Student Answer Appendix

CHAPTER 1

Exercises 1.1, pp. 14–18

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

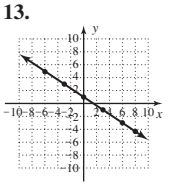
7.

$D = \{1, 2, 3, 4, 5\}$
$R = \{2.75, 3.00, 3.25, 3.50, 3.75\}$

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

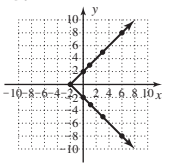
11. $D = \{4, -1, 2, -3\}$; $R = \{0, 5, 4, 2, 3\}$

13.



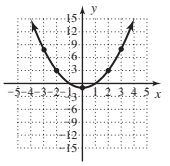
x	y
-6	5
-3	3
0	1
3	-1
6	-3
8	$\frac{-13}{3}$

15.



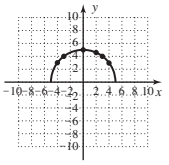
x	y
-2	0
0	$2, -2$
1	$3, -3$
3	$5, -5$
6	$8, -8$
7	$9, -9$

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



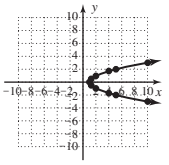
x	y
-3	8
-2	3
0	-1
2	3
3	8
4	15

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



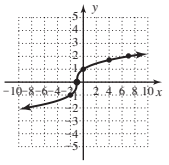
x	y
-4	3
-3	4
0	5
2	$\sqrt{21}$
3	4
4	3

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



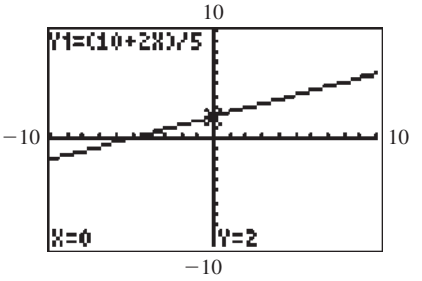
x	y
10	$3, -3$
5	$2, -2$
4	$\sqrt{3}, -\sqrt{3}$
2	$1, -1$
1.25	$0.5, -0.5$
1	0

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

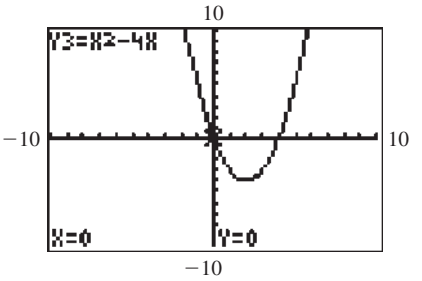


x	y
-9	-2
-2	-1
-1	0
0	1
4	$\sqrt[3]{5}$
7	2

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



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

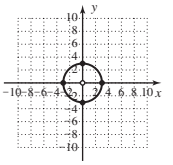


29. $(3, 1)$ **31.** $(-0.7, -0.3)$ **33.** $(\frac{1}{20}, \frac{1}{24})$ **35.** $(0, -1)$ **37.** $(-1, 0)$

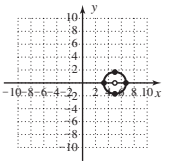
39. $2\sqrt{34}$ **41.** 10 **43.** right triangle **45.** not a right triangle

47. right triangle

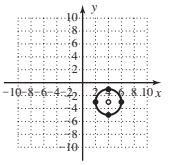
49. $x^2 + y^2 = 9$



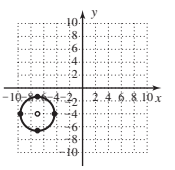
51. $(x - 5)^2 + y^2 = 3$



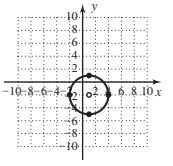
53. $(x - 4)^2 + (y + 3)^2 = 4$



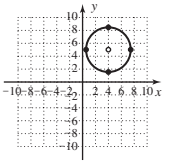
55. $(x + 7)^2 + (y + 4)^2 = 7$



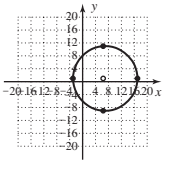
57. $(x - 1)^2 + (y + 2)^2 = 9$



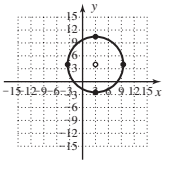
59. $(x - 4)^2 + (y - 5)^2 = 12$



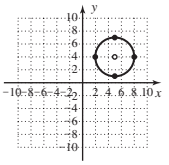
61. $(x - 7)^2 + (y - 1)^2 = 100$



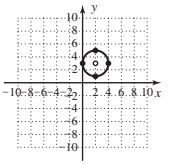
63. $(x - 3)^2 + (y - 4)^2 = 41$



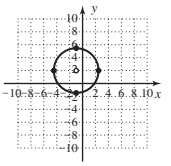
65. $(x-5)^2+(y-4)^2=9$



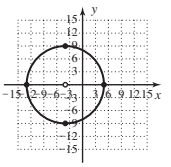
67. $(2,3)$, $r=2$, $x\in[0,4]$, $y\in[1,5]$



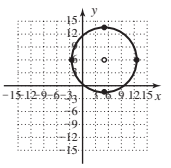
69. $(-1,2)$, $r=2\sqrt{3}$, $x\in[-1-2\sqrt{3},\,-1+2\sqrt{3}]$, $y\in[2-2\sqrt{3},\,2+2\sqrt{3}]$



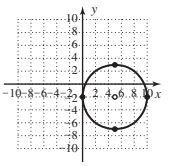
71. $(-4,0)$, $r=9$, $x\in[-13,5]$, $y\in[-9,9]$



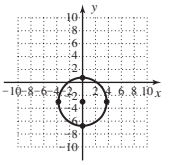
73. $(x-5)^2+(y-6)^2=57$, $(5,6)$, $r=\sqrt{57}$



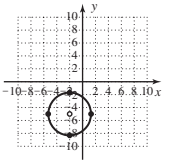
75. $(x-5)^2+(y+2)^2=25$, $(5,-2)$, $r=5$



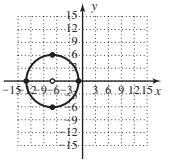
77. $x^2+(y+3)^2=14$, $(0,-3)$, $r=\sqrt{14}$



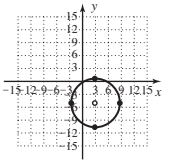
79. $(x+2)^2+(y+5)^2=11$, $(-2,-5)$, $r=\sqrt{11}$



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

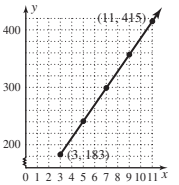


83. $(x-3)^2+(y+5)^2=32$, $(3,-5)$, $r=4\sqrt{2}$

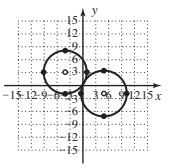


85. a. $y=x^2-6x$ **87. b.** $y=x^2+(y-3)^2=36$
89. f. $(x-1)^2+(y+2)^2=49$ **91. j.** $6x+y=x^2+9$

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 $=12\pi$ units^2
99.



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

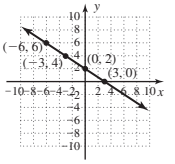
101. $y=\pm4.8$; $y=\pm3.6$, Answers will vary.
103. Answers will vary.
105. a. center: $(6,-2)$; $r=0$ (degenerate case) **b.** center: $(1,4)$; $r=5$
c. $r^2=-1$; degenerate case **107.** $x=\frac{7}{4}$
109. $n=1$ is a solution, $n=-2$ is extraneous

Exercises 1.2, pp. 28–32

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

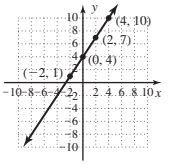
7.

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



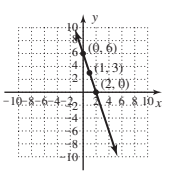
9.

x	y
-2	1
0	4
2	7
4	10

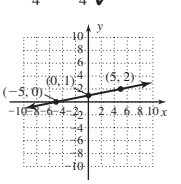


11. $-0.5=\frac{3}{2}(-3)+4$
$-0.5=-\frac{9}{2}+4$
$-0.5=-0.5$ ✓
$\frac{19}{4}=\frac{3}{2}\left(\frac{1}{2}\right)+4$
$\frac{19}{4}=\frac{3}{4}+4$
$\frac{19}{4}=\frac{19}{4}$ ✓

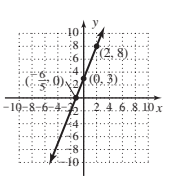
13.



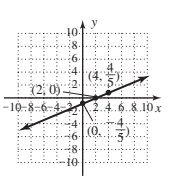
15.



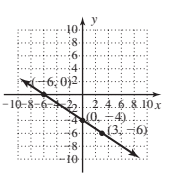
17.



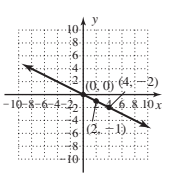
19.



21.



23.



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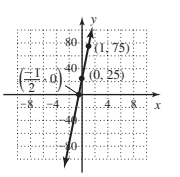

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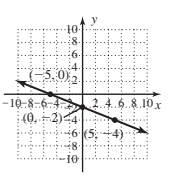

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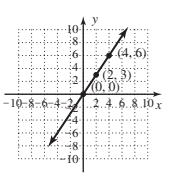
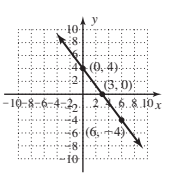
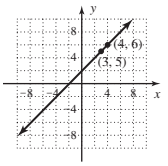


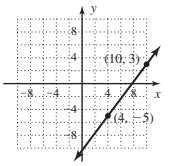
31.



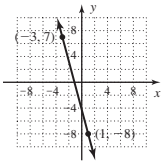
33. $m = 1$; (2, 4) and (1, 3)



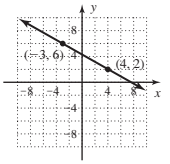
35. $m = \frac{4}{3}$; (7, −1) and (1, −9)



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

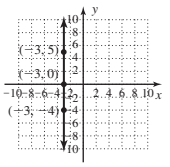


39. $m = \frac{-4}{7}$; (−10, 10) and (11, −2)

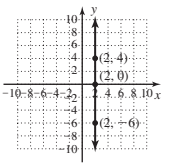


41. a. $m = 125$, cost increased \$125,000 per 1000 sq ft **b.** \$375,000
43. a. $m = 22.5$, distance increases 22.5 mph **b.** about 186 mi
45. a. $m = \frac{23}{6}$, a person weighs 23 lb more for each additional 6 in. in height **b.** ≈3.8
47. In inches: (0, −6) and (576, −18): $m = \frac{-1}{48}$. The sewer line is 1 in. deeper for each 48 in. in length.

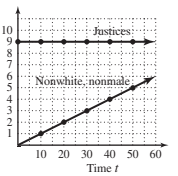
49.



51.



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.

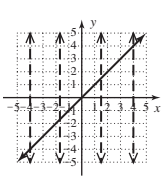


57. parallel **59.** neither **61.** parallel **63.** right triangle
65. not a right triangle **67.** right triangle **69. a.** 78.2 yr **b.** 2015
71. $v = -1250t + 8500$ **a.** \$3500 **b.** 5 yr
73. $h = -3t + 300$ **a.** 273 in. **b.** 20 months
75. Yes they will meet, the two roads are not parallel: $\frac{38}{12} \neq \frac{30}{9.5}$.
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

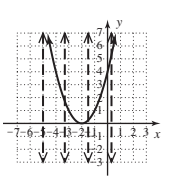
1. first **3.** range **5.** Answers will vary. **7.** function
9. Not a function. The Shaq is paired with two heights.
11. Not a function; 4 is paired with 2 and −5. **13.** function
15. function **17.** Not a function; −2 is paired with 3 and −4.
19. function **21.** function **23.** Not a function; 0 is paired with 4 and −4.
25. function **27.** Not a function; 4 is paired with −1 and 1.
29. function

31.



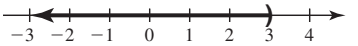
function

33.

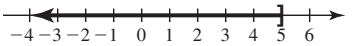


function

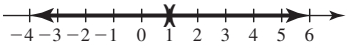
35. $w \geq 45$; $w \in [45, \infty)$ **37.** $250 < T < 450$; $T \in (250, 450)$
39. $p \in (-\infty, 3)$



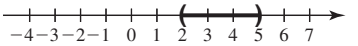
41. $m \in (-\infty, 5]$



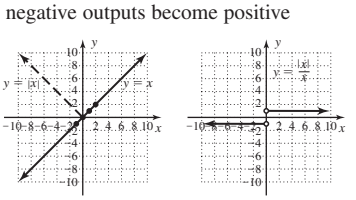
43. $x \in (-\infty, 1) \cup (1, \infty)$



45. $x \in (2, 5)$



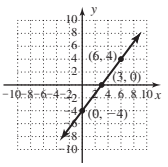
47. $\{x | x \geq -2\}$; $[-2, \infty)$ **49.** $\{x | -2 \leq x \leq 1\}$; $[-2, 1]$
51. function, $x \in [-4, 5]$, $y \in [-2, 3]$
53. function, $x \in [-4, \infty)$, $y \in [-4, \infty)$
55. function, $x \in [-4, 4]$, $y \in [-5, -1]$
57. function, $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$
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. $g(4) = 8\pi, g\left(\frac{3}{2}\right) = 3\pi, g(2c) = 4\pi c, g(c + 3) = 2\pi(c + 3)$
97. $g(4) = 16\pi, g\left(\frac{3}{2}\right) = \frac{9}{4}\pi, g(2c) = 4\pi c^2, g(c + 3) = (c^2 + 6c + 9)\pi$
99. $p(5) = \sqrt{13}, p\left(\frac{3}{2}\right) = \sqrt{6}, p(3a) = \sqrt{6a + 3}, p(a - 1) = \sqrt{2a + 1}$
101. $p(5) = \frac{14}{5}, p\left(\frac{3}{2}\right) = \frac{7}{9}, p(3a) = \frac{27a^2 - 5}{9a^2}, p(a - 1) = \frac{3a^2 - 6a - 2}{a^2 - 2a + 1}$
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.** $A = \frac{1}{2}(8) + 22 - 1 = 25$ units^2
113. a. $N(g) = 2.5g$ **b.** $g \in [0, 5]$; $N \in [0, 12.5]$ **115. a.** $[0, \infty)$
b. about 2356 units^3 **c.** 800 units^3 **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. $x \in (-\infty, -2) \cup (2, \infty)$; $x = \frac{2y + 3}{1 - y}$; $y \in (-\infty, 1) \cup (1, \infty)$
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.

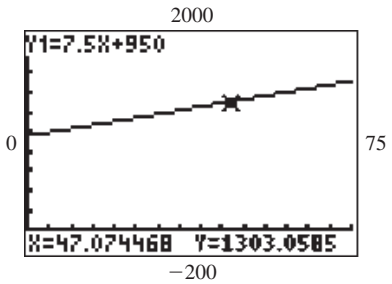


2. $m = \frac{-18}{7}$ **3.** positive, loss is decreasing (profit is increasing); $m = \frac{3}{2}$, yes; $\frac{1.5}{1}$, each year Data.com's loss decreases by 1.5 million.

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 → 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. $y = \frac{-4}{5}x + 2$

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

9. $y = 2x + 7$

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

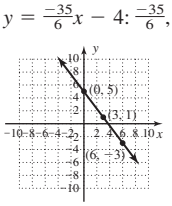
11. $y = \frac{-5}{3}x - 5$

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

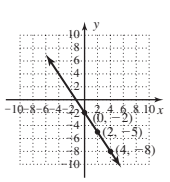
13. $y = 2x - 3$: 2, -3 **15.** $y = \frac{5}{-3}x - 7$: $\frac{5}{-3}$, -7

17. $y = \frac{-35}{6}x - 4$: $\frac{-35}{6}$, -4

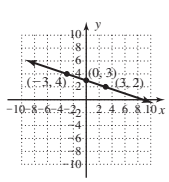
19.



21.



23.



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)

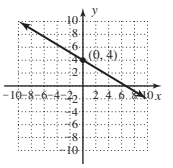
35. $y = \frac{1}{3}x$, $f(x) = \frac{1}{3}x$, $m = \frac{1}{3}$, y-intercept (0, 0)

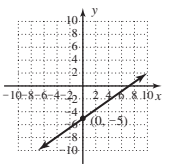
37. $y = \frac{-3}{4}x + 3$, $f(x) = \frac{-3}{4}x + 3$, $m = \frac{-3}{4}$, y-intercept (0, 3)

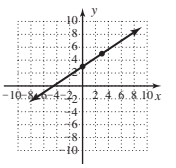
39. $y = \frac{2}{3}x + 1$ **41.** $y = 3x + 3$ **43.** $y = 3x + 2$

45. $y = -4x - 10$ **47.** $y = \frac{-3}{2}x + 1$ **49.** $y = \frac{75}{2}x + 150$

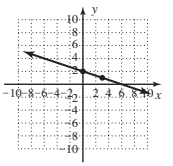
51. $y = -\frac{3}{5}x + 4$ **53.** $y = \frac{2}{3}x - 5$ **55.**



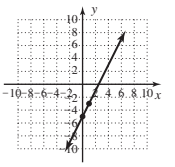




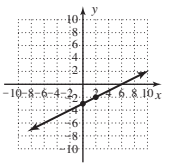
57.



59.



61.



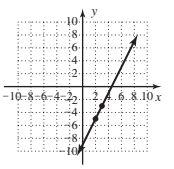
63. $y = \frac{2}{5}x + 4$ **65.** $y = \frac{-5}{3}x + 7$ **67.** $y = \frac{-12}{5}x - \frac{29}{5}$

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.** $y = \frac{4}{9}x + \frac{31}{9}$

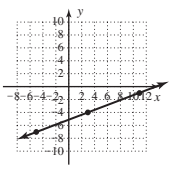
b. $y = \frac{-9}{4}x + \frac{3}{4}$ **81. a.** $y = \frac{-1}{2}x - 2$ **b.** $y = 2x - 2$

83.



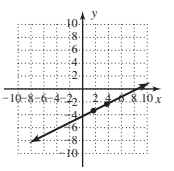
$y + 5 = 2(x - 2)$

85.



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

87.



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

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.** $9|x|$

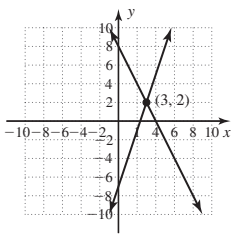
119. 113.10 yd^2

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.

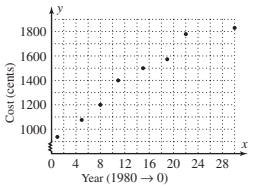


$x = 3$

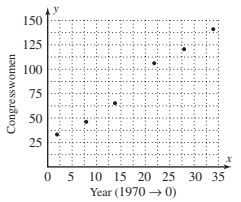
9. $x = -3$ **11.** $x \in (-\infty, \infty)$ **13.** $x = -9$ **15.** no solutions
17. $x = 3$, answers match **19.** $x = -2$ **21.** $x = 0$
23. no solutions **25.** $x \in (-\infty, \infty)$ **27.** $x \in (3, \infty)$, verified graphically in Exercise 7 **29.** $x \in (-\infty, 0]$ **31.** $x \in (-5, \infty)$
33. $x \in (-\infty, \infty)$ **35.** no solutions **37.** $C = \dfrac{P}{1 + M}$ **39.** $r = \dfrac{C}{2\pi}$
41. $T_2 = \dfrac{T_1 P_2 V_2}{P_1 V_1}$ **43.** $h = \dfrac{3V}{4\pi r^2}$ **45.** $n = \dfrac{2S_n}{a_1 + a_n}$
47. $P = \dfrac{2(S - B)}{S}$ **49.** $y = \dfrac{-A}{B}x + \dfrac{C}{B}$ **51.** $y = \dfrac{-20}{9}x + \dfrac{16}{3}$
53. $y = \dfrac{-4}{5}x - 5$ **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

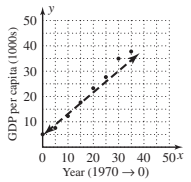
1. scatterplot **3.** linear **5.** Answers will vary.
7. a. **b.** positive



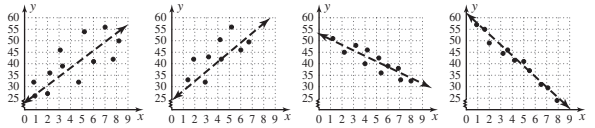
9. a. **b.** linear **c.** positive



11. a. **b.** positive **c.** strong

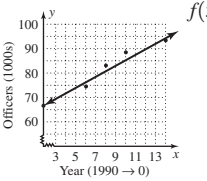


13. a. (A) (D) (C) (B)
b.

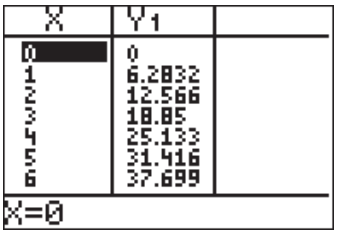


c. positive, **d.** $m \approx 3.8$; **c.** positive, **d.** $m \approx 4.2$; **c.** negative, **d.** $m \approx -2.4$; **c.** negative, **d.** $m \approx -4.6$

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)

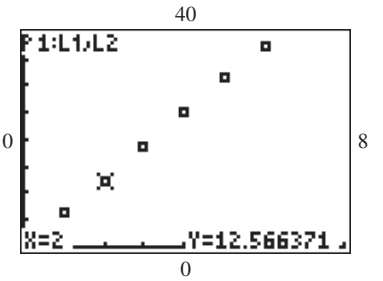


23. Using (5, 7.6) and (20, 23.3): $y \approx 1.05x + 2.37$; GDP in 2010 will be near 44,370
25. a.

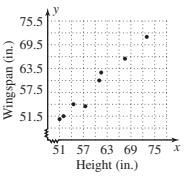


X	Y1
0	0
1	6.2832
2	12.566
3	18.85
4	25.133
5	31.416
6	37.699

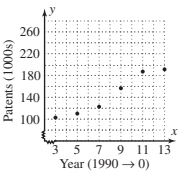
X=0



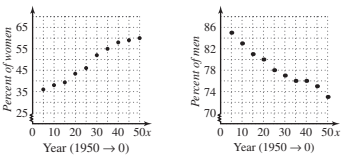
b. positive, larger radius ⇒ larger area **c.** perfect correlation
d. $m = 2\pi$
27. a. **b.** linear **c.** positive
d. $y = 0.96x + 1.55$, 63.95 in.



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.

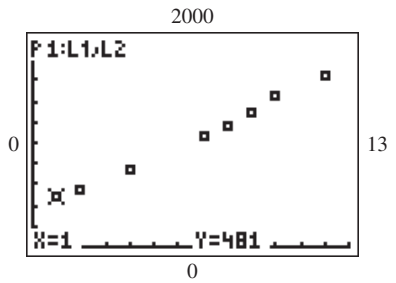


31. a.



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

33. a.



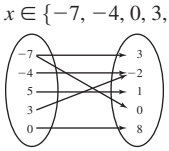
a. linear **b.** $y = 108.18x + 330.20$
c. \$1736.54 billion; about \$2601.98 billion
35. a. $r \approx 0.9783$ **b.** $r \approx 0.9783$ **c.** they are almost identical; context, pattern of scatterplot, anticipated growth, etc.
37. No. Except for the endpoints of the domain, one x is mapped to two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

Making Connections, p. 93

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

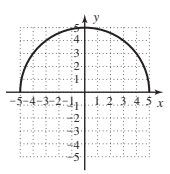
Summary and Concept Review, pp. 94–98

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



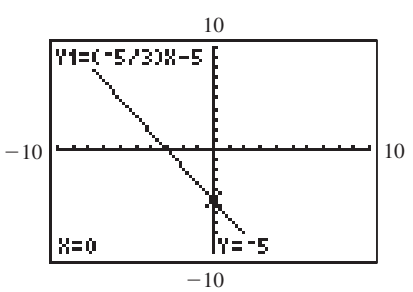
2.

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



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

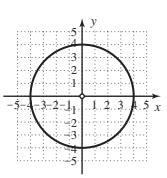
3.



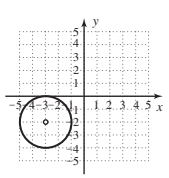
$(0, -5), (-3, 0)$

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

6.

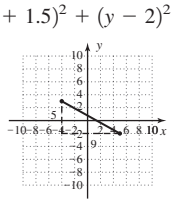


7.

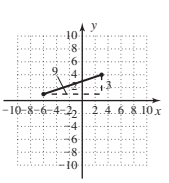


8. $(x + 1.5)^2 + (y - 2)^2 = 6.25$

9. a.



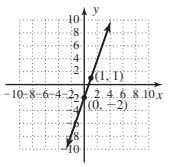
b.



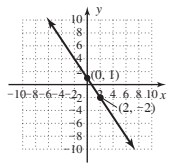
$\frac{-5}{9}, (14, -7)$ $\frac{1}{3}, (0, 3)$

10. a. parallel **b.** perpendicular

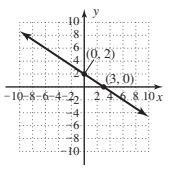
11. a.



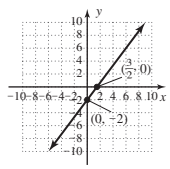
b.



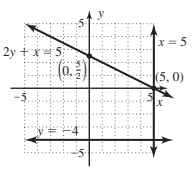
12. a.



b.

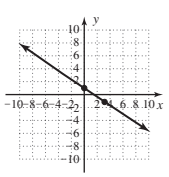


13. a. vertical
b. horizontal
c. neither

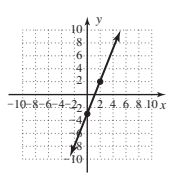


14. yes **15.** $m = \frac{2}{3}$, y-intercept (0, 2); when the rodent population increases by 3000, the hawk population increases by 200.
16. a. $x \in [\frac{-5}{4}, \infty)$ **b.** $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$
17. 14; $\frac{26}{9}$; $18a^2 - 9a$ **18.** It is a function.
19. 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 $(0, -5)$

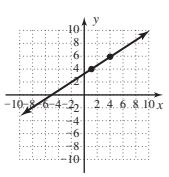
21. a.



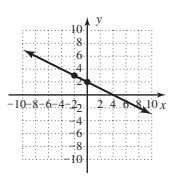
b.



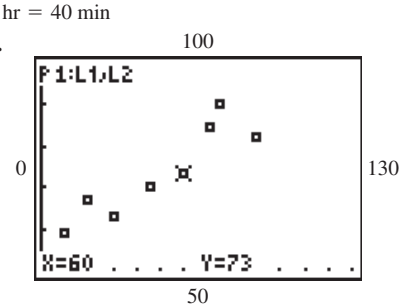
22. a.



b.



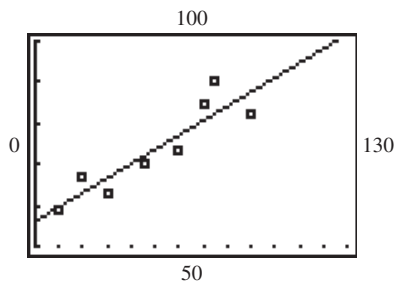
23. $y = 5$, $x = -2$; $y = 5$ **24.** $y = \frac{-3}{4}x + \frac{11}{4}$ **25.** $f(x) = \frac{4}{3}x$
26. $m = \frac{2}{5}$, y-intercept (0, 2), $y = \frac{2}{5}x + 2$. When the rabbit population increases by 500, the wolf population increases by 200.
27. a. $(y - 90) = \frac{-15}{2}(x - 2)$ **b.** (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.** $L = \frac{P - 2W}{2}$ **33.** $x = \frac{c - b}{a}$
34. $y = \frac{2}{3}x - 2$ **35.** 8 gal **36.** $12 + \frac{9}{8}\pi$ ft$^2 \approx 15.5$ ft^2
37. $\frac{2}{3}$ hr $= 40$ 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

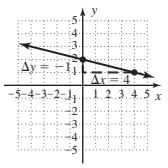
1. a. $x = 27$ **b.** $x = 2$ **c.** $C = \frac{P}{1 + k}$ **d.** $W = \frac{P - 2L}{2}$

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

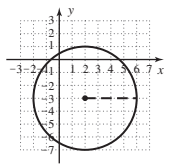
5. a and c are nonfunctions, they do not pass the vertical line test

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.** $\frac{-a^2 - 6a - 7}{a^2 + 6a + 9}$

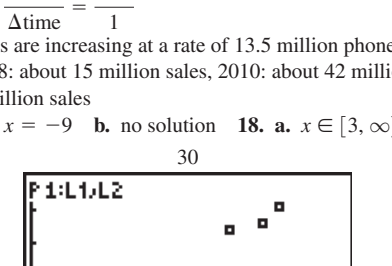
16. a. $\frac{\Delta\text{sales}}{\Delta\text{time}} = \frac{13.5}{1}$

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.



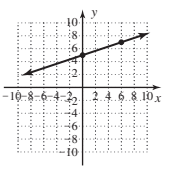
b. linear **c.** positive

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

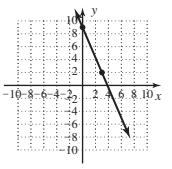
1. a. $\frac{1}{3}$, increasing **b.** $y - 5 = \frac{1}{3}(x - 0)$, $y = \frac{1}{3}x + 5$

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



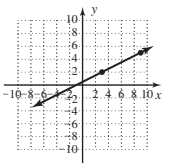
2. a. $\frac{-7}{3}$, decreasing **b.** $y - 9 = \frac{-7}{3}(x - 0)$, $y = \frac{-7}{3}x + 9$

c. $(0, 9)$, $(\frac{22}{7}, 0)$



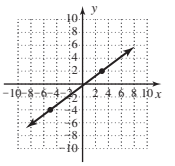
3. a. $\frac{1}{2}$, increasing **b.** $y - 2 = \frac{1}{2}(x - 3)$, $y = \frac{1}{2}x + \frac{1}{2}$

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



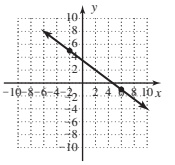
4. a. $\frac{3}{4}$, increasing **b.** $y + 4 = \frac{3}{4}(x + 5)$, $y = \frac{3}{4}x - \frac{1}{4}$

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



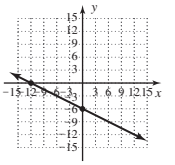
5. a. $\frac{-3}{4}$, decreasing **b.** $y - 5 = \frac{-3}{4}(x + 2)$, $y = \frac{-3}{4}x + \frac{7}{2}$

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.** $y = -36x - 1$

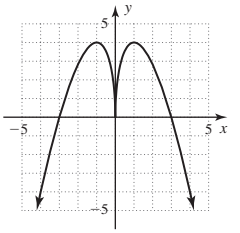
9. $y = -\frac{1}{2}x - \frac{5}{2}$ **11.** $y = \frac{1}{2}x + \frac{3}{2}$ **13.** $y = -\frac{3}{4}x + \frac{7}{4}$

CHAPTER 2

Exercises 2.1, pp. 114–119

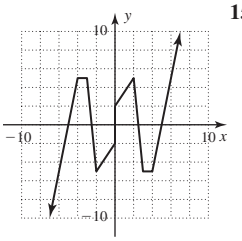
1. linear, bounce **3.** increasing **5.** Answers will vary.

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. $p(x)\uparrow$: $x \in (-\infty, \infty)$; $p(x)\downarrow$: none **b.** down, up

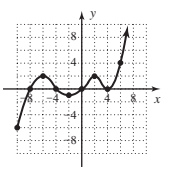
39. a. $f(x)\uparrow$: $x \in (-3, 0) \cup (3, \infty)$; $f(x)\downarrow$: $x \in (-\infty, -3) \cup (0, 3)$

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 $(2, 5)$

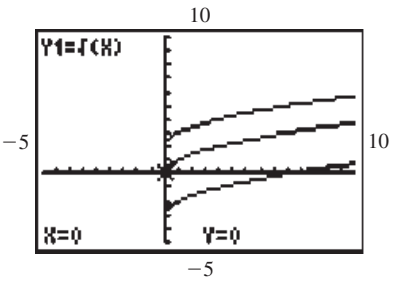
43. a. $x \in (-\infty, \infty)$; $y \in (-\infty, \infty)$ **b.** $x = -1, 5$
c. $g(x) \geq 0$: $x \in [-1, \infty)$; $g(x) \leq 0$: $x \in (-\infty, -1] \cup \{3.5\}$
d. $g(x)\uparrow$: $x \in (-\infty, 1) \cup (5, \infty)$; $g(x)\downarrow$: $x \in (1, 5)$ **e.** local max: $y = 6$ at (1, 6); local 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. $x = \pm\sqrt{\dfrac{9y^2 + 36}{2}}$ **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: $(-6, 2)$, $(2, 2)$



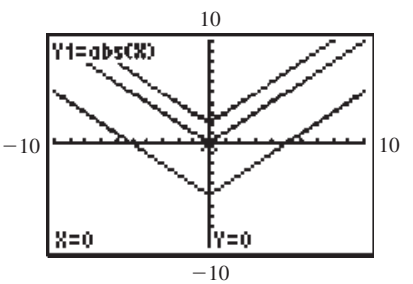
65. no; no; answers will vary. **67. a.** Thorpe; Rosolino **b.** two times, at 190 sec and 219 sec **c.** about 29 sec $(219 - 190 = 29$ sec) **d.** Thorpe
e. about 2 sec $(223 - 221 = 2$ sec) **f.** 221 sec = 3 min 41 sec
69. $h(-k) = h(k)$
$[(-k)^{\frac{1}{3}}]^2 = (k^{\frac{1}{3}})^2$
$(-k^{\frac{1}{3}})^2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

Exercises 2.2, pp. 130–135

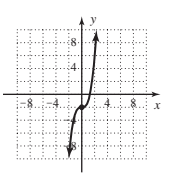
1. stretch, compression **3.** $(-5, -9)$, upward **5.** Answers will vary.
7. a. quadratic; **b.** up/up, $(-2, -4)$, $x = -2$, $(-4, 0)$, $(0, 0)$, $(0, 0)$;
c. D: $x \in \mathbb{R}$, R: $y \in [-4, \infty)$
9. a. quadratic; **b.** up/up, $(1, -4)$, $x = 1$, $(-1, 0)$, $(3, 0)$, $(0, -3)$;
c. D: $x \in \mathbb{R}$, 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.



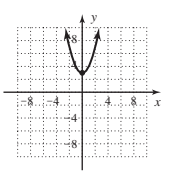
the graph of g is f shifted up 2 units; the graph of h is f shifted down 3 units
37.



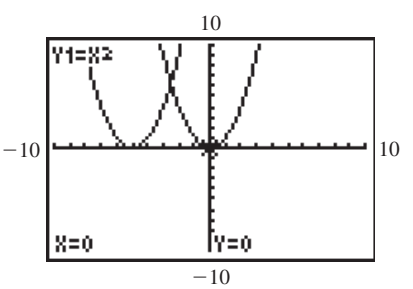
the graph of q is p shifted down 5 units; the graph of r is p shifted up 2 units
39.



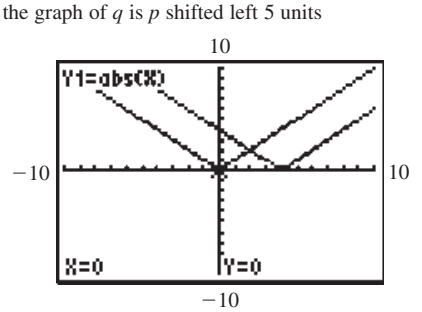
41.



43.

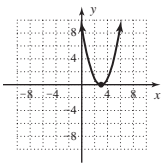


the graph of q is p shifted left 5 units
45.

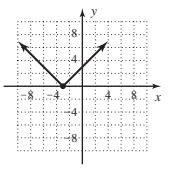


the graph of Y_2 is Y_1 shifted right 4 units

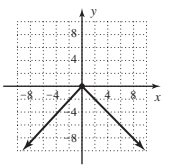
47.



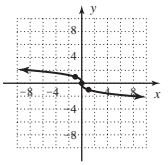
49.



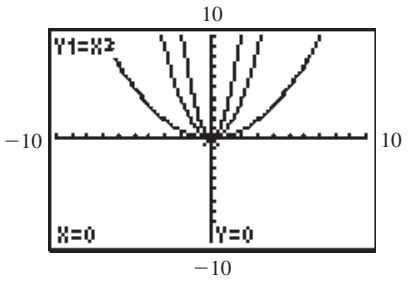
51.



53.

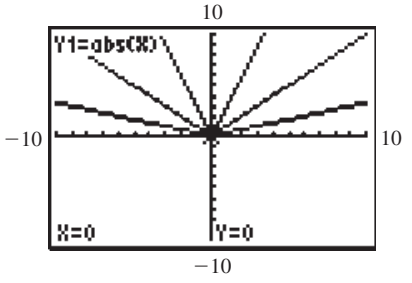


55.



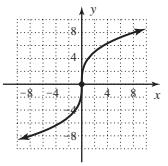
the graph of q is p vertically stretched;
the graph of r is p vertically compressed

57.

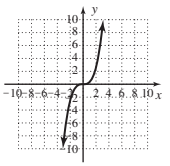


the graph of Y_2 is Y_1 vertically stretched;
the graph of Y_3 is Y_1 vertically compressed

59.

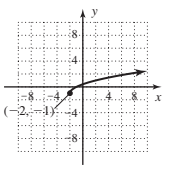


61.

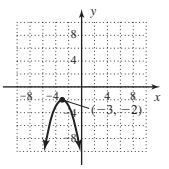


63. g **65.** i **67.** e **69.** j **71.** l **73.** c

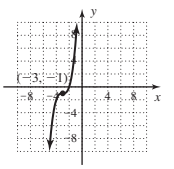
75. left 2, down 1



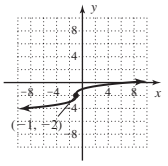
77. left 3, reflected across x-axis, down 2



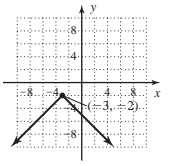
79. left 3, down 1



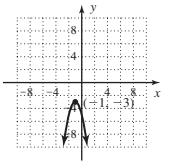
81. left 1, down 2



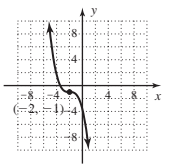
83. left 3, reflected across x-axis, down 2



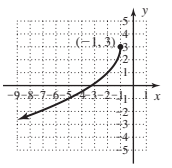
85. left 1, reflected across x-axis, stretched vertically, down 3



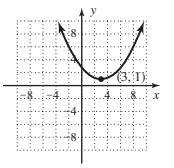
87. left 2, reflected across x-axis, compressed vertically, down 1



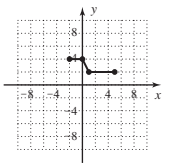
89. left 1, reflected across $x = -1$, reflected across x-axis, stretched vertically, up 3



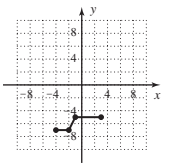
91. right 3, compressed vertically, up 1



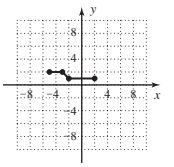
93. a.



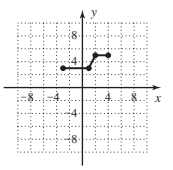
b.



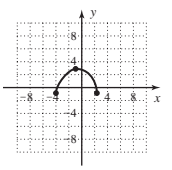
c.



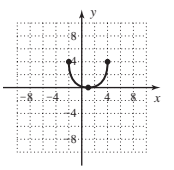
d.



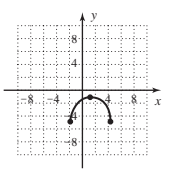
95. a.



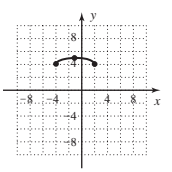
b.



c.



d.

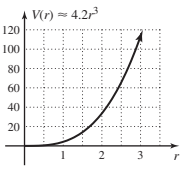


97. $f(x) = -(x-2)^2$

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

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

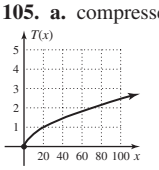
103. a.



b. about 65 units^3, V≈65.4 units^3; yes;

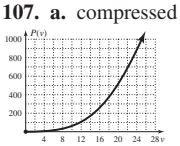
c. $r = \sqrt[3]{\frac{3}{4\pi}V}$

105. a. compressed vertically



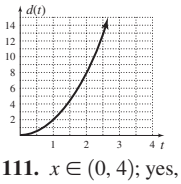
b. 2.25 sec

107. a. compressed vertically

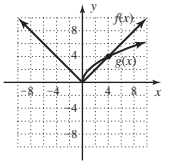


b. 216 W

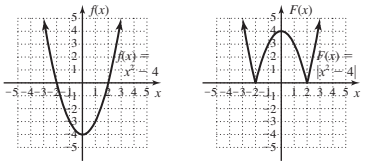
109. a. vertical stretch by a factor of 2 **b.** 12.5 ft



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.



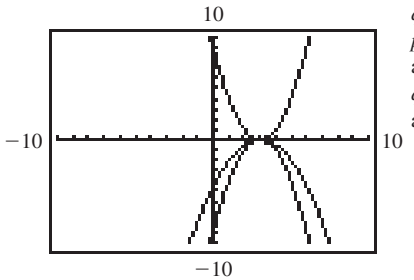
115. $P = (4x^2 + 16x + 14)$ units **117.** $f(x)\uparrow$: $x \in (4, \infty)$; $f(x)\downarrow$: $x \in (-\infty, 4)$

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. $\left[\frac{8}{3}, \frac{14}{3}\right]$ **33.** $\{\ \}$ **35.** $\left(-1, \frac{3}{5}\right)$ **37.** $\left[-\frac{7}{4}, 0\right]$
39. $(-\infty, -10) \cup (4, \infty)$ **41.** $(-\infty, -3] \cup [3, \infty)$
43. $\left(-\infty, -\frac{7}{3}\right] \cup \left[\frac{7}{3}, \infty\right)$ **45.** $\left(-\infty, \frac{3}{7}\right] \cup [1, \infty)$
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.** $45 \le d \le 51$ in. **b.** $d - L \le x \le d + L$
61. in feet: [32,500, 37,600]; yes **63.** in feet: $d < 210$ or $d > 578$
65. a. $|s - 37.58| \le 3.35$ **b.** [34.23, 40.93]
67. a. $|s - 125| \le 23$ **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.** $k = 1$
6.



$q(x)$ is a reflection of $p(x)$ across the x-axis, and $r(x)$ is the same as $q(x)$, but compressed by a factor of $\frac{1}{2}$

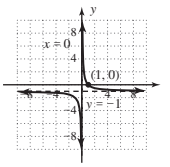
7. a. $\{-4, 14\}$ **b.** $\{\ \}$ **8. a.** $q \in (-8, 0)$ **b.** $\{-6\}$
9. a. $d \in (-\infty, 0] \cup [4, \infty)$ **b.** $y \in \left(-\infty, -\frac{19}{2}\right) \cup \left(\frac{23}{2}, \infty\right)$
c. $k \in (-\infty, \infty)$ **10.** $w \in [8, 26]$; no, yes

Reinforcing Basic Concepts, p. 147

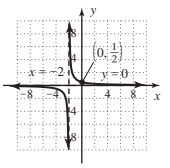
1. $x = -3$ or $x = 7$ **2.** $x \in [-5, 3]$ **3.** $x \in (-\infty, -1] \cup [4, \infty)$

Exercises 2.4, pp. 159–163

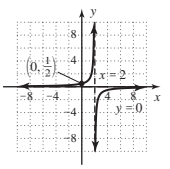
1. as $x \to -\infty$, $y \to 2$ **3.** vertical, $y = 2$ **5.** Answers will vary.
7. a. as $x \to -\infty$, $y \to 2$; as $x \to \infty$, $y \to 2$
b. as $x \to 1^-$, $y \to -\infty$; as $x \to 1^+$, $y \to \infty$
9. a. as $x \to -\infty$, $y \to 1$; as $x \to \infty$, $y \to 1$
b. $y = 1$
c. as $x \to -2^-$, $y \to \infty$; as $x \to -2^+$, $y \to \infty$
11. down 1, $x \in (-\infty, 0) \cup (0, \infty)$, $y \in (-\infty, -1) \cup (-1, \infty)$



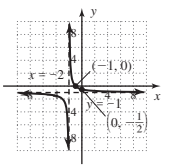
13. left 2, $x \in (-\infty, -2) \cup (-2, \infty)$, $y \in (-\infty, 0) \cup (0, \infty)$



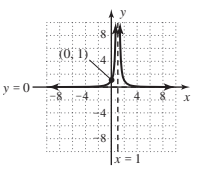
15. right 2, reflected across x-axis, $x \in (-\infty, 2) \cup (2, \infty)$, $y \in (-\infty, 0) \cup (0, \infty)$



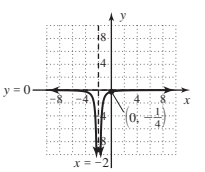
17. left 2, down 1, $x \in (-\infty, -2) \cup (-2, \infty)$, $y \in (-\infty, -1) \cup (-1, \infty)$



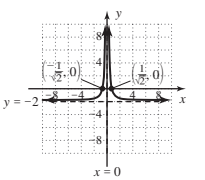
19. right 1, $x \in (-\infty, 1) \cup (1, \infty)$, $y \in (0, \infty)$



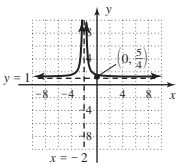
21. left 2, reflected across x-axis, $x \in (-\infty, -2) \cup (-2, \infty)$, $y \in (-\infty, 0)$



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, $S(x) = \dfrac{1}{(x+1)^2} - 2$

29. reciprocal function, $Q(x) = \dfrac{1}{x+1} - 2$

31. reciprocal quadratic, $v(x) = \dfrac{1}{(x+2)^2} - 5$ **33.** $\to -2$

35. $\to -\infty$ **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 $\left(\dfrac{4}{5} > \dfrac{2}{3}\right)$ **a.** $x = -1$, 0, and 1, **b.** $(-1, 0) \cup (0, 1)$, **c.** $(-\infty, -1) \cup (1, \infty)$

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

47. $g(x)$ increases faster $\left(\dfrac{5}{4} > \dfrac{2}{3}\right)$ **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

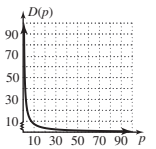
59. F is the graph of f shifted left 1 unit and down 2; verified

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.** $m_2 = \frac{d^2F}{km_1}$

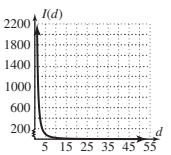
65. **a.** It decreases; 75, 25, 15 **b.** It approaches 0.

c. as $p \to 0$, $D \to \infty$



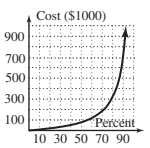
67. a. It decreases; 100, 25, $11.\overline{1}$. **b.** toward the light source

c. as $d \to 0$, $l \to \infty$



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

b.

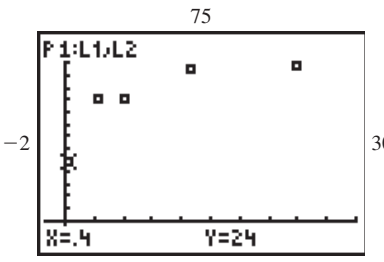


c. as $p \to 100$, $C \to \infty$

71. **a.** 253 ft/sec (about 172 mph) **b.** approx. 791 ft

73. **a.** size 11 **b.** approx. 5 ft, 5 in.

75. **a.**

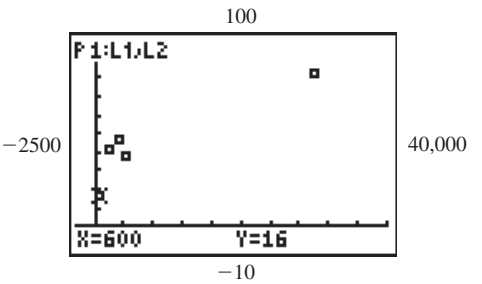


b. $P = 32.251\, w^{0.246}$

c. about 63 days

d. about 6.9 kg

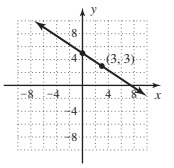
77. **a.**



b. $S = 1.687a^{0.386}$ **c.** about 33 species **d.** about 37,200 mi^2

79. The area is always 1 unit^2; The area is always $\frac{1}{x}$ units^2

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



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

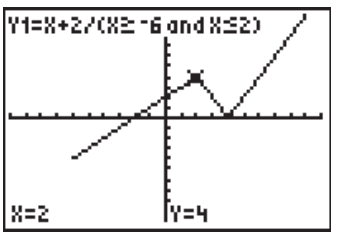
Exercises 2.5, pp. 172–176

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

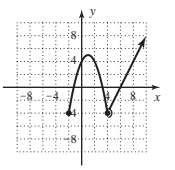
9. -2, 2, $\frac{1}{2}$, 0, 2.999, 5 **11.** 5, 5, 0, -4, 5, 11

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

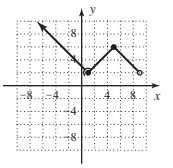


$p(2) = 4$
$p(0) = 2$

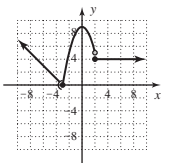
15. D: $x \in [-2, \infty)$; R: $y \in [-4, \infty)$



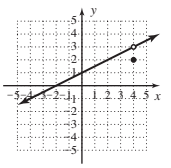
17. D: $x \in (-\infty, 9)$; R: $y \in [2, \infty)$



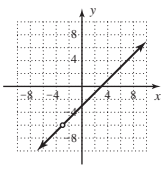
19. D: $x \in (-\infty, \infty)$; R: $y \in [0, \infty)$



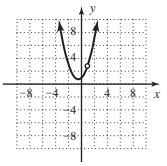
21. D: $x \in (-\infty, \infty)$; R: $y \in (-\infty, 3) \cup (3, \infty)$



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



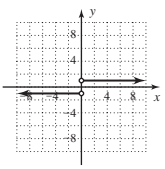
25. discontinuity at $x = 1$, redefine $f(x) = 3$ at $x = 1$; $c = 3$



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

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

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



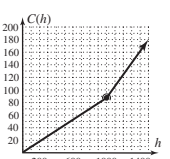
33. a. $S(t) = \begin{cases} -t^2 + 6t & 0 \le t \le 5 \\ 5 & t > 5 \end{cases}$ **b.** $S(t) \in [0, 9]$

35. a.

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

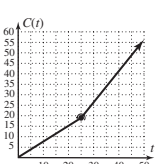
b. Each piece gives a slightly different value due to rounding of coefficients in each model. At $t = 30$, we use the "first" piece: $P(30) = 13.08$.

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



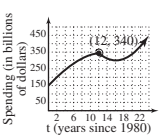
$C(1200) = \$126$

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



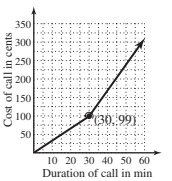
$C(45) = \$48.75$

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



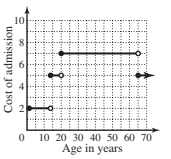
$\$498$ billion, $\$653$ billion, $\$931$ billion

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



$\$2.11$

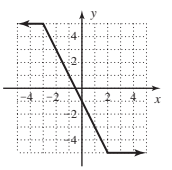
45. $C(a) = \begin{cases} 0 & a < 2 \\ 2 & 2 \le a < 13 \\ 5 & 13 \le a < 20 \\ 7 & 20 \le a < 65 \\ 5 & a \ge 65 \end{cases}$



$\$38$

47. a. $C(w - 1) = 17\lceil w - 1 \rceil + 88$ **b.** $0 < w \le 13$ **c.** $88¢$ **d.** $173¢$ **e.** $173¢$ **f.** $173¢$ **g.** $190¢$

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



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.

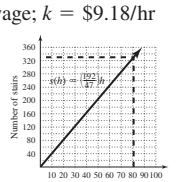
7. $d = kr$ **9.** $F = ka$

11. $y = 0.025x$

x	y
500	12.5
650	16.25
750	18.75

13. $w = 9.18h$; $321.30; the hourly wage; $k = \$9.18$/hr

15. a. $k = \frac{192}{47}$, $S = \frac{192}{47}h$ **b.**



c. 330 stairs **d.** $S = 331$; yes

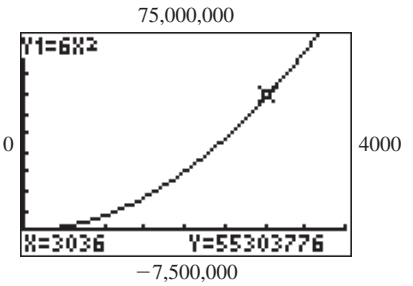
17. $A = kS^2$ **19.** $P = kc^2$

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.



d.

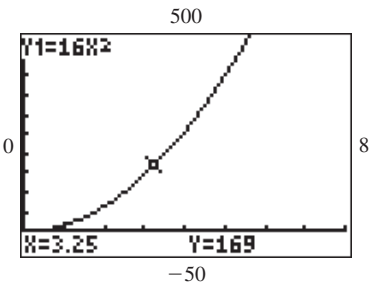
X	Y1
0	0
5	150
10	600
15	1350
20	2400
25	3750
30	5400

X=0

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

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

c.



d.

X	Y1
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. $F = \frac{k}{d^2}$ **29.** $S = \frac{k}{L}$

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

Z	*Y*
37	9
74	2.25
111	1

33. $w = \dfrac{3{,}072{,}000{,}000}{r^2}$; 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.** $M = \frac{1}{6}E$; ≈41.7 kg

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

55. $C \approx (4.4 \times 10^{-4})\frac{P_1P_2}{d^2}$; about 222 calls

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

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

63. $\dfrac{9y^2}{4x^2}$ **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

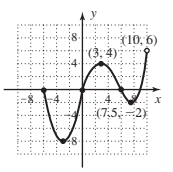
1. D: $x \in (-\infty, \infty)$, R: $y \in [-5, \infty)$, $f(x)\uparrow$: $x \in (2, \infty)$, $f(x)\downarrow$: $x \in (-\infty, 2)$, $f(x) > 0$: $x \in (-\infty, -1) \cup (5, \infty)$, $f(x) < 0$: $x \in (-1, 5)$

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

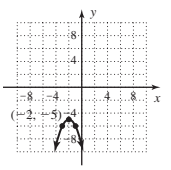
8. square root function **a.** down on the right; **b.** x-intercept: (0, 0); y-intercept: (0, 0) **c.** initial point (−1, 2); **d.** $x \in [-1, \infty)$, $y \in (-\infty, 2]$

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

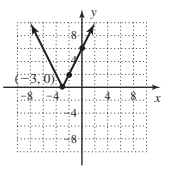
10. absolute value function **a.** down on left/down on the right **b.** x-intercepts: (−1, 0), (3, 0); y-intercept: (0, 1) **c.** vertex: (1, 2); **d.** $x \in (-\infty, \infty)$, $y \in (-\infty, 2]$

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

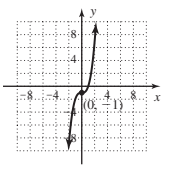
12. quadratic



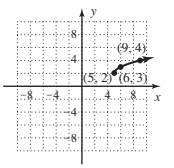
13. absolute value



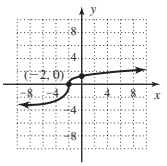
14. cubic



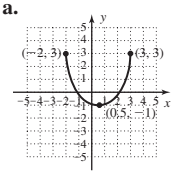
15. square root



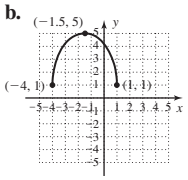
16. cube root



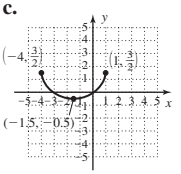
17. a.



b.

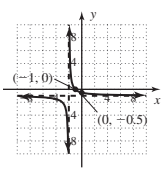


c.

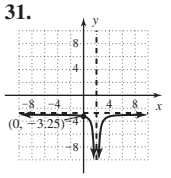


18. $\{-4, 10\}$ **19.** $\{-7, 3\}$ **20.** $\{-5, 8\}$ **21.** $\{-4, -1\}$
22. $(-\infty, -6) \cup (2, \infty)$ **23.** $[4, 32]$ **24.** $\{\ \}$ **25.** $\{\ \}$ **26.** $(-\infty, \infty)$
27. $[-2, 6]$ **28.** $(-\infty, -2] \cup [\frac{10}{3}, \infty)$ **29. a.** $|r - 2.5| \le 1.7$
b. highest: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

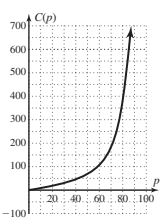
30.



31.

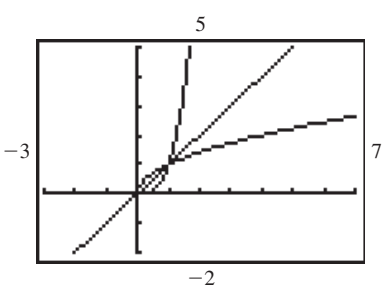


32. a. ≈\$32,143; \$75,000; \$175,000; \$675,000; cost increases dramatically
b.



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

33.

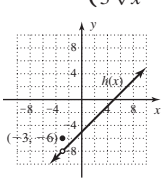


Domain of $f(x)$ is $(-\infty, \infty)$; Domain of $g(x)$ and $h(x)$ is $[0, \infty)$.

34. a. 88.4 hr, **b.** 570 km

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

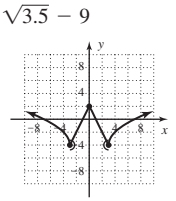
36.



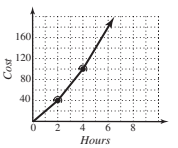
D: $x \in (-\infty, \infty)$,
R: $y \in (-\infty, -8) \cup (-8, \infty)$,
discontinuity at $x = -3$;
define $h(x) = -8$ at $x = -3$

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. $\begin{cases} 20x & x \le 2 \\ 30x - 20 & 2 < x \le 4 \\ 40x - 60 & x > 4 \end{cases}$
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

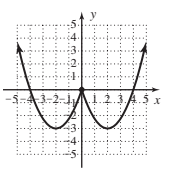
v	w	z
196	7	2.88
38.75	1.25	17.856
24	0.6	48

42. $t = 160$ **43.** 4.5 sec

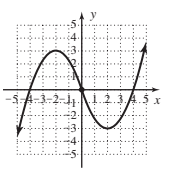
Practice Test, pp. 193–195

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. $f(x)\uparrow$: $x \in (-4, \infty)$; $f(x)\downarrow$: none **e.** $f(x) = 3\sqrt{x + 4} - 3$

2.



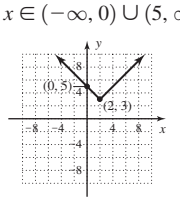
3.



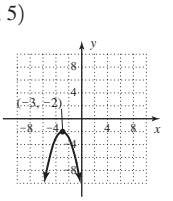
4. max: $y = 8$ at $x = -2$; min: $y = -7$ at $x \approx -5.87$ and $y = -7$ at $x \approx 1.87$

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.** $x \in (0, 5)$

6.

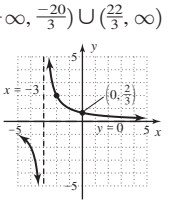


7.



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

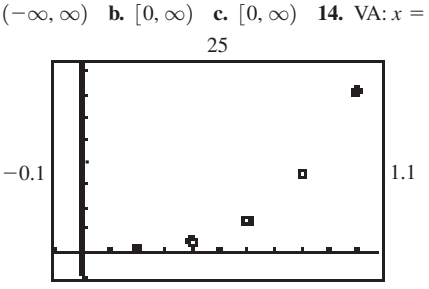
11.



12. 13.5 sec

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

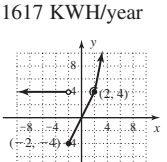
15. a.



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. $M = kd^3\left(\frac{1}{P^2}\right)$, approx. 2.2788×10^8 **20.** 520 lb

Strengthening Core Skills, p. 196

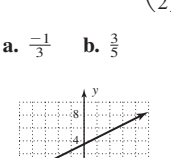
1. $k = \frac{1}{6^{\frac{3}{2}}}$ or $\frac{1}{\sqrt{6^3}}$

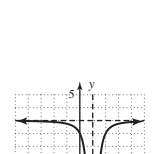
Cumulative Review Chapters 1–2, pp. 197–198

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

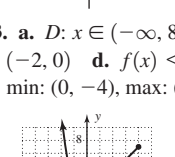
7. a. $\frac{-1}{3}$ **b.** $\frac{3}{5}$

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.** $f(x)\uparrow$: $x \in (0, 8)$; $f(x)\downarrow$: $x \in (-\infty, 0)$



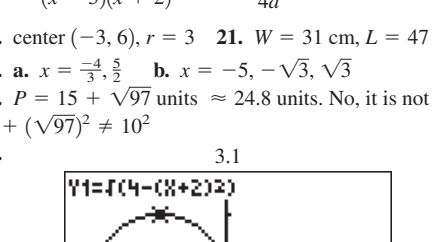
15. a. $\frac{x-7}{(x-5)(x+2)}$ **b.** $\frac{b^2 - 4ac}{4a^2}$ **17.** $x^2 + 2$

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

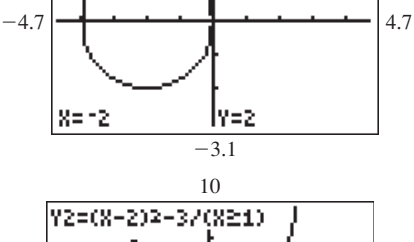
23. a. $x = \frac{-4}{3}, \frac{5}{2}$ **b.** $x = -5, -\sqrt{3}, \sqrt{3}$

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 $\left|x - \frac{3}{2}\right| < \delta$, 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.** $\frac{1}{2} + \frac{2}{3}i$; $\frac{25}{36}$ **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. $(a + bi)(a - bi) = a^2 - abi + abi - (bi)^2$
$= a^2 - b^2(-1)$
$= a^2 + b^2$ ✓
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

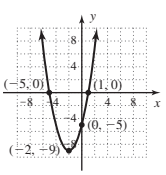
Exercises 3.2, pp. 230–235

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 $m \approx -3.30$

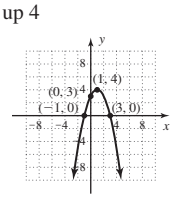
51. $n = \frac{5}{2} \pm \frac{3\sqrt{5}}{2}$; $n \approx 5.85$ or $n \approx -0.85$
53. a. $x = \frac{1}{2}$ or $x = -4$ **b.** $x = 0.5$ or $x = -4$
55. a. $n = 3$ or $n = \frac{-3}{2}$ **b.** $n = 3$ or $n = -1.5$
57. a. $p = \frac{3}{8} \pm \frac{\sqrt{41}}{8}$ **b.** $p \approx 1.18$ or $p \approx -0.43$
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.** $a = \frac{1}{6} \pm \frac{\sqrt{23}}{6}i$; $a \approx 0.1\overline{6} \pm 0.80i$
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.** $x \in (0, 4)$
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. $t = \dfrac{v \pm \sqrt{v^2 - 64h}}{32}$ **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.** $z = \dfrac{-3}{4}i$; $z = 2i$
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

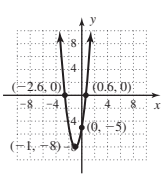
1. $\frac{25}{2}$ **3.** $0, f(x)$ **5.** Answers will vary.
7. left 2, down 9



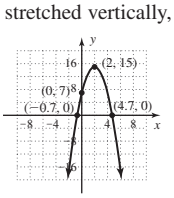
9. right 1, reflected across x-axis, up 4



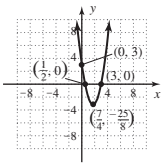
11. left 1, stretched vertically, down 8



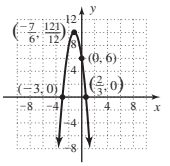
13. right 2, reflected across x-axis, stretched vertically, up 15



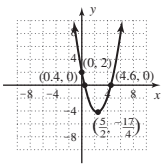
15. right $\frac{7}{4}$, stretched vertically, down $\frac{25}{8}$



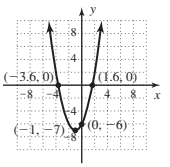
17. left $\frac{7}{6}$, reflected across x-axis, stretched vertically, up $\frac{121}{12}$



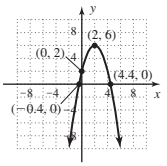
19. right $\frac{5}{2}$, down $\frac{17}{4}$



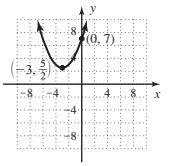
21. left 1, down 7



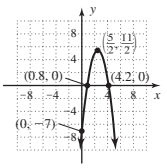
23. right 2, reflected across x-axis, up 6



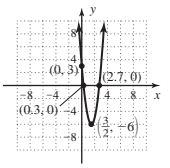
25. left 3, compressed vertically up $\frac{5}{2}$



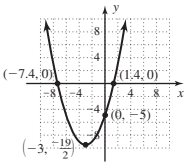
27. right $\frac{5}{2}$, reflected across x-axis, stretched vertically, up $\frac{11}{2}$



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. $y = -\dfrac{3}{2}(x + 2)^2 + 3$ **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 ft^2, 50 ft $\times$ 50 ft **b.** 5000 ft^2, 50 ft $\times$ 100 ft
55. a. approx. 29.5" wide by 18.7" long **b.** approx. 930 in^2
57. a. \$1.25 each, \$781.25 **b.** about \$0.85 each **59.** Answers will vary.
61. $y = \dfrac{-7}{18}\left(x - \dfrac{1}{2}\right)^2 + \dfrac{7}{2}$ **63.** $m = \frac{4}{3}$, y-intercept $(0, 3)$
65. $g(x) = -\sqrt[3]{x + 1} - 3$

Mid-Chapter Check, p. 249

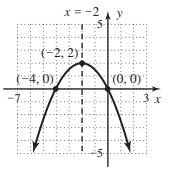
1. sum 4, product 13; both yield real numbers **2.** i

3. $(1 + 2i)^2 - 2(1 + 2i) + 5 = 0$
$1 + 4i + 4i^2 - 2 - 4i + 5 = 0$
$1 + (-4) - 2 + 5 = 0$
$0 = 0$✓ 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.



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

Reinforcing Basic Concepts, pp. 249–250

Exercise 1: $\frac{7}{2} + (-1) = \frac{5}{2} = -\frac{b}{a}$✓
$\frac{7}{2} \cdot (-1) = \frac{-7}{2} = \frac{c}{a}$✓

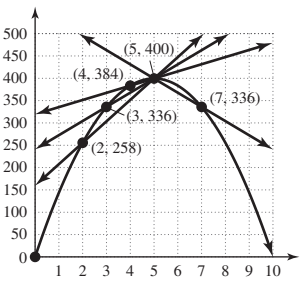
Exercise 2: $\frac{2 + 3\sqrt{2}}{2} + \frac{2 - 3\sqrt{2}}{2} = \frac{4}{2} = \frac{-b}{a}$✓
$\frac{2 + 3\sqrt{2}}{2} \cdot \frac{2 - 3\sqrt{2}}{2} = \frac{-14}{4} = \frac{-7}{2} = \frac{c}{a}$✓

Exercise 3: $(5 + 2\sqrt{3}i) + (5 - 2\sqrt{3}i) = 10 = \frac{-b}{a}$✓
$(5 + 2\sqrt{3}i)(5 - 2\sqrt{3}i) = 25 + 12 = 37 = \frac{c}{a}$✓

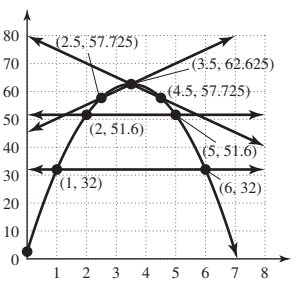
Exercise 4: $x_1 + x_2 = -\frac{b}{a}$ since radical terms sum to 0, and $2\left(\frac{-b}{2a}\right) = \frac{-b}{a}$;
$x_1 x_2 = \frac{c}{a}$ since $\left(\frac{-b}{2a}\right)^2 - \left(\frac{\sqrt{b^2 - 4ac}}{2a}\right)^2 = \frac{b^2}{4a^2} - \frac{b^2 - 4ac}{4a^2} = \frac{4ac}{4a^2} = \frac{c}{a}$

Exercises 3.4, pp. 257–261

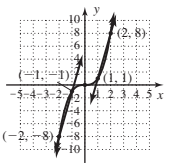
1. quadratic, negative **3.** average, slope, secant line
5. Answers will vary. **7. a.** $y = 1.45x^2 - 2.59x - 4.55$ **b.** 4.1475
c. $x = 6.446$ **9. a.** $y = -0.851x^2 + 3.153x + 64.428$ **b.** 65.037
c. $x = 7.623$ **11. a.** $y = 3.485x^2 - 26.424x - 60.505$ **b.** 10.422
c. $x = 1.746$ or 5.836 **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. $\frac{\Delta A}{\Delta r} \approx 37.70$ **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 time greater in the later weeks. **51. a.** 7 **b.** 7
c. They are the same.
d. Slopes are equal.



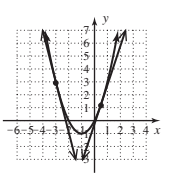
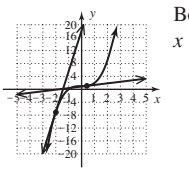
53. a. 176 ft **b.** 320 ft **c.** 144 ft/sec **d.** −144 ft/sec; The arrow is going down. **55. a.** 17.89 ft/sec; 25.30 ft/sec **b.** 30.98 ft/sec; 35.78 ft/sec **c.** Between 5 and 10. **d.** 1.482 ft/sec, 0.96 ft/sec
57. a. about 3569 in^3 **b.** about 3800 in^3 **c.** $\frac{\Delta r}{\Delta t}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

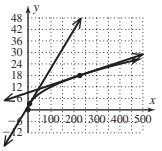
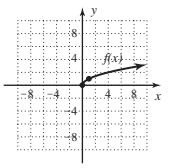
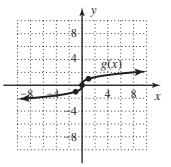
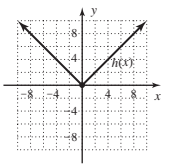
Exercises 3.5, pp. 268–274

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: $\dfrac{3x+1}{\sqrt{x-3}}, x \in (3, \infty)$
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: $\dfrac{2x^2}{\sqrt{x+1}}, x \in (-1, \infty)$
45. sum: $\dfrac{7x-11}{(x-3)(x+2)}, x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; difference: $\dfrac{-3x+19}{(x-3)(x+2)}, x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; product: $\dfrac{10}{(x-3)(x+2)}, x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; quotient: $\dfrac{2x+4}{5(x-3)}, x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$
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.** $-\dfrac{1}{3}$ **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. $x = \dfrac{-148}{9}$ **87. a.** $6x + 5y = -13$ **b.** $d = \sqrt{61}$

Exercises 3.6, pp. 287–291

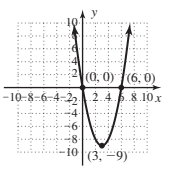
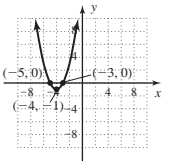
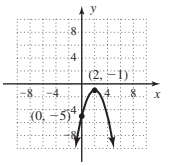
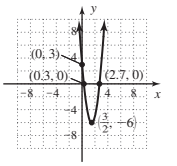
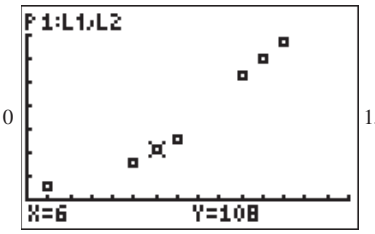
1. composition **3.** domain, $g(x)$ **5.** Answers will vary.
7. 0, 0, $4a^2 - 10a - 14$, $a^2 - 9a$
9. a. $h(x) = \sqrt{2x-2}$ **b.** $H(x) = 2\sqrt{x+3} - 5$
c. D of $h(x)$: $x \in [1, \infty)$; D of $H(x)$: $x \in [-3, \infty)$
11. a. $h(x) = \sqrt{3x+1}$ **b.** $H(x) = 3\sqrt{x-3} + 4$
c. D of $h(x)$: $x \in [-\frac{1}{3}, \infty)$; 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. $h(-3) = 1, h(\sqrt{2}) \approx 145.91$
$h(\frac{1}{2}) = 64, h(5) =$ ERR;
$x = 5$ is not in the domain of g
23. $h(-3) = 2, h(\sqrt{2}) = 5$
$h(\frac{1}{2}) = 5.5, h(5) =$ 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 $f[g(x)] = \dfrac{2g(x)}{g(x)+3}$, $g(x) \neq -3$ so $x \neq -\dfrac{5}{3}$.
domain: all real numbers except $x = -3$ and $x = -\dfrac{5}{3}$
b. $(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq -3$.
For $g[f(x)] = \dfrac{5}{f(x)}, f(x) \neq 0$ so $x \neq 0$.
domain: all real numbers except $x = -3$ and $x = 0$
c. $(f \circ g)(x) = \dfrac{10}{5+3x}$; $(g \circ f)(x) = \dfrac{5x+15}{2x}$; 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 $f[g(x)] = \dfrac{4}{g(x)}$, $g(x) \neq 0$ 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 $g[f(x)] = \dfrac{1}{f(x)-5}, f(x) \neq 5$ so $x \neq \dfrac{4}{5}$.
domain: all real numbers except $x = 0$ and $x = \dfrac{4}{5}$
c. $(f \circ g)(x) = 4x - 20$; $(g \circ f)(x) = \dfrac{x}{4-5x}$; 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.** $\frac{-2}{x(x+h)}$
47. a. $\dfrac{\Delta g}{\Delta x} = 2x + 2 + h$ **b.** $\dfrac{\Delta g}{\Delta x} = -3.9$ **c.** $\dfrac{\Delta g}{\Delta x} = 3.01$
d.  The rates of change have opposite sign, with the secant line to the left being slightly more steep.
49. a. $\dfrac{\Delta g}{\Delta x} = 3x^2 + 3xh + h^2$ **b.** $\dfrac{\Delta g}{\Delta x} = 12.61$ **c.** $\dfrac{\Delta g}{\Delta x} \approx 0.49$
d.  Both lines have a positive slope, but the line at $x = -2$ is much steeper.
51. $\dfrac{\Delta j}{\Delta x} = \dfrac{-2x - h}{x^2(x+h)^2}$;
$[0.50, 0.51]$: $\dfrac{\Delta j}{\Delta x} \approx -15.5$;
$[1.50, 1.51]$: $\dfrac{\Delta j}{\Delta x} \approx -0.6$;
Answers will vary.
53. $\dfrac{\Delta g}{\Delta x} = 3x^2 + 3xh + h^2$;
$[-2.01, -2.00]$: $\dfrac{\Delta g}{\Delta x} \approx 12.1$;
$[0.40, 0.41]$: $\dfrac{\Delta g}{\Delta x} \approx 0.5$;
Answers will vary.

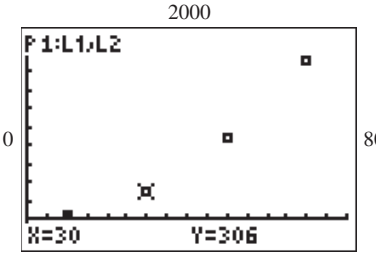
55. a. $f[g(x)] = (x-2)^2 + 4(x-2) + 3$
$= x^2 - 4x + 4 + 4x - 8 + 3$
$= x^2 - 1$✓
b. verified
57. $h(x) = x - 2.5$; 10.5 **59. a.** 4160 **b.** 45,344
c. $M(x) = 453.44x$; yes **61. a.** 6 ft **b.** 36π ft^2 **c.** $A(t) = 9\pi t^2$; yes
63. a. $L(0) = 500$ lions and $H(500) = 400$ hyenas
b. $H[L(x)] = 400 + 0.0075x$, $(H \circ L)(16{,}000) = 520$ hyenas **c.** prior to an increase of 30,000
65. a. $\dfrac{\Delta d}{\Delta h} \approx 0.2$ **b.** $\dfrac{\Delta d}{\Delta h} \approx 0.04$
c.  As height increases you can see farther, but the sight distance increases at a slower rate.
67. a. March: $\dfrac{\Delta d}{\Delta t} \approx 15$, June: $\dfrac{\Delta d}{\Delta t} \approx 3$, 5 times faster
b. $t = 6.75$, late June **c.** decreasing $\left(\dfrac{\Delta d}{\Delta t} < 0\right)$; 5000 units/month
69. Answers will vary.
71. a. For $y = \dfrac{1}{x} : \dfrac{\Delta y}{\Delta x} \approx -3.91$; For $y = \dfrac{1}{x^2} : \dfrac{\Delta y}{\Delta x} \approx -15.53$
b. Less—decrease is more gradual; For $y = \dfrac{1}{x} : \dfrac{\Delta y}{\Delta x} \approx -1.54$;
For $y = \dfrac{1}{x^2} : \dfrac{\Delta y}{\Delta x} \approx -3.83$
73. a.  **b.**  **c.** 
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. $(5i)^2 - 9 = -34$ $(-5i)^2 - 9 = -34$
$25i^2 - 9 = -34$ $25i^2 - 9 = -34$
$-25 - 9 = -34$✓ $-25 - 9 = -34$✓
12. $(2 + i\sqrt{5})^2 - 4(2 + i\sqrt{5}) + 9 = 0$
$4 + 4i\sqrt{5} + 5i^2 - 8 - 4i\sqrt{5} + 9 = 0$
$5 + (-5) = 0$✓
$(2 - i\sqrt{5})^2 - 4(2 - i\sqrt{5}) + 9 = 0$
$4 - 4i\sqrt{5} + 5i^2 - 8 + 4i\sqrt{5} + 9 = 0$
$5 + (-5) = 0$✓
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
21. 
22. 
23. 
24. 
25. a. 0 ft **b.** 108 ft **c.** 2.25 sec **d.** 144 ft, $t = 3$ sec
26. \$3.75; 3000
27. a.


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


, quadratic
b. $F_d(x) = 0.35x^2 - 0.3x$, 1242 units **c.** about 82 mph
29. a. $\dfrac{\Delta N}{\Delta t} = \dfrac{2.95}{1}$, 295 stores per year **b.** for 2000 to 2002: $\dfrac{\Delta N}{\Delta t} \approx \dfrac{11.93}{1}$, 1193 stores per year; $295 \times 4 \approx 1180$ ✓ **c.** for 2002 to 2004: $\dfrac{\Delta N}{\Delta t} \approx \dfrac{13.42}{1}$, 1342 stores per year; for 2006 to 2008: $\dfrac{\Delta N}{\Delta t} \approx \dfrac{13.20}{1}$, 1320 stores per year, very close **30. a.** 20 ft^3 **b.** approx. 18.251 ft^3
c. approx. -1.749 ft^3/sec **d.** approx. -0.149 ft^3/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. $f(x) = x^2 - 3x - 10$; $g(x) = x^{\frac{1}{3}}$ **41.** $A(t) = \pi(2t + 3)^2$
42. a. 0 **b.** 7 **c.** 7 **d.** 2 **e.** 4 **43.** $2x - 1 + h$; 3.01

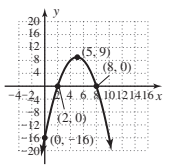
Practice Test, pp. 297–298

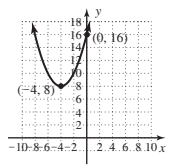
1. a. $(0, \frac{11}{2})$ **b.** $(-\infty, 1) \cup (1, \infty)$ **c.** $(-\infty, -\frac{7}{3}] \cup [3, \infty)$ **d.** $\{\ \}$
2. $x = \pm 5i$ **3.** $x = 1 \pm i\sqrt{3}$ **4.** $x = \frac{2}{3}, x = 6$ **5. a.** $t = 5$ (May)
b. $t = 9$ (Sept.) **c.** July; \$3000 more **6. a.** $-\frac{4}{3} + \frac{\sqrt{5}}{3}i$ **b.** $-i$
7. a. 1 **b.** $i\sqrt{3}$ **c.** 1 **8.** $-\frac{3}{2} + \frac{3}{2}i$ **9.** 34
10. $(2 - 3i)^2 - 4(2 - 3i) + 13 = 0$
$4 - 12i - 9 - 8 + 12i + 13 = 0$
$-13 + 13 = 0$
$0 = 0$✓

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.** $x = 1 \pm 3i$

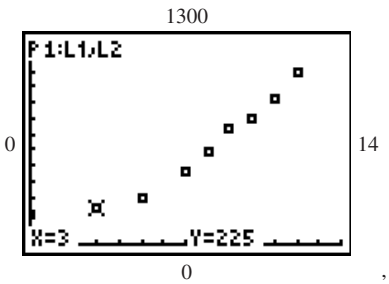
13. a. $f(x) = -(x - 5)^2 + 9$ **b.** $g(x) = \frac{1}{2}(x + 4)^2 + 8$





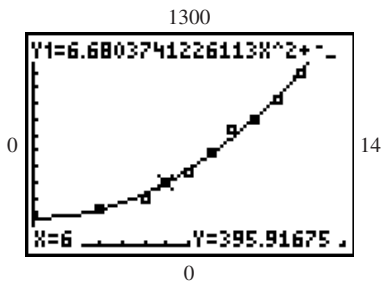
14. $(-2, 0)$, $y = 2x^2 + 4x$ **15. a.** 40 ft, 48 ft **b.** 49 ft **c.** 14 sec

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

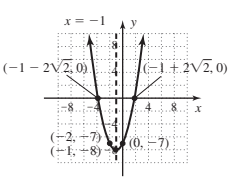
18. $3x + 1$; $x \in [\frac{1}{3}, \infty)$

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 $\frac{37{,}000 \text{ unit}}{1 \text{ mo}}$ 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

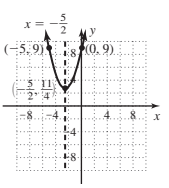
20. a. $V(t) = \frac{4}{3}\pi(\sqrt{t})^3$ **b.** 36π in^3

Strengthening Core Skills, pp. 300–301

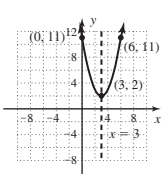
1.



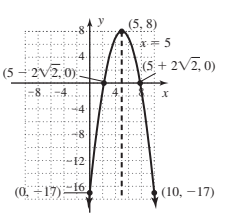
2.



3.



4.



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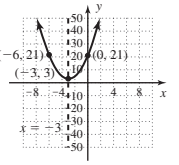

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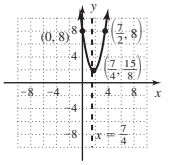
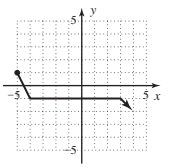


Cumulative Review Chapters 1–3, pp. 301–302

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.** $g(x)$

15.



17. $X = 63$

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

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

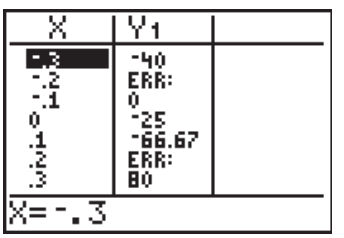
c. $(fg)(0) = (-2)(4) = -8, (\frac{g}{f})(0) = \frac{4}{-2} = -2$

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



Connections to Calculus Exercises, pp. 305–306

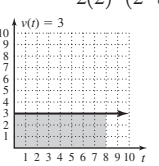
1. a. −3 **b.** as $h \to 0$, −3 remains constant **3. a.** $2x - 3 + h$

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

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

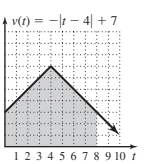
b. as $h \to 0$, $\frac{-2(2) - h}{2(2)^2 (2 + h)^2} \to \frac{-1}{8}$

9.



$A = 24$, distance $= 24$ ft

11.



$A = 40$, 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. $\dfrac{x^3 - 3x^2 - 14x - 8}{x + 2} = (x^2 - 5x - 4) + \dfrac{0}{x + 2}$

b. $x^3 - 3x^2 - 14x - 8 = (x + 2)(x^2 - 5x - 4) + 0$

17. a. $\dfrac{x^3 - 5x^2 - 4x + 23}{x - 2} = (x^2 - 3x - 10) + \dfrac{3}{x - 2}$

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

19. a. $\dfrac{2x^3 - 5x^2 - 11x - 17}{x - 4} = (2x^2 + 3x + 1) + \dfrac{-13}{x - 4}$

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. $\dfrac{2x^3 + 7x^2 - x + 26}{x^2 + 3} = (2x + 7) + \dfrac{-7x + 5}{x^2 + 3}$

33. $\dfrac{x^4 - 5x^2 - 4x + 7}{x^2 - 1} = (x^2 - 4) + \dfrac{-4x + 3}{x^2 - 1}$

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.
$$\begin{array}{r|cccc} -3 & 1 & 2 & -5 & -6 \\ & & -3 & 3 & 6 \\ \hline & 1 & -1 & -2 & 0 \end{array}$$

53.
$$\begin{array}{r|cccc} 2 & 1 & 0 & -7 & 6 \\ & & 2 & 4 & -6 \\ \hline & 1 & 2 & -3 & 0 \end{array}$$

55.
$$\begin{array}{r|cccc} \frac{2}{3} & 9 & 18 & -4 & -8 \\ & & 6 & 16 & 8 \\ \hline & 9 & 24 & 12 & 0 \end{array}$$

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 ft^3 **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. $x = 3, -1, \frac{5}{3}$ **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.** $A = 15{,}000$ ft^2

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

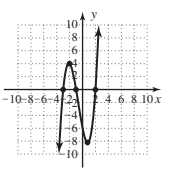
c. $f(x) = -(x + 1)^2(x - 3)$, deg 3 **d.** $x \in \mathbb{R}$, $y \in \mathbb{R}$

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

43.



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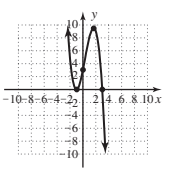

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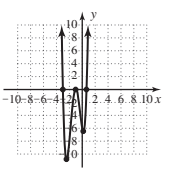
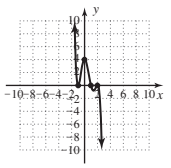
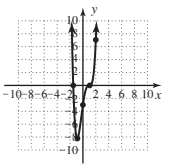
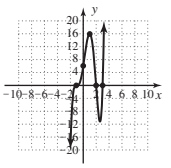
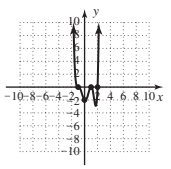
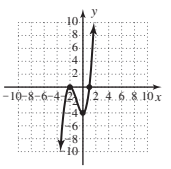


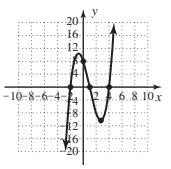
49. 

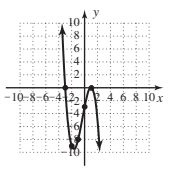
51. 

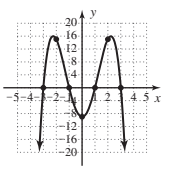
53. 

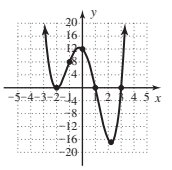
55. 

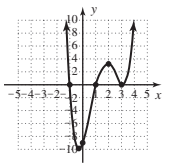
57. 

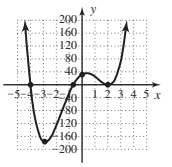
59. 

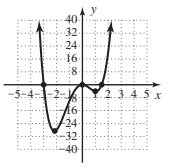
61. 

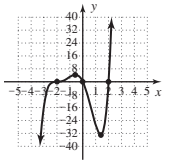
63. 

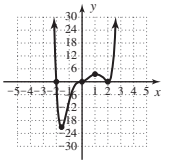
65. 

67. 

69. 

71. 

73. 

75. 

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. $(-3)^2 + (-1)^2 + (2)^2 + (4)^2 = (-2)^2 - 2(-13)$

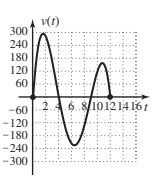
$9 + 1 + 4 + 16 = 4 + 26$

$30 = 30$ ✓

b. $(x + 3)(x + 1)(x - 2)(x - 4) = x^4 - 2x^3 - 13x^2 + 14x + 24$ ✓

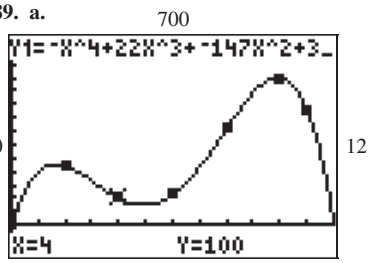
85. a. 280 vehicles above average, 216 vehicles below average, 154 vehicles above average **b.** 6:00 A.M. ($t = 0$), 10:00 A.M. ($t = 4$), 3:00 P.M. ($t = 9$), 6:00 P.M. ($t = 12$)

c. max: about 300 vehicles above average at 7:30 A.M.; min: about 220 vehicles below average at 12 noon

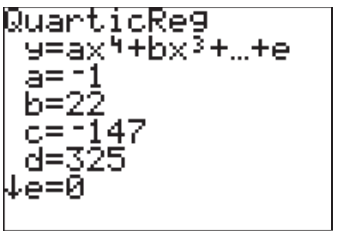


87. a. 3 **b.** 5 **c.** $B(x) = \frac{1}{4}x(x - 4)(x - 9)$, $-\$80{,}000$

89. a.



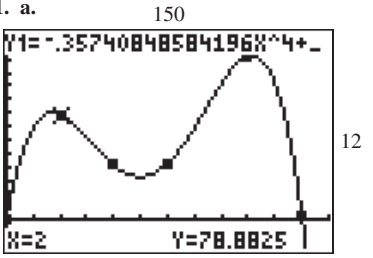
700, 0, 12, −100, quartic;



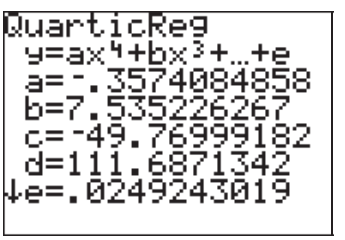
b. $t \approx 1.7$ (7:42 A.M.), 227 vehicles; $t \approx 9.9$ (3:54 P.M.), 551 vehicles

c. $t \approx 7.93$ (1:56 P.M.) and $t \approx 11.27$ (5:16 P.M.)

91. a.



150, 0, 12, −20, 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. $f(x) \to \infty, f(x) \to -\infty$ **b.** $g(x) \to \infty, g(x) \to \infty$; $x^4 \geq 0$ for all x

95. $c = -18$ **97.** verified **99.** verified, $x = 1 + 2i$ **101.** yes

Mid-Chapter Check, p. 354

1. a. $x^3 + 8x^2 + 7x - 14 = (x^2 + 6x - 5)(x + 2) - 4$

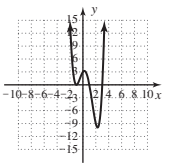
b. $\dfrac{x^3 + 8x^2 + 7x - 14}{x + 2} = x^2 + 6x - 5 - \dfrac{4}{x + 2}$

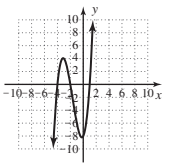
2. $f(x) = (2x + 3)(x + 1)(x - 1)(x - 2)$ **3.** $f(-2) = 7$

4. $f(x) = x^3 - 2x + 4$ **5.** $g(2) = -8$ and $g(3) = 5$ have opposite signs

6. $f(x) = (x - 2)(x + 1)(x + 2)(x + 4)$

7. $x = -2, x = 1, x = -1 \pm 3i$

8. 

9. 

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

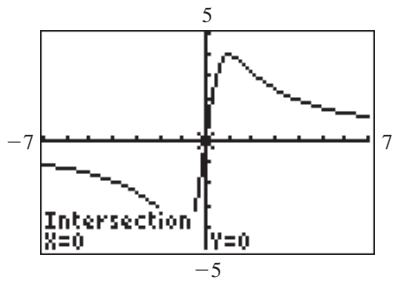
1. as $x \to -\infty, y \to 2$ **3.** denominator, numerator **5.** about $x = 98$

7. $x = 3, x \in (-\infty, 3) \cup (3, \infty)$

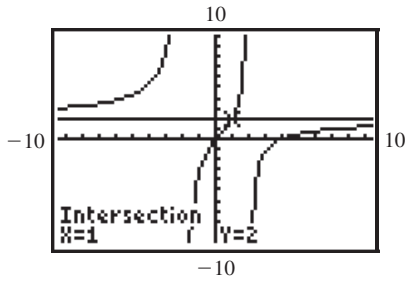
9. $x = 3, x = -3, x \in (-\infty, -3) \cup (-3, 3) \cup (3, \infty)$

11. $x = \frac{-5}{2}, x = 1, x \in (-\infty, -\frac{5}{2}) \cup (-\frac{5}{2}, 1) \cup (1, \infty)$

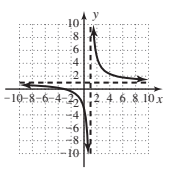
13. No V.A., $x \in (-\infty, \infty)$ **15.** $x = 3$, yes; $x = -2$, yes
17. $x = 3$, no **19.** $x = 2$, yes; $x = -2$, no **21.** $y = 0$, crosses at $(\frac{3}{2}, 0)$
23. $y = 4$, crosses at $(-\frac{21}{4}, 4)$ **25.** $y = 3$, does not cross
27. $q(x) = 0$, $r(x) = 8x$ directly; the graph will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

37.


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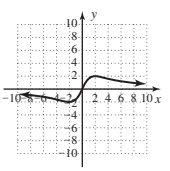

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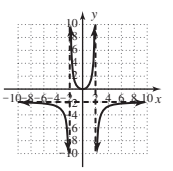

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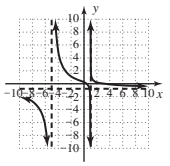

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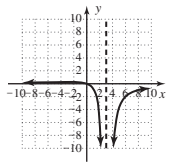

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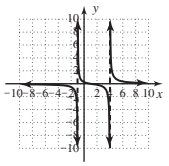

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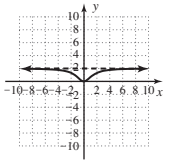

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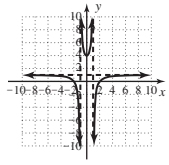

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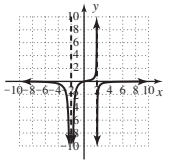
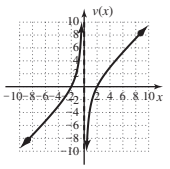


55. $f(x) = \dfrac{(x-4)(x+1)}{(x+2)(x-3)}$ **57.** $f(x) = \dfrac{x^2-4}{9-x^2}$

59.


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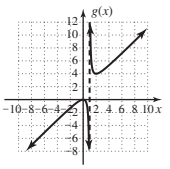
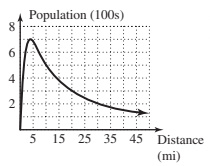
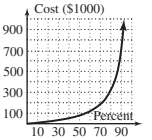


63. a.


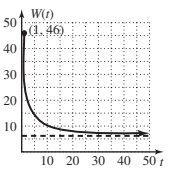
Population density approaches zero far from town. **b.** 10 mi, 20 mi **c.** 4.5 mi, 704 people per square mi

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

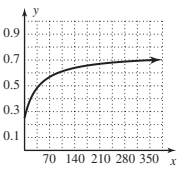
b.


c. as $p \to 100^-$, $C \to \infty$

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%

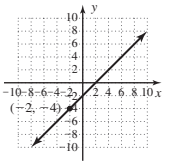
73. a. \$225; \$175 **b.** 2000 heaters **c.** 4000 heaters **d.** The horizontal asymptote at $y = 125$ means the average cost approaches \$125 as monthly production gets very large. Due to limitations on production (maximum of 5000 heaters) the average cost will never fall below $A(5000) = 135$.
75. 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. $y = \dfrac{-4}{3}x - \dfrac{1}{3}$ **81.** $\frac{-16}{3}, \frac{3}{4}$; $(3x + 16)(4x - 3) = 0$

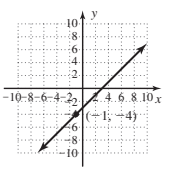
Exercises 4.5, pp. 380–384

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

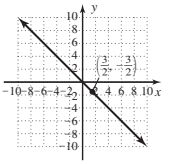
7. $F(x) = \begin{cases} \dfrac{x^2-4}{x+2} & x \neq -2 \\ -4 & x = -2 \end{cases}$



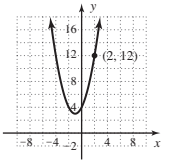
9. $G(x) = \begin{cases} \dfrac{x^2-2x-3}{x+1} & x \neq -1 \\ -4 & x = -1 \end{cases}$



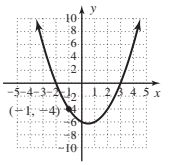
11. $H(x) = \begin{cases} \dfrac{3x-2x^2}{2x-3} & x \neq \dfrac{3}{2} \\ \dfrac{-3}{2} & x = \dfrac{3}{2} \end{cases}$



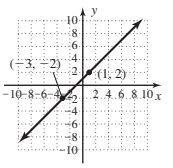
13. $P(x) = \begin{cases} \dfrac{x^3-8}{x-2} & x \neq 2 \\ 12 & x = 2 \end{cases}$



15. $Q(x) = \begin{cases} \dfrac{x^3 - 7x - 6}{x + 1} & x \neq -1 \\ -4 & x = -1 \end{cases}$



17. $R(x) = \begin{cases} \dfrac{x^3 + 3x^2 - x - 3}{x^2 + 2x - 3} & x \neq -3, x \neq 1 \\ -2 & x = -3 \\ 2 & x = 1 \end{cases}$



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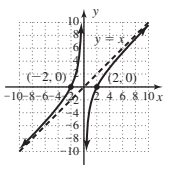

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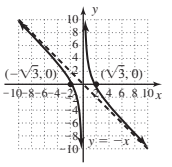

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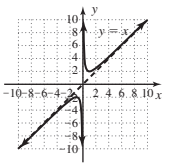

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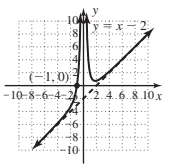

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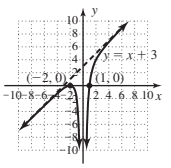

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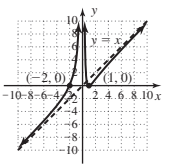

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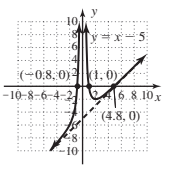

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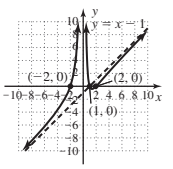

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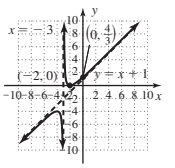

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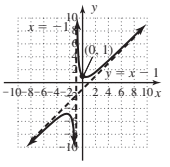

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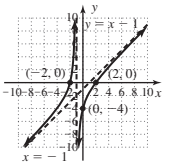

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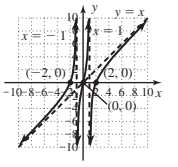
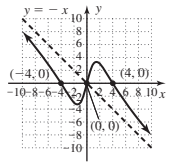
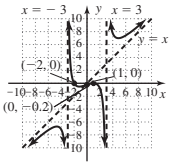


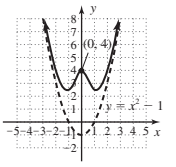
43.



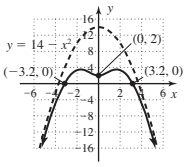
45.



47.



49.



51. 119.1

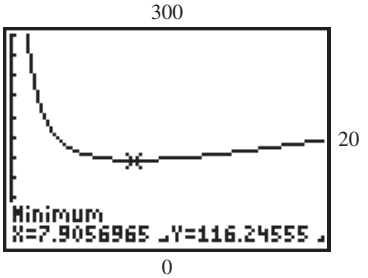
53. a. $a = 5, y = 3a + 15$ **b.** 60.5 **c.** 10

55. a. $A(x) = \dfrac{4x^2 + 53x + 250}{x}$; $x = 0$, $y = 4x + 53$

b. cost: \$307, \$372, \$445; Avg. cost: \$307, \$186, \$148.33

c. 8, \$116.25

d.



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

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.** $y = \dfrac{2x + 55}{x - 2.5}$;

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

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

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

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

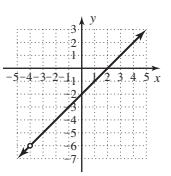
67. $y = \frac{3}{4}x - 4$, $m = \frac{3}{4}$, $(0, -4)$

69. a. $P = 30$ cm, **b.** $\overline{CD} = \frac{60}{13}$ cm, **c.** 30 cm^2,
d. $A = \frac{750}{169}$ cm^2, and $A = \frac{4320}{169}$ cm^2

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.** $[0°, 30°)$ **b.** $(20°, \infty)$
c. $(50°, \infty)$ **69. a.** $n \geq 4$ **b.** $n \leq 9$ **c.** 13
71. a. yes, $x^2 \geq 0$ **b.** yes, $\dfrac{x^2}{x^2 + 1} \geq 0$
73. $x(x + 2)(x - 1)^2 > 0$; $\dfrac{x(x + 2)}{(x - 1)^2} > 0$
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.

-7	2	13	-6	9	14
		-14	7	-7	-14
	2	-1	1	2	0

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.
$$\begin{array}{r|rrrr} \frac{1}{2} & 4 & 8 & -3 & -1 \\ & & 2 & 5 & 1 \\ \hline & 4 & 10 & 2 & \underline{0} \end{array}$$
Since $r = 0, \frac{1}{2}$ is a root and $(x - \frac{1}{2})$ is a factor.

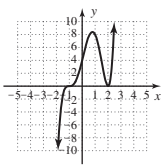
8.
$$\begin{array}{r|rrr} 3i & 1 & -2 & 9 & -18 \\ & & 3i & -9 - 6i & 18 \\ \hline & 1 & -2 + 3i & -6i & \underline{0} \end{array}$$
Since $r = 0, 3i$ is a zero

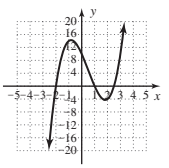
9.
$$\begin{array}{r|rrrr} -7 & 1 & 9 & 13 & -10 \\ & & -7 & -14 & 7 \\ \hline & 1 & 2 & -1 & \underline{-3} \end{array}$$
$h(-7) = -3$

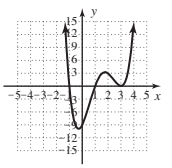
10. $P(x) = x^3 - x^2 - 5x + 5$ **11.** $C(x) = x^4 - 2x^3 + 5x^2 - 8x + 4$

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 $g(x) \to 1$ positive zero; three sign changes for $g(-x) \to 3$ 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. 

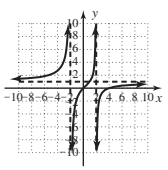
22. 

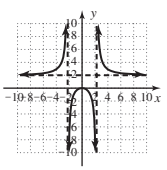
23. 

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

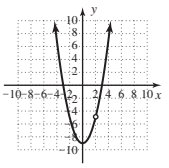
27. 

28. 

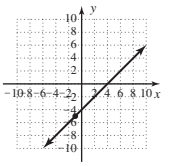
29. $V(x) = \dfrac{x^2 - x - 12}{x^2 - x - 6}$; $V(0) = 2$

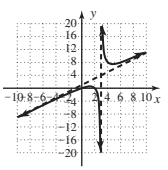
30. a. $y = 15$; as $|x| \to \infty\ A(x) \to 15^+$. As production increases, average cost decreases and approaches 15. **b.** $x > 2000$

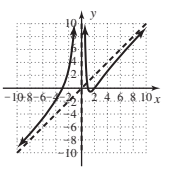
31. removable discontinuity at $(2, -5)$;

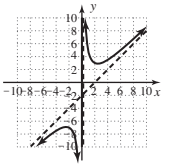


32. $H(x) = \begin{cases} \dfrac{x^2 - 3x - 4}{x + 1} & x \neq -1 \\ -5 & x = -1 \end{cases}$



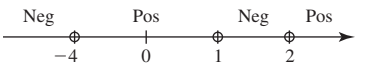
33. 

34. 

35. a. 

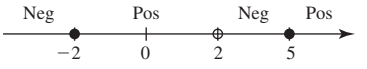
b. about 2450 favors **c.** about \$2.90 ea.

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



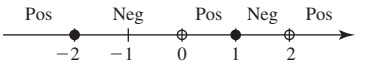
outputs are positive for $x \in (-4, 1) \cup (2, \infty)$

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



outputs are positive or zero for $x \in [-2, 2) \cup [5, \infty)$

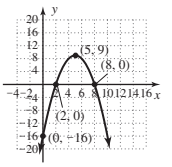
38. $\dfrac{(x + 2)(x - 1)}{x(x - 2)} \leq 0$

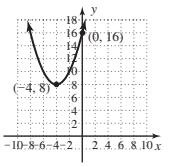


outputs are negative or zero for $x \in [-2, 0) \cup [1, 2)$

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. $x - 5 + \dfrac{14x + 3}{x^2 + 2x + 1}$ **5.** $x^2 + 2x - 9 + \dfrac{-2}{x + 2}$

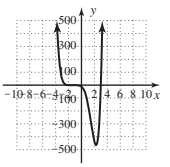
6.
$$\begin{array}{r|rrrrr} -3 & 1 & 0 & -15 & -10 & 24 \\ & & -3 & 9 & 18 & -24 \\ \hline & 1 & -3 & -6 & 8 & \underline{0} \end{array}$$
$r = 0$ ✓

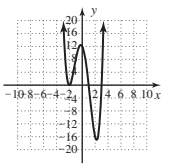
7. -1 **8.** $P(x) = x^3 - 2x^2 + 9x - 18$

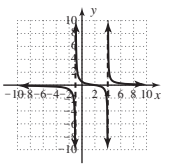
9. $Q(x) = (x - 2)^2(x - 1)^2(x + 1)$, 2 mult 2, 1 mult 2, -1 mult 1

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.** $C(x) = (x + 2)(x - 1)(x - 3i)(x + 3i)$

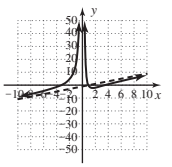
11. a. 2002, 2004, 2008 **b.** 4 yr **c.** deficit of \$7.5 million

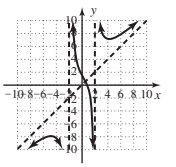
12. 

13. 

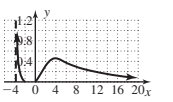
14. 

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 neglible.

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

Strengthening Core Skills, pp. 402–403

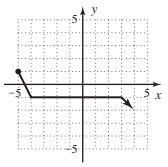
Exercise 1. $x \in (-\infty, 3]$ **Exercise 2.** $x \in (-2, -1) \cup (2, \infty)$
Exercise 3. $x \in (-\infty, -4) \cup (1, 3)$ **Exercise 4.** $x \in [-2, \infty)$
Exercise 5. $x \in (-\infty, -2) \cup (2, \infty)$ **Exercise 6.** $x \in [-3, 1] \cup [3, \infty)$

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

1. $R = \dfrac{R_1R_2}{R_1 + R_2}$ **3. a.** $(x - 1)(x^2 + x + 1)$ **b.** $(x - 3)(x + 2)(x - 2)$

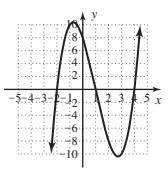
5. all reals **7.** verified **9.** $y = \dfrac{11}{60}x + \dfrac{1009}{60}$; 39 min, driving time increases 11 min every 60 days **11.** month 9 **13.** $f^{-1}(x) = \dfrac{x^3 + 3}{2}$

15.



17. $X = 63$

19.

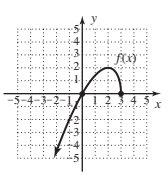


21. 87.91, −80.09, 1.99

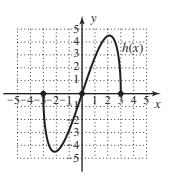
23. a. $-349.36 - 131.38i$ **b.** $-\dfrac{2}{41} - \dfrac{59}{41}i$ **c.** $27.63 + 14.59i$ **d.** $0 - i$ **25. a.** Y_6 **b.** Y_7 **c.** Y_4 **d.** Y_3 **e.** Y_5 **f.** Y_2

Connections to Calculus Exercises, pp. 407–408

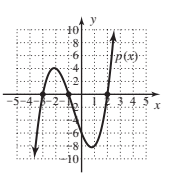
1. $x \in (-\infty, 3]$, as $x \to -\infty$, $y \to -\infty$; (0, 0); (0, 0), (3, 0)



3. $x \in [-3, 3]$, as $x \to -3$, $y \to 0$, as $x \to 3$, $y \to 0$; (0, 0); (−3, 0), (0, 0), (3, 0)



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

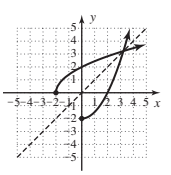


7. max $f(x) = 2$ at $x = 2$ **9.** max $h(x) = 4.5$ at $x = 1.5\sqrt{2}$; min $h(x) = -4.5$ at $x = -1.5\sqrt{2}$ **11.** $\left(\dfrac{-2 - \sqrt{19}}{3}, p\left(\dfrac{-2 - \sqrt{19}}{3}\right)\right)$ or about $(-2.11, 4.06)$. The skater has a maximum anxiety level of near 4, about 2 min before starting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

CHAPTER 5

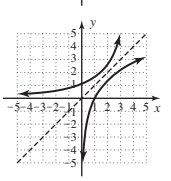
Exercises 5.1, pp. 418–421

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.** $p^{-1}(x) = \dfrac{-5}{4}x$ **35.** $f^{-1}(x) = \dfrac{x - 3}{4}$
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.** $v^{-1}(x) = \sqrt{\dfrac{8}{x}} + 3, x > 0, y > 3$
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. $f^{-1}(x) = \dfrac{x + 5}{3}$ **63.** $f^{-1}(x) = 2x + 5$ **65.** $f^{-1}(x) = 2x + 6$
67. $f^{-1}(x) = \sqrt[3]{x - 3}$ **69.** $f^{-1}(x) = \dfrac{x^3 - 1}{2}$ **71.** $f^{-1}(x) = 2\sqrt[3]{x} + 1$
73. $D: x \geq -\dfrac{2}{3}, R: y \geq 0; f^{-1}(x) = \dfrac{x^2 - 2}{3}, D: x \geq 0, R: y \geq -\dfrac{2}{3}$
75. $D: x \geq 3, R: y \geq 0; p^{-1}(x) = \dfrac{x^2}{4} + 3, D: x \geq 0, R: y \geq 3$
77. $D: x \geq 0, R: y \geq 3; v^{-1}(x) = \sqrt{x - 3}, D: x \geq 3, R: y \geq 0$
79.



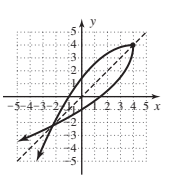
$D: x \in [0, \infty), R: y \in [-2, \infty)$; $D: x \in [-2, \infty), R: y \in [0, \infty)$

81.



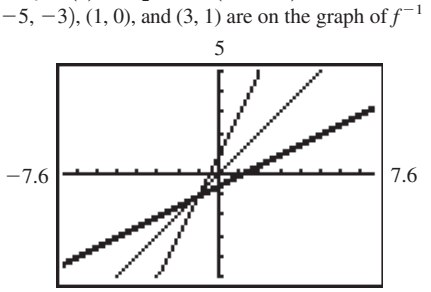
$D: x \in (0, \infty), R: y \in (-\infty, \infty)$; $D: x \in (-\infty, \infty), R: y \in (0, \infty)$

83.



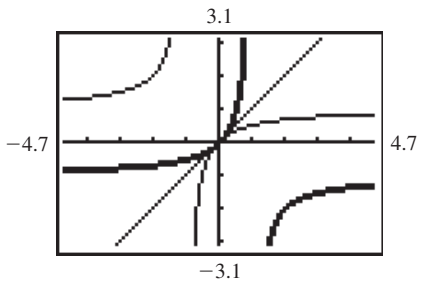
$D: x \in (-\infty, 4], R: y \in (-\infty, 4]$; $D: x \in (-\infty, 4], R: y \in (-\infty, 4]$

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
d.



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

d.



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.** $f^{-1}(x) = \dfrac{\sqrt{x}}{4}$, independent: distance fallen, dependent: time fallen **c.** 7 sec

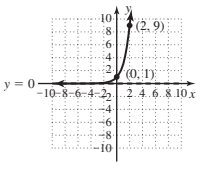
95. a. 28,260 ft^3 **b.** $f^{-1}(x) = \sqrt[3]{\dfrac{3x}{\pi}}$, independent: volume, dependent: height **c.** 9 ft **97.** Answers will vary.

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

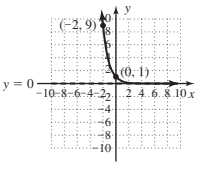
1. b^x, b, b, x **3.** a, 1 **5.** False; for $|b| < 1$ and $x_2 > x_1$, $b^{x_2} < b^{x_1}$, so function is decreasing **7.** 16, 2, 8, 11.036 **9.** 1, $\frac{1}{64}$, $\frac{1}{4}$, 64

11.



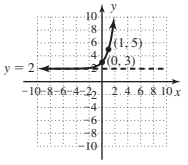
increasing

13.

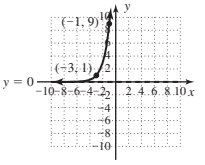


decreasing

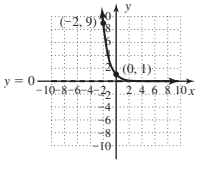
15. $y = 3^x$; up 2



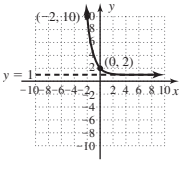
17. $y = 3^x$; left 3



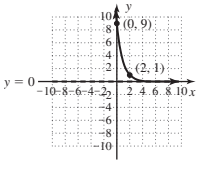
19. $y = 3^x$; reflect across y-axis



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



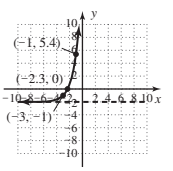
23. $y = (\frac{1}{3})^x$; right 2



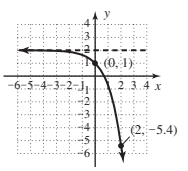
25. e **27.** a **29.** b

31. 2.718282 **33.** 7.389056 **35.** 4.113250

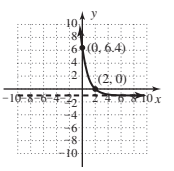
37.



39.

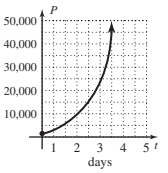


41.



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 $t \to \infty$, $P \to \infty$

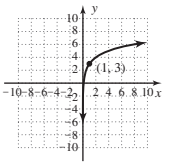
d.

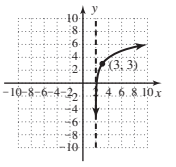


69. a. \$100,000 **b.** 3 yr **71. a.** ≈ \$86,806 **b.** 3 yr
73. a. \$40 million **b.** 7 yr **75.** no, they will have to wait about 5 min
77. 32% transparent **79.** 17% transparent **81.** ≈\$25,526
83. a. 8 g **b.** 48 min **85.** $\frac{1}{5}$ **87.** 75 **89.** 9.5×10^{-7}; answers will vary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

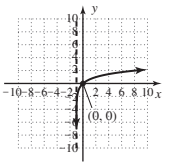
Exercises 5.3, pp. 442–446

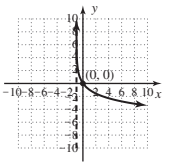
1. $\log_b x$, b, b, greater **3.** (1, 0), 0 **5.** 5; answers will vary **7.** $2^3 = 8$
9. $7^{-1} = \frac{1}{7}$ **11.** $9^0 = 1$ **13.** $8^{\frac{1}{3}} = 2$ **15.** $2^1 = 2$ **17.** $7^2 = 49$
19. $10^2 = 100$ **21.** $e^4 \approx 54.598$ **23.** $\log_4 64 = 3$ **25.** $\log_{3^9} \frac{1}{9} = -2$
27. $0 = \ln 1$ **29.** $\log_{\frac{1}{3}} 27 = -3$ **31.** $\log 1000 = 3$ **33.** $\log \frac{1}{100} = -2$
35. $\log_4 8 = \frac{3}{2}$ **37.** $\log_{\frac{1}{8}} \frac{1}{8} = \frac{-3}{2}$ **39.** 1 **41.** 2 **43.** 1 **45.** $\dfrac{1}{2}$ **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



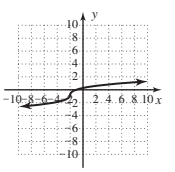


63. shift left 1 **65.** shift left 1, reflect across x-axis





67. II **69.** VI **71.** V **73.** $x \in (-\infty, -1) \cup (3, \infty)$
75. $x \in (\frac{3}{2}, \infty)$ **77.** $x \in (-3, 3)$ **79.** pH ≈ 4.1; acid
81. a. ≈4.7 **b.** ≈7.9 **83.** about 398 times **85.** about 3.2 times
87. a. ≈2.4 **b.** ≈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 ft^2
103. a. 95% **b.** 67% **c.** 39% **105.** ≈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.** $x = e^{\frac{8}{3}} - 4, x \approx 10.3919$
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, pH ≈ 7.32
77. no, pH ≈ 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.** $8^{\frac{5}{3}} = 32$ **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.** $27^{\frac{2}{3}} = 9$, 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. $t = \frac{\ln\left(\frac{\frac{C}{P} - 1}{a}\right)}{-k}$, $t \approx 55.45$ **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.**

$y = 2^{x+1}$	$x = 2^{y+1}$
$\ln x = (y+1)\ln 2$	$\frac{\ln x}{\ln 2} = y + 1$
$\frac{\ln x}{\ln 2} - 1 = y$	

b.

$y = 2\ln(x-3)$	$x = 2\ln(y-3)$
$\frac{x}{2} = \ln(y-3)$	$e^{\frac{x}{2}} = y - 3$
$y = e^{\frac{x}{2}} + 3$	

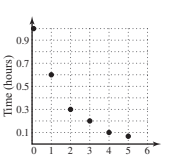
67. **a.** $y = e^{x \ln 2} = e^{\ln 2^x} = 2^x$;
$y = 2^x \Rightarrow \ln y = x \ln 2$, $e^{\ln y} = e^{x \ln 2} \Rightarrow y = e^{x \ln 2}$
b. $y = b^x$, $\ln y = x \ln b$, $e^{\ln y} = e^{x \ln b}$, $y = e^{xr}$ for $r = \ln b$
69. **a.** d **b.** e **c.** b **d.** f **e.** a **f.** c
71. **a.** $x \in [-\frac{3}{2}, \infty), y \in [0, \infty)$ **b.** $x \in (-\infty, \infty), y \in [-3, \infty)$
73. 13.5 tons

Exercises 5.6, pp. 477–482

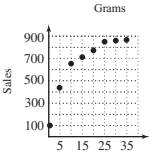
1. Compound **3.** $Q_0 e^{-rt}$ **5.** Answers will vary. **7.** \$4896
9. 250% **11.** \$2152.47 **13.** 5.25 yr **15.** 80% **17.** 4 yr **19.** 16 yr
21. \$7561.33 **23.** about 5 yr **25.** 7.5 yr **27.** no **29.** **a.** no
b. 9.12% **31.** 7.9 yr **33.** 7.5 yr **35.** **a.** no **b.** 9.4%
37. **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.** $r = n\left(\sqrt[nt]{\frac{A}{p}} - 1\right)$
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

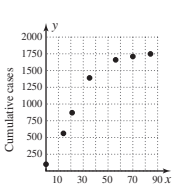
1. scatterplot, context, situation **3.** beyond **5.** (1) clear out old data, (2) enter new data, (3) display the data, (4) calculate the regression equation, (5) display and use the results; Answers will vary.
7. e **9.** a **11.** d **13.** linear **15.** exponential
17. logistic **19.** exponential
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. $y \approx 120.4938 + 217.2705 \ln(x)$



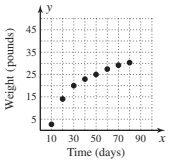
25. **a.**



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

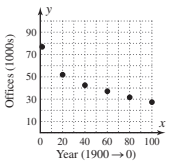
37. logarithmic, $y \approx -27.4 + 13.5 \ln x$

a. 9.2 lb **b.** 29 days **c.** 34.8 lb



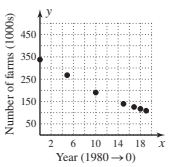
39. logarithmic, $y \approx 78.8 - 10.3 \ln x$

a. 51,000 **b.** 1977 **c.** 29,900



41. exponential, $y \approx 346.79(0.94)^x$

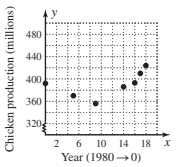
a. 155,100 **b.** 54,200 **c.** 2013



43. quadratic $y \approx 0.576x^2 - 8.879x + 394$

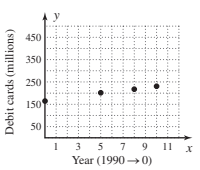
a. 360 million **b.** about 513 million

c. from 1984 to 1990

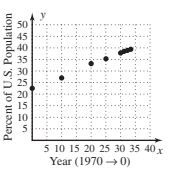


45. linear, $y \approx 6.555x + 165.308$

a. 224.3 million **b.** 329.2 million **c.** 2010



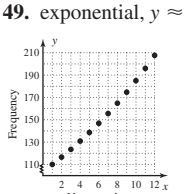
47. linear, $P(t) \approx 0.51t + 22.51$,
2005: 40.4%, 2010: 43.0%, 2015: 45.5%



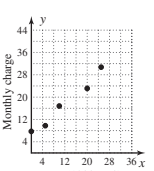
49. exponential, $y \approx 103.83\,(1.0595)^x$

a. 220 **b.** The 22nd note, or F#

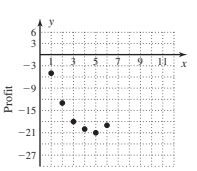
c. frequency doubles, yes



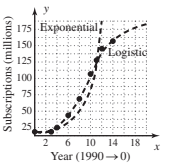
51. exponential, $y \approx 8.02\,(1.0564)^x$
\$41.59/mo, \$54.72/mo



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

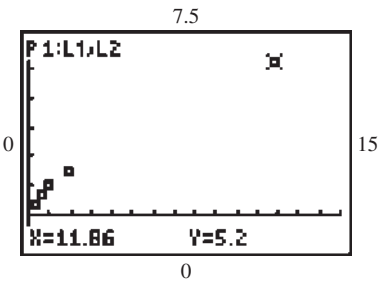


55. logistic, $y \approx \dfrac{222.133}{1 + 32.280e^{-0.336x}}$;



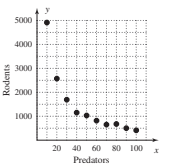
about 55 million, about 184 million, about 214 million; 2014

57.



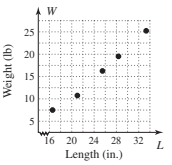
power regression,
a. $y \approx x^{0.665}$, 9.5 AU;
b. 84.8 yr

59.



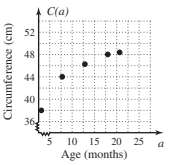
a. power regression, $y \approx 58{,}555.89x^{-1.056}$;
b. about 295 rodents **c.** about 17 predators

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

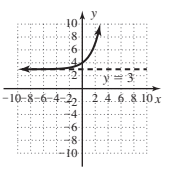
1. no **2.** no **3.** yes **4.** $f^{-1}(x) = \dfrac{x-2}{-3}$ **5.** $f^{-1}(x) = \sqrt{x+2}$

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

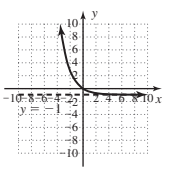
7. $f(x)$: D: $x \in [-4, \infty)$, R: $y \in [0, \infty)$; $f^{-1}(x)$: D: $x \in [0, \infty)$, R: $y \in [-4, \infty)$ **8.** $f(x)$: D: $x \in (-\infty, \infty)$, R: $y \in (-\infty, \infty)$; $f^{-1}(x)$: D: $(-\infty, \infty)$, R: $y \in (-\infty, \infty)$ **9.** $f(x)$: D: $x \in (-\infty, \infty)$, 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

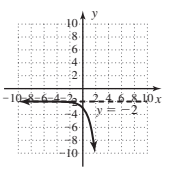
11.



12.



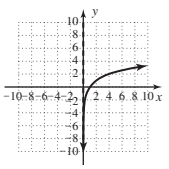
13.

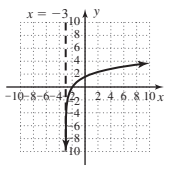


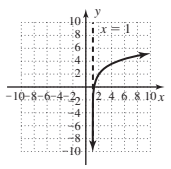
14. 2 **15.** -2 **16.** $\frac{5}{2}$ **17.** 12.1 yr **18.** $3^2 = 9$ **19.** $5^{-3} = \frac{1}{125}$

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.** $x = \dfrac{1}{2}\log 7$

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

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

35. a. $\ln 42$ **b.** $\log_9 30$ **c.** $\ln\left(\frac{x+3}{x-1}\right)$ **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. $\dfrac{\log 45}{\log 6} \approx 2.215$ **b.** $\dfrac{\log 128}{\log 3} \approx 4.417$ **c.** $\dfrac{\ln 124}{\ln 2} \approx 6.954$

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

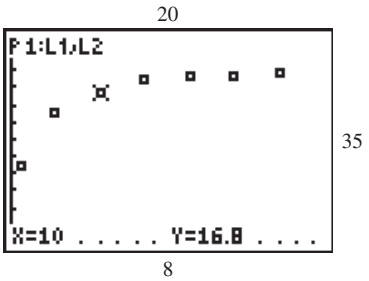
40. $x = \frac{\ln 5}{\ln 3} - 1$, $0 \approx x = .4650$ **41.** $\frac{2}{1 + \ln 3}$, $x \approx 0.9530$

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

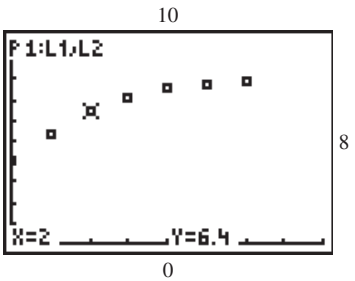
47. 18.5% **48.** Almost, she needs \$42.15 more. **49. a.** no **b.** \$268.93

50. 55.0%

51. 

a. logarithmic, $y \approx 12.772 + 1.595\ln x$ **b.** 16.9 mi/gal

c. the year 2011

52. 

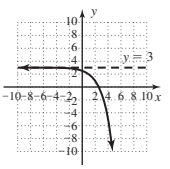
a. logistic, $g(t) = \dfrac{8.0}{1 + 1.0e^{-0.7t}}$ **b.** $\approx$ 6.8 microns

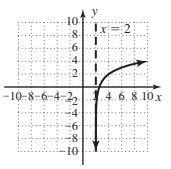
c. $(4 \times 1.96) = 7.84$; 5.56 hr (about 5 hr 34 min)

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

9. 

10. 

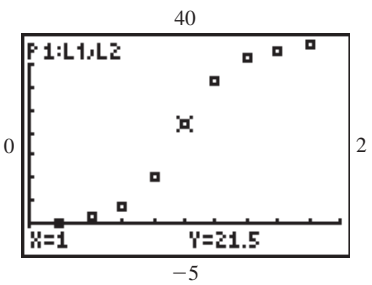
11. a. 4.19 **b.** -0.81 **12.** f is a parabola (hence not one-to-one), $x \in \mathbb{R}$, $y \in [-3, \infty)$; vertex is at $(2, -3)$, so restricted domain could be $x \in [2, \infty)$ to create a one-to-one function; $f^{-1}(x) = \sqrt{x + 3} + 2$, $x \in [-3, \infty)$, $y \in [2, \infty)$.

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

15. $\approx$5 yr **16. a.** $P = kM^{\alpha}$ **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; $y = \dfrac{39.1156}{1 + 314.6617e^{-5.9483x}}$; 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

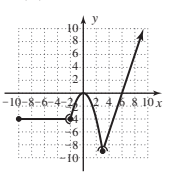
1. $x = 2 \pm 7i$ **3.** $(4 + 5i)^2 - 8(4 + 5i) + 41 = 0$

$-9 + 40i - 32 - 40i + 41 = 0$ $0 = 0$ ✓

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

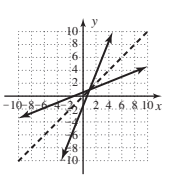
c. $T(6) = 5375$ sets of triplets, $T(17) = 10{,}380$ sets of triplets

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. $f^{-1}(x) = \dfrac{5x - 3}{2}$ **b.** 

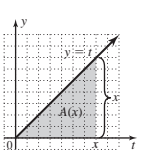
c. $f^{-1}(f(x)) = x$

17. $x = 5$, $x = -6$ is an extraneous root **19. a.** about 88 hp for sport wagon, about 81 hp for minivan **b.** $\approx$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. $5x + \dfrac{3}{2}\ln x$ **3.** $5\log x - 3\log y - \dfrac{1}{2}\log z$

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

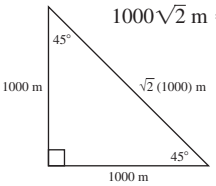
7. verified (factor out $\frac{1}{2}$, then combine like terms and simplify)

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

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° 15′ 00″ **21.** 67° 18′ 25.2″ **23.** 275° 19′ 48″ **25.** 5° 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°, −285°, 435°, 795° **39.** −765°, −405°, 315°, 675° **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.** $\mathcal{A} = 115.6\ \text{km}^2$ **53.** $\theta = 0.6$ rad **55.** $r \approx 3$ m **57.** $\theta = 1.5$ rad; $s = 7.5$ cm; $r = 5$ cm; $\mathcal{A} = 18.75\ \text{cm}^2$ **59.** $\theta = 4.3$ rad; $s = 43$ m; $r = 10$ m; $\mathcal{A} = 215\ \text{m}^2$ **61.** $\theta = 3$ rad; $\mathcal{A} = 864\ \text{mm}^2$; $s = 72$ 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 m^2 **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.** ≈50.3°/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.** $\left(\frac{5}{13}, \frac{-12}{13}\right)$ **11.** $\left(\frac{\sqrt{11}}{6}, \frac{5}{6}\right)$ **13.** $\left(\frac{-\sqrt{11}}{4}, \frac{\sqrt{5}}{4}\right)$ **15.** $(-0.9769, -0.2137)$ **17.** $(-0.9928, 0.1198)$ **19.** $\left(\frac{-\sqrt{3}}{2}, \frac{-1}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{-1}{2}\right)$ **21.** $\left(\frac{-\sqrt{11}}{6}, \frac{-5}{6}\right), \left(\frac{-\sqrt{11}}{6}, \frac{5}{6}\right), \left(\frac{\sqrt{11}}{6}, \frac{5}{6}\right)$ **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.** $\frac{\pi}{4}; \left(\frac{-\sqrt{2}}{2}, \frac{-\sqrt{2}}{2}\right)$ **31.** $\frac{\pi}{6}; \left(\frac{-\sqrt{3}}{2}, \frac{-1}{2}\right)$ **33.** $\frac{\pi}{4}; \left(\frac{-\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right)$ **35.** $\frac{\pi}{6}; \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$ **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.** $\sin t = 0.6$, $\cos t = -0.8$, $\tan t = -0.75$, $\csc t = 1.\overline{6}$, $\sec t = -1.25$, $\cot t = -1.\overline{3}$ **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.** $\left(\frac{3}{5}, \frac{4}{5}\right)$ **b.** $\left(\frac{-3}{5}, \frac{4}{5}\right)$ **79.** 2.3416 **81.** 1.7832 **83.** 3.5416 **85. a.** $\left(\frac{5}{13}, \frac{12}{13}, 1\right)$, $\left(\frac{5}{13}\right)^2 + \left(\frac{12}{13}\right)^2 = \frac{25}{169} + \frac{144}{169} = \frac{169}{169} = 1$; $\sin t = \frac{12}{13}$, $\cos t = \frac{5}{13}$, $\tan t = \frac{12}{5}$, $\csc t = \frac{13}{12}$, $\sec t = \frac{13}{5}$, $\cot t = \frac{5}{12}$ **b.** $\left(\frac{7}{25}, \frac{24}{25}, 1\right)$, $\left(\frac{7}{25}\right)^2 + \left(\frac{24}{25}\right)^2 = \frac{49}{625} + \frac{576}{625} = \frac{625}{625} = 1$; $\sin t = \frac{24}{25}$, $\cos t = \frac{7}{25}$, $\tan t = \frac{24}{7}$, $\csc t = \frac{25}{24}$, $\sec t = \frac{25}{7}$, $\cot t = \frac{7}{24}$ **c.** $\left(\frac{12}{37}, \frac{35}{37}, 1\right)$, $\left(\frac{12}{37}\right)^2 + \left(\frac{35}{37}\right)^2 = \frac{144}{1369} + \frac{1225}{1369} = \frac{1369}{1369} = 1$; $\sin t = \frac{35}{37}$, $\cos t = \frac{12}{37}$, $\tan t = \frac{35}{12}$, $\csc t = \frac{37}{35}$, $\sec t = \frac{37}{12}$, $\cot t = \frac{12}{35}$ **d.** $\left(\frac{9}{41}, \frac{40}{41}, 1\right)$, $\left(\frac{9}{41}\right)^2 + \left(\frac{40}{41}\right)^2 = \frac{81}{1681} + \frac{1600}{1681} = \frac{1681}{1681} = 1$; $\sin t = \frac{40}{41}$, $\cos t = \frac{9}{41}$, $\tan t = \frac{40}{9}$, $\csc t = \frac{41}{40}$, $\sec t = \frac{41}{9}$, $\cot t = \frac{9}{40}$ **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

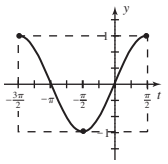
1. increasing **3.** $(-\infty, \infty)$, $[-1, 1]$ **5.** Answers will vary. **7.**

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

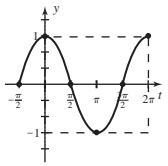
9. a. $\frac{\pi}{12}, \frac{\pi}{6}, \frac{\pi}{4}$ **b.** $\sin\frac{\pi}{12} \approx 0.25882$ **c.** same as second row

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

13.

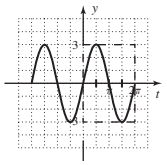


15.

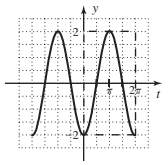


17. 3 **19.** 0.75

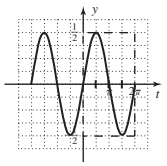
21. $|A| = 3, P = 2\pi$



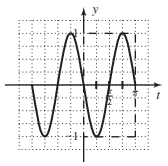
23. $|A| = 2, P = 2\pi$



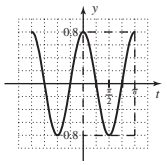
25. $|A| = \frac{1}{2}, P = 2\pi$



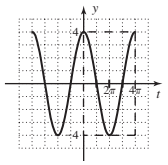
27. $|A| = 1, P = \pi$



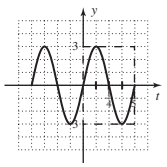
29. $|A| = 0.8, P = \pi$



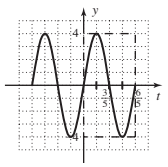
31. $|A| = 4, P = 4\pi$



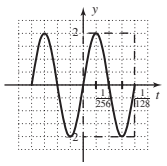
33. $|A| = 3, P = \frac{1}{2}$



35. $|A| = 4, P = \frac{6}{5}$



37. $|A| = 2, P = \frac{1}{128}$



39. $Y_2 \approx 0.86392$, Xmin = 0, Xmax = 1/1336, Xscl = 1/13,360, Ymin = −2, Ymax = 2, Yscl = 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. $y = 3\sin(\frac{1}{5}t)$ **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.** $200\ \text{cm}^2$; it is a square.

c.

n	$\mathcal{A}$
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

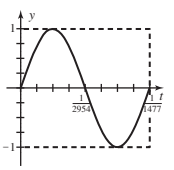
b. 620 nm → orange **73.** $I = 30\sin(50\pi t)$, $I \approx 21.2$ amps

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;



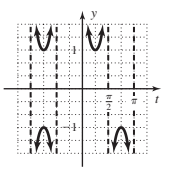
79. distance $= \frac{200}{\sqrt{3}}$ yd ≈ 115.5 yd

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

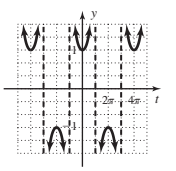
Exercises 6.4, pp. 571–577

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.

7.



9.



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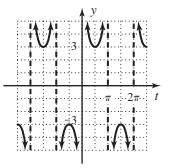

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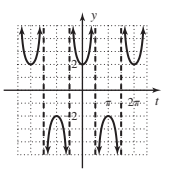


15. 0, $\frac{1}{\sqrt{3}}$, 1, $\sqrt{3}$, und. **17.** 1.6, 0.8, 0.5, 1.4, 0.7, 1.2

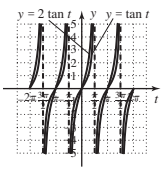
19. a. −1 **b.** $\sqrt{3}$ **c.** −1 **d.** $\sqrt{3}$

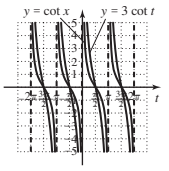
21. a. $\frac{7\pi}{4}$ **b.** $\frac{7\pi}{6}$ **c.** $\frac{5\pi}{3}$ **d.** $\frac{3\pi}{4}$

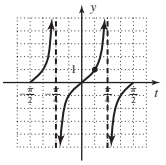
23. und., $\sqrt{3}$, 1, $\frac{1}{\sqrt{3}}$, 0 **25.** $\frac{-13\pi}{24}, \frac{35\pi}{24}, \frac{59\pi}{24}$

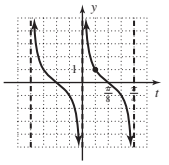
27. −1.6, 4.6, 7.8 **29.** $\frac{\pi}{10} + \pi k, k \in Z$

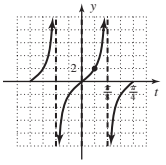
31. $\frac{\pi}{12} + \pi k, k \in Z$

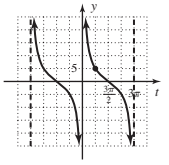
33. 

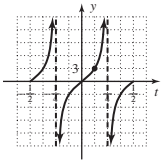
35. 

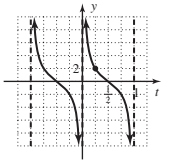
37. 

39. 

41. 

43. 

45. 

47. 

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; $\approx 35°$ **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 km^2

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.

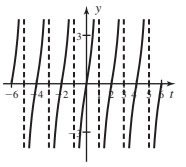
Mid-Chapter Check, p. 577

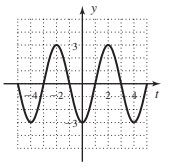
1. a. 36.11°N, 115.08°W **b.** 2495.7 mi. **2.** $\theta = 4.3$; $\mathcal{A} = 860$ cm^2

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°, 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 $x < 0$

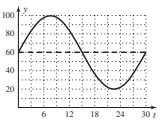
3. QIV, negative since $y < 0$ **4.** QI, $\cos t = \frac{1}{2}$, $\sin t = \frac{\sqrt{3}}{2}$, $t = \frac{\pi}{3}$

Exercises 6.5, pp. 590–595

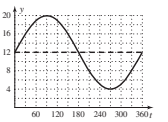
1. $y = A\sin(Bt + C) + D$, $y = A\cos(Bt + C) + D$

3. $0 \le Bt + C < 2\pi$ **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. $y = 40\sin\left(\frac{\pi}{15}t\right) + 60$

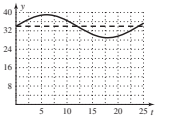


13. $y = 8\sin\left(\frac{\pi}{180}t\right) + 12$



15. a. $y = 5\sin\left(\frac{\pi}{12}t\right) + 34$

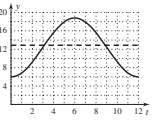
b.



c. $\approx$ 1:30 A.M., 10:30 A.M.

17. a. $y = -6.4\cos\left(\frac{\pi}{6}t\right) + 12.4$

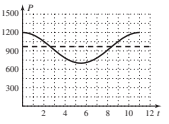
b.



c. $\approx$ 134 days

19. a. $P = 11$ yr

b.



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: $6 \le t < 30$

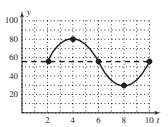
25. $|A| = 1$; $P = 12$; HS: 2 units right; VS: (none); PI: $2 \le t < 14$

27. $|A| = 1$; $P = 8$; HS: $\frac{2}{3}$ unit left; VS: (none); PI: $-\frac{2}{3} \le t < \frac{22}{3}$

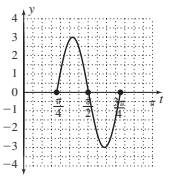
29. $|A| = 24.5$; $P = 20$; HS: 2.5 units right; VS: 15.5 units up; PI: $2.5 \le t < 22.5$

31. $|A| = 28$; $P = 12$; HS: $\frac{5}{2}$ units right; VS: 92 units up; PI: $\frac{5}{2} \le t < \frac{29}{2}$
33. $|A| = 2500$; $P = 8$; HS: $\frac{1}{3}$ unit left; VS: 3150 units up; PI: $-\frac{1}{3} \le t < \frac{23}{3}$
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. $y = 4 \sin\left(\frac{\pi}{180}t + \frac{\pi}{4}\right) + 7$

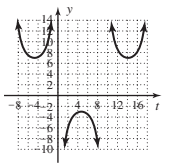
41.



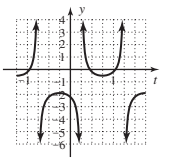
43.



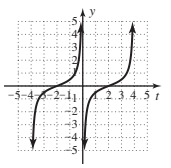
45.



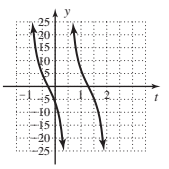
47.



49.

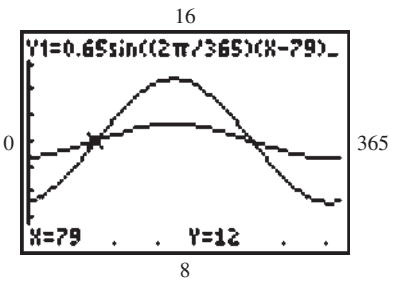


51.



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 $\to D_2$; blue $\to A_2$
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; $y = 11.95 \tan\theta$; $P = 180°$; asymptotes at $\theta = 90° + 180°k$; $|A| = 11.95$ from (30°, 6.9 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
$A = 30°$	$a = 98$ cm
$B = 60°$	$b = 98\sqrt{3}$ cm
$C = 90°$	$c = 196$ cm

15.

Angles	Sides
$A = 45°$	$a = 9.9$ mm
$B = 45°$	$b = 9.9$ mm
$C = 90°$	$c = 9.9\sqrt{2}$ mm

17.

Angles	Sides
$A = 22°$	$a = 14$ m
$B = 68°$	$b \approx 34.65$ m
$C = 90°$	$c \approx 37.37$ m

verified

19.

Angles	Sides
$A = 32°$	$a = 5.6$ mi
$B = 58°$	$b \approx 8.96$ mi
$C = 90°$	$c \approx 10.57$ mi

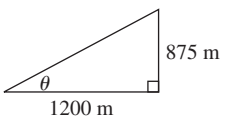
verified

21.

Angles	Sides
$A = 65°$	$a = 625$ mm
$B = 25°$	$b \approx 291.44$ mm
$C = 90°$	$c \approx 689.61$ 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.** $\theta \approx 11.0°$, $\beta \approx 23.9°$, $\gamma \approx 145.1°$
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°

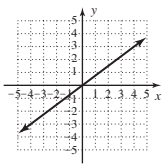


87. approx. 450 ft **89. a.** approx. 20.2 cm for each side
b. approx. 35.3° **91.** S 85° W **93. a.** approx. 3055.6 mi
b. approx. 9012.8 mi **c.** approx. 7 hr, 13 min
95. a. local max: $(-5, 2)$, $(2, 3)$; local min: $(-2, -1)$, $(-7, -2)$, $(6, -3)$
b. zeroes: $x = -6, -3, -1, 4$
c. $T(x)\downarrow$: $x \in (-5, -2) \cup (2, 6)$; $T(x)\uparrow$: $x \in (-7, -5) \cup (-2, 2)$
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.

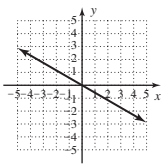
7. slope $= \sqrt{3}$, equation: $y = \sqrt{3}x$,
$\sin 60° = \dfrac{\sqrt{3}}{2}$, $\cos 60° = \dfrac{1}{2}$, $\tan 60° = \sqrt{3}$

9.  QI/III;

$(4, 3)$: $\sin\theta = \dfrac{3}{5}$; $(-4, -3)$: $\sin\theta = -\dfrac{3}{5}$

$\cos\theta = \dfrac{4}{5}$ $\cos\theta = -\dfrac{4}{5}$

$\tan\theta = \dfrac{3}{4}$ $\tan\theta = \dfrac{3}{4}$

11.  QII/QIV;

$(-3, \sqrt{3})$: $\sin\theta = \dfrac{1}{2}$; $(3, -\sqrt{3})$: $\sin\theta = -\dfrac{1}{2}$

$\cos\theta = -\dfrac{\sqrt{3}}{2}$ $\cos\theta = \dfrac{\sqrt{3}}{2}$

$\tan\theta = -\dfrac{1}{\sqrt{3}}$ $\tan\theta = -\dfrac{1}{\sqrt{3}}$

13. $\sin\theta = \dfrac{15}{17}$, $\csc\theta = \dfrac{17}{15}$, $\cos\theta = \dfrac{8}{17}$, $\sec\theta = \dfrac{17}{8}$, $\tan\theta = \dfrac{15}{8}$, $\cot\theta = \dfrac{8}{15}$

15. $\sin\theta = \dfrac{21}{29}$, $\csc\theta = \dfrac{29}{21}$, $\cos\theta = \dfrac{-20}{29}$, $\sec\theta = \dfrac{-29}{20}$, $\tan\theta = \dfrac{-21}{20}$, $\cot\theta = \dfrac{-20}{21}$

17. $\sin\theta = \dfrac{-\sqrt{2}}{2}$, $\csc\theta = -\sqrt{2}$, $\cos\theta = \dfrac{\sqrt{2}}{2}$, $\sec\theta = \sqrt{2}$, $\tan\theta = -1$, $\cot\theta = -1$

19. $\sin\theta = \dfrac{1}{2}$, $\csc\theta = 2$, $\cos\theta = \dfrac{\sqrt{3}}{2}$, $\sec\theta = \dfrac{2}{\sqrt{3}}$, $\tan\theta = \dfrac{1}{\sqrt{3}}$, $\cot\theta = \sqrt{3}$

21. $\sin\theta = \dfrac{4}{\sqrt{17}}$, $\csc\theta = \dfrac{\sqrt{17}}{4}$, $\cos\theta = \dfrac{1}{\sqrt{17}}$, $\sec\theta = \sqrt{17}$, $\tan\theta = 4$, $\cot\theta = \dfrac{1}{4}$

23. $\sin\theta = \dfrac{-2}{\sqrt{13}}$, $\csc\theta = \dfrac{-\sqrt{13}}{2}$, $\cos\theta = \dfrac{-3}{\sqrt{13}}$, $\sec\theta = \dfrac{-\sqrt{13}}{3}$, $\tan\theta = \dfrac{2}{3}$, $\cot\theta = \dfrac{3}{2}$

25. $\sin\theta = \dfrac{6}{\sqrt{61}}$, $\csc\theta = \dfrac{\sqrt{61}}{6}$, $\cos\theta = \dfrac{-5}{\sqrt{61}}$, $\sec\theta = \dfrac{-\sqrt{61}}{5}$, $\tan\theta = \dfrac{-6}{5}$, $\cot\theta = \dfrac{-5}{6}$

27. $\sin\theta = \dfrac{-2\sqrt{5}}{\sqrt{21}}$, $\csc\theta = -\dfrac{\sqrt{21}}{2\sqrt{5}}$, $\cos\theta = \dfrac{1}{\sqrt{21}}$, $\sec\theta = \sqrt{21}$, $\tan\theta = -2\sqrt{5}$, $\cot\theta = \dfrac{-1}{2\sqrt{5}}$

29. $r = 10$

31. $x = 0$, $y = k$; $k > 0$; $r = k$;
$\sin 90° = \dfrac{k}{k}$, $\cos 90° = \dfrac{0}{k}$, $\tan 90° = \dfrac{k}{0}$,
$\sin 90° = 1$, $\cos 90° = 0$, $\tan 90°$ is undefined
$\csc 90° = 1$, $\sec 90°$ is undefined
$\cot 90° = 0$

33. 60° **35.** 45° **37.** 45° **39.** 68° **41.** 40° **43.** 11.6° **45.** QII

47. QII **49.** $\sin\theta = -\dfrac{1}{2}$; $\cos\theta = \dfrac{\sqrt{3}}{2}$; $\tan\theta = -\dfrac{1}{\sqrt{3}}$

51. $\sin\theta = \dfrac{-\sqrt{2}}{2}$; $\cos\theta = \dfrac{\sqrt{2}}{2}$; $\tan\theta = -1$

53. $\sin\theta = \dfrac{-\sqrt{3}}{2}$; $\cos\theta = \dfrac{-1}{2}$; $\tan\theta = \sqrt{3}$

55. $\sin\theta = -\dfrac{1}{2}$; $\cos\theta = \dfrac{-\sqrt{3}}{2}$; $\tan\theta = \dfrac{1}{\sqrt{3}}$

57. $x = 4$, $y = -3$, $r = 5$; QIV; $\sin\theta = \dfrac{-3}{5}$, $\csc\theta = \dfrac{-5}{3}$, $\cos\theta = \dfrac{4}{5}$, $\sec\theta = \dfrac{5}{4}$, $\tan\theta = \dfrac{-3}{4}$, $\cot\theta = \dfrac{-4}{3}$

59. $x = -12$, $y = -35$, $r = 37$; QIII; $\sin\theta = \dfrac{-35}{37}$, $\csc\theta = \dfrac{-37}{35}$, $\cos\theta = \dfrac{-12}{37}$, $\sec\theta = \dfrac{-37}{12}$, $\tan\theta = \dfrac{35}{12}$, $\cot\theta = \dfrac{12}{35}$

61. $x = 2\sqrt{2}$, $y = 1$, $r = 3$; QI; $\sin\theta = \dfrac{1}{3}$, $\csc\theta = 3$, $\cos\theta = \dfrac{2\sqrt{2}}{3}$, $\sec\theta = \dfrac{3}{2\sqrt{2}}$, $\tan\theta = \dfrac{1}{2\sqrt{2}}$, $\cot\theta = 2\sqrt{2}$

63. $x = -\sqrt{15}$, $y = -7$, $r = 8$; QIII; $\sin\theta = \dfrac{-7}{8}$, $\csc\theta = \dfrac{-8}{7}$, $\cos\theta = \dfrac{-\sqrt{15}}{8}$, $\sec\theta = -\dfrac{8}{\sqrt{15}}$, $\tan\theta = \dfrac{7}{\sqrt{15}}$, $\cot\theta = \dfrac{\sqrt{15}}{7}$

65. $52° + 360°k$ **67.** $87.5° + 360°k$ **69.** $225° + 360°k$

71. $-107° + 360°k$ **73.** $\dfrac{\sqrt{3}}{2}, \dfrac{-1}{2}, -\sqrt{3}$ **75.** $-\dfrac{1}{2}, \dfrac{\sqrt{3}}{2}, \dfrac{1}{\sqrt{3}}$

77. $\sin\theta = \dfrac{-\sqrt{3}}{2}$, $\cos\theta = \dfrac{-1}{2}$, $\tan\theta = \sqrt{3}$

79. $\sin\theta = \dfrac{-\sqrt{3}}{2}$, $\cos\theta = -\dfrac{1}{2}$, $\tan\theta = \sqrt{3}$

81. $\sin\theta = \dfrac{-1}{2}$, $\cos\theta = \dfrac{-\sqrt{3}}{2}$, $\tan\theta = \dfrac{1}{\sqrt{3}}$

83. $\sin\theta = \dfrac{-1}{2}$, $\cos\theta = \dfrac{-\sqrt{3}}{2}$, $\tan\theta = \dfrac{1}{\sqrt{3}}$

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.** $\mathcal{A} = \dfrac{ab}{2}\sin\theta$

95. $\theta = 60° + 360°k$ and $\theta = 300° + 360°k$

97. $\theta = 240° + 360°k$ and $\theta = 300° + 360°k$

99. $\theta = 61.1° + 360°k$ and $\theta = 118.9° + 360°k$

101. $\theta = 113.0° + 180°k$ **103.** 1890°; $90° + 360°k$

105. head first; 900° **107.** approx. 701.6° **109.** Answers will vary.

111. a. 12,960° **b.** 125.66 in. **c.** 15,080 in. **d.** 85.68 mph

113. $t = \dfrac{\ln 0.32}{-0.05} \approx 22.79$ **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

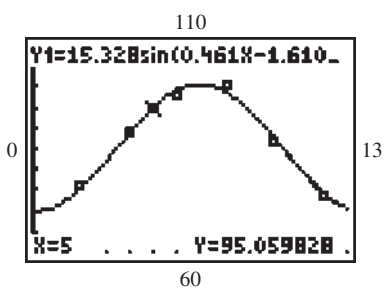
19. a. $T(x) = 19.6\sin\left(\frac{\pi}{6}x + \frac{4\pi}{3}\right) + 84.6$ **b.** about 94.4°F
c. beginning of May ($x \approx 5.1$) to end of August ($x \approx 8.9$)

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. $T(m) \approx 15.328\sin(0.461m - 1.610) + 85.244$



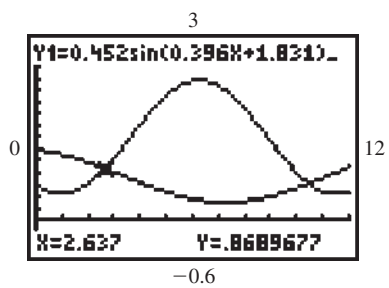
b.

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. $\dfrac{m - D}{A} = \dfrac{m - \left(\frac{M + m}{2}\right)}{\frac{M - m}{2}} = \dfrac{2m - M - m}{M - m} = \dfrac{m - M}{M - m} = -1$

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. $147.61\overline{3}°$ **2.** 32° 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, $\mathcal{A} = 191.25$ cm^2

10. $r \approx 41.74$ in., $\mathcal{A} \approx 2003.48$ in^2 **11.** $\theta = 4.75$ rad, $s = 38$ m

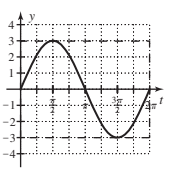
12. a. approx. 9.4248 rad/sec **b.** approx. 3.9 ft/sec **c.** about 15.4 sec

13. $y = -\frac{6}{7}$, $\left(-\frac{\sqrt{13}}{7}, \frac{6}{7}\right)$, $\left(-\frac{\sqrt{13}}{7}, -\frac{6}{7}\right)$, and $\left(\frac{\sqrt{13}}{7}, \frac{6}{7}\right)$

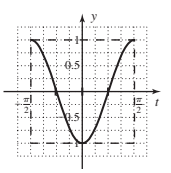
14. $\sin t = -\frac{\sqrt{7}}{4}$, $\csc t = -\frac{4}{\sqrt{7}}$,
$\cos t = \frac{3}{4}$, $\sec t = \frac{4}{3}$, $\tan t = -\frac{\sqrt{7}}{3}$, $\cot t = -\frac{3}{\sqrt{7}}$

15. $\frac{\pi}{3}$ and $\frac{2\pi}{3}$ **16.** $t \approx 2.44$ **17. a.** approx. 19.6667 rad **b.** 25 rad

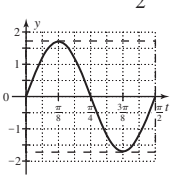
18. $|A| = 3$, $P = 2\pi$



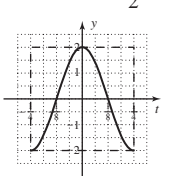
19. $|A| = 1$, $P = \pi$



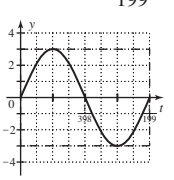
20. $|A| = 1.7$, $P = \frac{\pi}{2}$



21. $|A| = 2$, $P = \frac{1}{2}$



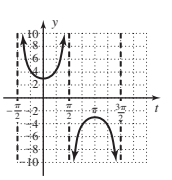
22. $|A| = 3$, $P = \frac{1}{199}$



23. $y = 0.75\sin(6t)$

24. green; red

25. $P = 2\pi$

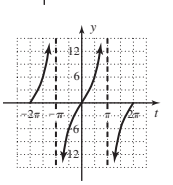


26. $y = 4\csc(3\pi t)$

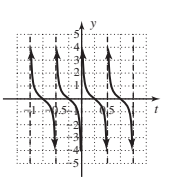
27. a. $\tan\left(\frac{7\pi}{4}\right) = -1$
b. $\cot\left(\frac{\pi}{3}\right) = \frac{1}{\sqrt{3}}$

28. a. $t = \frac{2\pi}{3}$ **b.** $t = \frac{2\pi}{3}$

29.



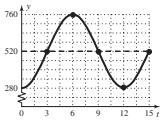
30.



31. $1.55 + k\pi$ radians; $k \in Z$ **32.** 3.5860 **33.** ≈ 151.14 m

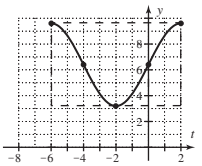
34. a. $|A| = 240$, $P = 12$, HS: 3 units right, VS: 520 units up

b.



35. a. $|A| = 3.2$, $P = 8$, HS: 6 units left, VS: 6.4 units up

b.



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 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.** $A \approx 64.3°$ **40. a.** $\cot 32.6°$ **b.** $\cos(70° 29' 45'')$

41.

Angles	Sides
$A = 49°$	$a = 89$ in.
$B = 41°$	$b \approx 77.37$ in.
$C = 90°$	$c \approx 117.93$ in.

42.

Angles	Sides
$A \approx 43.6°$	$a = 20$ m
$B \approx 46.4°$	$b = 21$ m
$C = 90°$	$c = 29$ 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.** $207° + 360°k$; answers will vary.
47. 28°, 19°, 30°

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; $\sin\theta = -\frac{3}{5}$, $\csc\theta = -\frac{5}{3}$,
$\cos\theta = \frac{4}{5}$, $\sec\theta = \frac{5}{4}$, $\tan\theta = \frac{-3}{4}$, $\cot\theta = \frac{-4}{3}$

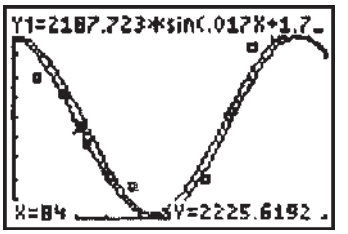
b. $x = 5$, $y = -12$, $r = 13$; QIV; $\sin\theta = \frac{-12}{13}$, $\csc\theta = \frac{-13}{12}$,
$\cos\theta = \frac{5}{13}$, $\sec\theta = \frac{13}{5}$, $\tan\theta = \frac{-12}{5}$, $\cot\theta = \frac{-5}{12}$

50. a. $\theta = 135° + 180°k$ **b.** $\theta = 30° + 360°k$ or $\theta = 330° + 360°k$
c. $\theta \approx 76.0° + 180°k$ **d.** $\theta \approx -27.0° + 360°k$ or $\theta = 207.0° + 360°k$

51. a. $y = 2187.723 \sin(0.017x + 1.751) + 2307.437$

b. $A = \frac{4450 - 90}{2} = 2180$;
$D = 90 + 2180 = 2270$;
$\frac{2\pi}{B} = 365$, $\frac{2\pi}{365} = B$; $C = \frac{3\pi}{2} - \frac{2\pi}{365}(184) = \frac{359}{730}\pi$
$y = 2180 \sin\left(\frac{2\pi}{365}x + \frac{359}{730}\pi\right) + 2270$

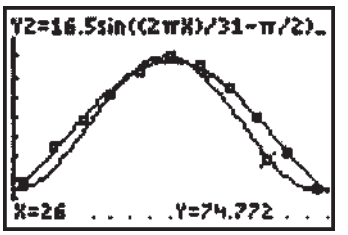
c. The largest difference from $0 \le x \le 365$ is about 372 at $x = 85$.



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. $x = 7$ $y = 87.01°$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.** $30° + 360°k$; $k \in Z$

3. a. 100.755° **b.** 48° 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. $\approx$ 225 ft 9.6 in. **b.** $\frac{23\pi}{480}$ rad/sec $\approx$ 0.1505 rad/sec

c. 11.29 ft/sec $\approx$ 7.7 mph

9.

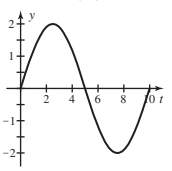
Angles	Sides
$A = 33°$	$a \approx 8.2$ cm
$B = 57°$	$b \approx 12.6$ cm
$C = 90°$	$c = 15.0$ cm

10. about 67 cm, 49.6° **11.** 57.9 m **12. a.** $\frac{7\pi}{6}$ **b.** $\frac{11\pi}{6}$ **c.** $\frac{3\pi}{4}$

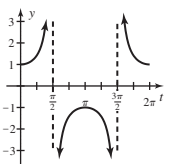
13. a. $W(t) = 18.4\sin\left(\frac{\pi}{12}t\right) + 34.1$, in ten-thousands of gallons

b. 433,000 gal; 249,000 gal

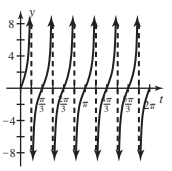
14. a. D: $t \in R$, R: $y \in [-2, 2]$, $P = 10$, $|A| = 2$;



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: $y \in R$, $P = \frac{\pi}{3}$



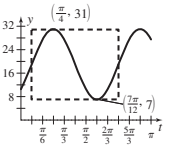
15. a. $y = 35.223\sin(0.576x - 2.589) + 6.120$

b.

Month (Jan → 1)	Low Temp. (°F)
1	−26
3	−21
5	16
7	41
9	25
11	−14

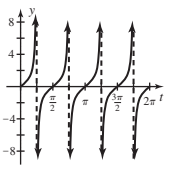
16. $|A| = 12$, $P = \frac{2\pi}{3}$, HS: $\frac{\pi}{12}$ units right, VS: 19 units up

PI: $\frac{\pi}{12} \le t < \frac{3\pi}{4}$

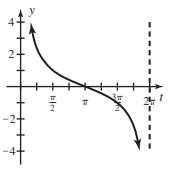


17. 1260°

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

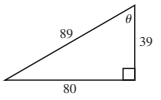
Exercise 2. a. $t = \frac{4\pi}{3}, \frac{5\pi}{3}$ **b.** $t = \frac{\pi}{4}, \frac{7\pi}{4}$ **c.** $t = \frac{\pi}{6}, \frac{7\pi}{6}$ **d.** $t = \frac{\pi}{4}, \frac{7\pi}{4}$

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. $-5 < x < 3$

3.



hyp = 89; $\theta \approx 64°$; $90 - \theta = 26°$

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: $(-4, 0)$

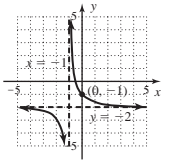
b. $f(x) \geq 0$: $x \in [-4, 0] \cup \{4\}$
$f(x) < 0$: $x \in (0, 4)$

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.

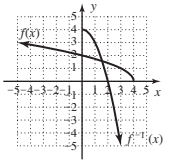


15. $x = -9$, $y = 40$, $r = 41$, QII;
$\cos\theta = \frac{-9}{41}$, $\sin\theta = \frac{40}{41}$, $\tan\theta = \frac{-40}{9}$, $\sec\theta = \frac{-41}{9}$, $\csc\theta = \frac{41}{40}$,
$\cot\theta = \frac{-9}{40}$, $\theta \approx 102.7°$

17. $S = 18$ m; $A = 135$ m^2

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%

27.

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

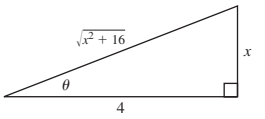
1. hyp $= x + 4$

$\sin\theta = \frac{4}{x+4}$, $\cos\theta = \frac{\sqrt{x^2+8x}}{x+4}$

$\csc\theta = \frac{x+4}{4}$, $\sec\theta = \frac{x+4}{\sqrt{x^2+8x}}$

$\tan\theta = \frac{4}{\sqrt{x^2+8x}}$, $\cot\theta = \frac{\sqrt{x^2+8x}}{4}$

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;
$\tan\theta = \frac{\sec\theta}{\csc\theta}; \frac{\sin\theta}{\cos\theta} = \frac{\sec\theta}{\csc\theta}; \frac{1}{\cot\theta} = \frac{\sec\theta}{\csc\theta}; \frac{1}{\cot\theta} = \frac{\sin\theta}{\cos\theta}$

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. $\sin\theta\cot\theta = \frac{\cancel{\sin\theta}}{}\frac{\cos\theta}{\cancel{\sin\theta}} = \cos\theta$

17. $\sec^2\theta\cot^2\theta = \frac{1}{\cancel{\cos^2\theta}}\frac{\cancel{\cos^2\theta}}{\sin^2\theta} = \frac{1}{\sin^2\theta} = \csc^2\theta$

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. $\tan\theta(\csc\theta + \cot\theta) = \tan\theta\csc\theta + \tan\theta\cot\theta =$
$\frac{\cancel{\sin\theta}}{\cos\theta}\frac{1}{\cancel{\sin\theta}} + 1 = \frac{1}{\cos\theta} + 1 = \sec\theta + 1$

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. $\frac{\sin\theta\cos\theta + \sin\theta}{\cos\theta + \cos^2\theta} = \frac{\sin\theta\,\cancel{(\cos\theta + 1)}}{\cos\theta\,\cancel{(1 + \cos\theta)}} = \frac{\sin\theta}{\cos\theta} = \tan\theta$

29. $\frac{1 + \sin\theta}{\cos\theta + \cos\theta\sin\theta} = \frac{(1)\cancel{(1 + \sin\theta)}}{(\cos\theta)\cancel{(1 + \sin\theta)}} = \frac{1}{\cos\theta} = \sec\theta$

31. $\frac{\sin\theta\tan\theta + \sin\theta}{\tan\theta + \tan^2\theta} = \frac{\sin\theta\cancel{(\tan\theta + 1)}}{\tan\theta\cancel{(1 + \tan\theta)}} =$
$\frac{\sin\theta}{\tan\theta} = \frac{\sin\theta}{\sin\theta/\cos\theta} = \frac{\cancel{\sin\theta}\cos\theta}{\cancel{\sin\theta}} = \cos\theta$

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. $\dfrac{\tan\theta}{\csc\theta} - \dfrac{\sin\theta}{\cos\theta} = \dfrac{\tan\theta\cos\theta - \sin\theta\csc\theta}{\csc\theta\cos\theta} = \dfrac{\dfrac{\sin\theta}{\cancel{\cos\theta}}\cancel{\cos\theta} - 1}{\dfrac{1}{\sin\theta}\cos\theta} = \dfrac{\sin\theta - 1}{\cot\theta}$

43. $\dfrac{\sec\theta}{\sin\theta} - \dfrac{\csc\theta}{\sec\theta} = \dfrac{\sec^2\theta - \sin\theta\csc\theta}{\sin\theta\sec\theta} = \dfrac{\sec^2\theta - 1}{\sin\theta\dfrac{1}{\cos\theta}} = \dfrac{\tan^2\theta}{\cancel{\tan\theta}} = \tan\theta$

45. $\dfrac{\sin\theta}{\pm\sqrt{1-\sin^2\theta}}$ **47.** $\pm\sqrt{\dfrac{1}{\cot^2\theta}+1}$ **49.** $\dfrac{\pm\sqrt{1-\sin^2\theta}}{\sin\theta}$

51. $\sin\theta = \dfrac{21}{29}, \tan\theta = -\dfrac{21}{20}, \sec\theta = -\dfrac{29}{20}, \csc\theta = \dfrac{29}{21}, \cot\theta = -\dfrac{20}{21}$

53. $\cos\theta = -\dfrac{8}{17}, \sin\theta = -\dfrac{15}{17}, \sec\theta = -\dfrac{17}{8}, \csc\theta = -\dfrac{17}{15}, \cot\theta = \dfrac{8}{15}$

55. $\cos\theta = \dfrac{x}{\sqrt{x^2+25}}, \sin\theta = \dfrac{5}{\sqrt{x^2+25}}, \tan\theta = \dfrac{5}{x}$,
$\sec\theta = \dfrac{\sqrt{x^2+25}}{x}, \csc\theta = \dfrac{\sqrt{x^2+25}}{5}$

57. $\cos\theta = -\dfrac{\sqrt{120}}{13} = -\dfrac{2\sqrt{30}}{13}, \tan\theta = \dfrac{7}{2\sqrt{30}}, \sec\theta = -\dfrac{13}{2\sqrt{30}}$,
$\csc\theta = -\dfrac{13}{7}, \cot\theta = \dfrac{2\sqrt{30}}{7}$

59. $\sin\theta = \dfrac{\sqrt{32}}{9} = \dfrac{4\sqrt{2}}{9}, \cos\theta = -\dfrac{7}{9}, \tan\theta = -\dfrac{4\sqrt{2}}{7}$,
$\csc\theta = \dfrac{9}{4\sqrt{2}}, \cot\theta = -\dfrac{7}{4\sqrt{2}}$

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. $\tan^2\theta\sec\theta - 4\tan^2\theta = \tan^2\theta(\sec\theta - 4)$
$= (\sec\theta - 4)(\tan^2\theta) = (\sec\theta - 4)(\sec^2 - 1)$
$= (\sec\theta - 4)(\sec\theta - 1)(\sec\theta + 1)$

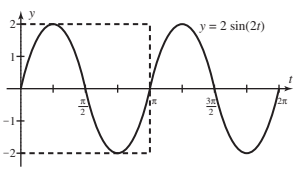
69. $\cos^2\theta\sin\theta - \cos^2\theta = \cos^2\theta(\sin\theta - 1)$
$= (1 - \sin^2\theta)(\sin\theta - 1)$
$= (1 + \sin\theta)(1 - \sin\theta)(\sin\theta - 1)$
$= (1 + \sin\theta)(1 - \sin\theta)(-1)(1 - \sin\theta)$
$= -1(1 + \sin\theta)(1 - \sin\theta)^2$

71. $\tan\theta = \dfrac{m_2 - m_1}{1 + m_1m_2}$

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. about 1148 ft **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. $\dfrac{1 - \sin(-x)}{\cos x + \cos(-x)\sin x} = \dfrac{1 + \sin x}{\cos x + \cos x\sin x} = \dfrac{1 + \sin x}{\cos x(1 + \sin x)}$
$= \dfrac{1}{\cos x} = \sec x$

13. $\cos^2 x\tan^2 x = \cancel{\cos^2 x}\dfrac{\sin^2 x}{\cancel{\cos^2 x}} = \sin^2 x = 1 - \cos^2 x$

15. $\tan x + \cot x = \dfrac{\sin x}{\cos x} + \dfrac{\cos x}{\sin x}$
$= \dfrac{\sin^2 x + \cos^2 x}{\cos x\sin x}$
$= \dfrac{1}{\cos x\sin x}$
$= \dfrac{1}{\cos x}\dfrac{1}{\sin x}$
$= \sec x\csc x$

17. $\csc x - \sin x = \dfrac{1}{\sin x} - \sin x$
$= \dfrac{1 - \sin^2 x}{\sin x}$
$= \dfrac{\cos^2 x}{\sin x}$
$= \dfrac{\cos x}{\sin x/\cos x}$
$= \dfrac{\cos x}{\tan x}$

19. $\dfrac{\sec x}{\cot x + \tan x} = \dfrac{\dfrac{1}{\cos x}(\sin x\cos x)}{\left(\dfrac{\cos x}{\sin x} + \dfrac{\sin x}{\cos x}\right)(\sin x\cos x)}$
$= \dfrac{\sin x}{\cos^2 x + \sin^2 x}$
$= \dfrac{\sin x}{1}$
$= \sin x$

21. $\dfrac{\sin x - \csc x}{\csc x} = \dfrac{\sin x - \dfrac{1}{\sin x}}{\dfrac{1}{\sin x}}$
$= \dfrac{\left(\sin x - \dfrac{1}{\sin x}\right)(\sin x)}{\dfrac{1}{\sin x}\sin x}$
$= \dfrac{\sin^2 x - 1}{1}$
$= -\cos^2 x$

23. $\dfrac{1}{\csc x - \sin x} = \dfrac{1}{\dfrac{1}{\sin x} - \sin x}$
$= \dfrac{1(\sin x)}{\left(\dfrac{1}{\sin x} - \sin x\right)(\sin x)}$
$= \dfrac{\sin x}{1 - \sin^2 x}$
$= \dfrac{\sin x}{\cos^2 x}$
$= \dfrac{\sin x}{\cos x}\dfrac{1}{\cos x}$
$= \tan x\sec x$

25. $\dfrac{\cos\theta}{1 - \sin\theta} = \dfrac{\cos\theta}{1 - \sin\theta}\cdot\dfrac{1 + \sin\theta}{1 + \sin\theta}$
$= \dfrac{\cos\theta(1 + \sin\theta)}{1 - \sin^2\theta}$
$= \dfrac{\cos\theta(1 + \sin\theta)}{\cos^2\theta}$
$= \dfrac{1 + \sin\theta}{\cos\theta}$
$= \dfrac{1}{\cos\theta} + \dfrac{\sin\theta}{\cos\theta}$
$= \sec\theta + \tan\theta$

27. $\dfrac{\cos x}{1+\sin x} = \dfrac{\cos x}{1+\sin x}\cdot\dfrac{1-\sin x}{1-\sin x}$
$= \dfrac{\cos x(1-\sin x)}{1-\sin^2 x}$
$= \dfrac{\cos x(1-\sin x)}{\cos^2 x}$
$= \dfrac{1-\sin x}{\cos x}$

29. $\dfrac{\csc x}{\cos x} - \dfrac{\cos x}{\csc x} = \dfrac{\csc^2 x - \cos^2 x}{\cos x \csc x}$
$= \dfrac{\csc^2 x - (1-\sin^2 x)}{\cos x \dfrac{1}{\sin x}}$
$= \dfrac{\csc^2 x - 1 + \sin^2 x}{\cot x}$
$= \dfrac{\cot^2 x + \sin^2 x}{\cot x}$

31. $\dfrac{\sin x}{1+\sin x} - \dfrac{\sin x}{1-\sin x} = \dfrac{\sin x(1-\sin x) - \sin x(1+\sin x)}{(1+\sin x)(1-\sin x)}$
$= \dfrac{\cancel{\sin x} - \sin^2 x - \cancel{\sin x} - \sin^2 x}{1-\sin^2 x}$
$= \dfrac{-2\sin^2 x}{\cos^2 x}$
$= -2\tan^2 x$

33. $\dfrac{\cot x}{1+\csc x} - \dfrac{\cot x}{1-\csc x} = \dfrac{\cot x(1-\csc x) - \cot x(1+\csc x)}{(1+\csc x)(1-\csc x)}$
$= \dfrac{\cancel{\cot x} - \cot x \csc x - \cancel{\cot x} - \cot x \csc x}{1-\csc^2 x}$
$= \dfrac{-2\cot x \csc x}{-\cot^2 x}$
$= \dfrac{2\csc x}{\cot x}$
$= \dfrac{2\dfrac{1}{\cancel{\sin x}}}{\dfrac{\cos x}{\cancel{\sin x}}}$
$= \dfrac{2}{\cos x}$
$= 2\sec x$

35. $\dfrac{\sec^2 x}{1+\cot^2 x} = \dfrac{\sec^2 x}{\csc^2 x}$
$= \dfrac{\dfrac{1}{\cos^2 x}}{\dfrac{1}{\sin^2 x}}$
$= \dfrac{\sin^2 x}{\cos^2 x}$
$= \tan^2 x$

37. $\sin^2 x(\cot^2 x - \csc^2 x) = \sin^2 x \cot^2 x - \sin^2 x \csc^2 x$
$= \cancel{\sin^2 x}\dfrac{\cos^2 x}{\cancel{\sin^2 x}} - 1$
$= \cos^2 x - 1$
$= -\sin^2 x$

39. $\cos x \cot x + \sin x = \cos x \dfrac{\cos x}{\sin x} + \sin x$
$= \dfrac{\cos^2 x}{\sin x} + \sin x$
$= \dfrac{\cos^2 x + \sin^2 x}{\sin x}$
$= \dfrac{1}{\sin x}$
$= \csc x$

41. $\dfrac{1+\sin x}{1-\sin x} = \dfrac{(1+\sin x)}{(1-\sin x)}\dfrac{(1+\sin x)}{(1+\sin x)}$
$= \dfrac{1+2\sin x+\sin^2 x}{1-\sin^2 x}$
$= \dfrac{1+2\sin x+\sin^2 x}{\cos^2 x}$
$= \dfrac{1}{\cos^2 x} + 2\dfrac{\sin x}{\cos x}\dfrac{1}{\cos x} + \dfrac{\sin^2 x}{\cos^2 x}$
$= \sec^2 x + 2\tan x \sec x + \tan^2 x$
$= (\sec x + \tan x)^2$
$= (\tan x + \sec x)^2$

43. $\dfrac{\cos x - \sin x}{1-\tan x} = \dfrac{(\cos x - \sin x)}{(1-\tan x)}\dfrac{(\cos x + \sin x)}{(\cos x + \sin x)}$
$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x + \sin x - \sin x - \dfrac{\sin^2 x}{\cos x}}$
$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x\left(1 - \dfrac{\sin^2 x}{\cos^2 x}\right)}$
$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x(1-\tan^2 x)}$
$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x(1-\tan x)(1+\tan x)}$
$= \dfrac{\cancel{(\cos x - \sin x)}(\cos x + \sin x)}{\cancel{(\cos x - \sin x)}(1+\tan x)}$
$= \dfrac{\cos x + \sin x}{1+\tan x}$

45. $\dfrac{\tan^2 x - \cot^2 x}{\tan x - \cot x} = \dfrac{(\tan x + \cot x)(\tan x - \cot x)}{\tan x - \cot x}$
$= \tan x + \cot x$
$= \dfrac{\sin x}{\cos x} + \dfrac{\cos x}{\sin x}$
$= \dfrac{\sin^2 x + \cos^2 x}{\cos x \sin x}$
$= \dfrac{1}{\cos x \sin x}$
$= \dfrac{1}{\cos x}\dfrac{1}{\sin x}$
$= \sec x \csc x$
$= \csc x \sec x$

47. $\dfrac{\cot x}{\cot x + \tan x} = \dfrac{\dfrac{\cos x}{\sin x}}{\left(\dfrac{\cos x}{\sin x} + \dfrac{\sin x}{\cos x}\right)}\dfrac{(\cos x \sin x)}{(\cos x \sin x)}$
$= \dfrac{\cos^2 x}{\cos^2 x + \sin^2 x}$
$= \dfrac{\cos^2 x}{1}$
$= 1 - \sin^2 x$

49. $\dfrac{\sec^4 x - \tan^4 x}{\sec^2 x + \tan^2 x} = \dfrac{(\sec^2 x - \tan^2 x)(\cancel{\sec^2 x + \tan^2 x})}{(\cancel{\sec^2 x + \tan^2 x})}$
$= \sec^2 x - \tan^2 x$
$= 1$

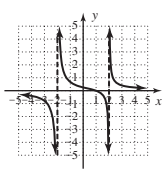
51. $\dfrac{\cos^4 x - \sin^4 x}{\cos^2 x} = \dfrac{(\cos^2 x - \sin^2 x)(\cos^2 x + \sin^2 x)}{\cos^2 x}$
$= \dfrac{(\cos^2 x - \sin^2 x)(1)}{\cos^2 x}$
$= \dfrac{\cos^2 x}{\cos^2 x} - \dfrac{\sin^2 x}{\cos^2 x}$
$= 1 - \tan^2 x$
$= 1 - (\sec^2 x - 1)$
$= 1 - \sec^2 x + 1$
$= 2 - \sec^2 x$

53. $(\sec x + \tan x)^2 = \sec^2 x + 2\sec x \tan x + \tan^2 x$
$= \dfrac{1}{\cos^2 x} + \dfrac{2\sin x}{\cos^2 x} + \dfrac{\sin^2 x}{\cos^2 x}$
$= \dfrac{1 + 2\sin x + \sin^2 x}{\cos^2 x}$
$= \dfrac{(1 + \sin x)^2}{\cos^2 x}$
$= \dfrac{(\sin x + 1)^2}{\cos^2 x}$

55. $\dfrac{\cos x}{\sin x} + \dfrac{\sin x}{\cos x} + \dfrac{\csc x}{\sec x} = \dfrac{\cos^2 x \sec x + \sin^2 x \sec x + \csc x \sin x \cos x}{\sin x \cos x \sec x}$
$= \dfrac{\sec x(\cos^2 x + \sin^2 x) + (1)\cos x}{\sin x(1)}$
$= \dfrac{\sec x + \cos x}{\sin x}$

57. $\dfrac{\sin^4 x - \cos^4 x}{\sin^3 x + \cos^3 x} = \dfrac{(\sin^2 x + \cos^2 x)(\sin^2 x - \cos^2 x)}{(\sin x + \cos x)(\sin^2 x - \sin x \cos x + \cos^2 x)}$
$= \dfrac{(1)(\cancel{\sin x + \cos x})(\sin x - \cos x)}{(\cancel{\sin x + \cos x})(\sin^2 x + \cos^2 x - \sin x \cos x)}$
$= \dfrac{\sin x - \cos x}{1 - \sin x \cos x}$

59. Answers will vary. **61.** Answers will vary. **63.** Answers will vary.
65. identity **67.** not an identity
69. a. $d^2 = (20 + x\cos\theta)^2 + (20 - x\sin\theta)^2$
$= 400 + 40x\cos\theta + x^2\cos^2\theta + 400 - 40x\sin\theta + x^2\sin^2\theta$
$= 800 + 40x(\cos\theta - \sin\theta) + x^2(\cos^2\theta + \sin^2\theta)$
$= 800 + 40x(\cos\theta - \sin\theta) + x^2$
b. ≈42.2 ft
71. a. $h = \sqrt{\cot x + \tan x}$;
$h \approx 3.76$
b. $\cot x + \tan x = \dfrac{\cos x}{\sin x} + \dfrac{\sin x}{\cos x}$
$= \dfrac{\cos^2 x + \sin^2 x}{\sin x \cos x}$
$= \dfrac{1}{\sin x \cos x}$
$= \csc x \sec x$;
$h = \sqrt{\csc x \sec x}$
$h \approx 3.76$; yes
73. $D^2 = 400 + 40x\cos\theta + x^2$
$D \approx 40.5$ ft
75. $\sin\alpha = \cos\theta$
77. $\dfrac{\sin^6 x - \cos^6 x}{\sin^4 x - \cos^4 x} = \dfrac{(\sin^3 x - \cos^3 x)(\sin^3 x + \cos^3 x)}{(\sin^2 x + \cos^2 x)(\sin^2 x - \cos^2 x)}$
$= \dfrac{(\cancel{\sin x - \cos x})(\sin^2 x + \sin x\cos x + \cos^2 x)(\cancel{\sin x + \cos x})(\sin^2 x - \sin x\cos x + \cos^2 x)}{(1)(\cancel{\sin x + \cos x})(\cancel{\sin x - \cos x})}$
$= (1 + \sin x\cos x)(1 - \sin x\cos x)$
$= 1 - \sin^2 x\cos^2 x$
79.



81. ≈752.3 yd

Exercises 7.3, pp. 675–680

1. false, QII **3.** repeat, opposite **5.** Answers will vary.
7. $\dfrac{\sqrt{2} - \sqrt{6}}{4}$ **9.** $\dfrac{\sqrt{2} - \sqrt{6}}{4}$
11. a. $\cos(45° + 30°) = \cos 45°\cos 30° - \sin 45°\sin 30° = \dfrac{\sqrt{6} - \sqrt{2}}{4}$
b. $\cos(120° - 45°) = \cos 120°\cos 45° + \sin 120°\sin 45° =$
$\dfrac{-\sqrt{2} + \sqrt{6}}{4} = \dfrac{\sqrt{6} - \sqrt{2}}{4}$
13. $\cos(5\theta)$ **15.** $\dfrac{\sqrt{3}}{2}$ **17.** $-\dfrac{16}{65}$ **19.** $\sin 33°$ **21.** $\cot\left(\dfrac{\pi}{12}\right)$
23. $\cos\left(\dfrac{\pi}{3} + \theta\right)$ **25.** $\sin(8x)$ **27.** $\tan(3\theta)$ **29.** 1 **31.** $\sqrt{3}$
33. a. $\dfrac{-304}{425}$ **b.** $\dfrac{-304}{297}$ **35.** $\dfrac{\sqrt{6} + \sqrt{2}}{4}$ **37.** $\dfrac{\sqrt{6} + \sqrt{2}}{4}$
39. $-\dfrac{1}{\sqrt{3}} = -\dfrac{\sqrt{3}}{3}$ **41.** $\dfrac{3 + \sqrt{3}}{3 - \sqrt{3}}$
43. a. $\sin(45° - 30°) = \sin 45°\cos 30° - \cos 45°\sin 30° = \dfrac{\sqrt{6} - \sqrt{2}}{4}$
b. $\sin(135° - 120°) = \sin 135°\cos 120° - \cos 135°\sin 120°$
$= \left(\dfrac{\sqrt{2}}{2}\right)\left(-\dfrac{1}{2}\right) - \left(\dfrac{-\sqrt{2}}{2}\right)\left(\dfrac{\sqrt{3}}{2}\right)$
$= \dfrac{-\sqrt{2}}{4} + \dfrac{\sqrt{6}}{4}$
$= \dfrac{\sqrt{6} - \sqrt{2}}{4}$
45. $\dfrac{-\sqrt{2} - \sqrt{6}}{4}$ **47. a.** $\dfrac{319}{481}$ **b.** $\dfrac{480}{481}$ **c.** $-\dfrac{319}{360}$
49. a. $\dfrac{3416}{4505}$ **b.** $-\dfrac{1767}{4505}$ **c.** $\dfrac{3416}{2937}$
51. a. $\dfrac{12 + 5\sqrt{3}}{26}$ **b.** $\dfrac{12\sqrt{3} - 5}{26}$ **c.** $\dfrac{12 + 5\sqrt{3}}{12\sqrt{3} - 5}$
53. a. $\dfrac{247}{265}$ **b.** $\dfrac{96}{265}$ **c.** $\dfrac{247}{96}$ $(90° - \alpha) + \theta + (90° - \beta) = 180°$
55. $\sin(\pi - \alpha) = \sin\pi\cos\alpha - \cos\pi\sin\alpha$
$= 0 - (-1)\sin\alpha$
$= \sin\alpha$
57. $\cos\left(x + \dfrac{\pi}{4}\right) = \cos x\cos\left(\dfrac{\pi}{4}\right) - \sin x\sin\left(\dfrac{\pi}{4}\right) =$
$\cos x\left(\dfrac{\sqrt{2}}{2}\right) - \sin x\left(\dfrac{\sqrt{2}}{2}\right) = \dfrac{\sqrt{2}}{2}(\cos x - \sin x)$
59. $\tan\left(x + \dfrac{\pi}{4}\right) = \dfrac{\tan x + \tan\left(\dfrac{\pi}{4}\right)}{1 - \tan x\tan\left(\dfrac{\pi}{4}\right)} = \dfrac{\tan x + 1}{1 - \tan x} = \dfrac{1 + \tan x}{1 - \tan x}$
61. $\cos(\alpha + \beta) + \cos(\alpha - \beta) =$
$\cos\alpha\cos\beta - \cancel{\sin\alpha\sin\beta} + \cos\alpha\cos\beta + \cancel{\sin\alpha\sin\beta} =$
$2\cos\alpha\cos\beta$
63. $\cos(2t) = \cos(t + t)$
$= \cos t\cos t - \sin t\sin t$
$= \cos^2 t - \sin^2 t$
65. $\sin(3t) = \sin(2t + t)$
$= \sin(2t)\cos t + \cos(2t)\sin t$
$= 2\sin t\cos t\cos t + (\cos^2 t - \sin^2 t)\sin t$
$= 2\sin t\cos^2 t + \sin t\cos^2 t - \sin^3 t$
$= 3\sin t\cos^2 t - \sin^3 t$
$= 3\sin t(1 - \sin^2 t) - \sin^3 t$
$= 3\sin t - 3\sin^3 t - \sin^3 t$
$= -4\sin^3 t + 3\sin t$
67. $\cos\left(x - \dfrac{\pi}{4}\right) = \cos x\cos\left(\dfrac{\pi}{4}\right) + \sin x\sin\left(\dfrac{\pi}{4}\right)$
$= \cos x\left(\dfrac{\sqrt{2}}{2}\right) + \sin x\left(\dfrac{\sqrt{2}}{2}\right)$
$= \dfrac{\sqrt{2}}{2}(\cos x + \sin x)$
69. $F = \dfrac{Wk}{c}\dfrac{1 - \sqrt{3}}{1 + \sqrt{3}}$

71. $R = \dfrac{\cos s \cos t}{\overline{\omega}C \sin(s + t)}$
$= \dfrac{\cos s \cos t}{\overline{\omega}C(\sin s \cos t + \cos s \sin t)}$
$= \dfrac{\cos s \cos t \dfrac{1}{\cos s \cos t}}{\overline{\omega}C(\sin s \cos t + \cos s \sin t)\dfrac{1}{\cos s \cos t}}$
$= \dfrac{1}{\overline{\omega}C\left(\dfrac{\sin s \cancel{\cos t}}{\cos s \cancel{\cos t}} + \dfrac{\cancel{\cos s} \sin t}{\cancel{\cos s} \cos t}\right)}$
$= \dfrac{1}{\overline{\omega}C(\tan s + \tan t)}$

73. $\dfrac{A}{B} = \dfrac{\sin\theta \cos(90° - \theta)}{\cos\theta \sin(90° - \theta)}$
$\dfrac{A}{B} = \dfrac{\sin\theta (\cos 90° \cos\theta + \sin 90° \sin\theta)}{\cos\theta (\sin 90° \cos\theta - \cos 90° \sin\theta)}$
$= \dfrac{\sin\theta(0 + \sin\theta)}{\cos\theta (\cos\theta - 0)}$
$= \dfrac{\sin^2\theta}{\cos^2\theta}$
$= \tan^2\theta$

75. verified using sum identity for sine

77. $\dfrac{f(x + h) - f(x)}{h} = \dfrac{\sin(x + h) - \sin x}{h}$
$= \dfrac{\sin x \cos h + \cos x \sin h - \sin x}{h} = \dfrac{\sin x \cos h - \sin x + \cos x \sin h}{h}$
$= \dfrac{\sin x(\cos h - 1) + \cos x \sin h}{h} = \sin x\left(\dfrac{\cos h - 1}{h}\right) + \cos x\left(\dfrac{\sin h}{h}\right)$

79. $\dfrac{-\sqrt{2}}{2}$ **81.** $\dfrac{1}{2}$

83. $D = d$, so $D^2 = d^2$, and
$D^2 = (\cos\alpha - \cos\beta)^2 + (\sin\alpha - \sin\beta)^2$
$= \cos^2\alpha - 2\cos\alpha\cos\beta + \cos^2\beta + \sin^2\alpha - 2\sin\alpha\sin\beta + \sin^2\beta$
$= 2 - 2\cos\alpha\cos\beta - 2\sin\alpha\sin\beta$
$d^2 = \sin^2(\alpha - \beta) + [\cos(\alpha - \beta) - 1]^2$
$= \sin^2(\alpha - \beta) + \cos^2(\alpha - \beta) - 2\cos(\alpha - \beta) + 1$
$= 2 - 2\cos(\alpha - \beta)$
$D^2 = d^2$ so
$2 - 2\cos\alpha\cos\beta - 2\sin\alpha\sin\beta = 2 - 2\cos(\alpha - \beta)$
$\dfrac{-2\cos\alpha\cos\beta - 2\sin\alpha\sin\beta}{-2} = \dfrac{-2\cos(\alpha - \beta)}{-2}$
$\cos\alpha\cos\beta + \sin\alpha\sin\beta = \cos(\alpha - \beta)$

85. a. $P = 16$ **b.** $P = \dfrac{\pi}{2}$ **87.** about 19.3 ft

Exercises 7.4, pp. 688–693

1. sum, $\alpha = \beta$ **3.** $2x$, x **5.** Answers will vary.

7. $\sin(2\theta) = -\dfrac{120}{169}, \cos(2\theta) = \dfrac{119}{169}, \tan(2\theta) = -\dfrac{120}{119}$

9. $\sin(2\theta) = -\dfrac{720}{1681}, \cos(2\theta) = -\dfrac{1519}{1681}, \tan(2\theta) = \dfrac{720}{1519}$

11. $\sin(2\theta) = \dfrac{2184}{7225}, \cos(2\theta) = \dfrac{6887}{7225}, \tan(2\theta) = \dfrac{2184}{6887}$

13. $\sin(2\theta) = -\dfrac{5280}{5329}, \cos(2\theta) = \dfrac{721}{5329}, \tan(2\theta) = \dfrac{-5280}{721}$

15. $\sin(2\theta) = -\dfrac{24}{25}, \cos(2\theta) = \dfrac{7}{25}, \tan(2\theta) = \dfrac{-24}{7}$

17. $\sin\theta = \dfrac{4}{5}, \cos\theta = \dfrac{3}{5}, \tan\theta = \dfrac{4}{3}$

19. $\sin\theta = \dfrac{21}{29}, \cos\theta = \dfrac{20}{29}, \tan\theta = \dfrac{21}{20}$

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. $\dfrac{1}{4}$ **25.** $\dfrac{\sqrt{2}}{2}$ **27.** 1 **29.** $4.5\sin(6x)$ **31.** $\dfrac{1}{8} - \dfrac{1}{8}\cos(4x)$

33. $\dfrac{9}{8} + \dfrac{3}{2}\cos(2x) + \dfrac{3}{8}\cos(4x)$

35. $\dfrac{5}{8} - \dfrac{7}{8}\cos(2x) + \dfrac{3}{8}\cos(4x) - \dfrac{1}{8}\cos(2x)\cos(4x)$

37. $\sin\theta = \dfrac{\sqrt{2 - \sqrt{2}}}{2}, \cos\theta = \dfrac{\sqrt{2 + \sqrt{2}}}{2}, \tan\theta = \sqrt{2} - 1$

39. $\sin\theta = \dfrac{\sqrt{2 - \sqrt{3}}}{2}, \cos\theta = \dfrac{\sqrt{2 + \sqrt{3}}}{2}, \tan\theta = 2 - \sqrt{3}$

41. $\sin\theta = \dfrac{\sqrt{2 + \sqrt{2}}}{2}, \cos\theta = \dfrac{\sqrt{2 - \sqrt{2}}}{2}, \tan\theta = \sqrt{2} + 1$

43. $\sin\theta = \dfrac{\sqrt{2 + \sqrt{2}}}{2}, \cos\theta = \dfrac{\sqrt{2 - \sqrt{2}}}{2}, \tan\theta = \sqrt{2} + 1$

45. $\dfrac{\sqrt{2 - \sqrt{2 + \sqrt{2}}}}{2}$ **47.** $\dfrac{\sqrt{2 - \sqrt{2 + \sqrt{3}}}}{2}$ **49.** $\cos 15°$

51. $\tan 2\theta$ **53.** $\tan x$

55. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{3}{\sqrt{13}}, \cos\left(\dfrac{\theta}{2}\right) = \dfrac{2}{\sqrt{13}}, \tan\left(\dfrac{\theta}{2}\right) = \dfrac{3}{2}$

57. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{3}{\sqrt{10}}, \cos\left(\dfrac{\theta}{2}\right) = \dfrac{1}{\sqrt{10}}, \tan\left(\dfrac{\theta}{2}\right) = 3$

59. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{7}{\sqrt{74}}, \cos\left(\dfrac{\theta}{2}\right) = \dfrac{5}{\sqrt{74}}, \tan\left(\dfrac{\theta}{2}\right) = \dfrac{7}{5}$

61. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{1}{\sqrt{226}}, \cos\left(\dfrac{\theta}{2}\right) = \dfrac{15}{\sqrt{226}}, \tan\left(\dfrac{\theta}{2}\right) = \dfrac{1}{15}$

63. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{5}{\sqrt{29}}, \cos\left(\dfrac{\theta}{2}\right) = -\dfrac{2}{\sqrt{29}}, \tan\left(\dfrac{\theta}{2}\right) = \dfrac{5}{-2}$

65. $\dfrac{1}{2}[\cos(12\theta) - \cos(4\theta)]$ **67.** $\sin(5t) - \sin(2t)$

69. $\cos(1540\pi t) + \cos(2418\pi t)$ **71.** $\dfrac{1 + \sqrt{3}}{2}$ **73.** $\dfrac{\sqrt{2}}{4}$

75. $2\cos\left(\dfrac{13}{2}h\right)\cos\left(\dfrac{5}{2}h\right)$ **77.** $2\cos x \sin\left(\dfrac{3}{8}x\right)$

79. $2\cos(1072\pi t)\cos(375\pi t)$

81. $\dfrac{\sqrt{6}}{2}$ **83.** $-\dfrac{\sqrt{2}}{2}$ **85.** $\dfrac{2\sin x \cos x}{\cos^2 x - \sin^2 x} = \dfrac{\sin(2x)}{\cos(2x)} = \tan(2x)$

87. $(\sin x + \cos x)^2 = \sin^2 x + 2\sin x\cos x + \cos^2 x$
$= \sin^2 x + \cos^2 x + 2\sin x\cos x$
$= 1 + 2\sin x\cos x$
$= 1 + \sin(2x)$

89. $\cos(8\theta) = \cos(2 \cdot 4\theta) = \cos^2(4\theta) - \sin^2(4\theta)$

91. $\dfrac{\cos(2\theta)}{\sin^2\theta} = \dfrac{\cos^2\theta - \sin^2\theta}{\sin^2\theta}$
$= \dfrac{\cos^2\theta}{\sin^2\theta} - \dfrac{\sin^2\theta}{\sin^2\theta}$
$= \cot^2\theta - 1$

93. $\tan(2\theta) = \dfrac{2\tan\theta}{1-\tan^2\theta}$

$= \dfrac{(2\tan\theta)\dfrac{1}{\tan\theta}}{(1-\tan^2\theta)\dfrac{1}{\tan\theta}}$

$= \dfrac{2}{\dfrac{1}{\tan\theta} - \tan\theta}$

$= \dfrac{2}{\cot\theta - \tan\theta}$

95. $2\csc(2x) = \dfrac{2}{\sin(2x)}$

$= \dfrac{2}{2\sin x\cos x}$

$= \dfrac{1}{\sin x\cos x}$

$= \dfrac{\sin^2 x + \cos^2 x}{\sin x\cos x}$

$= \dfrac{\sin^{\not 2} x}{\not{\sin x}\cos x} + \dfrac{\cos^{\not 2} x}{\sin x\,\not{\cos x}}$

$= \dfrac{\sin x}{\cos x} + \dfrac{\cos x}{\sin x}$

$= \tan x + \cot x$

97. $\cos^2\left(\dfrac{x}{2}\right) - \sin^2\left(\dfrac{x}{2}\right) = \cos\left(2\cdot\dfrac{x}{2}\right) = \cos x$

99. $1 - 4\sin^2\theta + 4\sin^4\theta = (1-2\sin^2\theta)^2$

$= [\cos(2\theta)]^2$

$= \cos^2(2\theta)$

$= 1 - \sin^2(2\theta)$

101. $\dfrac{\sin(120\pi t) + \sin(80\pi t)}{\cos(120\pi t) - \cos(80\pi t)} = \dfrac{2\,\sin(100\pi t)\cos(20\pi t)}{-2\,\sin(100\pi t)\sin(20\pi t)}$

$= -\dfrac{\cos(20\pi t)}{\sin(20\pi t)}$

$= -\cot(20\pi t)$

103. $\sin^2\alpha + (1-\cos\alpha)^2 = \sin^2\alpha + 1 - 2\cos\alpha + \cos^2\alpha$

$= \sin^2\alpha + \cos^2\alpha + 1 - 2\cos\alpha$

$= 1 + 1 - 2\cos\alpha$

$= 2 - 2\cos\alpha$

$= 2(1-\cos\alpha)$

$= 4\left(\dfrac{1-\cos\alpha}{2}\right)$

$= 4\sin^2\left(\dfrac{\alpha}{2}\right)$

$= \left[2\sin\left(\dfrac{\alpha}{2}\right)\right]^2$

105. $\sin(2\alpha) = \sin(\alpha+\alpha)$

$= \sin\alpha\cos\alpha + \cos\alpha\sin\alpha$

$= \sin\alpha\cos\alpha + \sin\alpha\cos\alpha$

$= 2\sin\alpha\cos\alpha$

$\tan(2\alpha) = \tan(\alpha+\alpha)$

$= \dfrac{\tan\alpha + \tan\alpha}{1 - \tan\alpha\tan\alpha}$

$= \dfrac{2\tan\alpha}{1-\tan^2\alpha}$

107.

$\cos\alpha\cos\beta + \sin\alpha\sin\beta = \cos(\alpha-\beta)$

$-(\cos\alpha\cos\beta - \sin\alpha\sin\beta) = -\cos(\alpha+\beta)$

$2\sin\alpha\sin\beta = \cos(\alpha-\beta) - \cos(\alpha+\beta)$

$\sin\alpha\sin\beta = \dfrac{1}{2}[\cos(\alpha-\beta) - \cos(\alpha+\beta)]$

109. a. $\mathcal{M} = \dfrac{2}{\sqrt{2-\sqrt{3}}}$, $\mathcal{M} \approx 3.9$ **b.** $\mathcal{M} = \dfrac{2}{\sqrt{2-\sqrt{2}}}$, $\mathcal{M} \approx 2.6$

c. $\theta = 60°$

111. a. $(288 - 144\sqrt{2})$ ft ≈ 84.3 ft **b.** $(288 - 144\sqrt{2})$ ft ≈ 84.3 ft

113. $y(t) = 2\cos(2174\pi t)\cos(780\pi t)$

115. $\cos[2\pi(1209)t] + \cos[2\pi(941)t]$; the [2nd] key

117. $d(t) = \left|6\sin\left(\dfrac{\pi t}{60}\right)\right|$

$= \left|6\sin\left(\dfrac{1}{2}\cdot\dfrac{\pi t}{30}\right)\right|$

$= \left|6\left(\pm\sqrt{\dfrac{1-\cos\left(\dfrac{\pi t}{30}\right)}{2}}\right)\right|$

$= 6\sqrt{\dfrac{1-\cos\left(\dfrac{\pi t}{30}\right)}{2}}$

$= \sqrt{36\dfrac{1-\cos\left(\dfrac{\pi t}{30}\right)}{2}}$

$= \sqrt{18\left[1-\cos\left(\dfrac{\pi t}{30}\right)\right]}$

119. A: $\sin(2\theta - 90°) + 1$

$= \sin(2\theta)\cos 90° - \cos(2\theta)\sin 90° + 1$

$= 0 - \cos(2\theta) + 1$

$= 1 - \cos(2\theta)$

B: $2\sin^2\theta = \sin^2\theta + \sin^2\theta$

$= 1 - \cos^2\theta + \sin^2\theta$

$= 1 - (\cos^2\theta - \sin^2\theta)$

$= 1 - \cos(2\theta)$

C: $1 + \sin^2\theta - \cos^2\theta = 1 - (\cos^2\theta - \sin^2\theta)$

$= 1 - \cos(2\theta)$

D: $1 - \cos(2\theta) = 1 - \cos(2\theta)$

121. a. ≈ 0.9659; ≈ 0.9659

b. $\left(\dfrac{\sqrt{2+\sqrt{3}}}{2}\right)^2 \stackrel{?}{=} \left(\dfrac{\sqrt{6}+\sqrt{2}}{4}\right)^2$

$\dfrac{2+\sqrt{3}}{4} \stackrel{?}{=} \dfrac{6+2\sqrt{12}+2}{16}$

$\dfrac{2+\sqrt{3}}{4} \stackrel{?}{=} \dfrac{8+4\sqrt{3}}{16}$

$\dfrac{2+\sqrt{3}}{4} = \dfrac{2+\sqrt{3}}{4}$

123. Answers will vary; One example is $\dfrac{\sqrt{3}}{3}$, 1, $-2-\sqrt{3}$

125. $\cos 15° = \dfrac{\sqrt{2+\sqrt{3}}}{2}$

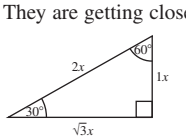
$\cos 7.5° = \dfrac{\sqrt{2+\sqrt{2+\sqrt{3}}}}{2}$

$\cos 3.75° = \dfrac{\sqrt{2+\sqrt{2+\sqrt{2+\sqrt{3}}}}}{2} \approx 0.9979$

$\cos 1.875° = \dfrac{\sqrt{2+\sqrt{2+\sqrt{2+\sqrt{2+\sqrt{3}}}}}}{2} \approx 0.9995$;

They are getting close to 1.

127.



129. $y = 2\sin\left(x + \dfrac{\pi}{4}\right) + 1$

Mid-Chapter Check, p. 693

1. $\sin x[\csc x - \sin x] = \sin x \csc x - \sin^2 x$
$= \sin x \dfrac{1}{\sin x} - \sin^2 x$
$= 1 - \sin^2 x$
$= \cos^2 x$

2. $\cos^2 x - \cot^2 x = \cos^2 x - \dfrac{\cos^2 x}{\sin^2 x}$
$= \cos^2 x\left(1 - \dfrac{1}{\sin^2 x}\right)$
$= \cos^2 x(1 - \csc^2 x)$
$= \cos^2 x(-\cot^2 x)$
$= -\cos^2 x \cot^2 x$

3. $\dfrac{2\sin x}{\sec x} - \dfrac{\cos x}{\csc x} = \dfrac{2\sin x \csc x - \cos x \sec x}{\sec x \csc x}$
$= \dfrac{2(1) - 1}{\sec x \csc x}$
$= \dfrac{1}{\sec x \csc x}$
$= \cos x \sin x$

4. $1 + \sec^2 x = \tan^2 x$
$1 + \sec^2 0 = \tan^2 0$
$1 + 1^2 = 0^2$
$1 + 1 = 0$
$2 = 0$ False

5. a. $\dfrac{\sin^3 x + \cos^3 x}{\sin x + \cos x} = \dfrac{\cancel{(\sin x + \cos x)}(\sin^2 x - \sin x \cos x + \cos^2 x)}{\cancel{(\sin x + \cos x)}}$
$= \sin^2 x + \cos^2 x - \sin x \cos x$
$= 1 - \sin x \cos x$

b. $\dfrac{1 + \sec x}{\csc x} - \dfrac{1 + \cos x}{\cot x} = \dfrac{1 + \dfrac{1}{\cos x}}{\dfrac{1}{\sin x}} - \dfrac{1 + \cos x}{\dfrac{\cos x}{\sin x}}$
$= \left(\sin x + \dfrac{\sin x}{\cos x}\right) - \left(\dfrac{\sin x}{\cos x} + \sin x\right)$
$= \sin x + \dfrac{\sin x}{\cos x} - \dfrac{\sin x}{\cos x} - \sin x$
$= 0$

6. a. $\dfrac{\sec^2 x - \tan^2 x}{\sec^2 x} = \dfrac{\sec^2 x}{\sec^2 x} - \dfrac{\tan^2 x}{\sec^2 x}$
$= 1 - \dfrac{\dfrac{\sin^2 x}{\cancel{\cos^2 x}}}{\dfrac{1}{\cancel{\cos^2 x}}}$
$= 1 - \sin^2 x$
$= \cos^2 x$

b. $\dfrac{\cot x - \tan x}{\csc x \sec x} = \dfrac{\cot x}{\csc x \sec x} - \dfrac{\tan x}{\csc x \sec x}$
$= \dfrac{\dfrac{\cos x}{\sin x}}{\dfrac{1}{\sin x} \cdot \dfrac{1}{\cos x}} - \dfrac{\dfrac{\sin x}{\cos x}}{\dfrac{1}{\sin x} \cdot \dfrac{1}{\cos x}}$
$= \dfrac{\cos^2 x \cancel{\sin x}}{\cancel{\sin x}} - \dfrac{\sin^2 x \cancel{\cos x}}{\cancel{\cos x}}$
$= \cos^2 x - \sin^2 x$

7. a. $\dfrac{456}{5785}$ **b.** $-\dfrac{3193}{5785}$ **c.** $\dfrac{456}{5767}$

8. $\sin A = \dfrac{7 + 24\sqrt{3}}{50}$, $\cos A = \dfrac{24 - 7\sqrt{3}}{50}$, $\tan A = \dfrac{7 + 24\sqrt{3}}{24 - 7\sqrt{3}}$

9. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{4}{\sqrt{17}}$, $\cos\left(\dfrac{\theta}{2}\right) = \dfrac{1}{\sqrt{17}}$

10. $\sin(2\alpha) = \dfrac{336}{625}$, $\cos(2\alpha) = \dfrac{527}{625}$, $\tan(2\alpha) = \dfrac{336}{527}$

Reinforcing Basic Concepts, pp. 693–694

1. $\cos^2 x + \sin^2 x = 1$
$\dfrac{\cos^2 x}{\sin^2 x} + \dfrac{\sin^2 x}{\sin^2 x} = \dfrac{1}{\sin^2 x}$
$\cot^2 x + 1 = \csc^2 x$ ✓
$\cos^2 x + \sin^2 x = 1$
$\dfrac{\cos^2 x}{\cos^2 x} + \dfrac{\sin^2 x}{\cos^2 x} = \dfrac{1}{\cos^2 x}$
$1 + \tan^2 x = \sec^2 x$ ✓

2. $\cos(2\alpha) = \cos(\alpha + \alpha)$
$= \cos\alpha \cos\alpha - \sin\alpha \sin\alpha$
$= \cos^2\alpha - \sin^2\alpha$
$= \cos^2\alpha - (1 - \cos^2\alpha)$
$= 2\cos^2\alpha - 1$
$= \cos^2\alpha - \sin^2\alpha$
$= (1 - \sin^2\alpha) - \sin^2\alpha$
$= 1 - 2\sin^2\alpha$

Exercises 7.5, pp. 705–710

1. horizontal, line, one, one **3.** $[-1, 1]$, $\left[-\dfrac{\pi}{2}, \dfrac{\pi}{2}\right]$ **5.** $\cos^{-1}\left(\frac{1}{5}\right)$

7. $0; \dfrac{1}{2}; -\dfrac{\pi}{6}; -\dfrac{\pi}{2}$ **9.** $\dfrac{\pi}{4}$ **11.** $\dfrac{\pi}{2}$ **13.** 1.0956, 62.8°

15. 0.3876, 22.2° **17.** $\dfrac{\sqrt{2}}{2}$ **19.** $\dfrac{\pi}{3}$ **21.** 45° **23.** 0.8205

25. $0; \dfrac{\sqrt{3}}{2}$; 120°; π **27.** $\dfrac{\pi}{3}$ **29.** π **31.** 1.4352; 82.2°

33. 0.7297; 41.8° **35.** $\dfrac{\pi}{4}$ **37.** 0.5560 **39.** $-\dfrac{\sqrt{2}}{2}$ **41.** $\dfrac{3\pi}{4}$

43. $0; -\sqrt{3}$; 30°; $\sqrt{3}; \dfrac{\pi}{3}$ **45.** $-\dfrac{\pi}{6}$ **47.** $\dfrac{\pi}{3}$ **49.** −1.1170, −64.0°

51. 0.9441, 54.1° **53.** $-\dfrac{\pi}{6}$ **55.** $\dfrac{\sqrt{3}}{3}$ **57.** $\sqrt{2}$ **59.** 120°

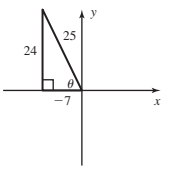
61. cannot evaluate $\tan\left(\dfrac{\pi}{2}\right)$

63. $\csc\dfrac{\pi}{4} = \sqrt{2} > 1$, not in domain of $\sin^{-1}x$.

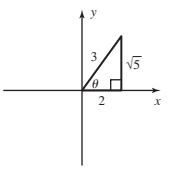
65. $\sin\theta = \dfrac{3}{5}$, $\cos\theta = \dfrac{4}{5}$, $\tan\theta = \dfrac{3}{4}$

67. $\sin\theta = \dfrac{\sqrt{x^2 - 36}}{x}$, $\cos\theta = \dfrac{6}{x}$, $\tan\theta = \dfrac{\sqrt{x^2 - 36}}{6}$

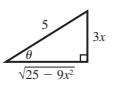
69. $\dfrac{24}{25}$



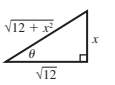
71. $\dfrac{\sqrt{5}}{3}$



73. $\dfrac{\sqrt{25 - 9x^2}}{3x}$



75. $\sqrt{\dfrac{12}{12 + x^2}}$



77. $0; 2$; 30°; $-1; \pi$ **79.** $\dfrac{\pi}{6}$ or 30° **81.** $\dfrac{\pi}{6}$ or 30° **83.** 80.1°

85. 67.8° **87.** $[-1, 1]$ **89.** $(-\infty, \infty)$

91. a. $F_N \approx 2.13$ N; $F_N \approx 1.56$ N

b. $\theta \approx 63°$ for $F_N = 1$ N, $\theta \approx 24.9°$ for $F_N = 2$ N

93. ≈ 30° **95.** $\theta \approx 72.3°$; straight line distance; ≈ 157.5 yd

97. a. $\theta = \tan^{-1}\left(\dfrac{75}{d}\right) - \tan^{-1}\left(\dfrac{50}{d}\right)$ **b.** $d \in (39.2, 95.7)$

c. $\theta \approx 11.5°$ at $d \approx 61.2$ ft

99. a. $\theta = \tan^{-1}\left(\dfrac{94}{d}\right) - \tan^{-1}\left(\dfrac{70}{d}\right)$ **b.** $\theta \approx 8.4°$ at $d \approx 81.1$ ft

101. a. $\theta \approx 15.5°$; $\theta \approx 0.2710$ rad **b.** ≈27 mi **103.** $\sin(\alpha + \beta) = 1$

105. a. $P = \dfrac{77}{5}t + 28$ **b.** sales increasing by 15.4 packages/year **c.** 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. $\theta \approx 70.5°$ or $289.5°$ **45.** $x = 30°, 90°, 150°$, or $270°$

47. $x = 120°, 240°$, or $x \approx 82.8°$ or $277.2°$

49. $x = 30°, 150°, 210°$, 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.** $\alpha = 35°, \beta \approx 25.5°$

91. $k \approx 1.36, \alpha \approx 20.6°$ **93. a.** 7 in. **b.** ≈1.05 in. and ≈5.24 in.

95. $\frac{\pi}{2} + \pi k$, explanations will vary

97.
$$\begin{aligned} f(2+i) &= (2+i)^2 - 4(2+i) + 5 \\ &= 4 + 4i + i^2 - 8 - 4i + 5 \\ &= \cancel{4} + \cancel{4i} - \cancel{1} - \cancel{8} - \cancel{4i} + \cancel{5} \\ &= 0 \end{aligned}$$

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.** $\frac{\pi}{2}\left(\frac{3\pi}{2}\text{ is extraneous}\right)$

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. $\left(\frac{5}{2}, \frac{5}{2}\right)$ **b.** $D = \sqrt{12.5}, \theta = \frac{\pi}{4}, y = \dfrac{\sqrt{12.5} - x\cos\left(\frac{\pi}{4}\right)}{\sin\left(\frac{\pi}{4}\right)}$

c. verified

II. a. (2, 4) **b.** $D = 2\sqrt{5}, \theta \approx 1.1071, y = \dfrac{2\sqrt{5} - x\cos 1.1071}{\sin 1.1071}$

c. verified

III. a. $(1, \sqrt{3})$ **b.** $D = 2, \theta = \frac{\pi}{3}, y = \dfrac{2 - x\cos\left(\frac{\pi}{3}\right)}{\sin\left(\frac{\pi}{3}\right)}$ **c.** verified

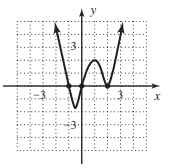
51. a. 2500π ft$^3 \approx 7853.98$ ft^3 **b.** ≈7824.09 ft^3 **c.** $\theta \approx 78.5°$

53. a. ≈78.53 m^3/sec **b.** during the months of August, September, October, and November **55. a.** ≈\$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. $y = 19\cos\left(\pi - \frac{\pi}{6}x\right) + 53$ **b.** $y = -21\sin\left(\frac{2\pi}{365}x\right) + 29$

67. a. $L \approx 25.5$ cm. **b.** $\theta \approx 38.9°$ or $31.6°$

69. $(-1, 0), (0, 0), (2, 0)$ (multiplicity 2): up/up;



71. $\theta \approx 4.56°$

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.
$$\begin{aligned} \sin x(\csc x - \sin x) &= \sin x \csc x - \sin x \sin x \\ &= \sin x \frac{1}{\sin x} - \sin^2 x \\ &= 1 - \sin^2 x \\ &= \cos^2 x \end{aligned}$$

2. $\dfrac{\tan^2 x \csc x + \csc x}{\sec^2 x} = \dfrac{\csc x(\tan^2 x + 1)}{\sec^2 x}$

$= \dfrac{\csc x \sec^2 x}{\sec^2 x}$

$= \csc x$

3. $\dfrac{(\sec x - \tan x)(\sec x + \tan x)}{\csc x} = \dfrac{\sec^2 x - \tan^2 x}{\csc x}$

$= \dfrac{1 + \tan^2 x - \tan^2 x}{\csc x}$

$= \dfrac{1}{\csc x}$

$= \sin x$

4. $\dfrac{\sec^2 x}{\csc x} - \sin x = \dfrac{\sec^2 x - \sin x \csc x}{\csc x}$

$= \dfrac{\sec^2 x - 1}{\csc x}$

$= \dfrac{\tan^2 x}{\csc x}$

5. $\sin\theta = -\dfrac{35}{37}, \csc\theta = -\dfrac{37}{35}, \cot\theta = \dfrac{12}{35}, \tan\theta = \dfrac{35}{12}, \sec\theta = -\dfrac{37}{12}$

6. $\sin\theta = -\dfrac{4\sqrt{6}}{25}, \csc\theta = -\dfrac{25}{4\sqrt{6}}, \cot\theta = -\dfrac{23}{4\sqrt{6}}, \tan\theta = -\dfrac{4\sqrt{6}}{23}$,

$\cos\theta = \dfrac{23}{25}$

7. $\dfrac{\csc^2 x(1 - \cos^2 x)}{\tan^2 x} = \dfrac{\csc^2 x \sin^2 x}{\tan^2 x}$

$= \dfrac{1}{\tan^2 x}$

$= \cot^2 x$

8. $\dfrac{\cot x}{\sec x} - \dfrac{\csc x}{\tan x} = \cot x \dfrac{1}{\sec x} - \cot x \csc x$

$= \cot x \cos x - \cot x \csc x$

$= \cot x(\cos x - \csc x)$

9. $\dfrac{\sin^4 x - \cos^4 x}{\sin x \cos x} = \dfrac{(\sin^2 x - \cos^2 x)(\sin^2 x + \cos^2 x)}{\sin x \cos x}$

$= \dfrac{(\sin^2 x - \cos^2 x)(1)}{\sin x \cos x}$

$= \dfrac{\sin x \cancel{\sin x}}{\cancel{\sin x} \cos x} - \dfrac{\cancel{\cos x} \cos x}{\sin x \cancel{\cos x}}$

$= \dfrac{\sin x}{\cos x} - \dfrac{\cos x}{\sin x}$

$= \tan x - \cot x$

10. $\dfrac{(\sin x + \cos x)^2}{\sin x \cos x} = \dfrac{\sin^2 x + 2 \sin x \cos x + \cos^2 x}{\sin x \cos x}$

$= \dfrac{\sin^2 x + \cos^2 x}{\sin x \cos x} + \dfrac{2 \sin x \cos x}{\sin x \cos x}$

$= \dfrac{1}{\sin x \cos x} + 2$

$= \csc x \sec x + 2$

11. a. $\cos 75° = \dfrac{\sqrt{6} - \sqrt{2}}{4}$

b. $\tan\left(\dfrac{\pi}{12}\right) = \dfrac{\sqrt{3} - 1}{1 + \sqrt{3}} = \dfrac{(\sqrt{3} - 1)^2}{2} = 2 - \sqrt{3}$

12. a. $\tan 15° = \dfrac{\sqrt{3} - 1}{1 + \sqrt{3}} = \dfrac{(\sqrt{3} - 1)^2}{2} = 2 - \sqrt{3}$

b. $\sin\left(-\dfrac{\pi}{12}\right) = \dfrac{\sqrt{2} - \sqrt{6}}{4}$ **13. a.** $\cos 180° = -1$ **b.** $\sin 120° = \dfrac{\sqrt{3}}{2}$

14. a. $\cos x$ **b.** $\sin\left(\dfrac{5x}{8}\right)$ **15. a.** $\cos 1170° = \cos 90° = 0$

b. $\sin\left(\dfrac{57\pi}{4}\right) = \sin\left(\dfrac{\pi}{4}\right) = \dfrac{\sqrt{2}}{2}$ **16. a.** $\cos\left(\dfrac{x}{8}\right) = \sin\left(\dfrac{\pi}{2} - \dfrac{x}{8}\right)$

b. $\sin\left(x - \dfrac{\pi}{12}\right) = \cos\left(\dfrac{7\pi}{12} - x\right)$

17. $\tan(45° - 30°) = \dfrac{\tan 45° - \tan 30°}{1 + \tan 45° \tan 30°}$

$= \dfrac{1 - \dfrac{\sqrt{3}}{3}}{1 + 1 \cdot \dfrac{\sqrt{3}}{3}} = \dfrac{1 - \dfrac{\sqrt{3}}{3}}{1 + \dfrac{\sqrt{3}}{3}} = \dfrac{\dfrac{3 - \sqrt{3}}{3}}{\dfrac{3 + \sqrt{3}}{3}}$

$= \dfrac{3 - \sqrt{3}}{\cancel{3}} \dfrac{\cancel{3}}{3 + \sqrt{3}} = \dfrac{3 - \sqrt{3}}{3 + \sqrt{3}} = \dfrac{\cancel{\sqrt{3}}(\sqrt{3} - 1)}{\cancel{\sqrt{3}}(\sqrt{3} + 1)} = \dfrac{\sqrt{3} - 1}{\sqrt{3} + 1}$

$\tan(135° - 120°) = \dfrac{\tan 135° - \tan 120°}{1 + \tan 135° \tan 120°}$

$= \dfrac{-1 + \sqrt{3}}{1 + (-1)(-\sqrt{3})} = \dfrac{\sqrt{3} - 1}{1 + \sqrt{3}} = \dfrac{\sqrt{3} - 1}{\sqrt{3} + 1}$

18. $\cos\left(x + \dfrac{\pi}{6}\right) + \cos\left(x - \dfrac{\pi}{6}\right)$

$= \cos x \cos\left(\dfrac{\pi}{6}\right) - \sin x \sin\left(\dfrac{\pi}{6}\right) + \cos x \cos\left(\dfrac{\pi}{6}\right) + \sin x \sin\left(\dfrac{\pi}{6}\right)$

$= 2 \cos x \cos\left(\dfrac{\pi}{6}\right) + 0 = 2 \cos x\left(\dfrac{\sqrt{3}}{2}\right) = \sqrt{3} \cos x$

19. a. $\sin(2\theta) = \dfrac{-2184}{7225}$

$\cos(2\theta) = \dfrac{-6887}{7225}$

$\tan(2\theta) = \dfrac{2184}{6887}$

b. $\sin(2\theta) = \dfrac{840}{841}$

$\cos(2\theta) = \dfrac{41}{841}$

$\tan(2\theta) = \dfrac{840}{41}$

20. a. $\sin\theta = \dfrac{21}{29}, \cos\theta = -\dfrac{20}{29}, \tan\theta = -\dfrac{21}{20}$,

b. $\sin\theta = \dfrac{7}{25}$ or $\sin\theta = \dfrac{24}{25}, \cos\theta = \dfrac{-24}{25}$ or $\cos\theta = \dfrac{-7}{25}, \tan\theta = \dfrac{-7}{24}$

or $\tan\theta = \dfrac{-24}{7}$

21. a. $\cos 45° = \dfrac{\sqrt{2}}{2}$ **b.** $\cos\left(\dfrac{\pi}{6}\right) = \dfrac{\sqrt{3}}{2}$

22. a. $\sin 67.5° = \dfrac{\sqrt{2 + \sqrt{2}}}{2}$

$\cos 67.5° = \dfrac{\sqrt{2 - \sqrt{2}}}{2}$

b. $\sin\left(\dfrac{5\pi}{8}\right) = \dfrac{\sqrt{2 + \sqrt{2}}}{2}$

$\cos\left(\dfrac{5\pi}{8}\right) = -\dfrac{\sqrt{2 - \sqrt{2}}}{2}$

23. a. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{1}{5\sqrt{2}}, \dfrac{\theta}{2}$ in QII

$\cos\left(\dfrac{\theta}{2}\right) = \dfrac{-7}{5\sqrt{2}}, \dfrac{\theta}{2}$ in QII

b. $\sin\left(\dfrac{\theta}{2}\right) = \dfrac{-3}{\sqrt{130}}, \dfrac{\theta}{2}$ in QIV

$\cos\left(\dfrac{\theta}{2}\right) = \dfrac{11}{\sqrt{130}}, \dfrac{\theta}{2}$ in QIV

24. $\dfrac{\cos(3\alpha) - \cos\alpha}{\cos(3\alpha) + \cos\alpha} = \dfrac{-2 \sin(2\alpha) \sin\alpha}{2 \cos(2\alpha) \cos\alpha}$

$= \dfrac{-2 \sin^2\alpha}{\cos^2\alpha - \sin^2\alpha} = \dfrac{2 \sin^2\alpha}{\sin^2\alpha - \cos^2\alpha}$

$= \dfrac{2 \sin^2\alpha}{1 - 2 \cos^2\alpha} = \dfrac{2 \tan^2\alpha}{\sec^2\alpha - 2}$

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. a. $A = 12^2\sin\left(\frac{30°}{2}\right)\cos\left(\frac{30°}{2}\right) = 144\sqrt{\frac{1 - \cos 30°}{2}}\sqrt{\frac{1 + \cos 30°}{2}}$

$= 144\sqrt{\frac{1 - \frac{\sqrt{3}}{2}}{2}}\sqrt{\frac{1 + \frac{\sqrt{3}}{2}}{2}} = 144\sqrt{\frac{2 - \sqrt{3}}{4}}\sqrt{\frac{2 + \sqrt{3}}{4}}$

$= \frac{144\sqrt{4 - 3}}{4} = 36 \text{ cm}^2$

b. Let $u = \frac{\theta}{2}$, then $x^2\sin\left(\frac{\theta}{2}\right)\cos\left(\frac{\theta}{2}\right) = x^2\sin u \cos u =$

$\frac{1}{2}x^2(2\sin u \cos u) = \frac{1}{2}x^2 \sin(2u)$

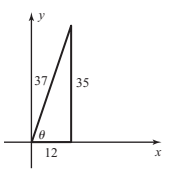
$= \frac{1}{2}x^2\sin\theta$; $A = \frac{1}{2}(12)^2 \sin(30°) = 72\left(\frac{1}{2}\right) = 36 \text{ cm}^2$; yes

27. $\frac{\pi}{4}$ or 45° **28.** $\frac{\pi}{6}$ or 30° **29.** $\frac{5\pi}{6}$ or 150° **30.** 1.3431 or 77.0°

31. 1.0956 or 62.8° **32.** 0.5054 or 29.0° **33.** $\frac{1}{2}$ **34.** $\frac{\pi}{4}$

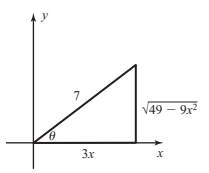
35. undefined **36.** 1.0245 **37.** 60° **38.** $\frac{3\pi}{4}$

39.



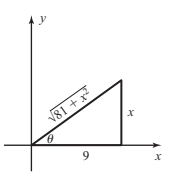
$\sin\theta = \frac{35}{37}$

40.



$\tan\theta = \frac{\sqrt{49 - 9r^2}}{3x}$

41.



$\cot\theta = \frac{9}{x}$

42. $\theta = \cos^{-1}\left(\frac{x}{5}\right)$ **43.** $\theta = \sec^{-1}\left(\frac{x}{7\sqrt{3}}\right)$

44. $\theta = \sin^{-1}\left(\frac{x}{4}\right) + \frac{\pi}{6}$ **45. a.** $\frac{\pi}{4}$ **b.** $\frac{\pi}{4}, \frac{3\pi}{4}$

c. $x = \frac{\pi}{4} + 2\pi k$ or $\frac{3\pi}{4} + 2\pi k, k \in \mathbb{Z}$ **46. a.** $\frac{2\pi}{3}$ **b.** $\frac{2\pi}{3}, \frac{4\pi}{3}$

c. $\frac{2\pi}{3} + 2\pi k$ or $\frac{4\pi}{3} + 2\pi k, k \in \mathbb{Z}$ **47. a.** $-\frac{\pi}{3}$ **b.** $\frac{2\pi}{3}, \frac{5\pi}{3}$

c. $\frac{2\pi}{3} + \pi k, k \in \mathbb{Z}$ **48. a.** ≈1.1102 **b.** ≈1.1102, 5.1729

c. ≈1.1102 + $2\pi k$ or 5.1729 + $2\pi k, k \in \mathbb{Z}$ **49. a.** ≈0.3376

b. ≈ 0.3376, 1.2332, 3.4792, 4.3748 **c.** ≈0.3376 + πk or

1.2332 + $\pi k, k \in \mathbb{Z}$ **50. a.** ≈0.3614 **b.** ≈0.3614, 2.7802

c. ≈0.3614 + $2\pi k$ or 2.7802 + $2\pi k, k \in \mathbb{Z}$ **51.** $x = \frac{\pi}{12}, \frac{5\pi}{12}$

52. $x \approx 0.7297, 2.4119$; $x = \frac{\pi}{6}, \frac{5\pi}{6}$

53. $x = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{11\pi}{6}$ **54.** $x = \frac{\pi}{2}$ **55.** $P = 12$; $x \approx 2.6931$, $x \approx 9.3069$

56. $P = 6$; $x = 0$, $x = \frac{9}{2}$ **57. a.** ≈ \$43,000 **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. $\frac{\sqrt{3} - 1}{\sqrt{3} + 1}$ **5.** $\cos 45° = \frac{\sqrt{2}}{2}$ **6.** $\frac{-\sqrt{2}}{2}$

7. $\sin\left(x + \frac{\pi}{4}\right) - \sin\left(x - \frac{\pi}{4}\right)$

$= \cancel{\sin x \cos}\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right) - \cancel{\sin x \cos}\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right)$

$= \sin\left(\frac{\pi}{4}\right)\cos x + \sin\left(\frac{\pi}{4}\right)\cos x$

$= 2\sin\left(\frac{\pi}{4}\right)\cos x$

$= \cancel{2}\frac{\sqrt{2}}{\cancel{2}}\cos x$

$= \sqrt{2}\cos x$

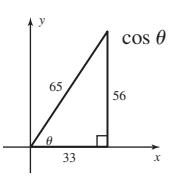
8. $\sin\theta = \frac{15}{17}, \cos\theta = \frac{8}{17}, \tan\theta = \frac{15}{8}$ **9.** $\frac{-\sqrt{3}}{2}$ **10.** $\frac{1}{\sqrt{37}}; \frac{6}{\sqrt{37}}$

11. $20\sqrt{2 - \sqrt{2}}$ **12.** $\frac{\sqrt{6} - \sqrt{2}}{4} \approx 0.2588; \frac{\sqrt{6} + \sqrt{2}}{4} \approx 0.9659$

13. a. $y = 30°$ **b.** $y = \frac{1}{2}$ **c.** $y = 30°$ **14. a.** $y = 0.8523$ rad or

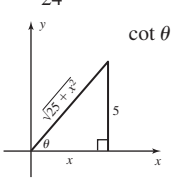
$y = 48.8°$ **b.** $y = 78.5°$ or $\frac{157\pi}{360}$ rad **c.** $y = \frac{7\pi}{24}$ rad

15.



$\cos\theta = \frac{33}{65}$

16.



$\cot\theta = \frac{x}{5}$

17. I. a. $\frac{3\pi}{4}$ **b.** $x = \frac{3\pi}{4}, \frac{5\pi}{4}$ **c.** $x = \frac{3\pi}{4} + 2\pi k$ or $\frac{5\pi}{4} + 2\pi k, k \in \mathbb{Z}$

II. a. $\frac{\pi}{6}$ **b.** $x = \frac{\pi}{6}, \frac{11\pi}{6}$ **c.** $x = \frac{\pi}{6} + 2\pi k$ or $\frac{11\pi}{6} + 2\pi k, k \in \mathbb{Z}$

18. I. a. $x \approx 0.1922$ **b.** $x \approx 0.1922, 1.3786, 3.3338, 4.5202$

c. $x \approx 0.1922 + \pi k$ or $1.3786 + \pi k, k \in \mathbb{Z}$ **II. a.** $x \approx 0.9204$

b. $x \approx 0.9204, 2.2212, 4.0620, 5.3628$

c. $x \approx 0.9204 + \pi k$ or $2.2212 + \pi k, k \in \mathbb{Z}$

19. a. $x \approx -1.6875, -0.3413, 1.1321, 2.8967$

b. $x \approx 0.9671, 2.6110, 3.4538$

20. a. $x = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, \frac{7\pi}{6}, \frac{11\pi}{6}$ **b.** $x = \frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$

21. $x = \frac{\pi}{2}, \frac{3\pi}{2}$; $x \approx 3.3090, 6.1157$ **22.** $x = \frac{5\pi}{6}, \frac{11\pi}{6}$

23. a. \$6,000 **b.** January through July

24.

Month (Jan → 1)	Low Temp. (°F)
1	−26
3	−21
5	16
7	41
9	24
11	−14

25. $\cos(2418\pi t) + \cos(1540\pi t)$

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. $x \in [0, 2.6154] \cup [9.3847, 12)$

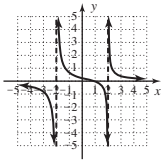
Exercise 4. $x \in (67.3927, 202.6073)$

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. $\frac{\cos x}{\sec x - 1} = \frac{\cos x(\sec x + 1)}{(\sec x - 1)(\sec x + 1)}$
$= \frac{1 + \cos x}{\sec^2 x - 1}$
$= \frac{\cos x + 1}{\tan^2 x}$

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

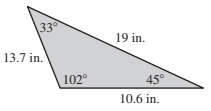
1. ambiguous **3.** I, II **5.** Answers will vary. **7.** $a \approx 8.98$

9. $C \approx 49.2°$ **11.** $C \approx 21.4°$

13. $\angle C = 78°$, $b \approx 109.5$ cm, $c \approx 119.2$ cm

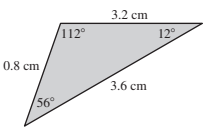
15. $\angle C = 90°$, $a = 10$ in., $c = 20$ in.

17.



19. $\angle C = 90°$, $a = 15$ mi, $b = 15$ mi

21. $\angle A = 57°$, $b \approx 49.5$ km, $c \approx 17.1$ km **23.**



25. a. 10 cm **b.** 0 **c.** 2 **d.** 1 **27.** not possible

29. $B = 60°$, $C = 90°$, $b = 12.9\sqrt{3}$ mi

31. $A \approx 39°$, $B \approx 82°$, $a \approx 42.6$ mi or $A \approx 23°$, $B \approx 98°$, $a \approx 26.4$ mi

33. $A \approx 39°$, $B \approx 82°$, $a \approx 42.6$ ft or $A \approx 23°$, $B \approx 98°$, $a \approx 26.4$ ft

35. not possible **37.** $A \approx 80.0°$, $B \approx 38.0°$, $b \approx 1.8 \times 10^{25}$ mi or $A \approx 100.0°$, $B \approx 18.0°$, $b \approx 9.1 \times 10^{24}$ mi

39. $A_1 \approx 19.3°$, $A_2 \approx 160.7°$, $48° + 160.7° > 180°$; no second solution possible **41.** $C_1 \approx 71.3°$, $C_2 \approx 108.7°$, $57° + 108.7° < 180°$; two solutions possible **43.** not possible, $\sin A > 1$

45. $\frac{\sqrt{2}}{2}$ **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
$A_1 \approx 41.1°$	$a = 12$ cm
$B = 26°$	$b = 8$ cm
$C_1 \approx 112.9°$	$c_1 \approx 16.8$ cm

Angles	Sides
$A_2 \approx 138.9°$	$a = 12$ cm
$B = 26°$	$b = 8$ cm
$C_2 \approx 15.1°$	$c_2 \approx 4.8$ cm

57.

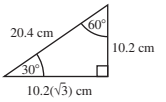
Angles	Sides
$A_1 \approx 48.0°$	$a = 9$
$B_1 \approx 107.6°$	$b_1 \approx 11.6$
$C \approx 24.4°$	$c = 5$

Angles	Sides
$A_2 \approx 132.0°$	$a = 9$
$B_2 \approx 23.6°$	$b_2 = 4.9$
$C \approx 24.4°$	$c = 5$

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.



$\sqrt{3} = \frac{\sin 60°}{\sin 30°}$; $\sqrt{2} = \frac{\sin 90°}{\sin 45°}$

69. $A = 19°$, $B = 31°$, $C = 130°$, $a = 45$ 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. $x^4 - 3x^3 + 5x^2 - x - 10 = 0$

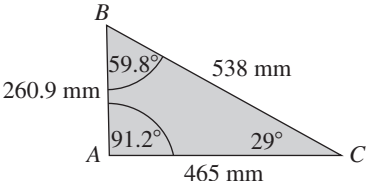
Exercises 8.2, pp. 766–771

1. cosines **3.** Pythagorean **5.** $B \approx 33.1°$, $C \approx 129.9°$, $a \approx 19.8$ m; law of sines **7.** yes **9.** no **11.** yes **13.** verified **15.** $B \approx 41.4°$

17. $a \approx 7.24$ **19.** $A \approx 41.6°$ **21.** $A \approx 120.4°$, $B \approx 21.6°$, $c \approx 53.5$ cm

23. $A \approx 23.8°$, $C \approx 126.2°$, $b \approx 16$ mi

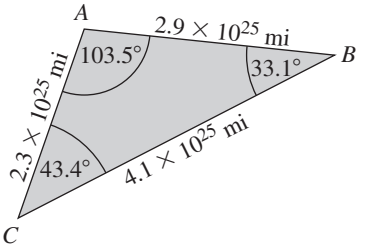
25.



27. $A \approx 137.9°$, $B \approx 15.6°$, $C \approx 26.5°$

29. $A \approx 119.3°$, $B \approx 41.5°$, $C = 19.2°$

31.



33. $A \approx 139.7°$, $B \approx 23.7°$, $C \approx 16.6°$ **35.** $A \approx 48.5°$

37. about 1688 mi **39.** It cannot be constructed (available length ≈ 10,703.6 ft). **41.** $P \approx 27.7°$; heading 297.7° **43.** 1678.2 mi

45. $P \approx 22.4$ cm, $A = 135°$, $B \approx 23.2°$, $C \approx 21.8°$

47. $A \approx 20.6°$, $B \approx 15.3°$, $C \approx 144.1°$ **49.** 58.78 cm

51. $a = 13$ $A \approx 133.2°$
$b = 5$ $B \approx 16.3°$
$c = \sqrt{82}$ $C \approx 30.5°$

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 $0 = 2c^2 - 2bc\cos A - 2ac\cos B$, $2bc\cos A + 2ac\cos B = 2c^2$, $b\cos A + a\cos B = c$

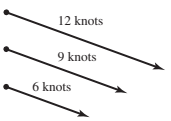
63. 2

65. $\sin x = \dfrac{-5}{13}$, $\csc x = \dfrac{-13}{5}$, $\cos x = \dfrac{12}{13}$, $\sec x = \dfrac{13}{12}$, $\tan x = \dfrac{-5}{12}$, $\cot x = \dfrac{-12}{5}$

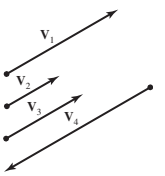
Exercises 8.3, pp. 782–786

1. scalar **3.** directed, line **5.** Answers will vary.

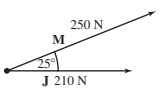
7.



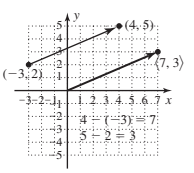
9.



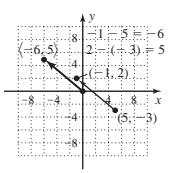
11.



13.



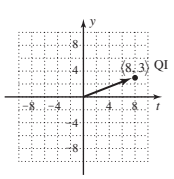
15.



17. Terminal point: $(5, -1)$, length: $\sqrt{53}$

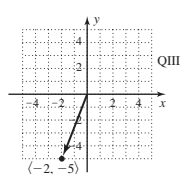
19. Terminal point: $(-1, 1)$, length: $\sqrt{34}$

21. a.



b. $\sqrt{73}$ **c.** 20.6°

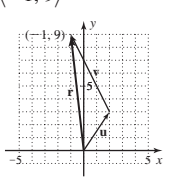
23. a.



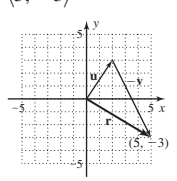
b. $\sqrt{29}$ **c.** 68.2°

25. $\langle -10.9, 5.1\rangle$ **27.** $\langle 106, -92.2\rangle$ **29.** $\langle -9.7, -2.6\rangle$

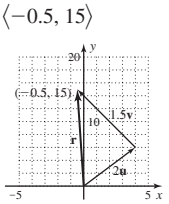
31. a. $\langle -1, 9\rangle$



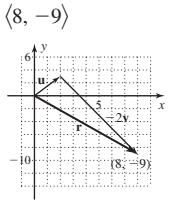
b. $\langle 5, -3\rangle$



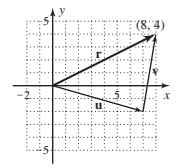
c. $\langle -0.5, 15\rangle$



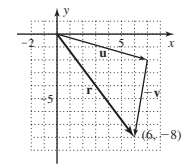
d. $\langle 8, -9\rangle$



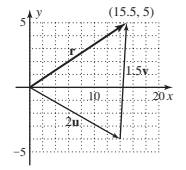
33. a. $\langle 8, 4\rangle$



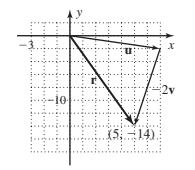
b. $\langle 6, -8\rangle$



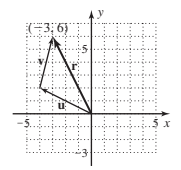
c. $\langle 15.5, 5\rangle$



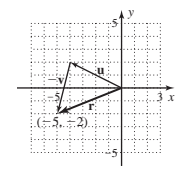
d. $\langle 5, -14\rangle$



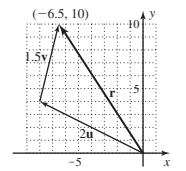
35. a. $\langle -3, 6\rangle$



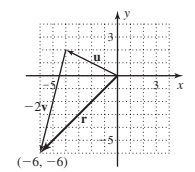
b. $\langle -5, -2\rangle$



c. $\langle -6.5, 10\rangle$

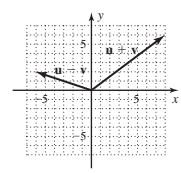


d. $\langle -6, -6\rangle$

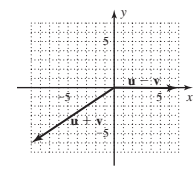


37. True **39.** False **41.** True

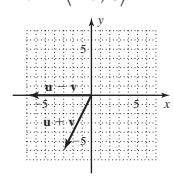
43. $\mathbf{u} + \mathbf{v} = \langle 8, 6\rangle$
$\mathbf{u} - \mathbf{v} = \langle -6, 2\rangle$



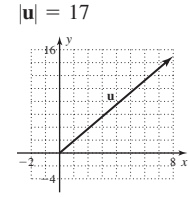
45. $\mathbf{u} + \mathbf{v} = \langle -9, -6\rangle$
$\mathbf{u} - \mathbf{v} = \langle 7, 0\rangle$



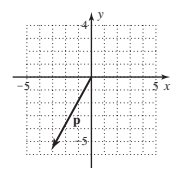
47. $\mathbf{u} + \mathbf{v} = \langle -3, -6\rangle$
$\mathbf{u} - \mathbf{v} = \langle -7, 0\rangle$



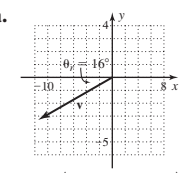
49. $\mathbf{u} = 8\mathbf{i} + 15\mathbf{j}$
$|\mathbf{u}| = 17$



51. $\mathbf{p} = -3.2\mathbf{i} - 5.7\mathbf{j}$
$|\mathbf{p}| \approx 6.54$

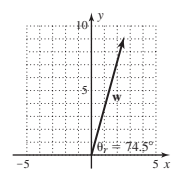


53. a.



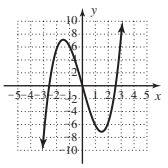
b. $\mathbf{v} \approx \langle -11.5, -3.3\rangle$
c. $\mathbf{v} \approx -11.5\mathbf{i} - 3.3\mathbf{j}$

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. $\mathbf{p} = -2\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| = 2\sqrt{2}$, $\theta = 135°$
b. $\mathbf{q} = 6\mathbf{i} - 8\mathbf{j}$; $|\mathbf{q}| = 10$, $\theta \approx 306.9°$
c. $\mathbf{r} = -2\mathbf{i} + 1.5\mathbf{j}$; $|\mathbf{r}| = 2.5$, $\theta \approx 143.1°$
d. $\mathbf{s} = 10\mathbf{i} - 13\mathbf{j}$; $|\mathbf{s}| \approx 16.4$, $\theta \approx 307.6°$
59. a. $\mathbf{p} = 2\sqrt{2}\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| \approx 3.5$, $\theta \approx 35.3°$
b. $\mathbf{q} = 8\sqrt{2}\mathbf{i} + 12\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 46.7°$
c. $\mathbf{r} = 5.5\sqrt{2}\mathbf{i} + 6.5\mathbf{j}$; $|\mathbf{r}| \approx 10.1$, $\theta \approx 39.9°$
d. $\mathbf{s} = 11\sqrt{2}\mathbf{i} + 17\mathbf{j}$; $|\mathbf{s}| \approx 23.0$, $\theta \approx 47.5°$
61. a. $\mathbf{p} = 8\mathbf{i} + 4\mathbf{j}$; $|\mathbf{p}| \approx 8.9$, $\theta \approx 26.6°$
b. $\mathbf{q} = 16\mathbf{i} + 4\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 14.0°$
c. $\mathbf{r} = 18\mathbf{i} + 8\mathbf{j}$; $|\mathbf{r}| \approx 19.7$, $\theta \approx 24.0°$
d. $\mathbf{s} = 20\mathbf{i} + 4\mathbf{j}$; $|\mathbf{s}| \approx 20.4$, $\theta \approx 11.3°$
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.** $\approx 24.3°$
83. hor. comp. $\approx$ 79.9 ft/sec; vert. comp. $\approx$ 60.2 ft/sec
85. heading 68.2° at 266.7 mph **87.** $\approx$ (82.10 cm, 22.00 cm)
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°, 81.4°, −33.9°
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, $B \approx 93.3°$, $C \approx 55.7°$
4. $A \approx 42.3°$, $B \approx 81.5°$, $C \approx 56.2°$
5. $A = 44°$ $a = 2.1$ km
$B \approx 68.1°$ $b \approx 2.8$ km
$C \approx 67.9°$ $c = 2.8$ km
or
$A = 44°$ $a = 2.1$ km
$B \approx 23.9°$ $b \approx 1.2$ km
$C \approx 112.1°$ $c = 2.8$ km
6. $A \approx 18.5°$ $a = 70$ yd
$B \approx 134.5°$ $b \approx 157.2$ yd
$C = 27°$ $c = 100$ yd
7. about 60.7 ft **8.** 169 m
9. $\alpha \approx 49.6°$
$\beta \approx 92.2°$
$\gamma \approx 38.2°$
10. 9.4 mi

Reinforcing Basic Concepts, pp. 786–787

1.

Angles	Sides
$A = 35°$	$a \approx 11.6$ cm
$B \approx 81.5°$	$a = 20$ cm
$C \approx 63.5°$	$c = 18$ cm

Very close.

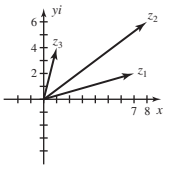
2. For $\angle A = 35°$, $a \approx 10.3$
For $\angle A = 50°$, $a \approx 14.2$
For $\angle A = 70°$, $a \approx 19.1$

Exercises 8.4, pp. 798–801

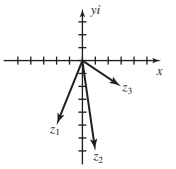
1. equilibrium, zero **3.** orthogonal **5.** Answers will vary **7.** $\langle 6, 8\rangle$
9. $\langle -5, 10\rangle$ **11.** $-6\mathbf{i} - 8\mathbf{j}$ **13.** $-2.2\mathbf{i} + 0.4\mathbf{j}$ **15.** $\langle -11.48, -9.16\rangle$
17. $\langle -24, -27\rangle$ **19.** $|\mathbf{F}_3| \approx 3336.8$; $\theta \approx 268.5°$ **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. $\theta \approx 56.9°$; answers will vary. **85.** $t \approx -20$
87. $a \approx 138.4°$,
$B \approx 106.8°$
$C \approx 41.2°$;
$P \approx 560.4$ m,
$A \approx 11{,}394.3$ m^2

Exercises 8.5, pp. 810–812

1. modulus, argument **3.** multiply, add
5. $2(\cos 240° + i \sin 240°)$, z is in QIII
7. $z_2 = z_1 + z_3$



9. $z_2 = z_1 + z_3$

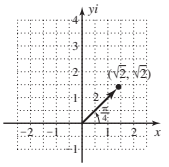


11. QIII; $2\sqrt{2}(\cos 225° + i \sin 225°)$
13. QIII; $10(\cos 210° + i \sin 210°)$
15. $6\left[\cos\left(\frac{3\pi}{4}\right) + i \sin\left(\frac{3\pi}{4}\right)\right]$ **17.** $8\left[\cos\left(\frac{11\pi}{6}\right) + i \sin\left(\frac{11\pi}{6}\right)\right]$
19. $10 \operatorname{cis}\left[\tan^{-1}\left(\frac{6}{8}\right)\right]$; $10 \operatorname{cis} 36.9°$
21. $13 \operatorname{cis}\left[180° + \tan^{-1}\left(\frac{12}{5}\right)\right]$; $13 \operatorname{cis} 247.4°$
23. $18.5 \operatorname{cis}\left[\tan^{-1}\left(\frac{17.5}{6}\right)\right]$; $18.5 \operatorname{cis} 1.2405$
25. $2\sqrt{34} \operatorname{cis}\left[\pi + \tan^{-1}\left(-\frac{5}{3}\right)\right]$; $2\sqrt{34} \operatorname{cis} 2.1112$

27. $r = 2, \theta = \dfrac{\pi}{4}$

$z = 2\operatorname{cis}\left(\dfrac{\pi}{4}\right)$

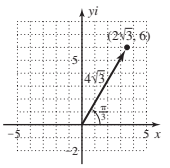
$= \sqrt{2} + i\sqrt{2}$



29. $r = 4\sqrt{3}, \theta = \dfrac{\pi}{3}$

$z = 4\sqrt{3}\operatorname{cis}\left(\dfrac{\pi}{3}\right)$

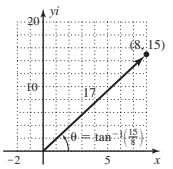
$= 2\sqrt{3} + 6i$



31. $r = 17, \theta = \tan^{-1}\left(\dfrac{15}{8}\right)$

$z = 17\operatorname{cis}\left[\tan^{-1}\left(\dfrac{15}{8}\right)\right]$

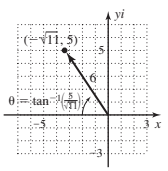
$= 17\left(\dfrac{8}{17} + \dfrac{15}{17}i\right) = 8 + 15i$



33. $r = 6, \theta = \pi - \tan^{-1}\left(\dfrac{5}{\sqrt{11}}\right)$

$z = 6\operatorname{cis}\left[\pi - \tan^{-1}\dfrac{5}{\sqrt{11}}\right]$

$= 6\left(-\dfrac{\sqrt{11}}{6} + \dfrac{5}{6}i\right) = -\sqrt{11} + 5i$



35. $r_1 = 2\sqrt{2}, \quad r_2 = 3\sqrt{2}, \quad \theta_1 = 135°, \quad \theta_2 = 45°;$
$z = z_1z_2 = -12 + 0i \Rightarrow r = 12, \quad \theta = 180°;$
$r_1r_2 = 2\sqrt{2}(3\sqrt{2}) = 12$ ✓
$\theta_1 + \theta_2 = 135° + 45° = 180°$ ✓

37. $r_1 = 2, r_2 = 2, \theta_1 = 30°, \theta_2 = 60°;$
$z = \dfrac{z_1}{z_2} = \dfrac{\sqrt{3}}{2} - \dfrac{1}{2}i \Rightarrow r = 1, \theta = -30°; \dfrac{r_1}{r_2} = \dfrac{2}{2} = 1$ ✓
$\theta_1 - \theta_2 = 30° - 60° = -30°$ ✓

39. $z_1z_2 = -24 + 0i, \dfrac{z_1}{z_2} = -\dfrac{4}{3} + \dfrac{4\sqrt{3}}{3}i$

41. $z_1z_2 = 21\sqrt{3} - 21i, \dfrac{z_1}{z_2} = \dfrac{\sqrt{3}}{7} + \dfrac{1}{7}i$

43. $z_1z_2 = -10.84 + 12.04i, \dfrac{z_1}{z_2} = -1.55 - 4.76i$

45. $z_1z_2 = 0 + 40i, \dfrac{z_1}{z_2} = \dfrac{5\sqrt{3}}{4} + \dfrac{5}{4}i$

47. $z_1z_2 = -10 - 10i\sqrt{3}, \dfrac{z_1}{z_2} = \dfrac{-5}{2} + 0i$

49. $z_1z_2 = -2.93 + 8.51i, \dfrac{z_1}{z_2} = 2.29 + 3.28i$

51. 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. a. $V(t) = 170\sin(120\pi t)$

b.

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

c. $t \approx 0.00257$ sec

55. a. 17 cis 28.1° **b.** 51 V **57. a.** 8.60 cis 324.5° **b.** 15.48 V

59. a. 13 cis 22.6° **b.** 22.1 V

61. $I = 2\operatorname{cis}30°; Z = 5\sqrt{2}\operatorname{cis}45°; V = 10\sqrt{2}\operatorname{cis}75°$

63. $I = \sqrt{13}\operatorname{cis}326.3°; Z = \dfrac{17}{4}\operatorname{cis}61.9°; V = \dfrac{17\sqrt{13}}{4}\operatorname{cis}28.2°$

65. $V = 4\operatorname{cis}60°; Z = 4\sqrt{2}\operatorname{cis}315°; I = \dfrac{\sqrt{2}}{2}\operatorname{cis}105°$

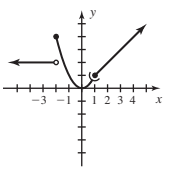
67. $V = 5\operatorname{cis}306.9°; Z = 8.5\operatorname{cis}61.9°; I = \dfrac{10}{17}\operatorname{cis}245°$

69. $\dfrac{\sqrt{65}\operatorname{cis}29.7°}{4}$ **71.** verified

73. $z_2 = \dfrac{24}{5} - \dfrac{7}{5}i, z_3 = -\dfrac{24}{5} + \dfrac{7}{5}i$

75. $\dfrac{5\pi}{24}, \dfrac{13\pi}{24}, \dfrac{29\pi}{24}, \dfrac{37\pi}{24}$

77.



Exercises 8.6, pp. 818–821

1. $r^5[\cos(5\theta) + i\sin(5\theta)]$, De Moivre's **3.** complex

5. $z_5 = 2\operatorname{cis}366° = 2\operatorname{cis}6°, z_6 = 2\operatorname{cis}438° = 2\operatorname{cis}78°,$
$z_7 = 2\operatorname{cis}510° = 2\operatorname{cis}150°$; Answers will vary.

7. $r = 3\sqrt{2}; n = 4; \theta = 45°; -324$

9. $r = 2; n = 3; \theta = 120°; 8$

11. $r = 1; n = 5; \theta = 300°; \dfrac{1}{2} + \dfrac{\sqrt{3}}{2}i$

13. $r = 1; n = 6; \theta = 315°; i$

15. $r = 4; n = 3; \theta = 330°; -64i$

17. $r = \dfrac{\sqrt{2}}{2}; n = 5; \theta = 135°; \dfrac{1}{8} - \dfrac{1}{8}i$

19. verified **21.** verified **23.** verified **25.** verified

27. roots: 1, $0.3090 \pm 0.9511i$, $-0.8090 \pm 0.5878i$

29. roots: 3, $0.9271 \pm 2.8532i$, $-2.4271 \pm 1.7634i$

31. roots: 3i, $\dfrac{-3\sqrt{3}}{2} - \dfrac{3}{2}i, \dfrac{3\sqrt{3}}{2} - \dfrac{3}{2}i$

33. 2, $0.6180 \pm 1.9021i$, $-1.6180 \pm 1.1756i$

35. $\dfrac{3\sqrt{3}}{2} + \dfrac{3}{2}i, -\dfrac{3\sqrt{3}}{2} + \dfrac{3}{2}i, -3i$

37. $1.1346 + 0.1797i, 0.1797 + 1.1346i, -1.0235 + 0.5215i,$
$-0.8123 - 0.8123i, 0.5215 - 1.0235i$

39. $x = 1, -\dfrac{1}{2} \pm \dfrac{\sqrt{3}}{2}i$. These are the same results as in Example 3.

41. $r = 16; n = 4; \theta = 120°$; roots:
$\sqrt{3} + i, -1 + i\sqrt{3}, -\sqrt{3} - i, 1 - i\sqrt{3}$

43. $r = 7\sqrt{2}; n = 4; \theta = 225°$; roots: $0.9855 + 1.4749i,$
$-1.4749 + 0.9855i, -0.9855 - 1.4749i, 1.4749 - 0.9855i$

45. $r = 8, \theta = 210°, n = 3; k = 0 \rightarrow 0.684 + 1.879i;$
$k = 1 \rightarrow -1.970 - 0.347i; k = 2 \rightarrow 1.286 - 1.532i$

47. $r = 81, \theta = 180°, n = 4; k = 0 \rightarrow 2.121 + 2.121i;$
$k = 1 \rightarrow -2.121 + 2.121i; k = 2 \rightarrow -2.121 - 2.121i;$
$k = 3 \rightarrow 2.121 - 2.121i$

49. $D = -4, z_0 = 8^{\frac{1}{6}}\operatorname{cis}45°, z_1 = 8^{\frac{1}{6}}\operatorname{cis}165°, z_2 = 8^{\frac{1}{6}}\operatorname{cis}285°,$
$z_0 = 8^{\frac{1}{6}}\operatorname{cis}75°, z_1 = 8^{\frac{1}{6}}\operatorname{cis}195°, z_2 = 8^{\frac{1}{6}}\operatorname{cis}315°$

51. verified **53. a.** numerator: $-117 + 44j$, denominator: $-21 + 72j$

b. $1 + \dfrac{4}{3}j$ **c.** verified **55.** 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
$A = 36°$	$a \approx 205.35$ cm
$B = 21°$	$b \approx 125.20$ cm
$C = 123°$	$c = 293$ cm

2.

Angles	Sides
$A = 28°$	$a \approx 140.59$ yd
$B = 10°$	$b = 52$ yd
$C = 142°$	$c \approx 184.36$ yd

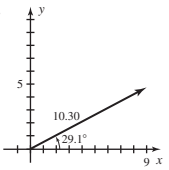
3. approx. 41.84 ft **4.** approx. 20.2° and 159.8°

5.

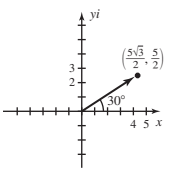
Angles	Sides
$A = 35°$	$a = 67$ cm
$B_1 \approx 64.0°$	$b = 105$ cm
$C_1 \approx 81.0°$	$c_1 \approx 115.37$ cm

Angles	Sides
$A = 35°$	$a = 67$ cm
$B_2 \approx 116.0°$	$b = 105$ cm
$C_2 \approx 29.0°$	$c_2 \approx 56.63$ cm

6. no; 36° **7.** approx. 36.9° **8.** approx. 385.5 m
9. 133.2°, 30.1°, and 16.7° **10.** 85,570.7 m^2
11.



12. $-8\mathbf{i} + 3\mathbf{j}$; $|\mathbf{u}| \approx 8.54$; $\theta \approx 159.4°$ **13.** horiz. comp. ≈ 11.08, vertical comp. ≈ 14.18 **14.** $\langle -4, -2\rangle$; $|2\mathbf{u} + \mathbf{v}| \approx 4.47$, $\theta \approx 206.6°$
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. $\mathbf{p} \cdot \mathbf{q} = -6$; $\theta \approx 97.9°$ **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.** $2(\cos 240° + i \sin 240°)$ **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. $|Z| \approx 10.44$; $\theta \approx 16.7°$, $10.44 \operatorname{cis} 16.7°$ **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.)
$A_1 \approx 58.8°$	$a = 15$
$B = 20°$	$b = 6$
$C_1 \approx 101.2°$	$c_1 \approx 17.21$

Angles	Sides (in.)
$A_2 \approx 121.2°$	$a = 15$
$B = 20°$	$b = 6$
$C_2 \approx 38.8°$	$c_2 \approx 11.0$

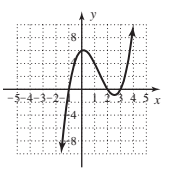
4. a. No **b.** 2.66 mi **5. a.** No **b.** 1 **c.** 8.43 sec
6. a. 2.30 mi **b.** 7516.5 ft **7.** $\mathcal{A} \approx 438{,}795$ mi^2, $P \approx 61.7°$, $B \approx 61.2°$, $M \approx 57.1°$ **8.** speed ≈ 73.36 mph, bearing $\approx 47.8°$
9. $\theta \approx 36.5°$ **10.** 63.48 cm to the right and 130.05 cm down from the initial point on the ceiling **11.** $|\mathbf{F}_3| \approx 212.94$ N, $\theta \approx 251.2°$
12. a. $\theta \approx 42.5°$ **b.** $\mathbf{proj_v u} = \langle -2.4, 7.2\rangle$
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.** $48\sqrt{2} \operatorname{cis} 75°$; 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.** $\approx 2{,}414{,}300$ mi^2

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°, 90° **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.** $\cos 19° \approx 0.94$, $\cos 125° \approx -0.58$
11. a. about \$66,825 **b.** 13, 13, $7\sqrt{2}$; $A = 59.5$ mi^2
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. $\angle A = 37°$, $a \approx 33$ cm,
$\angle B = 34.4°$, $b = 31$ cm,
$\angle C = 108.6°$, $c = 52$ cm
17. about 422.5 lb
19.

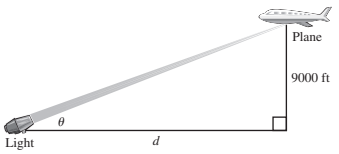


$x \in (-\infty, -1) \cup (2, 3)$

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.

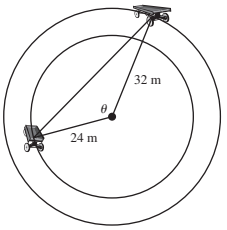
Connections to Calculus Exercises, pp. 834–835

1.



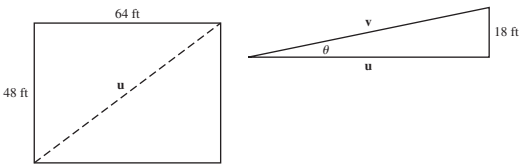
a. $\theta = \tan^{-1}\left(\frac{9000}{d}\right)$ **b.** $\theta \approx 35°$

3.



a. $d = \sqrt{24^2 + 32^2 - 2(24)(32)\cos\theta}$ **b.** $d \approx 54.13$ m **c.** about 106.1°

5.



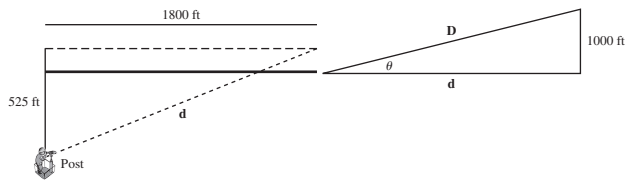
a. $|\mathbf{v}| = \sqrt{48^2 + 64^2 + 18^2} = 82$ ft

b. $\mathbf{u} = \langle 48, 64, 0\rangle$, $\mathbf{v} = \langle 48, 64, 18\rangle$

$$\cos\theta = \frac{\langle 48, 64, 0\rangle \cdot \langle 48, 64, 18\rangle}{(80)(82)}$$

$\theta = \cos^{-1}\left(\frac{40}{41}\right) \approx 12.68°$; verified

7.



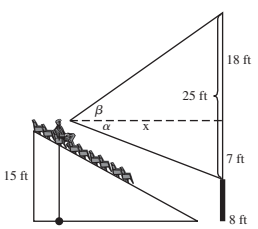
a. $|\mathbf{D}| = \sqrt{525^2 + 1800^2 + 1000^2} = 2125$ ft

b. $\mathbf{d} = \langle 525, 1800, 0\rangle$, $\mathbf{D} = \langle 525, 1800, 1000\rangle$

$$\cos\theta = \frac{\langle 525, 1800, 0\rangle \cdot \langle 525, 1800, 1000\rangle}{(1875)(2125)}$$

$\theta = \cos^{-1}\left(\frac{15}{17}\right) \approx 28.07°$; verified

9.



a. $\theta = \alpha + \beta$ **b.** $\theta = \tan^{-1}\left(\frac{7}{46}\right) + \tan^{-1}\left(\frac{18}{46}\right)$

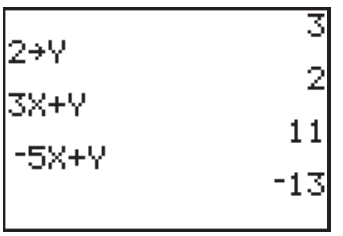
$= \tan^{-1}\left(\frac{7}{x}\right) + \tan^{-1}\left(\frac{18}{x}\right) \approx 30.02°$

CHAPTER 9

Exercises 9.1, pp. 848–853

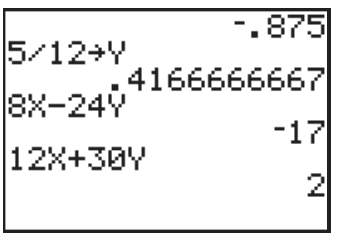
1. inconsistent **3.** consistent, independent **5.** Multiply the first equation by 6 and the second equation by 10. **7.** $y = \frac{7}{4}x - 6$, $y = \frac{-4}{3}x + 5$ **9.** $y = x + 2$ **11.** $x + 3y = -3$ **13.** $y = x + 2$, $x + 3y = -3$

15.



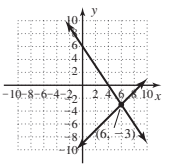
yes

17.

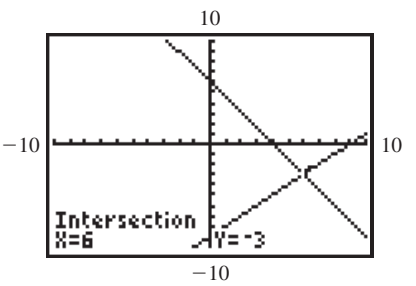


yes

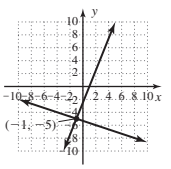
19.



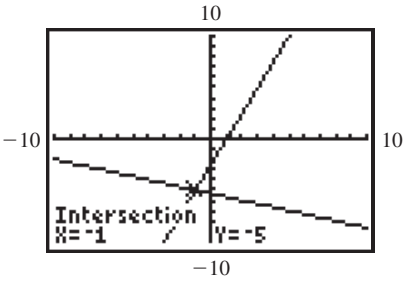
$Y_1 = \frac{12 - 3X}{2}$, $Y_2 = X - 9$



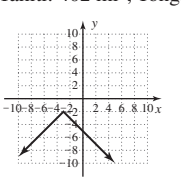
21.



$Y_1 = \frac{5 - 5X}{-2}$, $Y_2 = \frac{-16 - X}{3}$



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.** $\varnothing$; 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 mi^2, Tonga: 290 mi^2 **87.** $y = 2x + 3$ **89.** \$50,000
91.

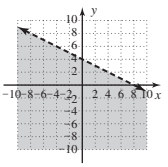


93. $x \approx 120.716$

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. $\{(x, y, z) | x \in \mathbb{R}, y = 2 - x, z = 2 - x\}$; $(p, 2 - p, 2 - p)$, other solutions possible
25. $\left\{(x, y, z) | x = -\frac{5}{3}z - \frac{2}{3}, y = -z - 2, z \in \mathbb{R}\right\}$; $\left(-\frac{5}{3}p - \frac{2}{3}, -p - 2, p\right)$, other solutions possible
27. $(p, 2p, p + 1)$ **29.** $(p + 9, p - 4, p)$
31. $\left\{(x, y, z) \middle| x + \frac{1}{2}y - 2z = 6\right\}$ **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.** $\left(\frac{1}{5}, \frac{1}{2}, -2\right)$ **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
11.

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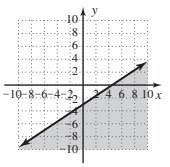
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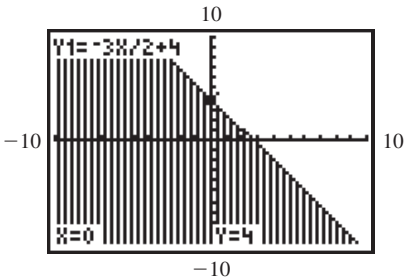
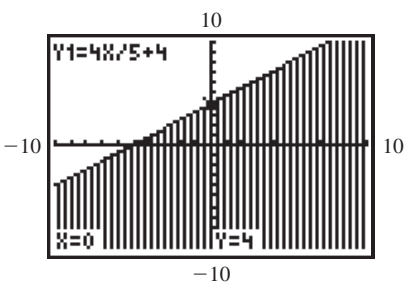
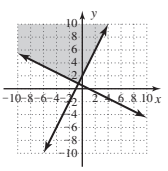


(0, 0) is in the solution region, and $3(0) + 2(0) \leq 8$ is true.
17.


(0, 0) is in the solution region, and $4(0) - 5(0) > -20$ is true.
19. No, No, No, Yes
21.

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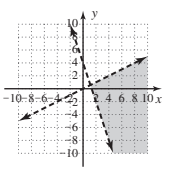
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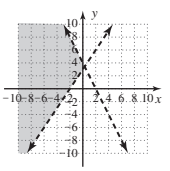
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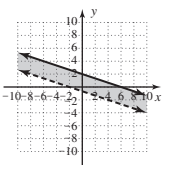
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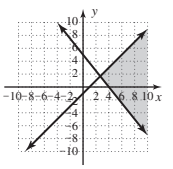
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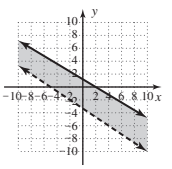
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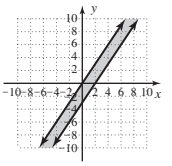
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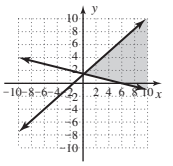
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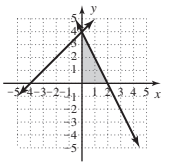
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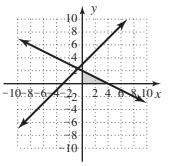
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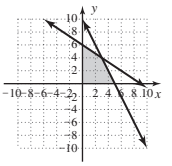
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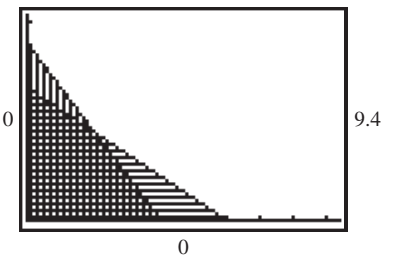
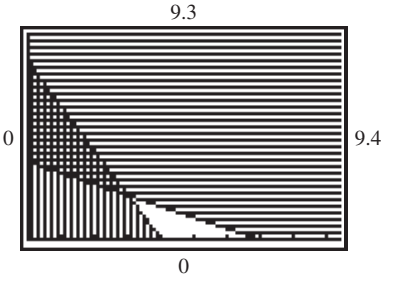
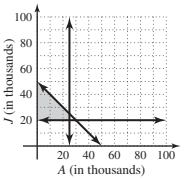
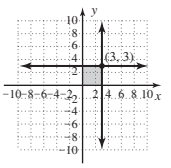


(2, 4)
45.


(3, 2)
47. $\begin{cases} y - x \leq 1 \\ x + y > 3 \end{cases}$ **49.** $\begin{cases} y - x \leq 1 \\ x + y < 3 \\ y \geq 0 \end{cases}$ **51.** (5, 3) **53.** (12, 11)
55. 26 at (2, 2) **57.** 264 at (4, 3) **59.** $5 < H < 10$
61.


$J + A \leq 50{,}000$
$J \geq 20{,}000$
$A \leq 25{,}000$
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,

$$\begin{cases}15.3R+35.7P=211.14\\ P=R+0.10\end{cases}$$

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.** 3×2, 5.8 **9.** 4×3, -1

11. $\left[\begin{array}{ccc|c}1&2&-1&1\\1&0&1&3\\2&-1&1&3\end{array}\right]$; diagonal entries 1, 0, 1

13. $\begin{cases}x+4y=5\\ y=\frac{1}{2}\end{cases}\rightarrow(3,\frac{1}{2})$ **15.** $\begin{cases}x+2y-z=0\\ y+2z=2\\ z=3\end{cases}\rightarrow(11,-4,3)$

17. $\begin{cases}x+3y-4z=29\\ y-\frac{3}{2}z=\frac{21}{2}\\ z=3\end{cases}\rightarrow(-4,15,3)$ **19.** $\left[\begin{array}{ccc}1&-6&-2\\0&-28&-6\end{array}\right]$

21. $\left[\begin{array}{ccc|c}1&-3&3&2\\0&23&-12&-15\\-2&1&0&4\end{array}\right]$ **23.** $\left[\begin{array}{ccc|c}3&1&1&8\\0&-3&-3&-6\\0&-10&-13&34\end{array}\right]$

25. $2R_1+R_2\rightarrow R_2$, $-3R_1+R_3\rightarrow R_3$ **27.** $-5R_1+R_2\rightarrow R_2$, $4R_1+R_3\rightarrow R_3$

29. (20, 10) **31.** (1, 6, 9) **33.** (1, 1, 2) **35.** (1, 1, 1) **37.** (2, -1, 3)

39. (10, 6, 8) **41.** $\left(\frac{1}{2},1,-\frac{1}{4}\right)$ **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 units^2

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.** $x=84°$; $y=25°$

71. a. $z_1=\sqrt{10}\,\text{cis}[\pi+\tan^{-1}(3)]$ **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.** 2×2, $a_{12}=-3$, $a_{21}=5$

9. 2×3, $a_{12}=-3$, $a_{23}=6$, $a_{22}=5$ **11.** 3×3, $a_{12}=1$, $a_{23}=1$, $a_{31}=5$

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.** $\begin{bmatrix}0&\frac{3}{4}&\frac{1}{4}\\\frac{-1}{2}&\frac{3}{8}&\frac{1}{8}\\\frac{-1}{4}&\frac{11}{16}&\frac{1}{16}\end{bmatrix}$

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; $A=27.7269$ cm^2

59. a.
$$V=\begin{array}{c}\\S\\D\\P\end{array}\begin{array}{c}\begin{array}{cc}T&S\end{array}\\\begin{bmatrix}3820&1960\\2460&1240\\1540&920\end{bmatrix}\end{array}\qquad M=\begin{array}{c}\\S\\D\\P\end{array}\begin{array}{c}\begin{array}{cc}T&S\end{array}\\\begin{bmatrix}4220&2960\\2960&3240\\1640&820\end{bmatrix}\end{array}$$

b. 3900 more by Minsk

c. $V=\begin{bmatrix}3972.8&2038.4\\2558.4&1289.6\\1601.6&956.8\end{bmatrix}$ $M=\begin{bmatrix}4388.8&3078.4\\3078.4&3369.6\\1705.6&852.8\end{bmatrix}$

d. $\begin{bmatrix}8361.6&5116.8\\5636.8&4659.2\\3307.2&1809.6\end{bmatrix}$

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 restaurants.

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. $z = 3\,\text{cis}\left(\frac{\pi}{8}\right), 3\,\text{cis}\left(\frac{5\pi}{8}\right), 3\,\text{cis}\left(\frac{9\pi}{8}\right), 3\,\text{cis}\left(\frac{13\pi}{8}\right)$

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. $p_1 = 72.25°$, $p_2 = 74.75°$, $p_3 = 80.25°$, $p_4 = 82.75°$

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. $D = \begin{vmatrix} 2 & 5 \\ -3 & 4 \end{vmatrix}$; $D_x = \begin{vmatrix} 7 & 5 \\ 1 & 4 \end{vmatrix}$; $D_y = \begin{vmatrix} 2 & 7 \\ -3 & 1 \end{vmatrix}$ **9.** $(-5, 9)$

11. $\left(\frac{-26}{3}, \frac{25}{3}\right)$ **13.** not possible

15. a. $D = \begin{vmatrix} 4 & -1 & 2 \\ -3 & 2 & -1 \\ 1 & -5 & 3 \end{vmatrix}$ $D_x = \begin{vmatrix} -5 & -1 & 2 \\ 8 & 2 & -1 \\ -3 & -5 & 3 \end{vmatrix}$

$D_y = \begin{vmatrix} 4 & -5 & 2 \\ -3 & 8 & -1 \\ 1 & -3 & 3 \end{vmatrix}$ $D_z = \begin{vmatrix} 4 & -1 & -5 \\ -3 & 2 & 8 \\ 1 & -5 & -3 \end{vmatrix}$,

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.** $8\ \text{cm}^2$ **27.** $27\ \text{ft}^2$ **29.** $19\ \text{m}^3$

31. $96\ \text{in}^3$ **33.** yes **35.** no **37.** yes; yes; yes

39. $\frac{1}{x} - \frac{\frac{1}{2}}{x+1} - \frac{\frac{3}{4}}{(x+1)^2} + \frac{\frac{1}{2}}{x-1} - \frac{\frac{1}{4}}{(x-1)^2}$

41. $\frac{3}{x+1} - \frac{2}{x-3} + \frac{1}{(x-3)^3}$ **43.** 214.5 ft^2 of skin, 231.0 ft^2 of wood veneer, 516 tension rods, and 498 ft of hoop **45.** 955 ft^2 of skin, 1021.5 ft^2 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.

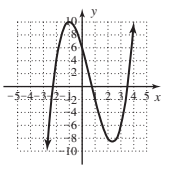
57. Answers will vary. **59.** Answers will vary. **61.** Answers will vary.

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.



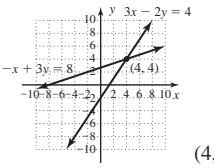
81. $\angle B \approx 76.3°$, $\angle C \approx 54.7°$, side $c = 9.4$ in.

Making Connections, p. 947

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

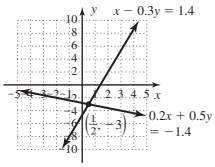
Summary and Concept Review, pp. 948–953

1.



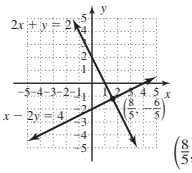
(4, 4)

2.



$(\frac{1}{2}, -3)$

3.



$\left(\frac{8}{5}, \frac{-6}{5}\right)$

4. no solution; inconsistent

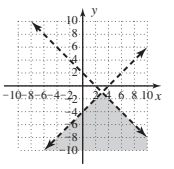
5. $(5, -1)$; consistent **6.** $(7, 2)$; consistent **7.** $(3, -1)$; consistent

8. $\left(\frac{11}{4}, \frac{-1}{6}\right)$; consistent **9.** Willis Tower is 1450 ft; Hancock Building is 1127 ft. **10.** \$1.20 **11.** $(0, 3, 2)$ **12.** $(1, 1, 1)$

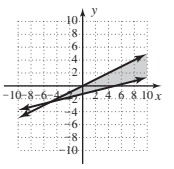
13. no solution, inconsistent **14.** 72 nickels, 85 dimes, 60 quarters

15. $y = -x^2 + 10x - 9$

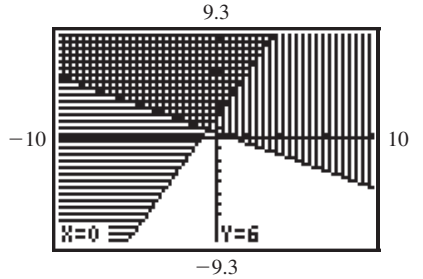
16.

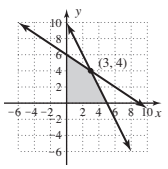


17.



18.



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.

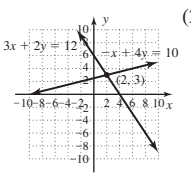
45. It's the inverse of B. **46.** E **47.** It's an identity matrix.

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.** $\frac{91}{2}$ units^2

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

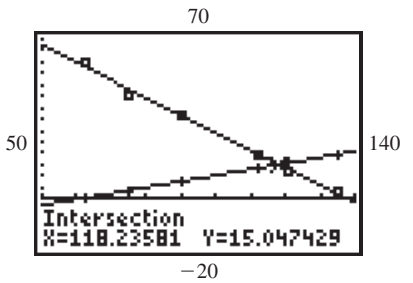
6. a. $\begin{bmatrix}0 & -0.1 & 0\\ 0.5 & -0.6 & 0\\ -0.2 & -0.8 & -0.9\end{bmatrix}$ **b.** $\begin{bmatrix}-0.3 & -0.06 & -0.12\\ 0.06 & -0.06 & 0\\ -0.18 & -0.24 & -0.48\end{bmatrix}$

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

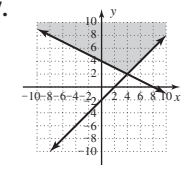
7. $\left(2, 1, \frac{-1}{3}\right)$ **8.** $(3, -2, 3)$ **9.** $\left(\frac{97}{34}, \frac{-18}{17}\right)$ **10.** $(1, 6, 9)$

11. 21.59 cm by 35.56 cm **12.** Tahiti 402 mi^2; Tonga 290 mi^2

13. \$15,000 at 7%; \$8000 at 5%; \$7000 at 9%

14. a. 

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.** $\frac{1}{x-3}+\frac{3x+2}{x^2+3x+9}$

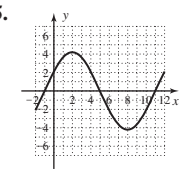
Strengthening Core Skills, pp. 955–956

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. $R = \pm\frac{1}{\pi}\sqrt{A + (\pi r)^2}$

5. 

7. a. $(a + bi) + (a - bi) = 2a$

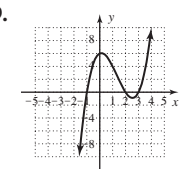
b. $(a + bi)(a - bi) = a^2 - (bi)^2 = a^2 + b^2$

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 $x = \pi^2$ (≈ 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. $\dfrac{-1}{x+3}+\dfrac{1}{x-3}$ **5.** $\dfrac{2}{x+7}+\dfrac{-2}{x-4}$

7. $\dfrac{-1}{x+8}+\dfrac{2}{x+5}$ **9.** 114 units^2 **11.** 36 units^2

13. 240 units^3; $V = LWH = (5)(6)(8) = 240$ units^3

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. $\left(x-\dfrac{13}{2}\right)^2+(y+9)^2=\left(\dfrac{25}{2}\right)^2$ **19.** $d = 13$; B, C, E, G

21. Verified, $d=\dfrac{8\sqrt{5}}{5}$ **23.** B, C, E **25.** Verified **27.** $y=-\dfrac{1}{16}x^2$

29. $4x^2+3y^2=48$ **31.** Verified, verified **33.** $3x^2-y^2=3$

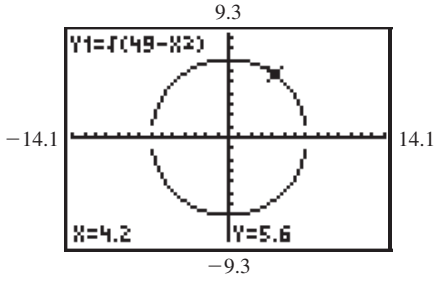
35. Verified **37.** $=\dfrac{\cos^2 x-\sin^2 x+\sin^2 x}{\sin^2 x}=\dfrac{\cos^2 x}{\sin^2 x}=\cot^2 x$

39. a. $x = 2\ln 9$, $x \approx 4.39$ **b.** $x=\dfrac{5}{2}\ln 54$, $x \approx 9.97$

Exercises 10.2, pp. 979–983

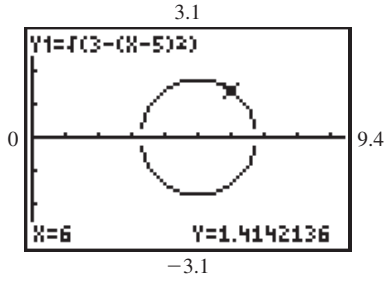
1. $c^2 = |a^2 - b^2|$ **3.** $2a, 2b$ **5.** Answers will vary.

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



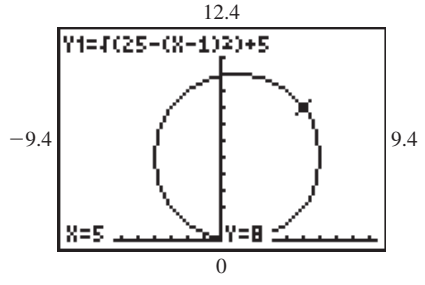
$(4.2, 5.6), (4.2, -5.6)$

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



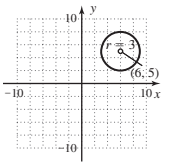
$(6, \sqrt{2}), (6, -\sqrt{2})$

11. $(x-1)^2+(y-5)^2=25$

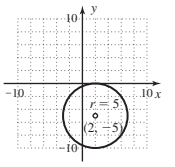


(5, 8), (5, 2)

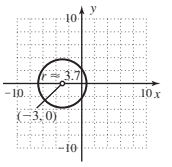
13. $(x-6)^2+(y-5)^2=9$
center: $(6, 5)$, $r = 3$



15. $(x-2)^2+(y+5)^2=25$
center: $(2, -5)$, $r = 5$



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



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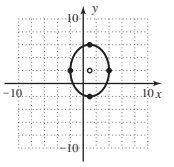

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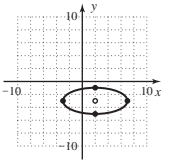

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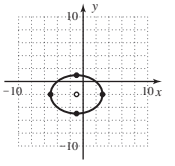
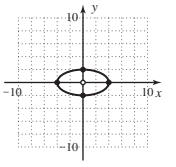
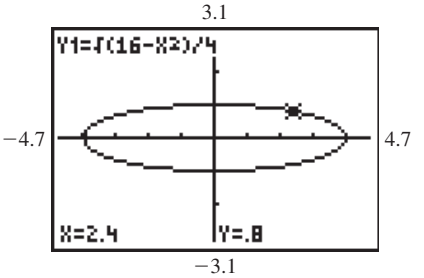


25. a. $\dfrac{x^2}{16}+\dfrac{y^2}{4}=1$, $(0, 0)$, $a = 4$, $b = 2$

b. $(-4, 0), (4, 0), (0, -2), (0, 2)$ **c.**



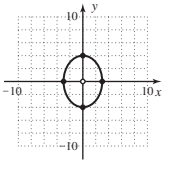
d.



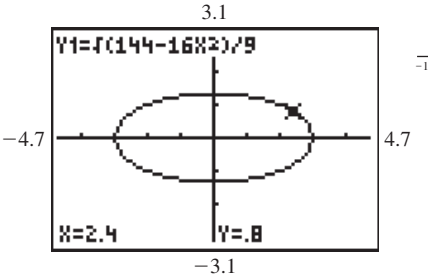
$(2.4, 0.8), (2.4, -0.8), (-2.4, 0.8), (-2.4, -0.8)$

27. a. $\dfrac{x^2}{9}+\dfrac{y^2}{16}=1$, $(0, 0)$, $a = 3$, $b = 4$

b. $(0, -4), (0, 4), (-3, 0), (3, 0)$ **c.**



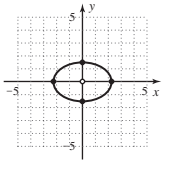
d.



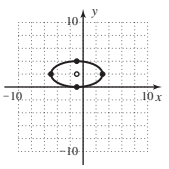
$(2.4, 0.8), (2.4, -0.8), (-2.4, 0.8), (-2.4, -0.8)$

29. a. $\dfrac{x^2}{5}+\dfrac{y^2}{2}=1$, $(0, 0)$, $a=\sqrt{5}$, $b=\sqrt{2}$

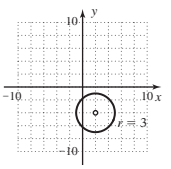
b. $(-\sqrt{5}, 0), (\sqrt{5}, 0), (0, -\sqrt{2}), (0, \sqrt{2})$ **c.**



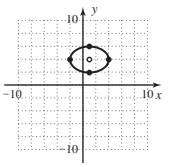
31. ellipse



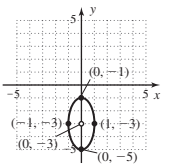
33. circle



35. ellipse

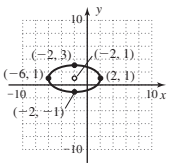


37. $x^2 + \dfrac{(y+3)^2}{4} = 1$



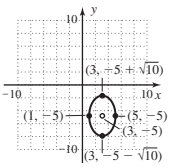
D: $x \in [-1, 1]$, R: $y \in [-5, -1]$

39. $\dfrac{(x+2)^2}{16} + \dfrac{(y-1)^2}{4} = 1$



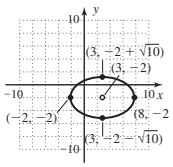
D: $x \in [-6, 2]$, R: $y \in [-1, 3]$

41. $\dfrac{(x-3)^2}{4} + \dfrac{(y+5)^2}{10} = 1$



D: $x \in [1, 5]$,
R: $y \in [-5 - \sqrt{10}, -5 + \sqrt{10}]$

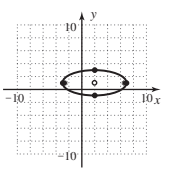
43. $\dfrac{(x-3)^2}{25} + \dfrac{(y+2)^2}{10} = 1$



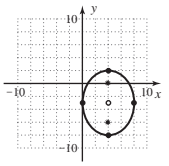
D: $x \in [-2, 8]$,
R: $y \in [-2 - \sqrt{10}, -2 + \sqrt{10}]$

45. $k = 20$ **47.** $k = 20$

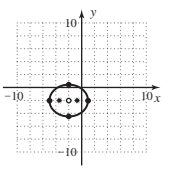
49. a. (2, 1) **b.** (−3, 1) and (7, 1) **c.** $(2 - \sqrt{21}, 1)$ and $(2 + \sqrt{21}, 1)$ **d.** (2, 3) and (2, −1) **e.**



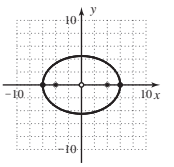
51. a. (4, −3) **b.** (4, 2) and (4, −8) **c.** (4, 0) and (4, −6) **d.** (0, −3) and (8, −3) **e.**



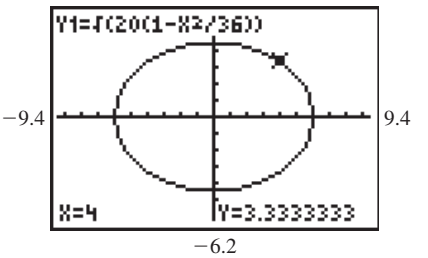
53. a. (−2, −2) **b.** (−5, −2) and (1, −2) **c.** $(-2 + \sqrt{3}, -2)$ and $(-2 - \sqrt{3}, -2)$ **d.** $(-2, -2 + \sqrt{6})$ and $(-2, -2 - \sqrt{6})$ **e.**



55. $\dfrac{x^2}{36} + \dfrac{y^2}{20} = 1$ **a.**

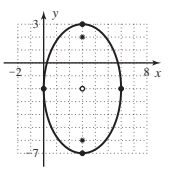


b.

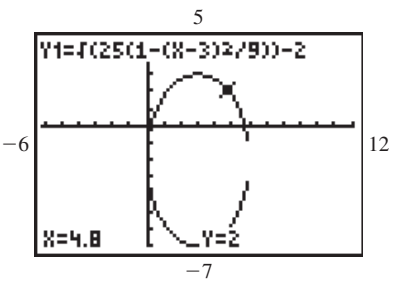


c. $L = 6.\overline{6}$ **d.** verified

57. $\dfrac{(x-3)^2}{9} + \dfrac{(y+2)^2}{25} = 1$ **a.**



b.



c. $L = 3.6$ **d.** verified

59. $\dfrac{x^2}{16} + \dfrac{y^2}{9} = 1$, $(\pm\sqrt{7}, 0)$

61. $\dfrac{(x+3)^2}{4} + \dfrac{(y+1)^2}{16} = 1$, $(-3, -1 \pm 2\sqrt{3})$

63. $A = 12\pi$ units^2 **65.** $\sqrt{7} \approx 2.65$ ft, 2.25 ft

67. 8.9 ft, 17.9 ft **69.** $\dfrac{x^2}{15^2} + \dfrac{y^2}{8^2} = 1$; 6.4 ft **71.** $\dfrac{x^2}{6.25} + \dfrac{y^2}{2.25} = 1$

73. $\dfrac{x^2}{36^2} + \dfrac{y^2}{(35.25)^2} = 1$ **75.** $a \approx 142$ million miles, $b \approx 141$ million miles, orbit time ≈ 686 days **77.** about 66,697 mph **79.** 90,000 π yd^2

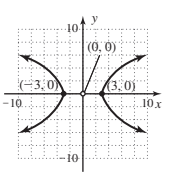
81. a. 45 ft **b.** 106 ft **c.** 25 ft **83.** ellipse, since squared terms are positive and $A \neq B$; $6(x+3)^2 + 3(y-4)^2 = 0$, the constant term becomes zero; the graph is the single point $(-3, 4)$

85. $\dfrac{\log 20}{\log 3} \approx 2.73$ **87.** $z = 64$

Exercises 10.3, pp. 993–997

1. transverse **3.** perpendicular, transverse, center **5.** Answers will vary.

7.



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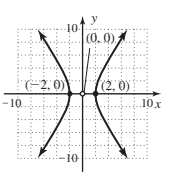

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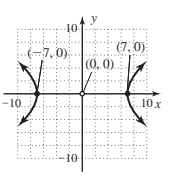
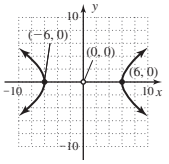
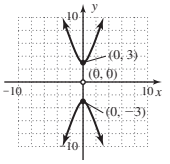
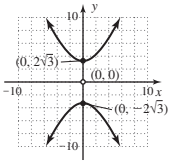
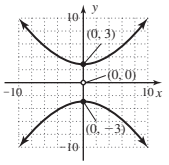
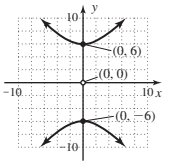


13. 

15. 

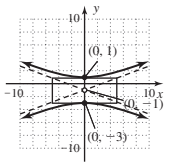
17. 

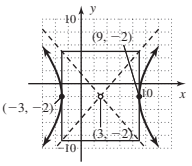
19. 

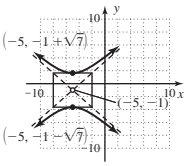
21. 

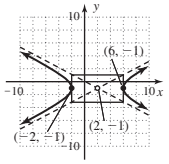
23. $(-4, -2), (2, -2), y = -2, (-1, -2), x = -1$

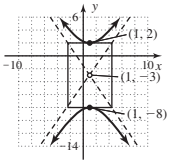
25. $(4, 1), (4, -3), x = 4, (4, -1), y = -1$

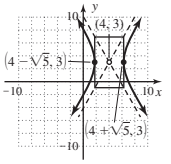
27. 

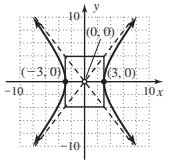
29. 

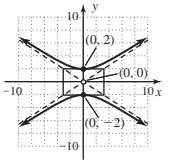
31. 

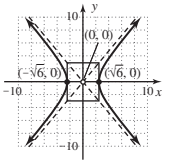
33. 

35. 

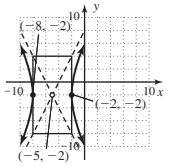
37. 

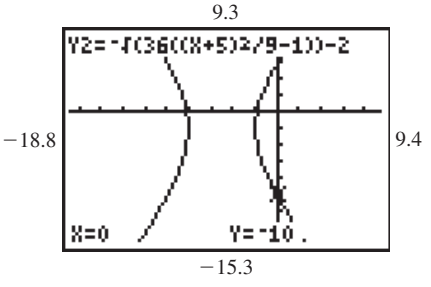
39. 

41. 

43. 

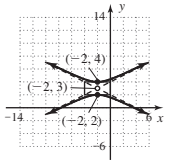
45. $\dfrac{(x+5)^2}{9} - \dfrac{(y+2)^2}{36} = 1$

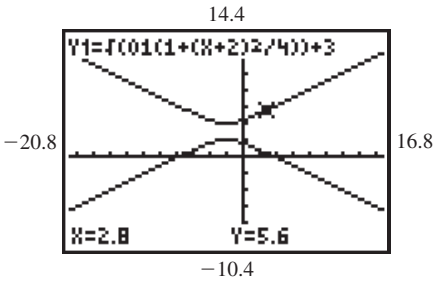




$(0, -10), (0, 6), (-10, -10), (-10, 6)$

47. $\dfrac{(y-3)^2}{1} - \dfrac{(x+2)^2}{4} = 1$





$(2.8, 5.6), (2.8, 0.4), (-6.8, 0.4), (-6.8, 5.6)$

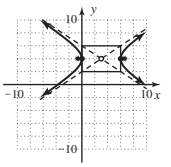
49. circle; $A = B$ **51.** circle; $A = B$ **53.** hyperbola; A, B opposite signs

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. $\dfrac{(x-3)^2}{9} - \dfrac{(y-4)^2}{4} = 1$ **a.** $(3, 4)$ **b.** $(0, 4)$ and $(6, 4)$

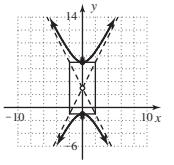
c. $(3 - \sqrt{13}, 4)$ and $(3 + \sqrt{13}, 4)$ **d.** $2a = 6, 2b = 4$

e. 

67. $\dfrac{(y-3)^2}{16} - \dfrac{x^2}{4} = 1$ **a.** $(0, 3)$ **b.** $(0, 7), (0, -1)$

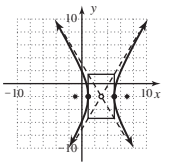
c. $(0, 3 + 2\sqrt{5}), (0, 3 - 2\sqrt{5})$ **d.** $2a = 4, 2b = 8$

e. $y = 2x + 3, y = -2x + 3$



69. $\dfrac{(x-3)^2}{4} - \dfrac{(y+2)^2}{12} = 1$ **a.** $(3, -2)$ **b.** $(1, -2)$ and $(5, -2)$

c. $(-1, -2)$ and $(7, -2)$ **d.** $2a = 4, 2b = 4\sqrt{3}$

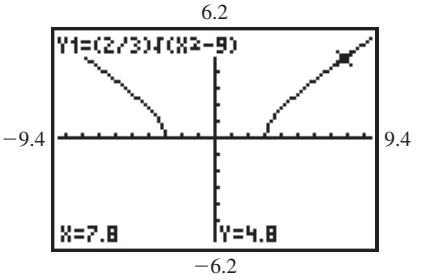
e. 

71. $\dfrac{x^2}{36} - \dfrac{y^2}{28} = 1$ **73.** $\dfrac{y^2}{9} - \dfrac{(x+2)^2}{9} = 1$

75. $\dfrac{x^2}{4} - \dfrac{y^2}{9} = 1, (\pm\sqrt{13}, 0)$ **77.** $\dfrac{(y-1)^2}{4} - \dfrac{(x-2)^2}{5} = 1$, 4 by $2\sqrt{5}$

79. **a.** $y = \frac{2}{3}\sqrt{x^2 - 9}$ **b.** $x \in (-\infty, -3] \cup [3, \infty)$

c. $y = \frac{-2}{3}\sqrt{x^2 - 9}$



81. 40 yd **83.** 12 microns

85. $\dfrac{x^2}{225} - \dfrac{y^2}{2275} = 1$, about $(24.1, 60)$ or $(-24.1, 60)$

87. $y = \pm\sqrt{\dfrac{b^2}{a^2}x^2 - b^2}$, as $x \to \infty$, $y \to \pm\sqrt{\dfrac{b^2}{a^2}x^2} = \pm\dfrac{b}{a}x$

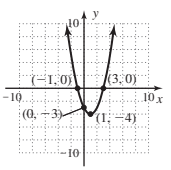
89. **a.** $\dfrac{(x-4)^2}{\frac{1}{4}} - (y-2)^2 = 0$ **b.** $(x-2)^2 + \dfrac{(y-4)^2}{\frac{1}{5}} = 0$

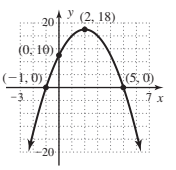
91. $\approx$ 6mph **93.** 42 solid, 46 liquid

Exercises 10.4, pp. 1003–1006

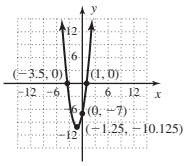
1. horizontal, right, $a < 0$ **3.** $(p, 0), x = -p$ **5.** Answers will vary.

7. $x \in (-\infty, \infty), y \in [-4, \infty)$ **9.** $x \in (-\infty, \infty), y \in (-\infty, 18]$

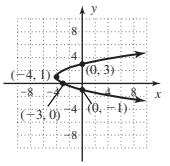




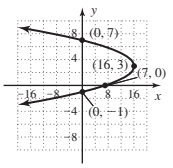
11. $x \in (-\infty, \infty)$, $y \in [-10.125, \infty)$



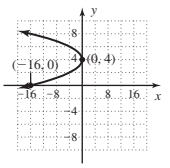
13. $x \in [-4, \infty)$, $y \in (-\infty, \infty)$



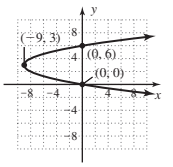
15. $x \in (-\infty, 16]$, $y \in (-\infty, \infty)$



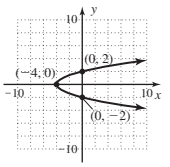
17. $x \in (-\infty, 0]$, $y \in (-\infty, \infty)$



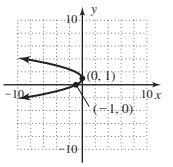
19. $x \in [-9, \infty)$, $y \in (-\infty, \infty)$



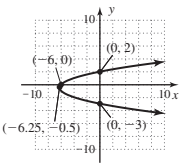
21. $x \in [-4, \infty)$, $y \in (-\infty, \infty)$



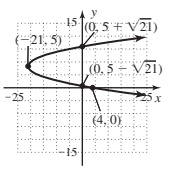
23. $x \in (-\infty, 0]$, $y \in (-\infty, \infty)$



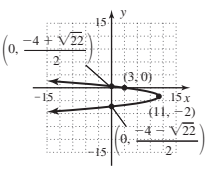
25. $x \in [-6.25, \infty)$, $y \in (-\infty, \infty)$



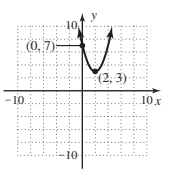
27. $x \in [-21, \infty)$, $y \in (-\infty, \infty)$



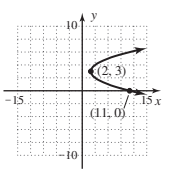
29. $x \in (-\infty, 11]$, $y \in (-\infty, \infty)$



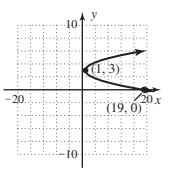
31. $x \in (-\infty, \infty)$, $y \in [3, \infty)$



33. $x \in [2, \infty)$, $y \in (-\infty, \infty)$



35. $x \in [1, \infty)$, $y \in (-\infty, \infty)$



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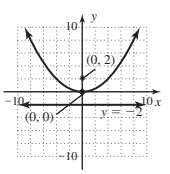

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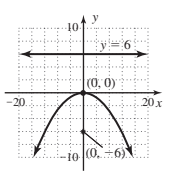

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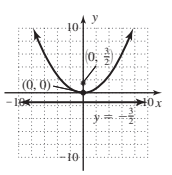

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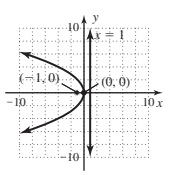

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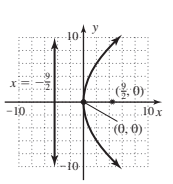

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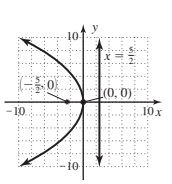

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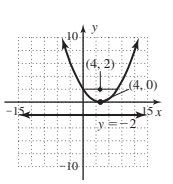

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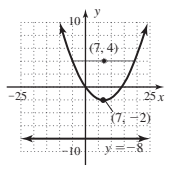

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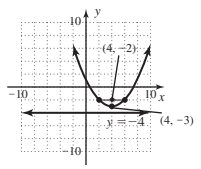

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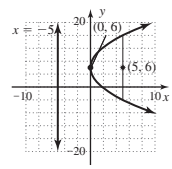

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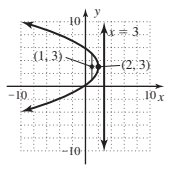

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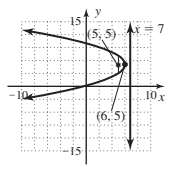


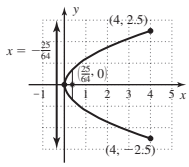
61. $x^2 = 8y$ **63.** $y^2 = 16x$ **65.** $x^2 = -20y$

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 units^2

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

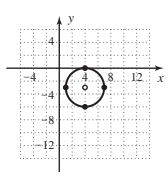
87. $(x - 2)^2 = \frac{1}{2}(y + 8)$; $p = \frac{1}{8}$; $(2, -8)$

89. Answers will vary.

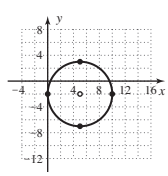
91. $\theta = 30° + 360°k$, $330° + 360°k$

Mid-Chapter Check, p. 1006

1.



2.



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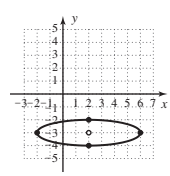

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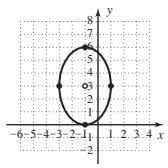

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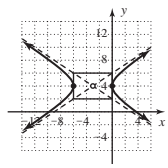
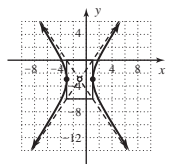


6.



7. a. $\dfrac{(x + 3)^2}{4} + \dfrac{(y - 1)^2}{16} = 1$; 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. $\dfrac{x^2}{16} + \dfrac{y^2}{4} = 1$

10. yes, distance $d \approx 49$ mi

Reinforcing Basic Concepts, pp. 1006–1007

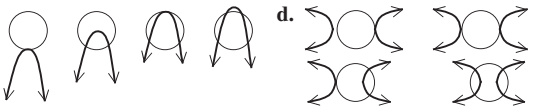
Exercise 1: $\dfrac{25(x - 2)^2}{2} + \dfrac{9(y - 3)^2}{4} = 1$

Exercise 2: $\dfrac{28(x - 1)^2}{25} + \dfrac{48(y + 2)^2}{25} = 1$

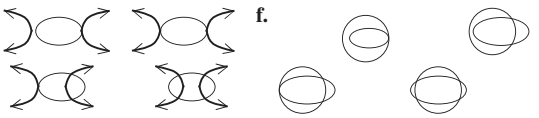
Exercises 10.5, pp. 1015–1018

1. a. 3 or 4 not possible **b.** 3 or 4 not possible

c. **d.**

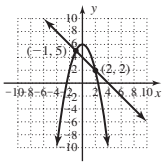


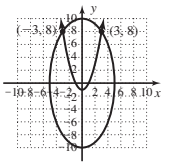
e. **f.**



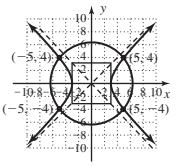
3. region, solutions **5.** Answers will vary.

7. first: parabola; second: line **9.** first: parabola; second: ellipse





11. first: hyperbola; second: circle



13. $(-4, -3), (3, 4)$ **15.** $\left(4, \frac{3}{2}\right), (3, 2)$

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.** $(-3, \ln 9 + 1), (4, \ln 16 + 1)$

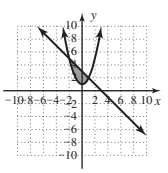
35. $(0, 10), (\ln 6, 45)$ **37.** $(-3, 1), (2, 1024)$

39. $(-3, -21), (1, -1), (2, 4)$ **41.** $(2, -4), (6, 4)$

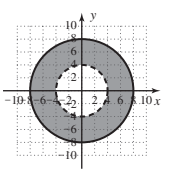
43. $(3, 5), (3, -5)$ **45.** $(-2.43, -2.81), (2, 1)$

47. $(0.72, 2.19), (2, 3), (4, 3), (5.28, 2.19)$

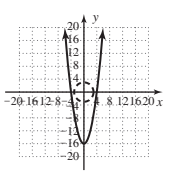
49.



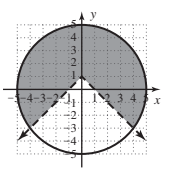
51.



53. no solution



55.



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 m × 10 m **65.** 5 km × 9 km **67.** 8 ft × 8 ft × 25 ft

69. \$1.83; \$3
90,000 gal
$\begin{cases} 10P^2 + 6D = 144 \\ 8P^2 - 8P - 4D = 12 \end{cases}$

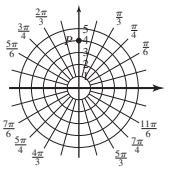
71. Answers will vary. **73.** 18 in. by 18 in. by 77 in. **75.** ≈62 ft

77. a. $m = \frac{-400}{1}$, the copier depreciates by \$400 a year.
b. $y = -400x + 4500$ **c.** \$1700 **d.** 9.5 yr

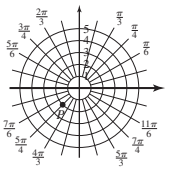
Exercises 10.6, pp. 1031–1035

1. polar **3.** II, IV **5.** Answers will vary.

7.



9.



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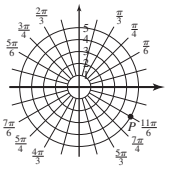

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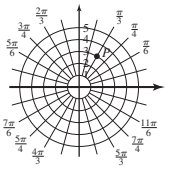


15. $\left(4, \frac{\pi}{2}\right)$ **17.** $\left(4\sqrt{2}, \frac{\pi}{4}\right)$ **19.** $\left(8, \frac{2\pi}{3}\right)$ **21.** $\left(4\sqrt{2}, \frac{3\pi}{4}\right)$

23. $\left(3\sqrt{2}, \frac{-5\pi}{4}\right), \left(-3\sqrt{2}, \frac{7\pi}{4}\right), \left(-3\sqrt{2}, \frac{-\pi}{4}\right)$

25. $\left(2, \frac{5\pi}{6}\right), \left(2, \frac{-7\pi}{6}\right), \left(-2, \frac{-\pi}{6}\right)$ **27.** *C* **29.** *C* **31.** *D* **33.** *B*

35. *D* **37.** $(8, 180°)$ or $(8, \pi)$ **39.** $(4\sqrt{2}, 45°)$ or $\left(4\sqrt{2}, \frac{\pi}{4}\right)$

41. $(10, 45°)$ or $\left(10, \frac{\pi}{4}\right)$ **43.** $(13, 247.4°)$ or $(13, 4.3176)$

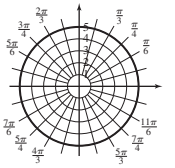
45. $(4\sqrt{2}, 4\sqrt{2})$ **47.** $(-2\sqrt{2}, 2\sqrt{2})$ **49.** $(\sqrt{3}, 1)$ **51.** $\left(\frac{5\sqrt{2}}{2}, \frac{5\sqrt{2}}{2}\right)$

53. $r = 5$ **55.** $r^2 \sin 2\theta = 6$ **57.** $\tan\theta = 3r\cos\theta + 1$ or $r = \dfrac{\tan\theta - 1}{3\cos\theta}$

59. $r^2 = \cos 2\theta$ **61.** $x^2 + y^2 = 6x$ **63.** $x = 2$ **65.** $x^2 + y^2 = x - 1$

67. $y = -\frac{1}{2}x^2 + \frac{1}{2}$

69.



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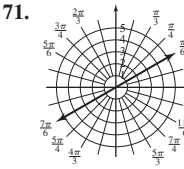

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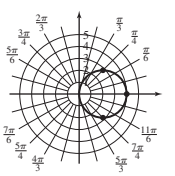

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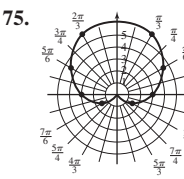

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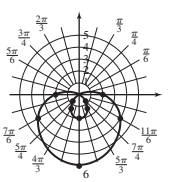

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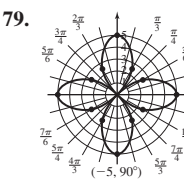
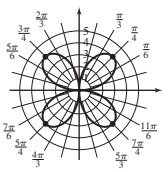
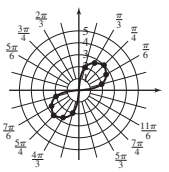
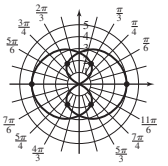
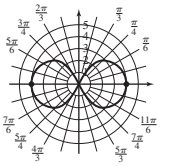
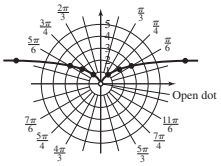


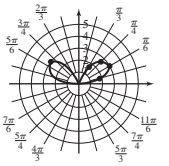
81. 

83. 

85. 

87. 

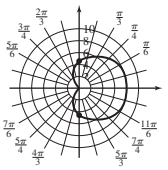
89. 

91. 

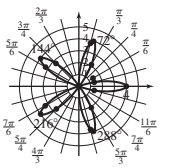
93. $\left(\dfrac{4\sqrt{3}+3\sqrt{2}}{2}, \dfrac{4+3\sqrt{2}}{2}\right)$; $(3\sqrt{2}, 3\sqrt{2})$; $(4\sqrt{3}, 4)$; yes

$M = \left(\dfrac{3\sqrt{2}+4\sqrt{3}}{2}, \dfrac{3\sqrt{2}+4}{2}\right)$

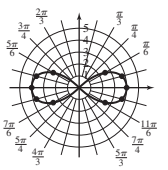
95. $r = 4 + 4\cos\theta$



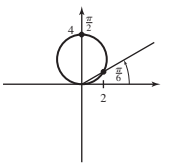
97. $r = 4\cos(5\theta)$



99. $r^2 = 16\cos(2\theta)$



101. $r = 4\sin\theta$



103. a; this is a circle through $(6, 0°)$ symmetric to the polar axis.

105. g; this is a circle through $\left(6, \dfrac{\pi}{2}\right)$ symmetric to $\theta = \dfrac{\pi}{2}$.

107. f; this is a limaçon symmetric to $\theta = \dfrac{\pi}{2}$ with an inner loop. Thus $a < b$.

109. b; this is a cardioid symmetric to $\theta = \dfrac{\pi}{2}$ through $\left(6, \dfrac{3\pi}{2}\right)$.

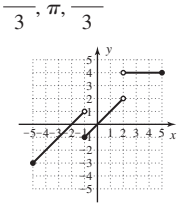
111. $r^2 = 7200^2\sin(2\theta)$ **113.** $r = 15\cos(5\theta)$ or $r = 15\sin(5\theta)$

115. π; π; π; 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 units^2 **121.** $t = 0, \dfrac{2\pi}{3}, \pi, \dfrac{5\pi}{3}$

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; $\dfrac{B}{A-C}$ **3.** invariants **5.** Answers will vary.

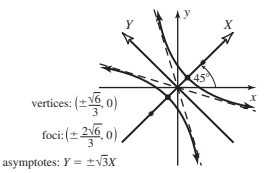
7. $\dfrac{Y^2}{8} - \dfrac{X^2}{8} = 1$ **9.** $6 + 3\sqrt{2} = X$, $-6 + 3\sqrt{2} = Y$

11. $\dfrac{5\sqrt{2}}{2} = X$, $\dfrac{5\sqrt{2}}{2} = Y$ **13.** $0 = x$, $4 = y$

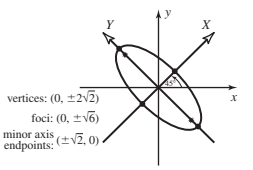
15. $\dfrac{3\sqrt{3}}{2} - 2 = x$; $\dfrac{3}{2} + 2\sqrt{3} = y$ **17.** $\dfrac{-x^2}{2} + xy\sqrt{3} + \dfrac{y^2}{2} = 9$

19. $4X^2 + 2Y^2 = 9$

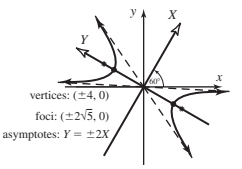
21. **a.** $3X^2 - Y^2 = 2$ **b.**



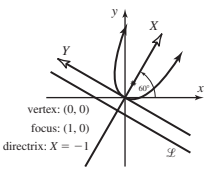
23. **a.** $4X^2 + Y^2 = 8$ **b.**



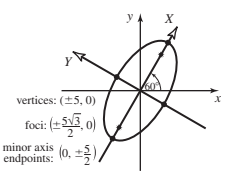
25. **a.** $Y^2 - 4X^2 = 16$ **b.**



27. **a.** $Y^2 - 4X = 0$ **b.**



29. **a.** $X^2 + 4Y^2 = 25$ **b.**

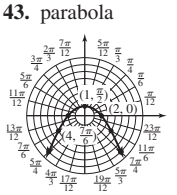


31. $336 > 0$; hyperbola; $\cos(2\beta) = \dfrac{7}{25}$; $\dfrac{4}{5} = \cos\beta$; $\dfrac{3}{5} = \sin\beta$

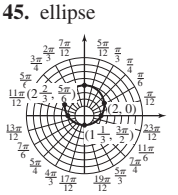
33. **a.** parabola **b.** $\beta = 45°$; $2Y^2 = 5$ **c.** verified

35. **a.** circle or ellipse **b.** $\beta = 60°$; $\dfrac{9}{2}X^2 + \dfrac{5Y^2}{2} + 2X - 2\sqrt{3}Y = 1$ (ellipse) **c.** verified **37.** f **39.** g **41.** h

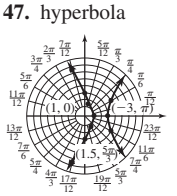
43. parabola



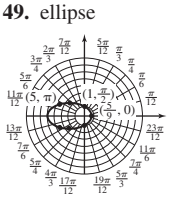
45. ellipse



47. hyperbola



49. ellipse



51. $r = \dfrac{3.2}{1 - 0.8\cos\theta}$, $r = \dfrac{3.2}{1 + 0.8\cos\theta}$, $r = \dfrac{3.2}{1 - 0.8\sin\theta}$, or $r = \dfrac{3.2}{1 + 0.8\sin\theta}$ **53.** $r = \dfrac{4}{1 - \cos\theta}$ **55.** $r = \dfrac{7.5}{1 + 1.5\sin\theta}$

57. **a.** $r = \dfrac{12}{2\cos\theta + 3\sin\theta}$ **b.** $-\dfrac{r(\pi/2)}{r(0)} = -\dfrac{2}{3}$ and $-\dfrac{A}{B} = -\dfrac{2}{3}$

59. Jupiter: $e \approx 0.0486$, Saturn: $e \approx 0.0567$

61. about 2756.0 million miles **63.** Saturn: $e \approx 0.0567$

65. $r \approx \dfrac{482.36}{1 - 0.0486\cos\theta}$ **67.** $r \approx \dfrac{1780.77}{1 - 0.0457\cos\theta}$

69. In millions of miles (approx): $\overline{JS}$: 405.3, $\overline{JU}$: 1298.4, $\overline{JN}$: 2310.3, $\overline{SU}$: 893.1, $\overline{SN}$: 1905.0, $\overline{UN}$: 1011.9

71. $r = \dfrac{0.7638}{1 \pm 0.7862\cos\theta}$ **73.** $r = \dfrac{0.2864}{1 \pm 0.7862\cos\theta}$

75. \$582.45; \$445.94; \$881.32; \$97.92 **77.** $y = \dfrac{3}{1 - \cos\theta}$

79. verified **81. a.** verified **b.** verified **c.** Answers will vary.

83. $r = 12\cos\left(\theta - \dfrac{\pi}{4}\right)$ 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)

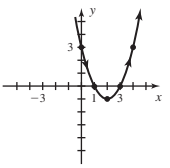
89. $x \approx 29.0$ **91.** 9.2 mph at heading 347.7°

Exercises 10.8, pp. 1059–1063

1. parameter **3.** direction **5.** Answers will vary.

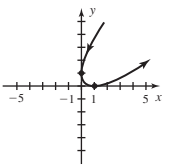
7. a. parabola with vertex at $(2, -1)$

b. $y = x^2 - 4x + 3$



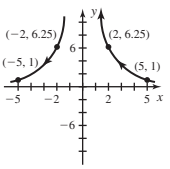
9. a. parabola

b. $y = x \pm 2\sqrt{x} + 1$



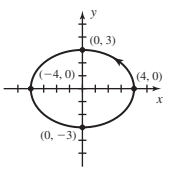
11. a. power function with $p = -2$

b. $y = \dfrac{25}{x^2}, x \neq 0$



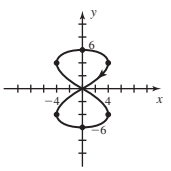
13. a. ellipse

b. $\dfrac{x^2}{16} + \dfrac{y^2}{9} = 1$

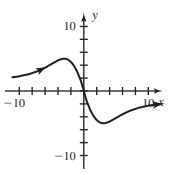


15. a. Lissajous figure

b. $y = 6\cos\left[\dfrac{1}{2}\sin^{-1}\left(\dfrac{x}{4}\right)\right]$



17.



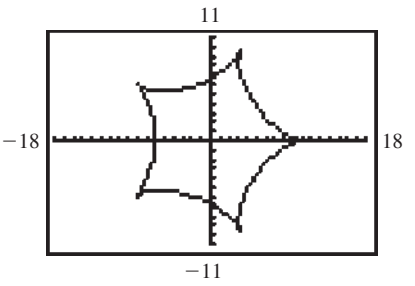
19. $x = t, y = 3t - 2$; $x = \dfrac{1}{3}t, y = t - 2$; $x = \tan t, y = 3\tan t - 2$, $t \in \left(-\dfrac{\pi}{2}, \dfrac{\pi}{2}\right)$

21. $x = t, y = (t + 3)^2 + 1$; $x = t - 3, y = t^2 + 1$; $x = \tan t - 3$, $y = \sec^2 t, t \in \left(-\dfrac{\pi}{2}, \dfrac{\pi}{2}\right)$

23. $x = t, y = \tan^2(t - 2) + 1, t \neq \pi k + \dfrac{\pi}{2} + 2, k \in \mathbb{Z}$; $x = t + 2$, $y = \sec^2 t, t \neq \left(k + \dfrac{1}{2}\right)\pi, k \in \mathbb{Z}$; $x = \tan^{-1} t + 2, y = t^2 + 1$

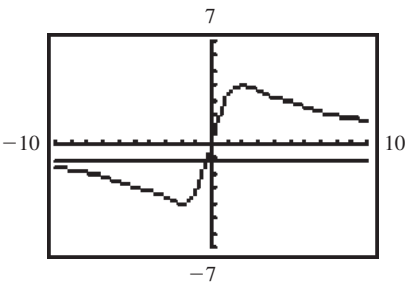
25. verified

27. a.



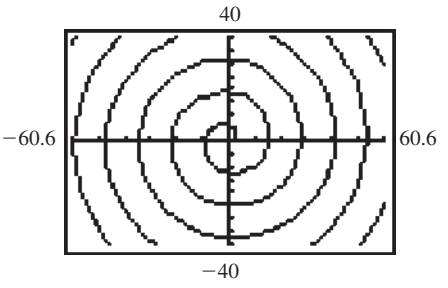
b. x-intercepts: $t = 0, x = 10$, $y = 0$ and $t = \pi, x = -6, y = 0$; y-intercepts: $t \approx 1.757, x = 0, y \approx 6.5$ and $t \approx 4.527, x = 0, y \approx -6.5$; minimum x-value is -8.1; maximum x-value is 10; minimum y-value is -9.5; maximum y-value is 9.5

29. a.



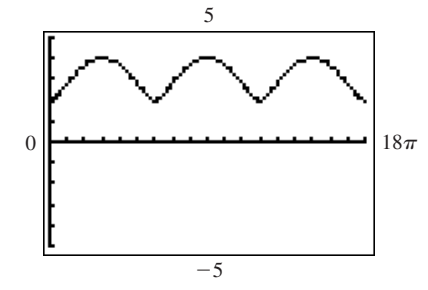
b. x-intercepts none, y-intercepts none; no minimum or maximum x-values; minimum y-value is -4 and maximum y-value is 4

31. a.



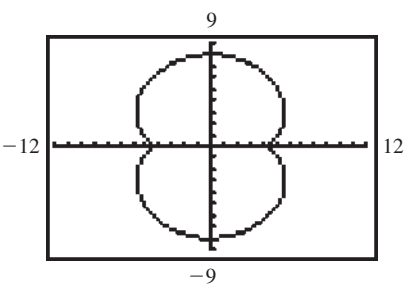
b. x-intercepts: $t = 0, x = 2, y = 0$ and $t \approx 4.493, x \approx -9.2, y = 0$; infinitely many others; y-intercepts: $t \approx 2.798, x = 0, y \approx 5.9$ and $t \approx 6.121, x = 0, y \approx -12.4$; infinitely many others; no minimum or maximum values for x or y

33. a.



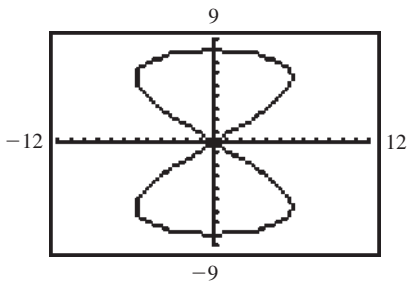
b. no x-intercepts; y-intercept is $t = 0, x = 0, y = 2$; no minimum or maximum x-values; minimum y-value is 2; maximum y-value is 4

35. a.



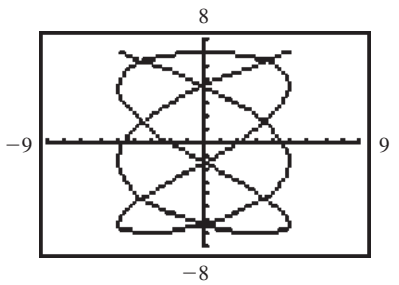
b. x-intercepts: $t = 0, x = 4, y = 0$ and $t = \pi, x = -4, y = 0$; y-intercepts: $t = \frac{\pi}{2}, x = 0, y = 8$ and $t = \frac{3\pi}{2}, x = 0, y = -8$; minimum and maximum x-values are approx. ± 5.657; minimum and maximum y-values are ± 8

37.



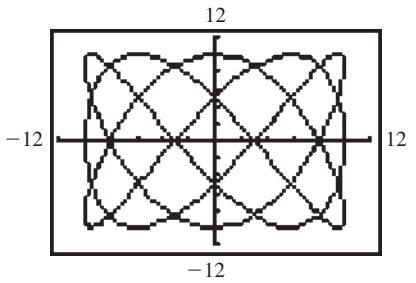
width 12 and height 16; including the endpoint $t = 2\pi$, the graph crosses itself two times from 0 to 2π.

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 $(x, y) = \left(a, \frac{b}{2}\right)$. The minimum value (as the graph dips to the valley) is at $(x, y) = \left(-a, \frac{-b}{2}\right)$.

45. a. The curve is approaching $y = 2$ as t approaches $\frac{3\pi}{2}$, but $\cot\left(\frac{3\pi}{2}\right)$ 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 $|t| \to \infty, y(t) \to 0$ **c.** The maximum value occurs at $(0, 2k)$.

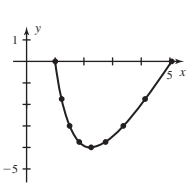
47. a. Yes **b.** Yes **c.** ≈ 0.82 ft **49.** No, the kick is short.

51. The electron is moving left and downward.

53. 3 orbits; about 2.1 orbits **55.** $\left(t, \frac{6t}{17} - \frac{6}{17}, \frac{13t}{17} + \frac{21}{17}\right)$

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.** $\theta \approx 55°$

Making Connections, p. 1064

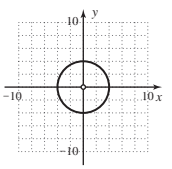
1. d **3.** f **5.** g **7.** c **9.** h **11.** e **13.** b **15.** g

Summary and Concept Review, pp. 1064–1068

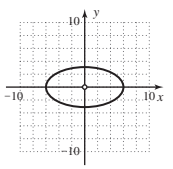
1. verified (segments are perpendicular and equal length)

2. $x^2 + (y - 1)^2 = 34$ **3.** yes **4.** verified

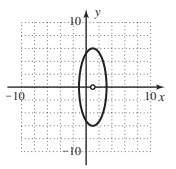
5.



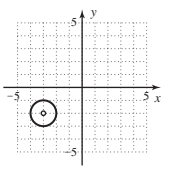
6.



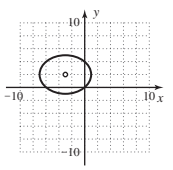
7.



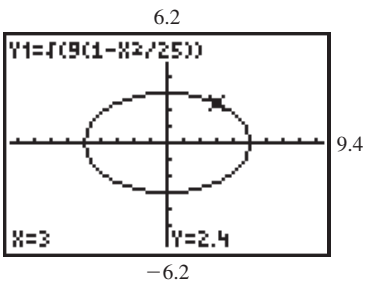
8.



9.



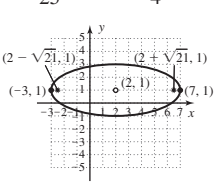
10. $\frac{x^2}{25} + \frac{y^2}{9} = 1$

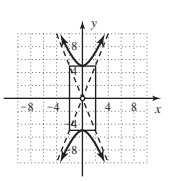


Four possibilities: $(3, 2.4), (-3, 2.4), (3, -2.4), (-3, -2.4)$

11. a. $\frac{x^2}{169} + \frac{y^2}{25} = 1$ **b.** $\frac{x^2}{144} + \frac{y^2}{400} = 1$

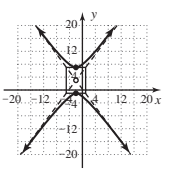
12. $\frac{(x-2)^2}{25} + \frac{(y-1)^2}{4} = 1$ **13.**





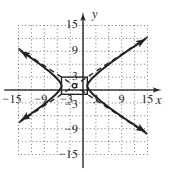
center: (0, 0)
vertices: 0, ±5)

14.



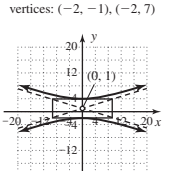
center: (−2, 3)
vertices: (−2, −1), (−2, 7)

15.



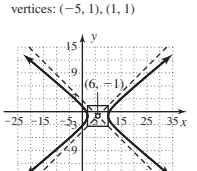
center: (−2, 1)
vertices: (−5, 1), (1, 1)

16.



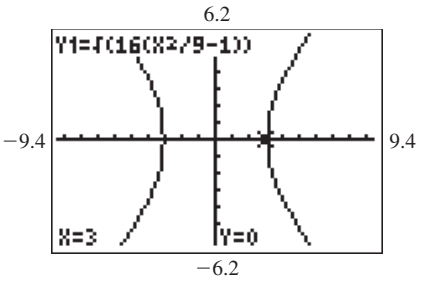
center: (0, 1)
vertices: (0, −2), (0, 4)

17.



center: (6, −1)
vertices: (2, −1), (10, −1)

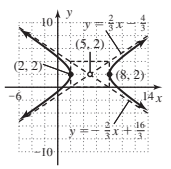
18. $\frac{x^2}{9} - \frac{y^2}{16} = 1$

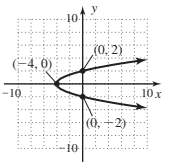


Answers may vary. One possibility: $(\pm 7.8,\ \pm 9.6)$.

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.**





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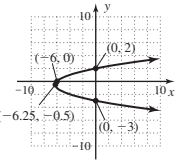
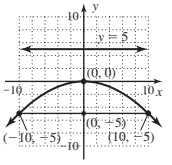


23.



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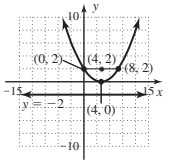
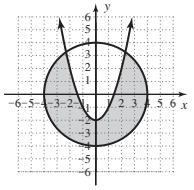


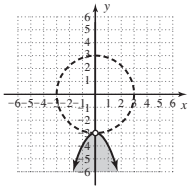
25. circle, line, $(4, 3), (-3, -4)$ **26.** parabola, line, $(3, -2)$

27. parabola, circle, $(\sqrt{3}, 2), (-\sqrt{3}, 2), (i\sqrt{2}, -3), (-i\sqrt{2}, -3)$

28. circle, parabola, $(1, 3), (-1, 3), \left(\frac{i\sqrt{10}}{3}, \frac{-10}{3}\right), \left(\frac{-i\sqrt{10}}{3}, \frac{-10}{3}\right)$

29. Parabola, circle **30.** Circle, parabola





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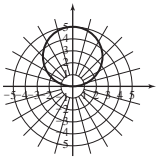

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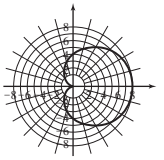

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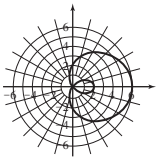
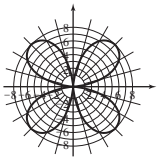
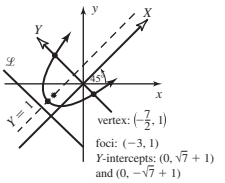


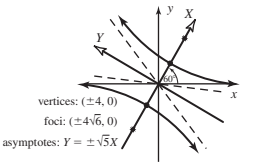
34.



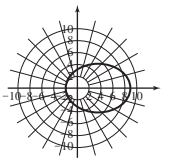
35. $Y^2 - 2Y - 2X - 6 = 0$ $(Y-1)^2 = 2\left(X + \frac{7}{2}\right)$

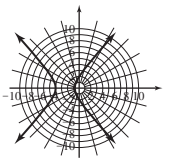


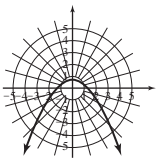
36. $5X^2 - Y^2 - 80 = 0$ $\frac{X^2}{16} - \frac{Y^2}{80} = 1$



37. ellipse, $e = \frac{2}{3}$; **38.** hyperbola, $e = \frac{3}{2}$; **39.** parabola, $e = 1$;

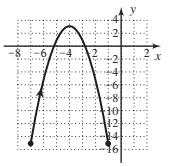


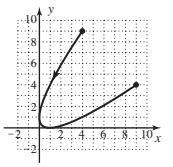


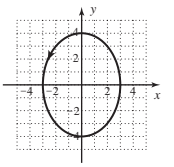


40. $r = \frac{de}{1 - e\cos\theta}$ with $e \approx 0.0935$ and $d \approx 1501.1$; focal cord: $\approx$280.82 million miles

41. $y = -2(x+4)^2 + 3$ **42.** $y = (-1 \pm \sqrt{x})^2$ **43.** $\frac{x^2}{9} + \frac{y^2}{16} = 1$

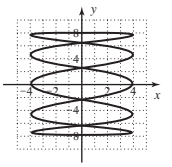






44. Answers will vary.

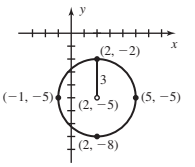
45. $x \in [-4, 4]$: $y \in [-8, 8]$



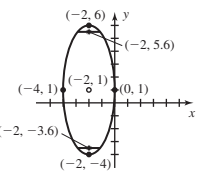
Practice Test, p. 1069

1. c **2.** d **3.** b **4.** a

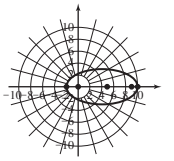
5. circle; center $(2, -5)$; radius 3



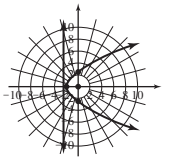
6. ellipse; center $(-2, 1)$; vertices $(-2, -4), (-2, 6)$; foci $(-2, 1 - \sqrt{21}), (-2, 1 + \sqrt{21})$



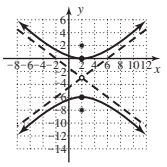
7. ellipse; center $(\frac{40}{9}, 0)$; vertices $(\frac{-10}{9}, 0), (10, 0)$; foci $(0, 0), (\frac{80}{9}, 0)$



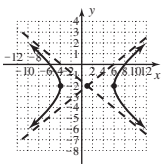
8. parabola; vertex $(-1.2, 0)$; focus $(0, 0)$; directrix at $y = -2.4$



9. hyperbola; center: $(2, -3)$; vertices: $(2, 0)$, $(2, -6)$; foci: $(2, -8)$, $(2, 2)$; asymptotes: $y = \frac{3}{4}x - \frac{9}{2}$, $y = \frac{-3}{4}x - \frac{3}{2}$

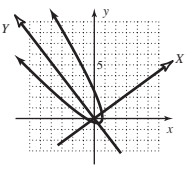


10. hyperbola; center $(1, -2)$; vertices $(-4, -2)$, $(6, -2)$; foci $(1 - \sqrt{29}, -2) \approx (-4.39, -2)$ $(1 + \sqrt{29}, -2) \approx (6.39, -2)$: asymptotes: $y = -\frac{2}{5}x - \frac{8}{5}$, $y = \frac{2}{5}x - \frac{12}{5}$

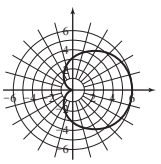


11. parabola; $\beta \approx 36.87°$; $\cos\beta = \frac{4}{5}$, $\sin\beta = \frac{3}{5}$

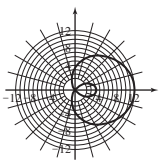
12. $Y = \frac{25}{16}X^2 - \frac{3}{4}X - \frac{11}{20}$



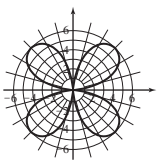
13.



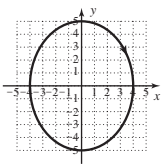
14.



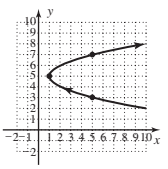
15.



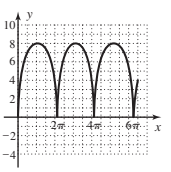
16. ellipse; $\frac{x^2}{16} + \frac{y^2}{25} = 1$



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. $r \approx \dfrac{1654(1 - 0.967^2)}{1 - 0.967\cos\theta}$ e is very close to 1. This makes its orbit a very elongated ellipse, where the orbit of most planets is nearly circular.

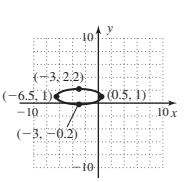
21. The ball is 0.43 ft above the ground at $x = 165$ ft, and will likely go into the goal. **22.** Perihelion: 128.41 million miles, Aphelion: 154.27 million miles **23.** $y = (x - 1)^2 - 4$; D: $x \in \mathbb{R}$; R: $y \in [-4, \infty)$; focus: $(1, -3.75)$

24. $(x - 1)^2 + (y - 1)^2 = 25$; D: $x \in [-4, 6]$; R: $y \in [-4, 6]$

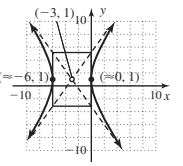
25. $\dfrac{(x + 2)^2}{9} + \dfrac{(y - 1)^2}{25} = 1$; D: $x \in [-5, 1]$; R: $y \in [-4, 6]$; foci $(-2, 5), (-2, -3)$

Strengthening Core Skills, p. 1071

1. $\dfrac{(x + 3)^2}{\left(\frac{7}{2}\right)^2} + \dfrac{(y - 1)^2}{\left(\frac{6}{5}\right)^2} = 1$; $a = \frac{7}{2}$, $b = \frac{6}{5}$



2. $\dfrac{(x + 3)^2}{\left(\frac{4\sqrt{5}}{3}\right)^2} - \dfrac{(y - 1)^2}{\left(\frac{9}{2}\right)^2} = 1$; $a = \frac{4\sqrt{5}}{3} \approx 3$, $b = \frac{9}{2}$



3. $\dfrac{(x - 2)^2}{\left(\frac{\sqrt{2}}{5}\right)^2} - \dfrac{(y + 3)^2}{\left(\frac{2}{3}\right)^2} = 1$

$a = \frac{\sqrt{2}}{5}$, $b = \frac{2}{3}$

4. $\dfrac{(x - 1)^2}{\left(\frac{5\sqrt{7}}{14}\right)^2} + \dfrac{(y + 2)^2}{\left(\frac{5\sqrt{3}}{12}\right)^2} = 1$

$a = \frac{5\sqrt{7}}{14}$, $b = \frac{5\sqrt{3}}{12}$

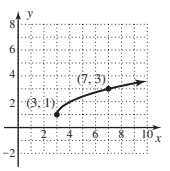
Cumulative Review Chapters 1–10, p. 1072

1. $(y - 3)^2 = 8(x - 2)$ **3.** $x = -6$ **5.** $x = 4$ **7.** $\dfrac{5\pi}{6} + k\pi, k \in \mathbb{Z}$

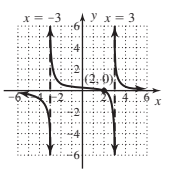
9. $x \approx 61.98° + 360°k; k \in \mathbb{Z}$
$x \approx 118.02° + 360°k; k \in \mathbb{Z}$

11. about 24.7 pesos/kg **13.** The formation is 1152.4 yd wide.

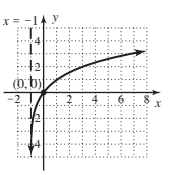
15.



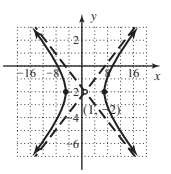
17. horizontal asymptote: $y = 0$
vertical asymptotes: $x = 3$, $x = -3$,
x-intercept: $(2, 0)$; y-intercept: $(0, \frac{2}{9})$



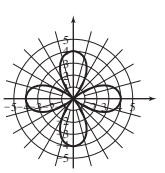
19.



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 $(-5, -2)$, $(7, -2)$



23.



25. 61.9° **27.** $(-3, 4), (3, 4), (-3, -4), (3, -4)$ **29.** $\dfrac{1}{x} - \dfrac{3}{x^2} + \dfrac{2x + 1}{x^2 + 1}$

Connections to Calculus Exercises, pp. 1075–1076

1. **a.** $-\dfrac{\cos(2\theta) + \cos\theta}{\sin(2\theta) + \sin\theta}$ **b.** 1, 1 **c.** $\frac{\pi}{3}, \frac{5\pi}{3}$ **d.** $0, \frac{2\pi}{3}, \frac{4\pi}{3}$

3. **a.** $-\dfrac{\cos(2\theta) - \sin(2\theta)}{\sin(2\theta) + \cos(2\theta)}$ **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, θ): $\left(0, \frac{\pi}{2}\right), \left(2\sqrt{3}, \frac{\pi}{6}\right), \left(-2\sqrt{3}, \frac{5\pi}{6}\right), \left(0, \frac{3\pi}{2}\right)$; (x, y): $(0, 0)$, $(3, \sqrt{3})$, $(3, -\sqrt{3})$

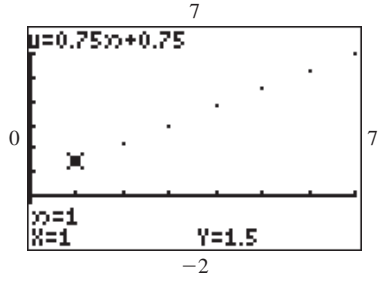
CHAPTER 11

Exercises 11.1, pp. 1086–1088

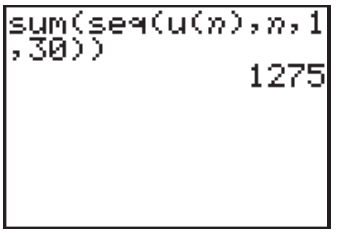
1. pattern, order **3.** recursive **5.** formula defining the sequence uses the preceding term(s); answers will vary. **7.** 1, 3, 5, 7; $a_8 = 15$; $a_{12} = 23$
9. 0, 9, 24, 45; $a_8 = 189$; $a_{12} = 429$ **11.** $-1, 2, -3, 4$; $a_8 = 8$; $a_{12} = 12$
13. $\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}$; $a_8 = \frac{8}{9}$; $a_{12} = \frac{12}{13}$ **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.
$$\sum_{j=1}^{n} ca_j = ca_1 + ca_2 + ca_3 + \cdots + ca_{n-1} + ca_n$$
$$= c(a_1 + a_2 + a_3 + \cdots + a_{n-1} + a_n)$$
$$= c\sum_{j=1}^{n} a_j$$
95. $\frac{1}{4}$ or 0.25 **97.** $\frac{3\pi}{4}, \frac{7\pi}{4}$ **99.** $\angle A \approx 53.1°$, $\angle B \approx 36.9°$, $\angle C = 90°$

Exercises 11.2, pp. 1095–1098

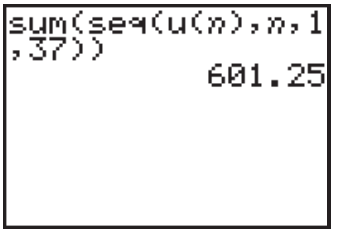
1. common, difference **3.** $\frac{n(a_1 + a_n)}{2}$, nth **5.** Answers will vary.
7. arithmetic; $d = 3$ **9.** arithmetic; $d = 2.5$ **11.** not arithmetic; all prime **13.** arithmetic; $d = \frac{1}{24}$ **15.** not arithmetic; $a_n = n^2$
17. arithmetic; $d = \frac{-\pi}{6}$ **19.** 2, 5, 8, 11 **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.** $a_n = 0.75n + 0.75$



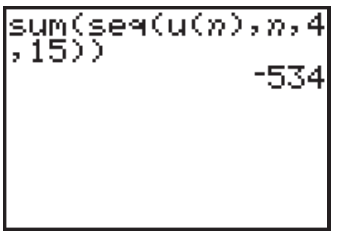
53. a. appears nonlinear **b.** no common difference
55. $d = 3$, $a_1 = 1$ **57.** $d = 0.375$, $a_1 = 0.65$ **59.** $d = \frac{115}{126}$, $a_1 = \frac{-472}{63}$
61. 1275



63. 601.25



65. −534

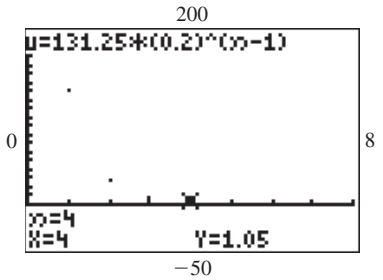


67. 82.5 **69.** 74.04 **71.** $210\sqrt{2}$ **73.** $S_6 = 21$; $S_{75} = 2850$
75. at 11 P.M. **77.** 5.5 in.; 54.25 in. **79.** $a_7 = 220$; $a_{12} = 2520$; yes
81. a. linear function **b.** quadratic
83. $A = 7$, $P = 6$, HS: $\frac{1}{2}$ unit right, VS: 10 units up, $\frac{1}{2} \le t < \frac{13}{2}$.
85. $f(x) = 49x + 972$, 1364 deer

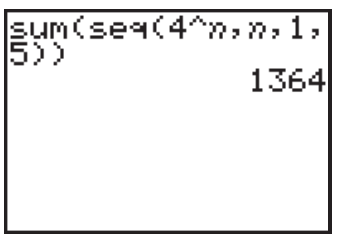
Exercises 11.3, pp. 1107–1111

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. $a_1 = 729$, $r = \frac{1}{3}$, $a_n = 729(\frac{1}{3})^{n-1}$, $a_6 = 3$, $a_{10} = \frac{1}{27}$, $a_{12} = \frac{1}{243}$
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

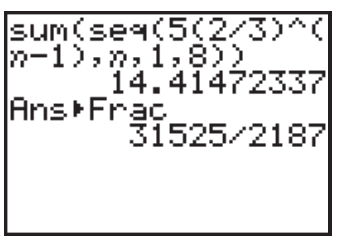
59. a. appears exponential **b.** $r = 0.2$ **c.** $a_n = 131.25(0.2)^{n-1}$



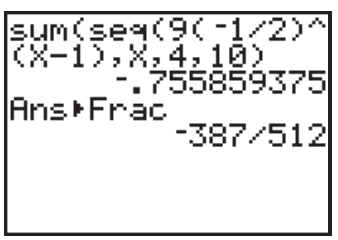
61. a. appears nonexponential **b.** no common ratio
63. $r = \frac{2}{3}$, $a_1 = 729$ **65.** $r = \frac{3}{2}$, $a_1 = \frac{32}{243}$ **67.** $r = \frac{3}{2}$, $a_1 = \frac{256}{81}$
69. $-10{,}920$ **71.** $\frac{3872}{27} \approx 143.41$ **73.** $\frac{2059}{8} = 257.375$ **75.** 728
77. $\frac{85}{8} = 10.625$ **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. $a_0 = 462$; $a_n = 277.2\left(\frac{3}{5}\right)^{n-1}$, $a_5 \approx 35.9$ in^3, 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,
total distance $= a_0 + 2S_\infty = 18$ 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
$d = \log(a_1 r^{k-1}) - \log(a_1 r^{k-2})$
$= \log(a_1) + \log(r^{k-1}) - [\log(a_1) + \log(r^{k-2})]$
$= \log(a_1) + (k-1)\log(r) - \log(a_1) - (k-2)\log(r)$
$= \log(r)[(k-1) - (k-2)]$
$= \log(r)$✓

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
$$r = \frac{10^{a_1+(k-1)d}}{10^{a_1+(k-2)d}} = \frac{10^{a_1}10^{(k-1)d}}{10^{a_1}10^{(k-2)d}} = \frac{10^{(k-1)d}}{10^{(k-2)d}} = 10^{(k-1)d-(k-2)d} = 10^{d[(k-1)-(k-2)]} = 10^d$$✓

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. $a_n = 10n - 6$; $S_n = n(5n-1)$
$S_4 = 4(5(4) - 1) = 4(20 - 1) = 4(19) = 76$;
$a_5 = 10(5) - 6 = 50 - 6 = 44$;
$S_5 = 5(5(5) - 1) = 5(25 - 1) = 5(24) = 120$;
$S_4 + a_5 = S_5$

$76 + 44 = 120$
$120 = 120$
Verified

21. $a_n = n; S_n = \dfrac{n(n+1)}{2}$
$S_4 = \dfrac{4(4+1)}{2} = \dfrac{4(5)}{2} = 10;$
$a_5 = 5;$
$S_5 = \dfrac{5(5+1)}{2} = \dfrac{5(6)}{2} = 15;$
$S_4 + a_5 = S_5$
$10 + 5 = 15$
$15 = 15$
Verified

23. $a_n = 2^{n-1}; S_n = 2^n - 1$
$S_4 = 2^4 - 1 = 16 - 1 = 15;$
$a_5 = 2^{5-1} = 2^4 = 16;$
$S_5 = 2^5 - 1 = 32 - 1 = 31;$
$S_4 + a_5 = S_5$
$15 + 16 = 31$
$31 = 31$
Verified

25. a. $a_n = n^3; S_n = (1 + 2 + 3 + 4 + \cdots + n)^2$
$S_1 = 1^2 = 1^3$
$S_5 = (1 + 2 + 3 + 4 + 5)^2$
$= 15^2$
$= 225$
$1 + 8 + 27 + 64 + 125 = 225$
$S_9 = (1 + 2 + \cdots + 9)^2$
$= 45^2$
$= 2025$
$1 + 8 + \cdots + 729 = 2025$

b. $\left[\dfrac{n(n+1)}{2}\right]^2 = \dfrac{n^2(n+1)^2}{4}$

27. 1. Show S_n is true for $n = 1$.
$S_1 = 1(1 + 1) = 1(2) = 2$
Verified
2. Assume S_k is true: $2 + 4 + 6 + 8 + 10 + \cdots + 2k = k(k + 1)$
and use it to show the truth of S_{k+1} follows. That is:
$2 + 4 + 6 + \cdots + 2k + 2(k + 1) = (k + 1)(k + 1 + 1)$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$2 + 4 + 6 + \cdots + 2k + 2(k + 1)$
$= k(k + 1) + 2(k + 1)$
$= (k + 1)(k + 2)$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

29. 1. Show S_n is true for $n = 1$.
$S_1 = \dfrac{5(1)(1+1)}{2} = \dfrac{5(2)}{2} = 5$
Verified
2. Assume S_k is true:
$5 + 10 + 15 + \cdots + 5k = \dfrac{5k(k+1)}{2}$
and use it to show the truth of S_{k+1} follows. That is:
$5 + 10 + 15 + \cdots + 5k + 5(k + 1) = \dfrac{5(k+1)(k+1+1)}{2}$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$5 + 10 + 15 + \cdots + 5k + 5(k + 1)$
$= \dfrac{5k(k+1)}{2} + 5(k + 1)$
$= \dfrac{5k(k+1) + 10(k+1)}{2}$
$= \dfrac{(k+1)(5k+10)}{2}$
$= \dfrac{5(k+1)(k+2)}{2}$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

31. 1. Show S_n is true for $n = 1$.
$S_1 = 1(2(1) + 3) = 5$
Verified
2. Assume S_k is true:
$5 + 9 + 13 + 17 + \cdots + (4k + 1) = k(2k + 3)$
and use it to show the truth of S_{k+1} follows. That is:
$5 + 9 + 13 + 17 + \cdots + (4k + 1) + [4(k + 1) + 1]$
$= (k + 1)(2(k + 1) + 3)$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$5 + 9 + 13 + 17 + \cdots + (4k + 1) + [4(k + 1) + 1]$
$= k(2k + 3) + 4k + 5$
$= 2k^2 + 3k + 4k + 5$
$= 2k^2 + 7k + 5$
$= (k + 1)(2k + 5)$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

33. 1. Show S_n is true for $n = 1$.
$S_1 = \dfrac{3(3^1 - 1)}{2} = \dfrac{3(3-1)}{2} = \dfrac{3(2)}{2} = 3$
Verified
2. Assume S_k is true:
$3 + 9 + 27 + \cdots + 3^k = \dfrac{3(3^k - 1)}{2}$
and use it to show the truth of S_{k+1} follows. That is:
$3 + 9 + 27 + \cdots + 3^k + 3^{k+1} = \dfrac{3(3^{k+1} - 1)}{2}$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$3 + 9 + 27 + \cdots + 3^k + 3^{k+1}$
$= \dfrac{3(3^k - 1)}{2} + 3^{k+1}$
$= \dfrac{3(3^k - 1) + 2(3^{k+1})}{2}$
$= \dfrac{3^{k+1} - 3 + 2(3^{k+1})}{2}$
$= \dfrac{3(3^{k+1}) - 3}{2}$
$= \dfrac{3(3^{k+1} - 1)}{2}$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

35. 1. Show S_n is true for $n = 1$.
$S_1 = 2^{1+1} - 2 = 2^2 - 2 = 4 - 2 = 2$
Verified
2. Assume S_k is true:
$2 + 4 + 8 + \cdots + 2^k = 2^{k+1} - 2$
and use it to show the truth of S_{k+1} follows. That is:
$2 + 4 + 8 + \cdots + 2^k + 2^{k+1} = 2^{k+2} - 2$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$2 + 4 + 8 + \cdots + 2^k + 2^{k+1}$
$= 2^{k+1} - 2 + 2^{k+1}$
$= 2(2^{k+1}) - 2$
$= 2^{k+2} - 2$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

37. 1. Show S_n is true for $n = 1$.

$S_1 = \dfrac{1}{2(1)+1} = \dfrac{1}{2+1} = \dfrac{1}{3}$

Verified

2. Assume S_k is true:

$\dfrac{1}{3} + \dfrac{1}{15} + \dfrac{1}{35} + \cdots + \dfrac{1}{(2k-1)(2k+1)} = \dfrac{k}{2k+1}$

and use it to show the truth of S_{k+1} follows. That is:

$\dfrac{1}{3} + \dfrac{1}{15} + \dfrac{1}{35} + \cdots + \dfrac{1}{(2k-1)(2k+1)}$

$+ \dfrac{1}{(2(k+1)-1)(2(k+1)+1)} = \dfrac{k+1}{2(k+1)+1}$

$S_k + a_{k+1} = S_{k+1}$

Working with the left hand side:

$\dfrac{1}{3} + \dfrac{1}{15} + \dfrac{1}{35} + \cdots + \dfrac{1}{(2k-1)(2k+1)} + \dfrac{1}{(2k+1)(2k+3)}$

$= \dfrac{k}{2k+1} + \dfrac{1}{(2k+1)(2k+3)}$

$= \dfrac{k(2k+3)+1}{(2k+1)(2k+3)}$

$= \dfrac{2k^2+3k+1}{(2k+1)(2k+3)}$

$= \dfrac{(2k+1)(k+1)}{(2k+1)(2k+3)}$

$= \dfrac{k+1}{2k+3}$

$= S_{k+1}$

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,

$6k + 3 \geq 2k + 3$

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, $4^{k+1} - 4 \leq 4^{k+1} - 1$

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:

$(1)^2 - 7(1) = 2m$

$1 - 7 = 2m$

$-6 = 2m$ 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:

$(k+1)^3 + 3(k+1)^2 + 2(k+1)$

$= k^3 + 3k^2 + 3k + 1 + 3(k^2 + 2k + 1) + 2k + 2$

$= k^3 + 3k^2 + 2k + 3(k^2 + 2k + 1) + 3k + 3$

$= k^3 + 3k^2 + 2k + 3(k^2 + 2k + 1) + 3(k + 1)$

$= 3m + 3(k^2 + 2k + 1) + 3(k + 1)$ 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. $S_{10} = \dfrac{-14{,}762}{27}$ **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.** $\frac{-343}{6}$

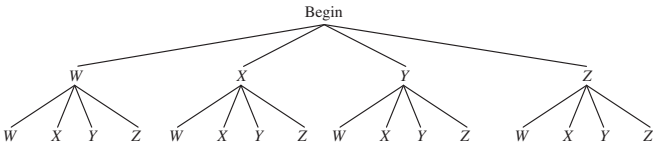
19. 1785 **20.** ≈4.5 ft; ≈127.9 ft

Reinforcing Basic Concepts, pp. 1119–1120

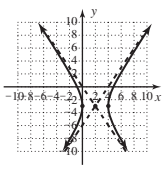
Exercise 1: $71,500

Exercises 11.5, pp. 1127–1132

1. experiment, well-defined **3.** N^t **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. ${}_8P_r\,3 = 336$ **75.** $20\ {}_nC_r\,5 = 15{,}504$ **77.** ${}_8C_r\,4 = 70$
79. a. ≈1.2% **b.** ≈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.** $6 \cdot (6\ {}_nC_r\,3 - 2) + 2 \cdot 20 = 148$
111. $\cos\theta = \frac{5}{13}$, $\tan\theta = \frac{12}{5}$, $\csc\theta = \frac{13}{12}$, $\sec\theta = \frac{13}{5}$, $\cot\theta = \frac{5}{12}$
113.



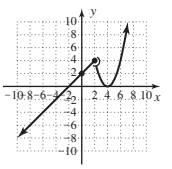
Exercises 11.6, pp. 1139–1145

1. $n(E)$ **3.** 0, 1, 1, 0 **5.** Answers will vary.
7. $S = \{HH, HT, TH, TT\}$, $\frac{1}{4}$ **9.** $S = \{$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. $\frac{1}{4}$; $\frac{1}{256}$; 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.** $\frac{2}{25}$ **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

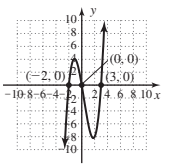
1. one **3.** $(a + (-2b))^5$ **5.** Answers will vary.
7. $x^5 + 5x^4y + 10x^3y^2 + 10x^2y^3 + 5xy^4 + y^5$
9. $16x^4 + 96x^3 + 216x^2 + 216x + 81$ **11.** $41 + 38i$ **13.** 35
15. 10 **17.** 1140 **19.** 9880 **21.** 1 **23.** 1
25. $c^5 + 5c^4d + 10c^3d^2 + 10c^2d^3 + 5cd^4 + d^5$
27. $a^6 - 6a^5b + 15a^4b^2 - 20a^3b^3 + 15a^2b^4 - 6ab^5 + b^6$
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.** ≈17.8%
b. ≈23.0% **47. a.** ≈0.89% **b.** ≈7.0% **c.** ≈99.0% **d.** ≈61.0%
49. 2^{n-1}, 2048

51.



$f(3) = 1$

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 $n = 1$: $S_1 = \frac{1(1+1)}{2} = 1$✓

(2) Assume S_k is true: $1 + 2 + 3 + \cdots + k = \frac{k(k+1)}{2}$

Use it to show the truth of S_{k+1}:

$$1 + 2 + 3 + \cdots + k + (k+1) = \frac{(k+1)(k+1+1)}{2}$$

left hand side: $1 + 2 + 3 + \cdots + k + (k+1)$

$$= \frac{k(k+1)}{2} + (k+1) = \frac{k(k+1) + 2(k+1)}{2}$$
$$= \frac{(k+1)(k+2)}{2}$$

36. (1) Show S_n is true for $n = 1$: $S_1 = \frac{1(1+1)[2(1)+1]}{6} = 1$✓

(2) Assume S_k is true: $1 + 4 + 9 + \cdots + k^2 = \frac{k(k+1)(2k+1)}{6}$

Use it to show the truth of S_{k+1}:

$$1 + 4 + 9 + \cdots + k^2 + (k+1)^2 = \frac{(k+1)(k+1+1)[2(k+1)+1]}{6}$$

left hand side: $1 + 4 + 9 + \cdots + k^2 + (k+1)^2$

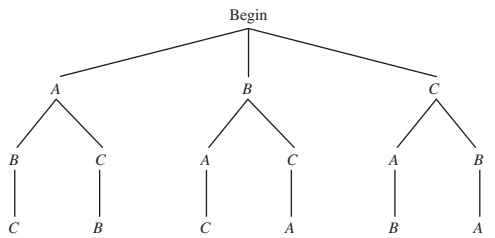
$$= \frac{k(k+1)(2k+1)}{6} + \frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2 + k + 6k + 6]}{6}$$
$$= \frac{(k+1)(2k^2+7k+6)}{6} = \frac{(k+1)(k+2)(2k+3)}{6}$$

37. (1) Show P_n is true for $n = 1$: P_1: $4^1 \geq 3(1) + 1$✓
(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: $6 \cdot 7^{1-1} \le 7^1 - 1$✓
(2) Assume P_k is true: $6 \cdot 7^{k-1} \le 7^k - 1$
Use it to show the truth of P_{k+1}:
$6 \cdot 7^k \le 7^{k+1} - 1$
left hand side: $6 \cdot 7^k = 7 \cdot 6 \cdot 7^{k-1}$
$\le 7 \cdot 7^k - 1$
$\le 7^{k+1} - 7$
Since k is a positive integer, $7^{k+1} - 7 \le 7^{k+1} - 1$.

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}:
$3^{k+1} - 1 = 2q$ for $q \in \mathbb{Z}$
left hand side: $3^{k+1} - 1 = 3 \cdot 3^k - 1$
$= 3 \cdot (2p + 1) - 1$
$= 3 \cdot 2p + 3 - 1$
$= 3 \cdot 2p + 2$
$= 2(3p + 1)$
$= 2q$ is divisible by 2

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. $a_k = 5k - 3, a_{k+1} = 5(k + 1) - 3$,

$S_k = \dfrac{5k^2 - k}{2}, S_{k+1} = \dfrac{5(k+1)^2 - (k+1)}{2}$;

For $n = 1$: $S_1 = \dfrac{5(1)^2 - 1}{2} = 2$✓

Assume: $S_k = \dfrac{5k^2 - k}{2}$ is true,

Prove: $\dfrac{5k^2 - k}{2} + 5(k + 1) - 3 = \dfrac{5(k+1)^2 - (k+1)}{2}$

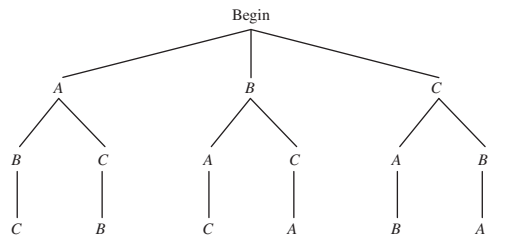
$\dfrac{5k^2 - k}{2} + \dfrac{10(k+1) - 6}{2} = \dfrac{(k+1)[5(k+1) - 1]}{2}$

$\dfrac{5k^2 + 9k + 4}{2} = \dfrac{(k+1)(5k+4)}{2}$

$\dfrac{(5k+4)(k+1)}{2} = \dfrac{(5k+4)(k+1)}{2}$✓

10. For $n = 1$: $2 \cdot 3^{1-1} \le 3^1 - 1$
$2(1) \le 2$✓
Assume: $2 \cdot 3^{k-1} \le 3^k - 1$
Prove: $2 \cdot 3^{(k+1)-1} \le 3^{k+1} - 1$
$2 \cdot 3^{(k+1)-1} = 2 \cdot 3^{(k-1)+1}$
$= 2 \cdot 3^{(k-1)} \cdot 3$
$\le (3^k - 1) \cdot 3$
$(3^k - 1) \cdot 3 = 3^{k+1} - 3 \le 3^{k+1} - 1$✓

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. $\dfrac{{}_4C_1 \cdot {}_{13}C_5 - 40}{{}_{52}C_5} \approx 0.001\,970$

Exercise 2. $\dfrac{4 \cdot {}_{13}C_3 \cdot {}_{39}C_2}{{}_{52}C_5} \approx 0.326\,170$

Exercise 3. $\dfrac{4 \cdot {}_{13}C_4 \cdot {}_{39}C_1}{{}_{52}C_5} \approx 0.042\,917$

Exercise 4. $\dfrac{4 \cdot {}_{10}C_5}{{}_{52}C_5} \approx 0.000\,388$

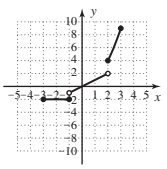
Cumulative Review Chapters 1–11, pp. 1162–1164

1. a. 23 cards are assembled each hour. **b.** 184 cards
c. $y = 23x - 155$ **d.** ≈ 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

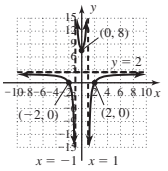
5. $x = \dfrac{-5 \pm \sqrt{109}}{6}$; $x \approx 0.91$; $x \approx -2.57$

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

9. 

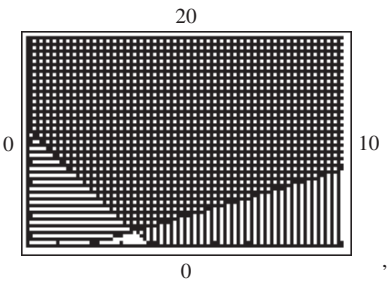
D: $x \in [-3, 3]$
R: $y \in \{-2\} \cup (-1, 2) \cup [4, 9]$

11. a. $4x + 2h - 3$ **b.** $\dfrac{-1}{(x + h - 2)(x - 2)}$

13. 

15. a. $x^3 = 125$ **b.** $e^5 = 2x - 1$ **17. a.** $x = \dfrac{1 + \ln 217}{2} \approx 3.19$
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.** $\dfrac{\sqrt{6} + \sqrt{2}}{4}$ **25.** 1333

27.

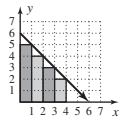


, (3.4044, 1.4539)

29. 0.2794

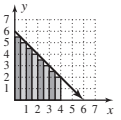
Connections to Calculus Exercises, p. 1167

1. a.



$$\sum LW = \sum_{i=1}^{4} f(i)(1) = 1\sum_{i=1}^{4} f(i)$$
$$1\sum_{i=1}^{4} f(i) = 1[f(1) + f(2) + f(3) + f(4)]$$
$$= 5 + 4 + 3 + 2$$
$$= 14 \text{ units}^2$$

b. $\displaystyle\sum LW = \sum_{i=1}^{8} f\left(\frac{1}{2}i\right)\left(\frac{1}{2}\right) = \frac{1}{2}\sum_{i=1}^{8} f\left(\frac{1}{2}i\right)$



$$\frac{1}{2}\sum_{i=1}^{8} f\left(\frac{1}{2}i\right) = \frac{1}{2}\left[f\left(\frac{1}{2}\right) + f(1) + f\left(\frac{3}{2}\right) + f(2) + f\left(\frac{5}{2}\right) + f(3) + f\left(\frac{7}{2}\right) + f(4)\right]$$
$$= \frac{1}{2}\left[\frac{11}{2} + 5 + \frac{9}{2} + 4 + \frac{7}{2} + 3 + \frac{5}{2} + 2\right]$$
$$= \frac{1}{2}[30] = 15 \text{ units}^2$$

True area is 16 units^2, more rectangles $\rightarrow$ 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 $f(\frac{1}{8})$, the second length is $f(\frac{2}{8})$, the third is $f(\frac{3}{8})$, and so on up to the 32nd rectangle. Since $A = LW$, we multiply each length $f(\frac{1}{8}i)$ by width $\frac{1}{8}$ and sum the areas of all such rectangles. Using i for a counter, this can be written as $A = \displaystyle\sum_{i=1}^{32} LW = \sum_{i=1}^{32} f\left(\frac{1}{8}i\right)\left(\frac{1}{8}\right)$. 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 $\frac{1}{8}\displaystyle\sum_{i=1}^{32}\left(-\frac{1}{8}i + 6\right)$.

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 units^2, even closer to the known area of 16 units^2.

CHAPTER 12

Exercises 12.1, pp. 1177–1180

1. infinity **3.** left-hand; right-hand; greater **5.** Answers will vary.
7. $\lim_{n\to\infty} V_n = \frac{4}{3}\pi r^3$ **9.** $\lim_{t\to-\infty} e^{f(t)} = 0$ **11.** $\lim_{x\to\infty} \cos\left(\frac{1}{x}\right) = 1$
13. 500 sides **15.** 425 sides **17.** $\lim_{t\to5} s_t = 5r$
19. $\lim_{x\to a} \tan^{-1}[g(x)] = \frac{\pi}{3}$ **21.** $\lim_{x\to-3} \dfrac{x + 3}{x^2 - 9} = -\dfrac{1}{6}$
23. As x approaches π, $p(x)$ approaches -2: $\lim_{x\to\pi} p(x) = -2$
25. As x approaches 2, $v(x)$ approaches $\frac{1}{4}$: $\lim_{x\to2} v(x) = \frac{1}{4}$
27. As x approaches 0, $s(x)$ approaches 0: $\lim_{x\to0} s(x) = 0$
29. $R(x) = \begin{cases} \dfrac{2x^2 - 7x + 6}{\sin(x - 2)} & x \neq 2 \\ 1 & x = 2 \end{cases}$
31. As x approaches 2, $f(x)$ approaches $\frac{1}{2}$: $\lim_{x\to2} f(x) = \frac{1}{2}$
33. As x approaches 1, $g(x)$ approaches 4: $\lim_{x\to1} g(x) = 4$
35. As x approaches 1, $f(x)$ approaches 0: $\lim_{x\to1} f(x) = 0$
37. 27 **39.** 24 **41.** 1
43. $\lim_{x\to3^-} I_x = 3\cos^2(R_1 + R_2)$ **45.** $\lim_{x\to m^-} f = L$ **47. a.** 1 **b.** -1
49. a. -2 **b.** 2 **51. a.** $-\dfrac{11}{2}$ **b.** $-\dfrac{11}{2}$ **53. a.** 0 **b.** 0
55. a. 43 **b.** 13 **c.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **57. a.** 1 **b.** -1 **c.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$
59. a. $\dfrac{\sqrt{2}}{2}$ **b.** $\dfrac{\sqrt{2}}{2}$ **c.** $\dfrac{\sqrt{2}}{2}$ **61.** $\left(\underset{\infty}{\text{dne}}\right)$ **63.** π **65.** $\left(\underset{-\infty}{\text{dne}}\right)$
67. $\left(\underset{\not\in}{\text{dne}}\right)$ **69.** 0 **71.** $(x - 5)(x - 2)(x + 1)(3x - 1)$ **73.** 19.90 in^2

Exercises 12.2, pp. 1188–1190

1. sum; limits **3.** root; nth; $f(x) > 0$ **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.** $\dfrac{7}{2}$ **31.** 0 **33.** 64 **35.** -36 **37.** -69 **39.** 29 **41.** 9
43. $\dfrac{3}{5}$ **45.** $-\dfrac{1}{4}$ **47.** 216 **49.** 15 **51.** 23 **53.** -1 **55.** $-\dfrac{17}{4}$
57. $\left(\underset{\infty}{\text{dne}}\right)$ **59.** 9 **61.** $\left(\underset{-\infty}{\text{dne}}\right)$ **63.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **65.** 6 **67.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$
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	$y = x + \dfrac{\sqrt{x-2}}{10^x}$
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	$y = x + \dfrac{\sqrt{x-2}}{10^x}$
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.** $\left[-1, \frac{3}{2}\right]$ **75.** verified

Mid-Chapter Check, pp. 1190–1191

1. $\lim\limits_{x\to-\infty} \dfrac{6x^2-3}{12x^3-x-1} = 0$ **2. a.** 1 **b.** 0 **3.** 49 per year (almost weekly)

4. $F(x) = \begin{cases} \dfrac{6x^2-19x-7}{2x-7} & x \neq \dfrac{7}{2} \\ \dfrac{23}{2} & x = \dfrac{7}{2} \end{cases}$ **5. a.** -1 **b.** 1 **c.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$

6. $\left(\underset{-\infty}{\text{dne}}\right)$

7. a.

x	$y = \cos\left(\dfrac{\pi}{x}\right)$
0.1	1
0.01	1
0.001	1
-0.001	1
-0.01	1
-0.1	1

b. Answers may vary.

8. $\dfrac{1}{2}$ **9.** $\sqrt[3]{4}$ **10.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$

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. $\dfrac{1}{2}$ **23.** Direct substitution not possible, -1 is not in the domain.
25. $\sqrt{55}$ **27.** $-\dfrac{1}{2}$ **29.** 4 **31.** 9 **33.** $\dfrac{1}{4}$ **35.** 0 **37.** $4x - 1$
39. $\dfrac{-3}{(x+2)^2}$ **41.** $\dfrac{1}{2\sqrt{x+2}}$ **43.** $3(x+2)^2$ **45.** $\dfrac{1}{2}$ **47.** 3
49. $\left(\underset{\infty}{\text{dne}}\right)$ **51.** 0 **53.** $\dfrac{1}{2}$ **55.** $\left(\underset{-\infty}{\text{dne}}\right)$ **57.** 0 **59.** $x = 1000$
61. $\dfrac{3}{8}$ **63.** 0 **65.** 2 **67.** $\dfrac{2\sqrt{3}}{7}$ **69.** 3 **71.** 3
73. not possible since $f(2)$ not defined **75.** 3 **77.** 0
79. 1 **81.** not possible, $\lim\limits_{x\to-2^-} g(x)$ does not exist $\left(\underset{-\infty}{\text{dne}}\right)$
83. not possible, $\lim\limits_{x\to0} g(x)$ does not exist $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **85.** -3 **87.** 3
89. a. $x = \dfrac{-2 \pm 2\sqrt{10}}{3}$ **b.** $x = 0, x = 8$ **c.** $x = 2$
91. $A = 55°$, $C = 90°$, $b = 9.6$ cm, $c = 16.7$ 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. $f'(x) = \dfrac{1}{2}$ **19.** $f'(x) = 3x^2$ **21.** $p'(t) = \dfrac{0.6}{\sqrt{t}}$
23. a. 600 people/yr **b.** 300 people/yr **c.** 150 people/yr
25. $f'(x) = \dfrac{-2}{(x-1)^2}$ **27.** $h'(x) = \dfrac{25}{(x+5)^2}$ **29.** $-\dfrac{1}{2}$
31. 1 **33.** 9 units^2 **35.** 15 units^2 **37.** 9 **39.** 15

41.
$$\begin{aligned}
&\frac{4}{n}\sum_{i=1}^{n}\left[\frac{1}{2}\left(\frac{4}{n}i\right)^2 + 3\right] \\
&= \frac{4}{n}\left[\sum_{i=1}^{n}\frac{1}{2}\left(\frac{4}{n}i\right)^2 + \sum_{i=1}^{n}3\right] && \text{summation properties (distribute)} \\
&= \frac{4}{n}\left[\frac{1}{2}\sum_{i=1}^{n}\frac{16}{n^2}i^2 + \sum_{i=1}^{n}3\right] && \text{simplify} \\
&= \frac{4}{n}\left[\frac{16}{2n^2}\sum_{i=1}^{n}i^2 + \sum_{i=1}^{n}3\right] && \text{factor } \frac{16}{n^2} \text{ from first summation} \\
&= \frac{4}{n}\left[\frac{8}{n^2}\left(\frac{2n^3+3n^2+n}{6}\right) + 3n\right] && \text{apply summation formula} \\
&= \frac{32}{n^3}\left(\frac{2n^3+3n^2+n}{6}\right) + 12 && \text{distribute } \frac{4}{n} \\
&= \frac{32}{6}\left(\frac{2n^3+3n^2+n}{n^3}\right) + 12 && \text{rewrite denominators} \\
&= \frac{16}{3}\left(2 + \frac{3}{n} + \frac{1}{n^2}\right) + 12 && \text{decompose rational expression}
\end{aligned}$$

Applying the limit properties gives $\frac{16}{3}\lim\limits_{n\to\infty}\left(2 + \frac{3}{n} + \frac{1}{n^2}\right) + \lim\limits_{n\to\infty} 12$, and the area under the curve is $\left(\frac{16}{3}\right)(2) + 12 = \frac{68}{3}$ units^2. The new employee has produced 22 complete parts.

43.
$$\begin{aligned}
A &= \sum_{i=1}^{n} LW \\
&= \sum_{i=1}^{n} f\left(\frac{6}{n}i\right)\left(\frac{6}{n}\right) && \text{area formula, rectangle method} \\
&= \frac{6}{n}\sum_{i=1}^{n} f\left(\frac{6}{n}i\right) && \text{factor } \frac{6}{n} \\
&= \frac{6}{n}\sum_{i=1}^{n}\left[-\frac{1}{2}\left(\frac{6}{n}i\right)^2 + 4\left(\frac{6}{n}i\right)\right] && \text{evaluate } f \text{ at } \frac{6}{n}i \\
&= \frac{6}{n}\left[-\frac{1}{2}\sum_{i=1}^{n}\left(\frac{6}{n}i\right)^2 + 4\sum_{i=1}^{n}\left(\frac{6}{n}i\right)\right] && \text{distribute summation} \\
&= \frac{6}{n}\left[-\frac{1}{2}\sum_{i=1}^{n}\frac{36}{n^2}i^2 + 4\sum_{i=1}^{n}\frac{6}{n}i\right] && \text{simplify} \\
&= \frac{6}{n}\left[-\frac{36}{2n^2}\sum_{i=1}^{n}i^2 + \frac{24}{n}\sum_{i=1}^{n}i\right] && \text{factor } \frac{36}{n^2} \text{ and } \frac{6}{n} \\
&= \frac{6}{n}\left[-\frac{18}{n^2}\left(\frac{2n^3+3n^2+n}{6}\right) + \frac{24}{n}\left(\frac{n^2+n}{2}\right)\right] && \text{summation formulas} \\
&= -\frac{108}{n^3}\left(\frac{2n^3+3n^2+n}{6}\right) + \frac{144}{n^2}\left(\frac{n^2+n}{2}\right) && \text{distribute } \frac{6}{n} \\
&= -\frac{108}{6}\left(\frac{2n^3+3n^2+n}{n^3}\right) + \frac{144}{2}\left(\frac{n^2+n}{n^2}\right) && \text{rewrite denominators} \\
&= -18\left(2 + \frac{3}{n} + \frac{1}{n^2}\right) + 72\left(1 + \frac{1}{n}\right) && \text{decompose rational expression}
\end{aligned}$$

As $n \to \infty$, $\frac{3}{n}, \frac{1}{n^2}, \frac{1}{n} \to 0$, and the area is $-(18)(2) + 72 = 36$ units^2.

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.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **2.** 2 **3.** 1 **4.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$

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.** $\left(\underset{-\infty}{\text{dne}}\right)$ **14.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$

15. -2 **16.** $f'(x) = 2x + 5$ **17.** $g'(x) = \dfrac{1}{\sqrt{2x-1}}$

18. $v'(x) = \dfrac{-1}{(x+3)^2}$ **19.** at $x = 4$, $m_{\tan} = -5$ **20.** 9 units^2

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. $\lim\limits_{x\to 1^+}(\sqrt{x-1}+2) = 2$.

6. a. II **b.** I **c.** IV **d.** III **7. a.** 2 **b.** $\left(\underset{-\infty}{\text{dne}}\right)$ **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.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **c.** $\frac{1}{3}$ **d.** 1

14. a. $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **b.** $\left(\underset{\not\exists}{\text{dne}}\right)$ **c.** $\left(\underset{-\infty}{\text{dne}}\right)$ **d.** 3 is not in the domain

15. 3 **16.** $\frac{3}{2}$ **17.** $\frac{1}{10}$ **18.** 1

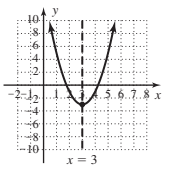
19. a. $d'(t) = -32t + 224$ **b.** $d'(2) = 160$, the debris is rising at a velocity of 160 ft/sec; $d'(6) = 32$, the upward velocity of the debris has slowed to 32 ft/sec; $d'(7) = 0$, the debris has reached its maximum height (velocity is 0 ft/sec); $d'(11) = -128$, the velocity of the debris is now in the downward direction ($v < 0$) at 128 ft/sec.

20. a. $\lim\limits_{n\to\infty}\sum\limits_{i=1}^{n} LW = \lim\limits_{n\to\infty}\sum\limits_{i=1}^{n} f\left(\frac{6}{n}i\right)\frac{6}{n} = \lim\limits_{n\to\infty}\frac{6}{n}\sum\limits_{i=1}^{n}\left[225 - \left(\frac{6}{n}i\right)^2\right]$

b. 1278 ft-lb

Cumulative Review Chapters 1–12, pp. 1220–1221

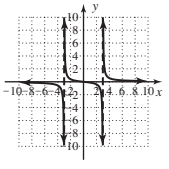
1.



3. $\frac{2}{3}\ln x + \frac{1}{2}\ln(x^2+3) - 4\ln(2x+1)$

5. $\sin\theta = -\dfrac{15}{17}, \cos\theta = \dfrac{8}{17}, \tan\theta = -\dfrac{15}{8}$

7.



9. a. $-\frac{1}{2}, \frac{1}{2}$ **b.** $\left(\underset{\text{LH}\neq\text{RH}}{\text{dne}}\right)$ **11.** $\alpha = \dfrac{\pi}{6} + 1, \dfrac{7\pi}{6} + 1$

13. The plane would be on a heading of 16.7°, traveling 297.5 mph.

15. $x = \dfrac{\ln 9.36 + 1}{2}$, $x \approx 1.618$ **17.** -3

19. $1 + \dfrac{-2}{x+2} + \dfrac{2}{x-1}$ **21.** $\dfrac{(x-1)^2}{25} + \dfrac{(y-1)^2}{9} = 1$

23. a. 1 **b.** 0 **c.** -3 **d.** 5 not in domain, limit does not exit

25. $(5)(4)(9)(8)(7) = 10{,}080$ PINs **27.** $(w, x, y, z) = (1, -2, 3, -4)$

29. $\left(-\infty, \dfrac{-4}{3}\right) \cup (2, \infty)$

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. $-\frac{2}{15}p + 6$ **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.** $\dfrac{p^2}{4q^2}$ **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 units^3 **27.** $3w^3$ **29.** $-3ab$

31. $\dfrac{27}{8}$ **33.** $2h^3$ **35.** $\dfrac{-1}{8}$ **37.** -8 **39.** $\dfrac{4p^8}{q^6}$ **41.** $\dfrac{8x^6}{27y^9}$ **43.** $\dfrac{25m^4n^6}{4r^8}$

45. $\dfrac{25p^2q^2}{4}$ **47.** $\dfrac{3p^2}{-4q^2}$ **49.** $\dfrac{5}{3h^7}$ **51.** $\dfrac{1}{a^3}$ **53.** $\dfrac{a^{12}}{b^4c^8}$ **55.** $\dfrac{-12}{5x^4}$

57. $\dfrac{-2b^7}{27a^9c^3}$ **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

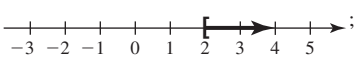
83. $\frac{-2}{3}x^2 + 12$; $\frac{-2}{3}$ **85.** $3p^3 - 3p^2 - 12$ **87.** $7.85b^2 - 0.6b - 1.9$

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.** $b = \dfrac{6}{5}$
13. $b = -15$ **15.** $m = -\dfrac{27}{4}$ **17.** $x = 12$ **19.** $x = 12$ **21.** $p = -56$
23. $a = -3.6$ **25.** $v = -0.5$ **27.** $n = \dfrac{20}{21}$ **29.** $p = \dfrac{12}{5}$
31. contradiction; $\{\ \}$ **33.** conditional; $n = -\dfrac{11}{10}$
35. identity; $\{x|x \in \mathbb{R}\}$ **37.** $\{x|x \geq -2\}$; $[-2, \infty)$
39. $\{x|-2 \leq x \leq 1\}$; $[-2, 1]$ **41.** $\{a|a \geq 2\}$;

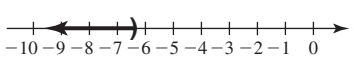


; $a \in [2, \infty)$

43. $\{n|n \geq 1\}$;

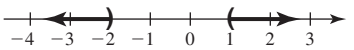
; $n \in [1, \infty)$

45. $\{x|x < \frac{-32}{5}\}$;

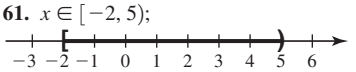


; $x \in (-\infty, \frac{-32}{5})$

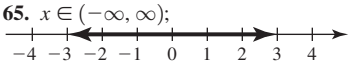
47. $\{\ \}$ **49.** $\{x|x \in \mathbb{R}\}$ **51.** $\{p|p \in \mathbb{R}\}$
53. $\{2\}$; $\{-3, -2, -1, 0, 1, 2, 3, 4, 6, 8\}$
55. $\{\ \}$; $\{-3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7\}$
57. $\{4, 6\}$; $\{2, 4, 5, 6, 7, 8\}$
59. $x \in (-\infty, -2) \cup (1, \infty)$;



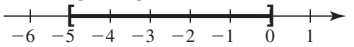
61. $x \in [-2, 5)$;



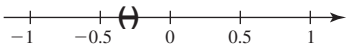
63. no solution
65. $x \in (-\infty, \infty)$;



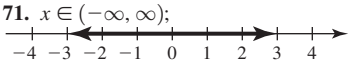
67. $x \in [-5, 0]$;



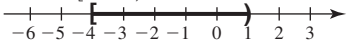
69. $x \in (-\frac{1}{3}, -\frac{1}{4})$;



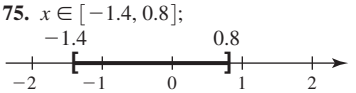
71. $x \in (-\infty, \infty)$;



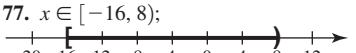
73. $x \in [-4, 1)$;



75. $x \in [-1.4, 0.8]$;



77. $x \in [-16, 8)$;



79. a. $8 + 6 - 12 = 2$ ✓ **b.** $6 + 8 - 12 = 2$ ✓ **c.** 20 vartices
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. $45 < \frac{9}{5}C + 32 < 85$, $7.2° < C < 29.4°$
99. $S = 4.5h + 20$, $K = 6h + 11$, more than 6 hr
101. a. 216.5 ft^2 **b.** 7 sheets will be needed **103.** about 337.4 in^3
105. $x = \dfrac{1}{2}$ **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 cm^2; 21,991 cm^2
103. $V = \dfrac{1}{3}\pi h(R + r)(R - r)$; 6π cm^3; 18.8 cm^3
105. $V = x(x + 5)(x + 3)$ **a.** 3 in. **b.** 5 in. **c.** $V = 24(29)(27) = 18{,}792$ in^3
107. $L = L_0\sqrt{\left(1 + \dfrac{v}{c}\right)\left(1 - \dfrac{v}{c}\right)}$, $L = 12\sqrt{(1 + 0.75)(1 - 0.75)}$
$= 3\sqrt{7}$ 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. $-\dfrac{1}{3}$ **b.** $\dfrac{x + 3}{2x(x - 2)}$ **9. a.** simplified **b.** $\dfrac{a - 4}{a - 7}$
11. a. -1 **b.** -1 **13. a.** $-3ab^9$ **b.** $\dfrac{x + 3}{9}$ **c.** $-1(y + 3)$ **d.** $\dfrac{-1}{m}$

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 **b.** It would require many resources. **c.** No

P	$\frac{450P}{100-P}$
40	300
60	675
80	1800
90	4050
93	5979
95	8550
98	22050
100	ERROR

89. Price rises rapidly for first four days, then begins a gradual decrease. Yes, on the 35th day of trading.

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.** $(16^{\frac{1}{4}})^3$ **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 a 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.** $\sqrt[12]{b}$ **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.** $m=-64$
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.** $12\pi\sqrt{34} \approx 219.82\ \text{m}^2$ **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.** $\frac{-7}{6}$ **c.** 0.5 **d.** -4.6 **4. a.** $\frac{28}{3}$ **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)