

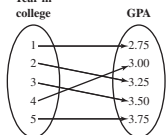
Student Answer Appendix

CHAPTER 1

Exercises 1.1, pp. 14–18

1. first, second 3. radius, center 5. Answers will vary.

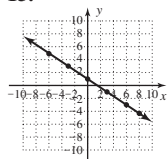
7. Year in college $D = \{1, 2, 3, 4, 5\}$
 GPA $R = \{2.75, 3.00, 3.25, 3.50, 3.75\}$



9. $D = \{1, 3, 5, 7, 9\}$; $R = \{2, 4, 6, 8, 10\}$

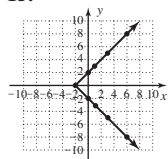
11. $D = \{4, -1, 2, -3\}$; $R = \{0, 5, 4, 2, 3\}$

13.



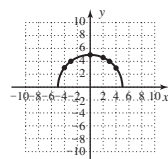
x	y
-6	5
-3	3
0	1
3	-1
6	-3
8	$-\frac{13}{3}$

15.



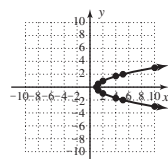
x	y
-2	0
0	2, -2
1	3, -3
3	5, -5
6	8, -8
7	9, -9

19. $D: -5 \leq x \leq 5$
 $R: 0 \leq y \leq 5$



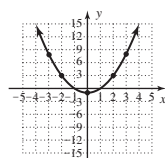
x	y
-4	3
-3	4
0	5
2	$\sqrt{21}$
3	4
4	3

21. $D: x \geq 1$
 $R: y \in \mathbb{R}$



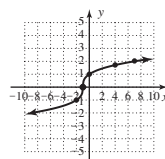
x	y
10	3, -3
5	2, -2
4	$\sqrt{3}, -\sqrt{3}$
2	1, -1
1.25	0.5, -0.5
1	0

17. $D: x \in \mathbb{R}$
 $R: y \geq -1$



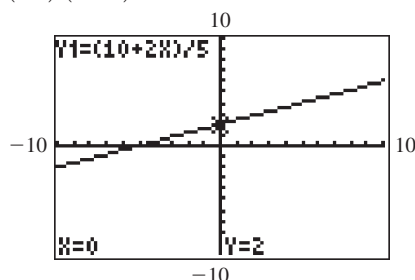
x	y
-3	8
-2	3
0	-1
2	3
3	8
4	15

23. $D: x \in \mathbb{R}$
 $R: y \in \mathbb{R}$

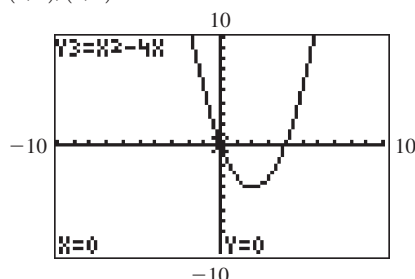


x	y
-9	-2
-2	-1
-1	0
0	1
4	$\sqrt[3]{5}$
7	2

25. (0, 2), (-5, 0)



27. (0, 0), (0, 4)

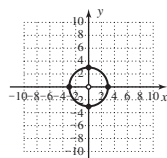


29. (3, 1) 31. (-0.7, -0.3) 33. $(\frac{1}{20}, \frac{1}{24})$ 35. (0, -1) 37. (-1, 0)

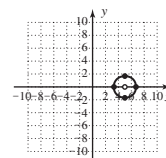
39. $2\sqrt{34}$ 41. 10 43. right triangle 45. not a right triangle

47. right triangle

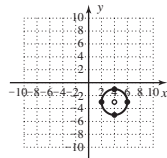
49. $x^2 + y^2 = 9$



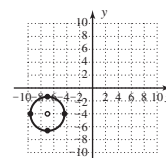
51. $(x - 5)^2 + y^2 = 3$



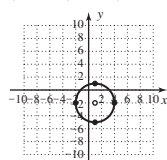
53. $(x - 4)^2 + (y + 3)^2 = 4$



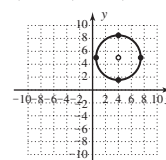
55. $(x + 7)^2 + (y + 4)^2 = 7$



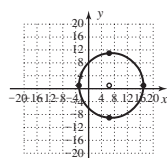
57. $(x - 1)^2 + (y + 2)^2 = 9$



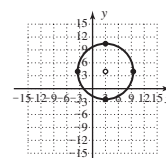
59. $(x - 4)^2 + (y - 5)^2 = 12$



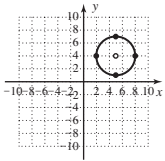
61. $(x - 7)^2 + (y - 1)^2 = 100$



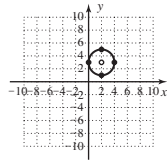
63. $(x - 3)^2 + (y - 4)^2 = 41$



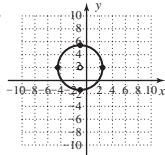
65. $(x - 5)^2 + (y - 4)^2 = 9$



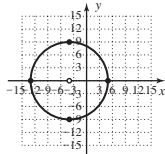
67. $(2, 3), r = 2, x \in [0, 4], y \in [1, 5]$



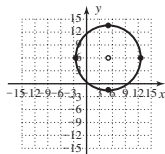
69. $(-1, 2), r = 2\sqrt{3}, x \in [-1 - 2\sqrt{3}, -1 + 2\sqrt{3}], y \in [2 - 2\sqrt{3}, 2 + 2\sqrt{3}]$



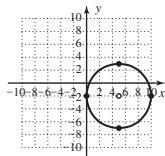
71. $(-4, 0), r = 9, x \in [-13, 5], y \in [-9, 9]$



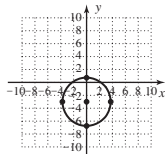
73. $(x - 5)^2 + (y - 6)^2 = 57, (5, 6), r = \sqrt{57}$



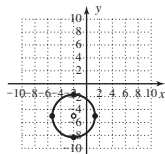
75. $(x - 5)^2 + (y + 2)^2 = 25, (5, -2), r = 5$



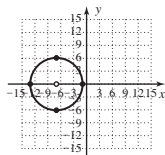
77. $x^2 + (y + 3)^2 = 14, (0, -3), r = \sqrt{14}$



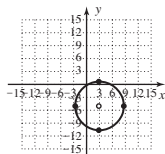
79. $(x + 2)^2 + (y + 5)^2 = 11, (-2, -5), r = \sqrt{11}$



81. $(x + 7)^2 + y^2 = 37, (-7, 0), r = \sqrt{37}$



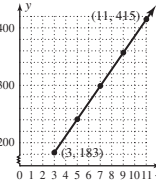
83. $(x - 3)^2 + (y + 5)^2 = 32, (3, -5), r = 4\sqrt{2}$



85. a. $y = x^2 - 6x$ 87. b. $y = x^2 + (y - 3)^2 = 36$

89. f. $(x - 1)^2 + (y + 2)^2 = 49$ 91. j. $6x + y = x^2 + 9$

93. a. $(3, 183), (5, 241), (7, 299), (9, 357), (11, 415)$; yes b. \$473
c. 2014 d.



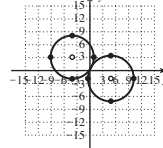
95. a. $(x - 5)^2 + (y - 12)^2 = 625$ b. no

97. Red: $(x - 2)^2 + (y - 2)^2 = 4$;

Blue: $(x - 2)^2 + y^2 = 16$;

Area blue = 12π units²

99.



No, distance between centers is less than sum of radii.

101. $y = \pm 4.8; y = \pm 3.6$, Answers will vary.

103. Answers will vary.

105. a. center: $(6, -2); r = 0$ (degenerate case) b. center: $(1, 4); r = 5$

c. $r^2 = -1$; degenerate case 107. $x = \frac{7}{4}$

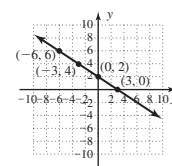
109. $n = 1$ is a solution, $n = -2$ is extraneous

Exercises 1.2, pp. 28–32

1. 0, 0 3. negative, downward 5. yes no
 $m_1 \neq m_2$ $m_1 \cdot m_2 \neq -1$

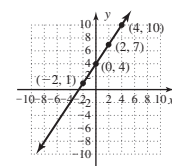
7.

x	y
-6	6
-3	4
0	2
3	0



9.

x	y
-2	1
0	4
2	7
4	10



11. $-0.5 = \frac{3}{2}(-3) + 4$ 13.

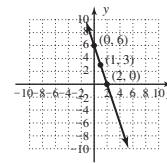
$-0.5 = -\frac{9}{2} + 4$

$-0.5 = -0.5 \checkmark$

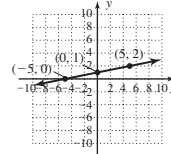
$\frac{19}{4} = \frac{3}{2}(\frac{1}{2}) + 4$

$\frac{19}{4} = \frac{3}{4} + 4$

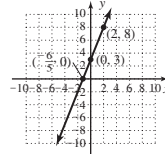
$\frac{19}{4} = \frac{19}{4} \checkmark$



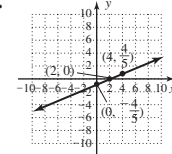
15.



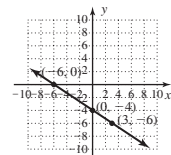
17.



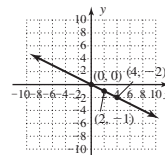
19.



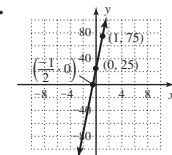
21.



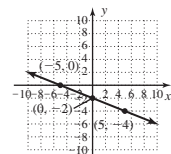
23.



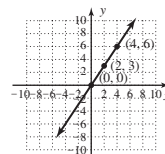
25.



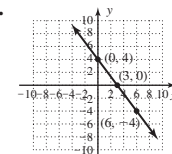
27.



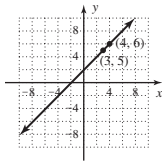
29.



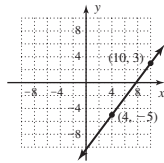
31.



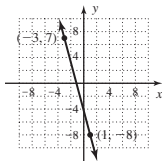
33. $m = 1$;
(2, 4) and (1, 3)



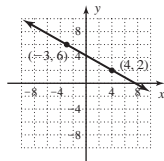
35. $m = \frac{4}{3}$;
(7, -1) and (1, -9)



37. $m = \frac{-15}{4}$;
(5, -23) and (-7, 22)



39. $m = \frac{-4}{7}$;
(-10, 10) and (11, -2)

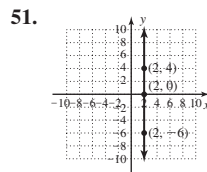
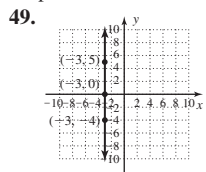


41. a. $m = 125$, cost increased \$125,000 per 1000 sq ft b. \$375,000

43. a. $m = 22.5$, distance increases 22.5 mph b. about 186 mi

45. a. $m = \frac{23}{6}$, a person weighs 23 lb more for each additional 6 in. in height b. ≈ 3.8

47. In inches: (0, -6) and (576, -18): $m = \frac{-1}{48}$. The sewer line is 1 in. deeper for each 48 in. in length.



53. $L_1: x = 2; L_2: y = 4$; point of intersection (2, 4)

55. a. For any two points chosen $m = 0$, indicating there has been no increase or decrease in the number of supreme court justices. b. For any two points chosen $m = \frac{1}{10}$, which indicates that over the last 5 decades, one nonwhite or nonfemale justice has been added to the court every 10 yr.



57. parallel 59. neither 61. parallel 63. right triangle

65. not a right triangle 67. right triangle 69. a. 78.2 yr b. 2015

71. $v = -1250t + 8500$ a. \$3500 b. 5 yr

73. $h = -3t + 300$ a. 273 in. b. 20 months

75. Yes they will meet, the two roads are not parallel: $\frac{38}{12} \neq \frac{30}{9.5}$.

77. a. \$7360 b. 2015 79. a. 21% b. 2016

81. $a = -6$ 83. a. 142 b. -83 c. 9 d. $\frac{27}{2}$

85. a. $10\sqrt{5}$ b. 4 87. a. $(x-3)(x+2)(x-2)$

- b. $(x-24)(x+1)$ c. $(x-5)(x^2+5x+25)$

Exercises 1.3, pp. 43–47

1. first 3. range 5. Answers will vary. 7. function

9. Not a function. The Shaq is paired with two heights.

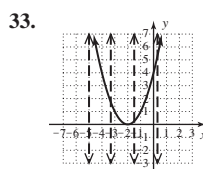
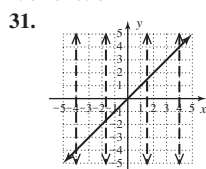
11. Not a function; 4 is paired with 2 and -5. 13. function

15. function 17. Not a function; -2 is paired with 3 and -4.

19. function 21. function 23. Not a function; 0 is paired with 4 and -4.

25. function 27. Not a function; 4 is paired with -1 and 1.

29. function



function

function

35. $w \geq 45$; $w \in [45, \infty)$ 37. $250 < T < 450$; $T \in (250, 450)$

39. $p \in (-\infty, 3)$

41. $m \in (-\infty, 5]$

43. $x \in (-\infty, 1) \cup (1, \infty)$

45. $x \in [2, \infty)$

47. $\{x|x \geq -2\}$; $[-2, \infty)$ 49. $\{x|-2 \leq x \leq 1\}$; $[-2, 1]$

51. function, $x \in [-4, 5]$, $y \in [-2, 3]$

53. function, $x \in [-4, \infty)$, $y \in [-4, \infty)$

55. function, $x \in [-4, 4]$, $y \in [-5, -1]$

57. function, $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$

59. not a function, $x \in [-3, 5]$, $y \in [-3, 3]$

61. not a function, $x \in (-\infty, 3]$, $y \in (-\infty, \infty)$

63. $x \in (-\infty, 5) \cup (5, \infty)$ 65. $a \in [\frac{-5}{3}, \infty)$

67. $x \in (-\infty, -5) \cup (-5, 5) \cup (5, \infty)$

69. $v \in (-\infty, -3\sqrt{2}) \cup (-3\sqrt{2}, 3\sqrt{2}) \cup (3\sqrt{2}, \infty)$

71. $x \in (-\infty, \infty)$ 73. $n \in (-\infty, \infty)$ 75. $x \in (-\infty, \infty)$

77. $x \in (-\infty, -2) \cup (-2, 5) \cup (5, \infty)$

79. $x \in [2, \frac{5}{2}) \cup (\frac{5}{2}, \infty)$ 81. $x \in (-4, \infty)$ 83. $x \in (3, \infty)$

85. $x \in (\frac{7}{3}, \infty)$

87. $f(-6) = 0, f(\frac{3}{2}) = \frac{15}{4}, f(2c) = c + 3, f(c + 1) = \frac{1}{2}c + \frac{7}{2}$

89. $f(-6) = 132, f(\frac{3}{2}) = \frac{3}{4}, f(2c) = 12c^2 - 8c, f(c + 1) = 3c^2 + 2c - 1$

91. $h(3) = 1, h(\frac{-2}{3}) = \frac{-9}{2}, h(3a) = \frac{1}{a}, h(a - 2) = \frac{3}{a - 2}$

93. $h(3) = 5, h(\frac{-2}{3}) = -5, h(3a) = -5$ if $a < 0$ or 5 if $a > 0$,
 $h(a - 2) = 5$ if $a > 2$ or -5 if $a < 2$

95. $g(4) = 8\pi, g(\frac{3}{2}) = 3\pi, g(2c) = 4\pi c, g(c + 3) = 2\pi(c + 3)$

97. $g(4) = 16\pi, g(\frac{3}{2}) = \frac{9}{4}\pi, g(2c) = 4\pi c^2, g(c + 3) = (c^2 + 6c + 9)\pi$

99. $p(5) = \sqrt{13}, p(\frac{3}{2}) = \sqrt{6}, p(3a) = \sqrt{6a + 3}, p(a - 1) = \sqrt{2a + 1}$

101. $p(5) = \frac{14}{5}, p(\frac{3}{2}) = \frac{7}{9}, p(3a) = \frac{27a^2 - 5}{9a^2}, p(a - 1) = \frac{3a^2 - 6a - 2}{a^2 - 2a + 1}$

103. a. $D: \{-1, 0, 1, 2, 3, 4, 5\}$ b. $R: \{-2, -1, 0, 1, 2, 3, 4\}$ c. 1

- d. -1 105. a. $D: [-5, 5]$ b. $y \in [-3, 4]$ c. -2 d. -4 and 0

107. a. $D: [-3, \infty)$ b. $y \in (-\infty, 4]$ c. 2 d. -2 and 2

109. a. 186.5 lb b. 37 lb 111. $A = \frac{1}{2}(8) + 22 - 1 = 25$ units²

113. a. $N(g) = 2.5g$ b. $g \in [0, 5]; N \in [0, 12.5]$ 115. a. $[0, \infty)$

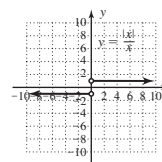
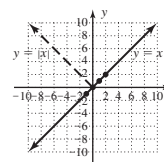
- b. about 2356 units³ c. 800 units³ 117. a. $c(t) = 42.50t + 50$

- b. \$156.25 c. 5 hr d. $t \in [0, 10.6]; c \in [0, 500]$

119. a. Yes. Each x is paired with exactly one y . b. 10 P.M. c. 0.9 m

- d. 7 P.M. and 1 A.M.

121. negative outputs become positive



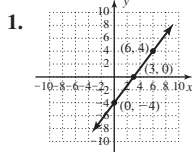
123. a. $x \in (-\infty, -2) \cup (2, \infty)$; $x = \frac{2y+3}{y}$; $y \in (-\infty, 1) \cup (1, \infty)$

- b. $x \in \mathbb{R}$ $x = \pm\sqrt{y+3}$; $y \in [-3, \infty)$ 125. a. $19\sqrt{6}$ b. 1

127. a. $(x-3)(x-5)(x+5)$ b. $(2x+3)(x-8)$

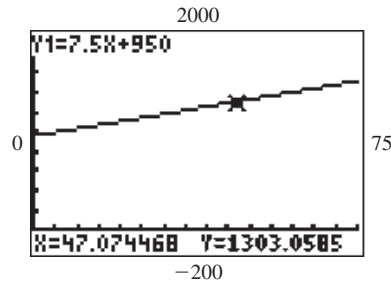
- c. $(2x-5)(4x^2+10x+25)$

Mid-Chapter Check, p. 48



1. $m = \frac{-18}{7}$ 3. positive, loss is decreasing (profit is increasing); $m = \frac{3}{2}$, yes; $\frac{1.5}{1}$, each year Data.com's loss decreases by 1.5 million.

4. a. $E(x) = 7.5x + 950$ b. \$1100, \$1175, \$1250
 c. $x \in [0, 75, 5]$ and $y \in [-200, 2000, 200]$
 d. 47 snowboards



5. $x = -3$; no; input -3 is paired with more than one output.
 6. $y = 2$; yes 7. a. 0 b. $x \in [-3, 5]$ c. -1 and 1 d. $y \in [-4, 5]$
 8. from $x = 1$ to $x = 2$; steeper line \rightarrow greater slope
 9. $\frac{\Delta F}{\Delta P} = \frac{3}{4}$; For each increase of 4000 pheasants, the fox population increases by 300; 1100 foxes. 10. a. $x \in \{-3, -2, -1, 0, 1, 2, 3, 4\}$, $y \in \{-3, -2, -1, 0, 1, 2, 3, 4\}$ b. $x \in [-3, 4]$, $y \in [-3, 4]$ c. $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$

Reinforcing Basic Concepts, pp. 48-49

1. $D: x \in (-\infty, \infty), R: y \in (-\infty, 7)$
 2. $D: x \in [-1, 7], R: y \in [-6, 9]$
 3. $D: x \in (-\infty, 9], R: y \in [-3, \infty)$
 4. $D: x \in (-\infty, \infty), R: y \in (-\infty, 9]$

Exercises 1.4, pp. 59-63

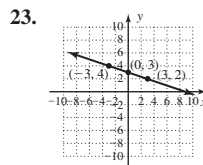
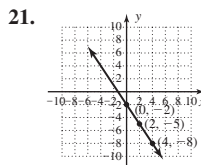
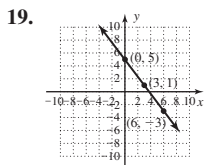
1. $\frac{-7}{4}, (0, 3)$ 3. 2.5 5. Answers will vary.
 7. $y = \frac{-4}{5}x + 2$ 9. $y = 2x + 7$ 11. $y = \frac{-5}{3}x - 5$

x	y
-5	6
-2	$\frac{18}{5}$
0	2
1	$\frac{6}{5}$
3	$\frac{-2}{5}$

x	y
-5	-3
-2	3
0	7
1	9
3	13

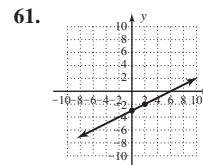
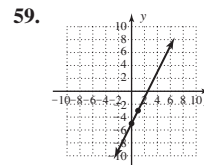
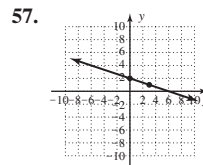
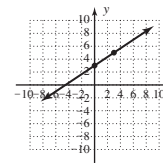
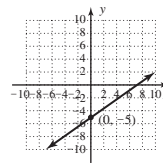
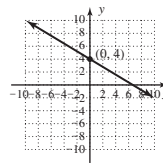
x	y
-5	$\frac{10}{3}$
-2	$\frac{-5}{3}$
0	-5
1	$\frac{-20}{3}$
3	-10

13. $y = 2x - 3$; 2, -3 15. $y = \frac{5}{3}x - 7$; $\frac{5}{3}, -7$
 17. $y = \frac{-35}{6}x - 4$; $\frac{-35}{6}, -4$

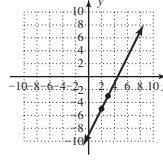


25. a. $\frac{-3}{4}$ b. $y = \frac{-3}{4}x + 3$ c. The coeff. of x is the slope and the constant is the y-intercept. 27. a. $\frac{2}{5}$ b. $y = \frac{2}{5}x - 2$ c. The coeff. of x is the slope and the constant is the y-intercept. 29. a. $\frac{4}{5}$ b. $y = \frac{4}{5}x + 3$ c. The coeff. of x is the slope and the constant is the y-intercept.
 31. $y = \frac{-2}{3}x + 2, f(x) = \frac{-2}{3}x + 2, m = \frac{-2}{3}, y$ -intercept $(0, 2)$

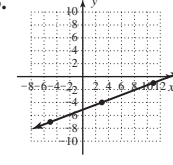
33. $y = \frac{-5}{4}x + 5, f(x) = \frac{-5}{4}x + 5, m = \frac{-5}{4}, y$ -intercept $(0, 5)$
 35. $y = \frac{1}{3}x, f(x) = \frac{1}{3}x, m = \frac{1}{3}, y$ -intercept $(0, 0)$
 37. $y = \frac{3}{4}x + 3, f(x) = \frac{3}{4}x + 3, m = \frac{3}{4}, y$ -intercept $(0, 3)$
 39. $y = \frac{2}{3}x + 1$ 41. $y = 3x + 3$ 43. $y = 3x + 2$
 45. $y = -4x - 10$ 47. $y = \frac{-3}{2}x + 1$ 49. $y = \frac{75}{2}x + 150$
 51. $y = \frac{-3}{5}x + 4$ 53. $y = \frac{2}{3}x - 5$ 55.



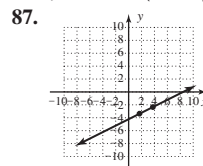
57. $y = \frac{2}{5}x + 4$ 59. $y = \frac{-5}{3}x + 7$ 61. $y = \frac{-12}{5}x - \frac{29}{5}$
 63. $y = \frac{2}{5}x + 4$ 65. $y = \frac{-5}{3}x + 7$ 67. $y = \frac{-12}{5}x - \frac{29}{5}$
 69. $y = 5$ 71. perpendicular 73. neither 75. parallel
 77. a. $y = \frac{-3}{4}x - \frac{5}{2}$ b. $y = \frac{4}{3}x - \frac{20}{3}$ 79. a. $y = \frac{4}{9}x + \frac{31}{9}$
 b. $y = \frac{-9}{4}x + \frac{3}{4}$ 81. a. $y = \frac{-1}{2}x - 2$ b. $y = 2x - 2$
 83. 85.



$y + 5 = 2(x - 2)$



$y + 4 = \frac{3}{8}(x - 3)$



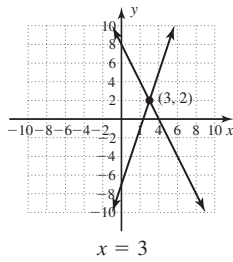
$y + 3.1 = 0.5(x - 1.8)$

89. $y - 2 = \frac{6}{5}(x - 4)$; For each 5000 additional sales, income rises \$6000. 91. $y - 100 = \frac{-20}{1}(x - 0.5)$; For every hour of television, a student's final grade falls 20%. 93. $y - 10 = \frac{35}{2}(x - \frac{1}{2})$; Every 2 in. of rainfall increases the number of cattle raised per acre by 35. 95. C 97. A
 99. B 101. D 103. $m = \frac{-a}{b}, y$ -intercept $= \frac{c}{b}$ a. $m = \frac{-3}{4}, y$ -intercept $(0, 2)$ b. $m = \frac{-2}{5}, y$ -intercept $(0, -3)$ c. $m = \frac{5}{6}, y$ -intercept $(0, 2)$
 d. $m = \frac{5}{3}, y$ -intercept $(0, 3)$ 105. a. As the temperature increases 5°C, the velocity of sound waves increases 3 m/s. At a temperature of 0°C, the velocity is 331 m/s. b. 343 m/s c. 50°C 107. a. $V = \frac{20}{3}t + 150$
 b. Every 3 yr the value of the coin increases by \$20; the initial value was \$150. c. \$223.33 d. 15 years, in 2013 e. 3 yr 109. a. $N = 7t + 9$
 b. Every 1 yr the number of homes with Internet access increases by 7 million. c. 1993 d. 86 million e. 13 yr f. 2010
 111. a. $P = 58,000t + 740,000$ b. Each year, the prison population increases by 58,000. c. 1,900,000 113. Answers will vary.
 115. 1. d. 2. a. 3. c. 4. b. 5. f. 6. h. 117. a. 9 b. $9|x|$
 119. 113.10 yd²

Exercises 1.5, pp. 75-78

1. intersection-of-graphs, Y_1, Y_2, x -coordinate, intersection
 3. literal, two 5. Answers will vary.

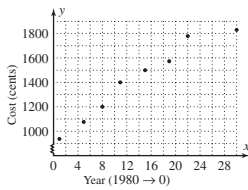
7.



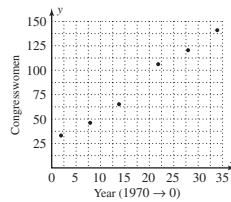
9. $x = -3$ 11. $x \in (-\infty, \infty)$ 13. $x = -9$ 15. no solutions
 17. $x = 3$, answers match 19. $x = -2$ 21. $x = 0$
 23. no solutions 25. $x \in (-\infty, \infty)$ 27. $x \in (3, \infty)$, verified graphically in Exercise 7 29. $x \in (-\infty, 0]$ 31. $x \in (-5, \infty)$
 33. $x \in (-\infty, \infty)$ 35. no solutions 37. $C = \frac{P}{1 + M}$ 39. $r = \frac{C}{2\pi}$
 41. $T_2 = \frac{T_1 P_2 V_2}{P_1 V_1}$ 43. $h = \frac{3V}{4\pi r^2}$ 45. $n = \frac{2S_n}{a_1 + a_n}$
 47. $P = \frac{2(S - B)}{S}$ 49. $y = \frac{-A}{B}x + \frac{C}{B}$ 51. $y = \frac{-20}{9}x + \frac{16}{3}$
 53. $y = \frac{-4}{5}x - 5$ 55. $a = 3; b = 2; c = -19; x = -7$
 57. $a = -6; b = 1; c = 33; x = \frac{16}{3}$
 59. $a = 7; b = -13; c = -27; x = -2$ 61. $h = 17$ cm 63. 510 ft
 65. 56 in 67. 3084 ft 69. 48; 50 71. 5; 7 73. 11:30 A.M.
 75. 36 min 77. 4 quarts; 50% O.J. 79. 16 lb; \$1.80 lb
 81. 12 lb 83. 16 lb 85. Answers will vary. 87. 69 89. $x = -7$
 91. a. $(2x + 3)(2x - 3)$ b. $(x - 3)(x^2 + 3x + 9)$

Exercises 1.6, pp. 87–93

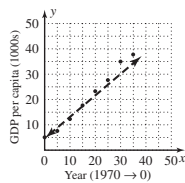
1. scatterplot 3. linear 5. Answers will vary.
 7. a. b. positive



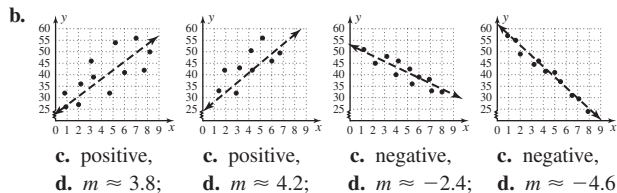
9. a. b. linear c. positive



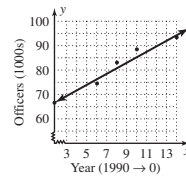
11. a. b. positive c. strong



13. a. (A) (D) (C) (B)



15. a. linear b. positive c. strong d. $m \approx 4.2$
 17. a. nonlinear b. positive c. NA d. NA
 19. a. nonlinear b. negative c. NA d. NA
 21. a. b. positive c. $f(x) = 2.4x + 62.3$,
 $f(5) = 74.3(74,300)$, $f(21) = 112.7(112,700)$

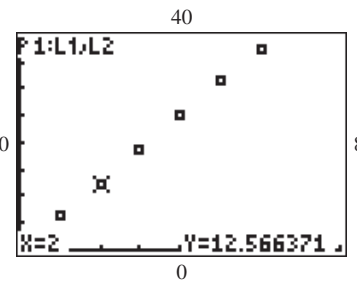


23. Using (5, 7.6) and (20, 23.3): $y \approx 1.05x + 2.37$; GDP in 2010 will be near 44,370

25. a.

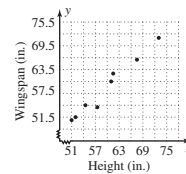
X	Y1
0	0
1	6.2832
2	12.5664
3	18.8496
4	25.1328
5	31.4160
6	37.6992

X=0

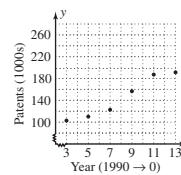


- b. positive, larger radius \Rightarrow larger area c. perfect correlation
 d. $m = 2\pi$

27. a. b. linear c. positive
 d. $y = 0.96x + 1.55$, 63.95 in.



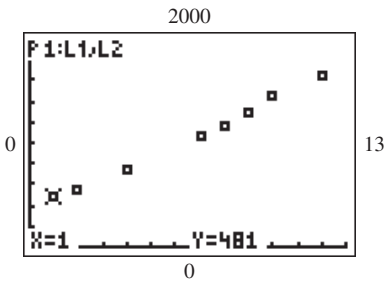
29. a. b. linear c. positive
 d. $y = 9.55x + 70.42$; about 271,000. The number of applications, since the line has a greater slope.



31. a.
-

- b. women: linear c. positive; b. men: linear c. negative
 d. yes, |slope| is greater

33. a.



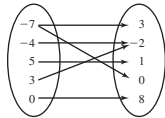
- a. linear b. $y = 108.18x + 330.20$
 c. \$1736.54 billion; about \$2601.98 billion
 35. a. $r \approx 0.9783$ b. $r \approx 0.9783$ c. they are almost identical; context, pattern of scatterplot, anticipated growth, etc.
 37. No. Except for the endpoints of the domain, one x is mapped to two y 's.
 39. $r = \frac{A - P}{Pt}$

Making Connections, p. 93

1. d 3. a 5. b 7. c 9. f 11. d 13. f 15. a

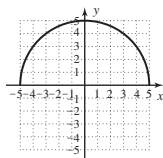
Summary and Concept Review, pp. 94–98

1. $x \in \{-7, -4, 0, 3, 5\}$ $y \in \{-2, 0, 1, 3, 8\}$



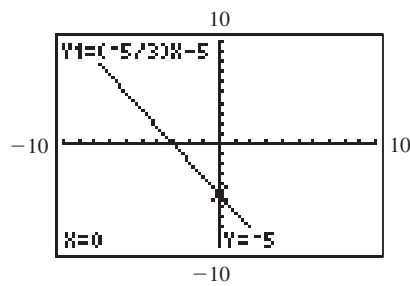
2.

x	y
-5	0
-4	3
-2	$\sqrt{21} \approx 4.58$
0	5
2	$\sqrt{21} \approx 4.58$
4	3
5	0



$x \in [-5, 5]$ $y \in [0, 5]$

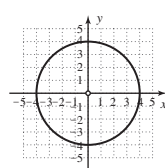
3.



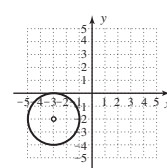
$(0, -5), (-3, 0)$

4. 65 mi 5. $(\frac{5}{2}, -3)$

6.

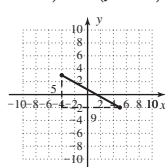


7.



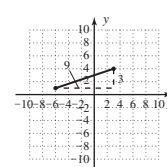
8. $(x + 1.5)^2 + (y - 2)^2 = 6.25$

9. a.



$-\frac{5}{9}, (14, -7)$

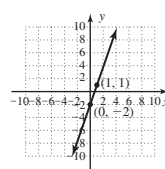
b.



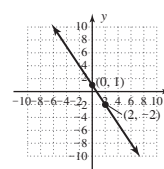
$\frac{1}{3}, (0, 3)$

10. a. parallel b. perpendicular

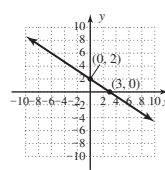
11. a.



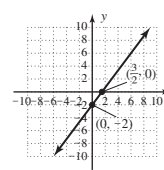
b.



12. a.



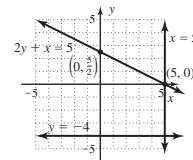
b.



13. a. vertical

b. horizontal

c. neither



14. yes 15. $m = \frac{2}{3}$, y-intercept (0, 2); when the rodent population increases by 3000, the hawk population increases by 200.

16. a. $x \in [-\frac{5}{4}, \infty)$ b. $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$

17. 14; $\frac{26}{9}$; $18a^2 - 9a$ 18. It is a function.

19. I. a. $D = \{-1, 0, 1, 2, 3, 4, 5\}$, $R = \{-2, 1, 0, 1, 2, 3, 4\}$ b. 1

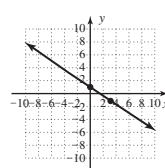
- c. 2 II. a. $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$ b. -1 c. 3

- III. a. $x \in [-3, \infty)$, $y \in [-4, \infty)$ b. -1 c. -3 or 3

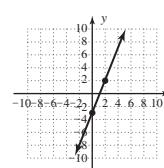
20. a. $y = -\frac{4}{3}x + 4$, $m = -\frac{4}{3}$, y-intercept (0, 4)

- b. $y = \frac{5}{3}x - 5$, $m = \frac{5}{3}$, y-intercept (0, -5)

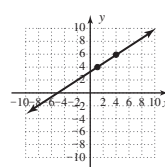
21. a.



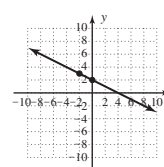
b.



22. a.



b.



23. $y = 5$, $x = -2$; $y = 5$ 24. $y = -\frac{3}{4}x + \frac{11}{4}$ 25. $f(x) = \frac{4}{3}x$

26. $m = \frac{2}{5}$, y-intercept (0, 2), $y = \frac{2}{5}x + 2$. When the rabbit population increases by 500, the wolf population increases by 200.

27. a. $(y - 90) = -\frac{15}{2}(x - 2)$ b. (14, 0), (0, 105) c. $f(x) = -\frac{15}{2}x + 105$

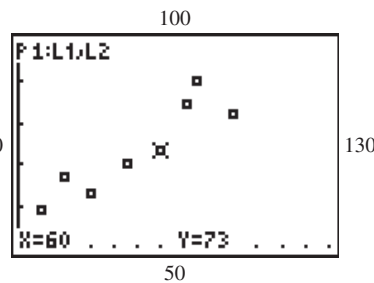
- d. $f(20) = -45$, $x = 12$ 28. $x = -6$ 29. $x \in (-\infty, \infty)$

30. $x \in (-\infty, -1)$ 31. $h = \frac{V}{\pi r^2}$ 32. $L = \frac{P - 2W}{a}$ 33. $x = \frac{c - b}{a}$

34. $y = \frac{2}{3}x - 2$ 35. 8 gal 36. $12 + \frac{9}{8}\pi \text{ ft}^2 \approx 15.5 \text{ ft}^2$

37. $\frac{2}{3} \text{ hr} = 40 \text{ min}$

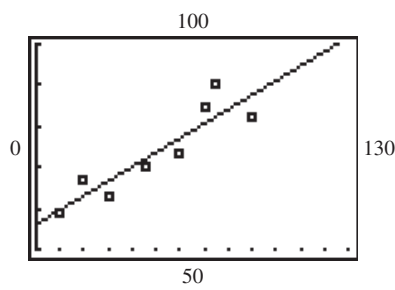
38. a.



- b. linear c. positive

39. a. $f(x) = 0.35x + 56.10$

b.



c. strong

40. $f(120) = 98.1$, over 98%

Practice Test, pp. 99–100

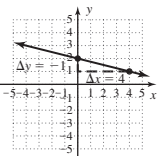
1. a. $x = 27$ b. $x = 2$ c. $C = \frac{P}{1+k}$ d. $W = \frac{P-2L}{2}$

2. 30 gal 3. $S \geq 177$ 4. about 5.1 sec

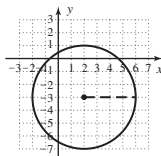
5. a and c are nonfunctions, they do not pass the vertical line test

6. neither

7.



8.



$(2, -3); r = 4$

9. $V = \frac{20}{3}t + \frac{20}{3}, 66\frac{2}{3}$ mph 10. $y = -\frac{6}{5}x + \frac{2}{5}$

11. a. $(7.5, 1.5)$, b. ≈ 61.27 mi 12. $L_1: x = -3$ $L_2: y = 4$

13. a. $x \in \{-4, -2, 0, 2, 4, 6\}$ $y \in \{-2, -1, 0, 1, 2, 3\}$

b. $x \in [-2, 6]$ $y \in [1, 4]$

14. a. 300 b. 30 c. $W(h) = \frac{25}{2}h$ d. Wages are \$12.50 per hr.

e. $h \in [0, 40]; w \in [0, 500]$ 15. a. $\frac{7}{2}$ b. $\frac{-a^2 - 6a - 7}{a^2 + 6a + 9}$

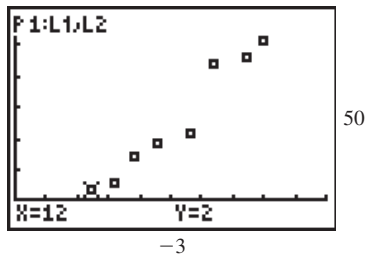
16. a. $\frac{\Delta \text{sales}}{\Delta \text{time}} = \frac{13.5}{1}$

b. sales are increasing at a rate of 13.5 million phones per year

c. 2008: about 15 million sales, 2010: about 42 million sales, 2011: about 55.5 million sales

17. a. $x = -9$ b. no solution 18. a. $x \in [3, \infty)$ b. $x \in (-\infty, \infty)$

19. a. 30 b. linear c. positive



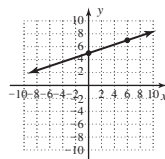
20. a. $f(x) = 0.91x - 10.78$ b. $f(50) \approx 35$ c. strong: $r \approx 0.974$

Strengthening Core Skills, pp. 100–101

1. a. $\frac{1}{3}$, increasing b. $y - 5 = \frac{1}{3}(x - 0)$,

$y = \frac{1}{3}x + 5$

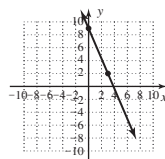
c. $(0, 5), (-15, 0)$



2. a. $-\frac{7}{3}$, decreasing b. $y - 9 = -\frac{7}{3}(x - 0)$,

$y = -\frac{7}{3}x + 9$

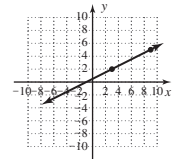
c. $(0, 9), (\frac{27}{7}, 0)$



3. a. $\frac{1}{2}$, increasing b. $y - 2 = \frac{1}{2}(x - 3)$,

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

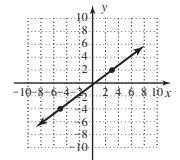
c. $(0, \frac{1}{2}), (-1, 0)$



4. a. $\frac{3}{4}$, increasing b. $y + 4 = \frac{3}{4}(x + 5)$,

$y = \frac{3}{4}x - \frac{1}{4}$

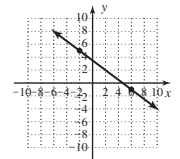
c. $(0, -\frac{1}{4}), (\frac{1}{3}, 0)$



5. a. $-\frac{3}{4}$, decreasing b. $y - 5 = -\frac{3}{4}(x + 2)$,

$y = -\frac{3}{4}x + \frac{7}{2}$

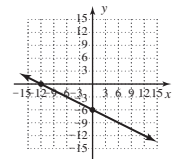
c. $(0, \frac{7}{2}), (\frac{14}{3}, 0)$



6. a. $-\frac{1}{2}$, decreasing b. $y + 7 = -\frac{1}{2}(x - 2)$,

$y = -\frac{1}{2}x - 6$

c. $(0, -6), (-12, 0)$



Connections to Calculus, p. 104

1. $y = -4x - 9$ 3. $y = -9$ 5. $y = 44$ 7. $y = -36x - 1$

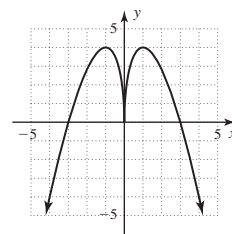
9. $y = -\frac{1}{2}x - \frac{5}{2}$ 11. $y = \frac{1}{2}x + \frac{3}{2}$ 13. $y = -\frac{3}{4}x + \frac{7}{4}$

CHAPTER 2

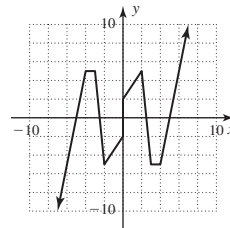
Exercises 2.1, pp. 114–119

1. linear, bounce 3. increasing 5. Answers will vary.

7. 9. even 11. even



13. 15. odd 17. not odd



19. neither 21. odd 23. neither 25. $x \in [-1, 1] \cup [3, \infty)$

27. $x \in (-\infty, -1) \cup (-1, 1) \cup (1, \infty)$ 29. $x \in [2, \infty)$

31. $x \in (-\infty, 2]$ 33. $V(x)\uparrow: x \in (-3, 1) \cup (4, 6);$

$V(x)\downarrow: x \in (-\infty, -3) \cup (1, 4);$ constant: none

35. $f(x)\uparrow: x \in (1, 4); f(x)\downarrow: x \in (-2, 1) \cup (4, \infty);$ constant: $x \in (-\infty, -2)$

37. a. $p(x)\uparrow: x \in (-\infty, \infty); p(x)\downarrow: \text{none}$ b. down, up

39. a. $f(x)\uparrow: x \in (-3, 0) \cup (3, \infty); f(x)\downarrow: x \in (-\infty, -3) \cup (0, 3)$

b. up, up 41. a. $x \in (-\infty, \infty); y \in (-\infty, 5]$ b. $x = 1, 3$

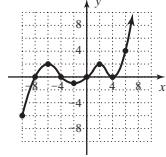
c. $H(x) \geq 0: x \in [1, 3]; H(x) \leq 0: x \in (-\infty, 1] \cup [3, \infty)$

d. $H(x)\uparrow: x \in (-\infty, 2); H(x)\downarrow: x \in (2, \infty)$ e. local max: $y = 5$ at $(2, 5)$

43. a. $x \in (-\infty, \infty); y \in (-\infty, \infty)$ b. $x = -1, 5$
 c. $g(x) \geq 0: x \in [-1, \infty); g(x) \leq 0: x \in (-\infty, -1] \cup \{3.5\}$
 d. $g(x) \uparrow: x \in (-\infty, 1) \cup (5, \infty); g(x) \downarrow: x \in (1, 5)$ e. local max: $y = 6$ at $(1, 6)$; local min: $y = 0$ at $(5, 0)$ 45. a. $x \in [-4, \infty); y \in (-\infty, 3]$
 b. $x = -4, 2$ c. $Y_1 \geq 0: x \in [-4, 2] Y_1 \leq 0: x \in [2, \infty]$
 d. $Y_1 \uparrow: x \in (-4, -2); Y_1 \downarrow: x \in (-2, \infty)$ e. local max: $y = 3$ at $(-2, 3)$; endpoint min $y = 0$ at $(-4, 0)$
 47. a. $x \in (-\infty, \infty), y \in (-\infty, \infty)$ b. $x = -4$
 c. $p(x) \geq 0: x \in [-4, \infty); p(x) \leq 0: x \in (-\infty, -4]$
 d. $p(x) \uparrow: x \in (-\infty, -3) \cup (-3, \infty); p(x) \downarrow$: never decreasing
 e. local max: none; local min: none
 49. max: $y \approx 1.58$ at $x \approx 0.78$; min: $y \approx -0.47$ at $x \approx 2.55$
 51. max: $y \approx 1.54$ at $x \approx -6.21, y \approx 3.28$ at $x \approx 2.55$; min: $y \approx -3.28$ at $x \approx -2.55, y \approx -1.54$ at $x \approx 6.21$
 53. max: $y \approx 3.08$ at $x = \frac{8}{3}$; min: $y = 0$ at $x = 4$ (endpoint)
 55. a. $x \in (-\infty, -3] \cup [3, \infty); y \in [0, \infty)$ b. $(-3, 0), (3, 0)$
 c. $f(x) \uparrow: x \in (3, \infty); f(x) \downarrow: x \in (-\infty, -3)$ d. even

e. $x = \pm \sqrt{\frac{9y^2 + 36}{2}}$ 57. a. $x \in [0, 260], y \in [0, 80]$ b. 80 ft
 c. 120 ft d. yes e. $(0, 120)$ f. $(120, 260)$

59. a. $x \in (-\infty, \infty); y \in [-1, \infty)$ b. $(-1, 0), (1, 0)$
 c. $f(x) \geq 0: x \in (-\infty, -1] \cup [1, \infty); f(x) < 0: x \in (-1, 1)$
 d. $f(x) \uparrow: x \in (0, \infty), f(x) \downarrow: x \in (-\infty, 0)$ e. min: $(0, -1)$
 61. a. $D: t \in [1983, 2009], R: I \in [5, 14]$; b. $I(t) \uparrow: t \in (1983, 1984) \cup (1986, 1987) \cup (1993, 1994) \cup (1998, 2000) \cup (2005, 2006);$
 $I(t) \downarrow: t \in (1984, 1986) \cup (1989, 1993) \cup (1994, 1998) \cup (2000, 2003) \cup (2006, 2009); I(t)$ constant: $(1987, 1989) \cup (2003, 2005)$; c. global max: $I = 14$ in 1984, global min: $I = 5$ in 2009 (also an endpoint min);
 d. greatest increase: $(1993, 1994)$, greatest decrease: $(1985, 1986)$
 63. zeroes: $(-8, 0), (-4, 0), (0, 0), (4, 0)$;
 min: $(-10, -6), (-2, -1), (4, 0)$; max: $(-6, 2), (2, 2)$

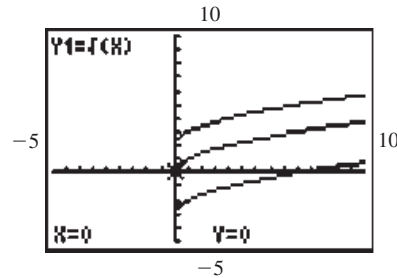


65. no; no; answers will vary. 67. a. Thorpe; Rosolino b. two times, at 190 sec and 219 sec c. about 29 sec $(219 - 190 = 29 \text{ sec})$ d. Thorpe
 e. about 2 sec $(223 - 221 = 2 \text{ sec})$ f. $221 \text{ sec} = 3 \text{ min } 41 \text{ sec}$
 69. $h(-k) = h(k)$
 $[(-k)^{\frac{1}{3}}]^2 = (k^{\frac{1}{3}})^2$
 $(-k^{\frac{1}{3}})^2 = (k^{\frac{1}{3}})^2$
 $(k^{\frac{1}{3}})^2 = (k^{\frac{1}{3}})^2 \checkmark$
 71. a. $\frac{12}{4-x^2}$ b. $\frac{9}{4-x^2}$ 73. $V = 5184\pi \text{ cm}^3, SA = 1152\pi \text{ cm}^2$

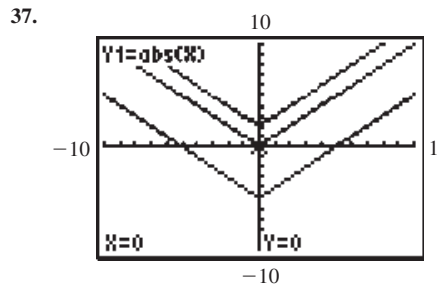
Exercises 2.2, pp. 130–135

1. stretch, compression 3. $(-5, -9)$, upward 5. Answers will vary.
 7. a. quadratic; b. up/up, $(-2, -4), x = -2, (-4, 0), (0, 0)$; c. $D: x \in \mathbb{R}, R: y \in [-4, \infty)$
 9. a. quadratic; b. up/up, $(1, -4), x = 1, (-1, 0), (3, 0), (0, -3)$; c. $D: x \in \mathbb{R}, R: y \in [-4, \infty)$
 11. a. quadratic; b. up/up, $(2, -9), x = 2, (-1, 0), (5, 0), (0, -5)$; c. $D: x \in \mathbb{R}, R: y \in [-9, \infty)$
 13. a. square root; b. up to the right, $(-4, -2), (-3, 0), (0, 2)$; c. $D: x \in [-4, \infty), R: y \in [-2, \infty)$
 15. a. square root; b. down to the left, $(4, 3), (3, 0), (0, -3)$; c. $D: x \in (-\infty, 4], R: y \in (-\infty, 3]$
 17. a. square root; b. up to the left, $(4, 0), (4, 0), (0, 4)$; c. $D: x \in (-\infty, 4], R: y \in [0, \infty)$
 19. a. absolute value; b. up/up, $(-1, -4), x = -1, (-3, 0), (1, 0), (0, -2)$; c. $D: x \in \mathbb{R}, R: y \in [-4, \infty)$
 21. a. absolute value; b. down/down, $(-1, 6), x = -1, (-4, 0), (2, 0), (0, 4)$; c. $D: x \in \mathbb{R}, R: y \in (-\infty, 6]$
 23. a. absolute value; b. down/down, $(0, 6), x = 0, (-2, 0), (2, 0), (0, 6)$; c. $D: x \in \mathbb{R}, R: y \in (-\infty, 6]$

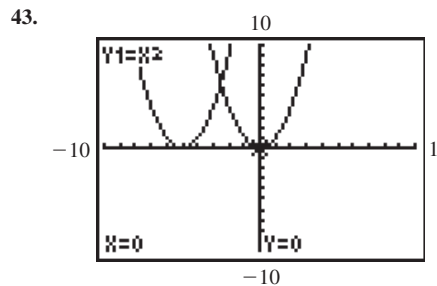
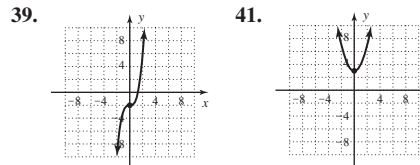
25. a. cubic; b. up/down, $(1, 0), (1, 0), (0, 1)$; c. $D: x \in \mathbb{R}, R: y \in \mathbb{R}$
 27. a. cubic; b. down/up, $(0, 1), (-1, 0), (0, 1)$; c. $D: x \in \mathbb{R}, R: y \in \mathbb{R}$
 29. a. cube root; b. down/up, $(1, -1), (2, 0), (0, -2)$; c. $D: x \in \mathbb{R}, R: y \in \mathbb{R}$
 31. square root function; y-int $(0, 2)$; x-int $(-3, 0)$; initial point $(-4, -2)$; up on right; $D: x \in [-4, \infty), R: y \in [-2, \infty)$
 33. cubic function; y-int $(0, -2)$; x-int $(-2, 0)$; inflection point $(-1, -1)$; up, down; $D: x \in \mathbb{R}, R: y \in \mathbb{R}$
 35.



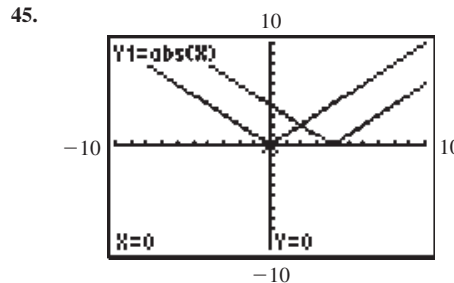
the graph of g is f shifted up 2 units; the graph of h is f shifted down 3 units



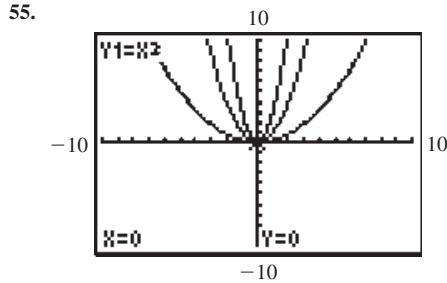
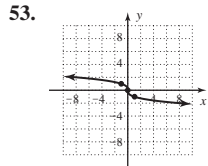
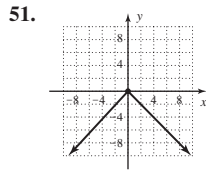
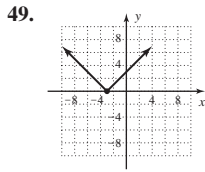
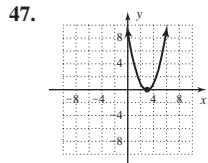
the graph of q is p shifted down 5 units; the graph of r is p shifted up 2 units



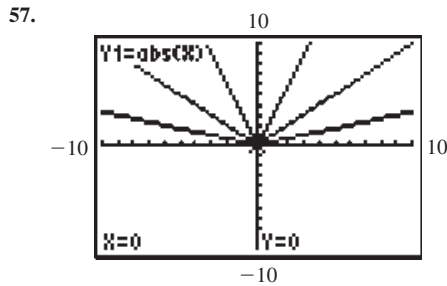
the graph of q is p shifted left 5 units



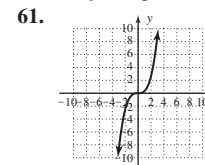
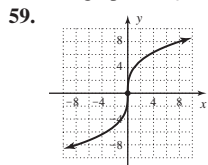
the graph of Y_2 is Y_1 shifted right 4 units



the graph of q is p vertically stretched;
the graph of r is p vertically compressed



the graph of Y_2 is Y_1 vertically stretched;
the graph of Y_3 is Y_1 vertically compressed

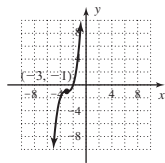
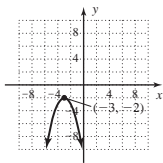
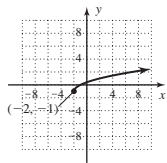


63. g 65. i 67. e 69. j 71. l 73. c

75. left 2, down 1

77. left 3, reflected across x -axis, down 2

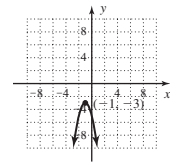
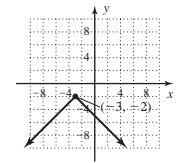
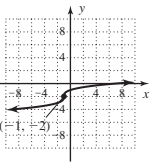
79. left 3, down 1



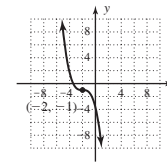
81. left 1, down 2

83. left 3, reflected across x -axis, down 2

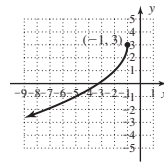
85. left 1, reflected across x -axis, stretched vertically, down 3



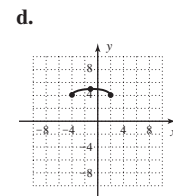
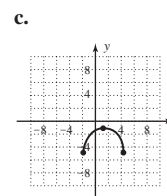
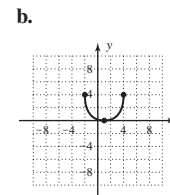
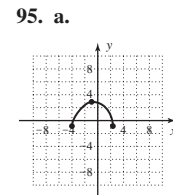
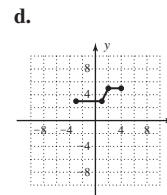
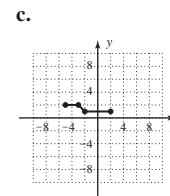
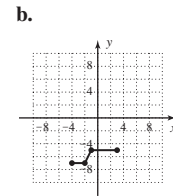
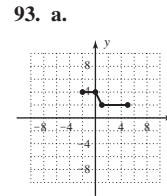
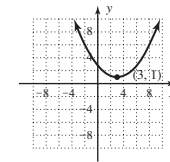
87. left 2, reflected across x -axis, compressed vertically, down 1



89. left 1, reflected across $x = -1$, reflected across x -axis, stretched vertically, up 3



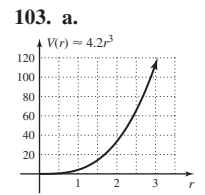
91. right 3, compressed vertically, up 1



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

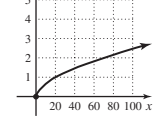
99. $p(x) = 1.5\sqrt{x + 3}$

101. $f(x) = \frac{4}{5}|x + 4|$

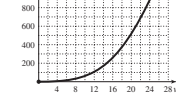


b. about 65 units³, $V \approx 65.4$ units³; yes;
c. $r = \sqrt[3]{\frac{3}{4\pi}V}$

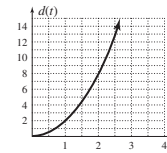
105. a. compressed vertically
b. 2.25 sec



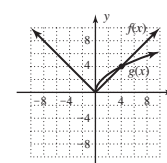
107. a. compressed vertically
b. 216 W



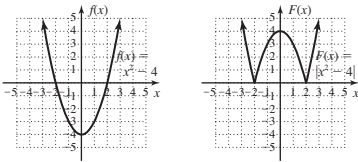
109. a. vertical stretch by a factor of 2
b. 12.5 ft



111. $x \in (0, 4)$; yes, $x \in (4, \infty)$; yes



113. Any points in Quadrants III and IV will reflect across the x -axis and move to Quadrants I and II.



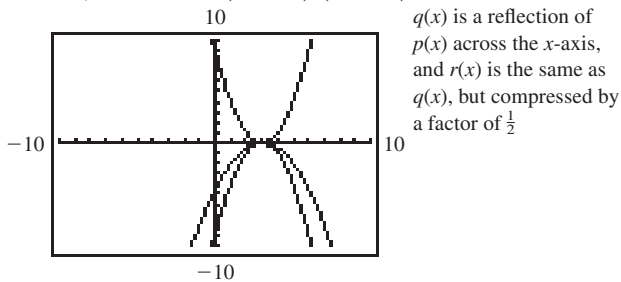
115. $P = (4x^2 + 16x + 14)$ units 117. $f(x) \uparrow : x \in (4, \infty)$;
 $f(x) \downarrow : x \in (-\infty, 4)$

Exercises 2.3, pp. 143–146

- 1. reverse 3. $-7, 7$ 5. no solution; answers will vary.
- 7. $\{-4, 6\}$ 9. $\{2, -12\}$ 11. $\{-3.35, 0.85\}$ 13. $\{-\frac{8}{7}, 2\}$
- 15. $\{-\frac{1}{2}, \frac{1}{2}\}$ 17. $\{\}$ 19. $\{-10, -6\}$ 21. $\{3.5, 11.5\}$
- 23. $\{-1.6, 1.6\}$ 25. $\{-3, -\frac{1}{2}\}$ 27. $(-5, -3)$ 29. $\{\}$
- 31. $[\frac{8}{3}, \frac{14}{3}]$ 33. $\{\}$ 35. $(-1, \frac{3}{5})$ 37. $[-\frac{7}{4}, 0]$
- 39. $(-\infty, -10) \cup (4, \infty)$ 41. $(-\infty, -3] \cup [3, \infty)$
- 43. $(-\infty, -\frac{7}{3}] \cup [\frac{7}{3}, \infty)$ 45. $(-\infty, \frac{3}{7}] \cup [1, \infty)$
- 47. $(-\infty, -\frac{7}{15}) \cup (1, \infty)$ 49. $(-\infty, 0) \cup (5, \infty)$ 51. $\{\}$
- 53. $(-\infty, \infty)$ 55. a. $x = 2$ and $x = 6$ b. $(-\infty, 2] \cup [6, \infty)$
- c. $[2, 6]$ 57. a. $x = -3$ and $x = 0.2$ b. $(-\infty, -3] \cup [0.2, \infty)$
- c. $(-3, 0.2)$ 59. a. $45 \leq d \leq 51$ in. b. $d - L \leq x \leq d + L$
- 61. in feet: $[32,500, 37,600]$; yes 63. in feet: $d < 210$ or $d > 578$
- 65. a. $|s - 37.58| \leq 3.35$ b. $[34.23, 40.93]$
- 67. a. $|s - 125| \leq 23$ b. $[102, 148]$ 69. a. $|d - 42.7| < 0.03$
- b. $|d - 73.78| < 1.01$ c. $|d - 57.150| < 0.127$
- d. $|d - 2171.05| < 12.05$ e. golf: $t \approx 0.0014$
- 71. a. $x = 4$ b. $[\frac{4}{3}, 4]$ c. $x = 0$ d. $(-\infty, \frac{3}{5}]$ e. $\{\}$
- 73. a. $\{-2, 8\}$ b. $(-\infty, 3) \cup (11, \infty)$ c. $[-6, 2]$ d. $\{-2, 10\}$
- 75. $\rho = \frac{2W}{V^2CA}$ 77. $x \in (-\infty, \frac{5}{2})$

Mid-Chapter Check, pp. 146–147

- 1. neither 2. max: $y \approx 11.12$ at $x \approx -0.50$,
 $y \approx 8.55$ at $x \approx 1.47$; min: $y \approx 7.80$ at $x \approx 0.75$
- 3. increasing on $(-\infty, -0.50) \cup (0.75, 1.47)$,
decreasing on $(-0.50, 0.75) \cup (1.47, \infty)$ 4. $g(x) = \sqrt{x + 4} + 2$
- 5. a. cubic b. up on the left, down on the right; inflection point: $(2, 2)$;
 x -int: $(4, 0)$; y -int: $(0, 5)$ c. $(-\infty, \infty); (-\infty, \infty)$ d. $k = 1$



- 7. a. $\{-4, 14\}$ b. $\{\}$ 8. a. $q \in (-8, 0)$ b. $\{-6\}$
- 9. a. $d \in (-\infty, 0] \cup [4, \infty)$ b. $y \in (-\infty, -\frac{19}{2}) \cup (\frac{23}{2}, \infty)$
- c. $k \in (-\infty, \infty)$ 10. $w \in [8, 26]$; no, yes

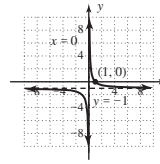
Reinforcing Basic Concepts, p. 147

- 1. $x = -3$ or $x = 7$ 2. $x \in [-5, 3]$ 3. $x \in (-\infty, -1] \cup [4, \infty)$

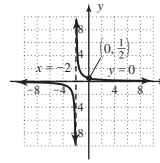
Exercises 2.4, pp. 159–163

- 1. as $x \rightarrow -\infty, y \rightarrow 2$ 3. vertical, $y = 2$ 5. Answers will vary.

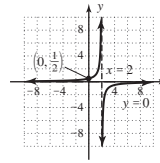
- 7. a. as $x \rightarrow -\infty, y \rightarrow 2$
as $x \rightarrow \infty, y \rightarrow 2$
- b. as $x \rightarrow 1^-, y \rightarrow -\infty$
as $x \rightarrow 1^+, y \rightarrow \infty$
- 9. a. as $x \rightarrow -\infty, y \rightarrow 1$
as $x \rightarrow \infty, y \rightarrow 1$
- b. $y = 1$
- c. as $x \rightarrow -2^-, y \rightarrow \infty$
as $x \rightarrow -2^+, y \rightarrow -\infty$
- 11. down 1, $x \in (-\infty, 0) \cup (0, \infty), y \in (-\infty, -1) \cup (-1, \infty)$



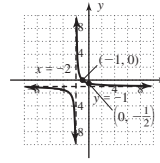
- 13. left 2, $x \in (-\infty, -2) \cup (-2, \infty), y \in (-\infty, 0) \cup (0, \infty)$



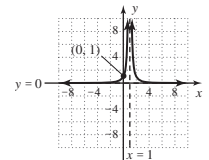
- 15. right 2, reflected across x -axis,
 $x \in (-\infty, 2) \cup (2, \infty), y \in (-\infty, 0) \cup (0, \infty)$



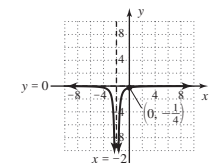
- 17. left 2, down 1,
 $x \in (-\infty, -2) \cup (-2, \infty), y \in (-\infty, -1) \cup (-1, \infty)$



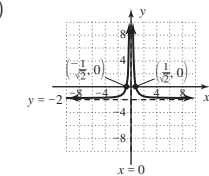
- 19. right 1, $x \in (-\infty, 1) \cup (1, \infty), y \in (0, \infty)$



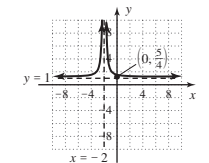
- 21. left 2, reflected across x -axis,
 $x \in (-\infty, -2) \cup (-2, \infty), y \in (-\infty, 0)$



- 23. down 2, $x \in (-\infty, 0) \cup (0, \infty), y \in (-2, \infty)$



- 25. left 2, up 1, $x \in (-\infty, -2) \cup (-2, \infty), y \in (1, \infty)$



27. reciprocal quadratic, $S(x) = \frac{1}{(x+1)^2} - 2$
 29. reciprocal function, $Q(x) = \frac{1}{x+1} - 2$
 31. reciprocal quadratic, $v(x) = \frac{1}{(x+2)^2} - 5$ 33. $\rightarrow -2$

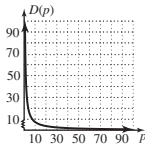
35. $\rightarrow -\infty$ 37. $-1, \pm\infty$

39. $g(x)$ increases faster ($3 > 2$) a. $x = 0$ and 1 ,
 b. $(-\infty, 0) \cup (0, 1)$, c. $(1, \infty)$
 41. $f(x)$ increases faster ($4 > 2$) a. $x = -1, 0$, and 1 ,
 b. $(-1, 0) \cup (0, 1)$, c. $(-\infty, -1) \cup (1, \infty)$
 43. $g(x)$ increases faster ($\frac{4}{5} > \frac{2}{3}$) a. $x = -1, 0$, and 1 ,
 b. $(-1, 0) \cup (0, 1)$, c. $(-\infty, -1) \cup (1, \infty)$

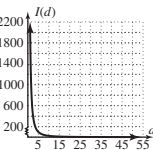
45. $g(x)$ increases faster ($\frac{1}{3} > \frac{1}{6}$) a. $x = 0$ and 1 , b. $(0, 1)$, c. $(1, \infty)$

47. $g(x)$ increases faster ($\frac{5}{4} > \frac{2}{3}$) a. $x = 0$ and 1 , b. $(0, 1)$, c. $(1, \infty)$

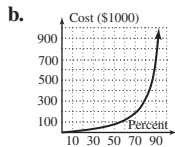
49. $[0, \infty)$ 51. $(-\infty, \infty)$ 53. $(-\infty, \infty)$
 55. defined: b, c, d; undefined: a 57. defined: a, b, d; undefined: c
 59. F is the graph of f shifted left 1 unit and down 2; verified
 61. P is the graph of p shifted right 2 units and reflected across the x -axis; verified
 63. a. F becomes very small b. $y = \frac{1}{x^2}$ c. $m_2 = \frac{d^2F}{km_1}$
 65. a. It decreases; 75, 25, 15 b. It approaches 0.
 c. as $p \rightarrow 0, D \rightarrow \infty$



67. a. It decreases; 100, 25, 11.1. b. toward the light source
 c. as $d \rightarrow 0, l \rightarrow \infty$

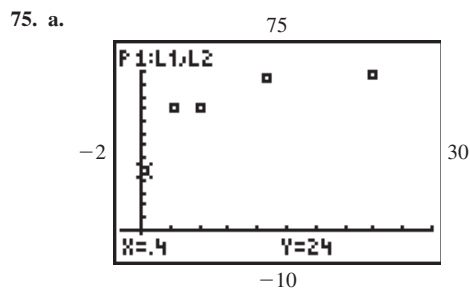


69. a. \$20,000, \$80,000, \$320,000; cost increases dramatically



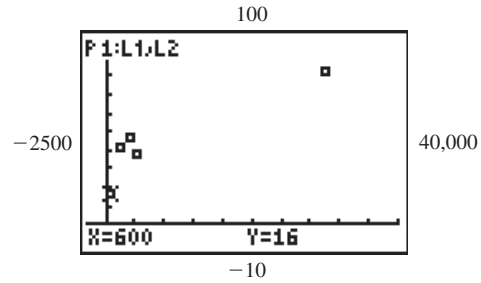
c. as $p \rightarrow 100, C \rightarrow \infty$

71. a. 253 ft/sec (about 172 mph) b. approx. 791 ft
 73. a. size 11 b. approx. 5 ft, 5 in.



- b. $P = 32.251 w^{0.246}$
 c. about 63 days
 d. about 6.9 kg

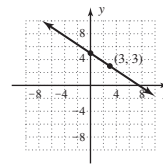
77. a.



b. $S = 1.687a^{0.386}$ c. about 33 species d. about 37,200 mi²

79. The area is always 1 unit²; The area is always $\frac{1}{x}$ units²

81. $y = \frac{-2}{3}x + 5$,



83. $c = \sqrt{\frac{E}{m}}$

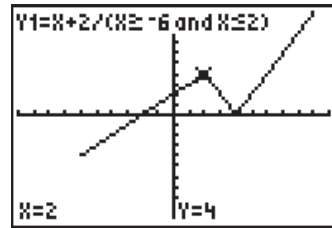
Exercises 2.5, pp. 172-176

1. continuous 3. smooth 5. Each piece must be continuous on the corresponding interval, and the function values at the endpoints of each interval must be equal. Answers will vary.

7. a. $f(x) = \begin{cases} x^2 - 6x + 10 & 0 \leq x \leq 5 \\ \frac{3}{2}x - \frac{5}{2} & 5 < x \leq 9 \end{cases}$ b. $y \in [1, 11]$

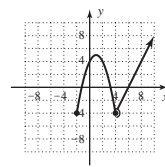
9. $-2, 2, \frac{1}{2}, 0, 2.999, 5$ 11. $5, 5, 0, -4, 5, 11$

13. $D: x \in [-6, \infty); R: y \in [-4, \infty)$

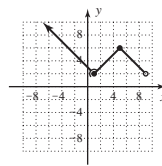


$p(2) = 4$
 $p(0) = 2$

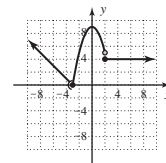
15. $D: x \in [-2, \infty); R: y \in [-4, \infty)$



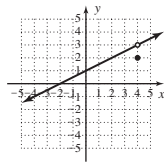
17. $D: x \in (-\infty, 9); R: y \in [2, \infty)$



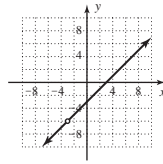
19. $D: x \in (-\infty, \infty); R: y \in [0, \infty)$



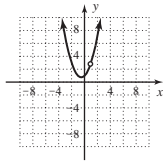
21. $D: x \in (-\infty, \infty); R: y \in (-\infty, 3) \cup (3, \infty)$



23. discontinuity at $x = -3$, redefine $f(x) = -6$ at $x = -3; c = -6$



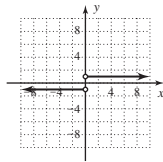
25. discontinuity at $x = 1$, redefine $f(x) = 3$ at $x = 1; c = 3$



27. $f(x) = \begin{cases} \frac{1}{2}x - 1 & -4 \leq x < 2 \\ 3x - 6 & x \geq 2 \end{cases}$

29. $p(x) = \begin{cases} x^2 + 2x - 3 & x \leq 1 \\ x + 1 & x > 1 \end{cases}$

31. Graph is discontinuous at $x = 0; f(x) = 1$ for $x > 0; f(x) = -1$ for $x < 0$.



33. a. $S(t) = \begin{cases} -t^2 + 6t & 0 \leq t \leq 5 \\ 5 & t > 5 \end{cases}$ b. $S(t) \in [0, 9]$

35. a.

Year (0 → 1950)	Percent
5	7.33
15	14.13
25	14.93
35	22.65
45	41.55
55	60.45
65	79.35

b. Each piece gives a slightly different value due to rounding of coefficients in each model. At $t = 30$, we use the "first" piece: $P(30) = 13.08$.

37. $C(h) = \begin{cases} 0.09h & 0 \leq h \leq 1000 \\ 0.18h - 90 & h > 1000 \end{cases}$

$C(1200) = \$126$

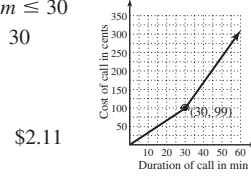
39. $C(t) = \begin{cases} 0.75t & 0 \leq t \leq 25 \\ 1.5t - 18.75 & t > 25 \end{cases}$

$C(45) = \$48.75$

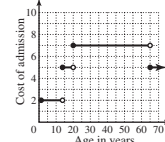
41. $S(t) = \begin{cases} -1.35t^2 + 31.9t + 152 & 0 \leq t \leq 12 \\ 2.5t^2 - 80.6t + 950 & 12 < t \leq 22 \end{cases}$

\$498 billion, \$653 billion, \$931 billion

43. $c(m) = \begin{cases} 3.3m & 0 \leq m \leq 30 \\ 7m - 111 & m > 30 \end{cases}$

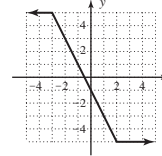


45. $C(a) = \begin{cases} 0 & a < 2 \\ 2 & 2 \leq a < 13 \\ 5 & 13 \leq a < 20 \\ 7 & 20 \leq a < 65 \\ 5 & a \geq 65 \end{cases}$



47. a. $C(w - 1) = 17[w - 1] + 88$ b. $0 < w \leq 13$ c. 88ϵ
d. 173ϵ e. 173ϵ f. 173ϵ g. 190ϵ

49. yes; $h(x) = \begin{cases} 5 & x \leq -3 \\ -2x - 1 & -3 < x < 2 \\ -5 & x \geq 2 \end{cases}$



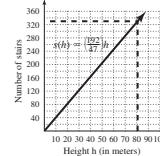
51. $f(x)$ has a removable discontinuity at $x = -2$;
 $g(x)$ has a discontinuity at $x = -2$ 53. $x = -7, x = 4$
55. $y = \frac{4}{3}x - 2$

Exercises 2.6, pp. 183–187

1. constant 3. directly, height, square 5. Answers will vary.
7. $d = kr$ 9. $F = ka$
11. $y = 0.025x$

x	y
500	12.5
650	16.25
750	18.75

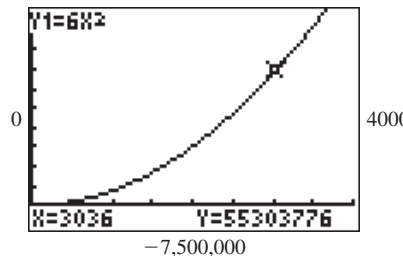
13. $w = 9.18h$; \$321.30; the hourly wage; $k = \$9.18/\text{hr}$
15. a. $k = \frac{192}{47}, S = \frac{192}{47}h$ b. c. 330 stairs d. $S = 331$; yes



17. $A = kS^2$ 19. $P = kc^2$
21. $k = 0.112; p = 0.112q^2$

q	p
45	226.8
55	338.8
70	548.8

23. a. Area varies directly as a side squared. b. $A = ks^2$
c. 75,000,000



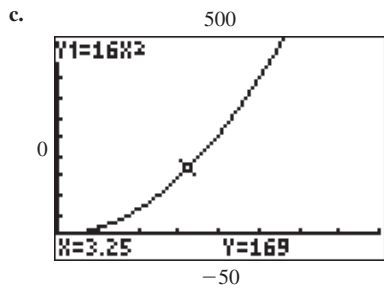
d.

X	Y ₁
0	0
5	150
10	600
15	1350
20	2400
25	3750
30	5400

X=0

e. $k = 6; A = 6s^2; 55,303,776 \text{ m}^2$

25. a. Distance varies directly as time squared. b. $D = kt^2$



d.

X	Y ₁
1	16
1.5	36
2	64
2.5	100
3	144
3.5	196
4	256

X=4

e. $k = 16; d = 16t^2$; about 3.5 sec; 121 ft

27. $F = \frac{k}{a^2}$ 29. $S = \frac{k}{L}$

31. $Y = \frac{12,321}{Z^2}$

Z	Y
37	9
74	2.25
111	1

33. $w = \frac{3,072,000,000}{r^2}$; 48 kg 35. $l = krt$ 37. $A = kh(B + b)$

39. $V = ktr^2$

41. $C = \frac{6.75R}{S^2}$

R	S	C
120	6	22.5
200	12.5	8.64
350	15	10.5

43. $E = 0.5mv^2$; 612.50 J

45. a. cube root family b. answers will vary c. 0.054 or 5.4%

d. $A = (R + 1)^3$

Amount A	Rate R
1.0	0.000
1.05	0.016
1.10	0.032
1.15	0.048
1.20	0.063
1.25	0.077

47. $T = \frac{48}{V}$; 32 volunteers 49. $M = \frac{1}{6}E$; $\approx 41.7 \text{ kg}$

51. $D = 21.6\sqrt{S}$; $\approx 144.9 \text{ ft}$ 53. $C = 8.5LD$; \$76.50

55. $C \approx (4.4 \times 10^{-4}) \frac{P_1 P_2}{d^2}$; about 222 calls

57. a. about 23.39 cm^3 b. about 191%

59. a. $M = kwh^2(\frac{1}{2})$ b. 180 lb 61. 6.67×10^{-7}

63. $\frac{9y^2}{4x^2}$ 65. a. $x \in (-\infty, -4) \cup (-4, 4) \cup (4, \infty)$

b. $x \in (-\infty, -4) \cup (4, \infty)$

Making Connections, p. 188

1. g 3. a 5. d 7. a 9. b 11. h 13. c 15. f

Summary and Concept Review, pp. 189–193

1. D: $x \in (-\infty, \infty)$, R: $y \in [-5, \infty)$, $f(x) \uparrow$: $x \in (2, \infty)$,

$f(x) \downarrow$: $x \in (-\infty, 2)$, $f(x) > 0$: $x \in (-\infty, -1) \cup (5, \infty)$,

$f(x) < 0$: $x \in (-1, 5)$

2. D: $x \in [-3, \infty)$, R: $y \in (-\infty, 0]$, $f(x) \uparrow$: none, $f(x) \downarrow$: $x \in (-3, \infty)$,

$f(x) > 0$: none, $f(x) < 0$: $x \in (-3, \infty)$

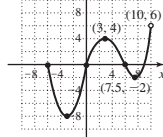
3. D: $x \in (-\infty, \infty)$, R: $y \in (-\infty, \infty)$, $f(x) \uparrow$: $x \in (-\infty, -3) \cup (1, \infty)$,

$f(x) \downarrow$: $x \in (-3, 1)$, $f(x) > 0$: $x \in (-5, -1) \cup (4, \infty)$,

$f(x) < 0$: $x \in (-\infty, -5) \cup [-1, 4)$

4. a. odd b. even c. neither d. odd

5. zeroes: $(-6, 0)$, $(0, 0)$,



$(6, 0)$, $(9, 0)$

min: $(-3, -8)$,

$(-7.5, -2)$

max: $(-6, 0)$, $(3, 4)$

6. max: $y = 0.73$ at $x = -0.48$; min: $y = -0.73$ at $x = 0.48$

7. squaring function a. up on left/up on the right; b. x-intercept:

$(-4, 0)$, $(0, 0)$; y-intercept: $(0, 0)$ c. vertex $(-2, -4)$

d. $x \in (-\infty, \infty)$, $y \in [-4, \infty)$

8. square root function a. down on the right; b. x-intercept: $(0, 0)$;

y-intercept: $(0, 0)$ c. initial point $(-1, 2)$; d. $x \in [-1, \infty)$,

$y \in (-\infty, 2]$

9. cubing function a. down on left/up on the right b. x-intercept(s):

$(2, 0)$; y-intercept: $(0, -2)$ c. inflection point: $(1, -1)$

d. $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$

10. absolute value function a. down on left/down on the right

b. x-intercepts: $(-1, 0)$, $(3, 0)$; y-intercept: $(0, 1)$ c. vertex: $(1, 2)$;

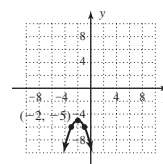
d. $x \in (-\infty, \infty)$, $y \in (-\infty, 2]$

11. cube root function a. up on left, down on right b. x-intercept: $(1, 0)$;

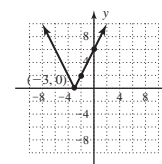
y-intercept: $(0, 1)$ c. inflection point: $(1, 0)$ d. $x \in (-\infty, \infty)$,

$y \in (-\infty, \infty)$

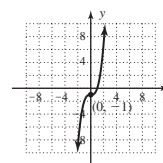
12. quadratic



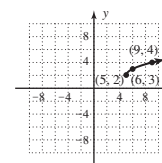
13. absolute value



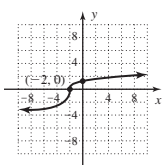
14. cubic



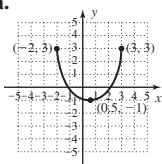
15. square root



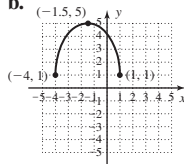
16. cube root



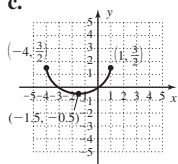
17. a.



b.

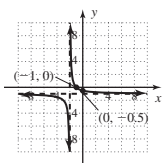


c.

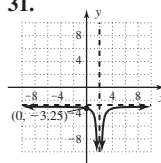


18. $\{-4, 10\}$ 19. $\{-7, 3\}$ 20. $\{-5, 8\}$ 21. $\{-4, -1\}$
 22. $(-\infty, -6) \cup (2, \infty)$ 23. $[4, 32]$ 24. $\{ \}$ 25. $\{ \}$ 26. $(-\infty, \infty)$
 27. $[-2, 6]$ 28. $(-\infty, -2] \cup [\frac{10}{3}, \infty)$ 29. a. $|r - 2.5| \leq 1.7$
 b. highest: 4.2 in., lowest: 0.8 in.

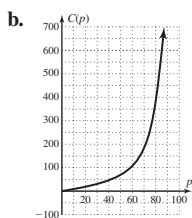
30.



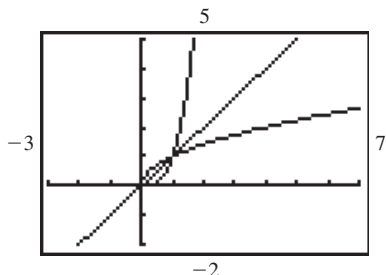
31.



32. a. $\approx \$32,143; \$75,000; \$175,000; \$675,000$; cost increases dramatically
 c. as $p \rightarrow 100, C \rightarrow \infty$



33.

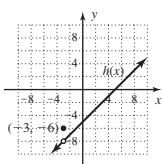


Domain of $f(x)$ is $(-\infty, \infty)$; Domain of $g(x)$ and $h(x)$ is $[0, \infty)$.

34. a. 88.4 hr, b. 570 km

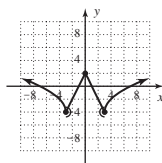
35. a. $f(x) = \begin{cases} 5 & x \leq -4 \\ -x + 1 & -4 < x \leq 3 \\ 3\sqrt{x-3} - 1 & x > 3 \end{cases}$ b. $R: y \in [-2, \infty)$

36.

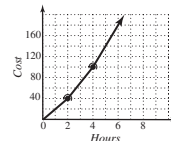


$D: x \in (-\infty, \infty)$,
 $R: y \in (-\infty, -8) \cup (-8, \infty)$,
 discontinuity at $x = -3$;
 define $h(x) = -8$ at $x = -3$

37. $-4, -4, -4.5, -4.99, 3\sqrt{3} - 9, 3\sqrt{3.5} - 9$
 38. $D: x \in (-\infty, \infty) R: y \in [-4, \infty)$



39. $\begin{cases} 20x & x \leq 2 \\ 30x - 20 & 2 < x \leq 4 \\ 40x - 60 & x > 4 \end{cases}$
 For 5 hr the total cost is \$140.



40. $k = 17.5; y = 17.5\sqrt[3]{x}$ 41. $k = 0.72; z = \frac{0.72v}{w^2}$

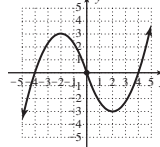
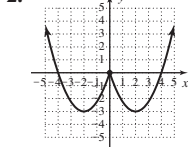
x	y
216	105
0.343	12.25
729	157.5

v	w	z
196	7	2.88
38.75	1.25	17.856
24	0.6	48

42. $t = 160$ 43. 4.5 sec

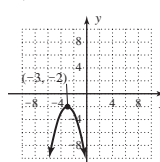
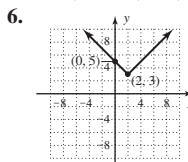
Practice Test, pp. 193-195

1. a. $D: x \in [-4, \infty)$; $R: y \in [-3, \infty)$ b. $f(-1) \approx 2.2$
 c. $f(x) < 0: x \in (-4, -3)$; $f(x) > 0: x \in (-3, \infty)$
 d. $f(x) \uparrow: x \in (-4, \infty)$; $f(x) \downarrow: \text{none}$ e. $f(x) = 3\sqrt{x+4} - 3$



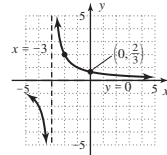
4. max: $y = 8$ at $x = -2$; min: $y = -7$ at $x \approx -5.87$ and $y = -7$ at $x \approx 1.87$

5. I. a. square root b. $x \in [-4, \infty), y \in [-3, \infty)$ c. $(-2, 0), (0, 1)$
 d. up on right e. $x \in (-2, \infty)$ f. $x \in [-4, -2)$
 II. a. cubic b. $x \in (-\infty, \infty), y \in (-\infty, \infty)$ c. $(2, 0), (0, -1)$
 d. down on left, up on right e. $x \in (2, \infty)$ f. $x \in (-\infty, 2)$
 III. a. absolute value b. $x \in (-\infty, \infty), y \in (-\infty, 4]$
 c. $(-1, 0), (3, 0), (0, 2)$ d. down on left, down on right e. $x \in (-1, 3)$
 f. $x \in (-\infty, -1) \cup (3, \infty)$
 IV. a. quadratic b. $x \in (-\infty, \infty); y \in [-5.5, \infty)$
 c. $(0, 0), (5, 0), (0, 0)$ d. up on left, up on right
 e. $x \in (-\infty, 0) \cup (5, \infty)$ f. $x \in (0, 5)$

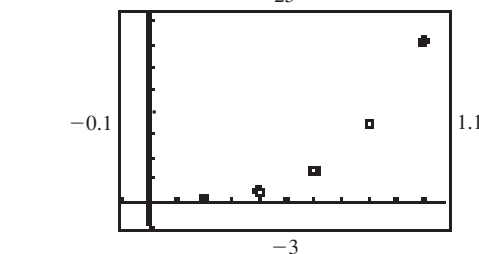


8. $(-\infty, -\frac{20}{3}) \cup (\frac{22}{3}, \infty)$ 9. $[-4, 0)$ 10. $x = 0.75$

11. 12. 13.5 sec

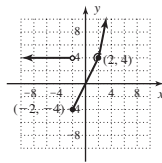


13. a. $(-\infty, \infty)$ b. $[0, \infty)$ c. $[0, \infty)$ 14. VA: $x = -2$; HA: $y = -1$



15. a. 25 b. $S(t) = 17.27 t^{2.50}$ c. 3.05 mm d. 0.95 sec

16. $a = 1, b = 4$ 17. 1617 KWH/year
 18. a. 4, -4, 6.25 b.



19. $M = kd^3(\frac{1}{p^3})$, approx. 2.2788×10^8 20. 520 lb

Strengthening Core Skills, p. 196

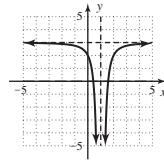
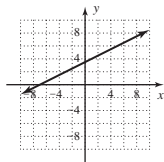
1. $k = \frac{1}{6^3}$ or $\frac{1}{\sqrt{6^3}}$

Cumulative Review Chapters 1–2, pp. 197–198

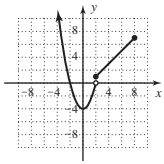
1. $f(-2) = -23, f(\frac{1}{2}) = -\frac{7}{4}$ 3. 29.45 cm 5. $x = 1$

7. a. $\frac{-1}{3}$ b. $\frac{3}{5}$

9. $y = \frac{1}{2}x + \frac{7}{2}$ 11.



13. a. $D: x \in (-\infty, 8], R: y \in [-4, \infty)$ b. 5, -3, -3, 1, 2
 c. $(-2, 0)$ d. $f(x) < 0: x \in (-2, 2); f(x) > 0: x \in (-\infty, -2) \cup [2, 8]$
 e. min: $(0, -4)$, max: $(8, 7)$ f. $f(x)\uparrow: x \in (0, 8); f(x)\downarrow: x \in (-\infty, 0)$



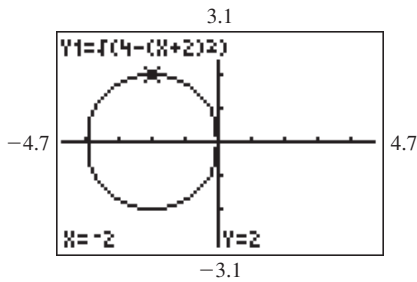
15. a. $\frac{x-7}{(x-5)(x+2)}$ b. $\frac{b^2-4ac}{4a^2}$ 17. $x^2 + 2$

19. center $(-3, 6), r = 3$ 21. $W = 31$ cm, $L = 47$ cm

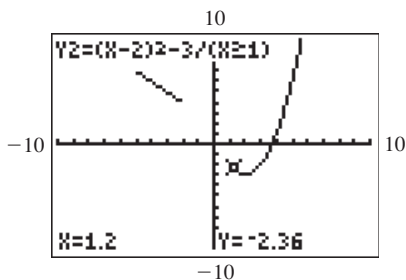
23. a. $x = \frac{-4}{3}, \frac{5}{2}$ b. $x = -5, -\sqrt{3}, \sqrt{3}$

25. $P = 15 + \sqrt{97}$ units ≈ 24.8 units. No, it is not a right triangle.
 $5^2 + (\sqrt{97})^2 \neq 10^2$

27.



29.



Connections to Calculus Exercises, p. 202

1. 4.24 in. 3. $t = \frac{6}{5}$ sec, $t = \frac{3}{2}$ sec 5. If the difference between x and $\frac{3}{2}$ is very small, then the difference between $h(x)$ and 6 is very small:

if $|x - \frac{3}{2}| < \delta$, then $|h(x) - 6| < \epsilon$. 7. If the difference between x and 2 is very small, then the difference between $w(x)$ and 14 is very small:
 if $|x - 2| < \delta$, then $|w(x) - 14| < \epsilon$.

CHAPTER 3

Exercises 3.1, pp. 211–214

1. $3 - 2i$ 3. $2, 3\sqrt{2}$ 5. (b) is correct. 7. a. $12i$ b. $7i$
 c. $3\sqrt{3}$ d. $6\sqrt{2}$ 9. a. $-3i\sqrt{2}$ b. $-5i\sqrt{2}$ c. $15i$ d. $6i$

11. a. $i\sqrt{19}$ b. $i\sqrt{31}$ c. $\frac{2\sqrt{3}}{5}i$ d. $\frac{3\sqrt{2}}{8}i$

13. a. $1 + i$ b. $2 + i\sqrt{3}$

15. a. $4 + 2i$ b. $2 - i\sqrt{2}$

17. a. $5 + 0i; a = 5, b = 0$ b. $0 + 3i; a = 0, b = 3$

19. a. $0 + 18i; a = 0, b = 18$ b. $0 + \frac{\sqrt{2}}{2}i; a = 0, b = \frac{\sqrt{2}}{2}$

21. a. $4 + 5i\sqrt{2}; a = 4, b = 5\sqrt{2}$

- b. $-5 + 3i\sqrt{3}; a = -5, b = 3\sqrt{3}$

23. a. $\frac{7}{4} + \frac{7\sqrt{2}}{8}i; a = \frac{7}{4}, b = \frac{7\sqrt{2}}{8}$ b. $\frac{1}{2} + \frac{\sqrt{10}}{2}i; a = \frac{1}{2}, b = \frac{\sqrt{10}}{2}$

25. a. $19 + i$ b. $2 - 4i$ c. $9 + 10i\sqrt{3}$

27. a. $-3 + 2i$ b. 8 c. $2 - 8i$ 29. a. $2.7 + 0.2i$ b. $15 + \frac{1}{12}i$

- c. $-2 - \frac{1}{8}i$ 31. a. $15 + 0i$ b. $16 + 0i$ 33. a. $-21 - 35i$

- b. $-42 - 18i$ 35. a. $-12 - 5i$ b. $1 + 5i$ 37. a. 41 b. 74

39. a. 11 b. $\frac{17}{36}$ 41. a. $-5 + 12i$ b. $-7 - 24i$

43. a. $-21 - 20i$ b. $7 + 6i\sqrt{2}$ 45. a. $4 - 5i; 41$

- b. $3 + i\sqrt{2}; 11$ 47. a. $-7i; 49$ b. $\frac{1}{2} + \frac{2i}{3}; \frac{25}{36}$ 49. no 51. yes

53. yes 55. no 57. yes 59. verified 61. a. 1 b. -1 c. -i

- d. i 63. a. $0 + \frac{2}{7}i$ b. $0 - \frac{4}{5}i$ 65. a. $\frac{21}{13} - \frac{14}{13}i$ b. $\frac{-10}{13} - \frac{15}{13}i$

67. a. $1 - \frac{3}{4}i$ b. $-1 - \frac{2}{3}i$ 69. a. $\sqrt{13}$ b. 5 c. $\sqrt{11}$

71. $A + B = 10$ $AB = 40$ 73. $(7 - 5i)\Omega$ 75. $(25 + 5i)V$

77. $(\frac{7}{4} + i)\Omega$

79. a. $(a + bi)(a - bi) = a^2 - abi + abi - (bi)^2$
 $= a^2 - b^2(-1)$
 $= a^2 + b^2 \checkmark$

b. $(x + 6i)(x - 6i)$ c. $(m + i\sqrt{3})(m - i\sqrt{3})$

d. $(n + 2i\sqrt{3})(n - 2i\sqrt{3})$ e. $(2x + 7i)(2x - 7i)$ 81. $-8 - 6i$

83. 5.6 hr (5 hr 36 min) 85. John

Exercises 3.2, pp. 230–235

1. exact, approximate 3. discriminant, 2 5. Answers will vary.

7. $x = -4$ or 3 9. $x = \frac{-3}{2}$ or 1 11. $x = -1$ or 2

13. $x \approx -4.19$ or 1.19 15. $x \approx -1.61$ or 3.11

17. $x \approx -1.14$ or 2.64 19. $\{ \}$ 21. $m = \pm 4$

23. $y = \pm 2\sqrt{7}; y \approx \pm 5.29$ 25. no real solutions

27. $x = \pm \frac{\sqrt{21}}{4}; x \approx \pm 1.15$ 29. $n = 9; n = -3$

31. $w = -5 \pm \sqrt{3}; w \approx -3.27$ or $w \approx -6.73$ 33. no real solutions

35. $m = 2 \pm \frac{3\sqrt{2}}{7}; m \approx 2.61$ or $m \approx 1.39$ 37. 9; $(x + 3)^2$

39. $\frac{9}{4}; (n + \frac{3}{2})^2$ 41. $\frac{1}{9}; (p + \frac{1}{3})^2$ 43. $x = -1; x = -5$

45. $p = 3 \pm \sqrt{6}; p \approx 5.45$ or $p \approx 0.55$

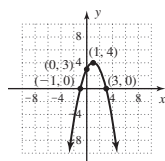
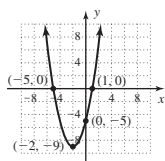
47. $p = -3 \pm \sqrt{5}; p \approx -0.76$ or $p \approx -5.24$

49. $m = \frac{-3}{2} \pm \frac{\sqrt{13}}{2}; m \approx 0.30$ or $m \approx -3.30$

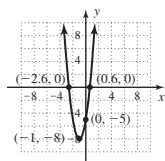
51. $n = \frac{5}{2} \pm \frac{3\sqrt{5}}{2}$; $n \approx 5.85$ or $n \approx -0.85$
 53. a. $x = \frac{1}{2}$ or $x = -4$ b. $x = 0.5$ or $x = -4$
 55. a. $n = 3$ or $n = \frac{-3}{2}$ b. $n = 3$ or $n = -1.5$
 57. a. $p = \frac{3}{8} \pm \frac{\sqrt{41}}{8}$ b. $p \approx 1.18$ or $p \approx -0.43$
 59. a. $m = \frac{7}{2} \pm \frac{\sqrt{33}}{2}$ b. $m \approx 6.37$ or $m \approx 0.63$
 61. $x = 6$ or $x = -3$ 63. $m = \pm \frac{5}{2}$
 65. $n = 1 \pm \frac{\sqrt{5}}{2}$; $n \approx 2.12$ or $n \approx -0.12$
 67. $w = \frac{2}{3}$ or $w = -\frac{1}{2}$
 69. $m = \frac{3}{2} \pm \frac{\sqrt{6}}{2}i$; $m \approx 1.5 \pm 1.12i$ 71. $n = \pm \frac{3}{2}$
 73. $w = -\frac{4}{5}$ or $w = 2$ 75. $a = \frac{1}{6} \pm \frac{\sqrt{23}}{6}i$; $a \approx 0.1\bar{6} \pm 0.80i$
 77. $p = \frac{3}{5} \pm \frac{2\sqrt{6}}{5}$; $p \approx 1.58$ or $p \approx -0.38$
 79. $w = \frac{1}{10} \pm \frac{\sqrt{21}}{10}$; $w \approx 0.56$ or $w \approx -0.36$
 81. $a = \frac{3}{4} \pm \frac{\sqrt{31}}{4}i$; $a \approx 0.75 \pm 1.39i$
 83. $p = 1 \pm \frac{3\sqrt{2}}{2}i$; $p \approx 1 \pm 2.12i$
 85. $w = -\frac{1}{3} \pm \frac{\sqrt{2}}{3}$; $w \approx 0.14$ or $w \approx -0.80$
 87. $a = -3 \pm \frac{3\sqrt{2}}{2}$; $a \approx -0.88$ or $a \approx -5.12$
 89. $p = \frac{2}{3} \pm \frac{\sqrt{394}}{6}$; $p \approx 3.97$ or $p \approx -2.64$
 91. two rational; factorable 93. two nonreal
 95. two rational; factorable 97. two nonreal 99. two irrational
 101. one repeated; factorable 103. $x = \frac{3}{2} \pm \frac{1}{2}i$
 105. $x = -\frac{1}{2} \pm \frac{\sqrt{3}}{2}i$ 107. $x = \frac{5}{4} \pm \frac{3\sqrt{7}}{4}i$ 109. $x \in (-1, 4)$
 111. $x \in (-\infty, -5] \cup [1, \infty)$ 113. $x \in (-1, \frac{7}{2})$
 115. $x \in [-\sqrt{7}, \sqrt{7}]$ 117. $x \in [-\frac{3}{2} - \frac{\sqrt{33}}{2}, -\frac{3}{2} + \frac{\sqrt{33}}{2}]$
 119. $x \in (-\infty, -\frac{5}{3}] \cup [1, \infty)$ 121. $x \in (-\infty, \infty)$ 123. $\{ \}$
 125. $x \in (-\infty, 5) \cup (5, \infty)$ 127. $\{ \}$ 129. $x \in (-\infty, \infty)$
 131. $x \in (-\infty, \infty)$ 133. $(-3, 1)$ 135. $(-\infty, \frac{-3}{2}) \cup [2, \infty)$
 137. $(-\infty, -1.3) \cup (-1.3, \infty)$ 139. $\{2.9\}$ 141. $\{ \}$ 143. $(-\infty, \infty)$
 145. $x \in (-\infty, -5] \cup [5, \infty)$ 147. $x \in (-\infty, 0] \cup [5, \infty)$
 149. $\{ \}$ 151. a 153. b
 155. $t = \frac{v \pm \sqrt{v^2 - 64h}}{32}$ 157. $t = 3 + \frac{\sqrt{138}}{2}$ sec, $t \approx 8.87$ sec
 159. a. $P = -x^2 + 120x - 2000$ b. 10,000
 161. $t = 2.5$ sec, 6.5 sec 163. 36 ft, 78 ft 165. 30,000 ovens
 167. $x \approx 13.5$, or the year 2008 169. a. $7x^2 + 6x - 16 = 0$
 b. $6x^2 + 5x - 14 = 0$ c. $5x^2 - x - 6 = 0$
 171. $z = -2i$; $z = 5i$ 173. $z = \frac{-3}{4}i$; $z = 2i$
 175. $z = -1 - i$; $z = -13 - i$
 177. a. $P = 2L + 2W$, $A = LW$ b. $P = 2\pi r$, $A = \pi r^2$
 c. $P = c + h + b_1 + b_2$, $A = \frac{1}{2}h(b_1 + b_2)$ d. $P = a + b + c$, $A = \frac{1}{2}bh$
 179. 700 \$30 tickets; 200 \$20 tickets

Exercises 3.3, pp. 244–248

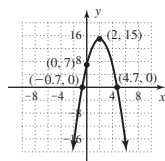
1. $\frac{25}{2}$ 3. 0, $f(x)$ 5. Answers will vary.
 7. left 2, down 9 9. right 1, reflected across x -axis, up 4



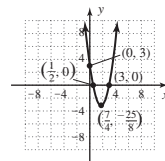
11. left 1, stretched vertically, down 8



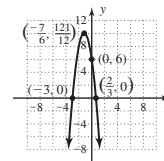
13. right 2, reflected across x -axis, stretched vertically, up 15



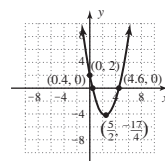
15. right $\frac{7}{4}$, stretched vertically, down $\frac{25}{8}$



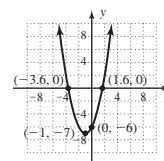
17. left $\frac{7}{6}$, reflected across x -axis, stretched vertically, up $\frac{121}{12}$



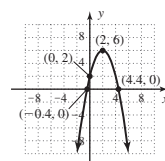
19. right $\frac{5}{2}$, down $\frac{17}{4}$



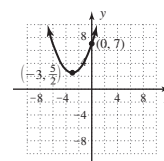
21. left 1, down 7



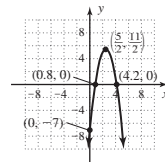
23. right 2, reflected across x -axis, up 6



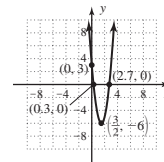
25. left 3, compressed vertically up $\frac{5}{2}$



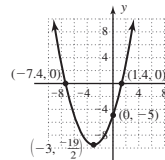
27. right $\frac{5}{2}$, reflected across x -axis, stretched vertically, up $\frac{11}{2}$



29. right $\frac{3}{2}$, stretched vertically, down 6



31. left 3, compressed vertically, down $\frac{19}{2}$

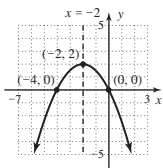


33. $y = 1(x - 2)^2 - 1$ 35. $y = -1(x + 2)^2 + 4$
 37. $y = -\frac{3}{2}(x + 2)^2 + 3$ 39. i. $x = -3 \pm \sqrt{5}$ ii. $x = 4 \pm \sqrt{3}$

- iii. $x = -4 \pm \frac{\sqrt{14}}{2}$ iv. $x = 2 \pm \sqrt{2}$ v. $t = -2.7$, $t = 1.3$
 vi. $t = -1.4$, $t = 2.6$ 41. a. $(0, -66,000)$; when no cars are produced, there is a loss of \$66,000. b. $(20, 0)$, $(330, 0)$; no profit will be made if fewer than 20 or more than 330 cars are produced. c. 175 d. \$240,250
 43. a. \$2 b. \$44 c. \$8800 d. \$23; \$44,100 45. 6000; \$3200
 47. a. $h(t) = -16t^2 + 240t + 544$ b. 544 ft; that is when the fuel is exhausted. c. 1344 ft d. 1344 ft e. It is coming back down.
 f. 1444 ft g. 17 sec 49. a. 14.4 ft b. 41 ft c. 48.02 ft d. 90 ft
 51. a. 25 ft b. approx. 3.43 sec c. 67.25 ft
 53. a. 2500 ft², 50 ft \times 50 ft b. 5000 ft², 50 ft \times 100 ft
 55. a. approx. 29.5" wide by 18.7" long b. approx. 930 in²
 57. a. \$1.25 each, \$781.25 b. about \$0.85 each 59. Answers will vary.
 61. $y = \frac{-7}{18}\left(x - \frac{1}{2}\right)^2 + \frac{7}{2}$ 63. $m = \frac{4}{3}$, y -intercept $(0, 3)$
 65. $g(x) = -\sqrt[3]{x + 1} - 3$

Mid-Chapter Check, p. 249

1. sum 4, product 13; both yield real numbers 2. i
 3. $(1 + 2i)^2 - 2(1 + 2i) + 5 = 0$
 $1 + 4i + 4i^2 - 2 - 4i + 5 = 0$
 $1 + (-4) - 2 + 5 = 0$
 $0 = 0 \checkmark$ Yes.
 4. $x = -1$ and 3 5. $x = 2 \pm \sqrt{\frac{5}{3}}$ 6. $x = \frac{7}{4} \pm \frac{\sqrt{17}}{4}$
 7. $(-\infty, -1] \cup [0.37, \infty)$ 8. a. about 29.6 in. b. about 7.17 ft
 c. yes; $3 \times 7.17 > 21.5$
 9. $f(x) = \frac{4}{9}(x - 3)^2 - 2$

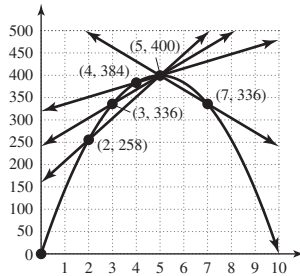


Reinforcing Basic Concepts, pp. 249–250

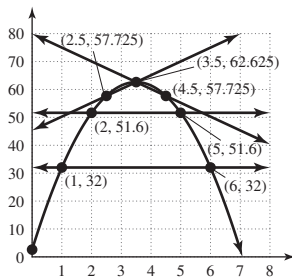
- Exercise 1:** $\frac{7}{2} + (-1) = \frac{5}{2} = -\frac{b}{a} \checkmark$
 $\frac{7}{2} \cdot (-1) = \frac{-7}{2} = \frac{c}{a} \checkmark$
Exercise 2: $\frac{2 + 3\sqrt{2}}{2} + \frac{2 - 3\sqrt{2}}{2} = \frac{4}{2} = \frac{-b}{a} \checkmark$
 $\frac{2 + 3\sqrt{2}}{2} \cdot \frac{2 - 3\sqrt{2}}{2} = \frac{-14}{4} = \frac{-7}{2} = \frac{c}{a} \checkmark$
Exercise 3: $(5 + 2\sqrt{3}i) + (5 - 2\sqrt{3}i) = 10 = \frac{-b}{a} \checkmark$
 $(5 + 2\sqrt{3}i)(5 - 2\sqrt{3}i) = 25 + 12 = 37 = \frac{c}{a} \checkmark$
Exercise 4: $x_1 + x_2 = -\frac{b}{a}$ since radical terms sum to 0, and $2\left(\frac{-b}{2a}\right) = \frac{-b}{a}$;
 $x_1x_2 = \frac{c}{a}$ since $\left(\frac{-b}{2a}\right)^2 - \left(\frac{\sqrt{b^2 - 4ac}}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{b^2 - 4ac}{4a^2} = \frac{4ac}{4a^2} = \frac{c}{a}$

Exercises 3.4, pp. 257–261

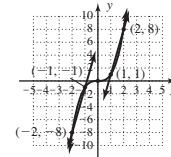
1. quadratic, negative 3. average, slope, secant line
 5. Answers will vary. 7. a. $y = 1.45x^2 - 2.59x - 4.55$ b. 4.1475
 c. $x = 6.446$ 9. a. $y = -0.851x^2 + 3.153x + 64.428$ b. 65.037
 c. $x = 7.623$ 11. a. $y = 3.485x^2 - 26.424x - 60.505$ b. 10.422
 c. $x = 1.746$ or 5.836 13. a. $y = 0.113x^2 - 5.796x + 61.583$
 b. -12.882 c. $x = 7.368$ or 44.019 15. 0 17. 1.4 19. -0.2
 21. -1.6 23. -0.1 25. 1.2 27. a. 48 ft/sec b. 32 ft/sec
 c. 16 ft/sec d. -32 ft/sec 29. a. 0 m/sec b. 0 m/sec
 c. 4.9 m/sec d. -4.9 m/sec
 31. Answers will vary.



33. Answers will vary.



35. $\frac{\Delta y}{\Delta x} = 39$ 37. $\frac{\Delta y}{\Delta x} = 1$ 39. $\frac{\Delta f}{\Delta m} = 9.8$
 41. $\frac{\Delta A}{\Delta r} = 37.70$ 43. a. 14,570 ft b. 14,174 ft c. -198 ft/sec
 d. $h(10) = 13,340$ ft; $h(12) = 12,624$ ft; average rate of change = -358 ft/sec, almost twice as fast 45. a. $R = -43.07t^2 + 976.53t - 126.8$
 b. 4598 c. $t \approx 8.26$ days (early in the ninth day)
 d. about 5408 participants 47. a. $T = 5.92n^2 - 83.13n + 349.86$
 b. about 82 sec c. 16 tourists d. about 58 sec with seven tourists
 49. a. $\frac{\Delta \text{weight}}{\Delta \text{time}} = \frac{50}{1}$, positive, 50 g are gained each week b. 25th to 29th;
 $\frac{\Delta w}{\Delta t} = \frac{50}{1}$; 32nd to 36th; $\frac{\Delta w}{\Delta t} = \frac{250}{1}$; the weight gain is five times greater in the later weeks. 51. a. 7 b. 7
 c. They are the same.
 d. Slopes are equal.



53. a. 176 ft b. 320 ft c. 144 ft/sec d. -144 ft/sec; The arrow is going down. 55. a. 17.89 ft/sec; 25.30 ft/sec b. 30.98 ft/sec; 35.78 ft/sec c. Between 5 and 10. d. 1.482 ft/sec, 0.96 ft/sec
 57. a. about 3569 in³ b. about 3800 in³ c. $\frac{\Delta r}{\Delta t} = 0.74$ in./sec when $t \in [0, 1]$ and 0.04 in./sec when $t \in [18, 19]$; $\frac{\Delta V}{\Delta r} \approx 64.745$ in³/in. when $t \in [0, 1]$ and 22.602 when $t \in [18, 19]$. Answers will vary. 59. $(\frac{1}{2}, \infty)$
 61. a. $(-\infty, -1) \cup (2, \infty)$ b. $\{ \}$ 63. $g(x) = \begin{cases} -|x| & x < 1 \\ \frac{1}{2}(x - 3) & x \geq 1 \end{cases}$

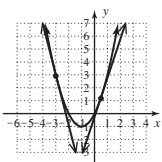
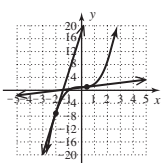
Exercises 3.5, pp. 268–274

1. $(f + g)(x)$, $A \cap B$ 3. intersection, $g(x)$ 5. Answers will vary.
 7. a. $x \in \mathbb{R}$ b. $f(-2) - g(-2) = 13$
 9. a. $h(x) = x^2 - 6x - 3$ b. $h(-2) = 13$ c. they are identical
 11. a. $x \in [3, \infty)$ b. $h(x) = \sqrt{x - 3} + 2x^3 - 54$
 c. $h(4) = 75$, 2 is not in the domain of h .
 13. a. $x \in [-5, 3]$ b. $r(x) = \sqrt{x + 5} + \sqrt{3 - x}$
 c. $r(2) = \sqrt{7} + 1$, 4 is not in the domain of r .
 15. a. $x \in [-4, \infty)$ b. $h(x) = \sqrt{x + 4}(2x + 3)$
 c. $h(-4) = 0$, $h(21) = 225$
 17. a. $x \in [-1, 7]$ b. $r(x) = \sqrt{-x^2 + 6x + 7}$
 c. 15 is not in the domain of r , $r(3) = 4$
 19. a. $x \in (-\infty, -4) \cup (-4, \infty)$ b. $h(x) = x - 4$, $x \neq -4$
 21. a. $x \in (-\infty, -4) \cup (-4, \infty)$ b. $h(x) = x^2 - 2$, $x \neq -4$
 23. a. $x \in (-\infty, 1) \cup (1, \infty)$ b. $h(x) = x^2 - 6x$, $x \neq 1$
 25. a. $x \in (-\infty, 5) \cup (5, \infty)$ b. $h(x) = \frac{x + 1}{x - 5}$, $x \neq 5$
 27. a. $x \in (-\infty, -2)$ b. $r(x) = \frac{2x - 3}{\sqrt{-2 - x}}$
 c. 6 is not in the domain of r , $r(-6) = -\frac{15}{2}$
 29. a. $x \in (5, \infty)$ b. $r(x) = \frac{x - 5}{\sqrt{x - 5}}$
 c. $r(6) = 1$, -6 is not in the domain of r .
 31. a. $x \in \left(-\frac{13}{2}, \infty\right)$ b. $r(x) = \frac{x^2 - 36}{\sqrt{2x + 13}}$ c. $r(6) = 0$, $r(-6) = 0$
 33. a. $h(x) = \frac{2x + 4}{x - 3}$ b. $x \in (-\infty, 3) \cup (3, \infty)$ c. $x \neq -2$, $x \neq 0$
 35. sum: $3x + 1$, $x \in (-\infty, \infty)$; difference: $x + 5$, $x \in (-\infty, \infty)$;
 product: $2x^2 - x - 6$, $x \in (-\infty, \infty)$;
 quotient: $\frac{2x + 3}{x - 2}$, $x \in (-\infty, 2) \cup (2, \infty)$
 37. sum: $x^2 + 3x + 5$, $x \in (-\infty, \infty)$; difference: $x^2 - 3x + 9$,
 $x \in (-\infty, \infty)$; product: $3x^3 - 2x^2 + 21x - 14$, $x \in (-\infty, \infty)$;
 quotient: $\frac{x^2 + 7}{3x - 2}$, $x \in \left(-\infty, \frac{2}{3}\right) \cup \left(\frac{2}{3}, \infty\right)$

39. sum: $x^2 + 3x - 4$, $x \in (-\infty, \infty)$; difference: $x^2 + x - 2$, $x \in (-\infty, \infty)$; product: $x^3 + x^2 - 5x + 3$, $x \in (-\infty, \infty)$; quotient: $x + 3$, $x \in (-\infty, 1) \cup (1, \infty)$
41. sum: $3x + 1 + \sqrt{x-3}$, $x \in [3, \infty)$; difference: $3x + 1 - \sqrt{x-3}$, $x \in [3, \infty)$; product: $(3x + 1)\sqrt{x-3}$, $x \in [3, \infty)$; quotient: $\frac{3x+1}{\sqrt{x-3}}$, $x \in (3, \infty)$
43. sum: $2x^2 + \sqrt{x+1}$, $x \in [-1, \infty)$; difference: $2x^2 - \sqrt{x+1}$, $x \in [-1, \infty)$; product: $2x^2\sqrt{x+1}$, $x \in [-1, \infty)$; quotient: $\frac{2x^2}{\sqrt{x+1}}$, $x \in (-1, \infty)$
45. sum: $\frac{7x-11}{(x-3)(x+2)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; difference: $\frac{-3x+19}{(x-3)(x+2)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; product: $\frac{10}{(x-3)(x+2)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; quotient: $\frac{2x+4}{5(x-3)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$
47. a. 6000 b. 3000 c. 8000 d. $C(9) - T(9)$; 4000
49. a. \$1 billion b. \$5 billion c. 2003, 2007, 2010
d. $t \in (2000, 2003) \cup (2007, 2010)$ e. $t \in (2003, 2007)$
f. $R(5) - C(5)$; \$4 billion

51. a. 4 b. 0 c. 2 d. 3 e. $-\frac{1}{3}$ f. 6 g. -3 h. 1 i. 1
j. undefined 53. $h(x) = -\frac{2}{3}x + 4$ 55. $h(x) = 4x - x^2$
57. a. $(-\infty, \infty)$ b. $(-\infty, 2) \cup (2, \infty)$ 59. a. $[-1, \infty)$ b. $(-1, \infty)$
61. a. $[-2, 3]$ b. $[-2, 3)$ 63. a. $[-4, \infty)$ b. $[-4, \infty)$
65. a. $(-\infty, \infty)$ b. $(-\infty, 4) \cup (4, \infty)$ 67. a. $[-4, 3]$ b. $[-4, 3)$
69. a. $V = 400 - 400e^{-0.08t}$ b. $f(t) = 400$, $g(t) = 400e^{-0.08t}$,
 $V(1) \approx 400 - 369 = 31$ ft/sec, $V(2) \approx 400 - 341 = 59$ ft/sec,
 $V(20) \approx 400 - 81 = 319$ ft/sec c. 400 ft/sec
71. a. $P(x) = 12,000x - 108,000$ b. nine boats must be sold
73. a. $P(n) = 11.45n - 0.1n^2$ b. \$123 c. \$327 d. $C(115) > R(115)$
75. km 115 77. Anywhere between km 115 and km 199.
Answers will vary. 79. a. 4 sec b. about 494 ft
81. a. 1995 to 1996; 1999 to 2004 b. 30; 1995 c. 20 seats; 1997
d. The total number of seats in the senate (50); the number of additional seats held by the majority
83. 67 a. $x = \frac{2}{3}$, where $Y_1 = Y_2$; 67 b. $x = -4$, where $Y_1 = 0$; 68 a. $x = 0$, where $Y_1 = -Y_2$; 68 b. $x = -1.2$ or 3, the zeroes of Y_1 and Y_2 .
85. $x = -\frac{148}{9}$ 87. a. $6x + 5y = -13$ b. $d = \sqrt{61}$

Exercises 3.6, pp. 287-291

1. composition 3. domain, $g(x)$ 5. Answers will vary.
7. 0, 0, $4a^2 - 10a - 14$, $a^2 - 9a$
9. a. $h(x) = \sqrt{2x-2}$ b. $H(x) = 2\sqrt{x+3} - 5$
c. D of $h(x)$: $x \in [1, \infty)$; D of $H(x)$: $x \in [-3, \infty)$
11. a. $h(x) = \sqrt{3x+1}$ b. $H(x) = 3\sqrt{x-3} + 4$
c. D of $h(x)$: $x \in [-\frac{1}{3}, \infty)$; D of $H(x)$: $x \in [3, \infty)$
13. a. $h(x) = x^2 + x - 2$ b. $H(x) = x^2 - 3x + 2$
c. D of $h(x)$: $x \in (-\infty, \infty)$; D of $H(x)$: $x \in (-\infty, \infty)$
15. a. $h(x) = x^2 + 7x + 8$ b. $H(x) = x^2 + x - 1$
c. D of $h(x)$: $x \in (-\infty, \infty)$; D of $H(x)$: $x \in (-\infty, \infty)$
17. a. $h(x) = |-3x + 1| - 5$ b. $H(x) = -3|x| + 16$
c. D of $h(x)$: $x \in (-\infty, \infty)$; D of $H(x)$: $x \in (-\infty, \infty)$
19. $h(-3) = -6$, $h(\sqrt{2}) \approx 9.071$
 $h(\frac{1}{2}) = 2.75$, $h(5) = 50$
21. $h(-3) = 1$, $h(\sqrt{2}) \approx 145.91$
 $h(\frac{1}{2}) = 64$, $h(5) = \text{ERR}$;
 $x = 5$ is not in the domain of g
23. $h(-3) = 2$, $h(\sqrt{2}) = 5$
 $h(\frac{1}{2}) = 5.5$, $h(5) = \text{ERR}$;
 $g(5)$ is not in the domain of f
25. a. $(f \circ g)(x)$: For $g(x)$ to be defined, $x \neq 0$.
For $f[g(x)] = \frac{2g(x)}{g(x)+3}$, $g(x) \neq -3$ so $x \neq -\frac{5}{3}$.
domain: all real numbers except $x = -3$ and $x = -\frac{5}{3}$
- b. $(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq -3$.
For $g[f(x)] = \frac{5}{f(x)}$, $f(x) \neq 0$ so $x \neq 0$.
domain: all real numbers except $x = -3$ and $x = 0$
- c. $(f \circ g)(x) = \frac{10}{5+3x}$; $(g \circ f)(x) = \frac{5x+15}{2x}$; the domain of a composition cannot always be determined from the composed form
27. a. $(f \circ g)(x)$: For $g(x)$ to be defined, $x \neq 5$.
For $f[g(x)] = \frac{4}{g(x)}$, $g(x) \neq 0$ and $g(x)$ is never zero
domain: $\{x | x \neq 5\}$
- b. $(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq 0$.
For $g[f(x)] = \frac{1}{f(x)-5}$, $f(x) \neq 5$ so $x \neq \frac{4}{5}$.
domain: all real numbers except $x = 0$ and $x = \frac{4}{5}$
- c. $(f \circ g)(x) = 4x - 20$; $(g \circ f)(x) = \frac{x}{4-5x}$; the domain of a composition cannot always be determined from the composed form
29. a. 41 b. 41 31. $g(x) = \sqrt{x-2} + 1$, $f(x) = x^3 - 5$
33. $p(x) = 2(x+4)^2 - 3$, $q(x) = (2x+7)^2 - 1$
35. a. 2 b. 2 c. 2 d. -1 e. -1 f. 1 g. 3 h. ≈ 0.5
37. a. $f(x)$: $x \geq -1$, $g(x)$: $x \neq 2$ c. $h(x)$: $x \in (-\infty, -2) \cup [1, \infty)$
39. 2 41. $2x + h$ 43. $2x + 2 + h$ 45. $\frac{-2}{x(x+\frac{1}{2})}$
47. a. $\frac{\Delta g}{\Delta x} = 2x + 2 + h$ b. $\frac{\Delta g}{\Delta x} = -3.9$ c. $\frac{\Delta g}{\Delta x} = 3.01$
- d.  The rates of change have opposite sign, with the secant line to the left being slightly more steep.
49. a. $\frac{\Delta g}{\Delta x} = 3x^2 + 3xh + h^2$ b. $\frac{\Delta g}{\Delta x} = 12.61$ c. $\frac{\Delta g}{\Delta x} \approx 0.49$
- d.  Both lines have a positive slope, but the line at $x = -2$ is much steeper.
51. $\frac{\Delta j}{\Delta x} = \frac{-2x-h}{x^2(x+h)^2}$;
[0.50, 0.51]: $\frac{\Delta j}{\Delta x} \approx -15.5$;
[1.50, 1.51]: $\frac{\Delta j}{\Delta x} \approx -0.6$;
Answers will vary.
53. $\frac{\Delta g}{\Delta x} = 3x^2 + 3xh + h^2$;
[-2.01, -2.00]: $\frac{\Delta g}{\Delta x} \approx 12.1$;
[0.40, 0.41]: $\frac{\Delta g}{\Delta x} \approx 0.5$;
Answers will vary.

55. a. $f[g(x)] = (x - 2)^2 + 4(x - 2) + 3$
 $= x^2 - 4x + 4 + 4x - 8 + 3$
 $= x^2 - 1\checkmark$

b. verified

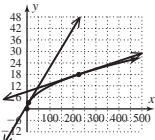
57. $h(x) = x - 2.5$; 10.5 59. a. 4160 b. 45,344

c. $M(x) = 453.44x$; yes 61. a. 6 ft b. $36\pi \text{ ft}^2$ c. $A(t) = 9\pi t^2$; yes

63. a. $L(0) = 500$ lions and $H(500) = 400$ hyenas

b. $H[L(x)] = 400 + 0.0075x$, $(H \circ L)(16,000) = 520$ hyenas c. prior to an increase of 30,000

65. a. $\frac{\Delta d}{\Delta h} \approx 0.2$ b. $\frac{\Delta d}{\Delta h} \approx 0.04$

c.  As height increases you can see farther, but the sight distance increases at a slower rate.

67. a. March: $\frac{\Delta d}{\Delta t} \approx 15$, June: $\frac{\Delta d}{\Delta t} \approx 3$, 5 times faster

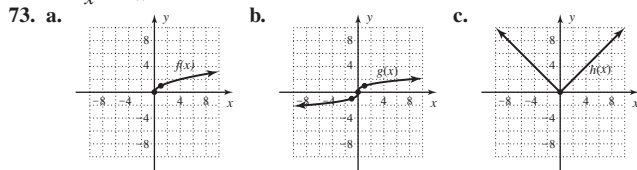
b. $t = 6.75$, late June c. decreasing ($\frac{\Delta d}{\Delta t} < 0$); 5000 units/month

69. Answers will vary.

71. a. For $y = \frac{1}{x}$: $\frac{\Delta y}{\Delta x} \approx -3.91$; For $y = \frac{1}{x^2}$: $\frac{\Delta y}{\Delta x} \approx -15.53$

b. Less—decrease is more gradual; For $y = \frac{1}{x}$: $\frac{\Delta y}{\Delta x} \approx -1.54$;

For $y = \frac{1}{x^2}$: $\frac{\Delta y}{\Delta x} \approx -3.83$



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

Making Connections, p. 292

1. b 3. h 5. d 7. a 9. g 11. f 13. c 15. a

Summary and Concept Review, pp. 292–297

1. $6i\sqrt{2}$ 2. $24i\sqrt{3}$ 3. $-2 + i\sqrt{2}$ 4. $3i\sqrt{2}$ 5. i 6. $21 + 20i$

7. $-2 + i$ 8. $-5 + 7i$ 9. 13 10. $-20 - 12i$

11. $(5i)^2 - 9 = -34$ $(-5i)^2 - 9 = -34$

$25i^2 - 9 = -34$ $25i^2 - 9 = -34$

$-25 - 9 = -34\checkmark$ $-25 - 9 = -34\checkmark$

12. $(2 + i\sqrt{5})^2 - 4(2 + i\sqrt{5}) + 9 = 0$

$4 + 4i\sqrt{5} + 5i^2 - 8 - 4i\sqrt{5} + 9 = 0$

$5 + (-5) = 0\checkmark$

$(2 - i\sqrt{5})^2 - 4(2 - i\sqrt{5}) + 9 = 0$

$4 - 4i\sqrt{5} + 5i^2 - 8 + 4i\sqrt{5} + 9 = 0$

$5 + (-5) = 0\checkmark$

13. a. $x = 5$ or $x = -2$ b. $x = -5$ or $x = 5$ c. $x = -\frac{5}{3}$ or $x = 3$

d. $x = -2$ or $x = 2$ or $x = 3$ 14. a. $x = \pm 3$ b. $x = 2 \pm \sqrt{5}$

c. $x = \pm i\sqrt{5}$ d. $x = \pm 5$ 15. a. $x = 3$ or $x = -5$

b. $x = -8$ or $x = 2$ c. $x = 1 \pm \frac{\sqrt{10}}{2}$; $x \approx 2.58$ or $x \approx -0.58$

d. $x = 2$ or $x = \frac{1}{3}$ 16. a. $x = 2 \pm i\sqrt{5}$; $x \approx 2 \pm 2.24i$

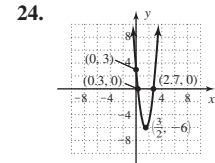
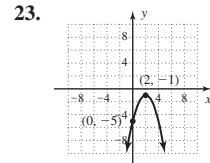
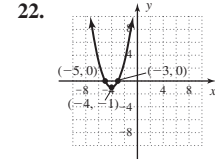
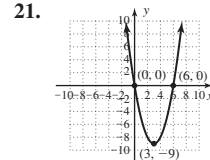
b. $x = \frac{3}{2} \pm \frac{\sqrt{2}}{2}$; $x \approx 2.21$ or $x \approx 0.79$ c. $x = \frac{3}{2} \pm \frac{1}{2}i$

17. a. $(-\infty, -2) \cup (3, \infty)$ b. $[-1, 1]$ c. $(-\infty, \infty)$

18. a. $[-4, 1]$ b. $(-\infty, -5) \cup (4, \infty)$ c. $\{-2\}$

19. a. 1.3 sec b. 4.7 sec c. 6 sec

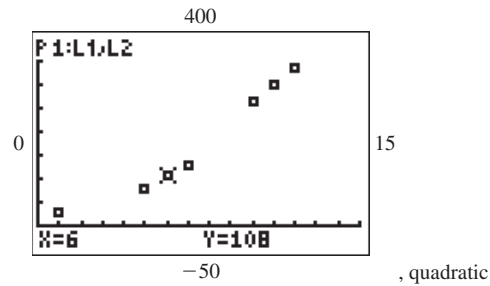
20. a. 0.8 sec b. 3.2 sec c. 5 sec



25. a. 0 ft b. 108 ft c. 2.25 sec d. 144 ft, $t = 3$ sec

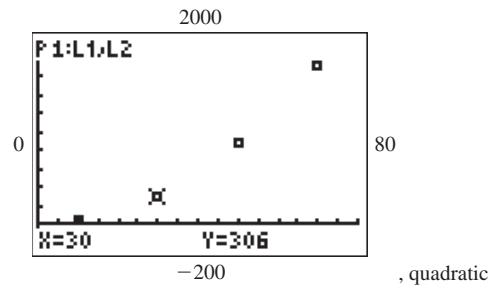
26. \$3.75; 3000

27. a.



b. $A(x) = 2.144x^2 + 1.010x + 25.847$, about \$48.2 billion c. about \$460.2 billion d. year 16 \rightarrow 2016

28. a.



b. $F_d(x) = 0.35x^2 - 0.3x$, 1242 units c. about 82 mph

29. a. $\frac{\Delta N}{\Delta t} = \frac{2.95}{1}$, 295 stores per year b. for 2000 to 2002: $\frac{\Delta N}{\Delta t} \approx \frac{11.93}{1}$,

1193 stores per year; $295 \times 4 \approx 1180 \checkmark$ c. for 2002 to 2004:

$\frac{\Delta N}{\Delta t} \approx \frac{13.42}{1}$, 1342 stores per year; for 2006 to 2008: $\frac{\Delta N}{\Delta t} \approx \frac{13.20}{1}$, 1320

stores per year, very close 30. a. 20 ft^3 b. approx. 18.251 ft^3

c. approx. $-1.749 \text{ ft}^3/\text{sec}$ d. approx. $-0.149 \text{ ft}^3/\text{sec}$ e. $t \approx 22.4$ sec

31. $a^2 + 7a - 2$ 32. 147 33. $x \in (-\infty, \frac{2}{3}) \cup (\frac{2}{3}, \infty)$

34. a. 4 b. 6 c. $-\frac{1}{5}$ d. 14

35. a. $P(x) = 84.95n - (-0.002n^2 + 20n + 30,000) =$

$0.002n^2 + 64.95n - 30,000$

b. $-\$3700$ c. $\$344,750$ d. 456 36. $4x^2 + 8x - 3$ 37. 99

38. x ; x 39. $f(x) = \sqrt{x} + 1$; $g(x) = 3x - 2$

40. $f(x) = x^2 - 3x - 10$; $g(x) = x^{\frac{3}{2}}$ 41. $A(t) = \pi(2t + 3)^2$

42. a. 0 b. 7 c. 7 d. 2 e. 4 43. $2x - 1 + h$; 3.01

Practice Test, pp. 297–298

1. a. $(0, \frac{1}{2})$ b. $(-\infty, 1) \cup (1, \infty)$ c. $(-\infty, -\frac{7}{3}) \cup [3, \infty)$ d. $\{ \}$

2. $x = \pm 5i$ 3. $x = 1 \pm i\sqrt{3}$ 4. $x = \frac{2}{3}$, $x = 6$ 5. a. $t = 5$ (May)

b. $t = 9$ (Sept.) c. July; \$3000 more 6. a. $-\frac{4}{3} + \frac{\sqrt{3}}{3}i$ b. $-i$

7. a. 1 b. $i\sqrt{3}$ c. 1 8. $-\frac{3}{2} + \frac{3}{2}i$ 9. 34

10. $(2 - 3i)^2 - 4(2 - 3i) + 13 = 0$

$4 - 12i - 9 - 8 + 12i + 13 = 0$

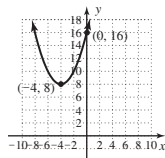
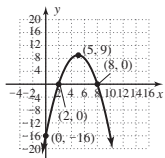
$-13 + 13 = 0$

$0 = 0 \checkmark$

11. a. $x = 5 \pm \frac{\sqrt{2}}{2}$ b. $x = \frac{5}{4} \pm \frac{\sqrt{7}}{4}i$

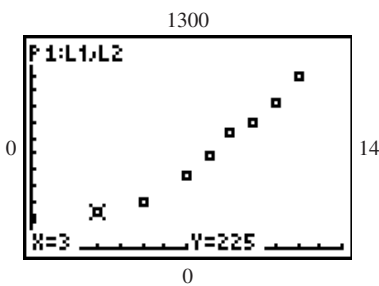
12. a. $x = \frac{3 \pm \sqrt{3}}{3}$ b. $x = 1 \pm 3i$

13. a. $f(x) = -(x - 5)^2 + 9$ b. $g(x) = \frac{1}{2}(x + 4)^2 + 8$



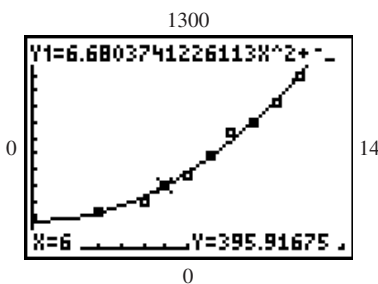
14. $(-2, 0)$, $y = 2x^2 + 4x$ 15. a. 40 ft, 48 ft b. 49 ft c. 14 sec

16. a.



, quadratic

b. $y \approx 6.68x^2 - 3.48x + 176.30$



c. about 396,000; about 4,264,000

17. a. 4750 books per year b. approx. 11,267 books per year

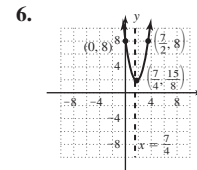
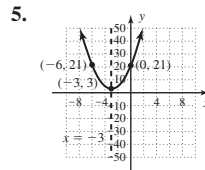
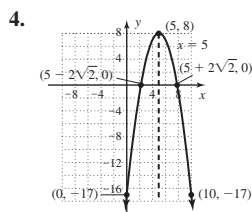
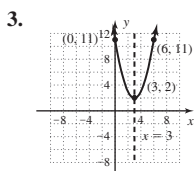
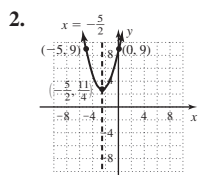
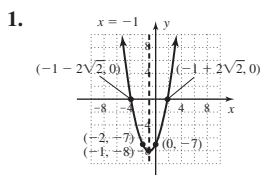
c. -2400 books per year and 18,100 books per year

18. $3x + 1$; $x \in [\frac{1}{3}, \infty)$

19. a. No, new company and sales should be growing b. 15 for [4, 5]; 19 for [5, 6] c. $\frac{\Delta S}{\Delta t} = 4t - 3 + 2h$. For small h , sales volume is approximately $\frac{37,000 \text{ units}}{1 \text{ mo}}$ in month 10, $\frac{69,000 \text{ units}}{1 \text{ mo}}$ in month 18, and $\frac{93,000 \text{ units}}{1 \text{ mo}}$ in month 24

20. a. $V(t) = \frac{4}{3}\pi(\sqrt{t})^3$ b. $36\pi \text{ in}^3$

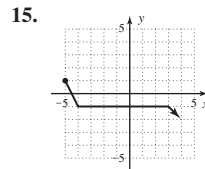
Strengthening Core Skills, pp. 300–301



Cumulative Review Chapters 1–3, pp. 301–302

1. $R = \frac{R_1 R_2}{R_1 + R_2}$ 3. a. $(x - 1)(x^2 + x + 1)$ b. $(x - 3)(x + 2)(x - 2)$

5. all reals 7. verified 9. $y = \frac{11}{60}x + \frac{1009}{60}$; 39 min, driving time increases 11 min every 60 days 11. Month 9 13. a. $f(x)$ b. $g(x)$



17. $X = 63$

19. a. $f(4) = -1$, $g(2) = 4$, $(f \circ g)(2) = -1$

b. $g(4) = 0$, $f(8) = 4$, $(g \circ f)(8) = 0$

c. $(fg)(0) = (-2)(4) = -8$, $(\frac{g}{f})(0) = \frac{-4}{-2} = 2$

d. $(f + g)(1) = -3 + 5 = 2$, $(g - f)(9) = 2 - 2 = 0$

21. $2x^2 - 9.2x + 14.5 = 0$ and $1.2x^2 = 5.52x - 8.7$

23. $y = 3x^2 - 1.5x + 7$

25. $x \in (-\infty, -0.2) \cup (-0.2, 0.2) \cup (0.2, \infty)$

X	Y1
-.3	-40
-.2	ERR:
-.1	0
0	-25
.1	-66.67
.2	ERR:
.3	80

X = -.3

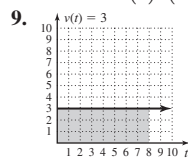
Connections to Calculus Exercises, pp. 305–306

1. a. -3 b. as $h \rightarrow 0$, -3 remains constant 3. a. $2x - 3 + h$

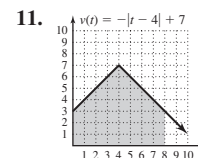
b. as $h \rightarrow 0$, $2(2) - 3 + h \rightarrow 1$ 5. a. $\frac{-1}{(x + h)x}$

b. as $h \rightarrow 0$, $\frac{-1}{(2 + h)(2)} \rightarrow \frac{-1}{4}$ 7. a. $\frac{-2x - h}{2x^2(x + h)^2}$

b. as $h \rightarrow 0$, $\frac{-2(2) - h}{2(2)^2(2 + h)^2} \rightarrow \frac{-1}{8}$



$A = 24$, distance = 24 ft



$A = 40$, distance = 40 ft

CHAPTER 4

Exercises 4.1, pp. 316–320

1. synthetic, zero 3. $P(c)$, remainder 5. Answers will vary.

7. $x^3 - 5x^2 - 4x + 23 = (x - 2)(x^2 - 3x - 10) + 3$

9. $2x^3 + 5x^2 + 4x + 17 = (x + 3)(2x^2 - x + 7) - 4$

11. $x^3 - 8x^2 + 11x + 20 = (x - 5)(x^2 - 3x - 4) + 0$

13. a. $\frac{2x^2 - 5x - 3}{x - 3} = (2x + 1) + \frac{0}{x - 3}$

b. $2x^2 - 5x - 3 = (x - 3)(2x + 1) + 0$

15. a. $\frac{x^3 - 3x^2 - 14x - 8}{x + 2} = (x^2 - 5x - 4) + \frac{0}{x + 2}$
 b. $x^3 - 3x^2 - 14x - 8 = (x + 2)(x^2 - 5x - 4) + 0$
 17. a. $\frac{x^3 - 5x^2 - 4x + 23}{x - 2} = (x^2 - 3x - 10) + \frac{3}{x - 2}$
 b. $x^3 - 5x^2 - 4x + 23 = (x - 2)(x^2 - 3x - 10) + 3$
 19. a. $\frac{2x^3 - 5x^2 - 11x - 17}{x - 4} = (2x^2 + 3x + 1) + \frac{-13}{x - 4}$
 b. $2x^3 - 5x^2 - 11x - 17 = (x - 4)(2x^2 + 3x + 1) - 13$
 21. $x^3 + 5x^2 + 7 = (x + 1)(x^2 + 4x - 4) + 11$
 23. $x^3 - 13x - 12 = (x - 4)(x^2 + 4x + 3) + 0$
 25. $3x^3 - 8x + 12 = (x - 1)(3x^2 + 3x - 5) + 7$
 27. $n^3 + 27 = (n + 3)(n^2 - 3n + 9) + 0$
 29. $x^4 + 3x^3 - 16x - 8 = (x - 2)(x^3 + 5x^2 + 10x + 4) + 0$
 31. $\frac{2x^3 + 7x^2 - x + 26}{x^2 + 3} = (2x + 7) + \frac{-7x + 5}{x^2 + 3}$
 33. $\frac{x^4 - 5x^2 - 4x + 7}{x^2 - 1} = (x^2 - 4) + \frac{-4x + 3}{x^2 - 1}$
 35. a. -30 b. 12 37. a. -2 b. -22 39. a. -1 b. 3
 41. a. 31 b. 0 43. a. -10 b. 0 45. a. yes b. yes
 47. a. no b. yes 49. a. yes b. yes
 51. $\begin{array}{r} \underline{-3} \quad 1 \quad 2 \quad -5 \quad -6 \\ 1 \quad -1 \quad -2 \quad 0 \end{array}$ 53. $\begin{array}{r} \underline{2} \quad 1 \quad 0 \quad -7 \quad 6 \\ 1 \quad 2 \quad -3 \quad 0 \end{array}$
 55. $\begin{array}{r} \underline{\frac{2}{3}} \quad 9 \quad 18 \quad -4 \quad -8 \\ 6 \quad 16 \quad 8 \\ 9 \quad 24 \quad 12 \quad 0 \end{array}$
 57. $P(x) = (x + 2)(x - 3)(x + 5)$, $P(x) = x^3 + 4x^2 - 11x - 30$
 59. $P(x) = (x + 2)(x - \sqrt{3})(x + \sqrt{3})$, $P(x) = x^3 + 2x^2 - 3x - 6$
 61. $P(x) = (x + 5)(x - 2\sqrt{3})(x + 2\sqrt{3})$, $P(x) = x^3 + 5x^2 - 12x - 60$
 63. $P(x) = (x - 1)(x + 2)(x - \sqrt{10})(x + \sqrt{10})$,
 $P(x) = x^4 + x^3 - 12x^2 - 10x + 20$
 65. $P(x) = (x + 2)(x - 3)(x - 4)$ 67. $p(x) = (x + 3)^2(x - 3)(x - 1)$
 69. $f(x) = 2(x - \frac{3}{2})(x + 2)(x + 5)$ 71. $p(x) = (x + 3)(x - 3)^2$
 73. $p(x) = (x - 2)^3$ 75. $p(x) = (x + 3)(x - 3)^3$
 77. $p(x) = (x + 3)(x - 3)^2(x + 4)^2$
 79. 4-in. squares; 16 in. \times 10 in. \times 4 in.
 81. a. week 10, 22.5 thousand b. one week before closing, 36 thousand
 c. week 9 83. a. 198 ft³ b. 2 ft c. about 7 ft 85. $k = 10$
 87. $k = -3$ 89. The theorems also apply to complex zeroes of polynomials. 91. $S_3 = 36$; $S_5 = 225$ 93. Yes, John wins.
 95. $G(t) = 1400t + 5000$

Exercises 4.2, pp. 332–336

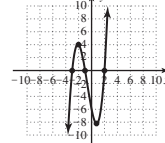
1. coefficients 3. $a - bi$ 5. b ; 4 is not a factor of 6
 7. $P(x) = (x + 2)(x - 2)(x + 3i)(x - 3i)$
 $x = -2, x = 2, x = 3i, x = -3i$
 9. $Q(x) = (x + 2)(x - 2)(x + 2i)(x - 2i)$
 $x = -2, x = 2, x = 2i, x = -2i$
 11. $P(x) = (x + 1)(x + 1)(x - 1)x = -1, x = -1, x = 1$
 13. $Q(x) = (x - 5)(x + 5)(x - 5)x = 5, x = -5, x = 5$
 15. $(x - 5)^3(x + 9)^2$; $x = 5$, multiplicity 3; $x = -9$, multiplicity 2
 17. $(x - 7)^2(x + 2)^2(x + 7)$; $x = 7$, multiplicity 2; $x = -2$, multiplicity 2; $x = -7$, multiplicity 1
 19. $P(x) = x^3 - 3x^2 + 4x - 12$ 21. $P(x) = x^4 - x^3 - x^2 - x - 2$
 23. $P(x) = x^4 - 6x^3 + 13x^2 - 24x + 36$
 25. $P(x) = x^4 + 2x^2 + 8x + 5$ 27. $P(x) = x^4 + 4x^3 + 27$
 29. a. yes b. yes 31. $[-4.7, -4.6], [-2.3, -2.2], [0.9, 1]$
 33. $\{\pm 1, \pm 15, \pm 3, \pm 5, \pm \frac{1}{4}, \pm \frac{15}{4}, \pm \frac{3}{4}, \pm \frac{5}{4}, \pm \frac{1}{2}, \pm \frac{15}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}\}$
 35. $\{\pm 1, \pm 15, \pm 3, \pm 5, \pm \frac{1}{2}, \pm \frac{15}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}\}$
 37. $\{\pm 1, \pm 28, \pm 2, \pm 14, \pm 4, \pm 7, \pm \frac{1}{6}, \pm \frac{14}{3}, \pm \frac{1}{3}, \pm \frac{7}{3}, \pm \frac{2}{3}, \pm \frac{7}{6}, \pm \frac{1}{2}, \pm \frac{7}{2}, \pm \frac{28}{3}, \pm \frac{4}{3}\}$
 39. $\{\pm 1, \pm 3, \pm \frac{1}{32}, \pm \frac{1}{2}, \pm \frac{1}{16}, \pm \frac{1}{4}, \pm \frac{1}{8}, \pm \frac{3}{32}, \pm \frac{3}{2}, \pm \frac{3}{16}, \pm \frac{3}{4}, \pm \frac{3}{8}\}$

41. $(x + 4)(x - 1)(x - 3)$, $x = -4, 1, 3$
 43. $(x + 3)(x + 2)(x - 5)$, $x = -3, -2, 5$
 45. $(x + 3)(x - 1)(x - 4)$, $x = -3, 1, 4$
 47. $(x + 2)(x - 3)(x - 5)$, $x = -2, 3, 5$
 49. $(x + 4)(x + 1)(x - 2)(x - 3)$, $x = -4, -1, 2, 3$
 51. $(x + 7)(x + 2)(x + 1)(x - 3)$, $x = -7, -2, -1, 3$
 53. $(2x + 3)(2x - 1)(x - 1)$; $x = -\frac{3}{2}, \frac{1}{2}, 1$
 55. $(2x + 3)^2(x - 1)$; $x = -\frac{3}{2}, 1$
 57. $(x + 2)(x - 1)(2x - 5)$; $x = -2, 1, \frac{5}{2}$
 59. $(x + 1)(2x + 1)(x - \sqrt{5})(x + \sqrt{5})$; $x = -1, -\frac{1}{2}, \sqrt{5}, -\sqrt{5}$
 61. $(x + 2)(3x - 2)(x - 2i)(x + 2i)$; $x = -2, \frac{2}{3}, 2i, -2i$
 63. $x = 1, 2, 3, -\frac{3}{2}$ 65. $x = -2, 1, -\frac{2}{3}$ 67. $x = -2, -\frac{3}{2}, 4$
 69. $x = 3, -1, \frac{3}{2}$ 71. $x = 1, 2, -3, \pm i\sqrt{7}$
 73. $x = -2, \frac{2}{3}, 1, \pm i\sqrt{3}$ 75. $x = 1, 2, 4, -2$ 77. $x = -3, 4, \pm\sqrt{2}$
 79. $x = -1, \frac{3}{2}, \pm i\sqrt{3}$ 81. $x = \frac{1}{2}, 1, 2, \pm i\sqrt{3}$
 83. a. possible roots: $\{\pm 1, \pm 8, \pm 2, \pm 4\}$; b. neither -1 nor 1 is a root;
 c. 3 or 1 positive roots, 1 negative root; d. roots must lie between -2
 and 2 85. a. possible roots: $\{\pm 1, \pm 2\}$; b. -1 is a root; c. 2 or 0
 positive roots, 3 or 1 negative roots; d. roots must lie between -3 and 2
 87. a. possible roots: $\{\pm 1, \pm 12, \pm 2, \pm 6, \pm 3, \pm 4\}$;
 b. $x = 1$ and $x = -1$ are roots; c. 4, 2, or 0 positive roots, 1 negative
 root; d. roots must lie between -1 and 4 89. a. possible roots:
 $\{\pm 1, \pm 20, \pm 2, \pm 10, \pm 4, \pm 5, \pm \frac{1}{2}, \pm \frac{5}{2}\}$; b. $x = 1$ is a root;
 c. 1 positive root, 1 negative root; d. roots must lie between -2 and 1
 91. $(x - 4)(2x - 3)(2x + 3)$; $x = 4, \frac{3}{2}, -\frac{3}{2}$
 93. $(2x + 1)(3x - 2)(x - 12)$; $x = -\frac{1}{2}, \frac{2}{3}, 12$
 95. $(x - 2)(x + 12)(4x^2 + 3)$; $x = 2, -12, \frac{\sqrt{3}}{2}i, -\frac{\sqrt{3}}{2}i$
 97. a. 5 b. 13 c. 2 99. yes 101. yes
 103. a. 4 cm \times 4 cm \times 4 cm b. 5 cm \times 5 cm \times 5 cm
 105. length 10 in., width 5 in., height 3 in.
 107. 1994, 1998, 2002, about 5 yr
 109. a. 8.97 m, 11.29 m, 12.05 m, 12.94 m b. 9.7 m, + 3.7
 111. a. yes b. no c. about 14.88
 113A. a. $(x + 5i)(x - 5i)$ b. $(x + 3i)(x - 3i)$
 c. $(x + i\sqrt{7})(x - i\sqrt{7})$ 113B. a. $x = -\sqrt{7}, \sqrt{7}$
 b. $x = -2\sqrt{3}, 2\sqrt{3}$ c. $x = -3\sqrt{2}, 3\sqrt{2}$
 115. a. $C(z) = (z - 4i)(z + 3)(z - 2)$
 b. $C(z) = (z - 9i)(z + 4)(z + 1)$
 c. $C(z) = (z - 3i)(z - 1 - 2i)(z - 1 + 2i)$
 d. $C(z) = (z - i)(z - 2 - 5i)(z - 2 + 5i)$
 e. $C(z) = (z - 6i)(z - 1 - i\sqrt{3})(z - 1 + i\sqrt{3})$
 f. $C(z) = (z + 4i)(z - 3 - i\sqrt{2})(z - 3 + i\sqrt{2})$
 g. $C(z) = (z - 2 + i)(z - 3i)(z + i)$
 h. $C(z) = (z - 2 + 3i)(z - 5i)(z + 2i)$
 117. a. $w = 150$ ft, $l = 300$ b. $A = 15,000$ ft²
 119. $r(x) = 2\sqrt{x + 4} - 2$

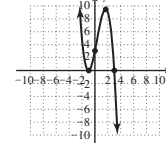
Exercises 4.3, pp. 349–354

1. zero, m 3. bounce, flatter 5. Answers will vary.
 7. polynomial, degree 3 9. not a polynomial, sharp turns
 11. polynomial, degree 2 13. up/down 15. down/down
 17. down/up; (0, -2) 19. down/down; (0, -6)
 21. up/down; (0, -6) 23. a. even b. -3 odd, -1 even, 3 odd
 c. $f(x) = (x + 3)(x + 1)^2(x - 3)$, deg 4 d. $x \in \mathbb{R}, y \in [-9, \infty)$
 25. a. even b. -3 odd, -1 odd, 2 odd, 4 odd
 c. $f(x) = -(x + 3)(x + 1)(x - 2)(x - 4)$, deg 4
 d. $x \in \mathbb{R}, y \in (-\infty, 25]$ 27. a. odd b. -1 even, 3 odd
 c. $f(x) = -(x + 1)^2(x - 3)$, deg 3 d. $x \in \mathbb{R}, y \in \mathbb{R}$
 29. degree 6; up/up; (0, -12) 31. degree 5; up/down; (0, -24)
 33. degree 6; up/up; (0, -192) 35. degree 5; up/down; (0, 2)
 37. b 39. e 41. c

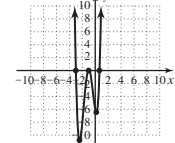
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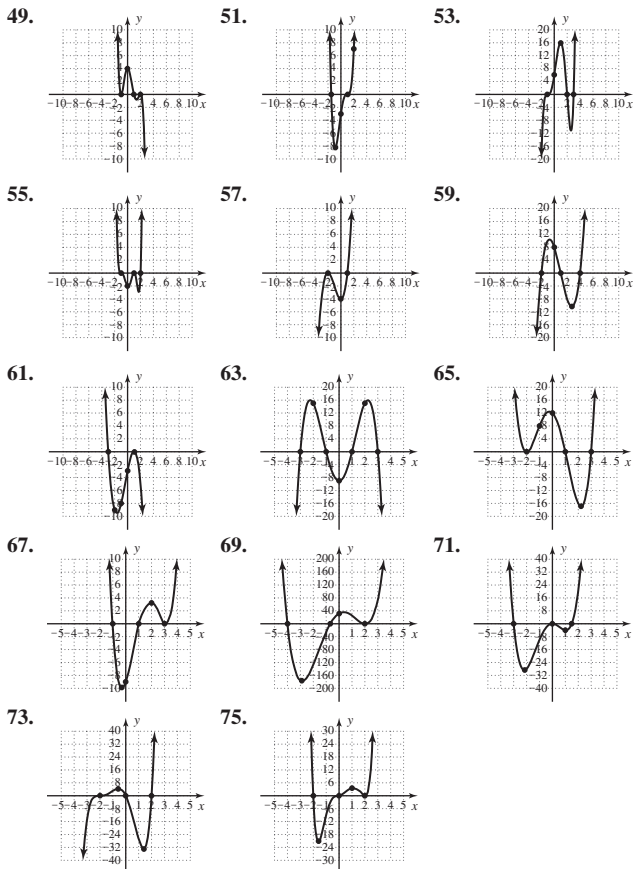


45.



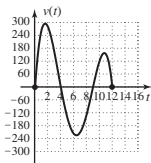
47.



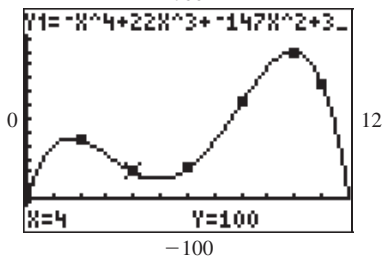


77. $h(x) = (x + 4)(x - \sqrt{3})(x + \sqrt{3})(x - i\sqrt{3})(x + i\sqrt{3})$
 79. $f(x) = 2(x + \frac{5}{2})(x - \sqrt{2})(x + \sqrt{2})(x - \sqrt{3})(x + \sqrt{3})$
 81. $P(x) = \frac{1}{6}(x + 4)(x - 1)(x - 3)$, $P(x) = \frac{1}{6}(x^3 - 13x + 12)$
 83. a. $(-3)^2 + (-1)^2 + (2)^2 + (4)^2 = (-2)^2 - 2(-13)$
 $9 + 1 + 4 + 16 = 4 + 26$
 $30 = 30 \checkmark$

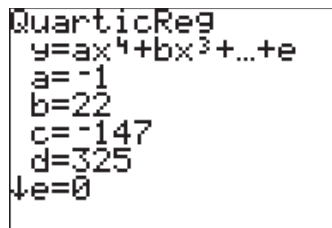
b. $(x + 3)(x + 1)(x - 2)(x - 4) = x^4 - 2x^3 - 13x^2 + 14x + 24 \checkmark$
 85. a. 280 vehicles above average, 216 vehicles below average, 154 vehicles above average b. 6:00 A.M. ($t = 0$), 10:00 A.M. ($t = 4$), 3:00 P.M. ($t = 9$), 6:00 P.M. ($t = 12$)
 c. max: about 300 vehicles above average at 7:30 A.M.; min: about 220 vehicles below average at 12 noon



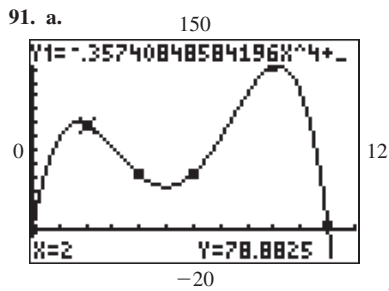
87. a. 3 b. 5 c. $B(x) = \frac{1}{4}x(x - 4)(x - 9)$, $-\$80,000$
 89. a. 700



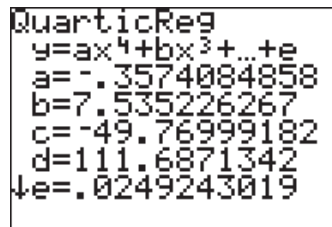
, quartic;



b. $t \approx 1.7$ (7:42 A.M.), 227 vehicles; $t \approx 9.9$ (3:54 P.M.), 551 vehicles
 c. $t \approx 7.93$ (1:56 P.M.) and $t \approx 11.27$ (5:16 P.M.)



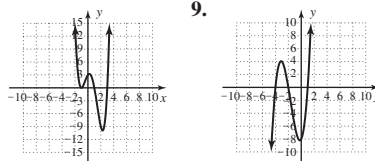
, quartic;



b. morning: $t \approx 1.72$ (11:43 A.M.); evening: $t \approx 9.11$, (7:07 P.M.)
 c. $t \approx 4.98$ (2:59 P.M.), about 33 customers
 d. $t \approx 7.92$ (5:55 P.M.) and $t \approx 10.02$ (8:01 P.M.)
 93. a. $f(x) \rightarrow \infty, f(x) \rightarrow -\infty$ b. $g(x) \rightarrow \infty, g(x) \rightarrow \infty; x^4 \geq 0$ for all x
 95. $c = -18$ 97. verified 99. verified, $x = 1 + 2i$ 101. yes

Mid-Chapter Check, p. 354

- a. $x^3 + 8x^2 + 7x - 14 = (x^2 + 6x - 5)(x + 2) - 4$
 b. $\frac{x^3 + 8x^2 + 7x - 14}{x + 2} = x^2 + 6x - 5 - \frac{4}{x + 2}$
- $f(x) = (2x + 3)(x + 1)(x - 1)(x - 2)$ 3. $f(-2) = 7$
- $f(x) = x^3 - 2x + 4$ 5. $g(2) = -8$ and $g(3) = 5$ have opposite signs
- $f(x) = (x - 2)(x + 1)(x + 2)(x + 4)$
- $x = -2, x = 1, x = -1 \pm 3i$



10. a. degree 4; three turning points b. 2 sec
 c. $A(t) = (t - 1)^2(t - 3)(t - 5)$, $A(t) = t^4 - 10t^3 + 32t^2 - 38t + 15$
 $A(2) = 3$; altitude is 300 ft above hard-deck, $A(4) = -9$; altitude is 900 ft below hard-deck

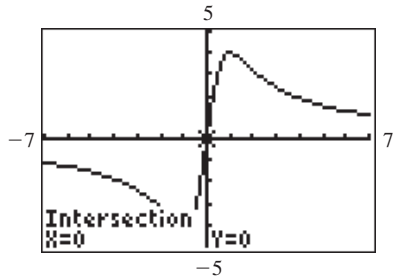
Reinforcing Basic Concepts, p. 355

Exercise 1. 1.532 Exercise 2. $-2.152, 1.765$

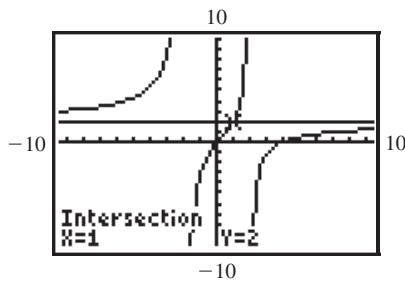
Exercises 4.4, pp. 366-371

- as $x \rightarrow -\infty, y \rightarrow 2$ 3. denominator, numerator 5. about $x = 98$
- $x = 3, x \in (-\infty, 3) \cup (3, \infty)$
- $x = 3, x = -3, x \in (-\infty, -3) \cup (-3, 3) \cup (3, \infty)$
- $x = \frac{5}{2}, x = 1, x \in (-\infty, -\frac{5}{2}) \cup (-\frac{5}{2}, 1) \cup (1, \infty)$

13. No V.A., $x \in (-\infty, \infty)$ 15. $x = 3$, yes; $x = -2$, yes
 17. $x = 3$, no 19. $x = 2$, yes; $x = -2$, no 21. $y = 0$, crosses at $(\frac{3}{2}, 0)$
 23. $y = 4$, crosses at $(-\frac{21}{4}, 4)$ 25. $y = 3$, does not cross
 27. $q(x) = 0$, $r(x) = 8x$ directly; the graph will cross the horizontal asymptote at $x = 0$.

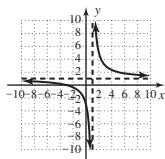


29. $q(x) = 2$, $r(x) = -8x - 8$; the graph will cross the horizontal asymptote at $x = 1$.

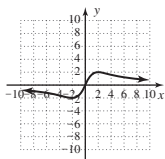


31. (0, 0) cross, (3, 0) cross 33. (-4, 0) cross, (0, 4)
 35. (0, 0) cross, (3, 0) bounce

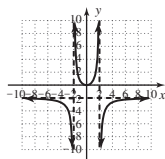
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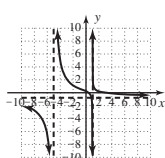
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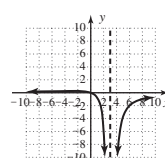
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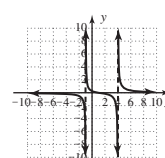
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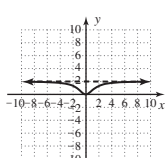
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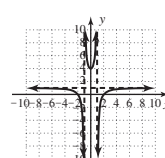
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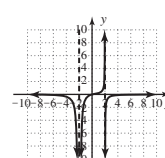
49.



51.



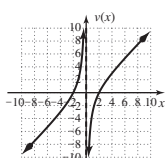
53.



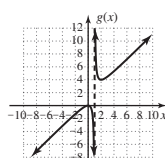
55. $f(x) = \frac{(x-4)(x+1)}{(x+2)(x-3)}$

57. $f(x) = \frac{x^2 - 4}{9 - x^2}$

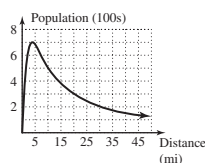
59.



61.



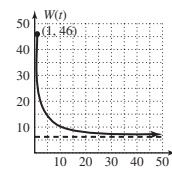
63. a.



Population density approaches zero far from town. b. 10 mi, 20 mi c. 4.5 mi, 704 people per square mi

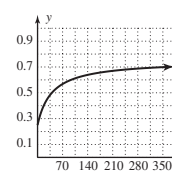
65. a. 5 hr; about 0.28 b. $-0.019, -0.005$; As the number of hours increases, the rate of change decreases. c. $h \rightarrow \infty, C \rightarrow 0$; horizontal asymptote 67. a. \$20,000, \$80,000, \$320,000; cost increases dramatically
 b. c. as $p \rightarrow 100^-, C \rightarrow \infty$

69. a. 2; 10



- b. 10; 20 c. On average, 6 words will be remembered for life.

71. a.



- b. 35%; 62.5%; 160 gal c. 160 gal; 200 gal
 d. 70%; 75%

73. a. \$225; \$175 b. 2000 heaters c. 4000 heaters d. The horizontal asymptote at $y = 125$ means the average cost approaches \$125 as monthly production gets very large. Due to limitations on production (maximum of 5000 heaters) the average cost will never fall below $A(5000) = 135$.

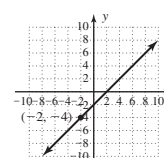
75. a. 5 b. 18 c. The horizontal asymptote at $y = 95$ means her average grade will approach 95 as the number of tests taken increases; no d. 6 77. a. 16.0, 28.7, 65.8, 277.8 b. 12.7, 37.1, 212.0
 c. a. 22.4, 40.2, 92.1, 388.9 b. 17.8, 51.9, 296.8; answers will vary.

79. $y = \frac{-4}{3}x - \frac{1}{3}$ 81. $\frac{-16}{3}, \frac{3}{4}; (3x + 16)(4x - 3) = 0$

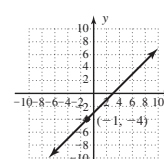
Exercises 4.5, pp. 380-384

1. slant 3. two 5. Answers will vary.

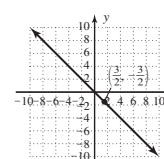
7. $F(x) = \begin{cases} x^2 - 4 & x \neq -2 \\ -4 & x = -2 \end{cases}$



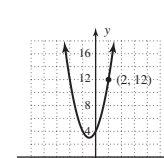
9. $G(x) = \begin{cases} x^2 - 2x - 3 & x \neq -1 \\ -4 & x = -1 \end{cases}$

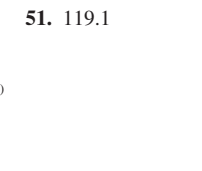
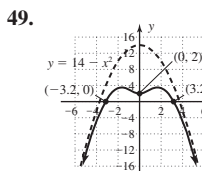
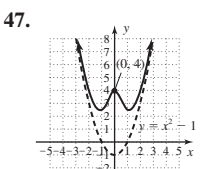
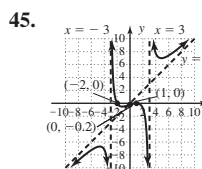
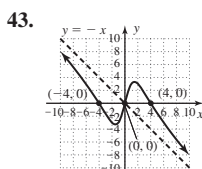
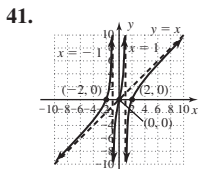
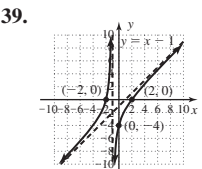
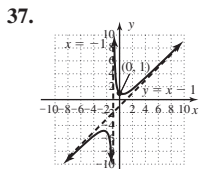
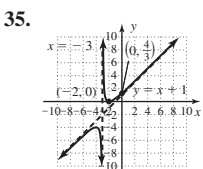
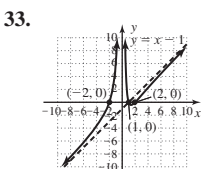
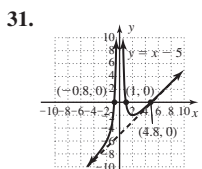
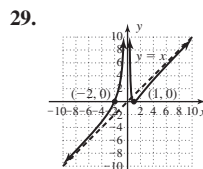
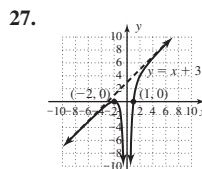
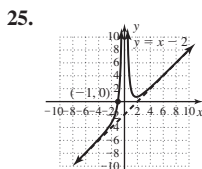
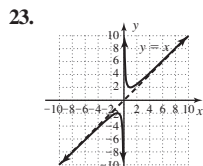
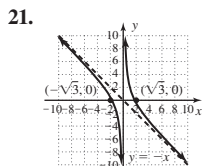
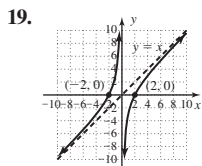
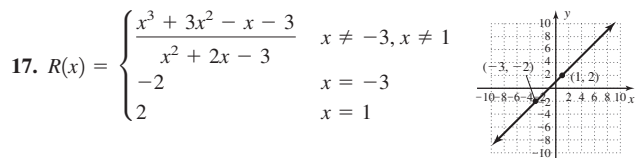
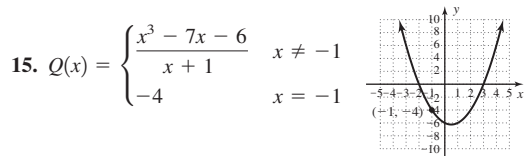


11. $H(x) = \begin{cases} 3x - 2x^2 & x \neq \frac{3}{2} \\ \frac{-3}{2} & x = \frac{3}{2} \end{cases}$



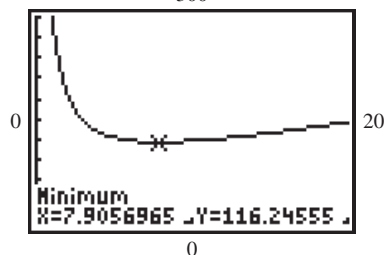
13. $P(x) = \begin{cases} x^3 - 8 & x \neq 2 \\ 12 & x = 2 \end{cases}$





53. a. $a = 5, y = 3a + 15$ b. 60.5 c. 10

55. a. $A(x) = \frac{4x^2 + 53x + 250}{x}; x = 0, y = 4x + 53$
 b. cost: \$307, \$372, \$445; Avg. cost: \$307, \$186, \$148.33
 c. 8, \$116.25
 d. 300



57. a. $S(x, y) = 2x^2 + 4xy; V(x, y) = x^2y$ b. $y = \frac{12}{x^2}; S(x) = \frac{2x^3 + 48}{x}$

c. $S(x)$ is asymptotic to $y = 2x^2$. d. $x \approx 2$ ft 3.5 in.; $y \approx 2$ ft 3.5 in.

59. a. $A(x, y) = xy; R(x, y) = (x - 2.5)(y - 2)$ b. $y = \frac{2x + 55}{x - 2.5}$

$A(x) = \frac{2x^2 + 55x}{x - 2.5}$ c. $A(x)$ is asymptotic to $y = 2x + 60$

d. $x \approx 11.16$ in.; $y \approx 8.93$ in. 61. a. $h = \frac{V}{\pi r^2}$ b. $S = 2\pi r^2 + \frac{2V}{r}$

c. $S = \frac{2\pi r^3 + 2V}{r}$ d. $r \approx 5.76$ cm, $h \approx 11.51$ cm; $S \approx 625.13$ cm²

63. Answers will vary. 65. $S = \frac{\pi r^3 + 2V}{r}; r \approx 3.1$ in., $h \approx 3$ in.

67. $y = \frac{3}{4}x - 4, m = \frac{3}{4}, (0, -4)$

69. a. $P = 30$ cm, b. $CD = \frac{60}{13}$ cm, c. 30 cm²,
 d. $A = \frac{750}{169}$ cm², and $A = \frac{4320}{169}$ cm²

Exercises 4.6, pp. 391–395

1. vertical, multiplicity 3. empty 5. Answers will vary.

7. $x \in (-3, 5)$ 9. $x \in [4, \infty) \cup \{-1\}$

11. $x \in (-\infty, -2] \cup \{2\} \cup [4, \infty)$ 13. $x \in (-2 - \sqrt{3}, -2 + \sqrt{3})$

15. $x \in (-\infty, -3] \cup \{1\}$ 17. $x \in (-3, 1) \cup (2, \infty)$

19. $x \in (-\infty, -3) \cup (-1, 1) \cup (3, \infty)$

21. $x \in (-\infty, -2) \cup (-2, 1) \cup (3, \infty)$ 23. $x \in [-1, 1] \cup \{3\}$

25. $x \in (-\infty, -2) \cup (2, 3)$ 27. $x \in (-\infty, -2] \cup (-1, 1) \cup [3, \infty)$

29. $x \in [-3, 2)$ 31. $x \in (-\infty, -2) \cup (-2, -1)$

33. $x \in (-\infty, -2) \cup [2, 3)$ 35. $x \in (-\infty, -5) \cup (0, 1) \cup (2, \infty)$

37. $x \in (-4, -2] \cup (1, 2] \cup (3, \infty)$ 39. $x \in (-7, -3) \cup (2, \infty)$

41. $x \in (-\infty, -2] \cup (0, 2)$ 43. $x \in (-\infty, -17) \cup (-2, 1) \cup (7, \infty)$

45. $x \in (-3, \frac{-7}{4}] \cup (2, \infty)$ 47. $x \in (-2, \infty)$ 49. $x \in (-1, \infty)$

51. $(-\infty, -3) \cup (3, \infty)$ 53. $x \in (-\infty, -3] \cup [5, \infty)$

55. $x \in [-3, 0] \cup [3, \infty)$ 57. d 59. b 61. a. verified

b. $D = -4(p + \frac{3}{4})(p + 3)^2; p = -3, q = -2; p = \frac{-3}{4}, q = \frac{1}{4}$

c. $(-\infty, -3) \cup (-3, \frac{-3}{4})$ d. verified

63. $d(x) = k(x^3 - 192x + 1024)$ a. $x \in (5, 8]$ b. $320k$ units

c. $x \in [0, 3)$ d. 2 ft 65. a. verified b. horizontal: $r_2 = 20$, as r_1

increases, r_2 decreases to maintain $R = 40$; vertical: $r_1 = 20$, as r_1

decreases, r_2 increases to maintain $R = 40$ c. $r_1 \in (20, 40)$

67. $R(t) = 0.01t^2 + 0.1t + 30$ a. $[0^\circ, 30^\circ)$ b. $(20^\circ, \infty)$

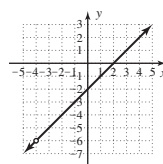
c. $(50^\circ, \infty)$ 69. a. $n \geq 4$ b. $n \leq 9$ c. 13

71. a. yes, $x^2 \geq 0$ b. yes, $\frac{x^2}{x^2 + 1} \geq 0$

73. $x(x + 2)(x - 1)^2 > 0; \frac{x(x + 2)}{(x - 1)^2} > 0$

75. $R(x) < 0$ for $x \in (2, 8) \cup (8, 14)$

77. $F(x) = \begin{cases} f(x) & x \neq -4 \\ -6 & x = -4 \end{cases}$ 79. $x \in [-3, 9]$



Making Connections, p. 396

1. e 3. b 5. a 7. h 9. d 11. a 13. g 15. c

Summary and Concept Review, pp. 396–400

1. $q(x) = x^2 + 6x + 7; r = 8$ 2. $q(x) = x + 1; r = 3x - 4$

3. $\frac{-7}{2} \mid \begin{array}{cccc} 2 & 13 & -6 & 9 & 14 \\ & -14 & 7 & -7 & -14 \\ \hline & 2 & -1 & 1 & 2 & 10 \end{array}$

Since $r = 0, -7$ is a root and $x + 7$ is a factor.

4. $x^3 - 4x + 5 = (x - 2)(x^2 + 2x) + 5$

5. $(x + 4)(x + 1)(x - 3)$ 6. $h(x) = (x - 1)(x - 4)(x^2 + 2x + 2)$

7. $\frac{1}{2}$ $\begin{array}{r} 4 \quad 8 \quad -3 \quad -1 \\ \underline{2 \quad 5 \quad 1} \\ 4 \quad 10 \quad 2 \quad \underline{0} \end{array}$

Since $r = 0, \frac{1}{2}$ is a root and $(x - \frac{1}{2})$ is a factor.

8. $3i$ $\begin{array}{r} 1 \quad \quad -2 \quad 9 \quad -18 \\ \quad \quad 3i \quad -9 - 6i \quad 18 \\ \underline{1 \quad -2 + 3i \quad -6i \quad \underline{0}} \end{array}$

Since $r = 0, 3i$ is a zero

9. -7 $\begin{array}{r} 1 \quad 9 \quad 13 \quad -10 \\ \quad -7 \quad -14 \quad 7 \\ \underline{1 \quad 2 \quad -1 \quad \underline{-3}} \end{array}$

$h(-7) = -3$

10. $P(x) = x^3 - x^2 - 5x + 5$ 11. $C(x) = x^4 - 2x^3 + 5x^2 - 8x + 4$

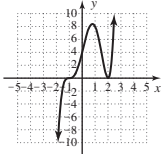
12. a. $C(0) = 350$ customers b. more at 2 P.M., 170

c. busier at 1 P.M., $760 > 710$ 13. $\{\pm 1, \pm 10, \pm 2, \pm 5, \pm \frac{1}{2}, \pm \frac{5}{2}, \pm \frac{1}{4}, \pm \frac{5}{4}\}$

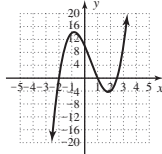
14. $x = -\frac{1}{2}, 2, \frac{5}{2}$ 15. $P(x) = (2x + 3)(x - 4)(x + 1)$ 16. only possibilities are $\pm 1, \pm 3$, none give a remainder of zero 17. $[1, 2], [4, 5]$; verified 18. one sign change for $g(x) \rightarrow 1$ positive zero; three sign changes for $g(-x) \rightarrow 3$ or 1 negative zeroes; 1 positive, 3 negative, 0 complex, or 1 positive, 1 negative, 2 complex; 1 positive, 1 negative, 2 complex, verified

19. degree 5; up/down; $(0, -4)$ 20. degree 4; up/up; $(0, 8)$

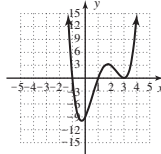
21.



22.



23.



24. a. even b. $x = -2$, odd; $x = -1$, even; $x = 1$, odd c. deg 6:

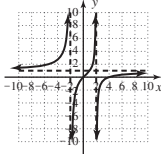
$P(x) = (x + 2)(x + 1)^2(x - 1)^3$

25. a. $\{x|x \in \mathbb{R}; x \neq -1, 4\}$ b. HA: $y = 1$; VA: $x = -1, x = 4$

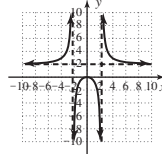
c. $V(0) = \frac{9}{4}$ (y-intercept); $x = -3, 3$ (x-intercepts) d. $V(1) = \frac{4}{3}$

26. No—even multiplicity; yes—odd multiplicity

27.



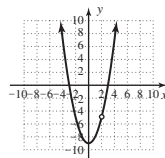
28.



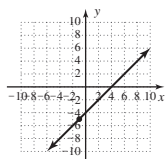
29. $V(x) = \frac{x^2 - x - 12}{x^2 - x - 6}$; $V(0) = 2$

30. a. $y = 15$; as $|x| \rightarrow \infty A(x) \rightarrow 15^+$. As production increases, average cost decreases and approaches 15. b. $x > 2000$

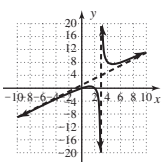
31. removable discontinuity at $(2, -5)$;



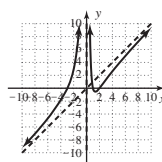
32. $H(x) = \begin{cases} \frac{x^2 - 3x - 4}{x + 1} & x \neq -1 \\ -5 & x = -1 \end{cases}$



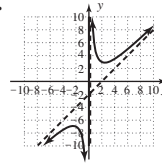
33.



34.

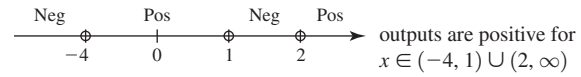


35. a.

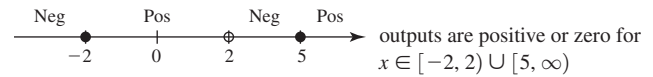


b. about 2450 favors c. about \$2.90 ea.

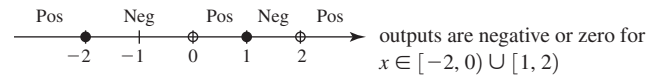
36. factored form $(x + 4)(x - 1)(x - 2) > 0$



37. $\frac{x^2 - 3x - 10}{x - 2} = \frac{(x - 5)(x + 2)}{x - 2} \geq 0$

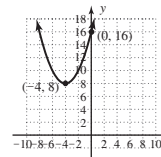
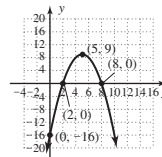


38. $\frac{(x + 2)(x - 1)}{x(x - 2)} \leq 0$



Practice Test, pp. 400–401

1. a. $f(x) = -(x - 5)^2 + 9$ b. $g(x) = \frac{1}{2}(x + 4)^2 + 8$



2. $(-2, 0), y = 2x^2 + 4x$ 3. a. 40 ft, 48 ft b. 49 ft c. 14 sec

4. $x - 5 + \frac{14x + 3}{x^2 + 2x + 1}$ 5. $x^2 + 2x - 9 + \frac{-2}{x + 2}$

6. $\frac{-3}{1} \frac{1}{-3} \frac{0}{-6} \frac{-15}{8} \frac{-10}{10} \frac{24}{10} \frac{-24}{10} \frac{r = 0 \checkmark}{10}$

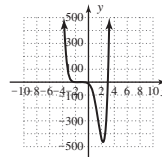
7. -1 8. $P(x) = x^3 - 2x^2 + 9x - 18$

9. $Q(x) = (x - 2)^2(x - 1)^2(x + 1)$, 2 mult 2, 1 mult 2, -1 mult 1

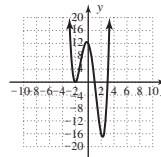
10. a. $\pm 1, \pm 18, \pm 2, \pm 9, \pm 3, \pm 6$ b. 1 positive zero, 3 or 1 negative zeroes; 2 or 0 complex zeroes c. $C(x) = (x + 2)(x - 1)(x - 3i)(x + 3i)$

11. a. 2002, 2004, 2008 b. 4 yr c. deficit of \$7.5 million

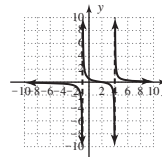
12.



13.

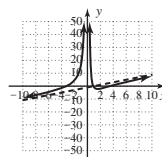


14.

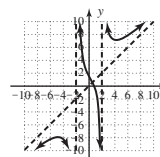


15. a. removal of 100% of the contaminants b. \$500,000; \$3,000,000; dramatic increase c. 88%

16. a.

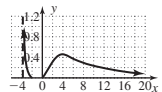


b.



17. 800 18. a. $x \in (-\infty, -3] \cup [-1, 4]$ b. $x \in (-\infty, -4) \cup (0, 2)$

19. a.



b. $h = -\sqrt[3]{55}$; no c. 28.6%, 29.6% d. ≈ 11.7 hr e. 4 hr, 43.7%

f. The amount of the chemical in the bloodstream becomes negligible.

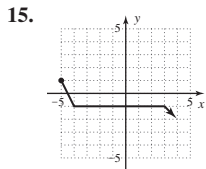
20. $V(x) = \frac{x^2 + x - 6}{x^2 - 2x - 3}$; $V(0) = 2$

Strengthening Core Skills, pp. 402–403

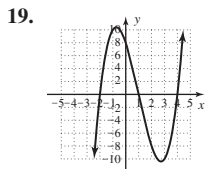
- Exercise 1. $x \in (-\infty, 3]$ Exercise 2. $x \in (-2, -1) \cup (2, \infty)$
 Exercise 3. $x \in (-\infty, -4) \cup (1, 3)$ Exercise 4. $x \in [-2, \infty)$
 Exercise 5. $x \in (-\infty, -2) \cup (2, \infty)$ Exercise 6. $x \in [-3, 1] \cup [3, \infty)$

Cumulative Review Chapters 1–4, pp. 403–404

1. $R = \frac{R_1 R_2}{R_1 + R_2}$ 3. a. $(x - 1)(x^2 + x + 1)$ b. $(x - 3)(x + 2)(x - 2)$
 5. all reals 7. verified 9. $y = \frac{11}{60}x + \frac{1009}{60}$; 39 min, driving time
 increases 11 min every 60 days 11. month 9 13. $f^{-1}(x) = \frac{x^3 + 3}{2}$



17. $X = 63$

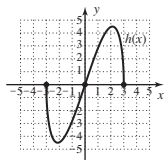
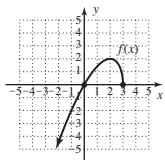


21. 87.91, -80.09, 1.99

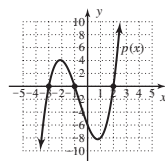
23. a. $-349.36 - 131.38i$ b. $-\frac{2}{41} - \frac{59}{41}i$ c. $27.63 + 14.59i$
 d. $0 - i$ 25. a. Y_6 b. Y_7 c. Y_4 d. Y_3 e. Y_5 f. Y_2

Connections to Calculus Exercises, pp. 407–408

1. $x \in (-\infty, 3]$, as $x \rightarrow -\infty, y \rightarrow -\infty$; $(0, 0)$, $(0, 0)$, $(3, 0)$
 3. $x \in [-3, 3]$, as $x \rightarrow -3, y \rightarrow 0$, as $x \rightarrow 3, y \rightarrow 0$; $(0, 0)$, $(-3, 0)$, $(0, 0)$, $(3, 0)$



5. $x \in (-\infty, \infty)$, down/up;
 $(0, -6)$; $(-3, 0)$, $(-1, 0)$, $(2, 0)$



7. $\max f(x) = 2$ at $x = 2$ 9. $\max h(x) = 4.5$ at $x = 1.5\sqrt{2}$; $\min h(x) = -4.5$
 at $x = -1.5\sqrt{2}$ 11. $\left(\frac{-2 - \sqrt{19}}{3}, p\left(\frac{-2 - \sqrt{19}}{3}\right)\right)$ or about $(-2.11, 4.06)$. The skater has a maximum anxiety level of near 4,
 about 2 min before starting his routine; $\left(\frac{-2 + \sqrt{19}}{3}, p\left(\frac{-2 + \sqrt{19}}{3}\right)\right)$ or
 about $(0.79, -8.21)$. The skater has a minimum anxiety level of near -8,
 shortly after starting his routine.

CHAPTER 5

Exercises 5.1, pp. 418–421

1. second, one 3. $(-11, -2)$, $(-5, 0)$, $(1, 2)$, $(19, 4)$
 5. False, answers will vary. 7. one-to-one 9. one-to-one
 11. not one-to-one, fails horizontal line test: $x = -3$, $x = -0.5$ and $x = 2$
 are paired with $y = 0$ 13. not a function 15. one-to-one 17. not one-
 to-one, $y = 1$ is paired with $x = -6$ and $x = 8$ 19. one-to-one

21. not one-to-one; $h(x) < 3$, corresponds to two x -values
 23. one-to-one 25. not one-to-one; $y = 3$ corresponds to more
 than one x -value 27. $f^{-1}(x) = \{(1, -2), (4, -1), (5, 0), (9, 2), (15, 5)\}$
 29. $v^{-1}(x) = \{(3, -4), (2, -3), (1, 0), (0, 5), (-1, 12), (-2, 21), (-3, 32)\}$

31. $f^{-1}(x) = x - 5$ 33. $p^{-1}(x) = \frac{-5}{4}x$ 35. $f^{-1}(x) = \frac{x - 3}{4}$

37. $t^{-1}x = x^3 + 4$
 39. $x \in \mathbb{R}, y \in \mathbb{R}; f^{-1}(x) = x^3 + 2, x \in \mathbb{R}, y \in \mathbb{R}$; verified

41. $x \in \mathbb{R}, y \in \mathbb{R}; f^{-1}(x) = \sqrt[3]{x - 1}, x \in \mathbb{R}, y \in \mathbb{R}$; verified

43. $x \neq -2, y \neq 0; f^{-1}(x) = \frac{8}{x} - 2, x \neq 0, y \neq -2$; verified

45. $x \neq -1, y \neq 1; f^{-1}(x) = \frac{x}{1 - x}, x \neq 1, y \neq -1$; verified

47. a. $x \geq -5, y \geq 0$ b. $f^{-1}(x) = \sqrt{x} - 5, x \geq 0, y \geq -5$

49. a. $x > 3, y > 0$ b. $v^{-1}(x) = \sqrt{\frac{8}{x}} + 3, x > 0, y > 3$

51. a. $x \geq -4, y \geq -2$ b. $p^{-1}(x) = \sqrt{x + 2} - 4, x \geq -2, y \geq -4$

53. $(f \circ g)(x) = x, (g \circ f)(x) = x$ 55. $(f \circ g)(x) = x, (g \circ f)(x) = x$

57. $(f \circ g)(x) = x, (g \circ f)(x) = x$ 59. $(f \circ g)(x) = x, (g \circ f)(x) = x$

61. $f^{-1}(x) = \frac{x + 5}{3}$ 63. $f^{-1}(x) = 2x + 5$ 65. $f^{-1}(x) = 2x + 6$

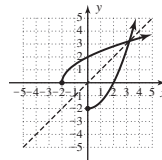
67. $f^{-1}(x) = \sqrt[3]{x - 3}$ 69. $f^{-1}(x) = \frac{x^3 - 1}{2}$ 71. $f^{-1}(x) = 2\sqrt[3]{x} + 1$

73. $D: x \geq -\frac{2}{3}, R: y \geq 0; f^{-1}(x) = \frac{x^2 - 2}{3}, D: x \geq 0, R: y \geq -\frac{2}{3}$

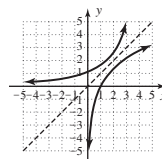
75. $D: x \geq 3, R: y \geq 0; p^{-1}(x) = \frac{x^2}{4} + 3, D: x \geq 0, R: y \geq 3$

77. $D: x \geq 0, R: y \geq 3; v^{-1}(x) = \sqrt{x - 3}, D: x \geq 3, R: y \geq 0$

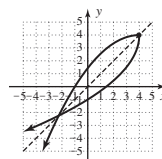
79. $D: x \in [0, \infty), R: y \in [-2, \infty);$
 $D: x \in [-2, \infty), R: y \in [0, \infty)$



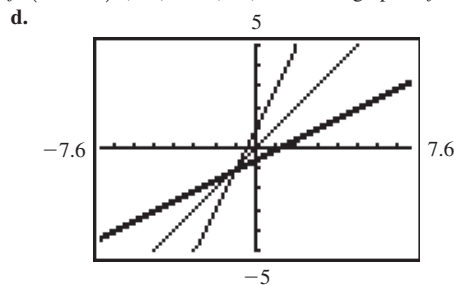
81. $D: x \in (0, \infty), R: y \in (-\infty, \infty);$
 $D: x \in (-\infty, \infty), R: y \in (0, \infty)$



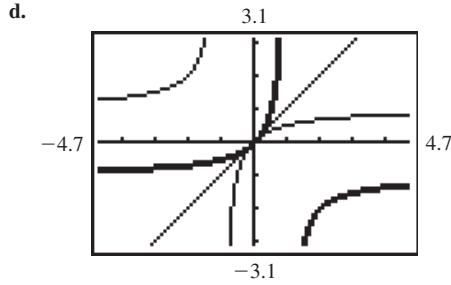
83. $D: x \in (-\infty, 4], R: y \in (-\infty, 4];$
 $D: x \in (-\infty, 4], R: y \in (-\infty, 4]$



85. a. $f^{-1}(x) = \frac{x - 1}{2}$ b. $(-3, -5)$, $(0, 1)$, and $(1, 3)$ are on the graph of f ;
 $(-5, -3)$, $(1, 0)$, and $(3, 1)$ are on the graph of f^{-1} c. verified



87. a. $h^{-1}(x) = \frac{x}{1 - x}$ b. $(0, 0)$, $(1, \frac{1}{2})$, and $(2, \frac{2}{3})$ are on the graph of h ;
 $(0, 0)$, $(\frac{1}{2}, 1)$, and $(\frac{2}{3}, 2)$ are on the graph of h^{-1} c. verified



89. a. 31.5 cm b. The result is 80 cm. It gives the distance of the projector from the screen. 91. a. -63.5°F b. $f^{-1}(x) = \frac{-2}{7}(x - 59)$; independent: temperature, dependent: altitude c. 22,000 ft

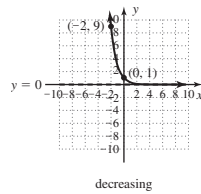
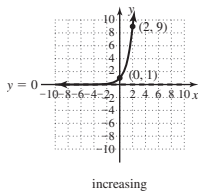
93. a. 144 ft b. $f^{-1}(x) = \frac{\sqrt{x}}{4}$, independent: distance fallen, dependent: time fallen c. 7 sec

95. a. 28,260 ft³ b. $f^{-1}(x) = \sqrt[3]{\frac{3x}{\pi}}$, independent: volume, dependent: height c. 9 ft 97. Answers will vary.

99. a. $P = 2l + 2w$ b. $A = \pi r^2$ c. $V = \pi r^2 h$ d. $V = \frac{1}{3}\pi r^2 h$
 e. $C = 2\pi r$ f. $A = \frac{1}{2}bh$ g. $A = \frac{1}{2}(b_1 + b_2)h$ h. $V = \frac{4}{3}\pi r^3$
 i. $a^2 + b^2 = c^2$ 101. ≈ 0.472 , ≈ 0.365 ; rate of change is greater in [1, 2] due to shape of the graph.

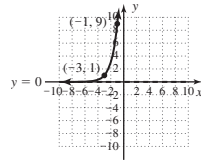
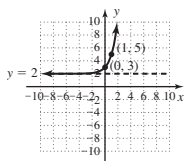
Exercises 5.2, pp. 429–433

1. b^x , b , b , x 3. a , 1 5. False; for $|b| < 1$ and $x_2 > x_1$, $b^{x_2} < b^{x_1}$, so function is decreasing 7. 16, 2, 8, 11.036 9. $1, \frac{1}{64}, \frac{1}{4}, 64$
 11. 13.



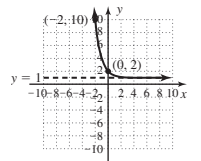
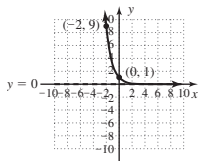
15. $y = 3^x$; up 2

17. $y = 3^x$; left 3



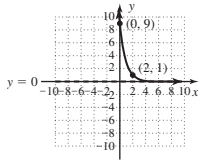
19. $y = 3^x$; reflect across y-axis

21. $y = (\frac{1}{3})^x$; up 1

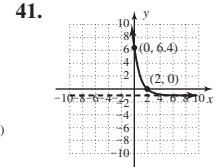
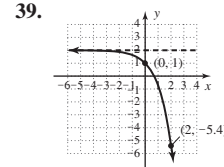
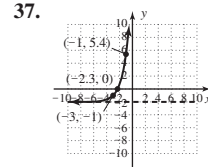


23. $y = (\frac{1}{3})^x$; right 2

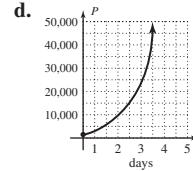
25. e 27. a 29. b



31. 2.718282 33. 7.389056 35. 4.113250



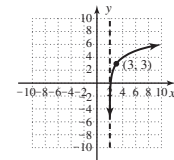
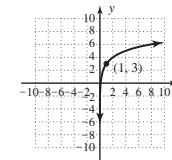
43. 3 45. $\frac{3}{2}$ 47. $-\frac{1}{3}$ 49. 4 51. -3 53. 3 55. 2 57. -2
 59. 2 61. 3 63. $x \approx 2.8$ 65. $x \approx 3.2$
 67. a. 1732, 3000, 5196, 9000 b. yes c. as $t \rightarrow \infty$, $P \rightarrow \infty$



69. a. \$100,000 b. 3 yr 71. a. \approx \$86,806 b. 3 yr
 73. a. \$40 million b. 7 yr 75. no, they will have to wait about 5 min
 77. 32% transparent 79. 17% transparent 81. \approx \$25,526
 83. a. 8 g b. 48 min 85. $\frac{1}{5}$ 87. 75 89. 9.5×10^{-7} ; answers will vary
 91. $5; \frac{-7}{9}; 2a^2 - 3a; 2a^2 + 4ah + 2h^2 - 3a - 3h$
 93. a. no solution b. $\{-5, 6\}$

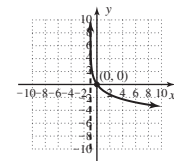
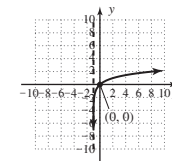
Exercises 5.3, pp. 442–446

1. $\log_b x$, b , b , greater 3. (1, 0), 0 5. 5; answers will vary 7. $2^3 = 8$
 9. $7^{-1} = \frac{1}{7}$ 11. $9^0 = 1$ 13. $8^{\frac{1}{3}} = 2$ 15. $2^1 = 2$ 17. $7^2 = 49$
 19. $10^2 = 100$ 21. $e^4 \approx 54.598$ 23. $\log_4 64 = 3$ 25. $\log_3 \frac{1}{9} = -2$
 27. $0 = \ln 1$ 29. $\log_3 27 = -3$ 31. $\log 1000 = 3$ 33. $\log_{100} \frac{1}{10} = -2$
 35. $\log_4 8 = \frac{3}{2}$ 37. $\log_{\frac{1}{4}} 8 = \frac{-3}{2}$ 39. 1 41. 2 43. 1 45. $\frac{1}{2}$ 47. -2
 49. -2 51. 1.6990 53. 0.4700 55. 5.4161 57. 0.7841
 59. shift up 3 61. shift right 2, up 3

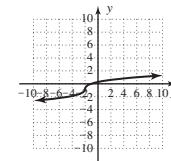


63. shift left 1

65. shift left 1, reflect across x-axis



67. II 69. VI 71. V 73. $x \in (-\infty, -1) \cup (3, \infty)$
 75. $x \in (\frac{3}{5}, \infty)$ 77. $x \in (-3, 3)$ 79. pH \approx 4.1; acid
 81. a. \approx 4.7 b. \approx 7.9 83. about 398 times 85. about 3.2 times
 87. a. \approx 2.4 b. \approx 1.2 89. a. 20 dB b. 120 dB
 91. about 501 times 93. about 3162 times 95. 6194 m
 97. a. about 5434 m b. 4000 m 99. a. 2225 items b. 2732 items
 c. \$117,000 101. a. about 58.6 cfm b. about 1605 ft²
 103. a. 95% b. 67% c. 39% 105. \approx 4.3; acid 107. Answers will vary.
 a. 0 dB b. 90 dB c. 15 dB d. 120 dB e. 100 f. 140 dB
 109. a. $\frac{-2}{3}$ b. $\frac{-3}{2}$ c. $\frac{-5}{2}$
 111. D: $x \in \mathbb{R}$, R: $y \in \mathbb{R}$



113. $x \in (-\infty, -5); f(x) = (x + 5)(x - 4)^2 = x^3 - 3x^2 - 24x + 80$

Exercises 5.4, pp. 453–456

1. e 3. extraneous 5. Answers will vary; Yes, $1.5663025 = 1.5663025$
 7. $x \approx 29.964$ 9. $x \approx 1.778$ 11. $x \approx 2.200$ 13. $x \approx 1.260$
 15. $x = \ln \frac{65}{4} + 2, x \approx 4.7881$ 17. $x = \log(78) - 5, x \approx -3.1079$
 19. $x = -\frac{\ln 2.32}{0.75}, x \approx -1.1221$ 21. $x = e^{\frac{3}{8}} - 4, x \approx 10.3919$
 23. $x = 5 - 10^{1.25}, x \approx -12.7828$ 25. $x = \frac{e^{0.4} - 5}{2}, x \approx -1.7541$
 27. $\ln(2x^2 - 14x)$ 29. $\log(x^2 - 1)$ 31. $\log_3 4$ 33. $\log\left(\frac{x}{x+1}\right)$
 35. $\ln\left(\frac{x-5}{x}\right)$ 37. $\ln(x-2)$ 39. $\log_2 42$ 41. $\log_5(x-2)$
 43. $(x+2) \log 8$ 45. $(2x-1) \ln 5$ 47. $\frac{1}{2} \log 22$ 49. $4 \log_5 3$
 51. $3 \log a + \log b$ 53. $\ln x + \frac{1}{4} \ln y$ 55. $2 \ln x - \ln y$
 57. $\frac{1}{2}[\log(x-2) - \log x]$ 59. $\frac{\ln 60}{\ln 7}; 2.104076884$
 61. $\frac{\ln 152}{\ln 5}; 3.121512475$ 63. $\frac{\log 1.73205}{\log 3}; 0.499999576$
 65. $\frac{\log 0.125}{\log 0.5}; 3$
 67. $f(x) = \frac{\log(x)}{\log(3)}$; $f(5) \approx 1.4650$; $f(15) \approx 2.4650$; $f(45) \approx 3.4650$;
 outputs increase by 1; $f(3^3 \cdot 5) \approx 4.4650$
 69. $h(x) = \frac{\log(x)}{\log(9)}$; $h(2) \approx 0.3155$; $h(4) \approx 0.6309$; $h(8) \approx 0.9464$;
 outputs are multiples of 0.3155; $h(2^4) \approx 4(0.3155) \approx 1.2619$
 71. verified 73. a. $N = AX^{-m}$ b. ≈ 3500 people 75. no, $\text{pH} \approx 7.32$
 77. no, $\text{pH} \approx 5.9$ and the soil must be treated further 79. 600^{601}
 81. zeroes at $x = 3$ and $x = -2$; HA: $y = 1$, VA $x = -1, x = 1$
 83. $x = 1$ or $x = -9$

Mid-Chapter Check, p. 456

1. a. $\frac{2}{3} = \log_{27} 9$ b. $\frac{5}{4} = \log_{81} 243$ 2. a. $8^{\frac{3}{5}} = 32$ b. $1296^{0.25} = 6$
 3. a. $x = 5$ b. $b = \frac{5}{4}$ 4. a. $x = 3$ b. $b = 5$ 5. a. \$71,191.41
 b. 6 yr 6. $F(x) = 4 \cdot 5^{x-3} + 2$ 7. $f^{-1}(x) = (x-1)^2 + 3$,
 $D: x \in [1, \infty)$; $R: y \in [3, \infty)$; verified 8. a. $4 = \log_3 81$, verified
 b. $4 \approx \ln 54.598$, verified 9. a. $27^{\frac{3}{8}} = 9$, verified
 b. $e^{1.4} \approx 4.0552$, verified 10. ≈ 7.9 times more intense

Reinforcing Basic Concepts, p. 457

- Exercise 1. Answers will vary. Exercise 2. a. $\log(x^2 + 3x)$
 b. $\ln(x^2 - 4)$ c. $\log_{\frac{x}{x+3}}$

Exercises 5.5, pp. 465–468

1. variable, constant 3. uniqueness, one, one 5. False; answers will vary.
 7. $x = 32$ 9. $x = 6.4$ 11. $x = 20, -5$ is extraneous
 13. $x = 2, -\frac{5}{2}$ is extraneous 15. $x = 0$ 17. $x = \frac{5}{2}$ 19. $x = \frac{2}{3}$
 21. $x = \frac{3}{2}$ 23. $x = \frac{-19}{9}$ 25. $x = \frac{e^2 - 63}{9}$; $x \approx -6.1790$
 27. $x = 2; -9$ is extraneous 29. $x = 3e^3 - \frac{1}{2}$; $x \approx 59.7566$
 31. no solution 33. $x = 2 + \sqrt{3}; 2 - \sqrt{3}$ is extraneous
 35. $x = \frac{\ln 231}{\ln 7}$; $x \approx 2.7968$ 37. $x = \frac{\ln 128,967}{3 \ln 5}$; $x \approx 2.4371$
 39. $x = \frac{\ln 2}{\ln 3 - \ln 2}$; $x \approx 1.7095$ 41. $x \approx -4.815, x \approx 102.084$
 43. $x \approx 2.013, x \approx 3.608$ 45. $x \approx 46.210$
 47. $t = \frac{\ln\left(\frac{C}{a} - 1\right)}{-k}$, $t \approx 55.45$ 49. about 3.2 cmHg
 51. a. 30 fish b. about 37 months 53. about 50.2 min

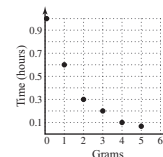
55. \$15,641 57. a. 6 hr b. 18.0% 59. $M_f = 52.76$ tons
 61. a. 26 planes b. 9 days 63. $x = 1.609438$
 65. a. $y = 2^{x+1}$ b. $y = 2 \ln(x-3)$
 $x = 2^{y+1}$ $x = 2 \ln(y-3)$
 $\ln x = (y+1) \ln 2$ $\frac{x}{2} = \ln(y-3)$
 $\frac{\ln x}{\ln 2} = y+1$ $e^{\frac{x}{2}} = y-3$
 $\frac{\ln x}{\ln 2} - 1 = y$ $y = e^{\frac{x}{2}} + 3$
 67. a. $y = e^{x \ln 2} = e^{\ln 2^x} = 2^x$;
 $y = 2^x \Rightarrow \ln y = x \ln 2, e^{\ln y} = e^{x \ln 2} \Rightarrow y = e^{x \ln 2}$
 b. $y = b^x, \ln y = x \ln b, e^{\ln y} = e^{x \ln b}, y = e^{x \ln b}$ for $r = \ln b$
 69. a. d b. e c. b d. f e. a f. c
 71. a. $x \in [-\frac{3}{2}, \infty)$, $y \in [0, \infty)$ b. $x \in (-\infty, \infty)$, $y \in [-3, \infty)$
 73. 13.5 tons

Exercises 5.6, pp. 477–482

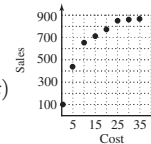
1. Compound 3. $Q_0 e^{-rt}$ 5. Answers will vary. 7. \$4896
 9. 250% 11. \$2152.47 13. 5.25 yr 15. 80% 17. 4 yr 19. 16 yr
 21. \$7561.33 23. about 5 yr 25. 7.5 yr 27. no 29. a. no
 b. 9.12% 31. 7.9 yr 33. 7.5 yr 35. a. no b. 9.4%
 37. a. no b. approx 13,609 euros 39. No; \$234,612.02
 41. about 7 yr 43. 22 yr 45. a. no b. \$298.31
 47. a. $t = \frac{A-p}{pr}$ b. $p = \frac{A}{1+rt}$ 49. a. $r = n\left(\sqrt[n]{\frac{A}{p}} - 1\right)$
 $\ln\left(\frac{A}{p}\right)$
 b. $t = \frac{\ln\left(\frac{A}{p}\right)}{n \ln\left(1 + \frac{r}{n}\right)}$ 51. a. $Q_0 = \frac{Q(t)}{e^{rt}}$ b. $t = \frac{\ln\left(\frac{Q(t)}{Q_0}\right)}{r}$
 53. \$709.74 55. a. 5.78% b. 91.67 hr 57. 0.65 g 59. about 816 yr
 61. about 12.4% 63. \$17,027,502.21 65. 7.2%
 67. a. $f(x) = x^3, f(x) = x, f(x) = \sqrt{x}, f(x) = \sqrt[3]{x}, f(x) = \frac{1}{x}$
 b. $f(x) = |x|, f(x) = x^2, f(x) = \frac{1}{x^2}$ c. $f(x) = x, f(x) = x^3, f(x) = \sqrt{x}$,
 $f(x) = \sqrt[3]{x}$ d. $f(x) = \frac{1}{x}, f(x) = \frac{1}{x^2}$
 69. $P(x) = x^4 - 4x^3 + 6x^2 - 4x - 15$

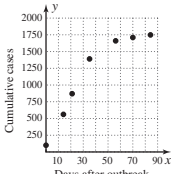
Exercises 5.7, pp. 487–495

1. scatterplot, context, situation 3. beyond 5. (1) clear out old data,
 (2) enter new data, (3) display the data, (4) calculate the regression
 equation, (5) display and use the results; Answers will vary.
 7. e 9. a 11. d 13. linear 15. exponential
 17. logistic 19. exponential
 21. As time increases, the amount of radioactive
 material decreases but will never truly reach 0 or
 become negative. Exponential with $b < 1$ and $k > 0$
 is the best choice. $y \approx (1.042)0.5626^x$

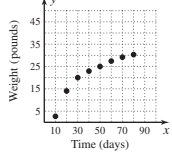


23. Sales will increase rapidly, then level off
 as the market is saturated with ads and advertising
 becomes less effective, possibly modeled by a
 logarithmic function. $y \approx 120.4938 + 217.2705 \ln(x)$

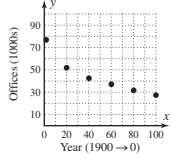


25. a.  logistic
 b. about 1750 c. $y \approx \frac{1719}{1 + 10.2e^{-0.11x}}$
 27. 4.95 29. 6.25 31. 5.75 33. 6.84
 35. a. about 19 boards b. about 15 days

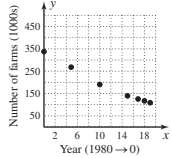
37. logarithmic, $y \approx -27.4 + 13.5 \ln x$
 a. 9.2 lb b. 29 days c. 34.8 lb



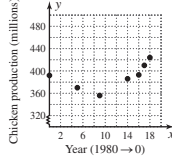
39. logarithmic, $y \approx 78.8 - 10.3 \ln x$
 a. 51,000 b. 1977 c. 29,900



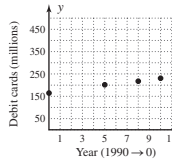
41. exponential, $y \approx 346.79(0.94)^x$
 a. 155,100 b. 54,200 c. 2013



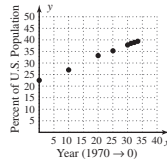
43. quadratic, $y \approx 0.576x^2 - 8.879x + 394$
 a. 360 million b. about 513 million
 c. from 1984 to 1990



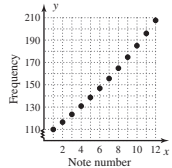
45. linear, $y \approx 6.555x + 165.308$
 a. 224.3 million b. 329.2 million c. 2010



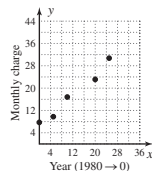
47. linear, $P(t) \approx 0.51t + 22.51$,
 2005: 40.4%, 2010: 43.0%, 2015: 45.5%



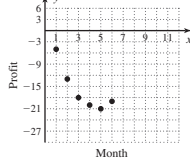
49. exponential, $y \approx 103.83(1.0595)^x$
 a. 220 b. The 22nd note, or F#
 c. frequency doubles, yes



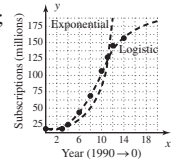
51. exponential, $y \approx 8.02(1.0564)^x$
 \$41.59/mo, \$54.72/mo



53. quadratic, $y \approx 1.18x^2 - 10.99x + 4.60$;
 month 8

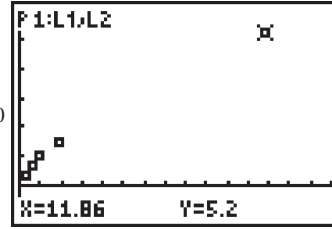


55. logistic, $y \approx \frac{222.133}{1 + 32.280e^{-0.336x}}$

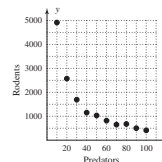


about 55 million, about 184 million, about 214 million; 2014

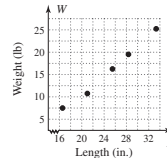
57. 7.5 power regression,
 a. $y \approx x^{0.665}$, 9.5 AU;
 b. 84.8 yr



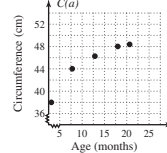
59. a. power regression, $y \approx 58,555.89x^{-1.056}$;
 b. about 295 rodents c. about 17 predators



61. a. linear, $W \approx 1.24L - 15.83$, 32.5 lb, 35.3 in.



61. b. logarithmic, $C(a) \approx 37.9694 + 3.4229 \ln(a)$,
 about 49.3 cm, about 34 mo



63. $D: x \in (-\infty, -2) \cup (-2, 1) \cup (1, 5) \cup (5, \infty), \frac{1}{x+2}$

65. max: $(-0.4, 1.8)$

- min: $(-3.5, -3.5), (2.3, -1.4)$

- $f(x) \uparrow: x \in (-3.5, -0.4) \cup (2.3, \infty)$

- $f(x) \downarrow: x \in (-\infty, -3.5) \cup (-0.4, 2.3)$

Making Connections, p. 495

1. a 3. e 5. c 7. e 9. b 11. g 13. c 15. d

Summary and Concept Review, pp. 496–500

1. no 2. no 3. yes 4. $f^{-1}(x) = \frac{x-2}{-3}$ 5. $f^{-1}(x) = \sqrt{x+2}$

6. $f^{-1}(x) = x^2 + 1; x \geq 0$

7. $f(x): D: x \in [-4, \infty), R: y \in [0, \infty); f^{-1}(x): D: x \in [0, \infty),$

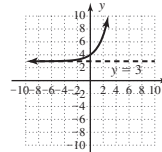
- $R: y \in [-4, \infty)$ 8. $f(x): D: x \in (-\infty, \infty), R: y \in (-\infty, \infty);$

- $f^{-1}(x): D: (-\infty, \infty), R: y \in (-\infty, \infty)$ 9. $f(x): D: x \in (-\infty, \infty),$

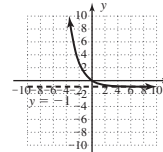
- $R: y \in (0, \infty); f^{-1}(x): D: x \in (0, \infty), R: y \in (-\infty, \infty)$

10. a. \$3.05 b. $f^{-1}(t) = \frac{t-2}{0.15}, f^{-1}(3.05) = 7$ c. 12 days

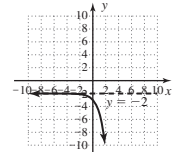
- 11.



- 12.



- 13.

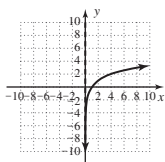


14. 2 15. -2 16. $\frac{5}{2}$ 17. 12.1 yr 18. $3^2 = 9$ 19. $5^{-3} = \frac{1}{125}$

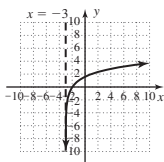
20. $e^{3.7612} \approx 43$ 21. $\log_5 25 = 2$ 22. $\ln 0.7788 \approx -0.25$

23. $\log_3 81 = 4$ 24. 5 25. -1 26. $\frac{1}{2}$

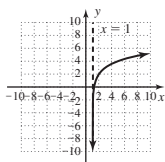
27.



28.



29.



30. $x \in (-\frac{3}{2}, \infty)$ 31. $x \in (-\infty, 0) \cup (6, \infty)$ 32. a. 4.79 b. $10^{7.3}I_0$

33. a. $x = e^{32}$ b. $x = 10^{2.38}$ c. $x = \ln 9.8$ d. $x = \frac{1}{2} \log 7$

34. a. $x = \frac{\ln 4}{0.5}, x \approx 2.7726$ b. $x = \frac{\log 19}{0.2}, x \approx 6.3938$

c. $x = \frac{10^3}{3}, x \approx 333.3333$ d. $x = e^{-2.75}, x \approx 0.0639$

35. a. $\ln 42$ b. $\log_9 30$ c. $\ln(\frac{x+3}{x-1})$ d. $\log(x^2 + x)$

36. a. $2 \log_5 9$ b. $2 \log_7 4$ c. $(2x - 1) \ln 5$ d. $(3x + 2) \ln 10$

37. a. $\ln x + \frac{1}{4} \ln y$ b. $\frac{1}{3} \ln p + \ln q$

c. $\frac{5}{3} \log x + \frac{4}{3} \log y - \frac{5}{2} \log x - \frac{3}{2} \log y$

d. $\log 4 + \frac{5}{3} \log p + \frac{4}{3} \log q - \frac{3}{2} \log p - \log q$

38. a. $\frac{\log 45}{\log 6} \approx 2.215$ b. $\frac{\log 128}{\log 3} \approx 4.417$ c. $\frac{\ln 124}{\ln 2} \approx 6.954$

d. $\frac{\ln 0.42}{\ln 5} \approx -0.539$ 39. $x = \frac{\ln 7}{\ln 2}, x \approx 2.8074$

40. $x = \frac{\ln 5}{\ln 3} - 1, 0 \approx x = .4650$ 41. $\frac{2}{1 + \ln 3}, x \approx 0.9530$

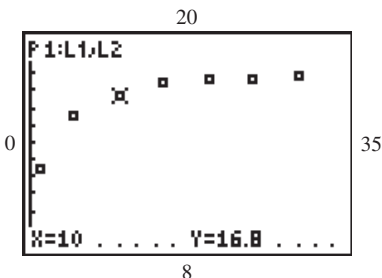
42. $x = e^2 - 1, x \approx 6.3891$ 43. $x = 5; -2$ is extraneous

44. $x = 4.25$ 45. a. 17.77% b. 23.98 days 46. 38.6 cmHg

47. 18.5% 48. Almost, she needs \$42.15 more. 49. a. no b. \$268.93

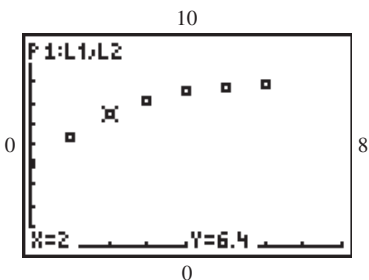
50. 55.0%

51.



a. logarithmic, $y \approx 12.772 + 1.595 \ln x$ b. 16.9 mi/gal
c. the year 2011

52.



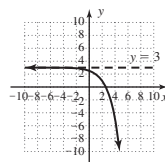
a. logistic, $g(t) = \frac{8.0}{1 + 1.0e^{-0.7t}}$ b. ≈ 6.8 microns
c. $(4 \times 1.96) = 7.84; 5.56$ hr (about 5 hr 34 min)

Practice Test, p. 501

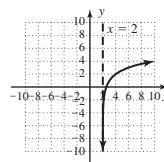
1. $3^4 = 81$ 2. $\log_{25} 5 = \frac{1}{2}$ 3. $\frac{5}{2} \log_b x + 3 \log_b y - \log_b z$

4. $\log_b \frac{m\sqrt{n^3}}{\sqrt{p}}$ 5. $x = 10$ 6. $x = \frac{-5}{3}$ 7. 2.68 8. -1.24

9.



10.



11. a. 4.19 b. -0.81 12. f is a parabola (hence not one-to-one), $x \in \mathbb{R}, y \in [-3, \infty)$; vertex is at $(2, -3)$, so restricted domain could be $x \in [2, \infty)$ to create a one-to-one function;

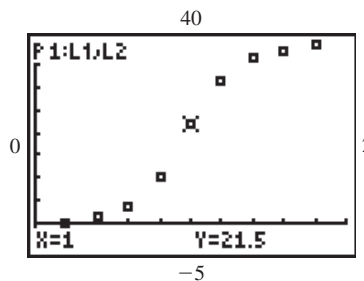
$f^{-1}(x) = \sqrt{x+3} + 2, x \in [-3, \infty), y \in [2, \infty)$.

13. $x = 1 + \frac{\ln 89}{\ln 3}, x \approx 5.0857$ 14. $x = 1, x = -5$ is extraneous

15. ≈ 5 yr 16. a. $P = kM^a$ b. $P \approx 15.3$ lb ($M = 20$)

17. 19.1 months 18. a. no b. \$54.09 19. a. 10.2 lb b. 34 weeks

20. logistic; $y = \frac{39.1156}{1 + 314.6617e^{-5.9483x}}$; 0.89 sec



Strengthening Core Skills, p. 503

Exercise 1. about 126 times hotter Exercise 2. about 4.2 hb

Cumulative Review Chapters 1–5, p. 504

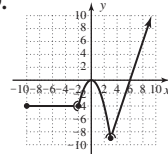
1. $x = 2 \pm 7i$ 3. $(4 + 5i)^2 - 8(4 + 5i) + 41 = 0$
 $-9 + 40i - 32 - 40i + 41 = 0 \Rightarrow 0 = 0 \checkmark$

5. $f(g(x)) = x; g(f(x)) = x$; Since $(f \circ g)(x) = (g \circ f)(x)$, they are inverse functions. 7. a. $T(t) = 455t + 2645$ (1991 \rightarrow year 1)

b. $\frac{\Delta T}{\Delta t} = \frac{455}{1}$, triple births increase by 455 each year

c. $T(6) = 5375$ sets of triplets, $T(17) = 10,380$ sets of triplets

9. $D: x \in [-10, \infty), R: y \in [-9, \infty)$
 $h(x) \uparrow: x \in (-2, 0) \cup (3, \infty) h(x) \downarrow: x \in (0, 3)$



11. $x = 3, x = 2$ (multiplicity 2); $x = -4$ 13. $\sqrt{\frac{2V}{\pi a}} = b$

15. a. $f^{-1}(x) = \frac{5x - 3}{2}$ b.  c. $f^{-1}(f(x)) = x$

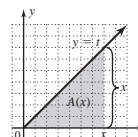
17. $x = 5, x = -6$ is an extraneous root 19. a. about 88 hp for sport wagon, about 81 hp for minivan b. ≈ 3294 rpm c. minivan, 208 hp at 5800 rpm 21. $x \approx 5.064$ 23. $x \approx 0.649, x \approx -4.967$

25. $x \approx 2.013, x \approx 3.608$

Connections to Calculus Exercises, p. 507

1. $5x + \frac{3}{2} \ln x$ 3. $5 \log x - 3 \log y - \frac{1}{2} \log z$

5. $A(x) = \frac{1}{2}x^2$



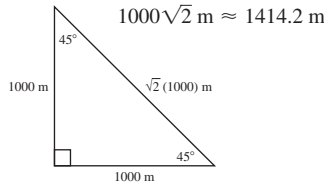
7. verified (factor out $\frac{1}{2}$, then combine like terms and simplify)

9. $t = \frac{1}{2} \ln\left(\frac{x+1}{1-x}\right)$

CHAPTER 6

Exercises 6.1, pp. 521–526

1. Complementary, 180, less, greater 3. $r\theta$; $\frac{1}{2}r^2\theta$; radians 5. Answers will vary. 7. a. 77.5° b. 30.8° 9. 53° 11. 42.5° 13. 67.555°
 15. 285.0025° 17. 45.7625° 19. $20^\circ 15' 00''$ 21. $67^\circ 18' 25.2''$
 23. $275^\circ 19' 48''$ 25. $5^\circ 27' 9''$ 27. No, $19 + 16 < 40$ 29. 69°
 31. 25° 33. 62.5 m 35. $41\sqrt{2}$ ft + 10 ft ≈ 68 ft
 37. $-645^\circ, -285^\circ, 435^\circ, 795^\circ$ 39. $-765^\circ, -405^\circ, 315^\circ, 675^\circ$
 41. $s = 980$ m 43. $\theta = 0.75$ rad 45. $r \approx 1760$ yd 47. $s \approx 8.38$
 49. $r \approx 9.4$ km 51. $\mathcal{A} = 115.6$ km² 53. $\theta = 0.6$ rad 55. $r \approx 3$ m
 57. $\theta = 1.5$ rad; $s = 7.5$ cm; $r = 5$ cm; $\mathcal{A} = 18.75$ cm²
 59. $\theta = 4.3$ rad; $s = 43$ m; $r = 10$ m; $\mathcal{A} = 215$ m²
 61. $\theta = 3$ rad; $\mathcal{A} = 864$ mm²; $s = 72$ mm; $r = 24$ mm
 63. 2π rad 65. $\frac{\pi}{4}$ rad 67. $\frac{7\pi}{6}$ rad 69. $\frac{-2\pi}{3}$ rad 71. 0.4712 rad
 73. 3.9776 rad 75. 60° 77. 30° 79. 120° 81. 720° 83. 165°
 85. 186.4° 87. $h \approx 7.06$ cm; $m \approx 3.76$ cm; $n \approx 13.24$ cm
 89. approx. 960.7 mi apart 91. a. ≈ 50.3 m² b. 80° c. ≈ 17 m
 93. a. 1.5π rad/sec b. about 15 mi/hr 95. a. 40π rad/min
 b. $\frac{\pi}{6}$ ft/sec ≈ 0.52 ft/sec c. about 11.5 sec 97. a. 3142 radians per minute b. 524 feet per minute c. 34 seconds 99. a. 1000 m b. 1000 m



- c. $1000\sqrt{2}$ m ≈ 1414.2 m
 101. $50\sqrt{2}$ or about 70.7 mi apart 103. a. $\approx 50.3^\circ/\text{day}$; ≈ 0.8788 rad/day
 b. ≈ 0.0366 rad/hr c. ≈ 6.67 mi/sec 105. 34.9 m/hr 107. Answers will vary. 109. Shift left 3 units, reflect across x-axis, stretch by a factor of 2, shift down 1 unit 111. $y = 2x - 3$

Exercises 6.2, pp. 537–542

1. x, y , origin 3. $x, y, \frac{y}{x}$; sec t , csc t , cot t 5. Answers will vary.
 7. $(-0.6, -0.8)$ 9. $(\frac{5}{13}, \frac{-12}{13})$ 11. $(\frac{\sqrt{11}}{6}, \frac{5}{6})$ 13. $(\frac{-\sqrt{11}}{4}, \frac{\sqrt{5}}{4})$
 15. $(-0.9769, -0.2137)$ 17. $(-0.9928, 0.1198)$
 19. $(\frac{-\sqrt{3}}{2}, \frac{-1}{2}), (\frac{\sqrt{3}}{2}, \frac{1}{2}), (\frac{\sqrt{3}}{2}, \frac{-1}{2})$
 21. $(\frac{-\sqrt{11}}{6}, \frac{-5}{6}), (\frac{-\sqrt{11}}{6}, \frac{5}{6}), (\frac{\sqrt{11}}{6}, \frac{5}{6})$
 23. $(-0.3325, 0.9431), (-0.3325, -0.9431), (0.3325, -0.9431)$
 25. $(0.9937, 0.1121), (-0.9937, 0.1121), (-0.9937, -0.1121)$
 27. verified 29. $\frac{\pi}{4}; (\frac{-\sqrt{2}}{2}, \frac{-\sqrt{2}}{2})$ 31. $\frac{\pi}{6}; (\frac{-\sqrt{3}}{2}, \frac{-1}{2})$
 33. $\frac{\pi}{4}; (\frac{-\sqrt{2}}{2}, \frac{\sqrt{2}}{2})$ 35. $\frac{\pi}{6}; (\frac{\sqrt{3}}{2}, \frac{1}{2})$ 37. a. $\frac{\sqrt{2}}{2}$ b. $\frac{\sqrt{2}}{2}$
 c. $\frac{-\sqrt{2}}{2}$ d. $\frac{-\sqrt{2}}{2}$ e. $\frac{\sqrt{2}}{2}$ f. $\frac{-\sqrt{2}}{2}$ g. $\frac{\sqrt{2}}{2}$ h. $\frac{-\sqrt{2}}{2}$
 39. a. -1 b. 1 c. 0 d. 0 41. a. $\frac{\sqrt{3}}{2}$ b. $\frac{-\sqrt{3}}{2}$ c. $\frac{-\sqrt{3}}{2}$
 d. $\frac{\sqrt{3}}{2}$ e. $\frac{\sqrt{3}}{2}$ f. $\frac{\sqrt{3}}{2}$ g. $\frac{-\sqrt{3}}{2}$ h. $\frac{\sqrt{3}}{2}$

43. a. 0 b. 0 c. undefined d. undefined
 45. $\sin t = 0.6, \cos t = -0.8, \tan t = -0.75, \csc t = 1.6, \sec t = -1.25, \cot t = -1.3$
 47. $\sin t = -\frac{12}{13}, \cos t = -\frac{5}{13}, \tan t = \frac{12}{5}, \csc t = -\frac{13}{12}, \sec t = -\frac{13}{5}, \cot t = \frac{5}{12}$
 49. $\sin t = \frac{\sqrt{21}}{5}, \cos t = \frac{-2}{5}, \tan t = \frac{-\sqrt{21}}{2}, \csc t = \frac{5\sqrt{21}}{21}, \sec t = \frac{-5}{2}, \cot t = \frac{-2\sqrt{21}}{21}$
 51. $\sin t = \frac{-2\sqrt{2}}{3}, \cos t = \frac{-1}{3}, \tan t = 2\sqrt{2}, \csc t = \frac{-3\sqrt{2}}{4}, \sec t = -3, \cot t = \frac{\sqrt{2}}{4}$ 53. QI, 0.7 55. QIV, 0.7 57. QI, 1
 59. QII, 1.1 61. $\frac{2\pi}{3}$ 63. $\frac{7\pi}{6}$ 65. $\frac{2\pi}{3}$ 67. $\frac{\pi}{2}$ 69. $\frac{3\pi}{4}, \frac{5\pi}{4}$
 71. $\frac{\pi}{2}, \frac{3\pi}{2}$ 73. $\frac{3\pi}{4}, \frac{5\pi}{4}$ 75. $0, \pi$ 77. a. $(\frac{3}{5}, \frac{4}{5})$ b. $(\frac{-3}{5}, \frac{4}{5})$
 79. 2.3416 81. 1.7832 83. 3.5416
 85. a. $(\frac{5}{13}, \frac{12}{13}, 1), (\frac{5}{13})^2 + (\frac{12}{13})^2 = \frac{25}{169} + \frac{144}{169} = \frac{169}{169} = 1; \sin t = \frac{12}{13}, \cos t = \frac{5}{13}, \tan t = \frac{12}{5}, \csc t = \frac{13}{12}, \sec t = \frac{13}{5}, \cot t = \frac{5}{12}$
 b. $(\frac{7}{25}, \frac{24}{25}, 1), (\frac{7}{25})^2 + (\frac{24}{25})^2 = \frac{49}{625} + \frac{576}{625} = \frac{625}{625} = 1; \sin t = \frac{24}{25}, \cos t = \frac{7}{25}, \tan t = \frac{24}{7}, \csc t = \frac{25}{24}, \sec t = \frac{25}{7}, \cot t = \frac{7}{24}$
 c. $(\frac{12}{37}, \frac{35}{37}, 1), (\frac{12}{37})^2 + (\frac{35}{37})^2 = \frac{144}{1369} + \frac{1225}{1369} = \frac{1369}{1369} = 1; \sin t = \frac{35}{37}, \cos t = \frac{12}{37}, \tan t = \frac{35}{12}, \csc t = \frac{37}{35}, \sec t = \frac{37}{12}, \cot t = \frac{12}{35}$
 d. $(\frac{9}{41}, \frac{40}{41}, 1), (\frac{9}{41})^2 + (\frac{40}{41})^2 = \frac{81}{1681} + \frac{1600}{1681} = \frac{1681}{1681} = 1; \sin t = \frac{40}{41}, \cos t = \frac{9}{41}, \tan t = \frac{40}{9}, \csc t = \frac{41}{40}, \sec t = \frac{41}{9}, \cot t = \frac{9}{40}$

87. $(-0.4161, 0.9093)$ 89. $(0.2837, -0.9589)$ 91. 193.2 cm, 51.8 cm
 93. 50 cm right and 86.6 cm above center of circle 95. a. 5 rad
 b. 30 rad 97. a. 5 dm b. ≈ 6.28 dm 99. a. 2.5 AU b. ≈ 6.28 AU
 101. yes 103. range of $\sin t$ and $\cos t$ is $[-1, 1]$ 105. a. $2t \approx 2.2$
 b. QI c. $\cos t \approx 0.5$ d. No 107. a. $d = 10$ b. midpoint: $(1, -1)$
 c. $m = \frac{3}{4}$ 109. a. $x = -6, 4$ b. $x = 24$

Exercises 6.3, pp. 555–560

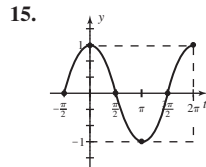
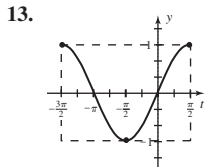
1. increasing 3. $(-\infty, \infty), [-1, 1]$ 5. Answers will vary.

7.

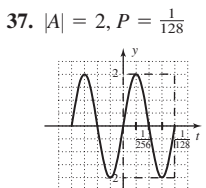
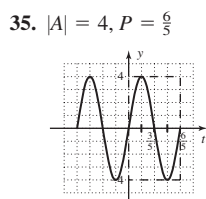
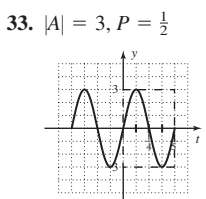
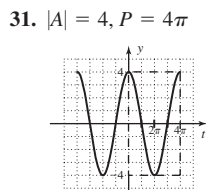
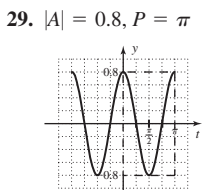
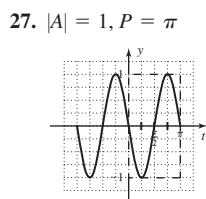
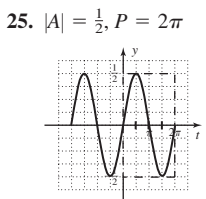
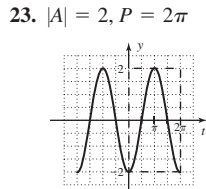
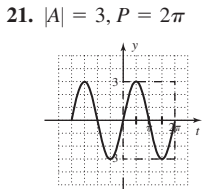
t	$y = \cos t$
π	-1
$\frac{7\pi}{6}$	$-\frac{\sqrt{3}}{2}$
$\frac{5\pi}{4}$	$-\frac{\sqrt{2}}{2}$
$\frac{4\pi}{3}$	$-\frac{1}{2}$
$\frac{3\pi}{2}$	0
$\frac{5\pi}{3}$	$\frac{1}{2}$
$\frac{7\pi}{4}$	$\frac{\sqrt{2}}{2}$
$\frac{11\pi}{6}$	$\frac{\sqrt{3}}{2}$
2π	1

9. a. $\frac{\pi}{12}, \frac{\pi}{6}, \frac{\pi}{4}$ b. $\sin \frac{\pi}{12} \approx 0.25882$ c. same as second row

11. a. II b. V c. IV d. I e. III



17. 3 19. 0.75



39. $Y_2 \approx 0.86392$, $X_{\min} = 0$, $X_{\max} = 1/1336$, $X_{\text{scl}} = 1/13,360$, $Y_{\min} = -2$, $Y_{\max} = 2$, $Y_{\text{scl}} = 1$

41. $|A| = 2$, $P = \frac{\pi}{2}$, g 43. $|A| = 3$, $P = \pi$, f 45. $|A| = \frac{3}{4}$, $P = 5\pi$, b

47. $|A| = 4$, $P = \frac{1}{72}$, d 49. $y = -\frac{3}{4} \cos(8t)$ 51. $y = 6 \cos\left(\frac{2\pi}{3}t\right)$

53. $y = 3 \sin\left(\frac{1}{5}t\right)$ 55. $y = -\frac{3}{22} \sin(10\pi t)$

57. red: $y = -\cos x$; blue: $y = \sin x$; $x = \frac{3\pi}{4}, \frac{7\pi}{4}$

59. red: $y = -2 \cos x$; blue: $y = 2 \sin(3x)$;

$x = \frac{3\pi}{8}, \frac{3\pi}{4}, \frac{7\pi}{8}, \frac{11\pi}{8}, \frac{7\pi}{4}, \frac{15\pi}{8}$

61. a. $100\pi \text{ cm}^2 \approx 314.2 \text{ cm}^2$ b. 200 cm^2 ; it is a square.

c.

n	A
10	293.89
20	309.02
30	311.87
100	313.95

The area of the polygon seems to be approaching the area of the circle.

63. a. 3 ft b. 80 mi c. $h = 1.5 \cos\left(\frac{\pi}{40}x\right)$

65. a. $D = -4 \cos\left(\frac{\pi}{12}t\right)$ b. $D \approx 3.86$ c. 72°

67. a. $D = 15 \cos(\pi t)$ b. at center
c. Swimming leisurely. One complete cycle in 2 sec.

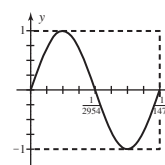
69. a. Graph a b. 76 days c. 96 days 71. a. 480 nm → blue
b. 620 nm → orange 73. $I = 30 \sin(50\pi t)$, $I \approx 21.2$ amps

75. Since $m = -M$, 0;

t	y
0	3
$\frac{\pi}{2}$	5
π	3
$\frac{3\pi}{2}$	1
2π	3

avg. value = 3; shifted up 3 units; avg. value = 1

77. $g(t)$ has the shortest period;

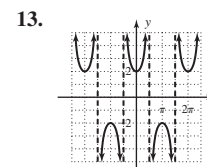
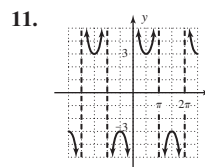
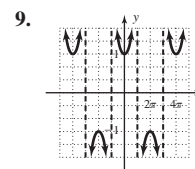
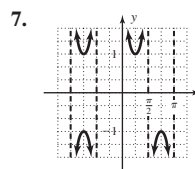


79. distance = $\frac{200}{\sqrt{3}}$ yd ≈ 115.5 yd

81. a. $3 - 4i$ b. $-1 + 6i$ c. $7 - 3i$ d. $-\frac{3}{2} - \frac{7}{2}i$

Exercises 6.4, pp. 571–577

1. π , $P = \frac{\pi}{|B|}$ 3. odd, $-f(t)$, -0.268 5. a. Use reciprocals of standard values. b. Use reciprocals of given values.



15. $0, \frac{1}{\sqrt{3}}, 1, \sqrt{3}$, und. 17. 1.6, 0.8, 0.5, 1.4, 0.7, 1.2

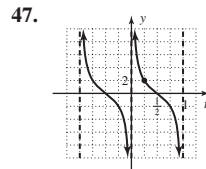
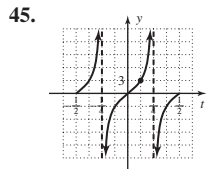
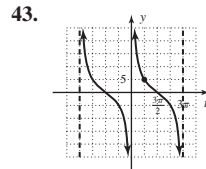
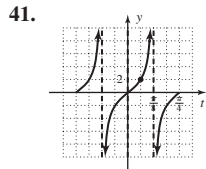
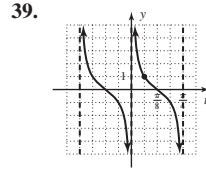
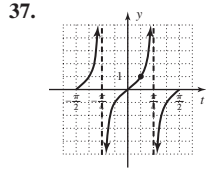
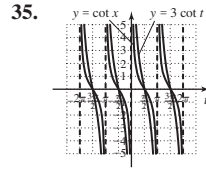
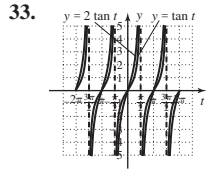
19. a. -1 b. $\sqrt{3}$ c. -1 d. $\sqrt{3}$

21. a. $\frac{7\pi}{4}$ b. $\frac{7\pi}{6}$ c. $\frac{5\pi}{3}$ d. $\frac{3\pi}{4}$

23. und., $\sqrt{3}$, 1, $\frac{1}{\sqrt{3}}$, 0 25. $-\frac{13\pi}{24}, \frac{35\pi}{24}, \frac{59\pi}{24}$

27. $-1.6, 4.6, 7.8$ 29. $\frac{\pi}{10} + \pi k, k \in \mathbb{Z}$

31. $\frac{\pi}{12} + \pi k, k \in \mathbb{Z}$



49. $P = 4\pi$, b. 51. $P = \frac{1}{4}$, d. 53. $y = 2 \csc(5\pi t)$ 55. $y = 3 \tan\left(\frac{1}{2}t\right)$

57. $y = 2 \cot\left(\frac{2\pi}{3}t\right)$ 59. $\frac{\pi}{8}, \frac{3\pi}{8}$ 61. about 137.8 ft

63. a. 20π cm \approx 62.8 cm b. 80 cm; it is a square.

c.

n	P
10	64.984
20	63.354
30	63.063
100	62.853

getting close to 20π

65. a. no; $\approx 35^\circ$ b. 1.05 c. Angles will be greater than 68.2° ; soft rubber on sandstone

67. a. 5.67 units b. 86.5° c. Yes. Range of $\tan \theta$ is $(-\infty, \infty)$.

d. The closer θ gets to 90° , the longer the line segment gets.

69. $\sin 0.6662394325 = 0.618033989 \approx \frac{-1 + \sqrt{5}}{2}$; $\cos x = \tan x$ can be

rewritten as $\sin^2 x = 1 - \sin x$, which can in turn be converted to $\sin^2(-x) = 1 + \sin(-x)$, which is the basis of the golden ratio.

71. 21,266,032 km²

73.

t	x	y
0	1	0
$\frac{\pi}{4}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{2}}{2}$
$\frac{\pi}{2}$	0	1
π	-1	0
$\frac{3\pi}{4}$	$-\frac{\sqrt{2}}{2}$	$\frac{\sqrt{2}}{2}$
$\frac{3\pi}{2}$	0	-1
2π	1	0

$\tan\left(\frac{\pi}{2}\right)$ is undefined because $\frac{1}{0}$ is und.

Mid-Chapter Check, p. 577

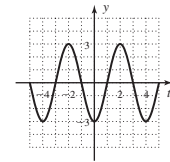
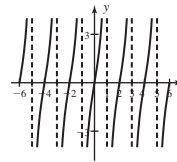
1. a. $36.11^\circ\text{N}, 115.08^\circ\text{W}$ b. 2495.7 mi 2. $\theta = 4.3$; $A = 860 \text{ cm}^2$

3. a. $\frac{\sqrt{3}}{3}$ b. $-\frac{\sqrt{2}}{2}$ 4. a. ≈ 1.0353 b. ≈ 8.9152

5. $y = \frac{-2}{3}$; $\sin \theta = \frac{-2}{3}$, $\csc \theta = \frac{-3}{2}$, $\cos \theta = \frac{-\sqrt{5}}{3}$, $\sec \theta = \frac{-3\sqrt{5}}{5}$,

$\tan \theta = \frac{2\sqrt{5}}{5}$, $\cot \theta = \frac{\sqrt{5}}{2}$ 6. $221.8^\circ, 3.8713$

7. asymptotes: $x = -5, -3, -1, 1, 3, 5$; 8. $|A| = 3, P = 4$;



9. a. QIV b. $2\pi - 5.94 \approx 0.343$ c. $\sin t, \tan t$

10. a. $|A| = 6, P = \frac{3\pi}{4}$ b. $f(t) = -6 \cos\left(\frac{8}{3}t\right)$ c. $f(\pi) = 3$

Reinforcing Basic Concepts, pp. 577–578

1. $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$, $\cos t = -\frac{1}{2}$, $\sin t = \frac{\sqrt{3}}{2}$ 2. $t = \frac{5\pi}{6}$, negative since $x < 0$

3. QIV, negative since $y < 0$ 4. QI, $\cos t = \frac{1}{2}$, $\sin t = \frac{\sqrt{3}}{2}$, $t = \frac{\pi}{3}$

Exercises 6.5, pp. 590–595

1. $y = A \sin(Bt + C) + D$, $y = A \cos(Bt + C) + D$

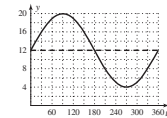
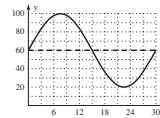
3. $0 \leq Bt + C < 2\pi$ 5. Answers will vary. 7. a. $|A| = 50, P = 24$

b. ≈ -25 c. $[1.6, 10.4]$ 9. a. $|A| = 200, P = 3$ b. -175

c. $[1.75, 2.75]$

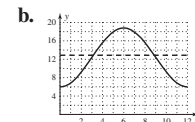
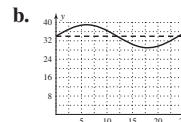
11. $y = 40 \sin\left(\frac{\pi}{15}t\right) + 60$

13. $y = 8 \sin\left(\frac{\pi}{180}t\right) + 12$



15. a. $y = 5 \sin\left(\frac{\pi}{12}t\right) + 34$

17. a. $y = -6.4 \cos\left(\frac{\pi}{6}t\right) + 12.4$

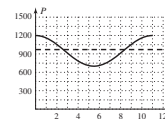


c. $\approx 1:30$ A.M., $10:30$ A.M.

c. ≈ 134 days

19. a. $P = 11$ yr

c. max = 1200, min = 700 d. about 2 yr.



21. $P(t) = 250 \cos\left[\frac{2\pi}{11}(t - 2.75)\right] + 950$; $P(t) = 250 \sin\left(\frac{2\pi}{11}t\right) + 950$

23. $|A| = 120$; $P = 24$; HS: 6 units right; VS: (none); PI: $6 \leq t < 30$

25. $|A| = 1$; $P = 12$; HS: 2 units right; VS: (none); PI: $2 \leq t < 14$

27. $|A| = 1$; $P = 8$; HS: $\frac{2}{3}$ unit left; VS: (none); PI: $-\frac{2}{3} \leq t < \frac{22}{3}$

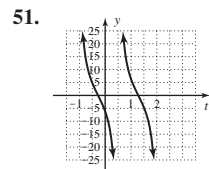
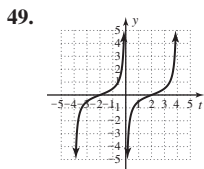
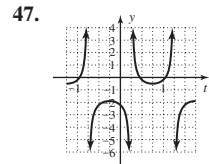
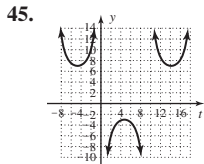
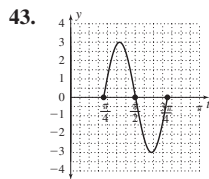
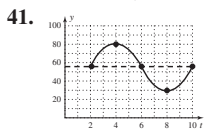
29. $|A| = 24.5$; $P = 20$; HS: 2.5 units right;

VS: 15.5 units up; PI: $2.5 \leq t < 22.5$

31. $|A| = 28$; $P = 12$; HS: $\frac{5}{2}$ units right; VS: 92 units up; PI: $\frac{5}{2} \leq t < \frac{29}{2}$
 33. $|A| = 2500$; $P = 8$; HS: $\frac{1}{3}$ unit left; VS: 3150 units up; PI: $-\frac{1}{3} \leq t < \frac{23}{3}$

35. $y = 250 \sin\left(\frac{\pi}{12}t\right) + 350$ 37. $y = 5 \sin\left(\frac{\pi}{50}t + \frac{\pi}{2}\right) + 13$

39. $y = 4 \sin\left(\frac{\pi}{180}t + \frac{\pi}{4}\right) + 7$



53. $P = \frac{2\pi}{B}$, $B = \frac{2\pi}{P}$; $f = \frac{1}{P}$, $P = \frac{1}{f}$; $B = \frac{2\pi}{1/f} = 2\pi f$.

$A \sin(Bt) = A \sin[(2\pi f)t]$ 55. a. $P = 4$ sec, $f = \frac{1}{4}$ cycle/sec
 b. -4.24 cm, moving away c. -4.24 cm, moving toward
 d. about 1.76 cm; avg. vel. = 3.52 cm/sec; greater, still gaining speed

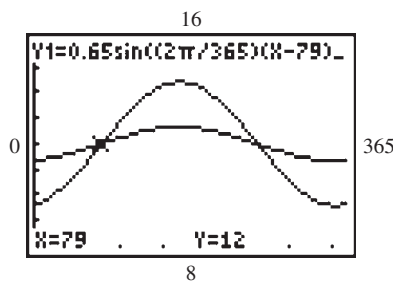
57. $d(t) = 15 \cos\left(\frac{5\pi}{4}t\right)$ 59. red $\rightarrow D_2$; blue $\rightarrow A_2$

61. $D_2: y = \sin[146.84(2\pi t)]$; $P \approx 0.0068$ sec;
 $G_3: y = \sin[392(2\pi t)]$; $P \approx 0.00255$ sec

63. $y = 5.2 \tan\left(\frac{\pi}{12}x\right)$; $P = 12$; asymptotes at $x = 6 + 12k$, $k \in \mathbb{Z}$;
 using (3, 5.2), $|A| = 5.2$; at $x = 2$, model gives $y \approx 3.002$; at $x = -2$,
 model gives $y \approx -3.002$; answers will vary.
 65. Answers will vary; $y = 11.95 \tan \theta$; $P = 180^\circ$; asymptotes at
 $\theta = 90^\circ + 180^\circ k$; $|A| = 11.95$ from $(30^\circ, 6.9 \text{ cm})$; pen is ≈ 12 cm long.

67. a. $L(t) = 10 \csc\left(\frac{\pi}{6}t\right)$ b. 20 m

69. a. Caracas: ≈ 11.4 hr, Tokyo: ≈ 9.9 hr
 b. (i) Same # of hours on 79th day & 261st day
 (ii) Caracas: ≈ 81 days, Tokyo: ≈ 158 days



71. a. Adds 12 hr. The sinusoidal behavior is actually based on hours more/less than an average of 12 hr of light. b. Means 12 hr of light and dark on March 20, day 79 (Solstice). c. Additional hours of deviation from average. In the north, the planet is tilted closer toward the Sun or farther from Sun, depending on date. Variations will be greater.
 73. Answers will vary. 75. QIII; $3.7 - \pi \approx 0.5584$

77. sum: -2 , difference: $2i\sqrt{5}$, product: 6, quotient: $\frac{-2}{3} - \frac{i\sqrt{5}}{3}$

Exercises 6.6, pp. 604–610

1. $\theta = \tan^{-1}x$ 3. opposite, hypotenuse 5. To find the measures of all three angles and all three sides.

7. $\sin \theta = \frac{12}{13}$, $\csc \theta = \frac{13}{12}$, $\sec \theta = \frac{13}{5}$, $\tan \theta = \frac{12}{5}$, $\cot \theta = \frac{5}{12}$

9. $\cos \theta = \frac{13}{85}$, $\sec \theta = \frac{85}{13}$, $\cot \theta = \frac{13}{84}$, $\sin \theta = \frac{84}{85}$, $\csc \theta = \frac{85}{84}$

11. $\sin \theta = \frac{11}{5\sqrt{5}}$, $\tan \theta = \frac{11}{2}$, $\csc \theta = \frac{5\sqrt{5}}{11}$, $\cos \theta = \frac{2}{5\sqrt{5}}$, $\sec \theta = \frac{5\sqrt{5}}{2}$

13.

Angles	Sides
$A = 30^\circ$	$a = 98$ cm
$B = 60^\circ$	$b = 98\sqrt{3}$ cm
$C = 90^\circ$	$c = 196$ cm

15.

Angles	Sides
$A = 45^\circ$	$a = 9.9$ mm
$B = 45^\circ$	$b = 9.9$ mm
$C = 90^\circ$	$c = 9.9\sqrt{2}$ mm

17.

Angles	Sides
$A = 22^\circ$	$a = 14$ m
$B = 68^\circ$	$b \approx 34.65$ m
$C = 90^\circ$	$c \approx 37.37$ m

19.

Angles	Sides
$A = 32^\circ$	$a = 5.6$ mi
$B = 58^\circ$	$b \approx 8.96$ mi
$C = 90^\circ$	$c \approx 10.57$ mi

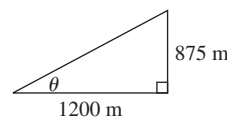
verified

21.

Angles	Sides
$A = 65^\circ$	$a = 625$ mm
$B = 25^\circ$	$b \approx 291.44$ mm
$C = 90^\circ$	$c \approx 689.61$ mm

verified

23. 0.4540 25. 0.8391 27. 1.3230 29. 0.9063 31. 27° 33. 40°
 35. 40.9° 37. 65° 39. 44.7° 41. 20.2° 43. 18.4° 45. 46.2°
 47. 61.6° 49. 21.98 mm 51. 3.04 mi 53. 177.48 furlongs
 55. They have like values. 57. They have like values.
 59. 43° 61. 21° 63. $\frac{1}{2}, \frac{\sqrt{3}}{2}, \frac{\sqrt{3}}{3}, \frac{\sqrt{3}}{2}, \frac{1}{2}, \sqrt{3}, 2, \frac{2\sqrt{3}}{3}, \sqrt{3}$
 65. $6 + 2\sqrt{3}$ 67. $7 + 4\sqrt{3}$ 69. $\theta \approx 11.0^\circ$, $\beta \approx 23.9^\circ$, $\gamma \approx 145.1^\circ$
 71. approx. 300.6 m 73. approx. 481.1 m 75. 87 ft 9 in.
 77. a. approx. 250.0 yd b. approx. 351.0 yd c. approx. 23.1 yd
 79. approx. 1815.2 ft; approx. 665.3 ft 81. approx. 118.1 mph
 83. approx. 386.0 Ω
 85. a. 875 m b. 1200 m
 c. 1485 m; 36.1°



87. approx. 450 ft 89. a. approx. 20.2 cm for each side
 b. approx. 35.3° 91. S 85° W 93. a. approx. 3055.6 mi
 b. approx. 9012.8 mi c. approx. 7 hr, 13 min
 95. a. local max: $(-5, 2)$, $(2, 3)$; local min: $(-2, -1)$, $(-7, -2)$, $(6, -3)$
 b. zeroes: $x = -6, -3, -1, 4$
 c. $T(x)\downarrow: x \in (-5, -2) \cup (2, 6)$; $T(x)\uparrow: x \in (-7, -5) \cup (-2, 2)$
 d. $T(x) > 0: x \in (-6, -3) \cup (-1, 4)$;
 $T(x) < 0: x \in (-7, -6) \cup (-3, -1) \cup (4, 6)$
 97. $d \approx 53.74$ in. $D \approx 65.82$ in.

Exercises 6.7, pp. 618–621

1. origin, x-axis 3. positive, clockwise 5. Answers will vary.

7. slope = $\sqrt{3}$, equation: $y = \sqrt{3}x$,

$$\sin 60^\circ = \frac{\sqrt{3}}{2}, \cos 60^\circ = \frac{1}{2}, \tan 60^\circ = \sqrt{3}$$

9.  QI/III;

$$(4, 3): \sin \theta = \frac{3}{5}; (-4, -3): \sin \theta = -\frac{3}{5}$$

$$\cos \theta = \frac{4}{5} \qquad \cos \theta = -\frac{4}{5}$$

$$\tan \theta = \frac{3}{4} \qquad \tan \theta = -\frac{3}{4}$$

11.  QII/QIV;

$$(-3, \sqrt{3}): \sin \theta = \frac{1}{2}; \quad (3, -\sqrt{3}): \sin \theta = -\frac{1}{2}$$

$$\cos \theta = -\frac{\sqrt{3}}{2} \qquad \cos \theta = \frac{\sqrt{3}}{2}$$

$$\tan \theta = -\frac{1}{\sqrt{3}} \qquad \tan \theta = -\frac{1}{\sqrt{3}}$$

13. $\sin \theta = \frac{15}{17}, \csc \theta = \frac{17}{15}, \cos \theta = \frac{8}{17}, \sec \theta = \frac{17}{8}, \tan \theta = \frac{15}{8},$

$$\cot \theta = \frac{8}{15}$$

15. $\sin \theta = \frac{21}{29}, \csc \theta = \frac{29}{21}, \cos \theta = \frac{-20}{29},$

$$\sec \theta = \frac{-29}{20}, \tan \theta = \frac{-21}{20}, \cot \theta = \frac{-20}{21}$$

17. $\sin \theta = \frac{-\sqrt{2}}{2}, \csc \theta = -\sqrt{2}, \cos \theta = \frac{\sqrt{2}}{2},$

$$\sec \theta = \sqrt{2}, \tan \theta = -1, \cot \theta = -1$$

19. $\sin \theta = \frac{1}{2}, \csc \theta = 2, \cos \theta = \frac{\sqrt{3}}{2},$

$$\sec \theta = \frac{2}{\sqrt{3}}, \tan \theta = \frac{1}{\sqrt{3}}, \cot \theta = \sqrt{3}$$

21. $\sin \theta = \frac{4}{\sqrt{17}}, \csc \theta = \frac{\sqrt{17}}{4}, \cos \theta = \frac{1}{\sqrt{17}},$

$$\sec \theta = \sqrt{17}, \tan \theta = 4, \cot \theta = \frac{1}{4}$$

23. $\sin \theta = \frac{-2}{\sqrt{13}}, \csc \theta = \frac{-\sqrt{13}}{2}, \cos \theta = \frac{-3}{\sqrt{13}},$

$$\sec \theta = \frac{-\sqrt{13}}{3}, \tan \theta = \frac{2}{3}, \cot \theta = \frac{3}{2}$$

25. $\sin \theta = \frac{6}{\sqrt{61}}, \csc \theta = \frac{\sqrt{61}}{6}, \cos \theta = \frac{-5}{\sqrt{61}},$

$$\sec \theta = \frac{-\sqrt{61}}{5}, \tan \theta = \frac{-6}{5}, \cot \theta = \frac{-5}{6}$$

27. $\sin \theta = \frac{-2\sqrt{5}}{\sqrt{21}}, \csc \theta = -\frac{\sqrt{21}}{2\sqrt{5}}, \cos \theta = \frac{1}{\sqrt{21}},$

$$\sec \theta = \sqrt{21}, \tan \theta = -2\sqrt{5}, \cot \theta = \frac{-1}{2\sqrt{5}}$$

29. $r = 10$

31. $x = 0, y = k; k > 0; r = k;$

$$\sin 90^\circ = \frac{k}{k}, \cos 90^\circ = \frac{0}{k}, \tan 90^\circ = \frac{k}{0},$$

$$\sin 90^\circ = 1, \cos 90^\circ = 0, \tan 90^\circ \text{ is undefined}$$

$$\csc 90^\circ = 1, \sec 90^\circ \text{ is undefined}$$

$$\cot 90^\circ = 0$$

33. 60° 35. 45° 37. 45° 39. 68° 41. 40° 43. 11.6° 45. QII

47. QII 49. $\sin \theta = -\frac{1}{2}; \cos \theta = \frac{\sqrt{3}}{2}; \tan \theta = -\frac{1}{\sqrt{3}}$

51. $\sin \theta = \frac{-\sqrt{2}}{2}; \cos \theta = \frac{\sqrt{2}}{2}; \tan \theta = -1$

53. $\sin \theta = \frac{-\sqrt{3}}{2}; \cos \theta = \frac{-1}{2}; \tan \theta = \sqrt{3}$

55. $\sin \theta = -\frac{1}{2}; \cos \theta = \frac{-\sqrt{3}}{2}; \tan \theta = \frac{1}{\sqrt{3}}$

57. $x = 4, y = -3, r = 5; \text{QIV}; \sin \theta = \frac{-3}{5}, \csc \theta = \frac{-5}{3}, \cos \theta = \frac{4}{5},$

$$\sec \theta = \frac{5}{4}, \tan \theta = \frac{-3}{4}, \cot \theta = \frac{-4}{3}$$

59. $x = -12, y = -35, r = 37; \text{QIII}; \sin \theta = \frac{-35}{37}, \csc \theta = \frac{-37}{35},$

$$\cos \theta = \frac{-12}{37}, \sec \theta = \frac{-37}{12}, \tan \theta = \frac{35}{12}, \cot \theta = \frac{12}{35}$$

61. $x = 2\sqrt{2}, y = 1, r = 3; \text{QI}; \sin \theta = \frac{1}{3}, \csc \theta = 3, \cos \theta = \frac{2\sqrt{2}}{3},$

$$\sec \theta = \frac{3}{2\sqrt{2}}, \tan \theta = \frac{1}{2\sqrt{2}}, \cot \theta = 2\sqrt{2}$$

63. $x = -\sqrt{15}, y = -7, r = 8; \text{QIII}; \sin \theta = \frac{-7}{8}, \csc \theta = \frac{-8}{7},$

$$\cos \theta = \frac{-\sqrt{15}}{8}, \sec \theta = -\frac{8}{\sqrt{15}}, \tan \theta = \frac{7}{\sqrt{15}}, \cot \theta = \frac{\sqrt{15}}{7}$$

65. $52^\circ + 360^\circ k$ 67. $87.5^\circ + 360^\circ k$ 69. $225^\circ + 360^\circ k$

71. $-107^\circ + 360^\circ k$ 73. $\frac{\sqrt{3}}{2}, \frac{-1}{2}, -\sqrt{3}$ 75. $-\frac{1}{2}, \frac{\sqrt{3}}{2}, \frac{1}{\sqrt{3}}$

77. $\sin \theta = \frac{-\sqrt{3}}{2}, \cos \theta = \frac{-1}{2}, \tan \theta = \sqrt{3}$

79. $\sin \theta = \frac{-\sqrt{3}}{2}, \cos \theta = -\frac{1}{2}, \tan \theta = \sqrt{3}$

81. $\sin \theta = \frac{-1}{2}, \cos \theta = \frac{-\sqrt{3}}{2}, \tan \theta = \frac{1}{\sqrt{3}}$

83. $\sin \theta = \frac{-1}{2}, \cos \theta = \frac{-\sqrt{3}}{2}, \tan \theta = \frac{1}{\sqrt{3}}$

85. QIV, neg., -0.0175 87. QIV, neg., -1.6643

89. QIV, neg., -1.5890 91. QI, pos., 0.0872

93. a. approx. 144.78 units^2 b. 53° c. The parallelogram is a

rectangle whose area is $\mathcal{A} = ab$. d. $\mathcal{A} = \frac{ab}{2} \sin \theta$

95. $\theta = 60^\circ + 360^\circ k$ and $\theta = 300^\circ + 360^\circ k$

97. $\theta = 240^\circ + 360^\circ k$ and $\theta = 300^\circ + 360^\circ k$

99. $\theta = 61.1^\circ + 360^\circ k$ and $\theta = 118.9^\circ + 360^\circ k$

101. $\theta = 113.0^\circ + 180^\circ k$ 103. $1890^\circ; 90^\circ + 360^\circ k$

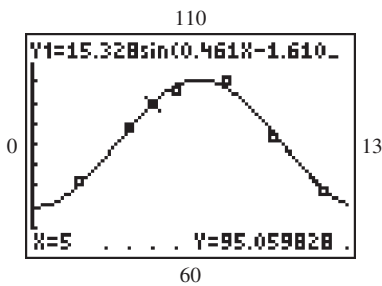
105. head first; 900° 107. approx. 701.6° 109. Answers will vary.

111. a. $12,960^\circ$ b. 125.66 in. c. $15,080 \text{ in.}$ d. 85.68 mph

113. $t = \frac{\ln 0.32}{-0.05} \approx 22.79$ 115. $y = -\frac{5}{4}x + 2$

Exercises 6.8, pp. 628–633

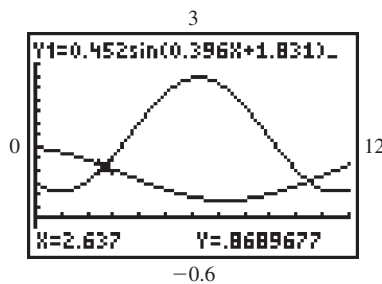
1. $\sin(Bx + C)$, $A + D$ 3. critical 5. Answers will vary.
 7. $y = 25 \sin\left(\frac{\pi}{6}x\right) + 50$ 9. $y = 2.25 \sin\left(\frac{\pi}{12}x + \frac{\pi}{4}\right) + 5.25$
 11. $y = 503 \sin\left(\frac{\pi}{6}x + \frac{2\pi}{3}\right) + 782$
 13. a. $y \approx 49.26 \sin(0.213x - 1.104) + 51.43$
 b. $y \approx 49 \sin(0.203x - 0.963) + 51$ c. at day 31 ≈ 5.6
 15. a. $y \approx 5.88 \sin(0.523x - 0.521) + 16.00$
 b. $y \approx 6 \sin(0.524x - 0.524) + 16$ c. at month 9 ≈ 0.12
 17. a. $D = 2000 \cos\left(\frac{\pi}{60}t\right)$ b. north, 1258.6 mi
 19. a. $T(x) = 19.6 \sin\left(\frac{\pi}{6}x + \frac{4\pi}{3}\right) + 84.6$ b. about 94.4°F
 c. beginning of May ($x \approx 5.1$) to end of August ($x \approx 8.9$)
 21. a. $T(t) = 0.4 \sin\left(\frac{\pi}{12}t + \frac{13\pi}{12}\right) + 98.6$
 b. at 11 A.M. and 11 P.M. c. from $t = 1$ to $t = 9$, about 8 hr
 23. $P = 12$, $B = \frac{\pi}{12}$, $C = \frac{\pi}{2}$; using (4, 3) gives $A = -3\sqrt{3}$,
 so $f(x) = -3\sqrt{3} \tan\left(\frac{\pi}{12}x + \frac{\pi}{2}\right)$ a. $f(2.5) \approx 6.77$
 b. $f(x) = 16$ for $x \approx 1.20$
 25. a. using (18, 10) gives $A \approx 4.14$; $H(d) = 4.14 \tan\left(\frac{\pi}{48}d\right)$
 b. ≈ 12.2 cm c. ≈ 21.9 mi
 27. a. $T(m) \approx 15.328 \sin(0.461m - 1.610) + 85.244$



b.

Month	Temp. (°F)
1	71
3	82
5	95
7	101
9	94
11	80

- c. max difference is about 1°F in months 6 and 8
 29. a. $f(x) \approx 49.659 \sin(0.214x - 0.689) + 48.328$ b. about 26.8%
 c. $g(x) = 49.5 \sin\left(\frac{2\pi}{31}x - \frac{7\pi}{62}\right) + 49.5$; values for A , B , and D are very close; some variation in C .
 31. a. Reno: $R(t) \approx 0.452 \sin(0.396t + 1.831) + 0.750$
 b. The graphs intersect at $t \approx 2.6$ and $t \approx 10.5$. Reno gets more rainfall than Cheyenne for about 4 months of the year.



$$33. \frac{m - D}{A} = \frac{m - \left(\frac{M + m}{2}\right)}{\frac{M - m}{2}} = \frac{2m - M - m}{M - m} = \frac{m - M}{M - m} = -1$$

35. a. $[0, \infty)$ b. $(-\infty, \infty)$ c. $(-\infty, \infty)$ 37. $15\pi \approx 47.1$ ft/min

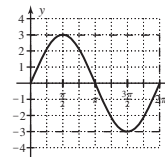
Making Connections, p. 633

1. h 3. d 5. e 7. e 9. c 11. b 13. f 15. h

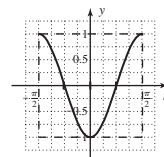
Summary and Concept Review, pp. 634–642

1. $147.61\bar{3}^\circ$ 2. $32^\circ 52' 12''$ 3. $10.125 \times 13.5 \times 16.875$
 4. approx. 692.82 yd 5. 120° 6. $\frac{7\pi}{6}$ 7. approx. 4.97 units
 8. $-\frac{1}{2}$ 9. $s = 25.5$ cm, $A = 191.25$ cm²
 10. $r \approx 41.74$ in., $A \approx 2003.48$ in² 11. $\theta = 4.75$ rad, $s = 38$ m
 12. a. approx. 9.4248 rad/sec b. approx. 3.9 ft/sec c. about 15.4 sec
 13. $y = -\frac{6}{7}, \left(-\frac{\sqrt{13}}{7}, \frac{6}{7}\right), \left(-\frac{\sqrt{13}}{7}, -\frac{6}{7}\right)$, and $\left(\frac{\sqrt{13}}{7}, \frac{6}{7}\right)$
 14. $\sin t = -\frac{\sqrt{7}}{4}, \csc t = -\frac{4}{\sqrt{7}}$,
 $\cos t = \frac{3}{4}, \sec t = \frac{4}{3}, \tan t = -\frac{\sqrt{7}}{3}, \cot t = -\frac{3}{\sqrt{7}}$
 15. $\frac{\pi}{3}$ and $\frac{2\pi}{3}$ 16. $t \approx 2.44$ 17. a. approx. 19.6667 rad b. 25 rad

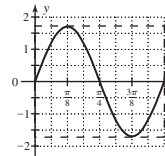
18. $|A| = 3, P = 2\pi$



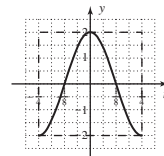
19. $|A| = 1, P = \pi$



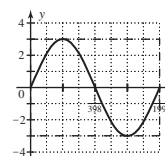
20. $|A| = 1.7, P = \frac{\pi}{2}$



21. $|A| = 2, P = \frac{1}{2}$



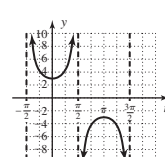
22. $|A| = 3, P = \frac{1}{199}$



23. $y = 0.75 \sin(6t)$

24. green; red

25. $P = 2\pi$



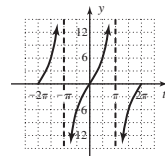
26. $y = 4 \csc(3\pi t)$

27. a. $\tan\left(\frac{7\pi}{4}\right) = -1$

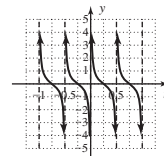
b. $\cot\left(\frac{\pi}{3}\right) = \frac{1}{\sqrt{3}}$

28. a. $t = \frac{2\pi}{3}$ b. $t = \frac{2\pi}{3}$

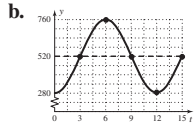
29.



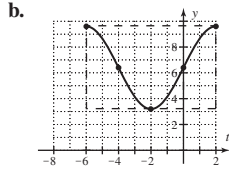
30.



31. $1.55 + k\pi$ radians; $k \in \mathbb{Z}$ 32. 3.5860 33. ≈ 151.14 m
 34. a. $|A| = 240, P = 12, HS: 3$ units right, VS: 520 units up



35. a. $|A| = 3.2, P = 8, HS: 6$ units left, VS: 6.4 units up



36. $|A| = 125, P = 24, HS: 3$ units right, VS: 175 units up,

$$y = 125 \cos\left[\frac{\pi}{12}(t - 3)\right] + 175$$

37. $A = 75, P = \frac{3\pi}{8}, HS: (none),$

$$VS: 105 \text{ units up, } y = 75 \sin\left(\frac{16}{3}t\right) + 105$$

38. a. $P(t) = 0.91 \sin\left(\frac{\pi}{6}t\right) + 1.35$ b. August: 1.81 in., Sept: 1.35 in.

39. a. $A \approx 0.80$ b. $A \approx 64.3^\circ$ 40. a. $\cot 32.6^\circ$ b. $\cos(70^\circ 29' 45'')$

41.

Angles	Sides
$A = 49^\circ$	$a = 89$ in.
$B = 41^\circ$	$b \approx 77.37$ in.
$C = 90^\circ$	$c \approx 117.93$ in.

42.

Angles	Sides
$A \approx 43.6^\circ$	$a = 20$ m
$B \approx 46.4^\circ$	$b = 21$ m
$C = 90^\circ$	$c = 29$ m

43. approx. 5.18 m 44. a. approx. 239.32 m b. approx. 240.68 m apart

45. approx. 54.5° and 35.5° 46. $207^\circ + 360^\circ k$; answers will vary.

47. $28^\circ, 19^\circ, 30^\circ$

48. a. $\sin \theta = \frac{35}{37}, \csc \theta = \frac{37}{35}, \cos \theta = \frac{-12}{37}, \sec \theta = \frac{-37}{12},$

$$\tan \theta = \frac{-35}{12}, \cot \theta = \frac{-12}{35}$$

- b. $\sin \theta = \frac{-3}{\sqrt{13}}, \csc \theta = \frac{-\sqrt{13}}{3}, \cos \theta = \frac{2}{\sqrt{13}}, \sec \theta = \frac{\sqrt{13}}{2},$

$$\tan \theta = \frac{-3}{2}, \cot \theta = \frac{-2}{3}$$

49. a. $x = 4, y = -3, r = 5; QIV; \sin \theta = -\frac{3}{5}, \csc \theta = -\frac{5}{3},$

$$\cos \theta = \frac{4}{5}, \sec \theta = \frac{5}{4}, \tan \theta = \frac{-3}{4}, \cot \theta = \frac{-4}{3}$$

- b. $x = 5, y = -12, r = 13; QIV; \sin \theta = \frac{-12}{13}, \csc \theta = \frac{-13}{12},$

$$\cos \theta = \frac{5}{13}, \sec \theta = \frac{13}{5}, \tan \theta = \frac{-12}{5}, \cot \theta = \frac{-5}{12}$$

50. a. $\theta = 135^\circ + 180^\circ k$ b. $\theta = 30^\circ + 360^\circ k$ or $\theta = 330^\circ + 360^\circ k$

- c. $\theta \approx 76.0^\circ + 180^\circ k$ d. $\theta \approx -27.0^\circ + 360^\circ k$ or $\theta = 207.0^\circ + 360^\circ k$

51. a. $y = 2187.723 \sin(0.017x + 1.751) + 2307.437$

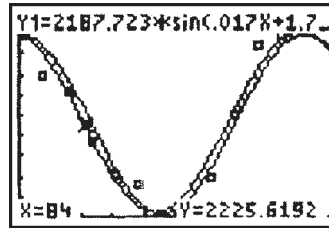
$$b. A = \frac{4450 - 90}{2} = 2180;$$

$$D = 90 + 2180 = 2270;$$

$$\frac{2\pi}{B} = 365, \frac{2\pi}{365} = B; C = \frac{3\pi}{2} - \frac{2\pi}{365}(184) = \frac{359}{730}\pi$$

$$y = 2180 \sin\left(\frac{2\pi}{365}x + \frac{359}{730}\pi\right) + 2270$$

- c. The largest difference from $0 \leq x \leq 365$ is about 372 at $x = 85$.



52. a. $y = 19.424 \sin(0.145x - 0.748) + 79.581$

$$b. A = \frac{100 - 67}{2} = 16.5;$$

$$D = 67 + 16.5 = 83.5;$$

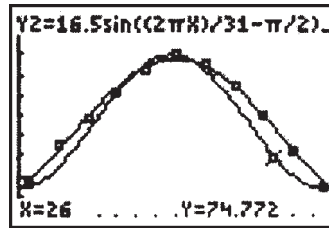
$$\frac{2\pi}{B} = 31,$$

$$\frac{2\pi}{31} = B$$

$$C = \frac{3\pi}{2} - \frac{2\pi}{31}(31) = -\frac{\pi}{2}$$

$$y = 16.5 \sin\left(\frac{2\pi}{31}x - \frac{\pi}{2}\right) + 83.5$$

- c. The largest difference is about 7, at $x = 26$.



53. a. $y = 16.800 \sin(0.602x - 2.341) + 70.968$

$$b. x = 7 \quad y = 87.01^\circ F$$

- c. The model alternates between slightly overpredicting and underpredicting output values, and appears to be a fairly accurate model.

Practice Test, pp. 643–644

1. a. 45° b. 30° c. $\frac{\pi}{6}$ d. $\frac{\pi}{3}$ 2. $30^\circ + 360^\circ k; k \in \mathbb{Z}$

3. a. 100.755° b. $48^\circ 12' 45''$ 4. a. 430 mi b. $215\sqrt{3} \approx 372$ mi

5.

t	$\sin t$	$\cos t$	$\tan t$	$\csc t$	$\sec t$	$\cot t$
0	0	1	0	undefined	1	undefined
$\frac{2\pi}{3}$	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$	$\frac{2\sqrt{3}}{3}$	-2	$-\frac{\sqrt{3}}{3}$
$\frac{7\pi}{6}$	$-\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$	-2	$-\frac{2\sqrt{3}}{3}$	$\sqrt{3}$
$\frac{5\pi}{4}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{2}}{2}$	1	$-\sqrt{2}$	$-\sqrt{2}$	1
$\frac{5\pi}{3}$	$-\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$-\sqrt{3}$	$-\frac{2\sqrt{3}}{3}$	2	$-\frac{\sqrt{3}}{3}$
$\frac{13\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$	2	$\frac{2\sqrt{3}}{3}$	$\sqrt{3}$

6. $\sec \theta = \frac{5}{2}, \sin \theta = \frac{-\sqrt{21}}{5}, \tan \theta = \frac{-\sqrt{21}}{2}, \csc \theta = \frac{-5}{\sqrt{21}}$
 $\cot \theta = \frac{-2}{\sqrt{21}}$ 7. $\left(\frac{1}{3}\right)^2 + \left(\frac{-2\sqrt{2}}{3}\right)^2 = \frac{1}{9} + \frac{8}{9} = 1$
 $\sin \theta = \frac{-2\sqrt{2}}{3}, \csc \theta = \frac{-3\sqrt{2}}{4}, \cos \theta = \frac{1}{3}$
 $\sec \theta = 3, \tan \theta = -2\sqrt{2}, \cot \theta = \frac{-\sqrt{2}}{4}$

8. a. ≈ 225 ft 9.6 in. b. $\frac{23\pi}{480}$ rad/sec ≈ 0.1505 rad/sec
 c. 11.29 ft/sec ≈ 7.7 mph

9.

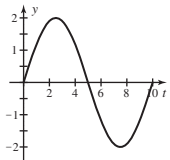
Angles	Sides
$A = 33^\circ$	$a \approx 8.2$ cm
$B = 57^\circ$	$b \approx 12.6$ cm
$C = 90^\circ$	$c = 15.0$ cm

10. about 67 cm, 49.6° 11. 57.9 m 12. a. $\frac{7\pi}{6}$ b. $\frac{11\pi}{6}$ c. $\frac{3\pi}{4}$

13. a. $W(t) = 18.4 \sin\left(\frac{\pi}{12}t\right) + 34.1$, in ten-thousands of gallons

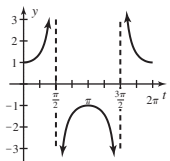
b. 433,000 gal; 249,000 gal

14. a. $D: t \in R, R: y \in [-2, 2]$,
 $P = 10, |A| = 2$;

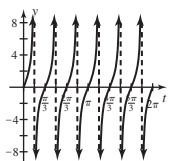


b. $D: t \neq \frac{\pi}{2}(2k + 1)$ for $k \in Z$,

$R: y \in (-\infty, -1] \cup [1, +\infty), P = 2\pi$



c. $D: t \neq \frac{\pi}{6}(2k + 1)$ for $k \in Z, R: y \in R, P = \frac{\pi}{3}$

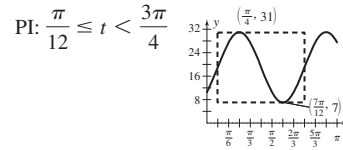


15. a. $y = 35.223 \sin(0.576x - 2.589) + 6.120$

b.

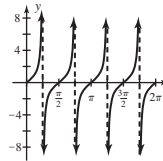
Month (Jan \rightarrow 1)	Low Temp. ($^\circ$ F)
1	-26
3	-21
5	16
7	41
9	25
11	-14

16. $|A| = 12, P = \frac{2\pi}{3}$, HS: $\frac{\pi}{12}$ units right, VS: 19 units up

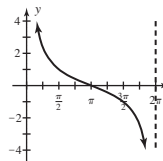


17. 1260°

18. a. $D: t \neq \frac{\pi}{4}(2k + 1), k \in Z; R: y \in R; P = \frac{\pi}{2}$;



b. $D: t \neq 2\pi k, k \in Z; R: y \in R, P = 2\pi$,



19. $y = 7.5 \sin\left(\frac{\pi}{6}t - \frac{\pi}{2}\right) + 12.5$

20. a. $t \approx 4$ b. $t \approx 2.3$

Strengthening Core Skills, pp. 646–647

Exercise 1.

t	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$
$\sin t = y$	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
$\cos t = x$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0
$\tan t = \frac{y}{x}$	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$	—
$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{7\pi}{6}$	$\frac{5\pi}{4}$
$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$
$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	$-\frac{\sqrt{3}}{2}$	$-\frac{\sqrt{2}}{2}$
$-\sqrt{3}$	-1	$-\frac{\sqrt{3}}{3}$	0	$\frac{\sqrt{3}}{3}$	1

Exercise 2. a. $t = \frac{4\pi}{3}, \frac{5\pi}{3}$ b. $t = \frac{\pi}{4}, \frac{7\pi}{4}$ c. $t = \frac{\pi}{6}, \frac{7\pi}{6}$

d. $t = \frac{\pi}{4}, \frac{7\pi}{4}$

Exercise 3. a. no solution b. $t \approx 1.2310, t \approx 5.0522$

c. $t \approx 2.8966, t \approx 6.0382$ d. $t \approx 1.9823, t \approx 4.3009$

Cumulative Review Chapters 1–6, pp. 648–649

1. $-5 < x < 3$



hyp = 89; $\theta \approx 64^\circ$; $90 - \theta = 26^\circ$

5. $\cos t = \frac{3}{4}$, $\sin t = \frac{-\sqrt{7}}{4}$, $\tan t = \frac{-\sqrt{7}}{3}$, $\sec t = \frac{4}{3}$,

$\csc t = \frac{-4}{\sqrt{7}} = \frac{-4\sqrt{7}}{7}$, $\cot t = \frac{-3}{\sqrt{7}} = \frac{-3\sqrt{7}}{7}$

7. a. $D: x \in \left[\frac{3}{2}, \infty\right)$, $R: y \in [0, \infty)$

b. $D: x \in (-\infty, -7) \cup (-7, 7) \cup (7, \infty)$, $R: y \in (-\infty, \infty)$

9. a. max: $(-2, 4)$, endpoint max: $(4, 0)$ min: $(2, -4)$, endpoint min: $(-4, 0)$

b. $f(x) \geq 0: x \in [-4, 0] \cup \{4\}$

$f(x) < 0: x \in (0, 4)$

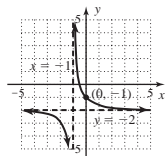
c. $f(x) \uparrow: x \in (-4, -2) \cup (2, 4)$

$f(x) \downarrow: x \in (-2, 2)$

d. function is odd: $f(-x) = -f(x)$

11. ≈ 114.3 ft

13.



15. $x = -9$, $y = 40$, $r = 41$, QII;

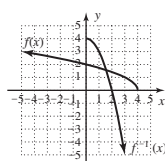
$\cos \theta = \frac{-9}{41}$, $\sin \theta = \frac{40}{41}$, $\tan \theta = \frac{-40}{9}$, $\sec \theta = \frac{-41}{9}$, $\csc \theta = \frac{41}{40}$,

$\cot \theta = \frac{-9}{40}$, $\theta \approx 102.7^\circ$

17. $S = 18$ m; $A = 135$ m²

19. $y = \frac{3}{2} \sin\left(4t - \frac{\pi}{2}\right) + \frac{1}{2}$

21.



23. $m = \frac{3}{4}$, y-intercept $(0, -2)$

25. about 6.85%

x	y
-0.2	0.98
-0.4	0.92
-0.6	0.8
-0.8	0.6

29. $x \approx 14.61$

Connections to Calculus Exercises, pp. 650–652

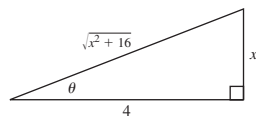
1. hyp = $x + 4$

$\sin \theta = \frac{4}{x+4}$, $\cos \theta = \frac{\sqrt{x^2+8x}}{x+4}$

$\csc \theta = \frac{x+4}{4}$, $\sec \theta = \frac{x+4}{\sqrt{x^2+8x}}$

$\tan \theta = \frac{4}{\sqrt{x^2+8x}}$, $\cot \theta = \frac{\sqrt{x^2+8x}}{4}$

3.



$\sin \theta = \frac{x}{\sqrt{x^2+16}}$, $\cos \theta = \frac{4}{\sqrt{x^2+16}}$

$\csc \theta = \frac{\sqrt{x^2+16}}{x}$, $\sec \theta = \frac{\sqrt{x^2+16}}{4}$

$\cot \theta = \frac{4}{x}$

5. $\cot \theta = \frac{13}{u}$, $\sec \theta = \frac{\sqrt{u^2+169}}{13}$ 7. $r = \frac{2}{\sin \theta}$

9. $r = \frac{3}{\sin \theta + 2 \cos \theta}$ 11. $x^2 + y^2 - 5y = 0$; circle

13. $3x - 2y = 6$; line

CHAPTER 7

Exercises 7.1, pp. 658–661

1. $\sin \theta$; $\sec \theta$; $\cos \theta$ 3. $\cos^2 \theta$, $\cot^2 \theta + 1 = \csc^2 \theta$

5. $\frac{1 - \sin^2 \theta}{\sin \theta \sec \theta}$, Answers will vary.

7. $1 + \tan^2 \theta = 1 + \frac{y^2}{x^2} = \frac{x^2}{x^2} + \frac{y^2}{x^2} = \frac{x^2 + y^2}{x^2} = \frac{r^2}{x^2} = \sec^2 \theta$

9. $\frac{\sin \theta}{\cos \theta} = \frac{\frac{y}{r}}{\frac{x}{r}} = \frac{y}{x} = \tan \theta$

11. Answers may vary;

$\tan \theta = \frac{\sec \theta}{\csc \theta}$; $\sin \theta = \frac{\sec \theta}{\csc \theta}$; $\frac{1}{\cot \theta} = \frac{\sec \theta}{\csc \theta}$; $\frac{1}{\cot \theta} = \frac{\sin \theta}{\cos \theta}$

13. Answers may vary:

$1 = \sec^2 \theta - \tan^2 \theta$; $\tan^2 \theta = \sec^2 \theta - 1$;

$1 = (\sec \theta + \tan \theta)(\sec \theta - \tan \theta)$; $\tan \theta = \pm \sqrt{\sec^2 \theta - 1}$

15. $\sin \theta \cot \theta = \frac{\cos \theta}{\sin \theta} = \cos \theta$

17. $\sec^2 \theta \cot^2 \theta = \frac{1}{\cos^2 \theta} \frac{\cos^2 \theta}{\sin^2 \theta} = \frac{1}{\sin^2 \theta} = \csc^2 \theta$

19. $\cos \theta (\sec \theta - \cos \theta) = \cos \theta \sec \theta - \cos^2 \theta = 1 - \cos^2 \theta = \sin^2 \theta$

21. $\sin \theta (\csc \theta - \sin \theta) = \sin \theta \csc \theta - \sin^2 \theta = 1 - \sin^2 \theta = \cos^2 \theta$

23. $\tan \theta (\csc \theta + \cot \theta) = \tan \theta \csc \theta + \tan \theta \cot \theta =$

$\frac{\sin \theta}{\cos \theta} \frac{1}{\sin \theta} + 1 = \frac{1}{\cos \theta} + 1 = \sec \theta + 1$

25. $\tan^2 \theta \csc^2 \theta - \tan^2 \theta = \tan^2 \theta (\csc^2 \theta - 1) = \tan^2 \theta (\cot^2 \theta) = 1$

27. $\frac{\sin \theta \cos \theta + \sin \theta}{\cos \theta + \cos^2 \theta} = \frac{\sin \theta (\cos \theta + 1)}{\cos \theta (1 + \cos \theta)} = \frac{\sin \theta}{\cos \theta} = \tan \theta$

29. $\frac{1 + \sin \theta}{\cos \theta + \cos \theta \sin \theta} = \frac{(1)(1 + \sin \theta)}{(\cos \theta)(1 + \sin \theta)} = \frac{1}{\cos \theta} = \sec \theta$

31. $\frac{\sin \theta \tan \theta + \sin \theta}{\tan \theta + \tan^2 \theta} = \frac{\sin \theta (\tan \theta + 1)}{\tan \theta (1 + \tan \theta)} =$

$\frac{\sin \theta}{\tan \theta} = \frac{\sin \theta}{\frac{\sin \theta}{\cos \theta}} = \frac{\sin \theta \cos \theta}{\sin \theta} = \cos \theta$

33. $\frac{(\sin \theta + \cos \theta)^2}{\cos \theta} = \frac{\sin^2 \theta + 2 \sin \theta \cos \theta + \cos^2 \theta}{\cos \theta} =$

$\frac{\cos^2 \theta + \sin^2 \theta + 2 \sin \theta \cos \theta}{\cos \theta} = \frac{1 + 2 \sin \theta \cos \theta}{\cos \theta} =$

$\frac{1}{\cos \theta} + \frac{2 \sin \theta \cos \theta}{\cos \theta} = \sec \theta + 2 \sin \theta$

35. $(1 + \sin \theta)(1 - \sin \theta) = 1 - \sin^2 \theta = \cos^2 \theta$

37. $\frac{(\csc \theta - \cot \theta)(\csc \theta + \cot \theta)}{\tan \theta} = \frac{\csc^2 \theta - \cot^2 \theta}{\tan \theta} = \frac{1}{\tan \theta} = \cot \theta$

39. $\frac{\cos^2 \theta}{\sin \theta} + \frac{\sin \theta}{1} = \frac{\cos^2 \theta + \sin^2 \theta}{\sin \theta} = \frac{1}{\sin \theta} = \csc \theta$

$$41. \frac{\tan \theta}{\csc \theta} - \frac{\sin \theta}{\cos \theta} = \frac{\tan \theta \cos \theta - \sin \theta \csc \theta}{\csc \theta \cos \theta} = \frac{\frac{\sin \theta}{\cos \theta} \cos \theta - 1}{\frac{1}{\sin \theta} \cos \theta} = \frac{\sin \theta - 1}{\cot \theta}$$

$$43. \frac{\sec \theta}{\sin \theta} - \frac{\csc \theta}{\sec \theta} = \frac{\sec^2 \theta - \sin \theta \csc \theta}{\sin \theta \sec \theta} = \frac{\sec^2 \theta - 1}{\sin \theta \frac{1}{\cos \theta}} = \frac{\tan^2 \theta}{\tan \theta} = \tan \theta$$

$$45. \frac{\sin \theta}{\pm \sqrt{1 - \sin^2 \theta}} \quad 47. \pm \sqrt{\frac{1}{\cot^2 \theta} + 1} \quad 49. \frac{\pm \sqrt{1 - \sin^2 \theta}}{\sin \theta}$$

$$51. \sin \theta = \frac{21}{29}, \tan \theta = -\frac{21}{20}, \sec \theta = -\frac{29}{20}, \csc \theta = \frac{29}{21}, \cot \theta = -\frac{20}{21}$$

$$53. \cos \theta = -\frac{8}{17}, \sin \theta = -\frac{15}{17}, \sec \theta = -\frac{17}{8}, \csc \theta = -\frac{17}{15}, \cot \theta = \frac{8}{15}$$

$$55. \cos \theta = \frac{x}{\sqrt{x^2 + 25}}, \sin \theta = \frac{5}{\sqrt{x^2 + 25}}, \tan \theta = \frac{5}{x},$$

$$\sec \theta = \frac{\sqrt{x^2 + 25}}{x}, \csc \theta = \frac{\sqrt{x^2 + 25}}{5}$$

$$57. \cos \theta = -\frac{\sqrt{120}}{13} = -\frac{2\sqrt{30}}{13}, \tan \theta = \frac{7}{2\sqrt{30}}, \sec \theta = -\frac{13}{2\sqrt{30}}$$

$$\csc \theta = -\frac{13}{7}, \cot \theta = \frac{2\sqrt{30}}{7}$$

$$59. \sin \theta = \frac{\sqrt{32}}{9} = \frac{4\sqrt{2}}{9}, \cos \theta = -\frac{7}{9}, \tan \theta = -\frac{4\sqrt{2}}{7},$$

$$\csc \theta = \frac{9}{4\sqrt{2}}, \cot \theta = -\frac{7}{4\sqrt{2}}$$

$$61. V = 2(1 - \cos^2 \theta)$$

$$63. \cos^3 \theta = \cos \theta \cos^2 \theta = \cos \theta (1 - \sin^2 \theta)$$

$$65. \tan \theta + \tan^3 \theta = \tan \theta (1 + \tan^2 \theta) = \tan \theta \sec^2 \theta$$

$$67. \tan^2 \theta \sec \theta - 4 \tan^2 \theta = \tan^2 \theta (\sec \theta - 4)$$

$$= (\sec \theta - 4)(\tan^2 \theta) = (\sec \theta - 4)(\sec^2 \theta - 1)$$

$$= (\sec \theta - 4)(\sec \theta - 1)(\sec \theta + 1)$$

$$69. \cos^2 \theta \sin \theta - \cos^2 \theta = \cos^2 \theta (\sin \theta - 1)$$

$$= (1 - \sin^2 \theta)(\sin \theta - 1)$$

$$= (1 + \sin \theta)(1 - \sin \theta)(\sin \theta - 1)$$

$$= (1 + \sin \theta)(1 - \sin \theta)(-1)(1 - \sin \theta)$$

$$= -1(1 + \sin \theta)(1 - \sin \theta)^2$$

$$71. \tan \theta = \frac{m_2 - m_1}{1 + m_1 m_2}$$

$$73. \tan \theta = 1$$

$$75. -2 \sin^4 \theta + \sqrt{3} \sin^3 \theta + 2 \sin^2 \theta - \sqrt{3} \sin \theta$$

$$= \sin \theta (-2 \sin^3 \theta + \sqrt{3} \sin^2 \theta + 2 \sin \theta - \sqrt{3})$$

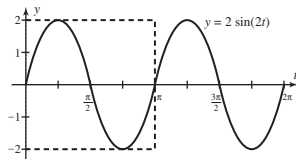
$$= \sin \theta [(-2 \sin^3 \theta + \sqrt{3} \sin^2 \theta) + (2 \sin \theta - \sqrt{3})]$$

$$= \sin \theta [-\sin^2 \theta (2 \sin \theta - \sqrt{3}) + 1(2 \sin \theta - \sqrt{3})]$$

$$= \sin \theta (1 - \sin^2 \theta)(2 \sin \theta - \sqrt{3})$$

$$= \sin \theta \cos^2 \theta (2 \sin \theta - \sqrt{3})$$

$$77. \text{about } 1148 \text{ ft} \quad 79.$$



Exercises 7.2, pp. 666–669

1. identities, symmetry 3. complicated, simplify, build 5. Because we don't know if the equation is true.

$$7. (1 + \sin x)[1 + \sin(-x)] = (1 + \sin x)(1 - \sin x) = 1 - \sin^2 x = \cos^2 x$$

$$9. \sin^2(-x) + \cos^2 x = (-\sin x)^2 + \cos^2 x = \sin^2 x + \cos^2 x = 1$$

$$11. \frac{1 - \sin(-x)}{\cos x + \cos(-x) \sin x} = \frac{1 + \sin x}{\cos x + \cos x \sin x} = \frac{1 + \sin x}{\cos x(1 + \sin x)}$$

$$= \frac{1}{\cos x} = \sec x$$

$$13. \cos^2 x \tan^2 x = \cos^2 x \frac{\sin^2 x}{\cos^2 x} = \sin^2 x = 1 - \cos^2 x$$

$$15. \tan x + \cot x = \frac{\sin x}{\cos x} + \frac{\cos x}{\sin x}$$

$$= \frac{\sin^2 x + \cos^2 x}{\cos x \sin x}$$

$$= \frac{1}{\cos x \sin x}$$

$$= \frac{1}{\frac{1}{2} \sin 2x} = \frac{2}{\sin 2x}$$

$$17. \csc x - \sin x = \frac{1}{\sin x} - \sin x$$

$$= \frac{1 - \sin^2 x}{\sin x}$$

$$= \frac{\cos^2 x}{\sin x}$$

$$= \frac{\sin x}{\cos x} = \tan x$$

$$19. \frac{\sec x}{\cot x + \tan x} = \frac{\frac{1}{\cos x}}{\left(\frac{\cos x}{\sin x} + \frac{\sin x}{\cos x}\right)(\sin x \cos x)}$$

$$= \frac{\frac{1}{\cos x}}{\frac{\cos^2 x + \sin^2 x}{\sin x \cos x}}$$

$$= \frac{1}{\cos x} \cdot \frac{\sin x \cos x}{\cos^2 x + \sin^2 x}$$

$$= \frac{\sin x}{\cos x} = \tan x$$

$$21. \frac{\sin x - \csc x}{\csc x} = \frac{\sin x - \frac{1}{\sin x}}{\frac{1}{\sin x}}$$

$$= \left(\sin x - \frac{1}{\sin x}\right)(\sin x)$$

$$= \frac{1}{\sin x} \sin x$$

$$= \frac{\sin^2 x - 1}{1}$$

$$= -\cos^2 x$$

$$23. \frac{1}{\csc x - \sin x} = \frac{1}{\frac{1}{\sin x} - \sin x}$$

$$= \frac{1}{\frac{1 - \sin^2 x}{\sin x}}$$

$$= \frac{\sin x}{1 - \sin^2 x}$$

$$= \frac{\cos^2 x}{\sin x} = \frac{1}{\cos x} \sec x = \tan x \sec x$$

$$25. \frac{\cos \theta}{1 - \sin \theta} = \frac{\cos \theta}{1 - \sin \theta} \cdot \frac{1 + \sin \theta}{1 + \sin \theta}$$

$$= \frac{\cos \theta (1 + \sin \theta)}{1 - \sin^2 \theta}$$

$$= \frac{\cos \theta (1 + \sin \theta)}{\cos^2 \theta (1 + \sin \theta)}$$

$$= \frac{\cos^2 \theta}{1 + \sin \theta}$$

$$= \frac{1}{\cos \theta} + \frac{\sin \theta}{\cos \theta}$$

$$= \sec \theta + \tan \theta$$

$$\begin{aligned}
 27. \frac{\cos x}{1 + \sin x} &= \frac{\cos x}{1 + \sin x} \cdot \frac{1 - \sin x}{1 - \sin x} \\
 &= \frac{\cos x(1 - \sin x)}{\cos x(1 - \sin x)} \\
 &= \frac{1 - \sin^2 x}{\cos x(1 - \sin x)} \\
 &= \frac{\cos^2 x}{\cos^2 x} \\
 &= \frac{1 - \sin x}{\cos x}
 \end{aligned}$$

$$\begin{aligned}
 29. \frac{\csc x}{\cos x} - \frac{\cos x}{\csc x} &= \frac{\csc^2 x - \cos^2 x}{\cos x \csc x} \\
 &= \frac{\csc^2 x - (1 - \sin^2 x)}{\cos x \frac{1}{\sin x}} \\
 &= \frac{\csc^2 x - 1 + \sin^2 x}{\frac{\cot x}{\sin x}} \\
 &= \frac{\cot^2 x + \sin^2 x}{\cot x}
 \end{aligned}$$

$$\begin{aligned}
 31. \frac{\sin x}{1 + \sin x} - \frac{\sin x}{1 - \sin x} &= \frac{\sin x(1 - \sin x) - \sin x(1 + \sin x)}{(1 + \sin x)(1 - \sin x)} \\
 &= \frac{\sin x - \sin^2 x - \sin x - \sin^2 x}{1 - \sin^2 x} \\
 &= \frac{-2 \sin^2 x}{\cos^2 x} \\
 &= -2 \tan^2 x
 \end{aligned}$$

$$\begin{aligned}
 33. \frac{\cot x}{1 + \csc x} - \frac{\cot x}{1 - \csc x} &= \frac{\cot x(1 - \csc x) - \cot x(1 + \csc x)}{(1 + \csc x)(1 - \csc x)} \\
 &= \frac{\cot x - \cot x \csc x - \cot x - \cot x \csc x}{1 - \csc^2 x} \\
 &= \frac{-2 \cot x \csc x}{- \cot^2 x} \\
 &= \frac{2 \csc x}{\cot x} \\
 &= \frac{2 \frac{1}{\sin x}}{\frac{\cos x}{\sin x}} \\
 &= \frac{2}{\cos x} \\
 &= 2 \sec x
 \end{aligned}$$

$$\begin{aligned}
 35. \frac{\sec^2 x}{1 + \cot^2 x} &= \frac{\sec^2 x}{\csc^2 x} \\
 &= \frac{\cos^2 x}{1} \\
 &= \frac{\sin^2 x}{\sin^2 x} \\
 &= \frac{\cos^2 x}{\cos^2 x} \\
 &= \tan^2 x
 \end{aligned}$$

$$\begin{aligned}
 37. \sin^2 x(\cot^2 x - \csc^2 x) &= \sin^2 x \cot^2 x - \sin^2 x \csc^2 x \\
 &= \sin^2 x \frac{\cos^2 x}{\sin^2 x} - 1 \\
 &= \cos^2 x - 1 \\
 &= -\sin^2 x
 \end{aligned}$$

$$\begin{aligned}
 39. \cos x \cot x + \sin x &= \cos x \frac{\cos x}{\sin x} + \sin x \\
 &= \frac{\cos^2 x}{\sin x} + \sin x \\
 &= \frac{\cos^2 x + \sin^2 x}{\sin x} \\
 &= \frac{1}{\sin x} \\
 &= \csc x
 \end{aligned}$$

$$\begin{aligned}
 41. \frac{1 + \sin x}{1 - \sin x} &= \frac{(1 + \sin x)(1 + \sin x)}{(1 - \sin x)(1 + \sin x)} \\
 &= \frac{1 + 2 \sin x + \sin^2 x}{1 - \sin^2 x} \\
 &= \frac{\cos^2 x}{\cos^2 x} \\
 &= \frac{1}{\cos^2 x} + 2 \frac{\sin x}{\cos x} \frac{1}{\cos x} + \frac{\sin^2 x}{\cos^2 x} \\
 &= \sec^2 x + 2 \tan x \sec x + \tan^2 x \\
 &= (\sec x + \tan x)^2 \\
 &= (\tan x + \sec x)^2
 \end{aligned}$$

$$\begin{aligned}
 43. \frac{\cos x - \sin x}{1 - \tan x} &= \frac{(\cos x - \sin x)(\cos x + \sin x)}{(1 - \tan x)(\cos x + \sin x)} \\
 &= \frac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x + \sin x - \sin x - \frac{\sin^2 x}{\cos x}} \\
 &= \frac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x \left(1 - \frac{\sin^2 x}{\cos^2 x}\right)} \\
 &= \frac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x(1 - \tan^2 x)} \\
 &= \frac{(\cos x - \sin x)(1 + \tan x)}{(\cos x - \sin x)(\cos x + \sin x)} \\
 &= \frac{(\cos x - \sin x)(1 + \tan x)}{\cos x + \sin x} \\
 &= \frac{1 + \tan x}{1 + \tan x}
 \end{aligned}$$

$$\begin{aligned}
 45. \frac{\tan^2 x - \cot^2 x}{\tan x - \cot x} &= \frac{(\tan x + \cot x)(\tan x - \cot x)}{\tan x - \cot x} \\
 &= \tan x + \cot x \\
 &= \frac{\sin x}{\cos x} + \frac{\cos x}{\sin x} \\
 &= \frac{\sin^2 x + \cos^2 x}{\cos x \sin x} \\
 &= \frac{1}{\cos x \sin x} \\
 &= \frac{1}{\cos x} \frac{1}{\sin x} \\
 &= \sec x \csc x \\
 &= \csc x \sec x
 \end{aligned}$$

$$\begin{aligned}
 47. \frac{\cot x}{\cot x + \tan x} &= \frac{\frac{\cos x}{\sin x}}{\frac{\cos x}{\sin x} + \frac{\sin x}{\cos x}} \frac{(\cos x \sin x)}{(\cos x \sin x)} \\
 &= \frac{\cos^2 x}{\cos^2 x + \sin^2 x} \\
 &= \frac{\cos^2 x}{1} \\
 &= 1 - \sin^2 x
 \end{aligned}$$

$$\begin{aligned}
 49. \frac{\sec^4 x - \tan^4 x}{\sec^2 x + \tan^2 x} &= \frac{(\sec^2 x - \tan^2 x)(\sec^2 x + \tan^2 x)}{(\sec^2 x + \tan^2 x)} \\
 &= \sec^2 x - \tan^2 x \\
 &= 1
 \end{aligned}$$

$$\begin{aligned}
 51. \frac{\cos^4 x - \sin^4 x}{\cos^2 x} &= \frac{(\cos^2 x - \sin^2 x)(\cos^2 x + \sin^2 x)}{(\cos^2 x - \sin^2 x)(1)} \\
 &= \frac{\cos^2 x}{\cos^2 x} - \frac{\sin^2 x}{\cos^2 x} \\
 &= 1 - \tan^2 x \\
 &= 1 - (\sec^2 x - 1) \\
 &= 1 - \sec^2 x + 1 \\
 &= 2 - \sec^2 x
 \end{aligned}$$

$$\begin{aligned}
 53. (\sec x + \tan x)^2 &= \sec^2 x + 2 \sec x \tan x + \tan^2 x \\
 &= \frac{1}{\cos^2 x} + \frac{2 \sin x}{\cos^2 x} + \frac{\sin^2 x}{\cos^2 x} \\
 &= \frac{1 + 2 \sin x + \sin^2 x}{\cos^2 x} \\
 &= \frac{(1 + \sin x)^2}{\cos^2 x} \\
 &= \frac{\cos^2 x}{(\sin x + 1)^2}
 \end{aligned}$$

$$\begin{aligned}
 55. \frac{\cos x}{\sin x} + \frac{\sin x}{\cos x} + \frac{\csc x}{\sec x} &= \frac{\cos^2 x \sec x + \sin^2 x \sec x + \csc x \sin x \cos x}{\sin x \cos x \sec x} \\
 &= \frac{\sec x (\cos^2 x + \sin^2 x) + (1) \cos x}{\sin x (1)} \\
 &= \frac{\sec x + \cos x}{\sin x}
 \end{aligned}$$

$$\begin{aligned}
 57. \frac{\sin^4 x - \cos^4 x}{\sin^3 x + \cos^3 x} &= \frac{(\sin^2 x + \cos^2 x)(\sin^2 x - \cos^2 x)}{(\sin x + \cos x)(\sin^2 x - \sin x \cos x + \cos^2 x)} \\
 &= \frac{(1)(\sin x + \cos x)(\sin x - \cos x)}{(\sin x + \cos x)(\sin^2 x + \cos^2 x - \sin x \cos x)} \\
 &= \frac{\sin x - \cos x}{1 - \sin x \cos x}
 \end{aligned}$$

59. Answers will vary. 61. Answers will vary. 63. Answers will vary.

65. identity 67. not an identity

$$\begin{aligned}
 69. \mathbf{a.} \ d^2 &= (20 + x \cos \theta)^2 + (20 - x \sin \theta)^2 \\
 &= 400 + 40x \cos \theta + x^2 \cos^2 \theta + 400 - 40x \sin \theta + x^2 \sin^2 \theta \\
 &= 800 + 40x(\cos \theta - \sin \theta) + x^2(\cos^2 \theta + \sin^2 \theta) \\
 &= 800 + 40x(\cos \theta - \sin \theta) + x^2
 \end{aligned}$$

b. ≈ 42.2 ft

$$\begin{aligned}
 71. \mathbf{a.} \ h &= \sqrt{\cot x + \tan x} \\
 h &\approx 3.76
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{b.} \ \cot x + \tan x &= \frac{\cos x}{\sin x} + \frac{\sin x}{\cos x} \\
 &= \frac{\cos^2 x + \sin^2 x}{\sin x \cos x} \\
 &= \frac{1}{\sin x \cos x} \\
 &= \csc x \sec x;
 \end{aligned}$$

$$h = \sqrt{\csc x \sec x}$$

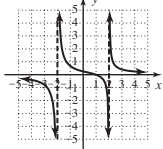
$$h \approx 3.76; \text{ yes}$$

$$\begin{aligned}
 73. D^2 &= 400 + 40x \cos \theta + x^2 \\
 D &\approx 40.5 \text{ ft}
 \end{aligned}$$

$$75. \sin \alpha = \cos \theta$$

$$\begin{aligned}
 77. \frac{\sin^6 x - \cos^6 x}{\sin^4 x - \cos^4 x} &= \frac{(\sin^3 x - \cos^3 x)(\sin^3 x + \cos^3 x)}{(\sin^2 x + \cos^2 x)(\sin^2 x - \cos^2 x)} \\
 &= \frac{(\sin x - \cos x)(\sin^2 x + \sin x \cos x + \cos^2 x)(\sin x + \cos x)(\sin^2 x - \sin x \cos x + \cos^2 x)}{(1)(\sin x + \cos x)(\sin x - \cos x)} \\
 &= (1 + \sin x \cos x)(1 - \sin x \cos x) \\
 &= 1 - \sin^2 x \cos^2 x
 \end{aligned}$$

$$79. \quad \mathbf{81.} \approx 752.3 \text{ yd}$$



Exercises 7.3, pp. 675–680

1. false, QII 3. repeat, opposite 5. Answers will vary.

$$7. \frac{\sqrt{2} - \sqrt{6}}{4} \quad 9. \frac{\sqrt{2} - \sqrt{6}}{4}$$

$$11. \mathbf{a.} \ \cos(45^\circ + 30^\circ) = \cos 45^\circ \cos 30^\circ - \sin 45^\circ \sin 30^\circ = \frac{\sqrt{6} - \sqrt{2}}{4}$$

$$\begin{aligned}
 \mathbf{b.} \ \cos(120^\circ - 45^\circ) &= \cos 120^\circ \cos 45^\circ + \sin 120^\circ \sin 45^\circ = \\
 &= \frac{-\sqrt{2} + \sqrt{6}}{4} = \frac{\sqrt{6} - \sqrt{2}}{4}
 \end{aligned}$$

$$13. \cos(5\theta) \quad 15. \frac{\sqrt{3}}{2} \quad 17. -\frac{16}{65} \quad 19. \sin 33^\circ \quad 21. \cot\left(\frac{\pi}{12}\right)$$

$$23. \cos\left(\frac{\pi}{3} + \theta\right) \quad 25. \sin(8x) \quad 27. \tan(3\theta) \quad 29. 1 \quad 31. \sqrt{3}$$

$$33. \mathbf{a.} \frac{-304}{425} \quad \mathbf{b.} \frac{-304}{297} \quad 35. \frac{\sqrt{6} + \sqrt{2}}{4} \quad 37. \frac{\sqrt{6} + \sqrt{2}}{4}$$

$$39. -\frac{1}{\sqrt{3}} = -\frac{\sqrt{3}}{3} \quad 41. \frac{3 + \sqrt{3}}{3 - \sqrt{3}}$$

$$43. \mathbf{a.} \ \sin(45^\circ - 30^\circ) = \sin 45^\circ \cos 30^\circ - \cos 45^\circ \sin 30^\circ = \frac{\sqrt{6} - \sqrt{2}}{4}$$

$$\begin{aligned}
 \mathbf{b.} \ \sin(135^\circ - 120^\circ) &= \sin 135^\circ \cos 120^\circ - \cos 135^\circ \sin 120^\circ \\
 &= \left(\frac{\sqrt{2}}{2}\right)\left(-\frac{1}{2}\right) - \left(-\frac{\sqrt{2}}{2}\right)\left(\frac{\sqrt{3}}{2}\right) \\
 &= \frac{-\sqrt{2}}{4} + \frac{\sqrt{6}}{4} \\
 &= \frac{\sqrt{6} - \sqrt{2}}{4}
 \end{aligned}$$

$$45. \frac{-\sqrt{2} - \sqrt{6}}{4} \quad 47. \mathbf{a.} \frac{319}{481} \quad \mathbf{b.} \frac{480}{481} \quad \mathbf{c.} -\frac{319}{360}$$

$$49. \mathbf{a.} \frac{3416}{4505} \quad \mathbf{b.} -\frac{1767}{4505} \quad \mathbf{c.} \frac{3416}{2937}$$

$$51. \mathbf{a.} \frac{12 + 5\sqrt{3}}{26} \quad \mathbf{b.} \frac{12\sqrt{3} - 5}{26} \quad \mathbf{c.} \frac{12 + 5\sqrt{3}}{12\sqrt{3} - 5}$$

$$53. \mathbf{a.} \frac{247}{265} \quad \mathbf{b.} \frac{96}{265} \quad \mathbf{c.} \frac{247}{96} \quad (90^\circ - \alpha) + \theta + (90^\circ - \beta) = 180^\circ$$

$$\begin{aligned}
 55. \sin(\pi - \alpha) &= \sin \pi \cos \alpha - \cos \pi \sin \alpha \\
 &= 0 - (-1)\sin \alpha \\
 &= \sin \alpha
 \end{aligned}$$

$$\begin{aligned}
 57. \cos\left(x + \frac{\pi}{4}\right) &= \cos x \cos\left(\frac{\pi}{4}\right) - \sin x \sin\left(\frac{\pi}{4}\right) = \\
 \cos x\left(\frac{\sqrt{2}}{2}\right) - \sin x\left(\frac{\sqrt{2}}{2}\right) &= \frac{\sqrt{2}}{2}(\cos x - \sin x)
 \end{aligned}$$

$$\begin{aligned}
 59. \tan\left(x + \frac{\pi}{4}\right) &= \frac{\tan x + \tan\left(\frac{\pi}{4}\right)}{1 - \tan x \tan\left(\frac{\pi}{4}\right)} = \frac{\tan x + 1}{1 - \tan x} = \frac{1 + \tan x}{1 - \tan x}
 \end{aligned}$$

$$\begin{aligned}
 61. \cos(\alpha + \beta) + \cos(\alpha - \beta) &= \\
 \cos \alpha \cos \beta - \sin \alpha \sin \beta + \cos \alpha \cos \beta + \sin \alpha \sin \beta &= \\
 2 \cos \alpha \cos \beta
 \end{aligned}$$

$$\begin{aligned}
 63. \cos(2t) &= \cos(t + t) \\
 &= \cos t \cos t - \sin t \sin t \\
 &= \cos^2 t - \sin^2 t
 \end{aligned}$$

$$\begin{aligned}
 65. \sin(3t) &= \sin(2t + t) \\
 &= \sin(2t) \cos t + \cos(2t) \sin t \\
 &= 2 \sin t \cos t \cos t + (\cos^2 t - \sin^2 t) \sin t \\
 &= 2 \sin t \cos^2 t + \sin t \cos^2 t - \sin^3 t \\
 &= 3 \sin t \cos^2 t - \sin^3 t \\
 &= 3 \sin t(1 - \sin^2 t) - \sin^3 t \\
 &= 3 \sin t - 3 \sin^3 t - \sin^3 t \\
 &= -4 \sin^3 t + 3 \sin t
 \end{aligned}$$

$$\begin{aligned}
 67. \cos\left(x - \frac{\pi}{4}\right) &= \cos x \cos\left(\frac{\pi}{4}\right) + \sin x \sin\left(\frac{\pi}{4}\right) \\
 &= \cos x\left(\frac{\sqrt{2}}{2}\right) + \sin x\left(\frac{\sqrt{2}}{2}\right) \\
 &= \frac{\sqrt{2}}{2}(\cos x + \sin x)
 \end{aligned}$$

$$69. F = \frac{Wk}{c} \frac{1 - \sqrt{3}}{1 + \sqrt{3}}$$

$$71. R = \frac{\cos s \cos t}{\omega C \sin(s+t)} = \frac{\cos s \cos t}{\omega C(\sin s \cos t + \cos s \sin t)} = \frac{1}{\omega C(\sin s \cos t + \cos s \sin t)} = \frac{1}{\omega C\left(\frac{\sin s \cos t}{\cos s \cos t} + \frac{\cos s \sin t}{\cos s \cos t}\right)} = \frac{1}{\omega C(\tan s + \tan t)}$$

$$73. \frac{A}{B} = \frac{\sin \theta \cos(90^\circ - \theta)}{\cos \theta \sin(90^\circ - \theta)} = \frac{\sin \theta (\cos 90^\circ \cos \theta + \sin 90^\circ \sin \theta)}{\cos \theta (\sin 90^\circ \cos \theta - \cos 90^\circ \sin \theta)} = \frac{\sin \theta (\cos \theta + \sin \theta)}{\cos \theta (\cos \theta - 0)} = \frac{\sin^2 \theta}{\cos^2 \theta} = \tan^2 \theta$$

75. verified using sum identity for sine

$$77. \frac{f(x+h) - f(x)}{h} = \frac{\sin(x+h) - \sin x}{h} = \frac{\sin x \cos h + \cos x \sin h - \sin x}{h} = \frac{\sin x \cos h - \sin x + \cos x \sin h}{h} = \frac{\sin x(\cos h - 1) + \cos x \sin h}{h} = \sin x \left(\frac{\cos h - 1}{h}\right) + \cos x \left(\frac{\sin h}{h}\right)$$

$$79. \frac{-\sqrt{2}}{2} \quad 81. \frac{1}{2}$$

$$83. D = d, \text{ so } D^2 = d^2, \text{ and } D^2 = (\cos \alpha - \cos \beta)^2 + (\sin \alpha - \sin \beta)^2 = \cos^2 \alpha - 2 \cos \alpha \cos \beta + \cos^2 \beta + \sin^2 \alpha - 2 \sin \alpha \sin \beta + \sin^2 \beta = 2 - 2 \cos \alpha \cos \beta - 2 \sin \alpha \sin \beta$$

$$d^2 = \sin^2(\alpha - \beta) + [\cos(\alpha - \beta) - 1]^2 = \sin^2(\alpha - \beta) + \cos^2(\alpha - \beta) - 2 \cos(\alpha - \beta) + 1 = 2 - 2 \cos(\alpha - \beta)$$

$$D^2 = d^2 \text{ so } 2 - 2 \cos \alpha \cos \beta - 2 \sin \alpha \sin \beta = 2 - 2 \cos(\alpha - \beta)$$

$$\frac{-2 \cos \alpha \cos \beta - 2 \sin \alpha \sin \beta}{-2} = \frac{-2 \cos(\alpha - \beta)}{-2}$$

$$\cos \alpha \cos \beta + \sin \alpha \sin \beta = \cos(\alpha - \beta)$$

85. a. $P = 16$ b. $P = \frac{\pi}{2}$ 87. about 19.3 ft

Exercises 7.4, pp. 688–693

1. sum, $\alpha = \beta$ 3. $2x$, x 5. Answers will vary.

$$7. \sin(2\theta) = -\frac{120}{169}, \cos(2\theta) = \frac{119}{169}, \tan(2\theta) = -\frac{120}{119}$$

$$9. \sin(2\theta) = -\frac{720}{1681}, \cos(2\theta) = -\frac{1519}{1681}, \tan(2\theta) = \frac{720}{1519}$$

$$11. \sin(2\theta) = \frac{2184}{7225}, \cos(2\theta) = \frac{6887}{7225}, \tan(2\theta) = \frac{2184}{6887}$$

$$13. \sin(2\theta) = -\frac{5280}{5329}, \cos(2\theta) = \frac{721}{5329}, \tan(2\theta) = \frac{-5280}{721}$$

$$15. \sin(2\theta) = -\frac{24}{25}, \cos(2\theta) = \frac{7}{25}, \tan(2\theta) = \frac{-24}{7}$$

$$17. \sin \theta = \frac{4}{5}, \cos \theta = \frac{3}{5}, \tan \theta = \frac{4}{3}$$

$$19. \sin \theta = \frac{21}{29}, \cos \theta = \frac{20}{29}, \tan \theta = \frac{21}{20}$$

$$21. \sin(3\theta) = \sin(2\theta + \theta) = \sin(2\theta)\cos \theta + \cos(2\theta)\sin \theta = (2 \sin \theta \cos \theta)\cos \theta + (1 - 2 \sin^2 \theta)\sin \theta = 2 \sin \theta \cos^2 \theta + \sin \theta - 2 \sin^3 \theta = 2 \sin \theta(1 - \sin^2 \theta) + \sin \theta - 2 \sin^3 \theta = 2 \sin \theta - 2 \sin^3 \theta + \sin \theta - 2 \sin^3 \theta = 3 \sin \theta - 4 \sin^3 \theta$$

$$23. \frac{1}{4} \quad 25. \frac{\sqrt{2}}{2} \quad 27. 1 \quad 29. 4.5 \sin(6x) \quad 31. \frac{1}{8} - \frac{1}{8} \cos(4x)$$

$$33. \frac{9}{8} + \frac{3}{2} \cos(2x) + \frac{3}{8} \cos(4x)$$

$$35. \frac{5}{8} - \frac{7}{8} \cos(2x) + \frac{3}{8} \cos(4x) - \frac{1}{8} \cos(2x)\cos(4x)$$

$$37. \sin \theta = \frac{\sqrt{2} - \sqrt{2}}{2}, \cos \theta = \frac{\sqrt{2} + \sqrt{2}}{2}, \tan \theta = \sqrt{2} - 1$$

$$39. \sin \theta = \frac{\sqrt{2} - \sqrt{3}}{2}, \cos \theta = \frac{\sqrt{2} + \sqrt{3}}{2}, \tan \theta = 2 - \sqrt{3}$$

$$41. \sin \theta = \frac{\sqrt{2} + \sqrt{2}}{2}, \cos \theta = \frac{\sqrt{2} - \sqrt{2}}{2}, \tan \theta = \sqrt{2} + 1$$

$$43. \sin \theta = \frac{\sqrt{2} + \sqrt{2}}{2}, \cos \theta = \frac{\sqrt{2} - \sqrt{2}}{2}, \tan \theta = \sqrt{2} + 1$$

$$45. \frac{\sqrt{2} - \sqrt{2} + \sqrt{2}}{2} \quad 47. \frac{\sqrt{2} - \sqrt{2} + \sqrt{3}}{2} \quad 49. \cos 15^\circ$$

$$51. \tan 2\theta \quad 53. \tan x$$

$$55. \sin\left(\frac{\theta}{2}\right) = \frac{3}{\sqrt{13}}, \cos\left(\frac{\theta}{2}\right) = \frac{2}{\sqrt{13}}, \tan\left(\frac{\theta}{2}\right) = \frac{3}{2}$$

$$57. \sin\left(\frac{\theta}{2}\right) = \frac{3}{\sqrt{10}}, \cos\left(\frac{\theta}{2}\right) = \frac{1}{\sqrt{10}}, \tan\left(\frac{\theta}{2}\right) = 3$$

$$59. \sin\left(\frac{\theta}{2}\right) = \frac{7}{\sqrt{74}}, \cos\left(\frac{\theta}{2}\right) = \frac{5}{\sqrt{74}}, \tan\left(\frac{\theta}{2}\right) = \frac{7}{5}$$

$$61. \sin\left(\frac{\theta}{2}\right) = \frac{1}{\sqrt{226}}, \cos\left(\frac{\theta}{2}\right) = \frac{15}{\sqrt{226}}, \tan\left(\frac{\theta}{2}\right) = \frac{1}{15}$$

$$63. \sin\left(\frac{\theta}{2}\right) = \frac{5}{\sqrt{29}}, \cos\left(\frac{\theta}{2}\right) = -\frac{2}{\sqrt{29}}, \tan\left(\frac{\theta}{2}\right) = \frac{5}{-2}$$

$$65. \frac{1}{2} [\cos(12\theta) - \cos(4\theta)] \quad 67. \sin(5t) - \sin(2t)$$

$$69. \cos(1540\pi t) + \cos(2418\pi t) \quad 71. \frac{1 + \sqrt{3}}{2} \quad 73. \frac{\sqrt{2}}{4}$$

$$75. 2 \cos\left(\frac{13}{2}h\right)\cos\left(\frac{5}{2}h\right) \quad 77. 2 \cos x \sin\left(\frac{3}{8}x\right)$$

$$79. 2 \cos(1072\pi t) \cos(375\pi t)$$

$$81. \frac{\sqrt{6}}{2} \quad 83. -\frac{\sqrt{2}}{2} \quad 85. \frac{2 \sin x \cos x}{\cos^2 x - \sin^2 x} = \frac{\sin(2x)}{\cos(2x)} = \tan(2x)$$

$$87. (\sin x + \cos x)^2 = \sin^2 x + 2 \sin x \cos x + \cos^2 x = \sin^2 x + \cos^2 x + 2 \sin x \cos x = 1 + \sin(2x)$$

$$89. \cos(8\theta) = \cos(2 \cdot 4\theta) = \cos^2(4\theta) - \sin^2(4\theta)$$

$$91. \frac{\cos(2\theta)}{\sin^2 \theta} = \frac{\cos^2 \theta - \sin^2 \theta}{\sin^2 \theta} = \frac{\cos^2 \theta}{\sin^2 \theta} - \frac{\sin^2 \theta}{\sin^2 \theta} = \cot^2 \theta - 1$$

$$\begin{aligned}
 93. \tan(2\theta) &= \frac{2 \tan \theta}{1 - \tan^2 \theta} \\
 &= \frac{(2 \tan \theta) \frac{1}{\tan \theta}}{(1 - \tan^2 \theta) \frac{1}{\tan \theta}} \\
 &= \frac{2}{\frac{1}{\tan \theta} - \tan \theta} \\
 &= \frac{2}{\cot \theta - \tan \theta}
 \end{aligned}$$

$$\begin{aligned}
 95. 2 \csc(2x) &= \frac{2}{\sin(2x)} \\
 &= \frac{2}{2 \sin x \cos x} \\
 &= \frac{1}{\sin x \cos x} \\
 &= \frac{\sin^2 x + \cos^2 x}{\sin x \cos x} \\
 &= \frac{\sin^2 x}{\sin x \cos x} + \frac{\cos^2 x}{\sin x \cos x} \\
 &= \frac{\sin x}{\cos x} + \frac{\cos x}{\sin x} \\
 &= \tan x + \cot x
 \end{aligned}$$

$$97. \cos^2\left(\frac{x}{2}\right) - \sin^2\left(\frac{x}{2}\right) = \cos\left(2 \cdot \frac{x}{2}\right) = \cos x$$

$$\begin{aligned}
 99. 1 - 4 \sin^2 \theta + 4 \sin^4 \theta &= (1 - 2 \sin^2 \theta)^2 \\
 &= [\cos(2\theta)]^2 \\
 &= \cos^2(2\theta) \\
 &= 1 - \sin^2(2\theta)
 \end{aligned}$$

$$\begin{aligned}
 101. \frac{\sin(120\pi t) + \sin(80\pi t)}{\cos(120\pi t) - \cos(80\pi t)} &= \frac{2 \sin(100\pi t) \cos(20\pi t)}{-2 \sin(100\pi t) \sin(20\pi t)} \\
 &= \frac{\cos(20\pi t)}{\sin(20\pi t)} \\
 &= -\cot(20\pi t)
 \end{aligned}$$

$$\begin{aligned}
 103. \sin^2 \alpha + (1 - \cos \alpha)^2 &= \sin^2 \alpha + 1 - 2 \cos \alpha + \cos^2 \alpha \\
 &= \sin^2 \alpha + \cos^2 \alpha + 1 - 2 \cos \alpha \\
 &= 1 + 1 - 2 \cos \alpha \\
 &= 2 - 2 \cos \alpha \\
 &= 2(1 - \cos \alpha) \\
 &= 4 \left(\frac{1 - \cos \alpha}{2} \right) \\
 &= 4 \sin^2 \left(\frac{\alpha}{2} \right) \\
 &= \left[2 \sin \left(\frac{\alpha}{2} \right) \right]^2
 \end{aligned}$$

$$\begin{aligned}
 105. \sin(2\alpha) &= \sin(\alpha + \alpha) \\
 &= \sin \alpha \cos \alpha + \cos \alpha \sin \alpha \\
 &= \sin \alpha \cos \alpha + \sin \alpha \cos \alpha \\
 &= 2 \sin \alpha \cos \alpha \\
 \tan(2\alpha) &= \tan(\alpha + \alpha) \\
 &= \frac{\tan \alpha + \tan \alpha}{1 - \tan \alpha \tan \alpha} \\
 &= \frac{2 \tan \alpha}{1 - \tan^2 \alpha}
 \end{aligned}$$

$$\begin{aligned}
 107. \frac{\cos \alpha \cos \beta + \sin \alpha \sin \beta}{-(\cos \alpha \cos \beta - \sin \alpha \sin \beta)} &= \frac{\cos(\alpha - \beta)}{-\cos(\alpha + \beta)} \\
 2 \sin \alpha \sin \beta &= \cos(\alpha - \beta) - \cos(\alpha + \beta) \\
 \sin \alpha \sin \beta &= \frac{1}{2} [\cos(\alpha - \beta) - \cos(\alpha + \beta)]
 \end{aligned}$$

$$109. \text{ a. } \mathcal{M} = \frac{2}{\sqrt{2 - \sqrt{3}}}, \mathcal{M} \approx 3.9 \quad \text{ b. } \mathcal{M} = \frac{2}{\sqrt{2 - \sqrt{2}}}, \mathcal{M} \approx 2.6$$

$$\text{ c. } \theta = 60^\circ$$

$$111. \text{ a. } (288 - 144\sqrt{2}) \text{ ft} \approx 84.3 \text{ ft} \quad \text{ b. } (288 - 144\sqrt{2}) \text{ ft} \approx 84.3 \text{ ft}$$

$$113. y(t) = 2 \cos(2174\pi t) \cos(780\pi t)$$

$$115. \cos[2\pi(1209)t] + \cos[2\pi(941)t]; \text{ the } \boxed{\text{key}}$$

$$\begin{aligned}
 117. d(t) &= \left| 6 \sin\left(\frac{\pi t}{60}\right) \right| \\
 &= \left| 6 \sin\left(\frac{1}{2} \cdot \frac{\pi t}{30}\right) \right| \\
 &= \left| 6 \left(\pm \sqrt{\frac{1 - \cos\left(\frac{\pi t}{30}\right)}{2}} \right) \right| \\
 &= 6 \sqrt{\frac{1 - \cos\left(\frac{\pi t}{30}\right)}{2}} \\
 &= \sqrt{36 \frac{1 - \cos\left(\frac{\pi t}{30}\right)}{2}} \\
 &= \sqrt{18 \left[1 - \cos\left(\frac{\pi t}{30}\right) \right]}
 \end{aligned}$$

$$\begin{aligned}
 119. \text{ A: } \sin(2\theta - 90^\circ) + 1 &= \sin(2\theta) \cos 90^\circ - \cos(2\theta) \sin 90^\circ + 1 \\
 &= 0 - \cos(2\theta) + 1 \\
 &= 1 - \cos(2\theta)
 \end{aligned}$$

$$\begin{aligned}
 \text{ B: } 2 \sin^2 \theta &= \sin^2 \theta + \sin^2 \theta \\
 &= 1 - \cos^2 \theta + \sin^2 \theta \\
 &= 1 - (\cos^2 \theta - \sin^2 \theta) \\
 &= 1 - \cos(2\theta)
 \end{aligned}$$

$$\begin{aligned}
 \text{ C: } 1 + \sin^2 \theta - \cos^2 \theta &= 1 - (\cos^2 \theta - \sin^2 \theta) \\
 &= 1 - \cos(2\theta)
 \end{aligned}$$

$$\text{ D: } 1 - \cos(2\theta) = 1 - \cos(2\theta)$$

$$121. \text{ a. } \approx 0.9659; \approx 0.9659$$

$$\begin{aligned}
 \text{ b. } \left(\frac{\sqrt{2} + \sqrt{3}}{2} \right)^2 &\stackrel{?}{=} \left(\frac{\sqrt{6} + \sqrt{2}}{4} \right)^2 \\
 \frac{2 + \sqrt{3}}{4} &\stackrel{?}{=} \frac{6 + 2\sqrt{12} + 2}{16} \\
 \frac{2 + \sqrt{3}}{4} &\stackrel{?}{=} \frac{8 + 4\sqrt{3}}{16} \\
 \frac{2 + \sqrt{3}}{4} &= \frac{2 + \sqrt{3}}{4}
 \end{aligned}$$

$$123. \text{ Answers will vary; One example is } \frac{\sqrt{3}}{3}, 1, -2 - \sqrt{3}$$

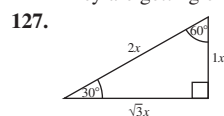
$$125. \cos 15^\circ = \frac{\sqrt{2 + \sqrt{3}}}{2}$$

$$\cos 7.5^\circ = \frac{\sqrt{2 + \sqrt{2 + \sqrt{3}}}}{2}$$

$$\cos 3.75^\circ = \frac{\sqrt{2 + \sqrt{2 + \sqrt{2 + \sqrt{3}}}}}{2} \approx 0.9979$$

$$\cos 1.875^\circ = \frac{\sqrt{2 + \sqrt{2 + \sqrt{2 + \sqrt{2 + \sqrt{3}}}}}}{2} \approx 0.9995;$$

They are getting close to 1.



$$129. y = 2 \sin\left(x + \frac{\pi}{4}\right) + 1$$

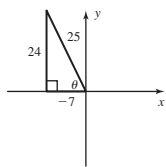
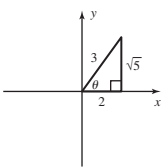
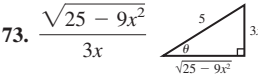
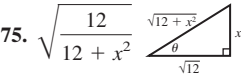
Mid-Chapter Check, p. 693

- $$\begin{aligned} \sin x[\csc x - \sin x] &= \sin x \csc x - \sin^2 x \\ &= \sin x \frac{1}{\sin x} - \sin^2 x \\ &= 1 - \sin^2 x \\ &= \cos^2 x \end{aligned}$$
- $$\begin{aligned} \cos^2 x - \cot^2 x &= \cos^2 x - \frac{\cos^2 x}{\sin^2 x} \\ &= \cos^2 x \left(1 - \frac{1}{\sin^2 x} \right) \\ &= \cos^2 x (1 - \csc^2 x) \\ &= \cos^2 x (-\cot^2 x) \\ &= -\cos^2 x \cot^2 x \end{aligned}$$
- $$\begin{aligned} \frac{2 \sin x}{\sec x} - \frac{\cos x}{\csc x} &= \frac{2 \sin x \csc x - \cos x \sec x}{\sec x \csc x} \\ &= \frac{2(1) - 1}{\sec x \csc x} \\ &= \frac{1}{\sec x \csc x} \\ &= \cos x \sin x \end{aligned}$$
- $$\begin{aligned} 1 + \sec^2 x &= \tan^2 x \\ 1 + \sec^2 0 &= \tan^2 0 \\ 1 + 1^2 &= 0^2 \\ 1 + 1 &= 0 \\ 2 &= 0 \text{ False} \end{aligned}$$
- $$\begin{aligned} \frac{\sin^3 x + \cos^3 x}{\sin x + \cos x} &= \frac{(\sin x + \cos x)(\sin^2 x - \sin x \cos x + \cos^2 x)}{(\sin x + \cos x)} \\ &= \sin^2 x + \cos^2 x - \sin x \cos x \\ &= 1 - \sin x \cos x \end{aligned}$$
 - $$\begin{aligned} \frac{1 + \sec x}{\csc x} - \frac{1 + \cos x}{\cot x} &= \frac{1 + \frac{1}{\cos x}}{\frac{1}{\sin x}} - \frac{1 + \cos x}{\frac{\cos x}{\sin x}} \\ &= \left(\sin x + \frac{\sin x}{\cos x} \right) - \left(\frac{\sin x}{\cos x} + \sin x \right) \\ &= \sin x + \frac{\sin x}{\cos x} - \frac{\sin x}{\cos x} - \sin x \\ &= 0 \end{aligned}$$
- $$\begin{aligned} \frac{\sec^2 x - \tan^2 x}{\sec^2 x} &= \frac{\sec^2 x}{\sec^2 x} - \frac{\tan^2 x}{\sec^2 x} \\ &= 1 - \frac{\frac{\sin^2 x}{\cos^2 x}}{\frac{1}{\cos^2 x}} \\ &= 1 - \frac{\sin^2 x}{\cos^2 x} \\ &= 1 - \tan^2 x \\ &= \cos^2 x \end{aligned}$$
 - $$\begin{aligned} \frac{\cot x - \tan x}{\csc x \sec x} &= \frac{\cot x}{\csc x \sec x} - \frac{\tan x}{\csc x \sec x} \\ &= \frac{\frac{\cos x}{\sin x}}{\frac{1}{\sin x} \cdot \frac{1}{\cos x}} - \frac{\frac{\sin x}{\cos x}}{\frac{1}{\sin x} \cdot \frac{1}{\cos x}} \\ &= \frac{1}{\sin x} \cdot \frac{1}{\cos x} - \frac{1}{\sin x} \cdot \frac{1}{\cos x} \\ &= \frac{\cos^2 x \sin x}{\sin x \cos x} - \frac{\sin^2 x \cos x}{\sin x \cos x} \\ &= \cos^2 x - \sin^2 x \end{aligned}$$
- $$\frac{456}{5785} \quad \text{b. } \frac{3193}{5785} \quad \text{c. } \frac{456}{5767}$$
- $$\sin A = \frac{7 + 24\sqrt{3}}{50}, \cos A = \frac{24 - 7\sqrt{3}}{50}, \tan A = \frac{7 + 24\sqrt{3}}{24 - 7\sqrt{3}}$$
- $$\sin\left(\frac{\theta}{2}\right) = \frac{4}{\sqrt{17}}, \cos\left(\frac{\theta}{2}\right) = \frac{1}{\sqrt{17}}$$
- $$\sin(2\alpha) = \frac{336}{625}, \cos(2\alpha) = \frac{527}{625}, \tan(2\alpha) = \frac{336}{527}$$

Reinforcing Basic Concepts, pp. 693–694

- $$\begin{aligned} \cos^2 x + \sin^2 x &= 1 \\ \frac{\cos^2 x}{\sin^2 x} + \frac{\sin^2 x}{\sin^2 x} &= \frac{1}{\sin^2 x} \\ \cot^2 x + 1 &= \csc^2 x \checkmark \\ \cos^2 x + \sin^2 x &= 1 \\ \frac{\cos^2 x}{\cos^2 x} + \frac{\sin^2 x}{\cos^2 x} &= \frac{1}{\cos^2 x} \\ 1 + \tan^2 x &= \sec^2 x \checkmark \end{aligned}$$
- $$\begin{aligned} \cos(2\alpha) &= \cos(\alpha + \alpha) \\ &= \cos \alpha \cos \alpha - \sin \alpha \sin \alpha \\ &= \cos^2 \alpha - \sin^2 \alpha \\ &= \cos^2 \alpha - (1 - \cos^2 \alpha) \\ &= 2 \cos^2 \alpha - 1 \\ &= \cos^2 \alpha - \sin^2 \alpha \\ &= (1 - \sin^2 \alpha) - \sin^2 \alpha \\ &= 1 - 2 \sin^2 \alpha \end{aligned}$$

Exercises 7.5, pp. 705–710

- horizontal, line, one, one
- $[-1, 1], \left[-\frac{\pi}{2}, \frac{\pi}{2}\right]$
- $\cos^{-1}\left(\frac{1}{5}\right)$
- $0; \frac{1}{2}; -\frac{\pi}{6}; -\frac{\pi}{2}$
- $\frac{\pi}{4}$
- $\frac{\pi}{2}$
- 1.0956, 62.8°
- 0.3876, 22.2°
- $\frac{\sqrt{2}}{2}$
- $\frac{\pi}{3}$
- 45°
- 0.8205
- $0; \frac{\sqrt{3}}{2}; 120^\circ; \pi$
- $\frac{\pi}{3}$
- π
- 1.4352; 82.2°
- 0.7297; 41.8°
- $\frac{\pi}{4}$
- 0.5560
- $-\frac{\sqrt{2}}{2}$
- $\frac{3\pi}{4}$
- $0; -\sqrt{3}; 30^\circ; \sqrt{3}; \frac{\pi}{3}$
- $-\frac{\pi}{6}$
- $\frac{\pi}{3}$
- 1.1170, -64.0°
- 0.9441, 54.1°
- $-\frac{\pi}{6}$
- $\frac{\sqrt{3}}{3}$
- $\sqrt{2}$
- 120°
- cannot evaluate $\tan\left(\frac{\pi}{2}\right)$
- $\csc \frac{\pi}{4} = \sqrt{2} > 1$, not in domain of $\sin^{-1}x$.
- $\sin \theta = \frac{3}{5}, \cos \theta = \frac{4}{5}, \tan \theta = \frac{3}{4}$
- $\sin \theta = \frac{\sqrt{x^2 - 36}}{x}, \cos \theta = \frac{6}{x}, \tan \theta = \frac{\sqrt{x^2 - 36}}{6}$
- 
- 
- 
- 
- 0; 2; 30°; -1; π
- $\frac{\pi}{6}$ or 30°
- $\frac{\pi}{6}$ or 30°
- 80.1°
- 67.8°
- $[-1, 1]$
- $(-\infty, \infty)$
- $F_N \approx 2.13 \text{ N}; F_T \approx 1.56 \text{ N}$
 - $\theta \approx 63^\circ$ for $F_N = 1 \text{ N}, \theta \approx 24.9^\circ$ for $F_N = 2 \text{ N}$
- $\approx 30^\circ$
- $\theta \approx 72.3^\circ$; straight line distance; $\approx 157.5 \text{ yd}$
- $\theta = \tan^{-1}\left(\frac{75}{d}\right) - \tan^{-1}\left(\frac{50}{d}\right)$
 - $d \in (39.2, 95.7)$
- $\theta \approx 11.5^\circ$ at $d \approx 61.2 \text{ ft}$
- $\theta = \tan^{-1}\left(\frac{94}{d}\right) - \tan^{-1}\left(\frac{70}{d}\right)$
 - $\theta \approx 8.4^\circ$ at $d \approx 81.1 \text{ ft}$
- $\theta \approx 15.5^\circ; \theta \approx 0.2710 \text{ rad}$
 - $\approx 27 \text{ mi}$
- $\sin(\alpha + \beta) = 1$
- $P = \frac{77}{5}t + 28$
 - sales increasing by 15.4 packages/year
 - 182

Exercises 7.6, pp. 717–721

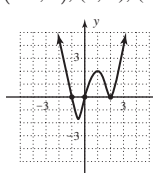
1. principal, $[0, 2\pi)$, real 3. $\frac{\pi}{4}, \frac{\pi}{4}, \frac{3\pi}{4}, \frac{\pi}{4} + 2\pi k; \frac{3\pi}{4} + 2\pi k$
 5. Answers will vary. 7. a. QIV b. 2 roots 9. a. QIV b. 2 roots

11.

θ	$\sin \theta$	$\cos \theta$	$\tan \theta$
0	0	1	0
$\frac{\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$
$\frac{\pi}{3}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$
$\frac{\pi}{2}$	1	0	und.
$\frac{2\pi}{3}$	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$
$\frac{5\pi}{6}$	$\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$-\frac{\sqrt{3}}{3}$
π	0	-1	0
$\frac{7\pi}{6}$	$-\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$
$\frac{4\pi}{3}$	$-\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$\sqrt{3}$

13. $\frac{\pi}{4}$ 15. $-\frac{\pi}{4}$ 17. $\frac{\pi}{6}$ 19. $-\frac{\pi}{3}$ 21. π 23. $\frac{\pi}{3}$ 25. $\frac{\pi}{6}$ 27. $\frac{5\pi}{6}$
 29. $\frac{\pi}{6}, \frac{5\pi}{6}$ 31. $\frac{2\pi}{3}, \frac{5\pi}{3}$ 33. $\frac{3\pi}{4}, \frac{7\pi}{4}$ 35. $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$
 37. $\frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3}$ 39. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$ 41. $\frac{\pi}{2}, \frac{3\pi}{2}$
 43. $\theta \approx 70.5^\circ$ or 289.5° 45. $x = 30^\circ, 90^\circ, 150^\circ$, or 270°
 47. $x = 120^\circ, 240^\circ$, or $x \approx 82.8^\circ$ or 277.2°
 49. $x = 30^\circ, 150^\circ, 210^\circ$, or 330° 51. $x = \frac{5\pi}{4} + 2\pi k$ or $\frac{7\pi}{4} + 2\pi k$
 53. $x = \frac{3\pi}{4} + 2\pi k$ or $\frac{5\pi}{4} + 2\pi k$ 55. $x = \frac{3\pi}{4} + \pi k$
 57. $x = \frac{\pi}{3} + \pi k$ or $\frac{2\pi}{3} + \pi k$ 59. $x = \frac{3\pi}{8} + \frac{\pi}{2}k$ 61. $x = 3\pi + 6\pi k$
 63. $x = \frac{\pi}{2} + \pi k$ 65. $x = \frac{\pi}{6} + \frac{\pi}{3}k$ or $\frac{\pi}{12} + \pi k$ or $\frac{5\pi}{12} + \pi k$
 67. a. $x \approx 1.2310$ b. $x \approx 1.2310 + 2\pi k, 5.0522 + 2\pi k$
 69. a. $x \approx 1.2094$ b. $x \approx 1.2094 + 2\pi k, 5.0738 + 2\pi k$
 71. a. $\theta \approx 0.3649$ b. $\theta \approx 0.3649 + \pi k, 1.2059 + \pi k$
 73. a. $\theta \approx 0.8861$ b. $\theta \approx 0.8861 + \pi k, 2.2555 + \pi k$
 75. $x = \frac{\pi}{6} + \pi k$ or $\frac{5\pi}{6} + \pi k$ 77. $x = \frac{2\pi}{9} + \frac{4\pi}{3}k$ or $\frac{10\pi}{9} + \frac{4\pi}{3}k$
 79. $\theta = \frac{\pi}{2}k$ 81. $\theta \approx 0.3398 + 2\pi k$ or $2.8018 + 2\pi k$
 83. 22.1° and 67.9° 85. 0° ; the ramp is horizontal
 87. 30.7° ; smaller 89. $\alpha = 35^\circ, \beta \approx 25.5^\circ$
 91. $k \approx 1.36, \alpha \approx 20.6^\circ$ 93. a. 7 in. b. ≈ 1.05 in. and ≈ 5.24 in.
 95. $\frac{\pi}{2} + \pi k$, explanations will vary
 97. $f(2+i) = (2+i)^2 - 4(2+i) + 5$
 $= 4 + 4i + i^2 - 8 - 4i + 5$
 $= 4 + 4i - 1 - 8 - 4i + 5$
 $= 0$
 99. a. $-\frac{1}{\sqrt{3}}$ b. $-\frac{\sqrt{2}}{2}$

Exercises 7.7, pp. 728–732

1. $\cos^2 x + \sin^2 x = 1, 1 + \tan^2 x = \sec^2 x, \cot^2 x + 1 = \csc^2 x$
 3. squaring 5. Answers will vary.
 7. $\frac{\pi}{12}, \frac{5\pi}{12}$ 9. 0 11. 0.4456, 1.1252 13. $\frac{\pi}{4}, \frac{5\pi}{4}, \frac{\pi}{6}, \frac{5\pi}{6}$
 15. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}, 0.8411, 5.4421$ 17. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$
 19. $\frac{\pi}{6}, \frac{5\pi}{6}, 0.7297, 2.4119$ 21. $\frac{2\pi}{3}$
 23. $\frac{\pi}{9} + \frac{2\pi}{3}k, \frac{5\pi}{9} + \frac{2\pi}{3}k; k = 0, 1, 2$ 25. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$
 27. $x \approx 0.7290$ 29. $x \approx 2.6649$ 31. $x \approx 0.4566$
 33. $x \approx 1.1706, 4.1287$ 35. $P = 12; x = 3; x = 11$
 37. $P = 24; x \approx 0.4909, x \approx 5.5091$ 39. $\frac{\pi}{12}, \frac{17\pi}{12}$
 41. 0.3747, 5.9085, 2.7669, 3.5163 43. $\frac{\pi}{2}$ ($\frac{3\pi}{2}$ is extraneous)
 45. $\frac{3\pi}{4}, \frac{7\pi}{4}$ 47. $\frac{\pi}{12}, \frac{5\pi}{12}, \frac{13\pi}{12}, \frac{17\pi}{12}$
 49. I. a. $(\frac{5}{2}, \frac{5}{2})$ b. $D = \sqrt{12.5}, \theta = \frac{\pi}{4}, y = \frac{\sqrt{12.5} - x \cos(\frac{\pi}{4})}{\sin(\frac{\pi}{4})}$
 c. verified
 II. a. (2, 4) b. $D = 2\sqrt{5}, \theta \approx 1.1071, y = \frac{2\sqrt{5} - x \cos 1.1071}{\sin 1.1071}$
 c. verified
 III. a. (1, $\sqrt{3}$) b. $D = 2, \theta = \frac{\pi}{3}, y = \frac{2 - x \cos(\frac{\pi}{3})}{\sin(\frac{\pi}{3})}$ c. verified
 51. a. $2500\pi \text{ ft}^3 \approx 7853.98 \text{ ft}^3$ b. $\approx 7824.09 \text{ ft}^3$ c. $\theta \approx 78.5^\circ$
 53. a. $\approx 78.53 \text{ m}^3/\text{sec}$ b. during the months of August, September, October, and November 55. a. $\approx \$3554.52$ b. during the months of May, June, July, and August 57. a. ≈ 12.67 in. b. during the months of April, May, June, July, and August 59. a. ≈ 8.39 gal b. approx. day 214 to day 333 61. a. 68 bpm b. ≈ 176.2 bpm c. from about 4.6 min to 7.4 min 63. 1.1547
 65. a. $y = 19 \cos(\pi - \frac{\pi}{6}x) + 53$ b. $y = -21 \sin(\frac{2\pi}{365}x) + 29$
 67. a. $L \approx 25.5$ cm. b. $\theta \approx 38.9^\circ$ or 31.6°
 69. $(-1, 0), (0, 0), (2, 0)$ (multiplicity 2): up/up;

 71. $\theta \approx 4.56^\circ$

Making Connections, p. 732

1. b 3. e 5. f 7. h 9. g 11. c 13. f 15. g

Summary and Concept Review, pp. 733–737

1. $\sin x(\csc x - \sin x) = \sin x \csc x - \sin x \sin x$
 $= \sin x \frac{1}{\sin x} - \sin^2 x$
 $= 1 - \sin^2 x$
 $= \cos^2 x$

$$2. \frac{\tan^2 x \csc x + \csc x}{\sec^2 x} = \frac{\csc x (\tan^2 x + 1)}{\sec^2 x}$$

$$= \frac{\csc x \sec^2 x}{\sec^2 x}$$

$$= \csc x$$

$$3. \frac{(\sec x - \tan x)(\sec x + \tan x)}{\csc x} = \frac{\sec^2 x - \tan^2 x}{\csc x}$$

$$= \frac{1 + \tan^2 x - \tan^2 x}{\csc x}$$

$$= \frac{1}{\csc x}$$

$$= \sin x$$

$$4. \frac{\sec^2 x}{\csc x} - \sin x = \frac{\sec^2 x - \sin x \csc x}{\csc x}$$

$$= \frac{\sec^2 x - 1}{\csc x}$$

$$= \frac{\tan^2 x}{\csc x}$$

$$5. \sin \theta = -\frac{35}{37}, \csc \theta = -\frac{37}{35}, \cot \theta = \frac{12}{35}, \tan \theta = \frac{35}{12}, \sec \theta = -\frac{37}{12}$$

$$6. \sin \theta = -\frac{4\sqrt{6}}{25}, \csc \theta = -\frac{25}{4\sqrt{6}}, \cot \theta = -\frac{23}{4\sqrt{6}}, \tan \theta = -\frac{4\sqrt{6}}{23},$$

$$\cos \theta = \frac{23}{25}$$

$$7. \frac{\csc^2 x (1 - \cos^2 x)}{\tan^2 x} = \frac{\csc^2 x \sin^2 x}{\tan^2 x}$$

$$= \frac{1}{\tan^2 x}$$

$$= \cot^2 x$$

$$8. \frac{\cot x}{\sec x} - \frac{\csc x}{\tan x} = \cot x \frac{1}{\sec x} - \csc x \csc x$$

$$= \cot x \cos x - \csc x \csc x$$

$$= \cot x (\cos x - \csc x)$$

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

$$= \frac{(\sin^2 x - \cos^2 x)(1)}{\sin x \cos x}$$

$$= \frac{\sin x \sin x}{\sin x \cos x} - \frac{\cos x \cos x}{\sin x \cos x}$$

$$= \frac{\sin x}{\cos x} - \frac{\cos x}{\sin x}$$

$$= \tan x - \cot x$$

$$10. \frac{(\sin x + \cos x)^2}{\sin x \cos x} = \frac{\sin^2 x + 2 \sin x \cos x + \cos^2 x}{\sin x \cos x}$$

$$= \frac{\sin^2 x + \cos^2 x}{\sin x \cos x} + \frac{2 \sin x \cos x}{\sin x \cos x}$$

$$= \frac{1}{\sin x \cos x} + 2$$

$$= \csc x \sec x + 2$$

$$11. \text{a. } \cos 75^\circ = \frac{\sqrt{6} - \sqrt{2}}{4}$$

$$\text{b. } \tan\left(\frac{\pi}{12}\right) = \frac{\sqrt{3} - 1}{1 + \sqrt{3}} = \frac{(\sqrt{3} - 1)^2}{2} = 2 - \sqrt{3}$$

$$12. \text{a. } \tan 15^\circ = \frac{\sqrt{3} - 1}{1 + \sqrt{3}} = \frac{(\sqrt{3} - 1)^2}{2} = 2 - \sqrt{3}$$

$$\text{b. } \sin\left(-\frac{\pi}{12}\right) = \frac{\sqrt{2} - \sqrt{6}}{4} \quad 13. \text{a. } \cos 180^\circ = -1 \quad \text{b. } \sin 120^\circ = \frac{\sqrt{3}}{2}$$

$$14. \text{a. } \cos x \quad \text{b. } \sin\left(\frac{5x}{8}\right) \quad 15. \text{a. } \cos 1170^\circ = \cos 90^\circ = 0$$

$$\text{b. } \sin\left(\frac{57\pi}{4}\right) = \sin\left(\frac{\pi}{4}\right) = \frac{\sqrt{2}}{2} \quad 16. \text{a. } \cos\left(\frac{x}{8}\right) = \sin\left(\frac{\pi}{2} - \frac{x}{8}\right)$$

$$\text{b. } \sin\left(x - \frac{\pi}{12}\right) = \cos\left(\frac{7\pi}{12} - x\right)$$

$$17. \tan(45^\circ - 30^\circ) = \frac{\tan 45^\circ - \tan 30^\circ}{1 + \tan 45^\circ \tan 30^\circ}$$

$$= \frac{1 - \frac{\sqrt{3}}{3}}{1 + 1 \cdot \frac{\sqrt{3}}{3}} = \frac{1 - \frac{\sqrt{3}}{3}}{1 + \frac{\sqrt{3}}{3}} = \frac{3 - \sqrt{3}}{3 + \sqrt{3}}$$

$$= \frac{3 - \sqrt{3}}{3 + \sqrt{3}} \cdot \frac{3 - \sqrt{3}}{3 - \sqrt{3}} = \frac{(3 - \sqrt{3})^2}{3^2 - (\sqrt{3})^2} = \frac{3 - \sqrt{3}}{\sqrt{3} + 1}$$

$$\tan(135^\circ - 120^\circ) = \frac{\tan 135^\circ - \tan 120^\circ}{1 + \tan 135^\circ \tan 120^\circ}$$

$$= \frac{-1 + \sqrt{3}}{1 + (-1)(-\sqrt{3})} = \frac{\sqrt{3} - 1}{1 + \sqrt{3}} = \frac{\sqrt{3} - 1}{\sqrt{3} + 1}$$

$$18. \cos\left(x + \frac{\pi}{6}\right) + \cos\left(x - \frac{\pi}{6}\right)$$

$$= \cos x \cos\left(\frac{\pi}{6}\right) - \sin x \sin\left(\frac{\pi}{6}\right) + \cos x \cos\left(\frac{\pi}{6}\right) + \sin x \sin\left(\frac{\pi}{6}\right)$$

$$= 2 \cos x \cos\left(\frac{\pi}{6}\right) + 0 = 2 \cos x \left(\frac{\sqrt{3}}{2}\right) = \sqrt{3} \cos x$$

$$19. \text{a. } \sin(2\theta) = \frac{-2184}{7225}$$

$$\cos(2\theta) = \frac{-6887}{7225}$$

$$\tan(2\theta) = \frac{2184}{6887}$$

$$\text{b. } \sin(2\theta) = \frac{840}{841}$$

$$\cos(2\theta) = \frac{41}{841}$$

$$\tan(2\theta) = \frac{840}{41}$$

$$20. \text{a. } \sin \theta = \frac{21}{29}, \cos \theta = -\frac{20}{29}, \tan \theta = -\frac{21}{20},$$

$$\text{b. } \sin \theta = \frac{7}{25} \text{ or } \sin \theta = \frac{24}{25}, \cos \theta = \frac{-24}{25} \text{ or } \cos \theta = \frac{-7}{25}, \tan \theta = \frac{-7}{24}$$

$$\text{or } \tan \theta = \frac{-24}{7}$$

$$21. \text{a. } \cos 45^\circ = \frac{\sqrt{2}}{2} \quad \text{b. } \cos\left(\frac{\pi}{6}\right) = \frac{\sqrt{3}}{2}$$

$$22. \text{a. } \sin 67.5^\circ = \frac{\sqrt{2 + \sqrt{2}}}{2}$$

$$\cos 67.5^\circ = \frac{\sqrt{2 - \sqrt{2}}}{2}$$

$$\text{b. } \sin\left(\frac{5\pi}{8}\right) = \frac{\sqrt{2 + \sqrt{2}}}{2}$$

$$\cos\left(\frac{5\pi}{8}\right) = -\frac{\sqrt{2 - \sqrt{2}}}{2}$$

$$23. \text{a. } \sin\left(\frac{\theta}{2}\right) = \frac{1}{5\sqrt{2}}, \frac{\theta}{2} \text{ in QII}$$

$$\cos\left(\frac{\theta}{2}\right) = \frac{-7}{5\sqrt{2}}, \frac{\theta}{2} \text{ in QII}$$

$$\text{b. } \sin\left(\frac{\theta}{2}\right) = \frac{-3}{\sqrt{130}}, \frac{\theta}{2} \text{ in QIV}$$

$$\cos\left(\frac{\theta}{2}\right) = \frac{11}{\sqrt{130}}, \frac{\theta}{2} \text{ in QIV}$$

$$24. \frac{\cos(3\alpha) - \cos \alpha}{\cos(3\alpha) + \cos \alpha} = \frac{-2 \sin(2\alpha) \sin \alpha}{2 \cos(2\alpha) \cos \alpha}$$

$$= \frac{-2 \sin^2 \alpha}{2 \sin^2 \alpha} = \frac{\sin^2 \alpha - \cos^2 \alpha}{\sin^2 \alpha}$$

$$= \frac{1 - 2 \cos^2 \alpha}{\sec^2 \alpha - 2}$$

$$25. \cos(3x) + \cos x = 0 \rightarrow 2 \cos(2x)\cos x = 0$$

$$\cos(2x) = 0: x = \frac{\pi}{4} + \frac{\pi}{2}k; k \in \mathbb{Z}$$

$$\cos x = 0: x = \frac{\pi}{2} + \pi k; k \in \mathbb{Z}$$

$$26. \text{ a. } A = 12^2 \sin\left(\frac{30^\circ}{2}\right) \cos\left(\frac{30^\circ}{2}\right) = 144 \sqrt{\frac{1 - \cos 30^\circ}{2}} \sqrt{\frac{1 + \cos 30^\circ}{2}}$$

$$= 144 \sqrt{\frac{1 - \frac{\sqrt{3}}{2}}{2}} \sqrt{\frac{1 + \frac{\sqrt{3}}{2}}{2}} = 144 \sqrt{\frac{2 - \sqrt{3}}{4}} \sqrt{\frac{2 + \sqrt{3}}{4}}$$

$$= \frac{144\sqrt{4 - 3}}{4} = 36 \text{ cm}^2$$

$$\text{ b. Let } u = \frac{\theta}{2}, \text{ then } x^2 \sin\left(\frac{\theta}{2}\right) \cos\left(\frac{\theta}{2}\right) = x^2 \sin u \cos u =$$

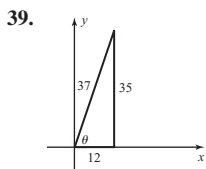
$$\frac{1}{2} x^2 (2 \sin u \cos u) = \frac{1}{2} x^2 \sin(2u)$$

$$= \frac{1}{2} x^2 \sin \theta; A = \frac{1}{2} (12)^2 \sin(30^\circ) = 72 \left(\frac{1}{2}\right) = 36 \text{ cm}^2; \text{ yes}$$

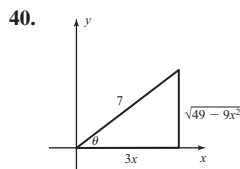
$$27. \frac{\pi}{4} \text{ or } 45^\circ \quad 28. \frac{\pi}{6} \text{ or } 30^\circ \quad 29. \frac{5\pi}{6} \text{ or } 150^\circ \quad 30. 1.3431 \text{ or } 77.0^\circ$$

$$31. 1.0956 \text{ or } 62.8^\circ \quad 32. 0.5054 \text{ or } 29.0^\circ \quad 33. \frac{1}{2} \quad 34. \frac{\pi}{4}$$

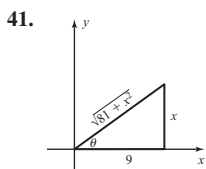
$$35. \text{ undefined} \quad 36. 1.0245 \quad 37. 60^\circ \quad 38. \frac{3\pi}{4}$$



$$\sin \theta = \frac{35}{37}$$



$$\tan \theta = \frac{\sqrt{49 - 9x^2}}{3x}$$



$$\cot \theta = \frac{9}{x}$$

$$42. \theta = \cos^{-1}\left(\frac{x}{5}\right) \quad 43. \theta = \sec^{-1}\left(\frac{x}{7\sqrt{3}}\right)$$

$$44. \theta = \sin^{-1}\left(\frac{x}{4}\right) + \frac{\pi}{6} \quad 45. \text{ a. } \frac{\pi}{4} \quad \text{ b. } \frac{\pi}{4}, \frac{3\pi}{4}$$

$$\text{ c. } x = \frac{\pi}{4} + 2\pi k \text{ or } \frac{3\pi}{4} + 2\pi k, k \in \mathbb{Z} \quad 46. \text{ a. } \frac{2\pi}{3} \quad \text{ b. } \frac{2\pi}{3}, \frac{4\pi}{3}$$

$$\text{ c. } \frac{2\pi}{3} + 2\pi k \text{ or } \frac{4\pi}{3} + 2\pi k, k \in \mathbb{Z} \quad 47. \text{ a. } -\frac{\pi}{3} \quad \text{ b. } \frac{2\pi}{3}, \frac{5\pi}{3}$$

$$\text{ c. } \frac{2\pi}{3} + \pi k, k \in \mathbb{Z} \quad 48. \text{ a. } \approx 1.1102 \quad \text{ b. } \approx 1.1102, 5.1729$$

$$\text{ c. } \approx 1.1102 + 2\pi k \text{ or } 5.1729 + 2\pi k, k \in \mathbb{Z} \quad 49. \text{ a. } \approx 0.3376$$

$$\text{ b. } \approx 0.3376, 1.2332, 3.4792, 4.3748 \quad \text{ c. } \approx 0.3376 + \pi k \text{ or } 1.2332 + \pi k, k \in \mathbb{Z}$$

$$50. \text{ a. } \approx 0.3614 \quad \text{ b. } \approx 0.3614, 2.7802$$

$$\text{ c. } \approx 0.3614 + 2\pi k \text{ or } 2.7802 + 2\pi k, k \in \mathbb{Z} \quad 51. x = \frac{\pi}{12}, \frac{5\pi}{12}$$

$$52. x \approx 0.7297, 2.4119; x = \frac{\pi}{6}, \frac{5\pi}{6} \quad 53. x = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{11\pi}{6} \quad 54. x = \frac{\pi}{2} \quad 55. P = 12; x \approx 2.6931, x \approx 9.3069$$

$$56. P = 6; x = 0, x = \frac{9}{2} \quad 57. \text{ a. } \approx \$43,000 \quad \text{ b. April through August}$$

$$58. \theta \approx 1.1547$$

Practice Test, pp. 737–738

$$1. \frac{(\csc x - \cot x)(\csc x + \cot x)}{\sec x} = \frac{\csc^2 x - \cot^2 x}{\sec x}$$

$$= \frac{1}{\sec x}$$

$$= \cos x$$

$$2. \frac{\sin^3 x - \cos^3 x}{1 + \cos x \sin x} = \frac{(\sin x - \cos x)(\sin^2 x + \sin x \cos x + \cos^2 x)}{1 + \cos x \sin x}$$

$$= \frac{(\sin x - \cos x)(1 + \sin x \cos x)}{1 + \cos x \sin x}$$

$$= \sin x - \cos x$$

$$3. \sin \theta = -\frac{55}{73}, \sec \theta = \frac{73}{48}, \cot \theta = -\frac{48}{55}, \tan \theta = -\frac{55}{48}, \csc \theta = -\frac{73}{55}$$

$$4. \frac{\sqrt{3} - 1}{\sqrt{3} + 1} \quad 5. \cos 45^\circ = \frac{\sqrt{2}}{2} \quad 6. \frac{-\sqrt{2}}{2}$$

$$7. \sin\left(x + \frac{\pi}{4}\right) - \sin\left(x - \frac{\pi}{4}\right)$$

$$= \sin x \cos\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right) - \sin x \cos\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right)$$

$$= \sin\left(\frac{\pi}{4}\right) \cos x + \sin\left(\frac{\pi}{4}\right) \cos x$$

$$= 2 \sin\left(\frac{\pi}{4}\right) \cos x$$

$$= 2 \frac{\sqrt{2}}{2} \cos x$$

$$= \sqrt{2} \cos x$$

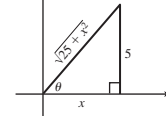
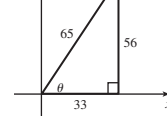
$$8. \sin \theta = \frac{15}{17}, \cos \theta = \frac{8}{17}, \tan \theta = \frac{15}{8} \quad 9. \frac{-\sqrt{3}}{2} \quad 10. \frac{1}{\sqrt{37}}, \frac{6}{\sqrt{37}}$$

$$11. 20\sqrt{2 - \sqrt{2}} \quad 12. \frac{\sqrt{6} - \sqrt{2}}{4} \approx 0.2588; \frac{\sqrt{6} + \sqrt{2}}{4} \approx 0.9659$$

$$13. \text{ a. } y = 30^\circ \quad \text{ b. } y = \frac{1}{2} \quad \text{ c. } y = 30^\circ \quad 14. \text{ a. } y = 0.8523 \text{ rad or}$$

$$y = 48.8^\circ \quad \text{ b. } y = 78.5^\circ \text{ or } \frac{157\pi}{360} \text{ rad} \quad \text{ c. } y = \frac{7\pi}{24} \text{ rad}$$

$$15. \cos \theta = \frac{33}{65} \quad 16. \cot \theta = \frac{x}{5}$$



$$17. \text{ I. a. } \frac{3\pi}{4} \quad \text{ b. } x = \frac{3\pi}{4}, \frac{5\pi}{4} \quad \text{ c. } x = \frac{3\pi}{4} + 2\pi k \text{ or } \frac{5\pi}{4} + 2\pi k, k \in \mathbb{Z}$$

$$\text{ II. a. } \frac{\pi}{6} \quad \text{ b. } x = \frac{\pi}{6}, \frac{11\pi}{6} \quad \text{ c. } x = \frac{\pi}{6} + 2\pi k \text{ or } \frac{11\pi}{6} + 2\pi k, k \in \mathbb{Z}$$

$$18. \text{ I. a. } x \approx 0.1922 \quad \text{ b. } x \approx 0.1922, 1.3786, 3.3338, 4.5202$$

$$\text{ c. } x \approx 0.1922 + \pi k \text{ or } 1.3786 + \pi k, k \in \mathbb{Z} \quad \text{ II. a. } x \approx 0.9204$$

$$\text{ b. } x \approx 0.9204, 2.2212, 4.0620, 5.3628$$

$$\text{ c. } x \approx 0.9204 + \pi k \text{ or } 2.2212 + \pi k, k \in \mathbb{Z}$$

$$19. \text{ a. } x \approx -1.6875, -0.3413, 1.1321, 2.8967$$

$$\text{ b. } x \approx 0.9671, 2.6110, 3.4538$$

$$20. \text{ a. } x = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, \frac{7\pi}{2}, \frac{11\pi}{2} \quad \text{ b. } x = \frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$$

$$21. x = \frac{\pi}{2}, \frac{3\pi}{2}; x \approx 3.3090, 6.1157 \quad 22. x = \frac{5\pi}{6}, \frac{11\pi}{6}$$

$$23. \text{ a. } \$6,000 \quad \text{ b. January through July}$$

$$24. \quad 25. \cos(2418\pi t) + \cos(1540\pi t)$$

Month (Jan → 1)	Low Temp. (°F)
1	-26
3	-21
5	16
7	41
9	24
11	-14

Strengthening Core Skills, pp. 739–740

Exercise 1. $x \in (0.6025, 2.5391)$

Exercise 2. $x \in [0, 0.7945] \cup [4.4415, 2\pi)$

Exercise 3. $x \in [0, 2.6154] \cup [9.3847, 12)$

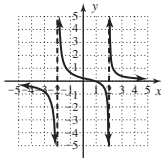
Exercise 4. $x \in (67.3927, 202.6073)$

Cumulative Review Chapters 1–7, pp. 741–742

1. $\sin \theta = \frac{84}{85}$, $\csc \theta = \frac{85}{84}$, $\cos \theta = \frac{-13}{85}$, $\sec \theta = \frac{-85}{13}$,
 $\tan \theta = \frac{-84}{13}$, $\cot \theta = \frac{-13}{84}$

3. $g(2 + \sqrt{3}) = (2 + \sqrt{3})^2 - 4(2 + \sqrt{3}) + 1$
 $= 4 + 4\sqrt{3} + 3 - 8 - 4\sqrt{3} + 1$
 $= 0$

5. about 474 ft 7.



9. 50.89 km/hr 11. $x \in \left[\frac{-9}{2}, \frac{11}{2} \right]$

13. a. $y = -\frac{1}{2}x + 31$ b. every 2 years, the amount of emissions decreases by 1 million tons. c. 23.5 million tons; 11 million tons

15. $x \in (1, 5)$ 17. \$7

19. $\frac{\cos x}{\sec x - 1} = \frac{\cos x(\sec x + 1)}{(\sec x - 1)(\sec x + 1)}$
 $= \frac{1 + \cos x}{\sec^2 x - 1}$
 $= \frac{1 + \cos x}{\cos x + 1}$
 $= \tan^2 x$

21. $\frac{99}{101}$ 23. a. $y = 5.4 \sin\left(\frac{\pi}{6}x - \frac{2\pi}{3}\right) + 27.1$

b. from early May until late August

25. a. volume of a cylinder b. volume of a rectangular solid
 c. circumference of a circle d. area of a triangle

27. a. The function is not in simplified form b. $x = 1.6$

29. $x \in \left[\frac{\pi}{4}, \frac{5\pi}{4} \right]$

Connections to Calculus Exercises, p. 744

1. a. $y = \csc \theta$, b. $y = \csc \left[\tan^{-1}\left(\frac{x}{13}\right) \right]$ c. verified 3. $4 \tan \theta \sec \theta$

5. $\sin \theta$ 7. $0, \frac{2\pi}{3}, \frac{4\pi}{3}, \pi$ 9. $x = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$

CHAPTER 8

Exercises 8.1, pp. 754–759

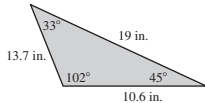
1. ambiguous 3. I, II 5. Answers will vary. 7. $a \approx 8.98$

9. $C \approx 49.2^\circ$ 11. $C \approx 21.4^\circ$

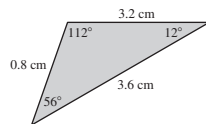
13. $\angle C = 78^\circ$, $b \approx 109.5$ cm, $c \approx 119.2$ cm

15. $\angle C = 90^\circ$, $a = 10$ in., $c = 20$ in.

17. 19. $\angle C = 90^\circ$, $a = 15$ mi, $b = 15$ mi



21. $\angle A = 57^\circ$, $b \approx 49.5$ km, $c \approx 17.1$ km 23.



25. a. 10 cm b. 0 c. 2 d. 1 27. not possible

29. $B = 60^\circ$, $C = 90^\circ$, $b = 12.9\sqrt{3}$ mi

31. $A \approx 39^\circ$, $B \approx 82^\circ$, $a \approx 42.6$ mi or $A \approx 23^\circ$, $B \approx 98^\circ$, $a \approx 26.4$ mi

33. $A \approx 39^\circ$, $B \approx 82^\circ$, $a \approx 42.6$ ft or $A \approx 23^\circ$, $B \approx 98^\circ$, $a \approx 26.4$ ft

35. not possible 37. $A \approx 80.0^\circ$, $B \approx 38.0^\circ$, $b \approx 1.8 \times 10^{25}$ mi or
 $A \approx 100.0^\circ$, $B \approx 18.0^\circ$, $b \approx 9.1 \times 10^{24}$ mi

39. $A_1 \approx 19.3^\circ$, $A_2 \approx 160.7^\circ$, $48^\circ + 160.7^\circ > 180^\circ$; no second solution possible
 41. $C_1 \approx 71.3^\circ$, $C_2 \approx 108.7^\circ$, $57^\circ + 108.7^\circ < 180^\circ$; two solutions possible
 43. not possible, $\sin A > 1$

45. $\sqrt{2}$ 47. 34.5 million miles or 119.7 million miles

49. a. No b. ≈ 3.9 mi 51. $V \leftrightarrow S \approx 41.8$ km, $V \leftrightarrow P \approx 80.8$ km

53. a. No b. about 201.5 ft c. ≈ 15 sec

55. Two triangles

Angles	Sides	Angles	Sides
$A_1 \approx 41.1^\circ$	$a = 12$ cm	$A_2 \approx 138.9^\circ$	$a = 12$ cm
$B = 26^\circ$	$b = 8$ cm	$B = 26^\circ$	$b = 8$ cm
$C_1 \approx 112.9^\circ$	$c_1 \approx 16.8$ cm	$C_2 \approx 15.1^\circ$	$c_2 \approx 4.8$ cm

57.

Angles	Sides	Angles	Sides
$A_1 \approx 48.0^\circ$	$a = 9$	$A_2 \approx 132.0^\circ$	$a = 9$
$B_1 \approx 107.6^\circ$	$b_1 \approx 11.6$	$B_2 = 23.6^\circ$	$b_2 = 4.9$
$C \approx 24.4^\circ$	$c = 5$	$C \approx 24.4^\circ$	$c = 5$

59. $a \approx 33.7$ ft, $c \approx 22.3$ ft 61. ≈ 3.2 mi

63. angle = 90° ; sides ≈ 9.8 cm, 11 cm; diameter ≈ 11 cm; it is a right triangle.
 65. a. about 3187 m b. about 2613 m c. about 2368 m

67. $\sqrt{3} = \frac{\sin 60^\circ}{\sin 30^\circ}$, $\sqrt{2} = \frac{\sin 90^\circ}{\sin 45^\circ}$

69. $A = 19^\circ$, $B = 31^\circ$, $C = 130^\circ$, $a = 45$ cm, $b \approx 71.2$ cm, $c \approx 105.9$ cm

71. $x \approx 0.3747 + 2\pi k$ or $2.7669 + 2\pi k$, $k \in \mathbb{Z}$

73. $x^4 - 3x^3 + 5x^2 - x - 10 = 0$

Exercises 8.2, pp. 766–771

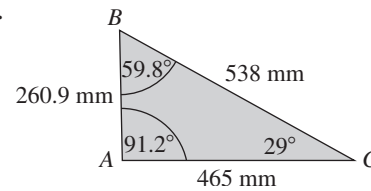
1. cosines 3. Pythagorean 5. $B \approx 33.1^\circ$, $C \approx 129.9^\circ$, $a \approx 19.8$ m; law

of sines 7. yes 9. no 11. yes 13. verified 15. $B \approx 41.4^\circ$

17. $a \approx 7.24$ 19. $A \approx 41.6^\circ$ 21. $A \approx 120.4^\circ$, $B \approx 21.6^\circ$, $c \approx 53.5$ cm

23. $A \approx 23.8^\circ$, $C \approx 126.2^\circ$, $b \approx 16$ mi

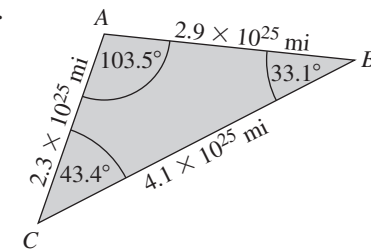
25.



27. $A \approx 137.9^\circ$, $B \approx 15.6^\circ$, $C \approx 26.5^\circ$

29. $A \approx 119.3^\circ$, $B \approx 41.5^\circ$, $C = 19.2^\circ$

31.



33. $A \approx 139.7^\circ$, $B \approx 23.7^\circ$, $C \approx 16.6^\circ$ 35. $A \approx 48.5^\circ$

37. about 1688 mi 39. It cannot be constructed (available length $\approx 10,703.6$ ft).
 41. $P \approx 27.7^\circ$; heading 297.7° 43. 1678.2 mi

45. $P \approx 22.4$ cm, $A = 135^\circ$, $B \approx 23.2^\circ$, $C \approx 21.8^\circ$

47. $A \approx 20.6^\circ$, $B \approx 15.3^\circ$, $C \approx 144.1^\circ$ 49. 58.78 cm

51. $a = 13$ $A \approx 133.2^\circ$
 $b = 5$ $B \approx 16.3^\circ$
 $c = \sqrt{82}$ $C \approx 30.5^\circ$

53. 33.7° ; 150 ft^2 55. a. 65% b. \$1,950,000 57. about 483,529 km^2

59. $387 + 502 = 889 < 902$

61. (1) $a^2 = b^2 + c^2 - 2bc \cos A$; (2) $b^2 = a^2 + c^2 - 2ac \cos B$, use substitution for a^2 and (2) becomes $b^2 = (b^2 + c^2 - 2bc \cos A) + c^2 - 2ac \cos B$. Then $0 = 2c^2 - 2bc \cos A - 2ac \cos B$, $2bc \cos A + 2ac \cos B = 2c^2$, $b \cos A + a \cos B = c$

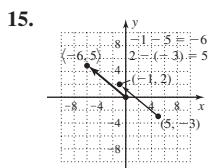
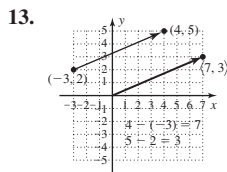
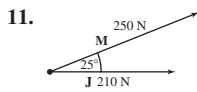
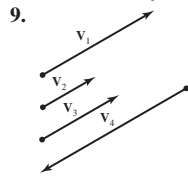
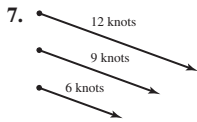
63. 2

65. $\sin x = \frac{-5}{13}$, $\csc x = \frac{-13}{5}$, $\cos x = \frac{12}{13}$, $\sec x = \frac{13}{12}$,

$\tan x = \frac{-5}{12}$, $\cot x = \frac{-12}{5}$

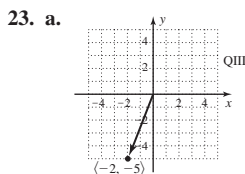
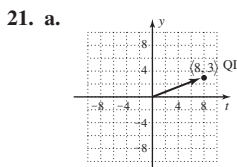
Exercises 8.3, pp. 782–786

1. scalar 3. directed, line 5. Answers will vary.



17. Terminal point: $(5, -1)$, length: $\sqrt{34}$

19. Terminal point: $(-1, 1)$, length: $\sqrt{34}$

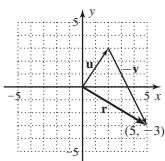
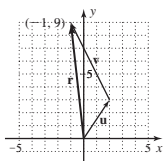


b. $\sqrt{73}$ c. 20.6°

b. $\sqrt{29}$ c. 68.2°

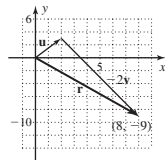
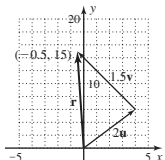
25. $\langle -10.9, 5.1 \rangle$ 27. $\langle 106, -92.2 \rangle$ 29. $\langle -9.7, -2.6 \rangle$

31. a. $\langle -1, 9 \rangle$ b. $\langle 5, -3 \rangle$

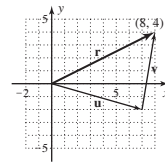


c. $\langle -0.5, 15 \rangle$

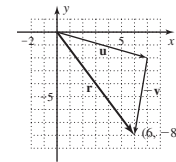
d. $\langle 8, -9 \rangle$



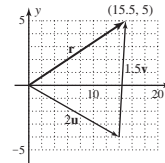
33. a. $\langle 8, 4 \rangle$



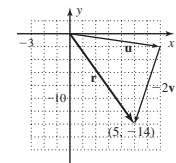
b. $\langle 6, -8 \rangle$



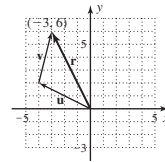
c. $\langle 15.5, 5 \rangle$



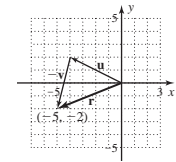
d. $\langle 5, -14 \rangle$



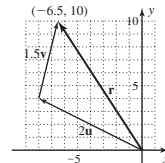
35. a. $\langle -3, 6 \rangle$



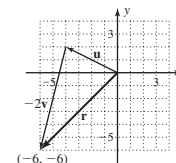
b. $\langle -5, -2 \rangle$



c. $\langle -6.5, 10 \rangle$



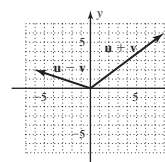
d. $\langle -6, -6 \rangle$



37. True 39. False 41. True

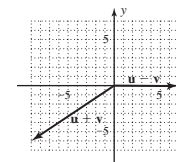
43. $\mathbf{u} + \mathbf{v} = \langle 8, 6 \rangle$

$\mathbf{u} - \mathbf{v} = \langle -6, 2 \rangle$



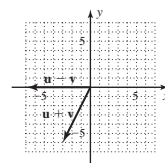
45. $\mathbf{u} + \mathbf{v} = \langle -9, -6 \rangle$

$\mathbf{u} - \mathbf{v} = \langle 7, 0 \rangle$



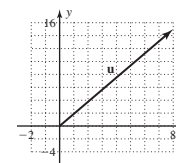
47. $\mathbf{u} + \mathbf{v} = \langle -3, -6 \rangle$

$\mathbf{u} - \mathbf{v} = \langle -7, 0 \rangle$



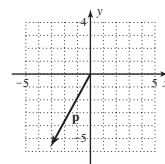
49. $\mathbf{u} = 8\mathbf{i} + 15\mathbf{j}$

$|\mathbf{u}| = 17$

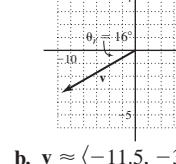


51. $\mathbf{p} = -3.2\mathbf{i} - 5.7\mathbf{j}$

$|\mathbf{p}| \approx 6.54$



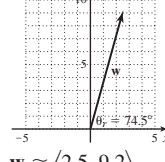
53. a.



b. $\mathbf{v} \approx \langle -11.5, -3.3 \rangle$

c. $\mathbf{v} \approx -11.5\mathbf{i} - 3.3\mathbf{j}$

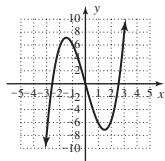
55. a.



b. $\mathbf{w} \approx \langle 2.5, 9.2 \rangle$

c. $\mathbf{w} \approx 2.5\mathbf{i} + 9.2\mathbf{j}$

57. a. $\mathbf{p} = -2\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| = 2\sqrt{2}$, $\theta = 135^\circ$
 b. $\mathbf{q} = 6\mathbf{i} - 8\mathbf{j}$; $|\mathbf{q}| = 10$, $\theta \approx 306.9^\circ$
 c. $\mathbf{r} = -2\mathbf{i} + 1.5\mathbf{j}$; $|\mathbf{r}| \approx 2.5$, $\theta \approx 143.1^\circ$
 d. $\mathbf{s} = 10\mathbf{i} - 13\mathbf{j}$; $|\mathbf{s}| \approx 16.4$, $\theta \approx 307.6^\circ$
 59. a. $\mathbf{p} = 2\sqrt{2}\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| \approx 3.5$, $\theta \approx 35.3^\circ$
 b. $\mathbf{q} = 8\sqrt{2}\mathbf{i} + 12\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 46.7^\circ$
 c. $\mathbf{r} = 5.5\sqrt{2}\mathbf{i} + 6.5\mathbf{j}$; $|\mathbf{r}| \approx 10.1$, $\theta \approx 39.9^\circ$
 d. $\mathbf{s} = 11\sqrt{2}\mathbf{i} + 17\mathbf{j}$; $|\mathbf{s}| \approx 23.0$, $\theta \approx 47.5^\circ$
 61. a. $\mathbf{p} = 8\mathbf{i} + 4\mathbf{j}$; $|\mathbf{p}| \approx 8.9$, $\theta \approx 26.6^\circ$
 b. $\mathbf{q} = 16\mathbf{i} + 4\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 14.0^\circ$
 c. $\mathbf{r} = 18\mathbf{i} + 8\mathbf{j}$; $|\mathbf{r}| \approx 19.7$, $\theta \approx 24.0^\circ$
 d. $\mathbf{s} = 20\mathbf{i} + 4\mathbf{j}$; $|\mathbf{s}| \approx 20.4$, $\theta \approx 11.3^\circ$
 63. $\left\langle \frac{7}{25}, \frac{24}{25} \right\rangle$, verified 65. $\left\langle \frac{-20}{29}, \frac{21}{29} \right\rangle$, verified
 67. $\frac{20}{29}\mathbf{i} - \frac{21}{29}\mathbf{j}$, verified 69. $\frac{7}{25}\mathbf{i} + \frac{24}{25}\mathbf{j}$, verified
 71. $\left\langle \frac{13}{\sqrt{178}}, \frac{3}{\sqrt{178}} \right\rangle$, verified 73. $\frac{6}{\sqrt{157}}\mathbf{i} + \frac{11}{\sqrt{157}}\mathbf{j}$, verified
 75. $\approx 4.48 \left\langle \frac{5}{\sqrt{29}}, \frac{2}{\sqrt{29}} \right\rangle \approx \langle 4.16, 1.66 \rangle$
 77. $\approx 5.83 \left\langle \frac{8}{\sqrt{73}}, \frac{-3}{\sqrt{73}} \right\rangle \approx \langle 5.46, -2.05 \rangle$ 79. ≈ 14.4 81. $\approx 24.3^\circ$
 83. hor. comp. ≈ 79.9 ft/sec; vert. comp. ≈ 60.2 ft/sec
 85. heading 68.2° at 266.7 mph 87. $\approx \langle 82.10 \text{ cm}, 22.00 \text{ cm} \rangle$
 89. $1\langle a, b \rangle = \langle 1a, 1b \rangle = \langle a, b \rangle$
 91. $\langle a, b \rangle - \langle c, d \rangle = \langle a - c, b - d \rangle = \langle a + (-c), b + (-d) \rangle$
 $= \langle a, b \rangle + \langle -c, -d \rangle = \langle a, b \rangle + -1\langle c, d \rangle = \mathbf{u} + (-1\mathbf{v})$
 93. $(ck)\mathbf{u} = \langle cka, ckb \rangle = c\langle ka, kb \rangle = c(k\mathbf{u})$
 $c(k\mathbf{u}) = \langle cka, ckb \rangle = \langle kca, kcb \rangle = k\langle ca, cb \rangle = k(c\mathbf{u})$
 95. $\mathbf{u} + (-\mathbf{u}) = \langle a, b \rangle + \langle -a, -b \rangle = \langle a - a, b - b \rangle = \langle 0, 0 \rangle$
 97. $(c + k)\mathbf{u} = (c + k)\langle a, b \rangle = \langle (c + k)a, (c + k)b \rangle$
 $= \langle ca + ka, cb + kb \rangle = \langle ca, cb \rangle + \langle ka, kb \rangle = c\mathbf{u} + k\mathbf{u}$
 99. $\langle 1, 3 \rangle + \langle 3, 3 \rangle + \langle 4, -1 \rangle + \langle 2, -4 \rangle + \langle -4, -3 \rangle + \langle -6, 2 \rangle = \langle 0, 0 \rangle$
 101. Answers will vary, one possibility: $0^\circ, 81.4^\circ, -33.9^\circ$
 103. a. not a real number b. not possible c. not a real number
 105. $x = 0, \pm\sqrt{7}$



Mid-Chapter Check, p. 786

1. $\sin B = \frac{b \sin A}{a}$ 2. $\cos B = \frac{a^2 + c^2 - b^2}{2ac}$
 3. $a \approx 129$ m, $B \approx 93.3^\circ$, $C \approx 55.7^\circ$
 4. $A \approx 42.3^\circ$, $B \approx 81.5^\circ$, $C \approx 56.2^\circ$
 5. $A = 44^\circ$ $a = 2.1$ km $B \approx 68.1^\circ$ $b \approx 2.8$ km $C \approx 67.9^\circ$ $c = 2.8$ km
 or
 $A = 44^\circ$ $a = 2.1$ km $B \approx 23.9^\circ$ $b \approx 1.2$ km $C \approx 112.1^\circ$ $c = 2.8$ km
 7. about 60.7 ft 8. 169 m
 9. $\alpha \approx 49.6^\circ$
 $\beta \approx 92.2^\circ$
 $\gamma \approx 38.2^\circ$
 10. 9.4 mi

Reinforcing Basic Concepts, pp. 786–787

Angles	Sides
$A = 35^\circ$	$a \approx 11.6$ cm
$B \approx 81.5^\circ$	$a = 20$ cm
$C \approx 63.5^\circ$	$c = 18$ cm

Very close.

Exercises 8.4, pp. 798–801

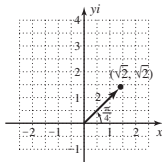
1. equilibrium, zero 3. orthogonal 5. Answers will vary 7. $\langle 6, 8 \rangle$
 9. $\langle -5, 10 \rangle$ 11. $-6\mathbf{i} - 8\mathbf{j}$ 13. $-2.2\mathbf{i} + 0.4\mathbf{j}$ 15. $\langle -11.48, -9.16 \rangle$
 17. $\langle -24, -27 \rangle$ 19. $|\mathbf{F}_3| \approx 3336.8$; $\theta \approx 268.5^\circ$ 21. 37.16 kg
 23. 644.49 lb 25. 2606.74 kg 27. approx. 286.79 lb
 29. approx. 43.8° 31. 1125 N·m 33. approx. 957.0 ft
 35. approx. 64,951.91 ft·lb 37. approx. 451.72 lb
 39. approx. 2819.08 N·m 41. 800 ft·lb 43. 118 ft·lb 45. verified
 47. verified 49. a. 29 b. 45° 51. a. 0 b. 90°
 53. a. 1 b. 89.4° 55. yes 57. no 59. yes 61. 3.68 63. -4
 65. 3.17 67. a. $\langle 3.73, 1.40 \rangle$ b. $\mathbf{u}_1 = \langle 3.73, 1.40 \rangle$, $\mathbf{u}_2 = \langle -1.73, 4.60 \rangle$
 69. a. $\langle -0.65, 0.11 \rangle$ b. $\mathbf{u}_1 = \langle -0.65, 0.11 \rangle$, $\mathbf{u}_2 = \langle -1.35, -8.11 \rangle$
 71. a. $10.54\mathbf{i} + 1.76\mathbf{j}$ b. $\mathbf{u}_1 = 10.54\mathbf{i} + 1.76\mathbf{j}$, $\mathbf{u}_2 = -0.54\mathbf{i} + 3.24\mathbf{j}$
 73. a. projectile is about 375 ft away, and 505.52 ft high b. approx.
 1.27 sec and 12.26 sec 75. a. projectile is about 424.26 ft away, and
 280.26 ft high b. approx. 2.44 sec and 6.40 sec
 77. about 74.84 ft; $t \approx 3.9 - 1.2 = 2.7$ sec
 79. $\mathbf{w} \cdot (\mathbf{u} + \mathbf{v}) = \langle e, f \rangle \cdot \langle a + c, b + d \rangle$
 $= e(a + c) + f(b + d) = ea + ec + fb + fd$
 $= (ea + fb) + (ec + fd)$
 $= \langle e, f \rangle \cdot \langle a, b \rangle + \langle e, f \rangle \cdot \langle c, d \rangle$
 $= \mathbf{w} \cdot \mathbf{u} + \mathbf{w} \cdot \mathbf{v}$
 81. $\mathbf{0} \cdot \mathbf{u} = \langle 0, 0 \rangle \cdot \langle a, b \rangle = 0(a) + 0(b) = 0$
 $\mathbf{u} \cdot \mathbf{0} = \langle a, b \rangle \cdot \langle 0, 0 \rangle = a(0) + b(0) = 0$
 83. $\theta \approx 56.9^\circ$; answers will vary. 85. $t \approx -20$
 87. $a \approx 138.4^\circ$,
 $B \approx 106.8^\circ$
 $C \approx 41.2^\circ$;
 $P \approx 560.4$ m,
 $A \approx 11,394.3$ m²

Exercises 8.5, pp. 810–812

1. modulus, argument 3. multiply, add
 5. $2(\cos 240^\circ + i \sin 240^\circ)$, z is in QIII
 7. $z_2 = z_1 + z_3$ 9. $z_2 = z_1 + z_3$
-
-
11. QIII; $2\sqrt{2}(\cos 225^\circ + i \sin 225^\circ)$
 13. QIII; $10(\cos 210^\circ + i \sin 210^\circ)$
 15. $6 \left[\cos\left(\frac{3\pi}{4}\right) + i \sin\left(\frac{3\pi}{4}\right) \right]$ 17. $8 \left[\cos\left(\frac{11\pi}{6}\right) + i \sin\left(\frac{11\pi}{6}\right) \right]$
 19. $10 \text{ cis } \left[\tan^{-1}\left(\frac{6}{8}\right) \right]$; $10 \text{ cis } 36.9^\circ$
 21. $13 \text{ cis } \left[180^\circ + \tan^{-1}\left(\frac{12}{5}\right) \right]$; $13 \text{ cis } 247.4^\circ$
 23. $18.5 \text{ cis } \left[\tan^{-1}\left(\frac{17.5}{6}\right) \right]$; $18.5 \text{ cis } 1.2405$
 25. $2\sqrt{34} \text{ cis } \left[\pi + \tan^{-1}\left(-\frac{5}{3}\right) \right]$; $2\sqrt{34} \text{ cis } 2.1112$

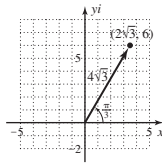
$$27. r = 2, \theta = \frac{\pi}{4}$$

$$z = 2 \operatorname{cis}\left(\frac{\pi}{4}\right) = \sqrt{2} + i\sqrt{2}$$



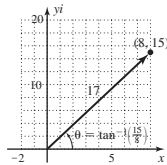
$$29. r = 4\sqrt{3}, \theta = \frac{\pi}{3}$$

$$z = 4\sqrt{3} \operatorname{cis}\left(\frac{\pi}{3}\right) = 2\sqrt{3} + 6i$$



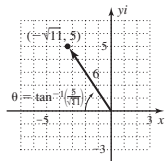
$$31. r = 17, \theta = \tan^{-1}\left(\frac{15}{8}\right)$$

$$z = 17 \operatorname{cis}\left[\tan^{-1}\left(\frac{15}{8}\right)\right] = 17\left(\frac{8}{17} + \frac{15}{17}i\right) = 8 + 15i$$



$$33. r = 6, \theta = \pi - \tan^{-1}\left(\frac{5}{\sqrt{11}}\right)$$

$$z = 6 \operatorname{cis}\left[\pi - \tan^{-1}\left(\frac{5}{\sqrt{11}}\right)\right] = 6\left(-\frac{\sqrt{11}}{6} + \frac{5}{6}i\right) = -\sqrt{11} + 5i$$



$$35. r_1 = 2\sqrt{2}, r_2 = 3\sqrt{2}, \theta_1 = 135^\circ, \theta_2 = 45^\circ;$$

$$z = z_1 z_2 = -12 + 0i \Rightarrow r = 12, \theta = 180^\circ;$$

$$r_1 r_2 = 2\sqrt{2}(3\sqrt{2}) = 12 \checkmark$$

$$\theta_1 + \theta_2 = 135^\circ + 45^\circ = 180^\circ \checkmark$$

$$37. r_1 = 2, r_2 = 2, \theta_1 = 30^\circ, \theta_2 = 60^\circ;$$

$$z = \frac{z_1}{z_2} = \frac{\sqrt{3}}{2} - \frac{1}{2}i \Rightarrow r = 1, \theta = -30^\circ; \frac{r_1}{r_2} = \frac{2}{2} = 1 \checkmark$$

$$\theta_1 - \theta_2 = 30^\circ - 60^\circ = -30^\circ \checkmark$$

$$39. z_1 z_2 = -24 + 0i, \frac{z_1}{z_2} = -\frac{4}{3} + \frac{4\sqrt{3}}{3}i$$

$$41. z_1 z_2 = 21\sqrt{3} - 21i, \frac{z_1}{z_2} = \frac{\sqrt{3}}{7} + \frac{1}{7}i$$

$$43. z_1 z_2 = -10.84 + 12.04i, \frac{z_1}{z_2} = -1.55 - 4.76i$$

$$45. z_1 z_2 = 0 + 40i, \frac{z_1}{z_2} = \frac{5\sqrt{3}}{4} + \frac{5}{4}i$$

$$47. z_1 z_2 = -10 - 10i\sqrt{3}, \frac{z_1}{z_2} = \frac{-5}{2} + 0i$$

$$49. z_1 z_2 = -2.93 + 8.51i, \frac{z_1}{z_2} = 2.29 + 3.28i$$

$$51. \text{verified; verified. } u^2 + v^2 + w^2 = uv + uw + vw \\ (1 + 4i\sqrt{3}) + (97 + 20i\sqrt{3}) + (-39 + 60i\sqrt{3}) \\ = (17 + 12i\sqrt{3}) + (-3 + 16i\sqrt{3}) + (45 + 56i\sqrt{3}), \\ 59 + 84i\sqrt{3} = 59 + 84i\sqrt{3}$$

$$53. \text{ a. } V(t) = 170 \sin(120\pi t)$$

t	$V(t)$
0	0
0.001	62.6
0.002	116.4
0.003	153.8
0.004	169.7
0.005	161.7
0.006	131.0
0.007	81.9
0.008	21.3

$$\text{ c. } t \approx 0.00257 \text{ sec}$$

$$55. \text{ a. } 17 \operatorname{cis} 28.1^\circ \quad \text{ b. } 51 \text{ V} \quad 57. \text{ a. } 8.60 \operatorname{cis} 324.5^\circ \quad \text{ b. } 15.48 \text{ V}$$

$$59. \text{ a. } 13 \operatorname{cis} 22.6^\circ \quad \text{ b. } 22.1 \text{ V}$$

$$61. I = 2 \operatorname{cis} 30^\circ; Z = 5\sqrt{2} \operatorname{cis} 45^\circ; V = 10\sqrt{2} \operatorname{cis} 75^\circ$$

$$63. I = \sqrt{13} \operatorname{cis} 326.3^\circ; Z = \frac{17}{4} \operatorname{cis} 61.9^\circ; V = \frac{17\sqrt{13}}{4} \operatorname{cis} 28.2^\circ$$

$$65. V = 4 \operatorname{cis} 60^\circ; Z = 4\sqrt{2} \operatorname{cis} 315^\circ; I = \frac{\sqrt{2}}{2} \operatorname{cis} 105^\circ$$

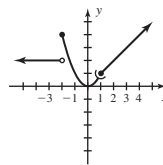
$$67. V = 5 \operatorname{cis} 306.9^\circ; Z = 8.5 \operatorname{cis} 61.9^\circ; I = \frac{10}{17} \operatorname{cis} 245^\circ$$

$$69. \frac{\sqrt{65} \operatorname{cis} 29.7^\circ}{4} \quad 71. \text{ verified}$$

$$73. z_2 = \frac{24}{5} - \frac{7}{5}i, z_3 = -\frac{24}{5} + \frac{7}{5}i$$

$$75. \frac{5\pi}{24}, \frac{13\pi}{24}, \frac{29\pi}{24}, \frac{37\pi}{24}$$

77.



Exercises 8.6, pp. 818–821

$$1. r^5[\cos(5\theta) + i \sin(5\theta)], \text{ De Moivre's } \quad 3. \text{ complex}$$

$$5. z_5 = 2 \operatorname{cis} 366^\circ = 2 \operatorname{cis} 6^\circ, z_6 = 2 \operatorname{cis} 438^\circ = 2 \operatorname{cis} 78^\circ,$$

$$z_7 = 2 \operatorname{cis} 510^\circ = 2 \operatorname{cis} 150^\circ; \text{ Answers will vary.}$$

$$7. r = 3\sqrt{2}; n = 4; \theta = 45^\circ; -324$$

$$9. r = 2; n = 3; \theta = 120^\circ; 8$$

$$11. r = 1; n = 5; \theta = 300^\circ; \frac{1}{2} + \frac{\sqrt{3}}{2}i$$

$$13. r = 1; n = 6; \theta = 315^\circ; i$$

$$15. r = 4; n = 3; \theta = 330^\circ; -64i$$

$$17. r = \frac{\sqrt{2}}{2}; n = 5; \theta = 135^\circ; \frac{1}{8} - \frac{1}{8}i$$

$$19. \text{ verified } \quad 21. \text{ verified } \quad 23. \text{ verified } \quad 25. \text{ verified}$$

$$27. \text{ roots: } 1, 0.3090 \pm 0.9511i, -0.8090 \pm 0.5878i$$

$$29. \text{ roots: } 3, 0.9271 \pm 2.8532i, -2.4271 \pm 1.7634i$$

$$31. \text{ roots: } 3i, \frac{-3\sqrt{3}}{2} - \frac{3}{2}i, \frac{3\sqrt{3}}{2} - \frac{3}{2}i$$

$$33. 2, 0.6180 \pm 1.9021i, -1.6180 \pm 1.1756i$$

$$35. \frac{3\sqrt{3}}{2} + \frac{3}{2}i, -\frac{3\sqrt{3}}{2} + \frac{3}{2}i, -3i$$

$$37. 1.1346 + 0.1797i, 0.1797 + 1.1346i, -1.0235 + 0.5215i, \\ -0.8123 - 0.8123i, 0.5215 - 1.0235i$$

$$39. x = 1, -\frac{1}{2} \pm \frac{\sqrt{3}}{2}i. \text{ These are the same results as in Example 3.}$$

$$41. r = 16; n = 4; \theta = 120^\circ; \text{ roots: } \\ \sqrt{3} + i, -1 + i\sqrt{3}, -\sqrt{3} - i, 1 - i\sqrt{3}$$

$$43. r = 7\sqrt{2}; n = 4; \theta = 225^\circ; \text{ roots: } 0.9855 + 1.4749i, \\ -1.4749 + 0.9855i, -0.9855 - 1.4749i, 1.4749 - 0.9855i$$

$$45. r = 8, \theta = 210^\circ, n = 3; k = 0 \rightarrow 0.684 + 1.879i; \\ k = 1 \rightarrow -1.970 - 0.347i; k = 2 \rightarrow 1.286 - 1.532i$$

$$47. r = 81, \theta = 180^\circ, n = 4; k = 0 \rightarrow 2.121 + 2.121i; \\ k = 1 \rightarrow -2.121 + 2.121i; k = 2 \rightarrow -2.121 - 2.121i; \\ k = 3 \rightarrow 2.121 - 2.121i$$

$$49. D = -4, z_0 = 8^{\frac{1}{5}} \operatorname{cis} 45^\circ, z_1 = 8^{\frac{1}{5}} \operatorname{cis} 165^\circ, z_2 = 8^{\frac{1}{5}} \operatorname{cis} 285^\circ, \\ z_0 = 8^{\frac{1}{5}} \operatorname{cis} 75^\circ, z_1 = 8^{\frac{1}{5}} \operatorname{cis} 195^\circ, z_2 = 8^{\frac{1}{5}} \operatorname{cis} 315^\circ$$

$$51. \text{ verified } \quad 53. \text{ a. numerator: } -117 + 44j, \text{ denominator: } -21 + 72j$$

$$\text{ b. } 1 + \frac{4}{3}j \quad \text{ c. verified } \quad 55. \text{ Answers will vary.}$$

57. $-7 - 24i$ 59. $z \approx -2.7321, z \approx 0.7321, z = 2$.
 Note: Using sum and difference identities, all three solutions can actually be given in exact form: $-1 - \sqrt{3}, -1 + \sqrt{3}, 2$.

$$61. \frac{\tan^2 x}{\sec x + 1} = \frac{\sec^2 x - 1}{\sec x + 1} = \frac{(\sec x + 1)(\sec x - 1)}{\sec x + 1} = \sec x - 1 = \frac{1}{\cos x} - \frac{\cos x}{\cos x} = \frac{1 - \cos x}{\cos x}$$

63. $y = -\frac{4}{5}x + \frac{12}{5}$

Making Connections, p. 821

1. e 3. b 5. h 7. c 9. g 11. d 13. f 15. a

Summary and Concept Review, pp. 822–826

1.

Angles	Sides
$A = 36^\circ$	$a \approx 205.35$ cm
$B = 21^\circ$	$b \approx 125.20$ cm
$C = 123^\circ$	$c = 293$ cm

2.

Angles	Sides
$A = 28^\circ$	$a \approx 140.59$ yd
$B = 10^\circ$	$b = 52$ yd
$C = 142^\circ$	$c \approx 184.36$ yd

3. approx. 41.84 ft 4. approx. 20.2° and 159.8°

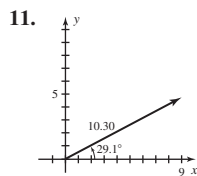
5.

Angles	Sides
$A = 35^\circ$	$a = 67$ cm
$B_1 \approx 64.0^\circ$	$b = 105$ cm
$C_1 \approx 81.0^\circ$	$c_1 \approx 115.37$ cm

Angles	Sides
$A = 35^\circ$	$a = 67$ cm
$B_2 \approx 116.0^\circ$	$b = 105$ cm
$C_2 \approx 29.0^\circ$	$c_2 \approx 56.63$ cm

6. no; 36° 7. approx. 36.9° 8. approx. 385.5 m

9. $133.2^\circ, 30.1^\circ,$ and 16.7° 10. 85,570.7 m²



12. $-8i + 3j$; $|\mathbf{u}| \approx 8.54$; $\theta \approx 159.4^\circ$ 13. horiz. comp. ≈ 11.08 , vertical comp. ≈ 14.18 14. $\langle -4, -2 \rangle$; $|\mathbf{u} + \mathbf{v}| \approx 4.47, \theta \approx 206.6^\circ$

15. $\frac{7}{\sqrt{193}}\mathbf{i} + \frac{12}{\sqrt{193}}\mathbf{j}$ 16. QII; since the x -component will be negative and the y -component is positive. 17. $\frac{1}{6}$ mi 18. approx. 19.7°

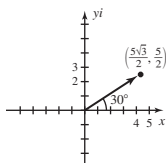
19. $\langle -25, -123 \rangle$ 20. approx. -0.87 21. 4

22. $\mathbf{p} \cdot \mathbf{q} = -6$; $\theta \approx 97.9^\circ$ 23. 4340 ft-lb 24. approx. 417.81 lb

25. approx. 8156.77 ft-lb 26. a. $x \approx 269.97$ ft; $y \approx 285.74$ ft

b. approx. 0.74 sec 27. $2(\cos 240^\circ + i \sin 240^\circ)$ 28. $3 + 3i$

29.



30. $z_1 z_2 = 16 \operatorname{cis}\left(\frac{5\pi}{12}\right)$; $\frac{z_1}{z_2} = 4 \operatorname{cis}\left(\frac{\pi}{12}\right)$ 31. $2\sqrt{3} + 2j$

32. $|Z| \approx 10.44$; $\theta \approx 16.7^\circ, 10.44 \operatorname{cis} 16.7^\circ$ 33. $-16 - 16i\sqrt{3}$

34. verified 35. $\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -5i$ 36. $6, -3 \pm 3i\sqrt{3}$

37. $2 - 2i, -2 \pm 2i$ 38. $1 \pm 2i, -1 \pm 2i$ 39. verified

Practice Test, pp. 826–827

1. 6.58 mi 2. 137.18 ft

3.

Angles	Sides (in.)	Angles	Sides (in.)
$A_1 \approx 58.8^\circ$	$a = 15$	$A_2 \approx 121.2^\circ$	$a = 15$
$B = 20^\circ$	$b = 6$	$B = 20^\circ$	$b = 6$
$C_1 \approx 101.2^\circ$	$c_1 \approx 17.21$	$C_2 \approx 38.8^\circ$	$c_2 \approx 11.0$

4. a. No b. 2.66 mi 5. a. No b. 1 c. 8.43 sec

6. a. 2.30 mi b. 7516.5 ft 7. $A \approx 438,795$ mi², $P \approx 61.7^\circ$, $B \approx 61.2^\circ, M \approx 57.1^\circ$ 8. speed ≈ 73.36 mph, bearing $\approx 47.8^\circ$

9. $\theta \approx 36.5^\circ$ 10. 63.48 cm to the right and 130.05 cm down from the initial point on the ceiling 11. $|\mathbf{F}_3| \approx 212.94$ N, $\theta \approx 251.2^\circ$

12. a. $\theta \approx 42.5^\circ$ b. $\operatorname{proj}_\mathbf{u} = \langle -2.4, 7.2 \rangle$

c. $\mathbf{u}_1 = \langle -2.4, 7.2 \rangle, \mathbf{u}_2 = \langle -6.6, -2.2 \rangle$

13. 104.53 ft; 3.27 sec 14. $2 \operatorname{cis}\left(\frac{\pi}{24}\right)$ 15. $48\sqrt{2} \operatorname{cis} 75^\circ$; verified

16. $-8 - 8\sqrt{3}i$ 17. verified 18. $\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -5i$

19. $2.3039 \pm 1.5192i, -2.3039 \pm 1.5192i$ 20. $\approx 2, 414,300$ mi²

Strengthening Core Skills, pp. 828–829

Exercise 1. 664.46 lb, 640.86 lb Exercise 2. 106.07 lb, 106.07 lb

Exercise 3. yes

Cumulative Review Chapters 1–8, pp. 829–831

1. $20\sqrt{3}, 40, 60^\circ, 90^\circ$ 3. $R = \frac{1}{\pi}\sqrt{A + (\pi r)^2}$

5. $\sin \theta = \frac{-3}{5}, \cos \theta = \frac{4}{5}, \tan \theta = \frac{-3}{4}, \csc \theta = -\frac{5}{3}, \sec \theta = \frac{5}{4}, \cot \theta = \frac{-4}{3}$

7. $\frac{-4 \pm \sqrt{6}}{5}$ 9. $\cos = 19^\circ \approx 0.94, \cos 125^\circ \approx -0.58$

11. a. about \$66,825 b. 13, 13, $7\sqrt{2}$; $A = 59.5$ mi²

13. a. $m = \frac{y_2 - y_1}{x_2 - x_1}$ b. $\left(\frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}\right)$

c. $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ d. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

e. $A = Pe^{rt}$

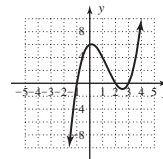
15. $\angle A = 37^\circ, a \approx 33$ cm,

$\angle B = 34.4^\circ, b = 31$ cm,

$\angle C = 108.6^\circ, c = 52$ cm

17. about 422.5 lb

19.



$x \in (-\infty, -1) \cup (2, 3)$

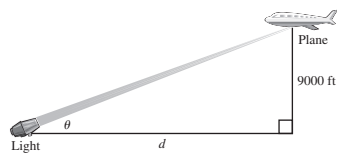
21. $-128 - 128i\sqrt{3}$ 23. about 3.6 yr 25. $A = 2, B = 1, C = \frac{\pi}{4}$

27. $[0, 0.71] \cup \left(\frac{\pi}{2}, 4.37\right] \cup \left(\frac{3\pi}{2}, 2\pi\right)$

29. 0; The vectors are orthogonal.

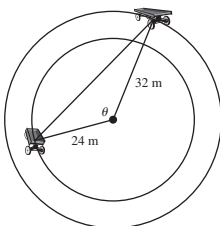
Connections to Calculus Exercises, pp. 834–835

1.



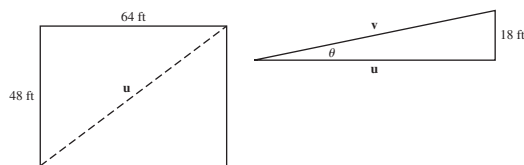
a. $\theta = \tan^{-1}\left(\frac{9000}{d}\right)$ b. $\theta \approx 35^\circ$

3.



a. $d = \sqrt{24^2 + 32^2 - 2(24)(32)\cos \theta}$ b. $d \approx 54.13$ m c. about 106.1°

5.



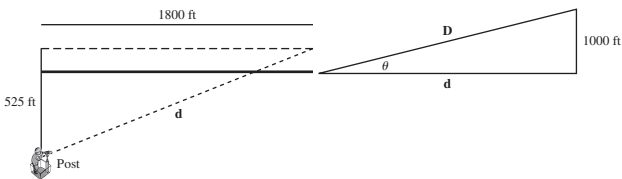
a. $|v| = \sqrt{48^2 + 64^2 + 18^2} = 82$ ft

b. $\mathbf{u} = \langle 64, 48, 0 \rangle$, $\mathbf{v} = \langle 64, 48, 18 \rangle$

$\cos \theta = \frac{\langle 64, 48, 0 \rangle \cdot \langle 64, 48, 18 \rangle}{(80)(82)}$

$\theta = \cos^{-1}\left(\frac{40}{41}\right) \approx 12.68^\circ$; verified

7.



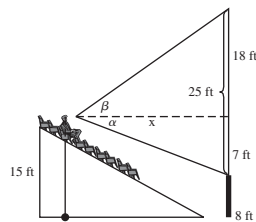
a. $|D| = \sqrt{525^2 + 1800^2 + 1000^2} = 2125$ ft

b. $\mathbf{d} = \langle 1800, 525, 0 \rangle$, $\mathbf{D} = \langle 1800, 525, 1000 \rangle$

$\cos \theta = \frac{\langle 1800, 525, 0 \rangle \cdot \langle 1800, 525, 1000 \rangle}{(1875)(2125)}$

$\theta = \cos^{-1}\left(\frac{15}{17}\right) \approx 28.07^\circ$; verified

9.



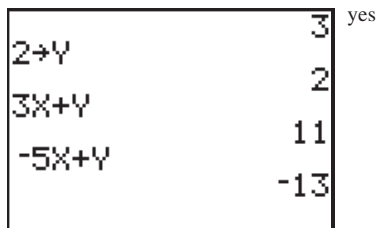
a. $\theta = \alpha + \beta$ b. $\theta = \tan^{-1}\left(\frac{7}{x}\right) + \tan^{-1}\left(\frac{18}{x}\right)$
 $= \tan^{-1}\left(\frac{7}{x}\right) + \tan^{-1}\left(\frac{18}{x}\right) \approx 30.02^\circ$

CHAPTER 9

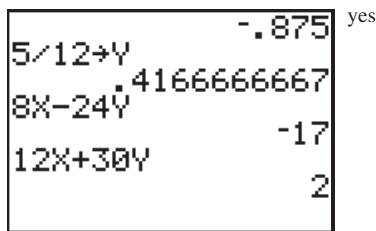
Exercises 9.1, pp. 848–853

1. inconsistent 3. consistent, independent 5. Multiply the first equation by 6 and the second equation by 10. 7. $y = \frac{7}{4}x - 6$, $y = \frac{-4}{3}x + 5$
 9. $y = x + 2$ 11. $x + 3y = -3$ 13. $y = x + 2$, $x + 3y = -3$

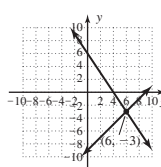
15.



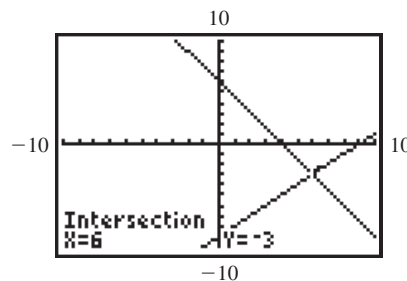
17.



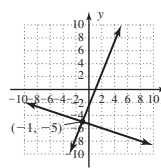
19.



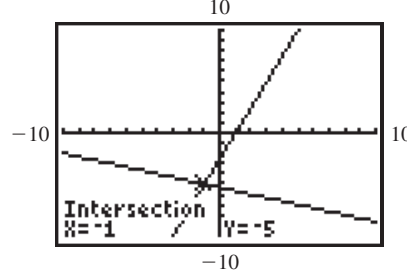
$Y_1 = \frac{12 - 3X}{2}$, $Y_2 = X - 9$



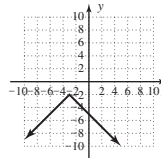
21.



$Y_1 = \frac{5 - 5X}{-2}$, $Y_2 = \frac{-16 - X}{3}$



23. $(-4, 1)$ 25. $(3, -5)$ 27. second equation, $y, (4, -3)$
 29. second equation, $x, (10, -1)$ 31. second equation, $x, (\frac{5}{2}, \frac{7}{4})$
 33. $(-2, \frac{5}{2})$ 35. $(2, -1)$ 37. $(3, -1)$ 39. $(-2, -3)$
 41. $(\frac{11}{2}, 2)$ 43. $(-2, 3)$ 45. $(-3, 4)$ 47. $(-6, 12)$
 49. $(2, 8)$; consistent/independent 51. \emptyset ; inconsistent
 53. $\{(x, y) | 6x + y = 22\}$; consistent/dependent
 55. $(4, 1)$; consistent/independent 57. $(-3, -4)$; consistent/independent
 59. $(-\frac{1}{2}, \frac{4}{3})$; consistent/independent 61. 1 mph; 4 mph 63. 2318 adult tickets; 1482 child tickets 65. premium: \$3.97, regular: \$3.87
 67. nursing student \$6500; science major \$3500
 69. 150 quarters, 75 dimes 71. a. 3 mph b. 5 mph
 73. a. 3.6 ft/sec b. 4.4 ft/sec 75. a. 100 lawns/mo b. \$11,500/mo
 77. a. 1.6 billion bu, 3 billion bu, yes b. 2.7 billion bu, 2.25 billion bu, yes
 c. \$6.65, 2.43 billion bu 79. about 227 boards at \$410 a piece
 81. about 90,000,000 gal at \$3.04/gal 83. 1776; 1865
 85. Tahiti: 402 mi², Tonga: 290 mi² 87. $y = 2x + 3$ 89. \$50,000
 91. 93. $x \approx 120.716$

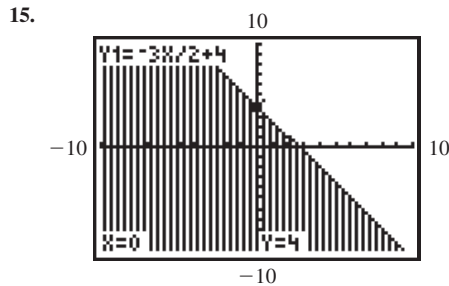
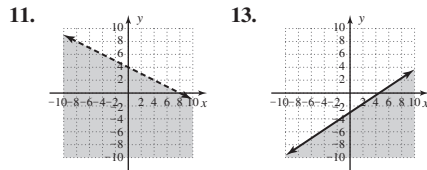


Exercises 9.2, pp. 861–864

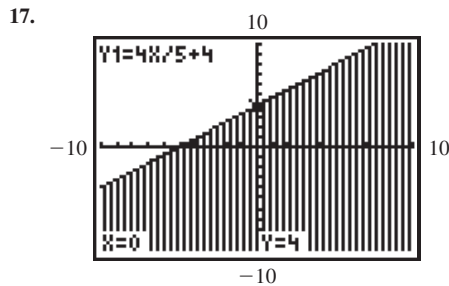
1. triple 3. equivalent, systems 5. $z = 5$ 7. Answers will vary.
 9. Answers will vary. 11. yes, no; R2, R3 13. (5, 7, 4)
 15. (-2, 4, 3) 17. (4, 0, -3) 19. (5, 12, 13)
 21. no solution, inconsistent
 23. $\{(x, y, z) \mid x \in \mathbb{R}, y = 2 - x, z = 2 - x\}; (p, 2 - p, 2 - p)$,
 other solutions possible
 25. $\{(x, y, z) \mid x = -\frac{5}{3}z - \frac{2}{3}, y = -z - 2, z \in \mathbb{R}\}; (-\frac{5}{3}p - \frac{2}{3}, -p - 2, p)$,
 other solutions possible
 27. $(p, 2p, p + 1)$ 29. $(p + 9, p - 4, p)$
 31. $\{(x, y, z) \mid x + \frac{1}{2}y - 2z = 6\}$ 33. $(-1, \frac{-3}{2}, 2)$
 35. $(-p - 17, -p - 4, p)$ 37. (12, 6, 4) 39. (1, -5, -6)
 41. (1, -2, 3) 43. $(\frac{1}{5}, \frac{1}{2}, -2)$ 45. (5 cm, 3 cm, 4 cm)
 47. \$80,000 at 4%; \$90,000 at 5%; \$110,000 at 7%
 49. World War II, 1945; Korean, 1953; Vietnam, 1973
 51. Declaration of Independence, 1776; 13th Amendment, 1865; Civil Rights Act, 1964 53. 1 L 20% solution; 3 L 30% solution; 6 L 45% solution
 55. saturated: 1.2 g, monounsaturated: 1.0 g, polyunsaturated: 0.6 g
 57. $h(t) = -5t^2 + 30t + 1$ a. 46 ft b. 17.2 ft 59. 2
 61. $\langle -11, -5 \rangle; \langle 6, -\frac{43}{2} \rangle$ 63. $x = 1$

Exercises 9.3, pp. 875–878

1. half; planes 3. solution 5. The feasible region may be bordered by three or more oblique lines, with two of them intersecting outside and away from the feasible region. 7. No, No, No, No 9. No, Yes, Yes, No

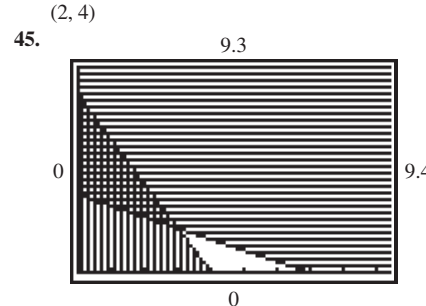
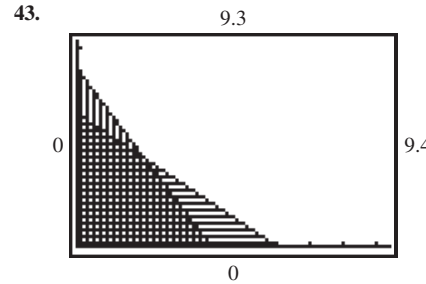
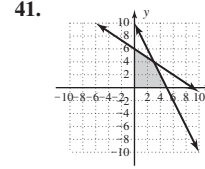
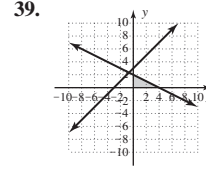
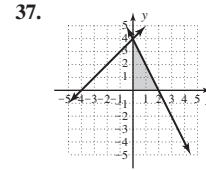
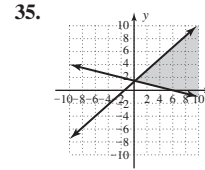
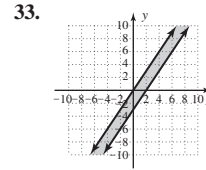
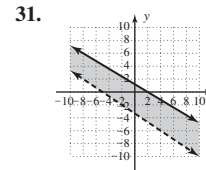
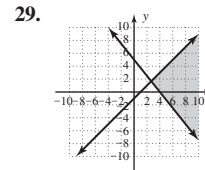
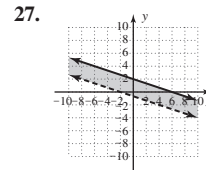
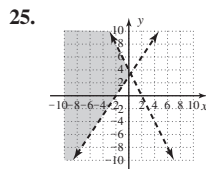
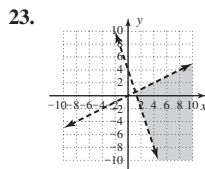
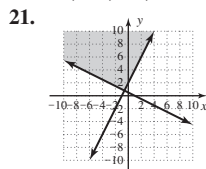


(0, 0) is in the solution region, and $3(0) + 2(0) \leq 8$ is true.



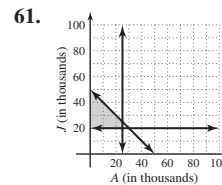
(0, 0) is in the solution region, and $4(0) - 5(0) > -20$ is true.

19. No, No, No, Yes



47. $\begin{cases} y - x \leq 1 \\ x + y > 3 \end{cases}$ 49. $\begin{cases} y - x \leq 1 \\ x + y \leq 3 \\ y \geq 0 \end{cases}$ 51. (5, 3) 53. (12, 11)

55. 26 at (2, 2) 57. 264 at (4, 3) 59. $5 < H < 10$



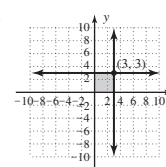
$J + A \leq 50,000$
 $J \geq 20,000$
 $A \leq 25,000$

63. 300 acres of corn; 200 acres of soybeans 65. 240 sheet metal screws; 480 wood screws

67. 65 traditionals, 30 Double-T's

69. 3 buses from company X; 4 buses from company Y

71. a. the region is a square
 b. maximum is 35.1 at (3, 3)
 c. optimal solutions occur at vertices



73. a. $-\frac{3}{5}$ b. $\frac{5}{4}$ c. $-\frac{3}{4}$ 75. 324 Ω

Exercises 9.4, pp. 889–891

1. template 3. repeated linear 5. Answers will vary

7. $\frac{A}{x+3} + \frac{B}{x-2}$ 9. $\frac{A}{x-1} + \frac{B}{(x-1)^2}$

11. $\frac{A}{x-1} + \frac{B}{x+2} + \frac{C}{x-3}$ 13. $\frac{A}{x} + \frac{B}{x-3} + \frac{C}{x+1}$

15. $\frac{A}{x-5} + \frac{B}{(x-5)^2} + \frac{C}{(x-5)^3}$ 17. $\frac{A}{x} + \frac{B}{x^2} + \frac{C}{x+2}$

19. $\frac{A}{x} + \frac{B}{x^2} + \frac{C}{x-5} + \frac{D}{(x-5)^2}$ 21. $\frac{A}{x-3} + \frac{Bx+C}{x^2+5x+7}$

23. $\frac{A}{x+1} + \frac{Bx+C}{x^2+2} + \frac{Dx+E}{(x^2+2)^2}$ 25. $\frac{-4}{2x-5} + \frac{3}{x+3}$

27. $\frac{7}{x} + \frac{2}{x+1} - \frac{1}{x-1}$ 29. $\frac{-1}{x} + \frac{4}{x+1} + \frac{5}{(x+1)^2}$

31. $\frac{2}{x^2+1} + \frac{3x+1}{x^2+2}$ 33. $\frac{5}{x+2} + \frac{x-1}{x^2+3}$ 35. $\frac{1}{x} - \frac{5x+2}{(x^2+1)^2}$

37. $\frac{2}{x} + \frac{1}{x^2} + \frac{x-1}{x^2+x+3}$ 39. $\frac{3}{2-x} - \frac{4}{4+2x+x^2}$

41. $\frac{5}{x+3} - \frac{2}{(x+3)^2}$ 43. $\frac{2x+1}{x^2+1} + \frac{3x}{(x^2+1)^2}$

45. $\frac{2}{x-1} + \frac{3}{(x-1)^3}$ 47. $\frac{\frac{1}{100}}{P} + \frac{\frac{1}{10}}{100-10P}$

49. $\frac{\frac{1}{10}}{P} + \frac{\frac{1}{100}}{10-\frac{1}{10}P}$ 51. $\frac{49}{50}$ 53. $\frac{62}{125}$

55. $\frac{4}{\ln x - 2} - \frac{4}{\ln x - 1} - \frac{3}{(\ln x - 1)^2}$

57. Factor out -1 from the denominator:

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

59. $2x - 1 + \frac{1}{x^2 - x + 6}$ 61. Verified

Mid-Chapter Check, p. 891

1. (1, 1); consistent 2. (5, 3); consistent 3. 20 oz 4. no; R2, R3

5. The second equation is a multiple of the first equation. 6. (1, 2, 3)

7. (1, 2, 3) 8. $\frac{2}{x+1} - \frac{3}{x-2} + \frac{1}{(x-2)^2}$

9. Mozart = 8 yr; Morphy = 13 yr; Pascal = 16 yr

10. 2 table candles, 9 holiday candles

Reinforcing Basic Concepts, p. 892

Exercise 1: Premium: \$4.17/gal, Regular: \$4.07/gal,

$$\begin{cases} 15.3R + 35.7P = 211.14 \\ P = R + 0.10 \end{cases}$$

$$\begin{cases} P = R + 0.10 \end{cases}$$

Exercise 2: Verified

Exercises 9.5, pp. 901–905

1. square 3. 2, 3, 1 5. Multiply R1 by -2 and add that result to R2.This sum will be the new R2. 7. $3 \times 2, 5.8$ 9. $4 \times 3, -1$

11. $\begin{bmatrix} 1 & 2 & -1 & \vdots & 1 \\ 1 & 0 & 1 & \vdots & 3 \\ 2 & -1 & 1 & \vdots & 3 \end{bmatrix}$; diagonal entries 1, 0, 1

13. $\begin{cases} x+4y=5 \\ y=\frac{1}{2} \end{cases} \rightarrow (3, \frac{1}{2})$ 15. $\begin{cases} x+2y-z=0 \\ y+2z=2 \end{cases} \rightarrow (11, -4, 3)$
 $z=3$

17. $\begin{cases} x+3y-4z=29 \\ y-\frac{3}{2}z=\frac{21}{2} \\ z=3 \end{cases} \rightarrow (-4, 15, 3)$ 19. $\begin{bmatrix} 1 & -6 & -2 \\ 0 & -28 & -6 \end{bmatrix}$

21. $\begin{bmatrix} 1 & -3 & 3 & \vdots & 2 \\ 0 & 23 & -12 & \vdots & -15 \\ -2 & 1 & 0 & \vdots & 4 \end{bmatrix}$ 23. $\begin{bmatrix} 3 & 1 & 1 & \vdots & 8 \\ 0 & -3 & -3 & \vdots & -6 \\ 0 & -10 & -13 & \vdots & 34 \end{bmatrix}$

25. $2R_1 + R_2 \rightarrow R_2$ 27. $-5R_1 + R_2 \rightarrow R_2$
 $-3R_1 + R_3 \rightarrow R_3$ $4R_1 + R_3 \rightarrow R_3$

29. (20, 10) 31. (1, 6, 9) 33. (1, 1, 2) 35. (1, 1, 1) 37. (2, -1, 3)

39. (10, 6, 8) 41. $(\frac{1}{2}, 1, -\frac{1}{4})$ 43. $(-1, \frac{-3}{2}, 2)$

45. linear dependence ($p - 4, -2p + 8, p$)47. coincident dependence $\{(x, y, z) | 3x - 4y + 2z = -2\}$ 49. inconsistent, no solution 51. linear dependence, $(p, \frac{1}{3}p, 4 - \frac{5}{3}p)$ 53. (2, 1, -1) 55. (3, 0, -2) 57. (1, -2, 3, -1) 59. 28 units²

61. LA to STL, 1600 mi; STL to CIN, 310 mi; CIN to NY, 570 mi

63. Moe 90, Larry 45, Curly 30 65. 15 m, 36 m, 39 m

67. \$2000 at 5%; \$3000 at 7%; \$5000 at 9% 69. $x = 84^\circ; y = 25^\circ$

71. a. $z_1 = \sqrt{10} \operatorname{cis}[\pi + \tan^{-1}(3)]$ b. $z_2 = \frac{-5}{2} + \frac{5\sqrt{3}}{2}i$

73. $C > 30,000$ in the year 2011 ($t \approx 6.39$)

Exercises 9.6, pp. 913–917

1. a_{ij}, b_{ij} 3. scalar 5. Answers will vary. 7. $2 \times 2, a_{12} = -3, a_{21} = 5$ 9. $2 \times 3, a_{12} = -3, a_{23} = 6, a_{22} = 5$ 11. $3 \times 3, a_{12} = 1, a_{23} = 1, a_{31} = 5$

13. true 15. conditional, $c = -2, a = -4, b = 3$ 17. $\begin{bmatrix} 10 & 0 \\ 0 & 10 \end{bmatrix}$

19. different orders, sum not possible

21. $\begin{bmatrix} \frac{263}{32} & -\frac{19}{8} \\ -\frac{85}{16} & \frac{35}{16} \end{bmatrix}$ 23. $\begin{bmatrix} -\frac{1}{2} & \frac{13}{8} & -\frac{1}{4} \\ \frac{1}{4} & \frac{5}{2} & -\frac{21}{8} \\ -\frac{31}{8} & -\frac{9}{4} & \frac{7}{2} \end{bmatrix}$ 25. $\begin{bmatrix} 20 & -15 \\ -25 & -10 \end{bmatrix}$

27. $\begin{bmatrix} \frac{-5}{2} & -1 & 0 \\ 0 & \frac{-7}{2} & 1 \\ 2 & \frac{3}{2} & -6 \end{bmatrix}$ 29. $\begin{bmatrix} 1 & -2 & 0 \\ 0 & -1 & 2 \\ 4 & 3 & -6 \end{bmatrix}$ 31. $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

33. matrix mult. not possible 35. $\begin{bmatrix} 12 & -24 & 90 \\ -6 & 15 & -57 \end{bmatrix}$

37. $\begin{bmatrix} 79 & -30 \\ -50 & 19 \end{bmatrix}$ 39. $\begin{bmatrix} 42 & 18 & -60 \\ -12 & -42 & 36 \end{bmatrix}$ 41. $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

43. $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 45. $\begin{bmatrix} \frac{-3}{19} & \frac{4}{57} \\ \frac{1}{19} & \frac{5}{57} \end{bmatrix}$ 47. $\begin{bmatrix} 0 & \frac{3}{4} & \frac{1}{4} \\ -\frac{1}{4} & \frac{3}{8} & \frac{1}{8} \\ -\frac{1}{4} & \frac{1}{16} & \frac{1}{16} \end{bmatrix}$

49. $\begin{bmatrix} 1.75 & 2.5 \\ 7.5 & 13 \end{bmatrix}$ 51. $\begin{bmatrix} -4 & 28 & 4 \\ -8 & 17 & 3 \end{bmatrix}$ 53. verified 55. verified

57. $P = 21.448$ cm; $A = 27.7269$ cm²

59. a.

$$V = \begin{bmatrix} T & S \\ S & 3820 & 1960 \\ D & 2460 & 1240 \\ P & 1540 & 920 \end{bmatrix} \quad M = \begin{bmatrix} T & S \\ S & 4220 & 2960 \\ D & 2960 & 3240 \\ P & 1640 & 820 \end{bmatrix}$$

b. 3900 more by Minsk

c. $V = \begin{bmatrix} 3972.8 & 2038.4 \\ 2558.4 & 1289.6 \\ 1601.6 & 956.8 \end{bmatrix}$ d. $\begin{bmatrix} 8361.6 & 5116.8 \\ 5636.8 & 4659.2 \\ 3307.2 & 1809.6 \end{bmatrix}$

$$M = \begin{bmatrix} 4388.8 & 3078.4 \\ 3078.4 & 3369.6 \\ 1705.6 & 852.8 \end{bmatrix}$$

61. [22,000 19,000 23,500 14,000]; Total Profit N: \$22,000, S: \$19,000, E: \$23,500, W: \$14,000

63. a. \$108.20 b. \$101

c. $\begin{bmatrix} 100 & 101 & 119 \\ 108.2 & 107 & 129.5 \end{bmatrix}$ First row, total cost for science from each restaurant; second row, total cost for math from each restaurant.

65. $\begin{bmatrix} 32.4 & 10.3 & 21.3 \\ 29.9 & 9.6 & 19.5 \end{bmatrix}$ a. 10 b. 20

c. p_{13} gives the approximate number of females expected to join the writing club

67. $\begin{bmatrix} 2^{n-1} & 0 & 2^{n-1} \\ 2^n - 1 & 1 & 2^n - 1 \\ 2^{n-1} & 0 & 2^{n-1} \end{bmatrix}$ 69. $(-1, 1, -2)$

71. $z = 3 \operatorname{cis}\left(\frac{\pi}{8}\right), 3 \operatorname{cis}\left(\frac{5\pi}{8}\right), 3 \operatorname{cis}\left(\frac{9\pi}{8}\right), 3 \operatorname{cis}\left(\frac{13\pi}{8}\right)$

Exercises 9.7, pp. 927–932

1. diagonal, zeroes 3. AB, BA, I, A^{-1} 5. Answers will vary.
7. verified 9. verified 11. verified 13. verified

15. $\begin{bmatrix} \frac{1}{9} & \frac{2}{9} \\ -\frac{1}{9} & \frac{5}{18} \end{bmatrix}$ 17. $\begin{bmatrix} -5 & 1.5 \\ -2 & 0.5 \end{bmatrix}$ 19. verified 21. verified

23. $\begin{bmatrix} -\frac{2}{39} & \frac{1}{13} & \frac{10}{39} \\ \frac{1}{3} & 0 & \frac{1}{3} \\ -\frac{4}{39} & \frac{2}{13} & -\frac{19}{39} \end{bmatrix}$ 25. $\begin{bmatrix} -\frac{9}{80} & \frac{31}{400} & \frac{27}{400} \\ \frac{1}{80} & \frac{41}{400} & -\frac{3}{400} \\ -\frac{1}{20} & -\frac{1}{100} & -\frac{17}{100} \end{bmatrix}$ 27. $\begin{bmatrix} 2 & -3 \\ -5 & 7 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 9 \\ 8 \end{bmatrix}$

29. $\begin{bmatrix} 1 & 2 & -1 \\ 1 & 0 & 1 \\ 2 & -1 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 \\ 3 \\ 3 \end{bmatrix}$

31. $\begin{bmatrix} -2 & 1 & -4 & 5 \\ 2 & -5 & 1 & -3 \\ -3 & 1 & 6 & 1 \\ 1 & 4 & -5 & 1 \end{bmatrix} \begin{bmatrix} w \\ x \\ y \\ z \end{bmatrix} = \begin{bmatrix} -3 \\ 4 \\ 1 \\ -9 \end{bmatrix}$

33. $(4, 5)$ 35. $(12, 12)$ 37. $(\frac{1}{5}, \frac{1}{3})$ 39. $(1.5, -0.5, -1.5)$

41. $(3, 2, 5)$ 43. $(-1, -0.5, 1.5, 0.5)$ 45. 1, yes 47. 0, no 49. 1
51. singular matrix 53. -34 55. 7 57. singular matrix

59. $\det(A) = -5; (1, 6, 9)$ 61. $\det(A) = 0$ 63. $A^{-1} = \begin{bmatrix} \frac{1}{13} & \frac{5}{13} \\ -\frac{2}{13} & \frac{3}{13} \end{bmatrix}$, verified

65. singular 67. 31 behemoth, 52 gargantuan, 78 mammoth, 30 jumbo
69. Jumpin' Jack Flash: 3.75 min
Tumbling Dice: 3.75 min
You Can't Always Get: 7.5 min
Wild Horses: 5.75 min

71. 30 of clock A; 20 of clock B; 40 of clock C; 12 of clock D

73. $p_1 = 72.25^\circ, p_2 = 74.75^\circ, p_3 = 80.25^\circ, p_4 = 82.75^\circ$

75. $y = x^2 + 4x - 5$ 77. $y = x^3 + 2x^2 - 9x - 10$

79. \$450 in the CD, \$350 in the MM

81. \$1500 in retirement fund, \$1500 in mutual fund, \$1800 in stock fund

83. 2 oz Food I, 1 oz Food II, 4 oz Food III

85. Answers will vary. 87. $A = 125$, period = $\frac{2\pi}{3}$

89. $x \in \left(-\infty, -\frac{9}{2}\right] \cup \left[-\frac{1}{2}, \infty\right)$

Exercises 9.8, pp. 942–947

1. $a_{11}a_{22} - a_{21}a_{12}$ 3. constant 5. Answers will vary.

7. $D = \begin{bmatrix} 2 & 5 \\ -3 & 4 \end{bmatrix}; D_x = \begin{bmatrix} 7 & 5 \\ 1 & 4 \end{bmatrix}; D_y = \begin{bmatrix} 2 & 7 \\ -3 & 1 \end{bmatrix}$ 9. $(-5, 9)$

11. $\left(\frac{-26}{3}, \frac{25}{3}\right)$ 13. not possible

15. a. $D = \begin{bmatrix} 4 & -1 & 2 \\ -3 & 2 & -1 \\ 1 & -5 & 3 \end{bmatrix}$ $D_x = \begin{bmatrix} -5 & -1 & 2 \\ 8 & 2 & -1 \\ -3 & -5 & 3 \end{bmatrix}$
 $D_y = \begin{bmatrix} 4 & -5 & 2 \\ -3 & 8 & -1 \\ 1 & -3 & 3 \end{bmatrix}$ $D_z = \begin{bmatrix} -5 & -1 & 2 \\ -3 & 2 & 8 \\ 1 & -5 & -3 \end{bmatrix}$

b. $|D| = 22$, solutions possible

c. $|D| = 0$, Cramer's rule cannot be used: coefficients $R_1 + R_2 = R_3$

17. $(1, 2, 1)$ 19. $\left(\frac{3}{4}, \frac{5}{3}, -\frac{1}{3}\right)$ 21. $(0, -1, 2, -3)$

23. $320 + 32\pi \approx 420.5 \text{ in}^2$ 25. 8 cm^2 27. 27 ft^2 29. 19 m^3

31. 96 in^3 33. yes 35. no 37. yes; yes; yes

39. $\frac{1}{x} - \frac{1}{x+1} - \frac{3}{(x+1)^2} + \frac{1}{x-1} - \frac{1}{(x-1)^2}$

41. $\frac{3}{x+1} - \frac{2}{x-3} + \frac{1}{(x-3)^3}$ 43. 214.5 ft² of skin, 231.0 ft² of wood

vener, 516 tension rods, and 498 ft of hoop 45. 955 ft² of skin, 1021.5 ft² of wood veneer, 2180 tension rods, and 2129.5 ft of hoop 47. 5 Silver, 9 Gold, and 2 Platinum

49. one bundle of first class = 9.25 measures of grain;
one bundle of second class = 4.25 measures of grain;
one bundle of third class = 2.75 measures of grain

51. Answers will vary. 53. Answers will vary. 55. Answers will vary.

57. Answers will vary. 59. Answers will vary. 61. Answers will vary.

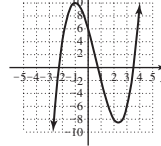
63. Answers will vary. 65. Answers will vary. 67. Answers will vary.

69. \$15,000 at 6%, \$25,000 at 8% 71. apples: 29¢/lb; kiwi: 39¢/lb;

pears: 19¢/lb 73. 10 lb of \$1.90, 8 lb of \$2.25, 6 lb of \$3.50

75. Answers will vary. 77. $x^2 + y^2 - 4x - 6y - 12 = 0$

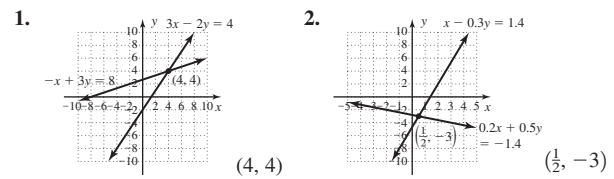
79. 81. $\angle B \approx 76.3^\circ, \angle C \approx 54.7^\circ$, side $c = 9.4 \text{ in}$.



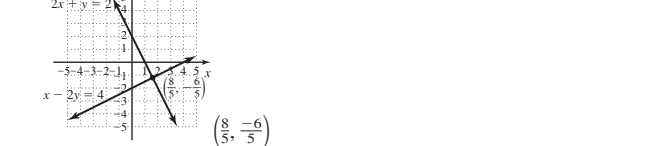
Making Connections, p. 947

1. h 3. d 5. a 7. f 9. b 11. f 13. h 15. c

Summary and Concept Review, pp. 948–953



3. 4. no solution; inconsistent

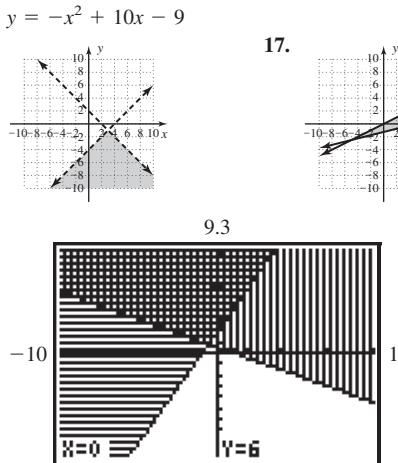


13. no solution, inconsistent 14. 72 nickels, 85 dimes, 60 quarters

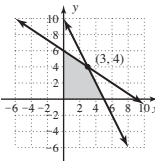
15. $y = -x^2 + 10x - 9$

16. 17.

18. 9.3



-9.3

19.  Maximum of 270 occurs at both (0, 6) and (3, 4)

20. 50 cows, 425 chickens 21. $\frac{4}{x-3} + \frac{2}{x+5}$ 22. $\frac{7}{x-3} + \frac{2}{2x+1}$

23. $\frac{1}{x+4} + \frac{2}{x^2+1}$ 24. $\frac{-3}{x-5} + \frac{x+2}{x^2+3}$ 25. $\frac{-3}{x+3} + \frac{x+1}{x^2-3x+9}$

26. $\frac{5}{x-1} + \frac{x-2}{x^2+x+1}$ 27. $\frac{5}{(x-2)^2} - \frac{1}{x-2} + \frac{3}{x+3}$

28. $\frac{1}{(x-1)^2} - \frac{3}{x-1} + \frac{2}{x+5}$ 29. $\frac{2}{x^2+3} - \frac{x+5}{(x^2+3)^2}$

30. (-2, -4) 31. (1, 6, 9) 32. (-2, 7, 1, 8)

33. $\begin{bmatrix} -7.25 & 5.25 \\ 0.875 & -2.875 \end{bmatrix}$ 34. $\begin{bmatrix} -6.75 & 6.75 \\ 1.125 & -1.125 \end{bmatrix}$ 35. not possible

36. $\begin{bmatrix} -2 & -6 \\ -1 & -7 \end{bmatrix}$ 37. $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ 38. $\begin{bmatrix} 1 & 0 & 4 \\ 5.5 & -1 & -1 \\ 10 & -2.9 & 7 \end{bmatrix}$

39. $\begin{bmatrix} 3 & -6 & -4 \\ -4.5 & 3 & -1 \\ -2 & 3.1 & 3 \end{bmatrix}$ 40. not possible 41. $\begin{bmatrix} -8 & 12 & 0 \\ -2 & -4 & 4 \\ -16 & -0.4 & -20 \end{bmatrix}$

42. $\begin{bmatrix} 15.5 & 6.4 & 17 \\ 9 & -17 & 2 \\ 18.5 & -20.8 & 13 \end{bmatrix}$ 43. D 44. It's an identity matrix.

45. It's the inverse of B. 46. E 47. It's an identity matrix.

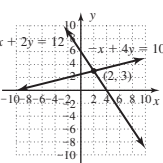
48. It's the inverse of F. 49. matrix multiplication is not generally commutative 50. (-8, -6) 51. (2, 0, -3)

52. $\left(\frac{-19}{35}, \frac{25}{14}\right)$ 53. (1, -1, 2) 54. $\left(\frac{-37}{19}, \frac{36}{19}, \frac{31}{19}\right)$ 55. $\frac{91}{2}$ units²

56. $\frac{5}{x-2} + \frac{2x-1}{x^2+3}$ 57. 92,250 gal gasoline, 595,000 lb corn, 227,500

oz yeast, and 134,750 gal water 58. 287,250 gal gasoline, 2,035,000 lb corn, 777,500 oz yeast, and 460,750 gal water 59. PIE ARE SQUARE

Practice Test, pp. 953-954

1.  (2, 3) 2. $\left(\frac{2}{5}, \frac{-4}{5}\right)$ 3. (-3, 2) 4. (2, -1, 4)

5. a. $\begin{bmatrix} -6 & -5 \\ 8 & 9 \end{bmatrix}$ b. $\begin{bmatrix} 1.2 & 1.2 \\ -1.2 & -2 \end{bmatrix}$ c. $\begin{bmatrix} -3 & 1 \\ 3 & -5 \end{bmatrix}$

d. $\begin{bmatrix} -2 & -1 \\ 2.5 & 1.5 \end{bmatrix}$ e. -2

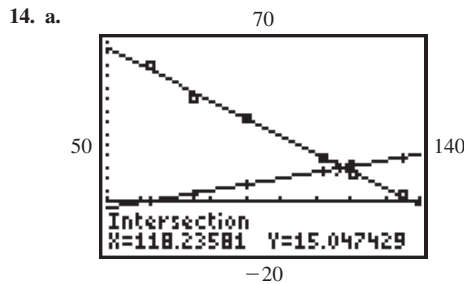
6. a. $\begin{bmatrix} 0 & -0.1 & 0 \\ 0.5 & -0.6 & 0 \\ -0.2 & -0.8 & -0.9 \end{bmatrix}$ b. $\begin{bmatrix} -0.3 & -0.06 & -0.12 \\ 0.06 & -0.06 & 0 \\ -0.18 & -0.24 & -0.48 \end{bmatrix}$

c. $\begin{bmatrix} 0.31 & -0.13 & 0.08 \\ -0.01 & -0.05 & -0.02 \\ 0.39 & -0.52 & -0.02 \end{bmatrix}$ d. $\begin{bmatrix} \frac{40}{17} & 0 & \frac{-10}{17} \\ \frac{40}{17} & 10 & \frac{-10}{17} \\ \frac{-35}{17} & -5 & \frac{30}{17} \end{bmatrix}$ e. 0.034

7. $\left(2, 1, \frac{-1}{3}\right)$ 8. (3, -2, 3) 9. $\left(\frac{97}{34}, \frac{-18}{17}\right)$ 10. (1, 6, 9)

11. 21.59 cm by 35.56 cm 12. Tahiti 402 mi²; Tonga 290 mi²

13. \$15,000 at 7%; \$8000 at 5%; \$7000 at 9%



b. equilibrium is achieved when approx 150,000 plugs are sold at a price near \$1.18 15. $h(t) = -16t^2 + 144$ 16. 144 ft, 3 sec

17.  18. maximum 250 at (5, 0)

19. 30 plain; 20 deluxe 20. $\frac{1}{x-3} + \frac{3x+2}{x^2+3x+9}$

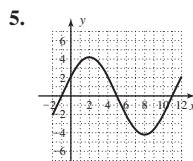
Strengthening Core Skills, pp. 955-956

Exercise 1: (1, -4, 1)

Cumulative Review Chapters 1-9, pp. 956-957

1. a. $x = \frac{2}{3}$ b. $x = 0, 7$ c. $x = 5, \pm i\sqrt{2}$ d. $x = -1, 0, 4$

3. $R = \pm \frac{1}{\pi} \sqrt{A + (\pi r)^2}$



7. a. $(a + bi) + (a - bi) = 2a$

b. $(a + bi)(a - bi) = a^2 - (bi)^2 = a^2 + b^2$

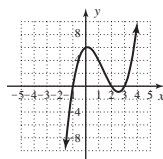
9. $x = 12 \pm \frac{\sqrt{15}}{3}$ 11. $\sin \theta = \frac{\sqrt{13}}{4}, \cos \theta = \frac{\sqrt{3}}{4}, \tan \theta = \frac{\sqrt{39}}{3}$

13. a. $m = \frac{y_2 - y_1}{x_2 - x_1}$ b. $\left(\frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}\right)$ c. $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

d. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ e. $A = Pe^{rt}$ 15. $\langle -3, -18 \rangle$

17. a. $\frac{\sqrt{121 + x^2}}{11}$ b. $\frac{x}{\sqrt{9 + x^2}}$

19. $x \in (-\infty, -1) \cup (2, 3)$



21. $-128 - 128i\sqrt{3}$ 23. about 3.6 yr

25. $A = 2, B = 1, C = \frac{\pi}{4}$

27. $q(x) = \pi^2, r(x) = \pi x - \pi^3$, crosses at $x = \pi^2 (\approx 9.87)$

29. $y = -4$ at $x = 2$

Connections to Calculus Exercises, p. 960

1. a. $\frac{k}{(x+a)(x+b)} = \frac{A}{x+a} + \frac{B}{x+b}; (A+B)x + (Ab+Ba) = k$

b. $B = -A \Rightarrow Ab + (-Aa) = k; A(b-a) = k$

c. $A = \frac{k}{b-a}; \frac{16}{(x+3)(x-5)} = \frac{-2}{x+3} + \frac{2}{x-5}$

3. $\frac{-1}{x+3} + \frac{1}{x-3}$ 5. $\frac{2}{x+7} + \frac{-2}{x-4}$
 7. $\frac{-1}{x+8} + \frac{2}{x+5}$ 9. 114 units² 11. 36 units²
 13. 240 units³; $V = LWH = (5)(6)(8) = 240$ units³

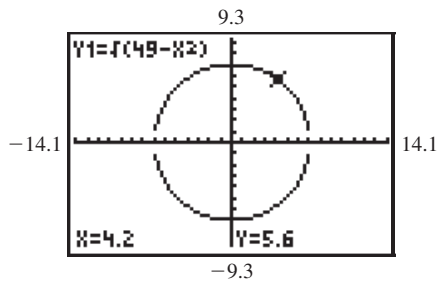
CHAPTER 10

Exercises 10.1, pp. 966–968

1. geometry, algebra 3. perpendicular 5. point, intersecting
 7. $(-2, -2)$; verified 9. $(2, -2)$; verified 11. $(\frac{13}{2}, -9)$; verified
 13. $(x+2)^2 + (y+2)^2 = 5^2$ 15. $(x-2)^2 + (y+2)^2 = 5^2$
 17. $(x - \frac{13}{2})^2 + (y+9)^2 = (\frac{25}{2})^2$ 19. $d = 13$; B, C, E, G
 21. Verified, $d = \frac{8\sqrt{5}}{5}$ 23. B, C, E 25. Verified 27. $y = -\frac{1}{16}x^2$
 29. $4x^2 + 3y^2 = 48$ 31. Verified, verified 33. $3x^2 - y^2 = 3$
 35. Verified 37. $= \frac{\cos^2 x - \sin^2 x + \sin^2 x}{\sin^2 x} = \frac{\cos^2 x}{\sin^2 x} = \cot^2 x$
 39. a. $x = 2 \ln 9, x \approx 4.39$ b. $x = \frac{5}{2} \ln 54, x \approx 9.97$

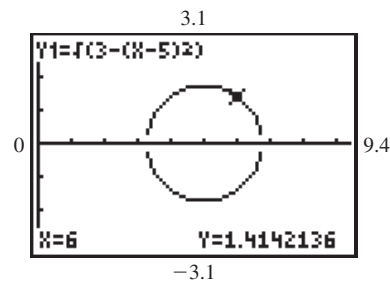
Exercises 10.2, pp. 979–983

1. $c^2 = |a^2 - b^2|$ 3. $2a, 2b$ 5. Answers will vary.
 7. $x^2 + y^2 = 49$



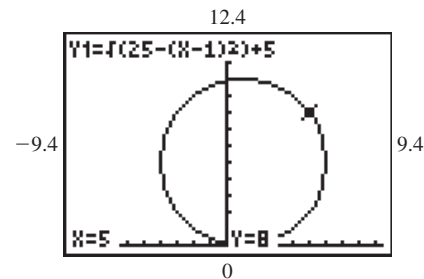
$(4.2, 5.6), (4.2, -5.6)$

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



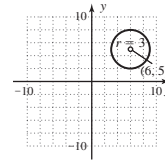
$(6, \sqrt{2}), (6, -\sqrt{2})$

11. $(x-1)^2 + (y-5)^2 = 25$

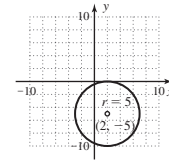


$(5, 8), (5, 2)$

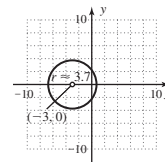
13. $(x-6)^2 + (y-5)^2 = 9$
 center: $(6, 5), r = 3$



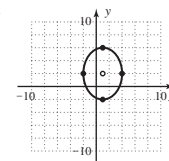
15. $(x-2)^2 + (y+5)^2 = 25$
 center: $(2, -5), r = 5$



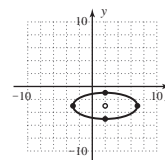
17. $(x+3)^2 + y^2 = 14$
 center: $(-3, 0), r = \sqrt{14}$



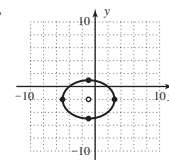
- 19.



- 21.



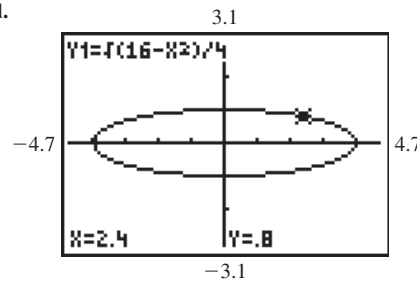
- 23.



25. a. $\frac{x^2}{16} + \frac{y^2}{4} = 1, (0, 0), a = 4, b = 2$

- b. $(-4, 0), (4, 0), (0, -2), (0, 2)$

- d.

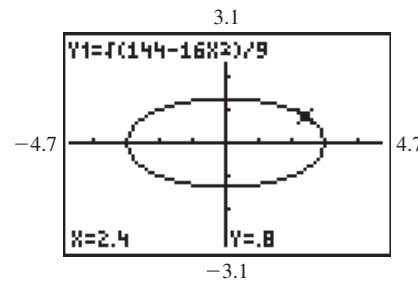


$(2.4, 0.8), (2.4, -0.8), (-2.4, 0.8), (-2.4, -0.8)$

27. a. $\frac{x^2}{9} + \frac{y^2}{16} = 1, (0, 0), a = 3, b = 4$

- b. $(0, -4), (0, 4), (-3, 0), (3, 0)$

- d.

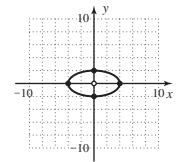


$(2.4, 0.8), (2.4, -0.8), (-2.4, 0.8), (-2.4, -0.8)$

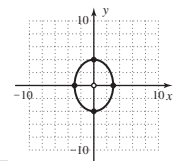
29. a. $\frac{x^2}{5} + \frac{y^2}{2} = 1, (0, 0), a = \sqrt{5}, b = \sqrt{2}$

- b. $(-\sqrt{5}, 0), (\sqrt{5}, 0), (0, -\sqrt{2}), (0, \sqrt{2})$

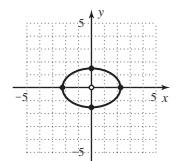
- c.



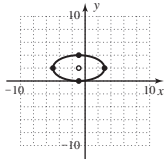
- c.



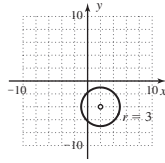
- c.



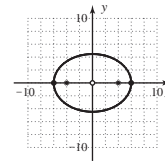
31. ellipse



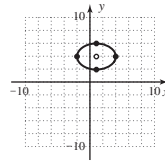
33. circle



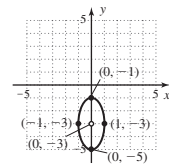
55. $\frac{x^2}{36} + \frac{y^2}{20} = 1$ a.



35. ellipse

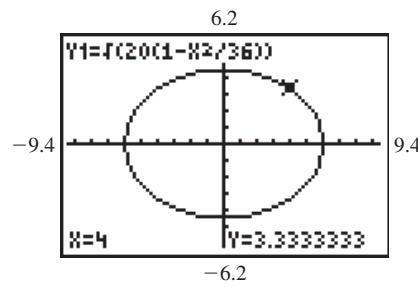


37. $x^2 + \frac{(y + 3)^2}{4} = 1$

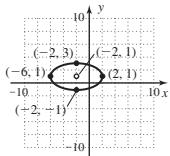


D: $x \in [-1, 1], R: y \in [-5, -1]$

b.

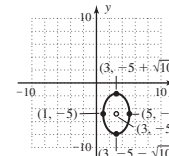


39. $\frac{(x + 2)^2}{16} + \frac{(y - 1)^2}{4} = 1$



D: $x \in [-6, 2], R: y \in [-1, 3]$

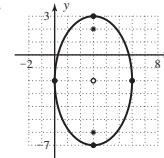
41. $\frac{(x - 3)^2}{4} + \frac{(y + 5)^2}{10} = 1$



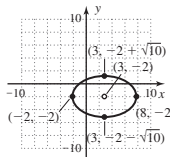
D: $x \in [1, 5], R: y \in [-5 - \sqrt{10}, -5 + \sqrt{10}]$

c. $L = 6\sqrt{6}$ d. verified

57. $\frac{(x - 3)^2}{9} + \frac{(y + 2)^2}{25} = 1$ a.

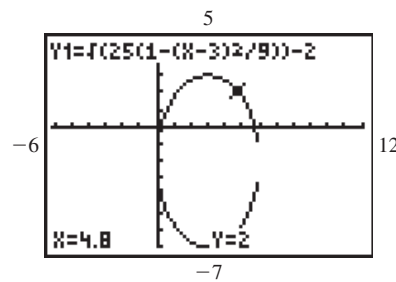


43. $\frac{(x - 3)^2}{25} + \frac{(y + 2)^2}{10} = 1$



D: $x \in [-2, 8], R: y \in [-2 - \sqrt{10}, -2 + \sqrt{10}]$

b.



c. $L = 3.6$ d. verified

59. $\frac{x^2}{16} + \frac{y^2}{9} = 1, (\pm\sqrt{7}, 0)$

61. $\frac{(x + 3)^2}{4} + \frac{(y + 1)^2}{16} = 1, (-3, -1 \pm 2\sqrt{3})$

63. $A = 12\pi$ units² 65. $\sqrt{7} \approx 2.65$ ft, 2.25 ft

67. 8.9 ft, 17.9 ft 69. $\frac{x^2}{15^2} + \frac{y^2}{8^2} = 1; 6.4$ ft 71. $\frac{x^2}{6.25} + \frac{y^2}{2.25} = 1$

73. $\frac{x^2}{36^2} + \frac{y^2}{(35.25)^2} = 1$ 75. $a \approx 142$ million miles, $b \approx 141$ million

miles, orbit time ≈ 686 days 77. about 66,697 mph 79. $90,000\pi$ yd²

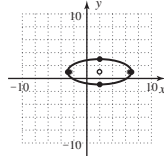
81. a. 45 ft b. 106 ft c. 25 ft 83. ellipse, since squared terms are positive and $A \neq B; 6(x + 3)^2 + 3(y - 4)^2 = 0$, the constant term becomes zero; the graph is the single point $(-3, 4)$

85. $\frac{\log 20}{\log 3} \approx 2.73$ 87. $z = 64$

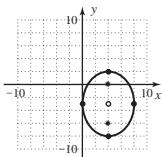
45. $k = 20$ 47. $k = 20$

49. a. (2, 1) b. (-3, 1) and (7, 1) c. $(2 - \sqrt{21}, 1)$ and $(2 + \sqrt{21}, 1)$

d. (2, 3) and (2, -1) e.

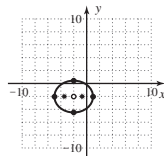


51. a. (4, -3) b. (4, 2) and (4, -8) c. (4, 0) and (4, -6) d. (0, -3) and (8, -3) e.



53. a. (-2, -2) b. (-5, -2) and (1, -2)

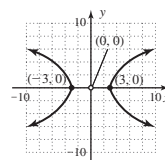
c. $(-2 + \sqrt{3}, -2)$ and $(-2 - \sqrt{3}, -2)$ d. $(-2, -2 + \sqrt{6})$ and $(-2, -2 - \sqrt{6})$ e.



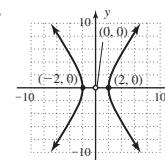
Exercises 10.3, pp. 993–997

1. transverse 3. perpendicular, transverse, center 5. Answers will vary.

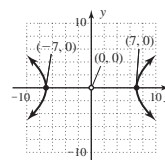
7.

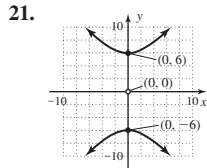
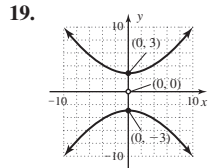
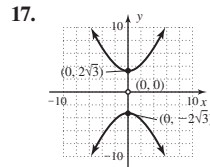
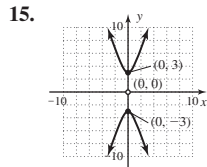
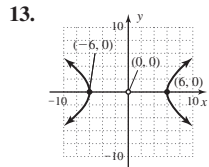


9.

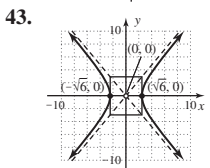
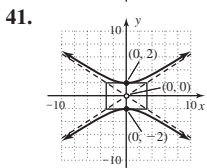
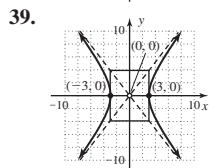
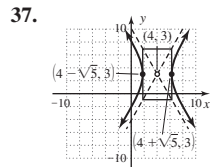
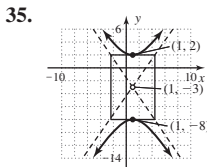
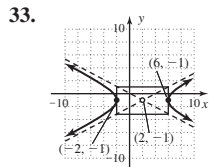
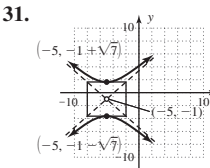
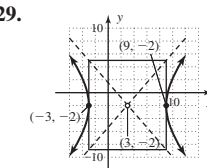
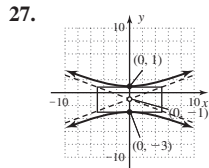


11.

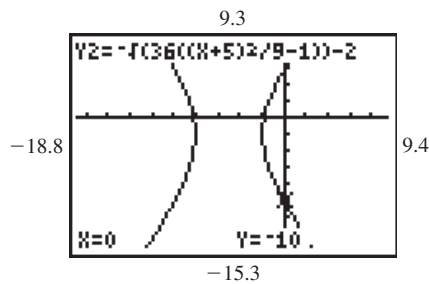
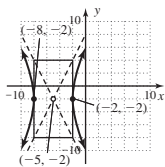




23. $(-4, -2), (2, -2), y = -2, (-1, -2), x = -1$
 25. $(4, 1), (4, -3), x = 4, (4, -1), y = -1$

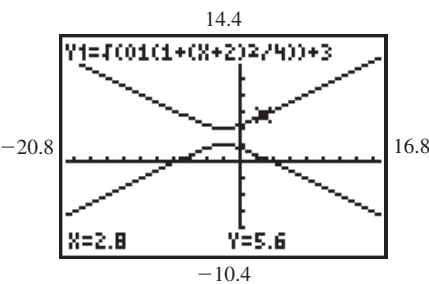
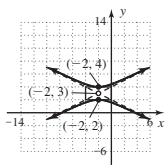


45. $\frac{(x+5)^2}{9} - \frac{(y+2)^2}{36} = 1$



- $(0, -10), (0, 6), (-10, -10), (-10, 6)$

47. $\frac{(y-3)^2}{1} - \frac{(x+2)^2}{4} = 1$

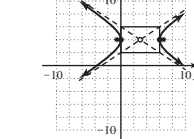


- $(2.8, 5.6), (2.8, 0.4), (-6.8, 0.4), (-6.8, 5.6)$

49. circle; $A = B$ 51. circle; $A = B$ 53. hyperbola; A, B opposite signs
 55. hyperbola; A, B opposite signs 57. circle; $A = B$ 59. ellipse; $A \neq B$
 61. $8, 2a = 8, 2b = 6$ 63. $12, 2a = 16, 2b = 12$

65. $\frac{(x-3)^2}{9} - \frac{(y-4)^2}{4} = 1$ a. $(3, 4)$ b. $(0, 4)$ and $(6, 4)$

- c. $(3 - \sqrt{13}, 4)$ and $(3 + \sqrt{13}, 4)$ d. $2a = 6, 2b = 4$



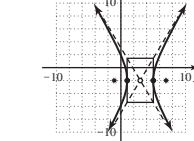
67. $\frac{(y-3)^2}{16} - \frac{x^2}{4} = 1$ a. $(0, 3)$ b. $(0, 7), (0, -1)$

- c. $(0, 3 + 2\sqrt{5}), (0, 3 - 2\sqrt{5})$ d. $2a = 4, 2b = 8$



69. $\frac{(x-3)^2}{4} - \frac{(y+2)^2}{12} = 1$ a. $(3, -2)$ b. $(1, -2)$ and $(5, -2)$

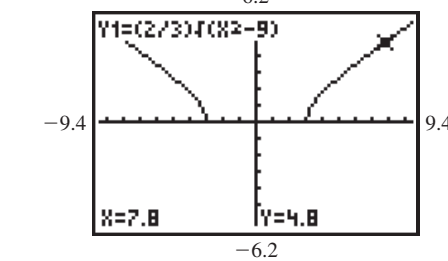
- c. $(-1, -2)$ and $(7, -2)$ d. $2a = 4, 2b = 4\sqrt{3}$



71. $\frac{x^2}{36} - \frac{y^2}{28} = 1$ 73. $\frac{y^2}{9} - \frac{(x+2)^2}{9} = 1$

75. $\frac{x^2}{4} - \frac{y^2}{9} = 1, (\pm\sqrt{13}, 0)$ 77. $\frac{(y-1)^2}{4} - \frac{(x-2)^2}{5} = 1, 4$ by $2\sqrt{5}$

79. a. $y = \pm\sqrt{\frac{2}{3}x^2 - 9}$ b. $x \in (-\infty, -3] \cup [3, \infty)$



81. 40 yd 83. 12 microns

85. $\frac{x^2}{225} - \frac{y^2}{2275} = 1$, about $(24.1, 60)$ or $(-24.1, 60)$

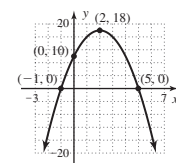
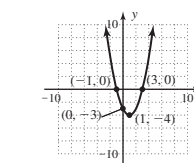
87. $y = \pm\sqrt{\frac{b^2}{a^2}x^2 - b^2}$, as $x \rightarrow \infty, y \rightarrow \pm\sqrt{\frac{b^2}{a^2}x^2} = \pm\frac{b}{a}x$

89. a. $\frac{(x-4)^2}{4} - (y-2)^2 = 0$ b. $(x-2)^2 + \frac{(y-4)^2}{5} = 0$

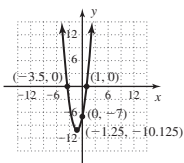
91. ≈ 6 mph 93. 42 solid, 46 liquid

Exercises 10.4, pp. 1003–1006

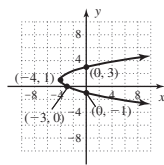
1. horizontal, right, $a < 0$ 3. $(p, 0), x = -p$ 5. Answers will vary.
 7. $x \in (-\infty, \infty), y \in [-4, \infty)$ 9. $x \in (-\infty, \infty), y \in (-\infty, 18]$



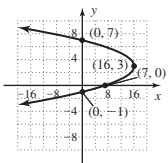
11. $x \in (-\infty, \infty)$,
 $y \in [-10.125, \infty)$



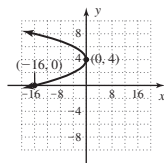
13. $x \in [-4, \infty)$, $y \in (-\infty, \infty)$



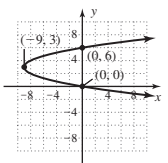
15. $x \in (-\infty, 16]$, $y \in (-\infty, \infty)$



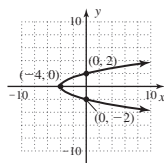
17. $x \in (-\infty, 0]$, $y \in (-\infty, \infty)$



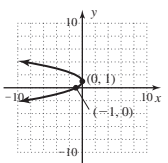
19. $x \in [-9, \infty)$, $y \in (-\infty, \infty)$



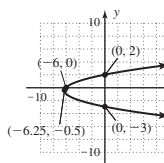
21. $x \in [-4, \infty)$, $y \in (-\infty, \infty)$



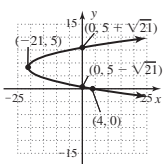
23. $x \in (-\infty, 0]$, $y \in (-\infty, \infty)$



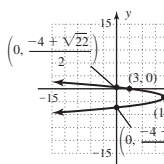
25. $x \in [-6.25, \infty)$, $y \in (-\infty, \infty)$



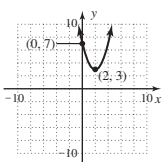
27. $x \in [-21, \infty)$, $y \in (-\infty, \infty)$



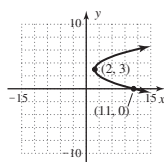
29. $x \in (-\infty, 11]$, $y \in (-\infty, \infty)$



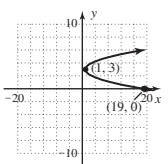
31. $x \in (-\infty, \infty)$, $y \in [3, \infty)$



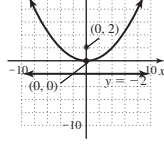
33. $x \in [2, \infty)$, $y \in (-\infty, \infty)$



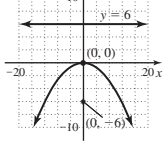
35. $x \in [1, \infty)$, $y \in (-\infty, \infty)$



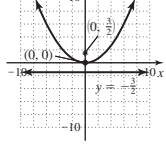
37.



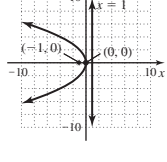
39.



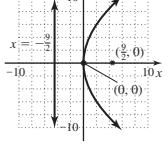
41.



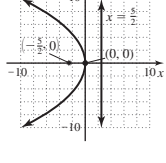
43.



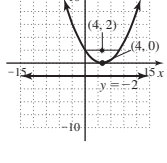
45.



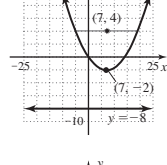
47.



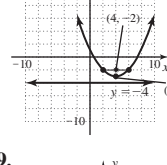
49.



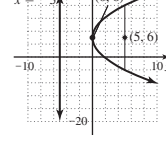
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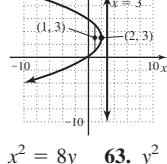
53.



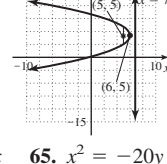
55.



57.



59.



61. $x^2 = 8y$ 63. $y^2 = 16x$ 65. $x^2 = -20y$

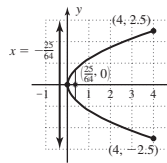
67. $(y + 2)^2 = -12(x - 2)$ 69. $(x - 4)^2 = 12(y + 7)$

71. $(x - 3)^2 = 8(y - 2)$ 73. $y^2 = 8(x + 1)$; vertex $(-1, 0)$; focus $(1, 0)$

75. $(x - 2)^2 = -12(y - 2)$; focus: $(2, -1)$; endpoints $(-4, -1)$ and $(8, -1)$

77. 16 units²

79.



81. 6 in.; $(13.5, 0)$ 83. ≈ 14.97 ft, $(0, 41.75)$

85. $y^2 = 5x$ or $x^2 = 5y$, 1.25 cm

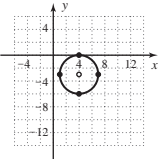
87. $(x - 2)^2 = \frac{1}{2}(y + 8)$; $p = \frac{1}{8}$; $(2, -8)$

89. Answers will vary.

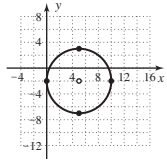
91. $\theta = 30^\circ + 360^\circ k, 330^\circ + 360^\circ k$

Mid-Chapter Check, p. 1006

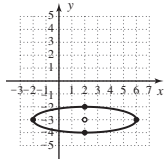
1.



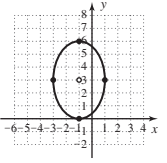
2.



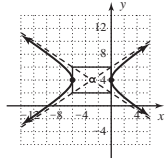
3.



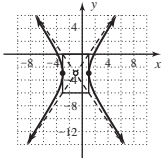
4.



5.



6.



7. a. $\frac{(x + 3)^2}{4} + \frac{(y - 1)^2}{16} = 1$; $D: x \in [-5, -1]$; $R: y \in [-3, 5]$

b. $(x - 3)^2 + (y - 2)^2 = 16$; $D: x \in [-1, 7]$; $R: y \in [-2, 6]$

c. $y = (x - 3)^2 - 4$; $D: x \in (-\infty, \infty)$; $R: y \in [-4, \infty)$

8. $(y - 2)^2 = 6(x - \frac{1}{2})$

9. $\frac{x^2}{16} + \frac{y^2}{4} = 1$

10. yes, distance $d \approx 49$ mi

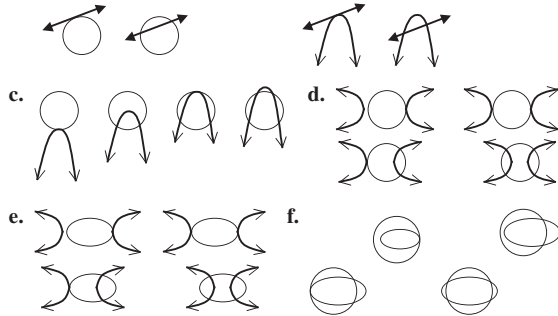
Reinforcing Basic Concepts, pp. 1006–1007

Exercise 1: $\frac{25(x - 2)^2}{2} + \frac{9(y - 3)^2}{4} = 1$

Exercise 2: $\frac{28(x - 1)^2}{25} + \frac{48(y + 2)^2}{25} = 1$

Exercises 10.5, pp. 1015–1018

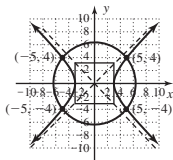
1. a. 3 or 4 not possible b. 3 or 4 not possible



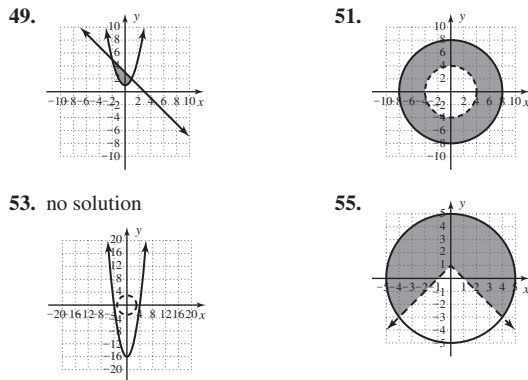
3. region, solutions 5. Answers will vary.
7. first: parabola; second: line 9. first: parabola; second: ellipse



11. first: hyperbola; second: circle



13. $(-4, -3), (3, 4)$ 15. $(4, \frac{3}{2}), (3, 2)$
17. $(\sqrt{10}, 3), (-\sqrt{10}, 3), (5, -12), (-5, -12)$
19. $(4i, 16 + 24i), (-4i, 16 - 24i)$
21. $(4, 3), (4, -3), (-4, 3), (-4, -3)$
23. $(2 + i, -2 + i), (2 - i, -2 - i)$
25. $(5, -5), (5, 5), (-5, 5), (-5, -5)$
27. $(4, 4), (6.187, -1.571)$ 29. $(-1.863, 11.808), (7.863, -1.808)$
31. $(5, \log 5 + 5)$ 33. $(-3, \ln 9 + 1), (4, \ln 16 + 1)$
35. $(0, 10), (\ln 6, 45)$ 37. $(-3, 1), (2, 1024)$
39. $(-3, -21), (1, -1), (2, 4)$ 41. $(2, -4), (6, 4)$
43. $(3, 5), (3, -5)$ 45. $(-2.43, -2.81), (2, 1)$
47. $(0.72, 2.19), (2, 3), (4, 3), (5.28, 2.19)$

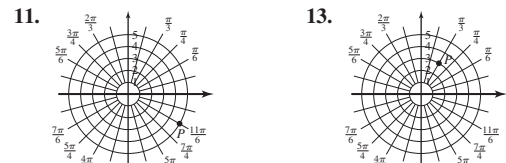
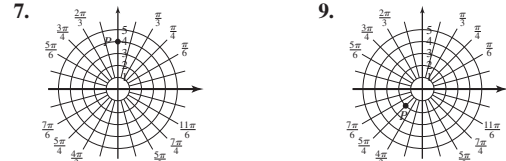


57. $h \approx 27.5$ ft; $h = 24$ ft; $h = 18$ ft
59. The company breaks even if either 18,400 or 48,200 cars are sold.
61. $\begin{cases} x^2y = 2000 \\ x^2 + 4xy = 800 \end{cases}$; approx. $(12.4, 13)$ or $(20, 5)$; The pool will likely have the dimensions 20 ft by 20 ft by 5 ft.

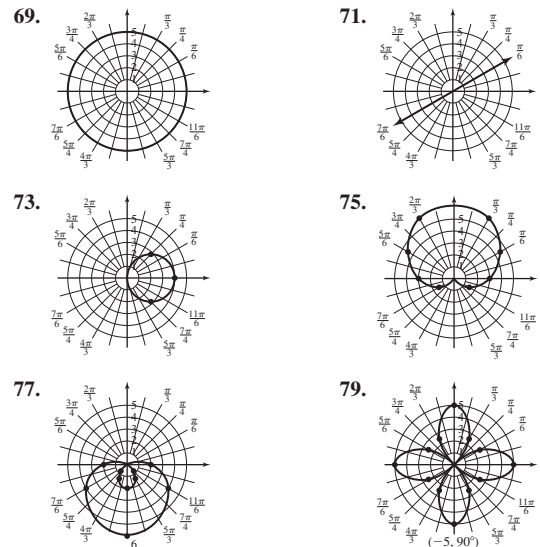
63. $8.5 \text{ m} \times 10 \text{ m}$ 65. $5 \text{ km} \times 9 \text{ km}$ 67. $8 \text{ ft} \times 8 \text{ ft} \times 25 \text{ ft}$
69. \$1.83; \$3
90,000 gal
 $\begin{cases} 10P^2 + 6D = 144 \\ 8P^2 - 8P - 4D = 12 \end{cases}$
71. Answers will vary. 73. 18 in. by 18 in. by 77 in. 75. ≈ 62 ft
77. a. $m = \frac{-400}{1}$, the copier depreciates by \$400 a year.
b. $y = -400x + 4500$ c. \$1700 d. 9.5 yr

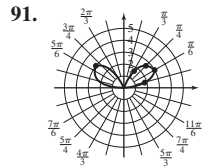
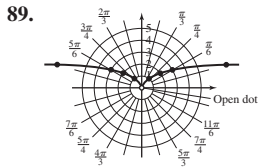
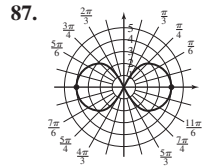
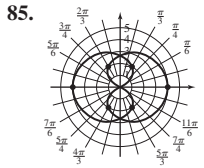
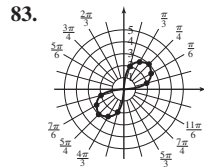
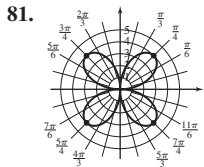
Exercises 10.6, pp. 1031–1035

1. polar 3. II, IV 5. Answers will vary.

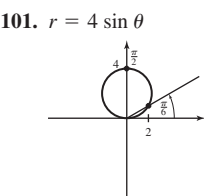
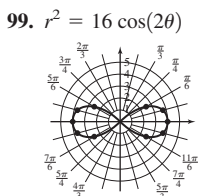
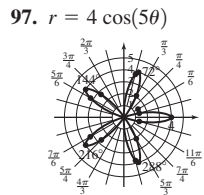
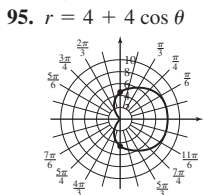


15. $(4, \frac{\pi}{2})$ 17. $(4\sqrt{2}, \frac{\pi}{4})$ 19. $(8, \frac{2\pi}{3})$ 21. $(4\sqrt{2}, \frac{3\pi}{4})$
23. $(3\sqrt{2}, \frac{-5\pi}{4}), (-3\sqrt{2}, \frac{7\pi}{4}), (-3\sqrt{2}, \frac{-\pi}{4})$
25. $(2, \frac{5\pi}{6}), (2, \frac{-7\pi}{6}), (-2, \frac{-\pi}{6})$ 27. C 29. C 31. D 33. B
35. D 37. $(8, 180^\circ)$ or $(8, \pi)$ 39. $(4\sqrt{2}, 45^\circ)$ or $(4\sqrt{2}, \frac{\pi}{4})$
41. $(10, 45^\circ)$ or $(10, \frac{\pi}{4})$ 43. $(13, 247.4^\circ)$ or $(13, 4.3176)$
45. $(4\sqrt{2}, 4\sqrt{2})$ 47. $(-2\sqrt{2}, 2\sqrt{2})$ 49. $(\sqrt{3}, 1)$ 51. $(\frac{5\sqrt{2}}{2}, \frac{5\sqrt{2}}{2})$
53. $r = 5$ 55. $r^2 \sin 2\theta = 6$ 57. $\tan \theta = 3r \cos \theta + 1$ or $r = \frac{\tan \theta - 1}{3 \cos \theta}$
59. $r^2 = \cos 2\theta$ 61. $x^2 + y^2 = 6x$ 63. $x = 2$ 65. $x^2 + y^2 = x - 1$
67. $y = -\frac{1}{2}x^2 + \frac{1}{2}$





93. $\left(\frac{4\sqrt{3} + 3\sqrt{2}}{2}, \frac{4 + 3\sqrt{2}}{2}\right); (3\sqrt{2}, 3\sqrt{2}); (4\sqrt{3}, 4);$ yes
 $M = \left(\frac{3\sqrt{2} + 4\sqrt{3}}{2}, \frac{3\sqrt{2} + 4}{2}\right)$



103. a; this is a circle through $(6, 0^\circ)$ symmetric to the polar axis.

105. g; this is a circle through $\left(6, \frac{\pi}{2}\right)$ symmetric to $\theta = \frac{\pi}{2}$.

107. f; this is a limaçon symmetric to $\theta = \frac{\pi}{2}$ with an inner loop. Thus $a < b$.

109. b; this is a cardioid symmetric to $\theta = \frac{\pi}{2}$ through $\left(6, \frac{3\pi}{2}\right)$.

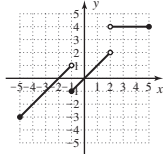
111. $r^2 = 7200^2 \sin(2\theta)$ 113. $r = 15 \cos(5\theta)$ or $r = 15 \sin(5\theta)$

115. $\pi; \pi; \pi$; Answers will vary.

117. Consider $r = a\sqrt{\cos(2\theta)}$ and $r = -a\sqrt{\cos(2\theta)}$; both satisfy $r^2 = a^2 \cos(2\theta)$. Thus, (r, θ) and $(-r, \theta)$ will both be on the curve. The same is true with $a\sqrt{\sin(2\theta)}$ and $-a\sqrt{\sin(2\theta)}$.

119. 9π units² 121. $t = 0, \frac{2\pi}{3}, \pi, \frac{5\pi}{3}$

123. $D: x \in [-5, 2) \cup (2, 5]$
 $R: y \in [-3, 2) \cup \{4\}$



Exercises 10.7, pp. 1046–1051

1. rotation of axes; $\frac{B}{A-C}$ 3. invariants 5. Answers will vary.

7. $\frac{Y^2}{8} - \frac{X^2}{8} = 1$ 9. $6 + 3\sqrt{2} = X, -6 + 3\sqrt{2} = Y$

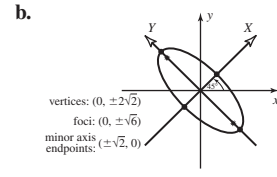
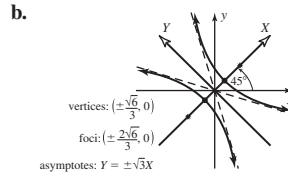
11. $\frac{5\sqrt{2}}{2} = X, \frac{5\sqrt{2}}{2} = Y$ 13. $0 = x, 4 = y$

15. $\frac{3\sqrt{3}}{2} - 2 = x; \frac{3}{2} + 2\sqrt{3} = y$ 17. $\frac{-x^2}{2} + xy\sqrt{3} + \frac{y^2}{2} = 9$

19. $4X^2 + 2Y^2 = 9$

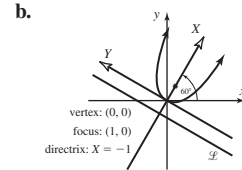
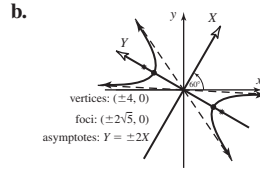
21. a. $3X^2 - Y^2 = 2$

23. a. $4X^2 + Y^2 = 8$

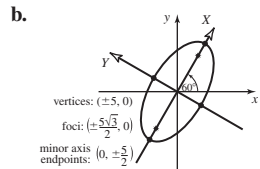


25. a. $Y^2 - 4X^2 = 16$

27. a. $Y^2 - 4X = 0$



29. a. $X^2 + 4Y^2 = 25$

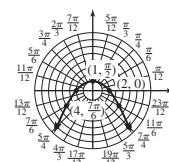


31. $336 > 0$; hyperbola; $\cos(2\beta) = \frac{7}{25}; \frac{4}{5} = \cos \beta; \frac{3}{5} = \sin \beta$

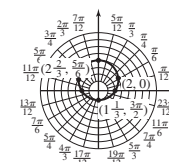
33. a. parabola b. $\beta = 45^\circ; 2Y^2 = 5$ c. verified

35. a. circle or ellipse b. $\beta = 60^\circ; \frac{9}{2}X^2 + \frac{5Y^2}{2} + 2X - 2\sqrt{3}Y = 1$ (ellipse) c. verified 37. f 39. g 41. h

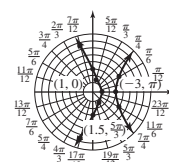
43. parabola



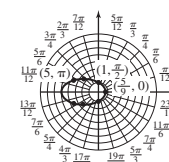
45. ellipse



47. hyperbola



49. ellipse



51. $r = \frac{3.2}{1 - 0.8 \cos \theta}, r = \frac{3.2}{1 + 0.8 \cos \theta}, r = \frac{3.2}{1 - 0.8 \sin \theta}$, or

$r = \frac{3.2}{1 + 0.8 \sin \theta}$ 53. $r = \frac{4}{1 - \cos \theta}$ 55. $r = \frac{7.5}{1 + 1.5 \sin \theta}$

57. a. $r = \frac{12}{2 \cos \theta + 3 \sin \theta}$ b. $-\frac{r(\pi/2)}{r(0)} = -\frac{2}{3}$ and $-\frac{A}{B} = -\frac{2}{3}$

59. Jupiter: $e \approx 0.0486$, Saturn: $e \approx 0.0567$

61. about 2756.0 million miles 63. Saturn: $e \approx 0.0567$

65. $r \approx \frac{482.36}{1 - 0.0486 \cos \theta}$ 67. $r \approx \frac{1780.77}{1 - 0.0457 \cos \theta}$

69. In millions of miles (approx): JS: 405.3, JU: 1298.4, JN: 2310.3, SU: 893.1, SN: 1905.0, UN: 1011.9

71. $r = \frac{0.7638}{1 \pm 0.7862 \cos \theta}$ 73. $r = \frac{0.2864}{1 \pm 0.7862 \cos \theta}$

75. \$582.45; \$445.94; \$881.32; \$97.92 77. $y = \frac{3}{1 - \cos \theta}$

79. verified 81. a. verified b. verified c. Answers will vary.

83. $r = 12 \cos\left(\theta - \frac{\pi}{4}\right)$ or $r = 6\sqrt{2}(\cos \theta + \sin \theta)$

85. $425X^2 - 416Y^2 - 400 = 0$ 87. (0, 0), (4, 0), (4, 4), (0, 4)

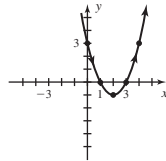
89. $x \approx 29.0$ 91. 9.2 mph at heading 347.7°

Exercises 10.8, pp. 1059–1063

1. parameter 3. direction 5. Answers will vary.

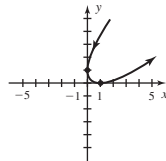
7. a. parabola with vertex at (2, -1)

b. $y = x^2 - 4x + 3$



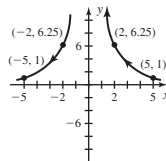
9. a. parabola

b. $y = x \pm 2\sqrt{x} + 1$



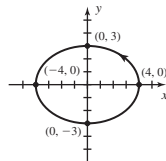
11. a. power function with $p = -2$

b. $y = \frac{25}{x^2}, x \neq 0$



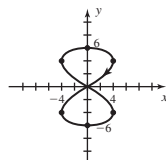
13. a. ellipse

b. $\frac{x^2}{16} + \frac{y^2}{9} = 1$

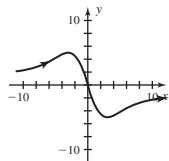


15. a. Lissajous figure

b. $y = 6 \cos\left[\frac{1}{2} \sin^{-1}\left(\frac{x}{4}\right)\right]$



17.



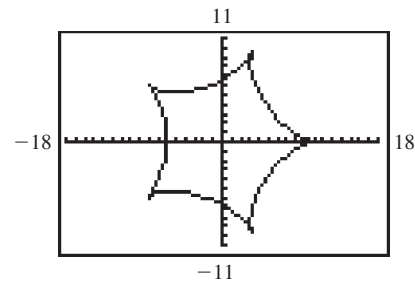
19. $x = t, y = 3t - 2; x = \frac{1}{3}t, y = t - 2; x = \tan t, y = 3 \tan t - 2,$
 $t \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

21. $x = t, y = (t + 3)^2 + 1; x = t - 3, y = t^2 + 1; x = \tan t - 3,$
 $y = \sec^2 t, t \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

23. $x = t, y = \tan^2(t - 2) + 1, t \neq \pi k + \frac{\pi}{2} + 2, k \in \mathbb{Z}; x = t + 2,$
 $y = \sec^2 t, t \neq \left(k + \frac{1}{2}\right)\pi, k \in \mathbb{Z}; x = \tan^{-1}t + 2, y = t^2 + 1$

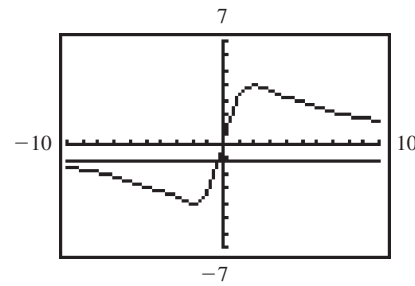
25. verified

27. a.



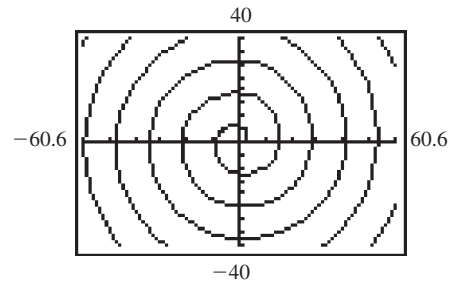
b. x-intercepts: $t = 0, x = 10, y = 0$ and $t = \pi, x = -6, y = 0$;
 y-intercepts: $t \approx 1.757, x = 0, y \approx 6.5$ and $t \approx 4.527, x = 0, y \approx -6.5$;
 minimum x-value is -8.1 ; maximum x-value is 10 ; minimum y-value is -9.5 ;
 maximum y-value is 9.5

29. a.



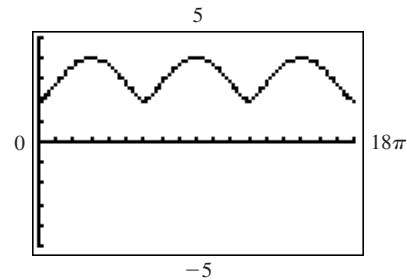
b. x-intercepts none, y-intercepts none; no minimum or maximum x-values; minimum y-value is -4 and maximum y-value is 4

31. a.



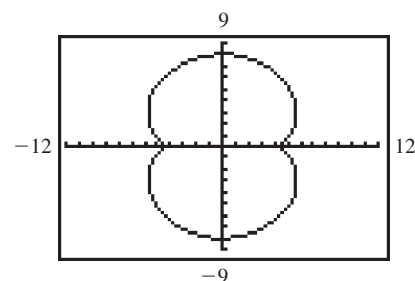
b. x-intercepts: $t = 0, x = 2, y = 0$ and $t \approx 4.493, x \approx -9.2, y = 0$;
 infinitely many others; y-intercepts: $t \approx 2.798, x = 0, y \approx 5.9$ and
 $t \approx 6.121, x = 0, y \approx -12.4$; infinitely many others; no minimum or
 maximum values for x or y

33. a.



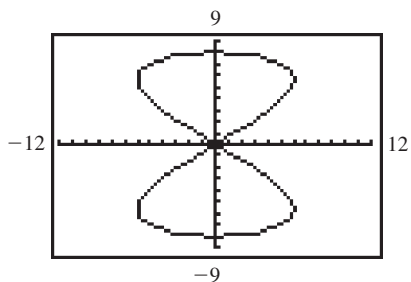
b. no x-intercepts; y-intercept is $t = 0, x = 0, y = 2$; no minimum or maximum x-values; minimum y-value is 2 ; maximum y-value is 4

35. a.



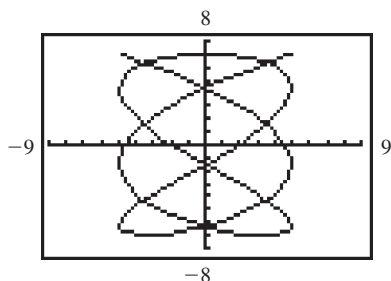
b. x -intercepts: $t = 0, x = 4, y = 0$ and $t = \pi, x = -4, y = 0$;
 y -intercepts: $t = \frac{\pi}{2}, x = 0, y = 8$ and $t = \frac{3\pi}{2}, x = 0, y = -8$; minimum
 and maximum x -values are approx. ± 5.657 ; minimum and maximum
 y -values are ± 8

37.



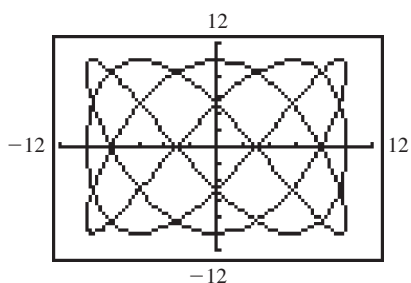
width 12 and height 16; including the endpoint $t = 2\pi$, the graph crosses
 itself two times from 0 to 2π .

39.



width 10 and height 14; including the endpoint $t = 2\pi$, the graph crosses
 itself nine times from 0 to 2π .

41.



width 20 and height 20; including the endpoint $t = 4\pi$, the graph crosses
 itself 23 times from 0 to 4π .

43. The maximum value (as the graph swells to a peak) is at

$(x, y) = (a, \frac{b}{2})$. The minimum value (as the graph dips to the valley)

is at $(x, y) = (-a, \frac{-b}{2})$.

45. a. The curve is approaching $y = 2$ as t approaches $\frac{3\pi}{2}$, but $\cot(\frac{3\pi}{2})$ is

undefined, and the trig form seems to indicate a hole at

$t = \frac{3\pi}{2}, x = 0, y = 2$. The algebraic form does not have this problem and

shows a maximum defined at $t = 0, x = 0, y = 2$.

b. As $|t| \rightarrow \infty, y(t) \rightarrow 0$ c. The maximum value occurs at $(0, 2k)$.

47. a. Yes b. Yes c. ≈ 0.82 ft 49. No, the kick is short.

51. The electron is moving left and downward.

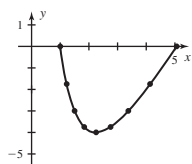
53. 3 orbits; about 2.1 orbits 55. $(t, \frac{6t}{17} - \frac{6}{17}, \frac{13t}{17} + \frac{21}{17})$

57. Inconsistent, no solutions

59. $x = 1.22475^t$

$y = 0.25t^2 - 2t$

The parametric equations fit the data very well.



61. $x = 2 \cos t - 3, y = \cos(2t)$; no, the range of $\cos(2t)$ is $[-1, 1]$

63. Taller (The Eiffel Tower is about 1063 ft tall) 65. $\theta \approx 55^\circ$

Making Connections, p. 1064

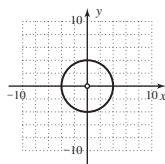
1. d 3. f 5. g 7. c 9. h 11. e 13. b 15. g

Summary and Concept Review, pp. 1064–1068

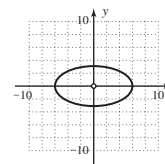
1. verified (segments are perpendicular and equal length)

2. $x^2 + (y - 1)^2 = 34$ 3. yes 4. verified

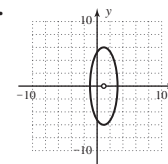
5.



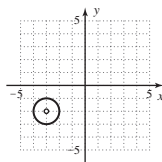
6.



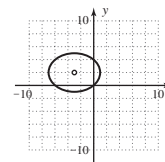
7.



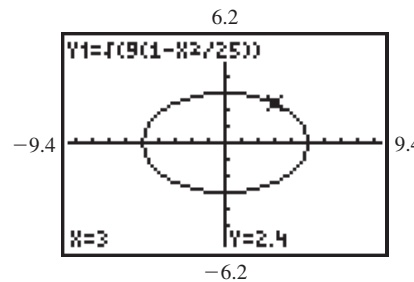
8.



9.



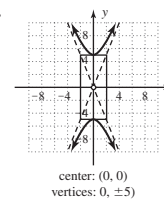
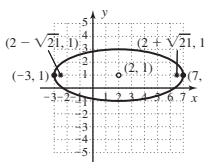
10. $\frac{x^2}{25} + \frac{y^2}{9} = 1$



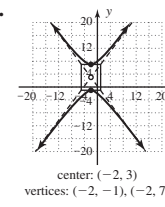
Four possibilities: $(3, 2.4), (-3, 2.4), (3, -2.4), (-3, -2.4)$

11. a. $\frac{x^2}{169} + \frac{y^2}{25} = 1$ b. $\frac{x^2}{144} + \frac{y^2}{400} = 1$

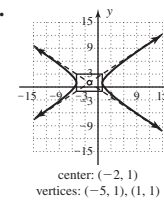
12. $\frac{(x - 2)^2}{25} + \frac{(y - 1)^2}{4} = 1$ 13.



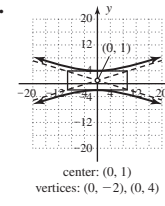
14.



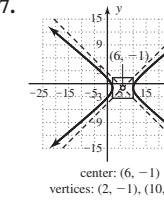
15.



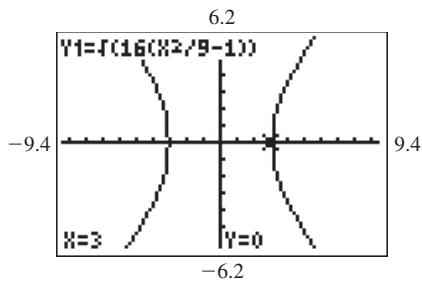
16.



17.



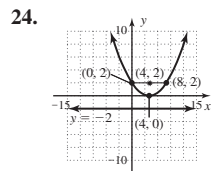
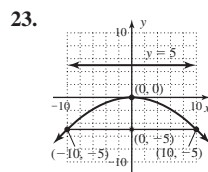
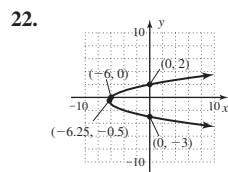
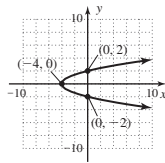
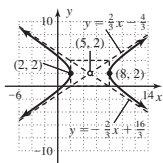
18. $\frac{x^2}{9} - \frac{y^2}{16} = 1$



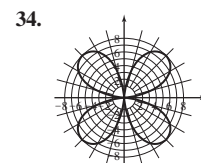
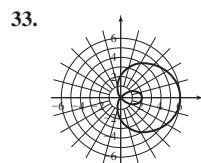
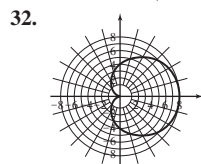
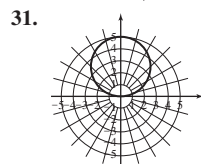
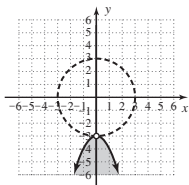
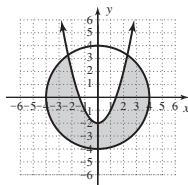
Answers may vary. One possibility: $(\pm 7.8, \pm 9.6)$.

19. a. $\frac{x^2}{225} - \frac{y^2}{64} = 1$ b. $\frac{y^2}{16} - \frac{x^2}{9} = 1$

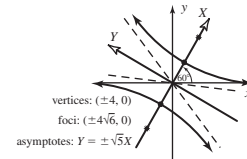
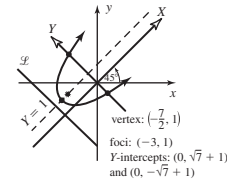
20. $\frac{(x-5)^2}{9} - \frac{(y-2)^2}{4} = 1$ 21.



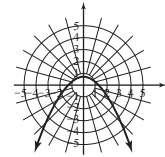
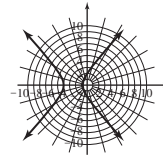
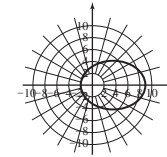
25. circle, line, (4, 3), (-3, -4) 26. parabola, line, (3, -2)
 27. parabola, circle, $(\sqrt{3}, 2)$, $(-\sqrt{3}, 2)$, $(i\sqrt{2}, -3)$, $(-i\sqrt{2}, -3)$
 28. circle, parabola, (1, 3), (-1, 3), $(\frac{i\sqrt{10}}{3}, -\frac{10}{3})$, $(\frac{-i\sqrt{10}}{3}, -\frac{10}{3})$
 29. Parabola, circle 30. Circle, parabola



35. $Y^2 - 2Y - 2X - 6 = 0$ 36. $5X^2 - Y^2 - 80 = 0$
 $(Y-1)^2 = 2(X + \frac{7}{2})$ $\frac{X^2}{16} - \frac{Y^2}{80} = 1$

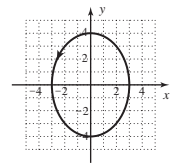
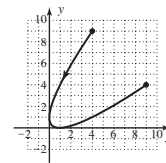
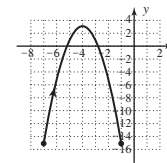


37. ellipse, $e = \frac{2}{3}$; 38. hyperbola, $e = \frac{3}{2}$; 39. parabola, $e = 1$;

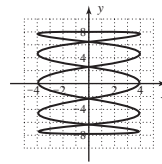


40. $r = \frac{de}{1 - e \cos \theta}$ with $e \approx 0.0935$ and $d \approx 1501.1$; focal cord: ≈ 280.82 million miles

41. $y = -2(x+4)^2 + 3$ 42. $y = (-1 \pm \sqrt{x})^2$ 43. $\frac{x^2}{9} + \frac{y^2}{16} = 1$

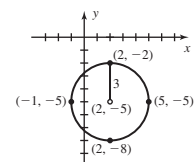


44. Answers will vary.
 45. $x \in [-4, 4]$; $y \in [-8, 8]$

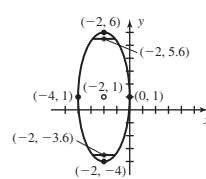


Practice Test, p. 1069

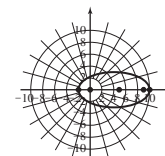
1. c 2. d 3. b 4. a
 5. circle; center (2, -5); radius 3



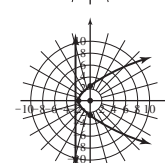
6. ellipse; center (-2, 1); vertices (-2, -4), (-2, 6); foci $(-2, 1 - \sqrt{21})$, $(-2, 1 + \sqrt{21})$



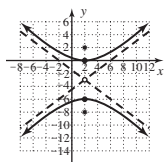
7. ellipse; center $(\frac{40}{9}, 0)$; vertices $(-\frac{10}{9}, 0)$, (10, 0); foci (0, 0), $(\frac{80}{9}, 0)$



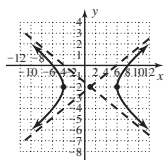
8. parabola; vertex (-1.2, 0); focus (0, 0); directrix at $y = -2.4$



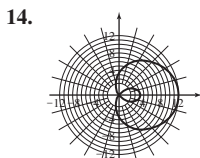
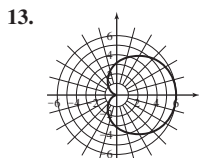
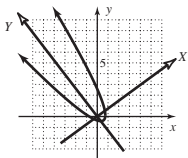
9. hyperbola; center: (2, -3); vertices: (2, 0), (2, -6); foci: (2, -8), (2, 2); asymptotes: $y = \frac{3}{4}x - \frac{9}{2}, y = -\frac{3}{4}x - \frac{3}{2}$



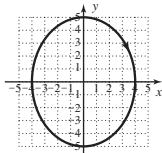
10. hyperbola; center (1, -2); vertices (-4, -2), (6, -2); foci $(1 - \sqrt{29}, -2) \approx (-4.39, -2)$ $(1 + \sqrt{29}, -2) \approx (6.39, -2)$; asymptotes: $y = -\frac{2}{5}x - \frac{8}{5}, y = \frac{2}{5}x - \frac{12}{5}$



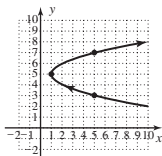
11. parabola; $\beta \approx 36.87^\circ; \cos \beta = \frac{4}{5}, \sin \beta = \frac{3}{5}$
 12. $Y = \frac{25}{16}X^2 - \frac{3}{4}X - \frac{11}{20}$



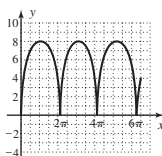
16. ellipse; $\frac{x^2}{16} + \frac{y^2}{25} = 1$



17. parabola; $x = (y - 5)^2 + 1$



18. max: $y = 8$; min: $y = 0$; $P = 2\pi$



19. a. $(3\frac{1}{3}, 5\frac{1}{3}), (-2, 0)$ b. $(2, 2), (-2, 2), (2, -2), (-2, -2)$

20. $r \approx \frac{1654(1 - 0.967^2)}{1 - 0.967 \cos \theta}$ e is very close to 1. This makes its orbit a very elongated ellipse, where the orbit of most planets is nearly circular.

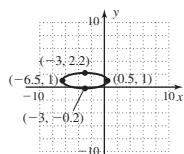
21. The ball is 0.43 ft above the ground at $x = 165$ ft, and will likely go into the goal. 22. Perihelion: 128.41 million miles, Aphelion: 154.27 million miles 23. $y = (x - 1)^2 - 4$; $D: x \in \mathbb{R}$; $R: y \in [-4, \infty)$; focus: $(1, -3.75)$

24. $(x - 1)^2 + (y - 1)^2 = 25$; $D: x \in [-4, 6]$; $R: y \in [-4, 6]$

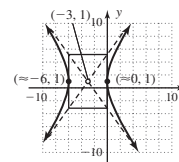
25. $\frac{(x + 2)^2}{9} + \frac{(y - 1)^2}{25} = 1$; $D: x \in [-5, 1]$; $R: y \in [-4, 6]$; foci $(-2, 5), (-2, -3)$

Strengthening Core Skills, p. 1071

1. $\frac{(x + 3)^2}{(\frac{7}{2})^2} + \frac{(y - 1)^2}{(\frac{6}{5})^2} = 1$; $a = \frac{7}{2}, b = \frac{6}{5}$



2. $\frac{(x + 3)^2}{(\frac{4\sqrt{5}}{3})^2} - \frac{(y - 1)^2}{(\frac{9}{2})^2} = 1$; $a = \frac{4\sqrt{5}}{3} \approx 3, b = \frac{9}{2}$



3. $\frac{(x - 2)^2}{(\frac{\sqrt{2}}{5})^2} - \frac{(y + 3)^2}{(\frac{2}{3})^2} = 1$

$a = \frac{\sqrt{2}}{5}, b = \frac{2}{3}$

4. $\frac{(x - 1)^2}{(\frac{5\sqrt{7}}{14})^2} + \frac{(y + 2)^2}{(\frac{5\sqrt{3}}{12})^2} = 1$

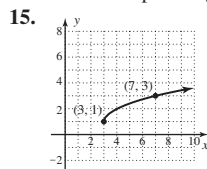
$a = \frac{5\sqrt{7}}{14}, b = \frac{5\sqrt{3}}{12}$

Cumulative Review Chapters 1-10, p. 1072

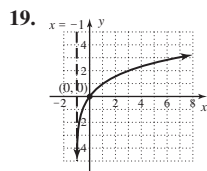
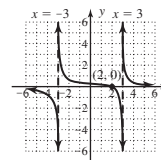
1. $(y - 3)^2 = 8(x - 2)$ 3. $x = -6$ 5. $x = 4$ 7. $\frac{5\pi}{6} + k\pi, k \in \mathbb{Z}$

9. $x \approx 61.98^\circ + 360^\circ k; k \in \mathbb{Z}$
 $x \approx 118.02^\circ + 360^\circ k; k \in \mathbb{Z}$

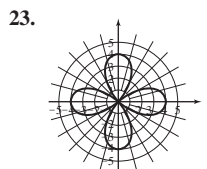
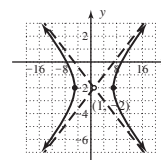
11. about 24.7 pesos/kg 13. The formation is 1152.4 yd wide.



17. horizontal asymptote: $y = 0$
 vertical asymptotes: $x = 3, x = -3$,
 x-intercept: $(2, 0)$; y-intercept: $(0, \frac{2}{9})$



21. center $(1, -2)$; foci $(1 + 2\sqrt{10}, -2) \approx (7.32, -2)$, $(1 - 2\sqrt{10}, -2) \approx (-5.32, -2)$; asymptotes $y = \frac{1}{3}x - \frac{7}{3}, y = -\frac{1}{3}x - \frac{5}{3}$; vertices $(-5, -2), (7, -2)$



25. 61.9° 27. $(-3, 4), (3, 4), (-3, -4), (3, -4)$ 29. $\frac{1}{x} - \frac{3}{x^2} + \frac{2x + 1}{x^2 + 1}$

Connections to Calculus Exercises, pp. 1075-1076

1. a. $-\frac{\cos(2\theta) + \cos \theta}{\sin(2\theta) + \sin \theta}$ b. 1, 1 c. $\frac{\pi}{3}, \frac{5\pi}{3}$ d. $0, \frac{2\pi}{3}, \frac{4\pi}{3}$

3. a. $-\frac{\cos(2\theta) - \sin(2\theta)}{\sin(2\theta) + \cos(2\theta)}$ b. 1, 1 c. $\frac{\pi}{8}, \frac{5\pi}{8}, \frac{9\pi}{8}, \frac{13\pi}{8}$

d. $\frac{3\pi}{8}, \frac{7\pi}{8}, \frac{11\pi}{8}, \frac{15\pi}{8}$ 5. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$; verified

7. four-leaf rose, circle; $\frac{\pi}{6}, \frac{\pi}{2}, \frac{5\pi}{6}, \frac{3\pi}{2}$; verified

9. $(r, \theta): (0, \frac{\pi}{2}), (2\sqrt{3}, \frac{\pi}{6}), (-2\sqrt{3}, \frac{5\pi}{6}), (0, \frac{3\pi}{2})$; $(x, y): (0, 0), (3, \sqrt{3}), (3, -\sqrt{3})$

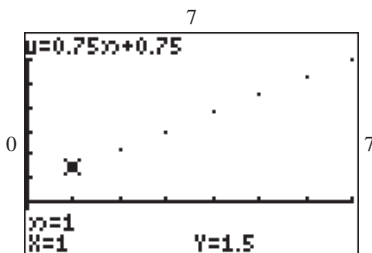
CHAPTER 11

Exercises 11.1, pp. 1086–1088

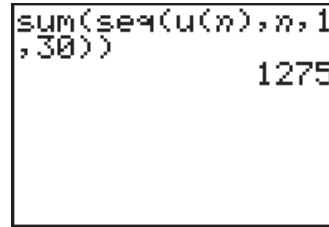
1. pattern, order 3. recursive 5. formula defining the sequence uses the preceding term(s); answers will vary. 7. 1, 3, 5, 7; $a_8 = 15$; $a_{12} = 23$
 9. 0, 9, 24, 45; $a_8 = 189$; $a_{12} = 429$ 11. -1, 2, -3, 4; $a_8 = 8$; $a_{12} = 12$
 13. $\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}$; $a_8 = \frac{8}{9}$; $a_{12} = \frac{12}{13}$ 15. $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$; $a_8 = \frac{1}{256}$; $a_{12} = \frac{1}{4096}$
 17. $1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}$; $a_8 = \frac{1}{8}$; $a_{12} = \frac{1}{12}$
 19. $\frac{-1}{2}, \frac{1}{6}, \frac{-1}{12}, \frac{1}{20}$; $a_8 = \frac{1}{72}$; $a_{12} = \frac{1}{156}$
 21. -2, 4, -8, 16; $a_8 = 256$; $a_{12} = 4096$
 23. a. 79 b. $\{-1, 2, 7, 14, 23\}$ 25. a. $\frac{1}{5}$ b. $\{1, \frac{-1}{2}, \frac{1}{3}, \frac{-1}{4}, \frac{1}{5}\}$
 27. a. $\frac{1}{32}$ b. $\{2, 1, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}\}$ 29. a. approx. 2.6 b. $\{2, \frac{9}{4}, \frac{64}{27}, \frac{625}{256}, \frac{7776}{3125}\}$
 31. a. $\frac{1}{36}$ b. $\{\frac{1}{3}, \frac{1}{10}, \frac{1}{21}, \frac{1}{36}, \frac{1}{55}\}$ 33. 2, 7, 32, 157, 782
 35. -1, 4, 19, 364, 132,499 37. 64, 32, 16, 8, 4 39. 336 41. 36
 43. 28 45. $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}$ 47. $\frac{1}{3}, \frac{1}{120}, \frac{1}{15,120}, \frac{1}{3,991,680}$ 49. 1, 2, $\frac{9}{2}, \frac{32}{3}$
 51. 15 53. 64 55. $\frac{137}{60}$ 57. $-2 + 1 + 4 + 7 = 10$
 59. $-1 + 5 + 15 + 29 + 47 = 95$
 61. $-1 + 2 + (-3) + 4 + (-5) + 6 + (-7) = -4$
 63. $0.5 + 2 + 4.5 + 8 = 15$ 65. $6 + 8 + 10 + 12 + 14 = 50$
 67. $-\frac{1}{3} + \frac{1}{8} + \left(-\frac{1}{15}\right) + \frac{1}{24} + \left(-\frac{1}{35}\right) + \frac{1}{48} = -\frac{27}{112}$
 69. a. $\sum_{n=1}^5 4n$ b. $\sum_{n=1}^5 5n$ 71. a. $\sum_{k=1}^{\infty} (2k - 1)$ b. $\sum_{k=1}^{\infty} \frac{1}{k^2}$
 73. $\sum_{n=1}^5 (n + 3)$ 75. $\sum_{n=1}^3 \frac{n^2}{3}$ 77. $\sum_{n=3}^7 \frac{n}{2^n}$ 79. 35 81. 100
 83. 35, verified 85. \$7.25, \$7.75, \$8.25, \$8.75, \$9.25; \$17,760
 87. $a_n = 6000(0.8)^{n-1}$; 6000, 4800, 3840, 3072, 2457.60, 1966.08
 89. ≈ 2690 91. approaches 1
 93. $\sum_{j=1}^n ca_j = ca_1 + ca_2 + ca_3 + \dots + ca_{n-1} + ca_n$
 $= c(a_1 + a_2 + a_3 + \dots + a_{n-1} + a_n)$
 $= c \sum_{j=1}^n a_j$
 95. $\frac{1}{4}$ or 0.25 97. $\frac{3\pi}{4}, \frac{7\pi}{4}$ 99. $\angle A \approx 53.1^\circ, \angle B \approx 36.9^\circ, \angle C = 90^\circ$

Exercises 11.2, pp. 1095–1098

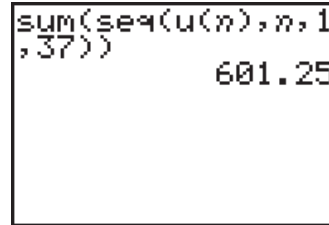
1. common, difference 3. $\frac{n(a_1 + a_n)}{2}$, n th 5. Answers will vary.
 7. arithmetic; $d = 3$ 9. arithmetic; $d = 2.5$ 11. not arithmetic; all prime 13. arithmetic; $d = \frac{1}{24}$ 15. not arithmetic; $a_n = n^2$
 17. arithmetic; $d = \frac{-\pi}{6}$ 19. 2, 5, 8, 11 21. 7, 5, 3, 1 23. 0.3, 0.33, 0.36, 0.39 25. $\frac{3}{2}, 2, \frac{5}{2}, 3$ 27. $\frac{3}{4}, \frac{5}{8}, \frac{1}{2}, \frac{3}{8}$ 29. -2, -5, -8, -11
 31. $a_1 = 2, d = 5, a_n = 5n - 3, a_6 = 27, a_{10} = 47, a_{12} = 57$
 33. $a_1 = 5.10, d = 0.15$,
 $a_n = 0.15n + 4.95, a_6 = 5.85$,
 $a_{10} = 6.45, a_{12} = 6.75$
 35. $a_1 = \frac{3}{2}, d = \frac{3}{4}, a_n = \frac{3}{4}n + \frac{3}{4}$,
 $a_6 = \frac{21}{4}, a_{10} = \frac{33}{4}, a_{12} = \frac{39}{4}$
 37. 61 39. 1 41. 2.425 43. 9 45. 43 47. 21 49. 26
 51. a. appears linear b. $d = 0.75$ c. $a_n = 0.75n + 0.75$



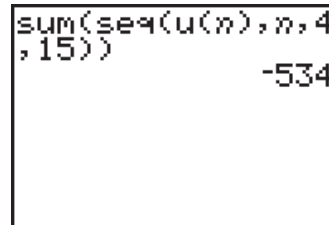
53. a. appears nonlinear b. no common difference
 55. $d = 3, a_1 = 1$ 57. $d = 0.375, a_1 = 0.65$ 59. $d = \frac{115}{126}, a_1 = \frac{-472}{63}$
 61. 1275



63. 601.25



65. -534

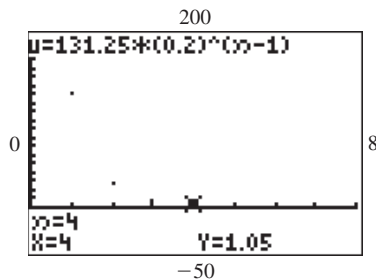


67. 82.5 69. 74.04 71. $210\sqrt{2}$ 73. $S_6 = 21; S_{75} = 2850$
 75. at 11 P.M. 77. 5.5 in.; 54.25 in. 79. $a_7 = 220; a_{12} = 2520$; yes
 81. a. linear function b. quadratic
 83. $A = 7, P = 6, HS: \frac{1}{2}$ unit right, VS: 10 units up, $\frac{1}{2} \leq t < \frac{13}{2}$.
 85. $f(x) = 49x + 972$, 1364 deer

Exercises 11.3, pp. 1107–1111

1. multiplying 3. $a_1 r^{n-1}$ 5. Answers will vary. 7. $r = 2$
 9. $r = -2$ 11. not geometric; $a_n = n^2 + 1$ 13. $r = 0.1$
 15. not geometric; ratio of terms decreases by 1 17. $r = \frac{2}{5}$
 19. $r = \frac{1}{2}$ 21. $r = \frac{4}{x}$ 23. not geometric; $a_n = \frac{240}{n!}$
 25. 5, 10, 20, 40 27. -6, 3, $\frac{-3}{2}, \frac{3}{4}$ 29. $4, 4\sqrt{3}, 12, 12\sqrt{3}$
 31. 0.1, 0.01, 0.001, 0.0001
 33. $a_n = -24\left(\frac{1}{2}\right)^{n-1}$; $a_7 = -\frac{3}{8}$ 35. $a_n = -\frac{1}{20}(-5)^{n-1}$; $a_4 = \frac{25}{4}$
 37. $a_n = 2(\sqrt{2})^{n-1} = (\sqrt{2})^{n+1}$; $a_7 = 16$
 39. $a_1 = \frac{1}{27}, r = -3, a_n = \frac{1}{27}(-3)^{n-1}, a_6 = -9, a_{10} = -729$,
 $a_{12} = -6561$
 41. $a_1 = 729, r = \frac{1}{3}, a_n = 729\left(\frac{1}{3}\right)^{n-1}, a_6 = 3, a_{10} = \frac{1}{27}, a_{12} = \frac{1}{343}$
 43. $a_1 = \frac{1}{2}, r = \sqrt{2}, a_n = \frac{1}{2}(\sqrt{2})^{n-1}, a_6 = 2\sqrt{2}, a_{10} = 8\sqrt{2}$,
 $a_{12} = 16\sqrt{2}$
 45. $a_1 = 0.2, r = 0.4, a_n = 0.2(0.4)^{n-1}$
 $a_6 = 0.002048, a_{10} = 0.0000524288, a_{12} = 0.000008388608$
 47. 5 49. 11 51. 9 53. 8 55. 13 57. 9

59. a. appears exponential b. $r = 0.2$ c. $a_n = 131.25(0.2)^{n-1}$



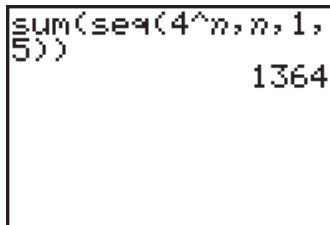
61. a. appears nonexponential b. no common ratio

63. $r = \frac{2}{3}$, $a_1 = 729$ 65. $r = \frac{3}{2}$, $a_1 = \frac{32}{243}$ 67. $r = \frac{3}{2}$, $a_1 = \frac{256}{81}$

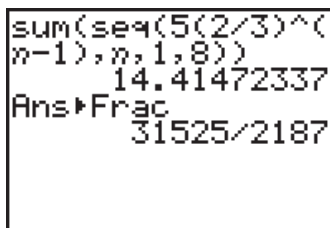
69. $-10,920$ 71. $\frac{3872}{27} \approx 143.41$ 73. $\frac{2059}{8} = 257.375$ 75. 728

77. $\frac{85}{8} = 10.625$ 79. ≈ 1.60

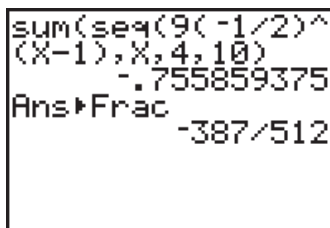
81. 1364



83. $\frac{31,525}{2187}$



85. $-\frac{387}{512}$



87. $\frac{521}{25}$ 89. $\frac{3367}{1296}$ 91. $14 + 15\sqrt{2}$ 93. $\frac{27}{7}$ 95. no 97. $\frac{125}{3}$

99. 12 101. 4 103. $\frac{1}{3}$ 105. $\frac{3}{2}$ 107. No finite sum exists.

109. 1296 111. $a_n = 24(0.8)^{n-1}$, $a_7 \approx 6.3$ ft, $S_\infty = 120$ ft

113. $a_0 = 46,000$; $a_n = 36,800(0.8)^{n-1}$, $a_4 = \$18,841.60$, 10 yr

115. $a_0 = 160$; $a_n = 155.2(0.97)^{n-1}$, $a_8 \approx 125.4$ gpm, 10 mo

117. $a_0 = 277$; $a_n = 283.37(1.023)^{n-1}$, $a_{10} \approx 347.7$ million

119. $a_0 = 462$; $a_n = 277.2\left(\frac{3}{5}\right)^{n-1}$, $a_5 \approx 35.9$ in³, 7 strokes

121. $a_0 = 8$, $a_n = 6(0.75)^{n-1}$, 2 days, 8 days

123. $a_0 = 50$; $a_n = 100(2)^{n-1}$, $a_{10} = 51,200$ bacterium, 12 half-hours (6 hr)

125. $a_0 = 2$ m; $a_n = 1.6\left(\frac{4}{5}\right)^{n-1}$, $a_7 \approx 0.42$ m,

$$\text{total distance} = a_0 + 2S_\infty = 18 \text{ m}$$

127. about 67,109 in. This is almost 1.06 mi.

129. $40,000 + 1750x$ vs. $40,000(1.04)^x$; 6 yr

131. a. For an arithmetic sequence, the difference $d = a_k - a_{k-1}$ must be constant. For $a_k = a_1 r^{k-1}$ and $a_{k-1} = a_1 r^{k-2}$, we have

$$\begin{aligned} d &= \log(a_1 r^{k-1}) - \log(a_1 r^{k-2}) \\ &= \log(a_1) + \log(r^{k-1}) - [\log(a_1) + \log(r^{k-2})] \\ &= \log(a_1) + (k-1)\log(r) - \log(a_1) - (k-2)\log(r) \\ &= \log(r)[(k-1) - (k-2)] \\ &= \log(r) \checkmark \end{aligned}$$

- b. For a geometric sequence, the ratio $r = \frac{a_k}{a_{k-1}}$ must be constant.

For $a_k = a_1 + (k-1)d$ and $a_{k-1} = a_1 + (k-2)d$ we have

$$\begin{aligned} r &= \frac{10^{a_1 + (k-1)d}}{10^{a_1 + (k-2)d}} \\ &= \frac{10^{a_1} 10^{(k-1)d}}{10^{a_1} 10^{(k-2)d}} \\ &= \frac{10^{(k-1)d}}{10^{(k-2)d}} \\ &= \frac{10^{(k-2)d}}{10^{(k-2)d}} \\ &= 10^{d[(k-1) - (k-2)]} \\ &= 10^d \checkmark \end{aligned}$$

133. $\frac{3}{\sqrt{58}}\mathbf{i} - \frac{7}{\sqrt{58}}\mathbf{j}$ 135. ≈ 942 ft per min, ≈ 10.7 mph

Exercises 11.4, pp. 1117–1118

1. finite, universally 3. induction, hypothesis 5. Answers will vary.

7. $a_n = 10n - 6$

$$a_4 = 10(4) - 6 = 40 - 6 = 34;$$

$$a_5 = 10(5) - 6 = 50 - 6 = 44;$$

$$a_k = 10k - 6;$$

$$a_{k+1} = 10(k+1) - 6 = 10k + 10 - 6 = 10k + 4$$

9. $a_n = n$

$$a_4 = 4;$$

$$a_5 = 5;$$

$$a_k = k;$$

$$a_{k+1} = k + 1$$

11. $a_n = 2^{n-1}$

$$a_4 = 2^{4-1} = 2^3 = 8;$$

$$a_5 = 2^{5-1} = 2^4 = 16;$$

$$a_k = 2^{k-1};$$

$$a_{k+1} = 2^{k+1-1} = 2^k$$

13. $S_n = n(5n - 1)$

$$S_4 = 4(5(4) - 1) = 4(20 - 1) = 4(19) = 76;$$

$$S_5 = 5(5(5) - 1) = 5(25 - 1) = 5(24) = 120;$$

$$S_k = k(5k - 1);$$

$$S_{k+1} = (k+1)(5(k+1) - 1) = (k+1)(5k + 5 - 1) = (k+1)(5k + 4)$$

15. $S_n = \frac{n(n+1)}{2}$

$$S_4 = \frac{4(4+1)}{2} = \frac{4(5)}{2} = 10;$$

$$S_5 = \frac{5(5+1)}{2} = \frac{5(6)}{2} = 15;$$

$$S_k = \frac{k(k+1)}{2};$$

$$S_{k+1} = \frac{(k+1)(k+1+1)}{2} = \frac{(k+1)(k+2)}{2}$$

17. $S_n = 2^n - 1$

$$S_4 = 2^4 - 1 = 16 - 1 = 15;$$

$$S_5 = 2^5 - 1 = 32 - 1 = 31;$$

$$S_k = 2^k - 1;$$

$$S_{k+1} = 2^{k+1} - 1$$

19. $a_n = 10n - 6$; $S_n = n(5n - 1)$

$$S_4 = 4(5(4) - 1) = 4(20 - 1) = 4(19) = 76;$$

$$a_5 = 10(5) - 6 = 50 - 6 = 44;$$

$$S_5 = 5(5(5) - 1) = 5(25 - 1) = 5(24) = 120;$$

$$S_4 + a_5 = S_5$$

37. 1. Show
- S_n
- is true for
- $n = 1$
- .

$$S_1 = \frac{1}{2(1) + 1} = \frac{1}{2 + 1} = \frac{1}{3}$$

Verified

2. Assume
- S_k
- is true:

$$\frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \cdots + \frac{1}{(2k-1)(2k+1)} = \frac{k}{2k+1}$$

and use it to show the truth of S_{k+1} follows. That is:

$$\frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \cdots + \frac{1}{(2k-1)(2k+1)} + \frac{1}{(2k+1)(2k+3)}$$

$$+ \frac{1}{(2k+1)(2k+3)} = \frac{k+1}{2k+3}$$

$$S_k + a_{k+1} = S_{k+1}$$

Working with the left hand side:

$$\frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \cdots + \frac{1}{(2k-1)(2k+1)} + \frac{1}{(2k+1)(2k+3)}$$

$$= \frac{k}{2k+1} + \frac{1}{(2k+1)(2k+3)}$$

$$= \frac{k(2k+3) + 1}{(2k+1)(2k+3)}$$

$$= \frac{2k^2 + 3k + 1}{(2k+1)(2k+3)}$$

$$= \frac{(2k+1)(k+1)}{(2k+1)(2k+3)}$$

$$= \frac{k+1}{2k+3}$$

$$= S_{k+1}$$

Since the truth of S_{k+1} follows from S_k , the formula is true for all n .

39. 1. Show
- P_n
- is true for
- $n = 1$
- .

 P_1 :

$$3^1 \geq 2(1) + 1$$

$$3 \geq 2 + 1$$

$$3 \geq 3$$

Verified

2. Assume
- P_k
- :
- $3^k \geq 2k + 1$
- is true and use it to show the truth of
- P_{k+1}
- follows. That is:
- $3^{k+1} \geq 2(k+1) + 1$
- .

Working with the left hand side:

$$3^{k+1} = 3(3^k)$$

$$\geq 3(2k + 1)$$

$$\geq 6k + 3$$

Since k is a positive integer,

$$6k + 3 \geq 2k + 3$$

$$\text{Showing } P_{k+1}: 3^{k+1} \geq 2k + 3$$

Since the truth of P_{k+1} follows from P_k , the statement is true for all n .

41. 1. Show
- P_n
- is true for
- $n = 1$
- .

 P_1 :

$$3 \cdot 4^{1-1} \leq 4^1 - 1$$

$$3 \cdot 4^0 \leq 4 - 1$$

$$3 \cdot 1 \leq 3$$

$$3 \leq 3$$

Verified

2. Assume
- P_k
- :
- $3 \cdot 4^{k-1} \leq 4^k - 1$
- is true and use it to show the truth of
- P_{k+1}
- follows. That is:
- $3 \cdot 4^{k+1-1} \leq 4^{k+1} - 1$
- .

Working with the left hand side:

$$3 \cdot 4^k = 3 \cdot 4(4^{k-1})$$

$$= 4 \cdot 3(4^{k-1})$$

$$\leq 4(4^k - 1)$$

$$\leq 4^{k+1} - 4$$

Since k is a positive integer, $4^{k+1} - 4 \leq 4^{k+1} - 1$

$$\text{Showing } P_{k+1}: 3 \cdot 4^k \leq 4^{k+1} - 1$$

Since the truth of P_{k+1} follows from P_k , the statement is true for all n .

- 43.
- $n^2 - 7n$
- is divisible by 2

1. Show
- P_n
- is true for
- $n = 1$
- .

$$P_n: n^2 - 7n = 2m$$

 P_1 :

$$(1)^2 - 7(1) = 2m$$

$$1 - 7 = 2m$$

$$-6 = 2m \text{ Verified}$$

2. Assume
- P_k
- :
- $k^2 - 7k = 2m$
- for
- $m \in \mathbb{Z}$
- and use it to show the truth of
- P_{k+1}
- follows. That is:
- $(k+1)^2 - 7(k+1) = 2p$
- for
- $p \in \mathbb{Z}$
- .

Working with the left hand side:

$$(k+1)^2 - 7(k+1)$$

$$= k^2 + 2k + 1 - 7k - 7$$

$$= k^2 - 7k + 2k - 6$$

$$= 2m + 2k - 6$$

$$= 2(m + k - 3)$$

is divisible by 2.

Since the truth of P_{k+1} follows from P_k , the statement is true for all n .

- 45.
- $n^3 + 3n^2 + 2n$
- is divisible by 3

1. Show
- P_n
- is true for
- $n = 1$
- .
- P_n
- :
- $n^3 + 3n^2 + 2n = 3m$

 P_1 :

$$(1)^3 + 3(1)^2 + 2(1) = 3m$$

$$1 + 3 + 2 = 3m$$

$$6 = 3m$$

$$2 = m$$

Verified

2. Assume
- P_k
- :
- $k^3 + 3k^2 + 2k = 3m$
- for
- $m \in \mathbb{Z}$
- and use it to show the truth of
- P_{k+1}
- follows.

That is: $(k+1)^3 + 3(k+1)^2 + 2(k+1) = 3p$ for $p \in \mathbb{Z}$.

Working with the left hand side:

$$(k+1)^3 + 3(k+1)^2 + 2(k+1)$$

$$= k^3 + 3k^2 + 3k + 1 + 3(k^2 + 2k + 1) + 2k + 2$$

$$= k^3 + 3k^2 + 2k + 3(k^2 + 2k + 1) + 3k + 3$$

$$= k^3 + 3k^2 + 2k + 3(k^2 + 2k + 1) + 3(k+1)$$

$$= 3m + 3(k^2 + 2k + 1) + 3(k+1) \text{ is divisible by 3.}$$

Since the truth of P_{k+1} follows from P_k , the statement is true for all n .

- 47.
- $6^n - 1$
- is divisible by 5

1. Show
- P_n
- is true for
- $n = 1$
- .
- P_n
- :
- $6^n - 1 = 5m$

 P_1 :

$$6^1 - 1 = 5m$$

$$6 - 1 = 5m$$

$$5 = 5m$$

$$1 = m$$

Verified

2. Assume
- P_k
- :
- $6^k - 1 = 5m$
- or
- $6^k = 5m + 1$
- for
- $m \in \mathbb{Z}$
- and use it to show the truth of
- P_{k+1}
- follows.

That is: $6^{k+1} - 1 = 5p$ for $p \in \mathbb{Z}$.

Working with the left hand side:

$$6^k - 1$$

$$= 6(6^k) - 1$$

$$= 6(5m + 1) - 1$$

$$= 30m + 6 - 1$$

$$= 30m + 5$$

$$= 5(6m + 1)$$

is divisible by 5.

Since the truth of P_{k+1} follows from P_k , the statement is true for all n .

49. verified 51. verified 53.
- $(x-4)^2 + (y-3)^2 = 25$

Mid-Chapter Check, p. 1119

1. 3, 10, 17,
- $a_9 = 59$
2. 4, 7, 12,
- $a_9 = 84$
3. -1, 3, -5,
- $a_9 = -17$

4. 360 5.
- $\sum_{k=1}^6 (3k-2)$
6. d 7. e 8. a 9. b 10. c

11. a.
- $a_1 = 2, d = 3, a_n = 3n - 1$
- b.
- $a_1 = \frac{3}{2}, d = \frac{3}{4}, a_n = \frac{3}{4}n + \frac{3}{4}$

- 12.
- $n = 25, S_{25} = 950$
- 13.
- $n = 16, S_{16} = 128$
- 14.
- $S_{10} = -5$

- 15.
- $S_{10} = \frac{-14,762}{27}$
16. a.
- $a_1 = 2, r = 3, a_n = 2(3)^{n-1}$

- b.
- $a_1 = \frac{1}{2}, r = \frac{1}{2}, a_n = (\frac{1}{2})^n$
- 17.
- $n = 8, S_8 = \frac{1640}{27}$
- 18.
- $\frac{-343}{6}$

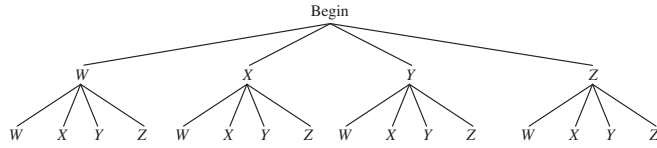
19. 1785 20.
- ≈ 4.5
- ft;
- ≈ 127.9
- ft

Reinforcing Basic Concepts, pp. 1119-1120

Exercise 1: \$71,500

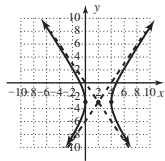
Exercises 11.5, pp. 1127–1132

1. experiment, well-defined 3. $N^!$ 5. Answers will vary.
7. a. 16 possible



- b. WW, WX, WY, WZ, XW, XX, XY, XZ, YW, YX, YY, YZ, ZW, ZX, ZY, ZZ
9. 32 11. 15,625 13. 2,704,000 15. a. 59,049 b. 15,120
17. 360 if double veggies are not allowed, 432 if double veggies are allowed. 19. a. 120 b. 625 c. 12 21. 24 23. 4 25. 120
27. 6 29. 720 31. 3024 33. 40,320 35. 6; 3 37. 90 39. 336
41. a. 720 b. 120 c. 24 43. 360 45. 60 47. 60 49. 120
51. 30 53. 60, BANANA 55. 126 57. 56 59. 1 61. verified
63. verified 65. 495 67. 364 69. 252 71. $8! = 40,320$
73. $8_n P_r 3 = 336$ 75. $20_n C_r 5 = 15,504$ 77. $8_n C_r 4 = 70$
79. a. $\approx 1.2\%$ b. $\approx 0.83\%$ 81. 7776 83. 324 85. 800
87. 6,272,000,000 89. 518,400 91. 357,696 93. 6720 95. 8
97. 10,080 99. 5040 101. 2880 103. 5005 105. 720
107. 52,650, no 109. $6 \cdot (6_n C_r 3 - 2) + 2 \cdot 20 = 148$
111. $\cos \theta = \frac{5}{13}$, $\tan \theta = \frac{12}{5}$, $\csc \theta = \frac{13}{5}$, $\sec \theta = \frac{13}{5}$, $\cot \theta = \frac{5}{12}$

113.



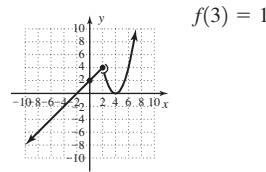
Exercises 11.6, pp. 1139–1145

1. $n(E)$ 3. 0, 1, 1, 0 5. Answers will vary.
7. $S = \{HH, HT, TH, TT\}$, $\frac{1}{4}$ 9. $S = \{\text{coach of Patriots, Cougars, Angels, Sharks, Eagles, Stars}\}$, $\frac{1}{6}$ 11. $P(E) = \frac{4}{9}$ 13. a. $\frac{1}{13}$
b. $\frac{1}{4}$ c. $\frac{1}{2}$ d. $\frac{1}{26}$ 15. $P(E_1) = \frac{1}{8}$, $P(E_2) = \frac{5}{8}$, $P(E_3) = \frac{3}{4}$
17. a. $\frac{3}{4}$ b. 1 c. $\frac{1}{4}$ d. $\frac{1}{2}$ 19. $\frac{3}{4}$ 21. $\frac{6}{7}$ 23. 0.991
25. a. $\frac{1}{12}$ b. $\frac{11}{12}$ c. $\frac{8}{9}$ d. $\frac{5}{6}$ 27. $\frac{10}{21}$ 29. $\frac{60}{143}$ 31. b, about 12%
33. a. 0.3651 b. 0.3651 c. 0.3969 35. 0.9 37. $\frac{7}{24}$ 39. 0.59
41. a. $\frac{1}{6}$ b. $\frac{7}{36}$ c. $\frac{1}{9}$ d. $\frac{4}{9}$ 43. a. $\frac{2}{25}$ b. $\frac{9}{50}$ c. 0 d. $\frac{2}{25}$ e. 1
45. $\frac{3}{4}$ 47. $\frac{11}{15}$ 49. a. $\frac{1}{18}$ b. $\frac{2}{9}$ c. $\frac{8}{9}$ d. $\frac{3}{4}$ e. $\frac{1}{36}$ f. $\frac{5}{12}$
51. $\frac{4}{256}$; answers will vary. 53. a. 0.33 b. 0.67 c. 1 d. 0
e. 0.67 f. 0.08 55. a. $\frac{1}{2}$ b. $\frac{1}{2}$ c. $\frac{1}{8}$ 57. a. $\frac{9}{16}$ b. $\frac{1}{4}$ c. $\frac{1}{16}$
d. $\frac{5}{16}$ 59. a. $\frac{3}{26}$ b. $\frac{3}{26}$ c. $\frac{1}{13}$ d. $\frac{9}{26}$ e. $\frac{2}{13}$ f. $\frac{11}{26}$ 61. a. $\frac{1}{8}$
b. $\frac{1}{16}$ c. $\frac{3}{16}$ 63. a. $\frac{47}{100}$ b. $\frac{1}{25}$ c. $\frac{3}{100}$ d. $\frac{9}{50}$ e. $\frac{11}{100}$ 65. a. $\frac{5}{429}$
b. $\frac{8}{2145}$ 67. $\frac{1}{3360}$ 69. $\frac{1}{1,048,576}$; answers will vary; 20 heads in a row.
71. $\sin \theta = \frac{1}{3}$, $\cos \theta = -\frac{2\sqrt{2}}{3}$, $\tan \theta = -\frac{\sqrt{2}}{4}$, $\sec \theta = -\frac{3\sqrt{2}}{4}$,
 $\cot \theta = -2\sqrt{2}$
73. $\sin(2\theta) = -\frac{840}{841}$, $\cos(2\theta) = \frac{41}{841}$, $\tan(2\theta) = -\frac{840}{41}$

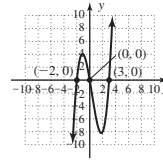
Exercises 11.7, pp. 1151–1153

1. one 3. $(a + (-2b))^5$ 5. Answers will vary.
7. $x^5 + 5x^4y + 10x^3y^2 + 10x^2y^3 + 5xy^4 + y^5$
9. $16x^4 + 96x^3 + 216x^2 + 216x + 81$ 11. $41 + 38i$ 13. 35
15. 10 17. 1140 19. 9880 21. 1 23. 1
25. $c^5 + 5c^4d + 10c^3d^2 + 10c^2d^3 + 5cd^4 + d^5$
27. $a^6 - 6a^5b + 15a^4b^2 - 20a^3b^3 + 15a^2b^4 - 6ab^5 + b^6$
29. $16x^4 - 96x^3 + 216x^2 - 216x + 81$
31. $-11 + 2i$ 33. $x^9 + 18x^8y + 144x^7y^2$ 35. $v^{24} - 6v^{22}w + \frac{33}{2}v^{20}w^2$
37. $35x^4y^3$ 39. $1792p^2$ 41. $264x^2y^{10}$ 43. ≈ 0.25 45. a. $\approx 17.8\%$
b. $\approx 23.0\%$ 47. a. $\approx 0.89\%$ b. $\approx 7.0\%$ c. $\approx 99.0\%$ d. $\approx 61.0\%$
49. 2^{n-1} , 2048

51.



53. $g(x) > 0: x \in (-2, 0) \cup (3, \infty)$



Making Connections, p. 1153

1. c 3. b 5. d 7. b 9. d 11. a 13. e 15. g

Summary and Concept Review, pp. 1154–1158

1. 1, 6, 11, 16; $a_{10} = 46$ 2. $1, \frac{3}{5}, \frac{2}{5}, \frac{5}{17}$; $a_{10} = \frac{11}{101}$
3. $a_n = n^4$; $a_6 = 1296$ 4. $a_n = -17 + (n - 1)(3)$; $a_6 = -2$
5. $\frac{255}{256}$ 6. -112 7. 140 8. 35 9. 2, 6, 12, 20, 30 10. $\frac{1}{2}, \frac{3}{4}, \frac{5}{4}, \frac{9}{4}, \frac{17}{4}$
11. $\sum_{i=1}^7 (i^2 + 3i - 2)$; 210 12. a. about 134 hawks b. 8 yr
13. $a_n = 2 + 3(n - 1)$; 119 14. $a_n = 3 + (-2)(n - 1)$; -65
15. 740 16. 1335 17. 630 18. -11.25 19. 875 20. 7.55 m
21. 3645 22. 32 23. 2401 24. 10.75 25. 6560 26. $\frac{819}{512}$
27. does not exist 28. $\frac{50}{9}$ 29. 4 30. $\frac{63,050}{6561}$ 31. does not exist 32. 5
33. $a_0 = 121,500$, $a_1 = 81,000$, $a_n = 81,000 \left(\frac{2}{3}\right)^{n-1}$, $a_7 \approx 7111 \text{ ft}^3$
34. $a_0 = 1225$, $a_1 \approx 1311$, $a_n = 1311(1.07)^{n-1}$, $a_{15} \approx 3380$, $S_{15} \approx 32,944$
35. (1) Show S_n is true for $n = 1$: $S_1 = \frac{1(1 + 1)}{2} = 1\checkmark$
(2) Assume S_k is true: $1 + 2 + 3 + \dots + k = \frac{k(k + 1)}{2}$
Use it to show the truth of S_{k+1} :
 $1 + 2 + 3 + \dots + k + (k + 1) = \frac{(k + 1)(k + 1 + 1)}{2}$
left hand side: $1 + 2 + 3 + \dots + k + (k + 1)$
 $= \frac{k(k + 1)}{2} + (k + 1) = \frac{k(k + 1) + 2(k + 1)}{2}$
 $= \frac{(k + 1)(k + 2)}{2}$
36. (1) Show S_n is true for $n = 1$: $S_1 = \frac{1(1 + 1)[2(1) + 1]}{6} = 1\checkmark$
(2) Assume S_k is true: $1 + 4 + 9 + \dots + k^2 = \frac{k(k + 1)(2k + 1)}{6}$
Use it to show the truth of S_{k+1} :
 $1 + 4 + 9 + \dots + k^2 + (k + 1)^2 = \frac{(k + 1)(k + 1 + 1)[2(k + 1) + 1]}{6}$
left hand side: $1 + 4 + 9 + \dots + k^2 + (k + 1)^2$
 $= \frac{k(k + 1)(2k + 1)}{6} + \frac{6(k + 1)^2}{6} = \frac{(k + 1)[2k^2 + k + 6k + 6]}{6}$
 $= \frac{(k + 1)(2k^2 + 7k + 6)}{6} = \frac{(k + 1)(k + 2)(2k + 3)}{6}$
37. (1) Show P_n is true for $n = 1$: $P_1: 4^1 \geq 3(1) + 1\checkmark$
(2) Assume P_k is true: $4^k \geq 3k + 1$
Use it to show the truth of P_{k+1} :
 $4^{k+1} \geq 3(k + 1) + 1 = 3k + 4$
left hand side: $4^{k+1} = 4(4^k)$
 $\geq 4(3k + 1) = 12k + 4$
Since k is a positive integer, $12k + 4 \geq 3k + 4$ showing
 $4^{k+1} \geq 3k + 4$

38. (1) Show P_n is true for $n = 1$: $P_1: 6 \cdot 7^{1-1} \leq 7^1 - 1$ ✓

(2) Assume P_k is true: $6 \cdot 7^{k-1} \leq 7^k - 1$

Use it to show the truth of P_{k+1} :

$$6 \cdot 7^k \leq 7^{k+1} - 1$$

$$\begin{aligned} \text{left hand side: } 6 \cdot 7^k &= 7 \cdot 6 \cdot 7^{k-1} \\ &\leq 7 \cdot 7^k - 1 \\ &\leq 7^{k+1} - 7 \end{aligned}$$

Since k is a positive integer, $7^{k+1} - 7 \leq 7^{k+1} - 1$.

39. (1) Show P_n is true for $n = 1$: $P_1: 3^1 - 1 = 2$ or $2(1)$ ✓

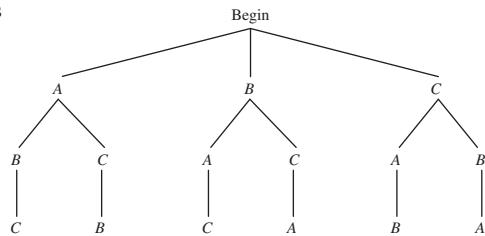
(2) Assume P_k is true: $3^k - 1 = 2p$ or $3^k = 2p + 1$ for $p \in \mathbb{Z}$

Use it to show the truth of P_{k+1} :

$$3^{k+1} - 1 = 2q \text{ for } q \in \mathbb{Z}$$

$$\begin{aligned} \text{left hand side: } 3^{k+1} - 1 &= 3 \cdot 3^k - 1 \\ &= 3 \cdot (2p + 1) - 1 \\ &= 3 \cdot 2p + 3 - 1 \\ &= 3 \cdot 2p + 2 \\ &= 2(3p + 1) \\ &= 2q \text{ is divisible by } 2 \end{aligned}$$

40. six ways



41. 720; 1000 42. 24 43. 220 44. a. 5040 b. 840 c. 35
 45. a. 720 b. 120 c. 24 46. 3360 47. a. 220 b. 1320
 48. $\frac{4}{13}$ 49. $\frac{3}{13}$ 50. $\frac{5}{6}$ 51. $\frac{7}{24}$ 52. $\frac{175}{396}$ 53. a. 0.608 b. 0.392
 c. 1 d. 0 e. 0.928 f. 0.178 54. a. 21 b. 56
 55. a. $x^4 - 4x^3y + 6x^2y^2 - 4xy^3 + y^4$ b. $41 - 38i$
 56. a. $a^8 + 8\sqrt{3}a^7 + 84a^6 + 168\sqrt{3}a^5$
 b. $78,125a^7 + 218,750a^6b + 262,500a^5b^2 + 175,000a^4b^3$
 57. a. $280x^4y^3$ b. $-64,064a^5b^9$ 58. a. about 93.3% b. about 62.4%

Practice Test, pp. 1158–1160

1. a. $\frac{1}{2}, \frac{4}{5}, 1, \frac{8}{7}; a_8 = \frac{16}{11}$ b. 6, 12, 20, 30; $a_8 = 90$
 c. $3, 2\sqrt{2}, \sqrt{7}, \sqrt{6}; a_8 = \sqrt{2}$ 2. a. 165 b. $\frac{311}{420}$ c. $-\frac{2343}{512}$ d. 7
 3. a. $a_1 = 7, d = -3, a_n = 10 - 3n$
 b. $a_1 = -8, d = 2, a_n = 2n - 10$ c. $a_1 = 4, r = -2, a_n = 4(-2)^{n-1}$
 d. $a_1 = 10, r = \frac{2}{5}, a_n = 10(\frac{2}{5})^{n-1}$ 4. a. 199 b. 9 c. $\frac{3}{4}$ d. 6
 5. a. 1712 b. 2183 c. 2188 d. 12 6. a. ≈ 8.82 ft b. ≈ 72.4 ft
 7. \$6756.57 8. \$22,185.27
 9. $a_k = 5k - 3, a_{k+1} = 5(k + 1) - 3,$

$$S_k = \frac{5k^2 - k}{2}, S_{k+1} = \frac{5(k+1)^2 - (k+1)}{2};$$

$$\text{For } n = 1: S_1 = \frac{5(1)^2 - 1}{2} = 2 \checkmark$$

$$\text{Assume: } S_k = \frac{5k^2 - k}{2} \text{ is true,}$$

$$\text{Prove: } \frac{5k^2 - k}{2} + 5(k+1) - 3 = \frac{5(k+1)^2 - (k+1)}{2}$$

$$\frac{5k^2 - k}{2} + \frac{10(k+1) - 6}{2} = \frac{(k+1)[5(k+1) - 1]}{2}$$

$$\frac{5k^2 + 9k + 4}{2} = \frac{(k+1)(5k+4)}{2}$$

$$\frac{(5k+4)(k+1)}{2} = \frac{(5k+4)(k+1)}{2} \checkmark$$

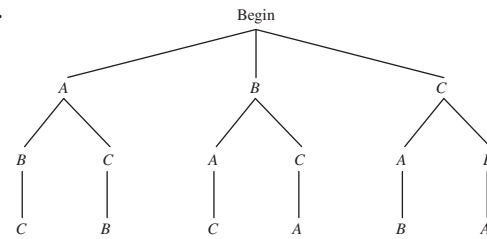
10. For $n = 1$: $2 \cdot 3^{1-1} \leq 3^1 - 1$
 $2(1) \leq 2 \checkmark$

Assume: $2 \cdot 3^{k-1} \leq 3^k - 1$

Prove: $2 \cdot 3^{(k+1)-1} \leq 3^{k+1} - 1$

$$\begin{aligned} 2 \cdot 3^{(k+1)-1} &= 2 \cdot 3^{(k-1)+1} \\ &= 2 \cdot 3^{(k-1)} \cdot 3 \\ &\leq (3^k - 1) \cdot 3 \\ (3^k - 1) \cdot 3 &= 3^{k+1} - 3 \leq 3^{k+1} - 1 \checkmark \end{aligned}$$

11. a.



b. ABC, ACB, BAC, BCA, CAB, CBA

12. 302,400 13. $\frac{1}{3}$ 14. a. 720 b. 120 c. 20 15. 900,900
 16. 302,400 17. a. $x^4 - 8x^3y + 24x^2y^2 - 32xy^3 + 16y^4$ b. -4
 18. a. $x^{10} + 10\sqrt{2}x^9 + 90x^8$ b. $a^8 - 16a^7b^3 + 112a^6b^6$
 19. 0.989 20. a. $\frac{1}{4}$ b. $\frac{5}{12}$ c. $\frac{1}{3}$ d. $\frac{1}{2}$ e. $\frac{7}{12}$ f. $\frac{1}{4}$ g. $\frac{5}{12}$ h. 0
 21. a. 0.08 b. 0.92 c. 1 d. 0 e. 0.95 f. 0.03 22. a. 0.1875
 b. 0.589 c. 0.4015 d. 0.2945 e. 0.4110 f. 0.2055 23. a. $\frac{59}{100}$
 b. $\frac{53}{100}$ c. $\frac{13}{100}$ d. $\frac{47}{100}$ 24. a. 0.8075 b. 0.0075 c. 0.9925
 25. a. about 27.9% b. about 97.6%

Strengthening Core Skills, pp. 1161–1162

Exercise 1. $\frac{{}^4C_1 \cdot {}^{13}C_5 - 40}{{}^{52}C_5} \approx 0.001970$

Exercise 2. $\frac{4 \cdot {}^{13}C_3 \cdot {}^{39}C_2}{{}^{52}C_5} \approx 0.326170$

Exercise 3. $\frac{4 \cdot {}^{13}C_4 \cdot {}^{39}C_1}{{}^{52}C_5} \approx 0.042917$

Exercise 4. $\frac{4 \cdot {}^{10}C_5}{{}^{52}C_5} \approx 0.000388$

Cumulative Review Chapters 1–11, pp. 1162–1164

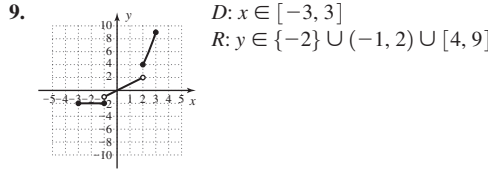
1. a. 23 cards are assembled each hour. b. 184 cards
 c. $y = 23x - 155$ d. $\approx 6:45$ A.M.

3.

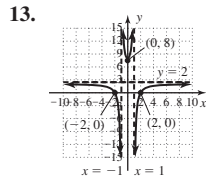
x	y
0	1
$\frac{\pi}{6}$	$\frac{\sqrt{3}}{2}$
$\frac{\pi}{4}$	$\frac{\sqrt{2}}{2}$
$\frac{\pi}{3}$	$\frac{1}{2}$
$\frac{\pi}{2}$	0
$\frac{2\pi}{3}$	$-\frac{1}{2}$
$\frac{5\pi}{6}$	$-\frac{\sqrt{3}}{2}$
π	-1

5. $x = \frac{-5 \pm \sqrt{109}}{6}; x \approx 0.91; x \approx -2.57$

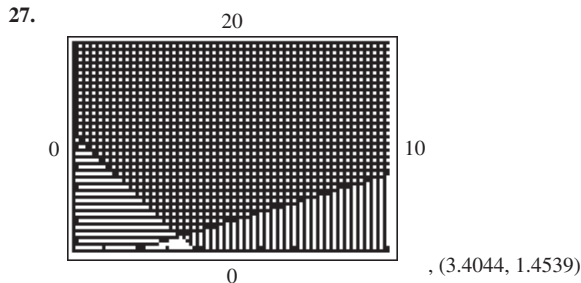
7. a. $x = 0$ b. $x \in (-1, 0)$ c. $x \in (-\infty, -1) \cup (0, \infty)$
 d. $x \in (-\infty, -1) \cup (-1, 1)$ e. $x \in (1, \infty)$ f. $y = 3$ at $(1, 3)$
 g. none h. $x \approx -2.3, 0.4, 2$ i. $g(4) \approx 0.25$ j. does not exist
 k. $-\infty$ l. 0 m. $x \in (-\infty, 1) \cup (-1, \infty)$



11. a. $4x + 2h - 3$ b. $\frac{-1}{(x + h - 2)(x - 2)}$



15. a. $x^3 = 125$ b. $e^5 = 2x - 1$ 17. a. $x = \frac{1 + \ln 217}{2} \approx 3.19$
b. $x = 334$ 19. (5, 10, 15) 21. (-3, 3); (-7, 3), (1, 3); (-3 - 2\sqrt{3}, 3), (-3 + 2\sqrt{3}, 3) 23. a. verified b. $\frac{\sqrt{6} + \sqrt{2}}{4}$ 25. 1333



29. 0.2794

Connections to Calculus Exercises, p. 1167

1. a. $\sum_{i=1}^4 LW = \sum_{i=1}^4 f(i)(1) = 1 \sum_{i=1}^4 f(i)$
 $1 \sum_{i=1}^4 f(i) = 1[f(1) + f(2) + f(3) + f(4)]$
 $= 5 + 4 + 3 + 2$
 $= 14 \text{ units}^2$

b. $\sum_{i=1}^8 LW = \sum_{i=1}^8 f\left(\frac{1}{2}i\right)\left(\frac{1}{2}\right) = \frac{1}{2} \sum_{i=1}^8 f\left(\frac{1}{2}i\right)$
 $\frac{1}{2} \sum_{i=1}^8 f\left(\frac{1}{2}i\right) = \frac{1}{2} \left[f\left(\frac{1}{2}\right) + f(1) + f\left(\frac{3}{2}\right) + f(2) + f\left(\frac{5}{2}\right) + f(3) + f\left(\frac{7}{2}\right) + f(4) \right]$
 $= \frac{1}{2} \left[\frac{11}{2} + 5 + \frac{9}{2} + 4 + \frac{7}{2} + 3 + \frac{5}{2} + 2 \right]$
 $= \frac{1}{2} [30] = 15 \text{ units}^2$

True area is 16 units², more rectangles → better estimate.

3. a. Since the interval [0, 4] is 4 units wide and we're using 32 subintervals of equal length, the width of each interval (the width of each rectangle) will be $\frac{4}{32} = \frac{1}{8}$. The length of each rectangle is determined by a point of the graph of $f(x) = -x + 6$, so the length of the first rectangle is $f\left(\frac{1}{8}\right)$, the second length is $f\left(\frac{2}{8}\right)$, the third is $f\left(\frac{3}{8}\right)$, and so on up to the 32nd rectangle.

Since $A = LW$, we multiply each length $f\left(\frac{1}{8}i\right)$ by width $\frac{1}{8}$ and sum the areas of all such rectangles. Using i for a counter, this can be written as

$A = \sum_{i=1}^{32} LW = \sum_{i=1}^{32} f\left(\frac{1}{8}i\right)\left(\frac{1}{8}\right)$. Since all lengths are multiplied by $\frac{1}{8}$

(the counter i does not affect the constant $\frac{1}{8}$), we can factor out this term

and evaluate $f(x) = -x + 6$ at $x = \frac{1}{8}i$. The result is $\frac{1}{8} \sum_{i=1}^{32} \left(-\frac{1}{8}i + 6\right)$.

b. $\frac{1}{8} \sum_{i=1}^{32} \left(-\frac{1}{8}i + 6\right) = \frac{1}{8} \left[\sum_{i=1}^{32} \left(-\frac{1}{8}i\right) + \sum_{i=1}^{32} 6 \right]$
 $= \frac{1}{8} \left[-\frac{1}{8} \sum_{i=1}^{32} i + \sum_{i=1}^{32} 6 \right]$
 $= \frac{1}{8} \left[-\frac{1}{8} \left(\frac{32^2 + 32}{2} \right) + 6(32) \right]$
 $= -\frac{1}{64} \left(\frac{1056}{2} \right) + 24$
 $= -8.25 + 24 = 15.75$

For $n = 32$ the approximate area under the graph is 15.75 units², even closer to the known area of 16 units².

CHAPTER 12

Exercises 12.1, pp. 1177–1180

1. infinity 3. left-hand; right-hand; greater 5. Answers will vary.

7. $\lim_{n \rightarrow \infty} V_n = \frac{4}{3} \pi r^3$ 9. $\lim_{t \rightarrow -\infty} e^{f(t)} = 0$ 11. $\lim_{x \rightarrow \infty} \cos\left(\frac{1}{x}\right) = 1$

13. 500 sides 15. 425 sides 17. $\lim_{t \rightarrow 5} s_t = 5r$

19. $\lim_{x \rightarrow a} \tan^{-1}[g(x)] = \frac{\pi}{3}$ 21. $\lim_{x \rightarrow -3} \frac{x + 3}{x^2 - 9} = -\frac{1}{6}$

23. As x approaches π , $p(x)$ approaches -2 : $\lim_{x \rightarrow \pi} p(x) = -2$
25. As x approaches 2, $v(x)$ approaches

$\frac{1}{4}$: $\lim_{x \rightarrow 2} v(x) = \frac{1}{4}$

27. As x approaches 0, $s(x)$ approaches 0: $\lim_{x \rightarrow 0} s(x) = 0$

29. $R(x) = \begin{cases} \frac{2x^2 - 7x + 6}{\sin(x - 2)} & x \neq 2 \\ 1 & x = 2 \end{cases}$

31. As x approaches 2, $f(x)$ approaches $\frac{1}{2}$: $\lim_{x \rightarrow 2} f(x) = \frac{1}{2}$

33. As x approaches 1, $g(x)$ approaches 4: $\lim_{x \rightarrow 1} g(x) = 4$

35. As x approaches 1, $f(x)$ approaches 0: $\lim_{x \rightarrow 1} f(x) = 0$

37. 27 39. 24 41. 1

43. $\lim_{x \rightarrow 3} I_x = 3 \cos^2(R_1 + R_2)$ 45. $\lim_{x \rightarrow m} f = L$ 47. a. 1 b. -1

49. a. -2 b. 2 51. a. $-\frac{11}{2}$ b. $-\frac{11}{2}$ 53. a. 0 b. 0

55. a. 43 b. 13 c. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ 57. a. 1 b. -1 c. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$

59. a. $\frac{\sqrt{2}}{2}$ b. $\frac{\sqrt{2}}{2}$ c. $\frac{\sqrt{2}}{2}$ 61. $\left(\frac{\text{dne}}{-\infty}\right)$ 63. π 65. $\left(\frac{\text{dne}}{-\infty}\right)$

67. $\left(\frac{\text{dne}}{z}\right)$ 69. 0 71. $(x - 5)(x - 2)(x + 1)(3x - 1)$ 73. 19.90 in²

Exercises 12.2, pp. 1188–1190

1. sum; limits 3. root; n th; $f(x) > 0$ 5. Answers will vary. 7. 9

9. -8 11. 2 13. 0 15. 7 17. 1 19. 9 21. 8 23. 0 25. 14

27. -16 29. $\frac{7}{2}$ 31. 0 33. 64 35. -36 37. -69 39. 29 41. 9

43. $\frac{3}{5}$ 45. $-\frac{1}{4}$ 47. 216 49. 15 51. 23 53. -1 55. $-\frac{17}{4}$

57. $\left(\frac{\text{dne}}{\infty}\right)$ 59. 9 61. $\left(\frac{\text{dne}}{-\infty}\right)$ 63. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ 65. 6 67. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$

69. a. limit appears to be 0 b. limit is actually -0.001

x	$f(x)$	x	$f(x)$
0.5	≈ 0.2510	-0.5	≈ 0.2510
0.4	≈ 0.1610	-0.4	≈ 0.1610
0.3	≈ 0.0910	-0.3	≈ 0.0910
0.2	≈ 0.0410	-0.2	≈ 0.0410
0.1	≈ 0.0110	-0.1	≈ 0.0110
0.01	≈ 0.0011	-0.01	≈ 0.0011
0.001	≈ 0.001001	-0.001	≈ 0.001001

71. a.

x	$y = x + \frac{\sqrt{x-2}}{10^x}$
2.7	≈ 2.7017
2.8	≈ 2.8014
2.9	≈ 2.9012
3.1	≈ 3.1008
3.2	≈ 3.2007
3.3	≈ 3.3006

b.

x	$y = x + \frac{\sqrt{x-2}}{10^x}$
2.99	≈ 2.991
2.999	≈ 3
2.9999	≈ 3.0009
3.0001	≈ 3.0011
3.001	≈ 3.002
3.01	≈ 3.011

c. 3 d. 3.001, verified 73. $[-1, \frac{3}{2}]$ 75. verified**Mid-Chapter Check, pp. 1190–1191**1. $\lim_{x \rightarrow -\infty} \frac{6x^2 - 3}{12x^3 - x - 1} = 0$ 2. a. 1 b. 0 3. 49 per year (almost weekly)

$$4. F(x) = \begin{cases} \frac{6x^2 - 19x - 7}{2x - 7} & x \neq \frac{7}{2} \\ \frac{23}{2} & x = \frac{7}{2} \end{cases} \quad 5. \text{ a. } -1 \quad \text{b. } 1 \quad \text{c. } \left(\begin{array}{l} \text{dne} \\ \text{LH} \neq \text{RH} \end{array} \right)$$

6. $\left(\begin{array}{l} \text{dne} \\ -\infty \end{array} \right)$

7. a.

x	$y = \cos\left(\frac{\pi}{x}\right)$
0.1	1
0.01	1
0.001	1
-0.001	1
-0.01	1
-0.1	1

b. Answers may vary.

8. $\frac{1}{2}$ 9. $\sqrt[3]{4}$ 10. $\left(\begin{array}{l} \text{dne} \\ \text{LH} \neq \text{RH} \end{array} \right)$ **Exercises 12.3, pp. 1201–1203**

1. asymptotic; removable; jump 3. direct substitution
 5. Answers will vary. 7. not continuous, condition 1 is violated
 9. continuous 11. not continuous, condition 2 is violated
 13. continuous 15. not continuous, condition 3 is violated
 17. 36 19. Direct substitution not possible, 5 is not in the domain.
 21. $\frac{1}{2}$ 23. Direct substitution not possible, -1 is not in the domain.
 25. $\sqrt{55}$ 27. $-\frac{1}{2}$ 29. 4 31. 9 33. $\frac{1}{4}$ 35. 0 37. $4x - 1$
 39. $\frac{-3}{(x+2)^2}$ 41. $\frac{1}{2\sqrt{x+2}}$ 43. $3(x+2)^2$ 45. $\frac{1}{2}$ 47. 3
 49. $\left(\begin{array}{l} \text{dne} \\ \infty \end{array} \right)$ 51. 0 53. $\frac{1}{2}$ 55. $\left(\begin{array}{l} \text{dne} \\ -\infty \end{array} \right)$ 57. 0 59. $x = 1000$
 61. $\frac{3}{8}$ 63. 0 65. 2 67. $\frac{2\sqrt{3}}{7}$ 69. 3 71. 3
 73. not possible since $f(2)$ not defined 75. 3 77. 0
 79. 1 81. not possible, $\lim_{x \rightarrow -2} g(x)$ does not exist $\left(\begin{array}{l} \text{dne} \\ -\infty \end{array} \right)$
 83. not possible, $\lim_{x \rightarrow 0} g(x)$ does not exist $\left(\begin{array}{l} \text{dne} \\ \text{LH} \neq \text{RH} \end{array} \right)$ 85. -3 87. 3
 89. a. $x = \frac{-2 \pm 2\sqrt{10}}{3}$ b. $x = 0, x = 8$ c. $x = 2$
 91. $A = 55^\circ, C = 90^\circ, b = 9.6 \text{ cm}, c = 16.7 \text{ cm}$

Exercises 12.4, pp. 1212–1214

1. difference 3. rectangles 5. Answers will vary.
 7. $f'(t) = 88.2 - 9.8t$ 9. a. 39.2 m/sec b. 0 m/sec c. -39.2 m/sec
 11. 896.9 m 13. $d'(t) = -9.8t$ 15. a. -9.8 m/sec b. -19.6 m/sec
 c. -29.4 m/sec

17. $f'(x) = \frac{1}{2}$ 19. $f'(x) = 3x^2$ 21. $p'(t) = \frac{0.6}{\sqrt{t}}$

23. a. 600 people/yr b. 300 people/yr c. 150 people/yr

25. $f'(x) = \frac{-2}{(x-1)^2}$ 27. $h'(x) = \frac{25}{(x+5)^2}$ 29. $-\frac{1}{2}$

31. 1 33. 9 units² 35. 15 units² 37. 9 39. 15

$$\begin{aligned} 41. & \frac{4}{n} \sum_{i=1}^n \left[\frac{1}{2} \left(\frac{4}{i} \right)^2 + 3 \right] \\ &= \frac{4}{n} \left[\sum_{i=1}^n \frac{1}{2} \left(\frac{4}{i} \right)^2 + \sum_{i=1}^n 3 \right] \quad \text{summation properties (distribute)} \\ &= \frac{4}{n} \left[\frac{1}{2} \sum_{i=1}^n \frac{16}{i^2} + \sum_{i=1}^n 3 \right] \quad \text{simplify} \\ &= \frac{4}{n} \left[\frac{16}{2n^2} \sum_{i=1}^n i^2 + \sum_{i=1}^n 3 \right] \quad \text{factor } \frac{16}{n^2} \text{ from first summation} \\ &= \frac{4}{n} \left[\frac{8}{n^2} \left(\frac{2n^3 + 3n^2 + n}{6} \right) + 3n \right] \quad \text{apply summation formula} \\ &= \frac{32}{n^3} \left(\frac{2n^3 + 3n^2 + n}{6} \right) + 12 \quad \text{distribute } \frac{4}{n} \\ &= \frac{32}{6} \left(\frac{2n^3 + 3n^2 + n}{n^3} \right) + 12 \quad \text{rewrite denominators} \\ &= \frac{16}{3} \left(2 + \frac{3}{n} + \frac{1}{n^2} \right) + 12 \quad \text{decompose rational expression} \end{aligned}$$

Applying the limit properties gives $\frac{16}{3} \lim_{n \rightarrow \infty} \left(2 + \frac{3}{n} + \frac{1}{n^2} \right) + \lim_{n \rightarrow \infty} 12$, andthe area under the curve is $\left(\frac{16}{3} \right) (2) + 12 = \frac{68}{3}$ units². The new employee has produced 22 complete parts.

$$\begin{aligned} 43. & A = \sum_{i=1}^n LW \\ &= \sum_{i=1}^n f\left(\frac{6}{i}\right) \left(\frac{6}{i}\right) \quad \text{area formula, rectangle method} \\ &= \frac{6}{n} \sum_{i=1}^n f\left(\frac{6}{i}\right) \quad \text{factor } \frac{6}{n} \\ &= \frac{6}{n} \sum_{i=1}^n \left[-\frac{1}{2} \left(\frac{6}{i} \right)^2 + 4 \left(\frac{6}{i} \right) \right] \quad \text{evaluate } f \text{ at } \frac{6}{i} \\ &= \frac{6}{n} \left[-\frac{1}{2} \sum_{i=1}^n \left(\frac{6}{i} \right)^2 + 4 \sum_{i=1}^n \left(\frac{6}{i} \right) \right] \quad \text{distribute summation} \\ &= \frac{6}{n} \left[-\frac{1}{2} \sum_{i=1}^n \frac{36}{i^2} + 4 \sum_{i=1}^n \frac{6}{i} \right] \quad \text{simplify} \\ &= \frac{6}{n} \left[-\frac{36}{2n^2} \sum_{i=1}^n i^2 + \frac{24}{n} \sum_{i=1}^n i \right] \quad \text{factor } \frac{36}{n^2} \text{ and } \frac{6}{n} \\ &= \frac{6}{n} \left[-\frac{18}{n^2} \left(\frac{2n^3 + 3n^2 + n}{6} \right) + \frac{24}{n} \left(\frac{n^2 + n}{2} \right) \right] \quad \text{summation formulas} \\ &= -\frac{108}{n^3} \left(\frac{2n^3 + 3n^2 + n}{6} \right) + \frac{144}{n^2} \left(\frac{n^2 + n}{2} \right) \quad \text{distribute } \frac{6}{n} \\ &= -\frac{108}{6} \left(\frac{2n^3 + 3n^2 + n}{n^3} \right) + \frac{144}{2} \left(\frac{n^2 + n}{n^2} \right) \quad \text{rewrite denominators} \\ &= -18 \left(2 + \frac{3}{n} + \frac{1}{n^2} \right) + 72 \left(1 + \frac{1}{n} \right) \quad \text{decompose rational expression} \end{aligned}$$

As $n \rightarrow \infty$, $\frac{3}{n}, \frac{1}{n^2}, \frac{1}{n} \rightarrow 0$, and the area is $-(18)(2) + 72 = 36$ units².45. $x \approx 29.87$ 47. $x = 5, \pm i\sqrt{3}$

Making Connections, p. 1215

1. d 3. e 5. g 7. f 9. b 11. c 13. a 15. e

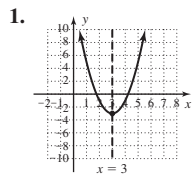
Summary and Concept Review, pp. 1216–1218

1. a. -3 b. 5 c. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ 2. 2 3. 1 4. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$
 5. -38 6. $\frac{2}{3}$ 7. $-\frac{1}{32}$ 8. $\frac{1}{2}$ 9. a. $x = -3$ b. $x = -2, -1, 3, 4$
 c. $x = 1, 2$ 10. 3 11. -1 12. 2 13. $\left(\frac{\text{dne}}{-\infty}\right)$ 14. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$
 15. -2 16. $f'(x) = 2x + 5$ 17. $g'(x) = \frac{1}{\sqrt{2x-1}}$
 18. $v'(x) = \frac{-1}{(x+3)^2}$ 19. at $x = 4, m_{\text{tan}} = -5$ 20. 9 units²

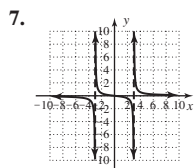
Practice Test, pp. 1218–1219

1. The limit of $f(x)$ as x approaches 5 is 10.
 2. $f(x)$; L ; sufficiently; c
 3. False, a limit can exist even if c is not in the domain.
 4. False, a limit can fail to exist even if a function is defined at c .
 5. As the domain of g is $x \geq 1$, the limit in b. exists and the limit in a. does not. $\lim_{x \rightarrow 1^+} (\sqrt{x-1} + 2) = 2$.
 6. a. II b. I c. IV d. III 7. a. 2 b. $\left(\frac{\text{dne}}{-\infty}\right)$ 8. a. 1 b. 0
 9. a. 3 b. 12 10. a. 4 b. undefined, $g(3) = 0$ 11. a. 4 b. -4
 12. a. 2 b. 9 13. a. 0 b. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ c. $\frac{1}{3}$ d. 1
 14. a. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ b. $\left(\frac{\text{dne}}{x}\right)$ c. $\left(\frac{\text{dne}}{-\infty}\right)$ d. 3 is not in the domain
 15. 3 16. $\frac{3}{2}$ 17. $\frac{1}{10}$ 18. 1
 19. a. $d'(t) = -32t + 224$ b. $d'(2) = 160$, the debris is rising at a velocity of 160 ft/sec; $d'(6) = 32$, the upward velocity of the debris has slowed to 32 ft/sec; $d'(7) = 0$, the debris has reached its maximum height (velocity is 0 ft/sec); $d'(11) = -128$, the velocity of the debris is now in the downward direction ($v < 0$) at 128 ft/sec.
 20. a. $\lim_{n \rightarrow \infty} \sum_{i=1}^n LW = \lim_{n \rightarrow \infty} \sum_{i=1}^n f\left(\frac{6-i}{n}\right) \frac{6}{n} = \lim_{n \rightarrow \infty} \frac{6}{n} \sum_{i=1}^n \left[225 - \left(\frac{6-i}{n}\right)^2\right]$
 b. 1278 ft-lb

Cumulative Review Chapters 1–12, pp. 1220–1221



3. $\frac{2}{3} \ln x + \frac{1}{2} \ln(x^2 + 3) - 4 \ln(2x + 1)$
 5. $\sin \theta = -\frac{15}{17}$, $\cos \theta = \frac{8}{17}$, $\tan \theta = -\frac{15}{8}$



9. a. $-\frac{1}{2}, \frac{1}{2}$ b. $\left(\frac{\text{dne}}{\text{LH} \neq \text{RH}}\right)$ 11. $\alpha = \frac{\pi}{6} + 1, \frac{7\pi}{6} + 1$
 13. The plane would be on a heading of 16.7° , traveling 297.5 mph.
 15. $x = \frac{\ln 9.36 + 1}{2}$, $x \approx 1.618$ 17. -3
 19. $1 + \frac{-2}{x+2} + \frac{2}{x-1}$ 21. $\frac{(x-1)^2}{25} + \frac{(y-1)^2}{9} = 1$
 23. a. 1 b. 0 c. -3 d. 5 not in domain, limit does not exist

25. $(5)(4)(9)(8)(7) = 10,080$ PINs 27. $(w, x, y, z) = (1, -2, 3, -4)$
 29. $\left(-\infty, -\frac{4}{3}\right) \cup (2, \infty)$

APPENDIX A

Exercises A.1, pp. A-7–A-9

1. constant 3. coefficient 5. Answers will vary
 7. two; 3 and -5 9. two; 2 and $\frac{1}{4}$ 11. three; $-2, 1$, and -5
 13. one; -1 15. $n - 7$ 17. $n + 4$ 19. $(n - 5)^2$ 21. $2n - 13$
 23. $n^2 + 2n$ 25. $\frac{2}{3}n - 5$ 27. $3(n + 5) - 7$ 29. Let w represent the width in meters. Then $2w$ represents twice the width and $2w - 3$ represents three meters less than twice the width. 31. Let b represent the speed of the bus. Then $b + 15$ represents 15 mph more than the speed of the bus. 33. $h = b + 150$ 35. $L = 2W + 20$ 37. $M = 2.5N$
 39. $T = 12.50g + 50$ 41. 14 43. 19 45. 0 47. 16 49. -36
 51. 51 53. 2 55. 144 57. $-\frac{41}{5}$ 59. 24

61.

x	Output
-3	14
-2	6
-1	0
0	-4
1	-6
2	-6
3	-4

-1 gives an output of 0.

63.

x	Output
-3	-18
-2	-15
-1	-12
0	-9
1	-6
2	-3
3	0

3 gives an output of 0.

65.

x	Output
-3	-5
-2	8
-1	9
0	4
1	-1
2	0
3	13

2 gives an output of 0.

67. a. $7 + (-5) = 2$ b. $n + (-2)$ c. $a + (-4.2) + 13.6 = a + 9.4$
 d. $x + 7 - 7 = x$ 69. a. 3.2 b. $\frac{5}{6}$ 71. $-5x + 13$
 73. $-\frac{1}{15}p + 6$ 75. $-2a$ 77. $\frac{17}{12}x$ 79. $-2a^2 + 2a$ 81. $6x^2 - 3x$
 83. $2a + 3b + 2c$ 85. $\frac{29}{8}n + \frac{38}{5}$ 87. $7a^2 - 13a - 5$ 89. 10 ohms
 91. a. $t = \frac{1}{2}j$ b. $t = 275$ mph 93. a. $L = 2W + 3$ b. 107 ft
 95. $t = c + 29$; 44¢ 97. $C = 25t + 43.50$; \$81
 99. a. positive odd integer

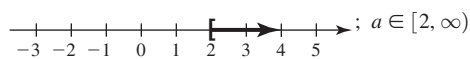
Exercises A.2, pp. A-20–A-23

1. power 3. $20x$; 0 5. a. cannot be simplified, unlike terms
 b. can be simplified, like bases 7. $14n^7$ 9. $-12p^5q^4$ 11. $a^{14}b^7$
 13. $216p^3q^6$ 15. $32.768h^3k^6$ 17. $\frac{p^2}{4q^2}$ 19. $49c^{14}d^4$ 21. $\frac{9}{16}x^6y^2$
 23. $\frac{9}{4}x^3y^2$ 25. a. $V = 27x^6$ b. 1728 units³ 27. $3w^3$ 29. $-3ab$
 31. $\frac{27}{8}$ 33. $2h^3$ 35. $-\frac{1}{8}$ 37. -8 39. $\frac{4p^8}{q^6}$ 41. $\frac{8x^6}{27y^9}$ 43. $\frac{25m^4n^6}{4r^8}$
 45. $\frac{25p^2q^2}{4}$ 47. $\frac{3p^2}{-4q^2}$ 49. $\frac{5}{3h^7}$ 51. $\frac{1}{a^3}$ 53. $\frac{a^{12}}{b^4c^8}$ 55. $-\frac{12}{5x^4}$
 57. $\frac{-2b^7}{27a^9c^3}$ 59. 2 61. $\frac{7}{10}$ 63. $\frac{13}{9}$ 65. -4 67. 6.77×10^9
 69. 0.000 000 006 5 71. 26,571 hrs; 1107 days 73. polynomial, none of these, degree 3 75. nonpolynomial because exponents are not whole numbers, NA, NA 77. polynomial, binomial, degree 3
 79. $-w^3 - 3w^2 + 7w + 8.2$; -1 81. $c^3 + 2c^2 - 3c + 6$; 1
 83. $-\frac{2}{3}x^2 + 12$; $-\frac{2}{3}$ 85. $3p^3 - 3p^2 - 12$ 87. $7.85b^2 - 0.6b - 1.9$
 89. $\frac{1}{4}x^2 - 8x + 6$ 91. $q^6 + q^5 - q^4 + 2q^3 - q^2 - 2q$

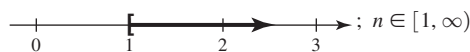
93. $-3x^3 + 3x^2 + 18x$ 95. $3r^2 - 11r + 10$ 97. $x^3 - 27$
 99. $b^3 - b^2 - 34b - 56$ 101. $21v^2 - 47v + 20$ 103. $9 - m^2$
 105. $p^2 + 1.1p - 9$ 107. $x^2 + \frac{3}{4}x + \frac{1}{8}$ 109. $m^2 - \frac{9}{16}$
 111. $6x^2 + 11xy - 10y^2$ 113. $12c^2 + 23cd + 5d^2$
 115. $2x^4 - x^2 - 15$ 117. $4m + 3; 16m^2 - 9$
 119. $7x + 10; 49x^2 - 100$ 121. $6 - 5k; 36 - 25k^2$
 123. $x - \sqrt{6}; x^2 - 6$ 125. $x^2 + 8x + 16$ 127. $16g^2 + 24g + 9$
 129. $16p^2 - 24pq + 9q^2$ 131. $16 - 8\sqrt{x} + x$
 133. $xy + 2x - 3y - 6$ 135. $k^3 + 3k^2 - 28k - 60$
 137. a. 340 mg, 292.5 mg b. Less, amount is decreasing. c. after 5 hr
 139. $F = kPQd^{-2}$ 141. $5x^{-3} + 3x^{-2} + 2x^{-1} + 4$ 143. \$15 145. 6

Exercises A.3, pp. A-34–A-38

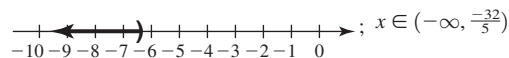
1. identity; unknown; contradiction; unknown 3. simple; compound
 5. Answers will vary. 7. $x = 3$ 9. $v = -11$ 11. $b = \frac{6}{5}$
 13. $b = -15$ 15. $m = -\frac{27}{4}$ 17. $x = 12$ 19. $x = 12$ 21. $p = -56$
 23. $a = -3.6$ 25. $v = -0.5$ 27. $n = \frac{20}{21}$ 29. $p = \frac{12}{5}$
 31. contradiction; $\{ \}$ 33. conditional; $n = -\frac{11}{10}$
 35. identity; $\{x|x \in \mathbb{R}\}$ 37. $\{x|x \geq -2\}; [-2, \infty)$
 39. $\{x|-2 \leq x \leq 1\}; [-2, 1]$ 41. $\{a|a \geq 2\};$



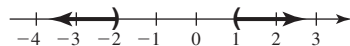
43. $\{n|n \geq 1\};$



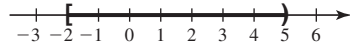
45. $\{x|x < -\frac{32}{5}\};$



47. $\{ \}$ 49. $\{x|x \in \mathbb{R}\}$ 51. $\{p|p \in \mathbb{R}\}$
 53. $\{2\}; \{-3, -2, -1, 0, 1, 2, 3, 4, 6, 8\}$
 55. $\{ \}; \{-3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7\}$
 57. $\{4, 6\}; \{2, 4, 5, 6, 7, 8\}$
 59. $x \in (-\infty, -2) \cup (1, \infty);$

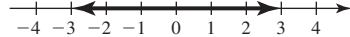


61. $x \in [-2, 5);$

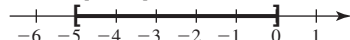


63. no solution

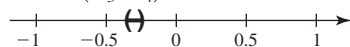
65. $x \in (-\infty, \infty);$



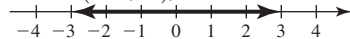
67. $x \in [-5, 0];$



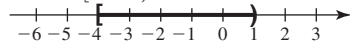
69. $x \in (-\frac{1}{3}, -\frac{1}{4});$



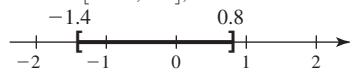
71. $x \in (-\infty, \infty);$



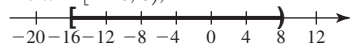
73. $x \in [-4, 1);$



75. $x \in [-1.4, 0.8];$



77. $x \in [-16, 8);$



79. $8 + 6 - 12 = 2$ ✓ b. $6 + 8 - 12 = 2$ ✓ c. 20 vertices
 81. $W < 177.34$ lb 83. $2f + 5 = 73$; 34 fans
 85. $2c + 13 = 1467$; 727 cal 87. $41 = \frac{2}{3}S + 1$; 60 yr
 89. $74 = \frac{10}{3}r + 34$; 12 in. 91. $\frac{82 + 76 + 65 + 71 + x}{5} \geq 75$, at least 81%
 93. $\frac{1125 + 850 + 625 + 400 + x}{5} \geq 1000$, at least \$2000
 95. $0 < 20w < 150$, $0 < w < 7.5$ m
 97. $45 < \frac{9}{5}C + 32 < 85$, $7.2^\circ < C < 29.4^\circ$
 99. $S = 4.5h + 20$, $K = 6h + 11$, more than 6 hr
 101. a. 216.5 ft² b. 7 sheets will be needed 103. about 337.4 in³
 105. $x = \frac{1}{2}$ 107. Answers may vary. 109. $<$ 111. $<$ 113. $<$
 115. $>$

Exercises A.4, pp. A-48–A-52

1. product 3. binomial; conjugate 5. Answers will vary.
 7. a. $-17(x^2 - 3)$ b. $7b(3b^2 - 2b + 8)$ c. $-3a^2(a^2 + 2a - 3)$
 9. a. $(a + 2)(2a + 3)$ b. $(b^2 + 3)(3b + 2)$ c. $(n + 7)(4m - 11)$
 11. a. $(3q + 2)(3q^2 + 5)$ b. $(h - 12)(h^4 - 3)$ c. $(k^2 - 7)(k^3 - 5)$
 13. a. $-1(p - 7)(p + 2)$ b. prime c. $(n - 4)(n - 5)$
 15. a. $(3p + 2)(p - 5)$ b. $(4q - 5)(q + 3)$ c. $(5u + 3)(2u - 5)$
 17. a. $(2s + 5)(2s - 5)$ b. $(3x + 7)(3x - 7)$ c. $2(5x + 6)(5x - 6)$
 d. $(11h + 12)(11h - 12)$ e. $(b + \sqrt{5})(b - \sqrt{5})$ 19. a. $(a - 3)^2$
 b. $(b + 5)^2$ c. $(2m - 5)^2$ d. $(3n - 7)^2$
 21. a. $(2p - 3)(4p^2 + 6p + 9)$ b. $(m + \frac{1}{2})(m^2 - \frac{1}{2}m + \frac{1}{4})$
 c. $(g - 0.3)(g^2 + 0.3g + 0.09)$ d. $-2t(t - 3)(t^2 + 3t + 9)$
 23. a. $(x + 3)(x - 3)(x + 1)(x - 1)$ b. $(x^2 + 9)(x^2 + 4)$
 c. $(x - 2)(x^2 + 2x + 4)(x + 1)(x^2 - x + 1)$
 25. a. $(n + 1)(n - 1)$ b. $(n - 1)(n^2 + n + 1)$
 c. $(n + 1)(n^2 - n + 1)$ d. $7x(2x + 1)(2x - 1)$
 27. $(a + 5)(a + 2)$ 29. $2(x - 2)(x - 10)$ 31. $-1(3m + 8)(3m - 8)$
 33. $(r - 3)(r - 6)$ 35. $(2h + 3)(h + 2)$ 37. $(3k - 4)^2$
 39. $-3x(2x - 7)(x - 3)$ 41. $4m(m + 5)(m - 2)$ 43. $(a + 5)(a - 12)$
 45. $(2x - 5)(4x^2 + 10x + 25)$ 47. prime 49. $(x - 5)(x + 3)(x - 3)$
 51. a. H b. E c. C d. F e. B f. A g. I h. D i. G
 53. $a = -1$; $b = 2$; $c = -15$ 55. not quadratic ($a = 0$)
 57. $a = \frac{1}{4}$; $b = -6$; $c = 0$ 59. $a = 2$; $b = 0$; $c = 7$
 61. not quadratic (degree 3) 63. $a = 1$; $b = -1$; $c = -5$
 65. $x = 5$ or $x = -3$ 67. $m = 4$ 69. $p = 0$ or $p = 2$
 71. $h = 0$ or $h = -\frac{1}{2}$ 73. $a = 3$ or $a = -3$ 75. $g = -9$
 77. $m = -5$ or $m = -3$ or $m = 3$ 79. $c = -3$ or $c = 15$
 81. $r = 8$ or $r = -3$ 83. $t = -13$ or $t = 2$
 85. $x = 5$ or $x = -3$ 87. $w = -\frac{1}{2}$ or $w = 3$
 89. $x = -2$, $x = 0$, $x = 11$ 91. $x = -3$, $x = 0$, $x = \frac{2}{3}$
 93. $p = -7$, $p = -3$, $p = 3$ 95. $x = -5$, $x = 2$, $x = 5$
 97. $x = -5$, $x = -2$, $x = 2$, $x = 5$ 99. $b = -2$, $b = -1$, $b = 4$, $b = 5$
 101. $2\pi r(r + h)$, 7000π cm²; 21,991 cm²
 103. $V = \frac{1}{3}\pi h(R + r)(R - r)$; 6π cm³; 18.8 cm³
 105. $V = x(x + 5)(x + 3)$ a. 3 in. b. 5 in. c. $V = 24(29)(27) = 18,792$ in³
 107. $L = L_0\sqrt{\left(1 + \frac{v}{c}\right)\left(1 - \frac{v}{c}\right)}$, $L = 12\sqrt{(1 + 0.75)(1 - 0.75)}$
 $= 3\sqrt{7}$ in. ≈ 7.94 in. 109. 11 in. by 13 in.
 111. a. $\frac{1}{8}(4x^4 + x^3 - 6x^2 + 32)$ b. $\frac{1}{18}(12b^5 - 3b^3 + 8b^2 - 18)$
 113. $2x(16x - 27)(6x + 5)$ 115. $(x + 3)(x - 3)(x^2 + 9)$
 117. $(p + 1)(p^2 - p + 1)(p - 1)(p^2 + p + 1)$
 119. $(q + 5)(q - 5)(q + \sqrt{3})(q - \sqrt{3})$

Exercises A.5, pp. A-60–A-63

1. 1; -1 3. common denominator 5. F; numerator should be -1
 7. a. $-\frac{1}{3}$ b. $\frac{x + 3}{2x(x - 2)}$ 9. a. simplified b. $\frac{a - 4}{a - 7}$
 11. a. -1 b. -1 13. a. $-3ab^9$ b. $\frac{x + 3}{9}$ c. $-1(y + 3)$ d. $-\frac{1}{m}$

15. a. $\frac{2n+3}{n}$ b. $\frac{3x+5}{2x+3}$ c. $x+2$ d. $n-2$ 17. $\frac{(a-2)(a+1)}{(a+3)(a+2)}$
 19. 1 21. $\frac{(p-4)^2}{p^2}$ 23. $\frac{-15}{4}$ 25. $\frac{3}{2}$ 27. $\frac{8(a-7)}{a-5}$ 29. $\frac{y}{x}$
 31. $\frac{m}{m-4}$ 33. $\frac{y+3}{3y(y+4)}$ 35. $\frac{x+0.3}{x-0.2}$ 37. $\frac{n+\frac{1}{5}}{n+\frac{2}{3}}$
 39. $\frac{3(a^2+3a+9)}{2}$ 41. $\frac{2n+1}{n}$ 43. $\frac{3+20x}{8x^2}$ 45. $\frac{14y-x}{8x^2y^4}$
 47. $\frac{2}{p+6}$ 49. $\frac{-3m-16}{(m+4)(m-4)}$ 51. $\frac{-5m+37}{m-7}$ 53. $\frac{-y+11}{(y+6)(y-5)}$
 55. $\frac{2a-5}{(a+4)(a-5)}$ 57. $\frac{1}{y+1}$ 59. $\frac{m^2-6m+21}{(m+3)^2(m-3)}$
 61. $\frac{y^2+26y-1}{(5y+1)(y+3)(y-2)}$ 63. a. $\frac{1}{p^2} - \frac{5}{p}; \frac{1-5p}{p^2}$
 b. $\frac{1}{x^2} + \frac{2}{x^3}; \frac{x+2}{x^3}$ 65. $\frac{4a}{a+20}$ 67. $p-1$ 69. $\frac{x}{3(3x-4)}$
 71. $\frac{-2}{y+31}$ 73. a. $\frac{1+\frac{3}{m}}{1-\frac{3}{m}}; \frac{m+3}{m-3}$ b. $\frac{1+\frac{2}{x^2}}{1-\frac{2}{x^2}}; \frac{x^2+2}{x^2-2}$ 75. $x=1$
 77. $a=\frac{3}{2}$ 79. $y=12$ 81. $x=3; x=7$ is extraneous 83. $n=7$
 85. $a=-1, a=-8$
 87. a. \$300 million; \$2550 million 89. Price rises rapidly for first four days, then begins a gradual decrease. Yes, on the 35th day of trading.

P	$\frac{450P}{100-P}$
40	300
60	675
80	1800
90	4050
93	5979
95	8550
98	22050
100	ERROR

Day	Price
0	10
1	16.67
2	32.76
3	47.40
4	53.51
5	52.86
6	49.25
7	44.91
8	40.75
9	37.03
10	33.81

91. $t=8$ weeks 93. $P \approx 80\%$
 95. b. $\frac{(2x+3y)}{5}$

Exercises A.6, pp. A-75–A-79

1. even 3. $(16^3)^3$ 5. Answers will vary. 7. a. $|9|=9$ b. $|-10|=10$
 9. a. $7|p|$ b. $|x-3|$ c. $9m^2$ d. $|x-3|$ 11. a. 4 b. $-6x$ c. $6z^4$
 d. $\frac{v}{-2}$ 13. a. 2 b. not a real number c. $3x^2$ d. $-3x$ e. $k-3$
 f. $|h+2|$ 15. a. -5 b. $-3|n^3|$ c. not real number d. $\frac{7|v^5|}{6}$
 17. a. 4 b. $\frac{64}{125}$ c. $\frac{125}{8}$ d. $\frac{9p^4}{4q^2}$ 19. a. -1728
 b. not a real number c. $\frac{1}{9}$ d. $\frac{-256}{81x^4}$ 21. a. $\frac{32n^{10}}{p^2}$ b. $\frac{1}{2y^{\frac{1}{4}}}$
 23. a. $3m\sqrt{2}$ b. $10pq^2\sqrt[3]{q}$ c. $\frac{3}{2}mn\sqrt[3]{n^2}$ d. $4pq^3\sqrt{2p}$
 e. $-3+\sqrt{7}$ f. $\frac{9}{2}-\sqrt{2}$ 25. a. $15a^2$ b. $-4b\sqrt{b}$ c. $\frac{x^4\sqrt{y}}{3}$
 d. $3u^2v\sqrt[3]{v}$ 27. a. $2m^2$ b. $3n$ c. $\frac{3\sqrt{5}}{4x}$ d. $\frac{18\sqrt[3]{3}}{z^3}$

29. a. $2x^2y^3$ b. $x^2\sqrt[4]{x}$ c. $\sqrt[4]{2b}$ d. $\frac{1}{\sqrt[6]{6}} = \frac{\sqrt[6]{6^5}}{6}$ e. $b^{\frac{3}{4}}$
 31. a. $9\sqrt{2}$ b. $14\sqrt{3}$ c. $16\sqrt{2m}$ d. $-5\sqrt{7p}$
 33. a. $-x\sqrt[3]{2x}$ b. $2-\sqrt{3x}+3\sqrt{5}$
 c. $6x\sqrt{2x}+5\sqrt{2}-\sqrt{7x}+3\sqrt{3}$ 35. a. 98 b. $\sqrt{15}+\sqrt{21}$
 c. n^2-5 d. $39-12\sqrt{3}$
 37. a. -19 b. $\sqrt{10}+\sqrt{65}-2\sqrt{7}-\sqrt{182}$
 c. $12\sqrt{5}+2\sqrt{14}+36\sqrt{15}+6\sqrt{42}$
 39. Verified 41. Verified 43. a. $\frac{\sqrt{3}}{2}$ b. $\frac{2\sqrt{15x}}{9x^2}$ c. $\frac{3\sqrt{6b}}{10b}$
 d. $\frac{\sqrt[3]{2p^2}}{2p}$ e. $\frac{5\sqrt[3]{a^2}}{a}$ 45. a. $-12+4\sqrt{11}; 1.27$ b. $\frac{6\sqrt{x}+6\sqrt{2}}{x-2}$
 47. a. $\sqrt{30}-2\sqrt{5}-3\sqrt{3}+3\sqrt{2}; 0.05$
 b. $\frac{7+7\sqrt{2}+\sqrt{6}+2\sqrt{3}}{-3}; -7.60$ 49. a. $x=\frac{14}{3}$
 b. $x=8, x=1$ is extraneous 51. a. $m=3$ b. $x=5$ c. $m=-4$
 d. $x=-16$ 53. a. $x=25$ b. $x=7; x=-2$ is extraneous
 c. $x=2, x=18$ d. $x=6; x=0$ is extraneous 55. a. $x=-32$
 b. $x=81$ 57. a. $x=-32, x=22$ b. $x=-30, x=34$
 59. $x=-27, x=125$ 61. 8.33 ft 63. a. $8\sqrt{10}m$ b. about 25.3 m
 65. a. 365.02 days b. 688.69 days c. 87.91 days 67. a. 36 mph
 b. 46.5 mph 69. $12\pi\sqrt{34} \approx 219.82 m^2$ 71. a. 36 million mi
 b. 67 million mi c. 93 million mi d. 142 million mi e. 484 million mi
 f. 887 million mi 73. a. $(x+\sqrt{5})(x-\sqrt{5})$ b. $(n+\sqrt{19})(n-\sqrt{19})$
 75. a. $13\sqrt{3x}+39\sqrt{x}$ b. Answers will vary. 77. $\frac{3\sqrt{2}}{2}$
 79. $x \in [1, 2) \cup (2, \infty)$

Practice Test, pp. A-82–A-83

1. a. False; parentheses first b. False; undefined c. True
 d. False; $-2x+6$ 2. a. 11 b. -5 c. not a real number d. 20
 3. a. $\frac{9}{8}$ b. $\frac{-7}{2}$ c. 0.5 d. -4.6 4. a. $\frac{23}{3}$ b. 0.9 c. 4 d. -7
 5. ≈ 4439.28 6. a. 0 b. undefined 7. a. 3; $-2, 6, 5$
 b. $2; \frac{1}{3}, 1$ 8. a. -13 b. ≈ 7.29 9. a. $x^3-(2x-9)$
 b. $2n-3\left(\frac{n}{2}\right)^2$ 10. a. Let r represent Earth's radius. Then $11r-119$
 represents Jupiter's radius. b. Let e represent this year's earnings. Then
 $4e+1.2$ million represents last year's earnings. 11. a. $9v^2+3v-7$
 b. $-7b+8$ c. x^2+6x 12. a. $(3x+4)(3x-4)$ b. $v(2v-3)^2$
 c. $(x+5)(x+3)(x-3)$ 13. a. $5b^3$ b. $4a^{12}b^{12}$ c. $\frac{m^6}{8n^3}$ d. $\frac{25}{4}p^2q^2$
 14. a. $-4ab$ b. $6.4 \times 10^{-2} = 0.064$ c. $\frac{a^{12}}{b^4c^8}$ d. -6
 15. a. $9x^4-25y^2$ b. $4a^2+12ab+9b^2$
 16. a. $7a^4-5a^3+8a^2-3a-18$ b. $-7x^4+4x^2+5x$ 17. a. -1
 b. $\frac{2+n}{2-n}$ c. $x-3$ d. $\frac{x-5}{3x-2}$ e. $\frac{x-5}{3x+1}$ f. $\frac{3(m+7)}{5(m+4)(m-3)}$
 18. a. $|x+11|$ b. $\frac{-2}{3v}$ c. $\frac{64}{125}$ d. $-\frac{1}{2}+\frac{\sqrt{2}}{2}$ e. $11\sqrt{10}$
 f. x^2-5 g. $\frac{\sqrt{10x}}{5x}$ h. $2(\sqrt{6}+\sqrt{2})$ 19. $-0.5x^2+10x+1200$;
 a. 10 decreases of 0.50 or \$5.00 b. Maximum revenue is \$1250.
 20. 58 cm 21. a. $b=6$ b. $n=4$ c. $m=-1$ d. $x=\frac{1}{6}$
 e. $\{ \}$ (contradiction) f. $g=10$
 22. $3+\frac{1}{4}(n+12)=16$, the number is 40
 23. a. $x=-2, x=2, x=7$ b. $r=0, r=-1, r=4$
 c. $g=-3, g=-1, g=1, g=3$ 24. a. $x=-\frac{1}{2}$ b. $h=-\frac{5}{3}, h=2$
 c. $n=13$ (-2 is extraneous) 25. a. $x=-3, x=3$
 b. $x=-4, x=5$ c. $x=-1$ (7 is extraneous)

