal shift of three units to the left, and vertical shift of one unit upward
(c) \( h(x) = f(x + 3) - 5 \)
(d) \( h(x) = -f(x + 3) + 1 \)

122. (a) \( f(x) = x^3 \)
(b) Reflection in the x-axis, horizontal shift of five units to the right, and vertical shift of five units downward
(c) \( h(x) = -f(x - 5) - 5 \)
(d) \( h(x) = -f(x - 5) - 5 \)

123. (a) \( f(x) = |x| \)
(b) Reflection in the x-axis and vertical shift of six units upward
(c) \( h(x) = -f(x + 1) - 3 \)
(d) \( h(x) = 5f(x - 9) \)

124. (a) \( f(x) = \sqrt{x} \)
(b) Reflection in the x-axis, horizontal shift of one unit to the left, and vertical shift of one unit upward
(c) \( h(x) = -f(x + 1) + 9 \)
(d) \( h(x) = -f(x + 1) + 9 \)

125. (a) \( f(x) = |x| \)
(b) Reflections in the x-axis and the y-axis, horizontal shift of four units to the right, and vertical shift of six units upward
(c) \( h(x) = -f(-x + 4) + 6 \)
(d) \( h(x) = -f(-x + 4) + 6 \)

126. (a) \( f(x) = x^2 \)
(b) Reflection in the x-axis, horizontal shift of one unit to the left, and vertical shift of three units downward
(c) \( h(x) = -f(x + 1) - 3 \)
(d) \( h(x) = 5f(x - 9) \)
Precalculus with Limits, Answers to Review Exercises

(Continued)

128. (a) \( f(x) = x^3 \)
(b) Reflection in the x-axis and vertical shrink
(c) \[ h(x) = -\frac{1}{3} f(x) \]
129. (a) \( f(x) = \sqrt{x} \)
(b) Reflection in the x-axis, vertical stretch, and horizontal shift of four units to the right
(c) \[ h(x) = -2 f(x - 4) \]
130. (a) \( f(x) = |x| \)
(b) Vertical shrink and vertical shift of one unit downward
(c) \[ h(x) = \frac{1}{2} f(x) - 1 \]
131. (a) \( x^2 + 2x + 2 \)
(b) \( x^2 - 2x + 4 \)
(c) \( 2x^3 - x^2 + 6x - 3 \)
(d) \( \frac{x^2 + 3}{2x - 1} \); all real numbers \( x \) except \( x = \frac{1}{2} \)
132. (a) \( x^2 - 4 + \sqrt{3 - x} \)
(b) \( x^2 - 4 - \sqrt{3 - x} \)
(c) \( (x^2 - 4)\sqrt{3 - x} \)
(d) \( \frac{x^2 - 4}{\sqrt{3 - x}} \); all real numbers \( x \) such that \( x < 3 \)
133. (a) \( x - \frac{5}{2} \)
(b) \( x - 8 \)
Domains of \( f, g, f \circ g, \) and \( g \circ f \): all real numbers
134. (a) \( x + 3 \)
(b) \( \sqrt[3]{x^3 + 3} \)
Domains of \( f, g, f \circ g, \) and \( g \circ f \): all real numbers
135. \( f(x) = x^3, g(x) = 6x - 5 \)
136. \( f(x) = \sqrt[3]{x}, g(x) = x + 2 \)
137. (a) \( (v + d)(t) = -36.04t^2 + 804.6t - 1112 \)
(b) \[ \begin{array}{c}
v(10) \\
d(10)
\end{array} \]
(c) \( (v + d)(10) = 3330 \)
138. (a) \( N(T) = 100r^2 + 275 \)
The composition function \( N(T(i)) \) represents the number of bacteria in the food as a function of time.
(b) \( t = 2.18 \)
139. \( f^{-1}(x) = x + 7 \)
140. \( f^{-1}(x) = x - 5 \)
141. The function has an inverse.
142. The function does not have an inverse.
143. The function has an inverse.
144. The function does not have an inverse.
145. The function has an inverse.
146. The function has an inverse.
147. (a) \( f^{-1}(x) = 2x + 6 \)
(b) \[ \begin{array}{c}
6 \\
-8
\end{array} \]
(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) Both \( f \) and \( f^{-1} \) have domains and ranges that are all real numbers.
148. (a) \( f^{-1}(x) = \frac{x + 7}{5} \)
(b) ![Graph of f and f^(-1)]
(c) The graphs are reflections of each other in the line \( y = x \).
(d) Both \( f \) and \( f^{-1} \) have domains and ranges that are all real numbers.

149. (a) \( f^{-1}(x) = x^2 - 1, \ x \geq 0 \)
(b) ![Graph of f and f^(-1)]
(c) The graph of \( f^{-1} \) is the reflection of the graph of \( f \) in the line \( y = x \).
(d) \( f \) has a domain of \([-1, \infty)\) and a range of \([0, \infty)\); \( f^{-1} \) has a domain of \([0, \infty)\) and a range of \([-1, \infty)\).

150. (a) \( f^{-1}(x) = \sqrt[3]{x} - 2 \)
(b) ![Graph of f and f^(-1)]
(c) The graphs are reflections of each other in the line \( y = x \).
(d) Both \( f \) and \( f^{-1} \) have domains and ranges that are all real numbers.

151. \( x \geq 4; \ f^{-1}(x) = \sqrt{x} + 4 \)
152. \( x \geq 2; \ f^{-1}(x) = x + 2, \ x \geq 0 \)

153. (a) ![Graph of Median income vs. Year]
(b) The model is a good fit for the actual data.

154. (a) and (b) This model is a good fit for the actual data.
(c) 2008: $10,940.36
(d) The factory sales of electronic gaming software in the U.S. increases by $627.02 million dollars each year.

155. Model: 3.2 kilometers, 16 kilometers
156. 2438.7 kilowatts
157. A factor of 4
158. 666 boxes
159. \( \approx 2 \) hours, 26 minutes
160. $44.80

161. False. The graph is reflected in the \( x \)-axis, shifted nine units to the left, and then shifted 13 units downward.

162. True. If \( f(x) = x^2 \) and \( g(x) = \sqrt[3]{x} \), then the domain of \( g \) is all real numbers, which is equal to the range of \( f \) and vice versa.

163. True. If \( y \) is directly proportional to \( x \), then \( y = kx \), so \( x = (1/k)y \). Therefore, \( x \) is directly proportional to \( y \).

164. The Vertical Line Test is used to determine if the graph of \( y \) is a function of \( x \). The Horizontal Line Test is used to determine if a function has an inverse function.

165. A function from a set \( A \) to a set \( B \) is a relation that assigns to each element \( x \) in the set \( A \) exactly one element \( y \) in the set \( B \).
Chapter Test  \(\text{(page 123)}\)

1. Midpoint: \((2, \frac{5}{2})\); Distance: \(\sqrt{89}\)

2. \(\approx 11.937\) centimeters

3. No symmetry  

4. y-axis symmetry

5. y-axis symmetry

6. \((x - 1)^2 + (y - 3)^2 = 16\)

7. \(2x + y - 1 = 0\)

8. \(17x + 10y - 59 = 0\)

9. (a) \(4x - 7y + 44 = 0\)  
   (b) \(7x + 4y - 53 = 0\)

10. (a) \(-\frac{1}{8}\)  
    (b) \(-\frac{1}{28}\)  
    (c) \(\frac{\sqrt{x}}{x^2 - 18x}\)

11. \(-10 \leq x \leq 10\)

12. (a) \(0, \pm 0.4314\)  
    (b) \(\pm 0.4314\)

   (c) Increasing on \((-0.31, 0), (0.31, \infty)\)  
   Decreasing on \((-\infty, -0.31), (0, 0.31)\)  
   (d) Even

13. (a) 0, 3
    (b) \[\text{Graph}\]
    (c) Increasing on \((-\infty, 2)\)  
    Decreasing on \((2, 3)\)
    (d) Neither even nor odd

14. (a) \(-5\)
    (b) \[\text{Graph}\]
    (c) Increasing on \((-5, \infty)\)  
    Decreasing on \((-\infty, -5)\)
    (d) Neither even nor odd

15. \[\text{Graph}\]

16. Reflection in the \(x\)-axis of \(y = [x]\)

17. Reflection in the \(x\)-axis, horizontal shift, and vertical shift of \(y = \sqrt{x}\)
(Continued)

18. (a) $2x^2 - 4x - 2$  
(b) $4x^2 + 4x - 12$  
(c) $-3x^4 - 12x^3 + 22x^2 + 28x - 35$  
(d) $\frac{3x^2 - 7}{-x^2 - 4x + 5}, \ x \neq -5, 1$  
(e) $3x^4 + 24x^3 + 18x^2 - 120x + 68$  
(f) $-9x^4 + 30x^3 - 16$

19. (a) $\frac{1 + 2x^{3/2}}{x}, \ x > 0$  
(b) $\frac{1 - 2x^{3/2}}{x}, \ x > 0$

(c) $\frac{2\sqrt{x}}{x}, \ x > 0$  
(d) $\frac{1}{2x^{1/2}}, \ x > 0$  
(e) $\frac{\sqrt{x}}{2x}, \ x > 0$  
(f) $\frac{2\sqrt{x}}{x}, \ x > 0$

20. $f^{-1}(x) = \sqrt[3]{x - 8}$  
21. No inverse

22. $f^{-1}(x) = (\frac{x}{3})^{2/3}, \ x \geq 0$  
23. $v = 6\sqrt{3}$

24. $A = \frac{25}{6}xy$  
25. $b = \frac{48}{a}$
Problem Solving  (page 125)

1. (a) $W_1 = 2000 + 0.075$  (b) $W_2 = 2300 + 0.05S$

(c) $\begin{array}{c}
\end{array}$

Both jobs pay the same monthly salary if sales equal $15,000. 
(d) No. Job 1 would pay $3400 and job 2 would pay $3300.

2. Mapping numbers onto letters is not a function since each number corresponds to three letters.
Mapping letters onto numbers is a function since every letter is assigned exactly one number.

3. (a) The function will be even.
(b) The function will be odd.
(c) The function will be neither even nor odd.

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

Both graphs are already symmetric with respect to the line $y = x$. 
General formula: $y = -x + c, c \geq 0$

5. $f(x) = a_{2n}x^{2n} + a_{2n-2}x^{2n-2} + \cdots + a_2x^2 + a_0$

\[ f(-x) = a_{2n}(-x)^{2n} + a_{2n-2}(-x)^{2n-2} + \cdots + a_2(-x)^2 + a_0 \]
\[ = f(x) \]

6. (6, 8)

\[ f(x) = \begin{cases} 
\frac{12}{7}x - \frac{16}{7}, & 2.5 \leq x \leq 6 \\
-\frac{12}{7}x + \frac{128}{7}, & 6 < x \leq 9.5 
\end{cases} \]

7. (a) $81\frac{7}{7}$ hours  (b) $25\frac{5}{9}$ miles per hour

(c) $y = -\frac{180}{7}x + 3400$

Domain: $0 \leq x \leq \frac{1190}{9}$
Range: $0 \leq y \leq 3400$

8. (a) 1  (b) 1.5  (c) 1.75  (d) 1.875  (e) 1.9375
(f) Yes, 2.
(g) a. $y = x - 1$
   b. $y = 1.5x - 1.5$
   c. $y = 1.75x - 1.75$
   d. $y = 1.875x - 1.875$
   e. $y = 1.9375x - 1.9375$

(h) $y = 2x - 2$

9. (a) $(f \circ g)(x) = 4x + 24$  (b) $(f \circ g)^{-1}(x) = \frac{1}{4}x - 6$

(c) $f^{-1}(x) = \frac{1}{4}x; \ g^{-1}(x) = x - 6$

(d) $(g^{-1} \circ f^{-1})(x) = \frac{1}{4}x - 6$

(e) $(f \circ g)(x) = 8x^3 + 1; \ (f \circ g)^{-1}(x) = \frac{1}{2}\sqrt[3]{x - 1} - 1$

\[ f^{-1}(x) = \frac{1}{2}\sqrt[3]{x - 1}; \ g^{-1}(x) = \frac{1}{2}x \]

\[ (g^{-1} \circ f^{-1})(x) = \frac{1}{2}\sqrt[3]{x - 1} \]

(f) Answers will vary.

(g) $(f \circ g)^{-1}(x) = (g^{-1} \circ f^{-1})(x)$

10. (a) $T = \frac{1}{2}\sqrt{4 + x^2 + \frac{1}{2}\sqrt{x^2 - 6x + 10}}$

(b) $0 \leq x \leq 3$

(c) $\begin{array}{c}
\end{array}$

(d) $x = 1$

(e) The distance $x = 1$ yields a time of $1.68$ hours.

11. (a) 

(b) 

Both graphs are already symmetric with respect to the line $y = x$. 
General formula: $y = -x + c, c \geq 0$
12. (a) Domain: all real numbers $x$ except $x = 1$
   Range: all real numbers $y$ except $y = 0$

   (b) $f(f(x)) = \frac{x - 1}{x}$
   Domain: all real numbers $x$ except $x = 0, 1$

   (c) $f(f(f(x))) = x$
   The graph is not a line because there are holes at $x = 0$
   and $x = 1$.

13. Proof

14. (a) 

(c) 

(d)

(e) 

(f)

(g)

15. (a) 

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<th>$x$</th>
<th>$-4$</th>
<th>$-2$</th>
<th>$0$</th>
<th>$4$</th>
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<tbody>
<tr>
<td>$f^{-1}(x)$</td>
<td>$-4$</td>
<td>$-2$</td>
<td>$0$</td>
<td>$4$</td>
</tr>
</tbody>
</table>

(b) 

<table>
<thead>
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<th>$x$</th>
<th>$-3$</th>
<th>$-2$</th>
<th>$0$</th>
<th>$1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(f + f^{-1})(x)$</td>
<td>$5$</td>
<td>$1$</td>
<td>$-3$</td>
<td>$-5$</td>
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</tbody>
</table>

(c) 

<table>
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<tr>
<th>$x$</th>
<th>$-3$</th>
<th>$-2$</th>
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<tbody>
<tr>
<td>$(f \cdot f^{-1})(x)$</td>
<td>$4$</td>
<td>$0$</td>
<td>$2$</td>
<td>$6$</td>
</tr>
</tbody>
</table>

(d) 

<table>
<thead>
<tr>
<th>$x$</th>
<th>$-4$</th>
<th>$-3$</th>
<th>$0$</th>
<th>$4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td>f^{-1}(x)</td>
<td>$</td>
<td>$2$</td>
<td>$1$</td>
</tr>
</tbody>
</table>