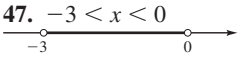
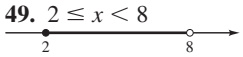
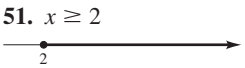
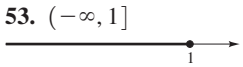
Answers to Selected Exercises and Chapter Tests

Prologue ■ Page P4

1. It can't go fast enough. **2.** 40% discount
3. 427, $3n + 1$ **4.** 57 min **5.** No, not necessarily
6. The same amount **7.** 2π
8. The North Pole is one such point; there are infinitely many others near the South Pole.

Chapter 1

Section 1.1 ■ Page 10

1. Answers may vary. Examples: **(a)** 2 **(b)** -3 **(c)** $\frac{3}{2}$ **(d)** $\sqrt{2}$ **2. (a)** ba; Commutative **(b)** $(a + b) + c$; Associative **(c)** $ab + ac$; Distributive **3. (a)** $\{x \mid -3 < x < 5\}$ **(b)** $(-3, 5)$ **(c)**  **4.** absolute-value; positive **5.** $|b - a|$; 7 **6. (a)** Yes **(b)** No
7. (a) No **(b)** No **8. (a)** Yes **(b)** Yes
9. (a) 100 **(b)** 0, 100, -8 **(c)** $-1.5, 0, \frac{5}{2}, 2.71, 3.1\overline{4}$, 100, -8 **(d)** $\sqrt{7}, -\pi$ **11.** Commutative Property of Addition
13. Associative Property of Addition **15.** Distributive Property **17.** Commutative Property of Multiplication
19. $3 + x$ **21.** $4A + 4B$ **23.** $-2x - 2y$ **25.** $10xy$
27. $-5x + 10y$ **29. (a)** $\frac{29}{21}$ **(b)** $\frac{1}{24}$ **31. (a)** 3 **(b)** $\frac{13}{20}$
33. (a) $<$ **(b)** $>$ **(c)** $=$ **35. (a)** False **(b)** True
37. (a) True **(b)** False **39. (a)** $x > 0$ **(b)** $t < 4$ **(c)** $a \geq \pi$ **(d)** $-5 < x < \frac{1}{3}$ **(e)** $|3 - p| \leq 5$
41. (a) $\{1, 2, 3, 4, 5, 6, 7, 8\}$ **(b)** $\{2, 4, 6\}$
43. (a) $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ **(b)** $\{7\}$
45. (a) $\{x \mid x \leq 5\}$ **(b)** $\{x \mid -1 < x < 4\}$
47. $-3 < x < 0$  **49.** $2 \leq x < 8$ 
51. $x \geq 2$  **53.** $(-\infty, 1]$ 
55. $(-2, 1]$ 
57. $(-1, \infty)$ 
59. (a) $[-3, 5]$ **(b)** $(-3, 5]$ **(c)** $(-3, \infty)$
61.  **63.** 
65. 
67. (a) 50 **(b)** 13 **69. (a)** 2 **(b)** -1 **71. (a)** 12 **(b)** 5
73. 5 **75. (a)** 15 **(b)** 24 **(c)** $\frac{67}{40}$ **77. (a)** $\frac{7}{9}$ **(b)** $\frac{13}{45}$ **(c)** $\frac{19}{33}$
79. $\pi - 3$ **81.** $b - a$ **83. (a)** $-$ **(b)** $+$ **(c)** $+$ **(d)** $-$
85. Distributive Property

Section 1.2 ■ Page 21

1. (a) 5^6 **(b)** base, exponent **2. (a)** add, 3^9 **(b)** subtract, 3^3
3. exponent; $\frac{1}{a^2}, b^2, \frac{1}{a^3b^2}, 6a^2b^3$ **4. (a)** $5^{1/3}$ **(b)** $\sqrt{5}$ **(c)** No
5. $(4^{1/2})^3 = 8, (4^3)^{1/2} = 8$ **6.** $\frac{1}{\sqrt{3}} = \frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3}} = \frac{\sqrt{3}}{3}$ **7.** $\frac{2}{3}$
8. (a) Yes **(b)** No **(c)** No **(d)** No
9. (a) -64 **(b)** 64 **(c)** $-\frac{27}{25}$ **11. (a)** $\frac{1}{2}$ **(b)** $\frac{1}{8}$ **(c)** $\frac{9}{4}$
13. (a) 625 **(b)** 25 **(c)** 64 **15. (a)** $6\sqrt[3]{2}$ **(b)** $\frac{\sqrt{2}}{3}$ **(c)** $\frac{3\sqrt{3}}{2}$ **17. (a)** $3\sqrt{5}$ **(b)** 4 **(c)** $6\sqrt[3]{2}$ **19. (a)** t^7 **(b)** $16z^6$ **(c)** x^2 **21. (a)** $\frac{1}{x^2}$ **(b)** $\frac{1}{w}$ **(c)** x^6
23. (a) a^6 **(b)** a^{18} **(c)** $\frac{5x^9}{8}$ **25. (a)** $6x^3y^5$ **(b)** $\frac{25w^4}{z}$
27. (a) $\frac{x^7}{y}$ **(b)** $\frac{a^9}{8b^6}$ **29. (a)** $\frac{a^{19}b}{c^9}$ **(b)** $\frac{v^{10}}{u^{11}}$
31. (a) $\frac{4a^8}{b^9}$ **(b)** $\frac{125}{x^6y^3}$ **33. (a)** $|x|$ **(b)** $2x^2$
35. (a) $2x^3y$ **(b)** $2x^2|y|$ **37. (a)** $7\sqrt{2}$ **(b)** $9\sqrt{3}$
39. (a) $(3a + 1)\sqrt{a}$ **(b)** $(4 + x^2)\sqrt{x}$
41. (a) $6x\sqrt{1 + x^2}$ **(b)** $9\sqrt{x^2 + y^2}$
43. $10^{1/2}$ **45.** $\sqrt[5]{7^3}$ **47.** $5^{-1/2}$ **49.** $\frac{1}{\sqrt{y^3}}$
51. (a) 2 **(b)** -2 **(c)** $\frac{1}{3}$ **53. (a)** 4 **(b)** $\frac{3}{2}$ **(c)** $\frac{8}{27}$
55. (a) 5 **(b)** $\sqrt[5]{3}$ **(c)** 4 **57. (a)** x^2 **(b)** y^2
59. (a) $w^{5/3}$ **(b)** $729x^3y^2$ **61. (a)** $4a^4b$ **(b)** $\frac{8b^9}{a^6}$
63. (a) $\frac{9}{y^4}$ **(b)** $\frac{4w^2}{81z^5}$ **65. (a)** $x^{3/2}$ **(b)** $x^{6/5}$
67. (a) $y^{3/2}$ **(b)** $10x^{7/12}$ **69. (a)** $2st^{11/6}$ **(b)** x
71. (a) $y^{1/2}$ **(b)** $\frac{3u}{v}$ **73. (a)** $\frac{\sqrt{6}}{6}$ **(b)** $\frac{\sqrt{6}}{2}$ **(c)** $\frac{9\sqrt[4]{8}}{2}$
75. (a) $\frac{\sqrt{5x}}{5x}$ **(b)** $\frac{\sqrt{5x}}{5}$ **(c)** $\frac{\sqrt[5]{x^2}}{x}$ **77. (a)** $\frac{1}{4}$ **(b)** $\frac{\sqrt{2}}{4}$
79. (a) y **(b)** $-9wz$ **81. (a)** 6.93×10^7 **(b)** 7.2×10^{12} **(c)** 2.8536×10^{-5} **(d)** 1.213×10^{-4} **83. (a)** 319,000 **(b)** 272,100,000 **(c)** 0.000 000 026 70 **(d)** 0.000 000 009 999
85. (a) 5.9×10^{12} mi **(b)** 4×10^{-13} cm **(c)** 3.3×10^{19} molecules **87.** 1.3×10^{-20}
89. 1.429×10^{19} **91.** 7.4×10^{-14} **93. (a)** Negative **(b)** Positive **(c)** Negative **(d)** Negative **(e)** Positive **(f)** Negative **95.** 2.5×10^{13} mi **97.** 1.3×10^{21} L
99. 3.18×10^{80} atoms **101. (a)** ≈28 mi/h **(b)** ≈167 ft

Section 1.3 ■ Page 33

1. $6x$; $6x(3x^2 + 5)$ **2. (a)** 3; $2x^3, 3x^2, 10x$ **(b)** x; $x(2x^2 + 3x + 10)$ **3.** 12, 8; 2, 6; $(x + 2)(x + 6)$
4. $A^2 + 2AB + B^2$; $4x^2 + 12x + 9$ **5.** $A^2 - B^2$; $36 - x^2$
6. $(A + B)(A - B)$; $(7x + 3)(7x - 3)$ **7.** $(A + B)^2$; $(x + 5)^2$
8. (a) No **(b)** Yes **(c)** Yes **(d)** No **9.** Binomial; $5x^3$, 6; 3
11. Monomial; -8; 0 **13.** Four terms; $-x^4, x^3, -x^2, x$; 4
15. $7x + 5$ **17.** $x^2 + 2x - 3$ **19.** $5x^3 + 3x^2 - 10x - 2$

21. $9x + 103$ **23.** $-x^5 + 3x^4 + 6x^3$ **25.** $2x^3$
27. $21t^2 - 26t + 8$ **29.** $6x^2 + 7x - 5$ **31.** $2x^2 + 5xy - 3y^2$
33. $16x^2 + 24x + 9$ **35.** $y^2 - 6xy + 9x^2$
37. $4x^2 + 12xy + 9y^2$ **39.** $w^2 - 49$ **41.** $9x^2 - 16$
43. $x - 4$ **45.** $y^3 + 6y^2 + 12y + 8$ **47.** $x^3 + 4x^2 + 7x + 6$
49. $2x^3 - 7x^2 + 7x - 5$ **51.** $x\sqrt{x} - x$ **53.** $y^2 + y$
55. $x - 2\sqrt{xy} + y$ **57.** $x^4 - a^4$ **59.** $a - b^2$
61. $-x^4 + x^2 - 2x + 1$ **63.** $4x^2 + 4xy + y^2 - 9$
65. $x^2(2x - 1)(2x + 1)$ **67.** $(y - 6)(y + 9)$
69. $2xy^2(2x^2 - 3y + 4xy^2)$ **71.** $(x + 3)^4(x + 2)^2$
73. $(z - 2)(z - 9)$ **75.** $(2x - 3)(5x - 2)$
77. $(3x - 1)(x - 5)$ **79.** $(3x + 4)(3x + 8)$
81. $(6a - 7)(6a + 7)$ **83.** $(3x + y)(9x^2 - 3xy + y^2)$
85. $(2s - 5t)(4s^2 + 10st + 25t^2)$ **87.** $(x + 6)^2$
89. $(x + 4)(x^2 + 1)$ **91.** $(x^2 + 1)(5x + 1)$
93. $(x + 1)(x^2 + 1)$ **95.** $x^{2/3}(1 + 3x)$
97. $x^{-3/2}(x^2 - x + 1)$ **99.** $(x^2 + 1)^{-1/2}(x^2 + 3)$
101. $2x(1 + 6x^2)$ **103.** $(x - 4)(x + 2)$
105. $(2x + 3)(x + 1)$ **107.** $9(x - 5)(x + 1)$
109. $(7 - 2y)(7 + 2y)$ **111.** $(t - 3)^2$ **113.** $(y - 5z)^2$
115. $4ab$ **117.** $(x - 1)(x + 1)(x - 3)(x + 3)$
119. $(2x - 5)(4x^2 + 10x + 25)$ **121.** $x(x + 1)^2$
123. $x^2y^3(x + y)(x - y)$ **125.** $(x - 2)(x + 2)(3x - 1)$
127. $x^{-3/2}(1 + x)^2$ **129.** $3(x - 1)(x + 2)$
131. $(a - 1)(a + 1)(a - 2)(a + 2)$
133. $(x - 1)^3(x + 2)^2(x^2 - 4x + 2)$
135. $2(x^2 + 4)^4(x - 2)^3(7x^2 - 10x + 8)$
137. $(x^2 + 3)^{-4/3}(\frac{1}{3}x^2 + 3)$
141. $(a + b + c)(a + b - c)(a - b + c)(-a + b + c)$

Section 1.4 ■ Page 42

1. (a), (c) **2.** numerator; denominator; $\dfrac{x + 1}{x + 3}$
3. numerators; denominators; $\dfrac{2x}{x^2 + 4x + 3}$
4. **(a)** 3 **(b)** $x(x + 1)^2$ **(c)** $\dfrac{-2x^2 + 1}{x(x + 1)^2}$
5. **(a)** Yes **(b)** No **6.** **(a)** Yes **(b)** No
7. $\mathbb{R}$ **9.** $\{x \mid x \neq 3\}$ **11.** $\{x \mid x \geq -3\}$
13. $\{x \mid x \neq -1, 2\}$ **15.** $\{x \mid x \geq 2\}$ **17.** $\frac{1}{2}(x + 5)$
19. $\dfrac{1}{x + 2}$ **21.** $\dfrac{x + 1}{x - 2}$ **23.** $\dfrac{y}{y - 1}$ **25.** $\dfrac{x(2x + 3)}{2x - 3}$
27. $\dfrac{1}{4(x - 2)}$ **29.** $\dfrac{x - 3}{x + 2}$ **31.** $\dfrac{1}{t^2 + 9}$ **33.** $\dfrac{x - 4}{x + 4}$
35. $\dfrac{x + 5}{(2x + 3)(x + 4)}$ **37.** $x^2(x + 1)$ **39.** $\dfrac{x}{yz}$
41. $\dfrac{x + 4}{x + 3}$ **43.** $\dfrac{3x + 7}{(x - 3)(x + 5)}$ **45.** $\dfrac{2x + 5}{(x + 1)(x + 2)}$
47. $\dfrac{2(5x - 9)}{(2x - 3)^2}$ **49.** $\dfrac{u^2 + 3u + 1}{u + 1}$ **51.** $\dfrac{2x + 1}{x^2(x + 1)}$
53. $\dfrac{2x + 7}{(x + 3)(x + 4)}$ **55.** $\dfrac{x - 2}{(x + 3)(x - 3)}$
57. $\dfrac{5x - 6}{x(x - 1)}$ **59.** $\dfrac{1}{x^3}$ **61.** $\dfrac{x + 1}{1 - 2x}$ **63.** $\dfrac{x + 3}{x + 1}$
65. $\dfrac{2}{(x - 1)(x + 3)}$ **67.** $\dfrac{x^2(y - 1)}{y^2(x - 1)}$
69. $-xy$ **71.** $\dfrac{y - x}{xy}$ **73.** $\dfrac{1}{1 - x}$ **75.** $\dfrac{-1}{(1 + x)(1 + x + h)}$
77. $-\dfrac{2x + h}{x^2(x + h)^2}$ **79.** $\dfrac{1}{\sqrt{1 - x^2}}$ **81.** $\dfrac{(x - 3)(19 - x)}{(x + 5)^4}$
83. $\dfrac{x + 2}{(x + 1)^{3/2}}$ **85.** $\dfrac{2x + 3}{(x + 1)^{4/3}}$ **87.** $\sqrt{10} - 3$
89. $\sqrt{5} + \sqrt{3}$ **91.** $\dfrac{y\sqrt{3} - y\sqrt{y}}{3 - y}$ **93.** $\dfrac{-1}{5(2 + \sqrt{5})}$
95. $\dfrac{r - 2}{5(\sqrt{r} - \sqrt{2})}$ **97.** $\dfrac{1}{\sqrt{x^2 + 1} + x}$
99. **(a)** $\dfrac{R_1R_2}{R_1 + R_2}$ **(b)** $\frac{20}{3} \approx 6.7$ ohms

Section 1.5 ■ Page 55

1. **(a)** Yes **(b)** Yes **(c)** No **2.** **(a)** Take (positive and negative) square roots of both sides. **(b)** Subtract 5 from both sides. **(c)** Subtract 2 from both sides.
3. **(a)** Factor the left side to $(x + 2)(x - 8)$, and use the Zero-Product Property. **(b)** Add 16 to each side, then complete the square by adding 9 to both sides. **(c)** Insert coefficients into the Quadratic Formula. **4.** **(a)** 0 **(b)** 0, 4 **(c)** factor
5. **(a)** $\sqrt{2x} = -x$ **(b)** $2x = x^2$ **(c)** 0, 2 **(d)** 0
6. quadratic; $x + 1$; $W^2 - 5W + 6 = 0$
7. $x(x + 2)$; $3(x + 2) + 5x = 2x(x + 2)$
8. square; $(2x + 1)^2 = x + 1$ **9.** **(a)** No **(b)** Yes
11. **(a)** Yes **(b)** No **13.** -1 **15.** 18 **17.** $\frac{3}{5}$
19. $-\frac{27}{4}$ **21.** $-\frac{3}{4}$ **23.** 30 **25.** $\frac{13}{6}$ **27.** $-\frac{1}{3}$
29. $m = \dfrac{2E}{v^2}$ **31.** $w = \dfrac{P - 2l}{2}$ **33.** $x = \dfrac{2d - b}{a - 2c}$
35. $x = \dfrac{1 - a}{a^2 - a - 1}$ **37.** $r = \pm\sqrt{\dfrac{3V}{\pi h}}$
39. $b = \pm\sqrt{c^2 - a^2}$ **41.** $-4, 3$ **43.** $-15, 2$
45. $-\frac{3}{2}, \frac{5}{2}$ **47.** ± 2 **49.** $-2, 7$ **51.** $-5 \pm \sqrt{2}$
53. $-5 \pm \sqrt{23}$ **55.** $3 \pm 2\sqrt{5}$ **57.** $-1 \pm \dfrac{\sqrt{30}}{5}$
59. $0, \frac{1}{4}$ **61.** $-3, 5$ **63.** $-\frac{3}{2}, 1$ **65.** $-1 \pm \frac{2\sqrt{6}}{3}$
67. $-\frac{2}{3}$ **69.** $-\frac{9}{2}, \frac{1}{2}$ **71.** No real solution **73.** 2
75. 1 **77.** No real solution **79.** $-50, 100$ **81.** 0, 3
83. $-\frac{7}{5}, 2$ **85.** 7 **87.** 4 **89.** 4 **91.** $\pm 2\sqrt{2}, \pm\sqrt{5}$
93. $-4, -3, -1, 0$ **95.** $\pm 3\sqrt{3}, \pm 2\sqrt{2}$ **97.** 2
99. $-2, -\frac{4}{3}$ **101.** 3.99, 4.01 **103.** -2 **105.** $-1, \frac{4}{3}$
107. $\frac{21}{11}$ **109.** $\dfrac{-3 + 3\sqrt{5}}{2}$ **111.** 256 **113.** $-\frac{19}{3}$, 13
115. 4, 6 **117.** ± 2 **119.** $-\frac{1}{2}$ **121.** 20 **123.** $-3, \dfrac{1 \pm \sqrt{13}}{2}$
125. $\pm\sqrt{a}, \pm 2\sqrt{a}$ **127.** $\sqrt{a^2 + 36}$ **129.** ≈ 4.24 s
131. **(a)** After 1 s and $1\frac{1}{2}$ s **(b)** Never **(c)** 25 ft
(d) After $1\frac{1}{4}$ s **(e)** After $2\frac{1}{2}$ s **133.** **(a)** 0.00055; ≈ 12.018 m
(b) 234.375 kg/m^3 **135.** **(a)** 211,810 **(b)** 160,760 Pa; 194,000 Pa **137.** 215,000 mi

Section 1.6 ■ Page 63

1. -1 **2.** 3, 4 **3. (a)** $3 - 4i$ **(b)** $9 + 16 = 25$ **4.** $3 - 4i$
5. Yes **6.** Yes **7.** Real part 3, imaginary part -8
9. Real part $-\frac{2}{3}$, imaginary part $-\frac{5}{3}$ **11.** Real part 3, imaginary part 0 **13.** Real part 0, imaginary part $-\frac{2}{3}$ **15.** Real part $\sqrt{3}$, imaginary part 2 **17.** $3 + 7i$ **19.** $1 - 10i$ **21.** $3 + 5i$
23. $2 - 2i$ **25.** $-19 + 4i$ **27.** $-4 + 8i$ **29.** $26 + 7i$
31. $27 - 8i$ **33.** 13 **35.** $5 - 12i$ **37.** $-i$ **39.** $-1 - i$
41. $-4 + 2i$ **43.** $2 - \frac{4}{3}i$ **45.** $-i$ **47.** $-i$ **49.** $243i$
51. 1 **53.** $5i$ **55.** -6 **57.** $(6 + \sqrt{3}) + (3 - 2\sqrt{3})i$ **59.** 2
61. $\pm 5i$ **63.** $3 \pm 2i$ **65.** $\frac{1}{2} \pm \frac{3}{2}i$ **67.** $-\frac{1}{2} \pm \frac{\sqrt{3}}{2}i$
69. $\frac{2}{9} \pm \frac{4\sqrt{2}}{9}i$ **71.** $-1 \pm \frac{\sqrt{6}}{6}i$ **73.** $8 + 2i$ **75.** 25

Section 1.7 ■ Page 75

2. principal; interest rate; time in years

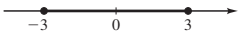
3. (a) x^2 **(b)** lw **(c)** πr^2 **4.** 1.6 **5.** $\frac{1}{x}$
6. $r = \frac{d}{t}, t = \frac{d}{r}$ **7.** $3n + 3$ **9.** $3n + 6$ **11.** $\frac{160 + s}{3}$
13. $0.025x$ **15.** $4w^2$ **17.** $\frac{d}{55}$ **19.** $\frac{25}{3 + x}$ **21.** 220 mi
23. 86 **25.** \$8400 at $2\frac{1}{2}\%$ and \$3600 at 3% **27.** 7.5%
29. \$14,400 **31.** 6 h **33.** 40 years old **35.** 7 nickels, 7 dimes, 7 quarters **37.** 45 ft **39.** 66 ft by 330 ft
41. 40 ft by 70 ft **43.** 60 ft by 40 ft **45.** 120 ft
47. (a) 9 cm **(b)** 5 in. **49.** 4 in. **51.** 18 ft **53.** 5 m
55. 200 mL **57.** 18 g **59.** 0.6 L **61.** 35% **63.** 14 min 35 s
65. 3.5 h **67.** you 3 h, roommate $4\frac{1}{2}$ h **69.** 4 h
71. 500 mi/h **73.** 50 mi/h (or 240 mi/h) **75.** 6 km/h
77. 6.4 ft from the fulcrum **79.** 2 ft by 6 ft by 15 ft
81. 13 in. by 13 in. **83.** 2.88 ft **85.** 16 mi; no **87.** 7.52 ft
89. 18 ft **91.** 4.55 ft

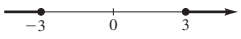
Section 1.8 ■ Page 88

1. (a) $<$ **(b)** $\leq$ **(c)** $\leq$ **(d)** $>$
2. $-1, 2$

Interval	$(-\infty, -1)$	$(-1, 2)$	$(2, \infty)$
Sign of $x + 1$	$-$	$+$	$+$
Sign of $x - 2$	$-$	$-$	$+$
Sign of $(x + 1)/(x - 2)$	$+$	$-$	$+$

yes, 2; $[-1, 2)$

3. (a) $[-3, 3]$ 

(b) $(-\infty, -3], [3, \infty)$ 

4. (a) < 3 **(b)** > 3 **5. (a)** No **(b)** No **6. (a)** Divide by 3 **(b)** Add 2 **(c)** Rewrite as $-8 \leq 3x + 2 \leq 8$

7. $\{\frac{5}{6}, 1, \sqrt{5}, 3, 5\}$ **9.** $\{3, 5\}$ **11.** $\{-5, -1, \sqrt{5}, 3, 5\}$

13. $(-\infty, \frac{7}{2}]$ 

15. $(4, \infty)$ 

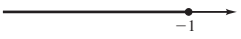
17. $(-\infty, 2]$ 

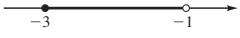
19. $(-\infty, -\frac{1}{2})$ 

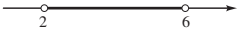
21. $(-3, \infty)$ 

23. $(3, \infty)$ 

25. $(-\infty, -18)$ 

27. $(-\infty, -1]$ 

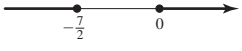
29. $[-3, -1)$ 

31. $(2, 6)$ 

33. $[\frac{9}{2}, 5)$ 

35. $(\frac{15}{2}, \frac{21}{2}]$ 

37. $(-2, 3)$

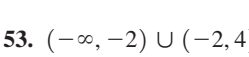
39. $(-\infty, -\frac{7}{2}] \cup [0, \infty)$ 

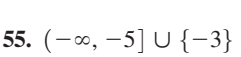
41. $[-3, 6]$

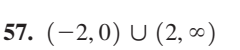
43. $(-\infty, -2] \cup [\frac{1}{3}, \infty)$ 

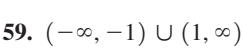
45. $(-1, 4)$

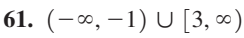
47. $(-\infty, -3) \cup (6, \infty)$

49. $(-2, 2)$ 

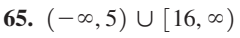
51. $(-\infty, -2] \cup [1, 3]$ 

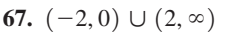
53. $(-\infty, -2) \cup (-2, 4)$ 

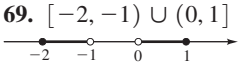
55. $(-\infty, -5] \cup \{-3\} \cup [2, \infty)$ 

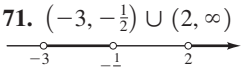
57. $(-2, 0) \cup (2, \infty)$ 

59. $(-\infty, -1) \cup (1, \infty)$ 

61. $(-\infty, -1) \cup [3, \infty)$ 

63. $(2, \frac{5}{2})$ 

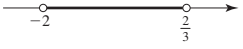
65. $(-\infty, 5) \cup [16, \infty)$ 

67. $(-2, 0) \cup (2, \infty)$ 

69. $[-2, -1) \cup (0, 1]$ 

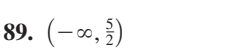
71. $(-3, -\frac{1}{2}) \cup (2, \infty)$ 

73. $(-4, 4)$

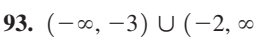
75. $(-\infty, -\frac{7}{2}) \cup (\frac{7}{2}, \infty)$ 

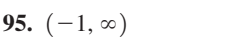
77. $[-7, 13]$ 

79. $(-2, \frac{2}{3})$ 

81. $(-\infty, -1] \cup [\frac{7}{3}, \infty)$ 

83. $(-4, 8)$ 

85. $(-6.001, -5.999)$ 

87. $[-\frac{1}{2}, \frac{3}{2}]$ 

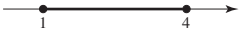
89. $(-\infty, \frac{5}{2})$

91. $[-4, 0] \cup [4, \infty)$

93. $(-\infty, -3) \cup (-2, \infty)$

95. $(-1, \infty)$

97. $[1, 4]$



99. $|x| < 3$ **101.** $|x - 7| \geq 5$

103. $|x| \leq 2$ **105.** $|x| > 3$

107. $|x - 1| \leq 3$ **109.** $x \leq -3$ or $x \geq 3$

111. $x < -2$ or $x > 5$ **113.** $x \geq \dfrac{(a + b)c}{ab}$

115. $x \leq \dfrac{ac - 4a + d}{ab}$ or $x \geq \dfrac{ac + 4a - d}{ab}$

117. $68 \leq F \leq 86$ **119.** More than 100 mi
121. Between 12,000 mi and 14,000 mi
123. **(a)** $-\frac{1}{3}P + \frac{560}{3}$ **(b)** From \$215 to \$290
125. Distances between 20,000 km and 100,000 km
127. **(a)** Acceleration greater than 26.4 ft/s^2 **(b)** ≈9.1 s
129. Between 0 and 60 mi/h
131. Between 20 and 40 ft
133. Between 62.4 and 74.0 in.

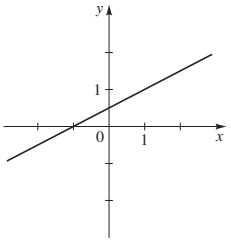
Section 1.9 ■ Page 101

1. **(a)** $(3, -5)$ **(b)** y-axis **2.** $\sqrt{(c - a)^2 + (d - b)^2}$; 10

3. $\left(\dfrac{a + c}{2}, \dfrac{b + d}{2}\right)$; $(4, 6)$

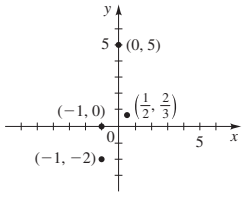
4. 2; 3; No

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

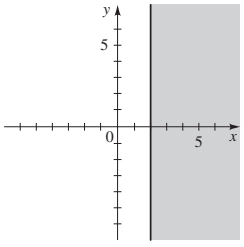


5. **(a)** y; x; -1 **(b)** x; y; $\frac{1}{2}$ **6.** **(a)** $(1, 2)$; 3
(b) $(x - 3)^2 + (y - 4)^2 = 9$ **7.** **(a)** $(a, -b)$ **(b)** $(-a, b)$
(c) $(-a, -b)$ **8.** **(a)** $-5, 3; \pm 2$ **(b)** x-axis **9.** Yes
10. No **11.** $A(5, 1)$, $B(1, 2)$, $C(-2, 6)$, $D(-6, 2)$, $E(-4, -1)$, $F(-2, 0)$, $G(-1, -3)$, $H(2, -2)$

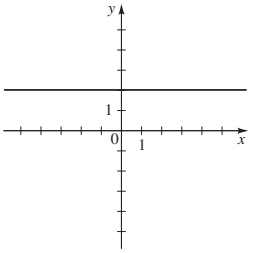
13.



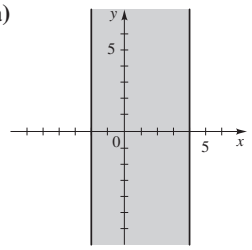
15. **(a)**



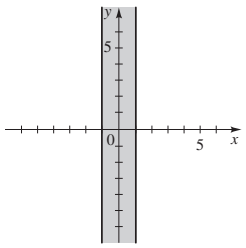
(b)



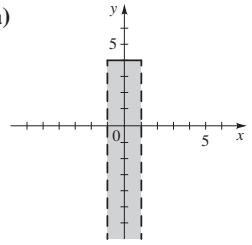
17. **(a)**



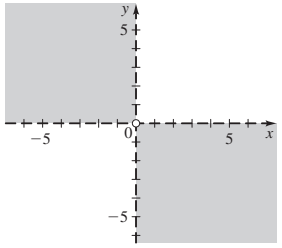
(b)



19. **(a)**

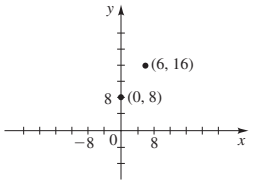


(b)



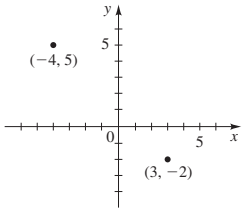
21. **(a)** $\sqrt{13}$ **(b)** $\left(\frac{3}{2}, 1\right)$ **23.** **(a)** 10 **(b)** $(1, 0)$

25. **(a)**



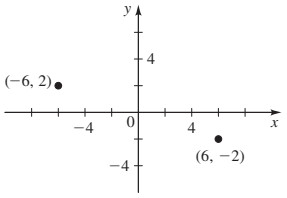
(b) 10 **(c)** $(3, 12)$

27. **(a)**



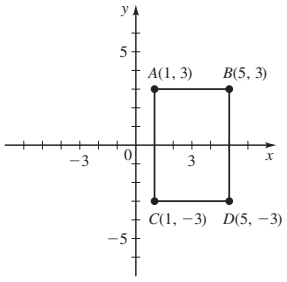
(b) $7\sqrt{2}$ **(c)** $\left(-\frac{1}{2}, \frac{3}{2}\right)$

29. **(a)**

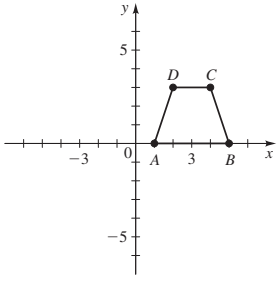


(b) $4\sqrt{10}$ **(c)** $(0, 0)$

31. 24

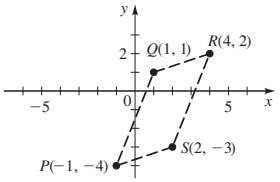


33. Trapezoid, 9

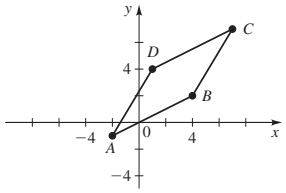


35. $A(6, 7)$ **37.** $Q(-1, 3)$ **41.** **(b)** 10 **45.** $(0, -4)$

47. $(2, -3)$



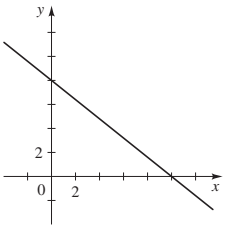
49. (a)



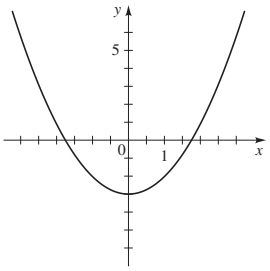
(b) $\left(\frac{5}{2}, 3\right), \left(\frac{5}{2}, 3\right)$

51. Yes, no, yes **53.** Yes, no, yes

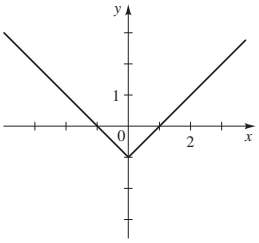
55.



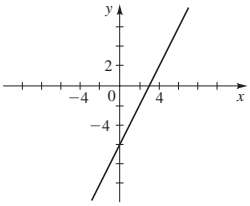
57.



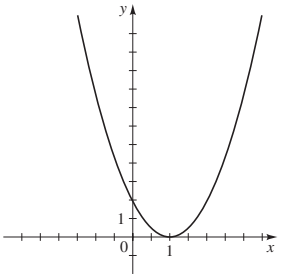
59.



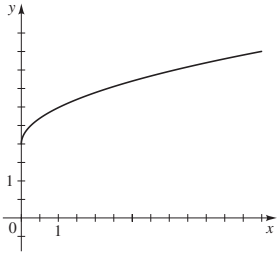
61. (a) x-intercept 3, y-intercept -6, no symmetry



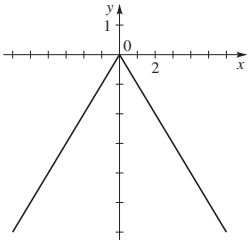
(b) x-intercept 1, y-intercept 2, no symmetry



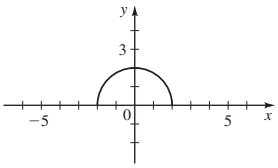
63. (a) No x-intercept, y-intercept 2, no symmetry



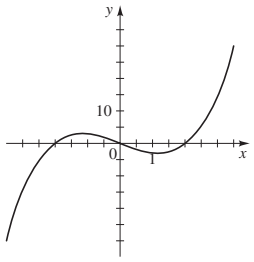
(b) x-intercept 0, y-intercept 0, symmetry with respect to y-axis



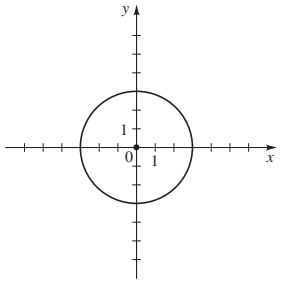
65. (a) x-intercepts ± 2, y-intercept 2, symmetry with respect to y-axis



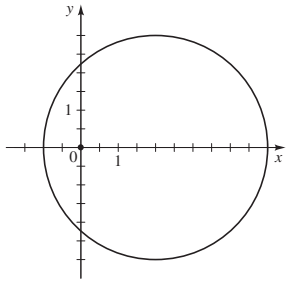
(b) x-intercepts 0 and ± 2, y-intercept 0, symmetry with respect to origin



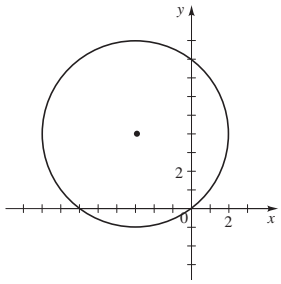
67. (a) x-intercept -6; y-intercept 6
(b) x-intercepts $\pm\sqrt{5}$; y-intercept -5
69. (a) x-intercepts ± 2; no y-intercept
(b) x-intercept $\frac{1}{4}$; y-intercept 1
71. x-intercepts 0, 4; y-intercept 0
73. x-intercepts -2, 2; y-intercepts -4, 4
75. $(0, 0)$, 3



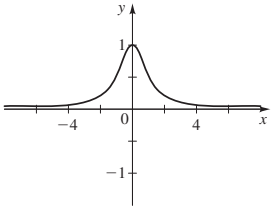
77. $(2, 0)$, 3



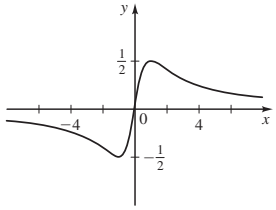
79. $(-3, 4)$, 5



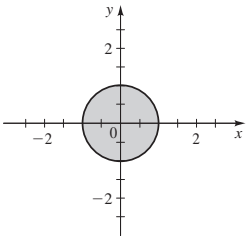
81. $(x + 3)^2 + (y - 1)^2 = 4$ **83.** $x^2 + y^2 = 65$
85. $(x - 2)^2 + (y - 5)^2 = 25$ **87.** $(x - 7)^2 + (y + 3)^2 = 9$
89. $(x + 2)^2 + (y - 2)^2 = 4$ **91.** $(-2, 3), 1$ **93.** $\left(\frac{1}{4}, -\frac{1}{4}\right), \frac{1}{2}$
95. $\left(\frac{3}{4}, 0\right), \frac{3}{4}$ **97.** Symmetry about y-axis **99.** Symmetry with respect to x-axis, y-axis, and origin
101. Symmetry with respect to origin
103.



105.

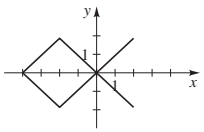


107.

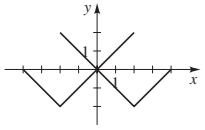


109. 12π **111. (a)** $(8, 5)$ **(b)** $(a + 3, b + 2)$ **(c)** $(0, 2)$ **(d)** $A'(-2, 1), B'(0, 4), C'(5, 3)$

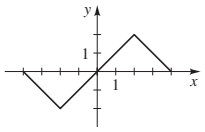
113. (a)



(b)



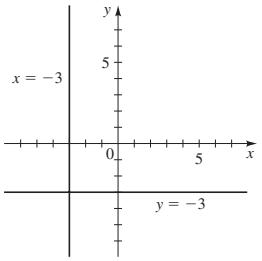
(c)



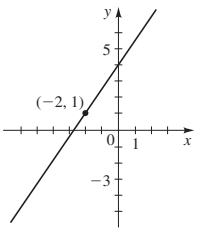
115. (a) 5 **(b)** 31; 25 **(c)** Points P and Q must either be on the same street or the same avenue.

Section 1.10 ■ Page 113

1. y; x; 2 **2. (a)** 3 **(b)** 3 **(c)** $-\frac{1}{3}$ **3.** $y - 2 = 3(x - 1)$
4. 6, 4; $-\frac{2}{3}x + 4$; $-\frac{2}{3}$ **5.** 0; $y = 3$ **6.** Undefined; $x = 2$
7. (a) Yes **(b)** Yes **(c)** No **(d)** Yes
8. Yes

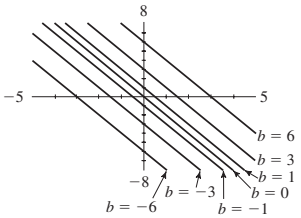


9. -2 **11.** $-\frac{5}{6}$ **13.** 0 **15.** -1 **17.** $-2, \frac{1}{2}, 3, -\frac{1}{4}$
19. $x + y - 4 = 0$ **21.** $3x - 2y - 6 = 0$ **23.** $3x - y - 2 = 0$
25. $3x - y - 11 = 0$ **27.** $2x - 3y + 19 = 0$
29. $5x + y - 11 = 0$ **31.** $2x - y - 9 = 0$
33. $3x - y - 3 = 0$ **35.** $y = 3$ **37.** $x = 2$
39. $2x - y + 6 = 0$ **41.** $y = 5$ **43.** $3x + 2y + 17 = 0$
45. $x = -1$ **47.** $4x - 3y + 11 = 0$ **49.** $x - y + 6 = 0$
51. (a)

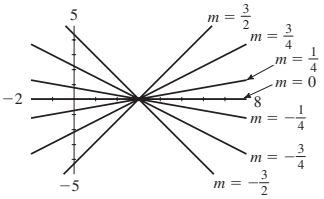


(b) $3x - 2y + 8 = 0$

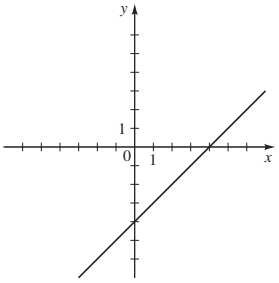
53. They all have the same slope.



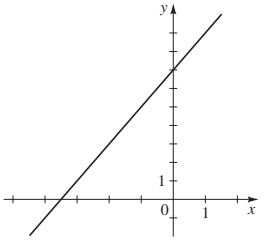
55. They all have the same x-intercept.



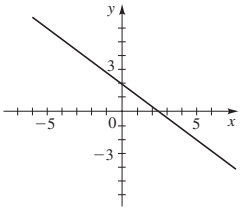
57. 1, -4



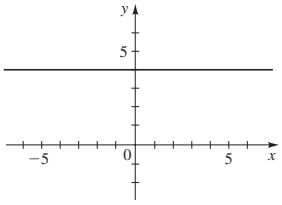
59. 2, 7



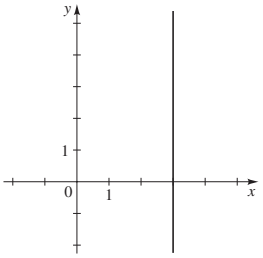
61. $-\frac{4}{5}$, 2



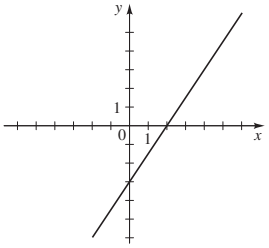
63. 0, 4



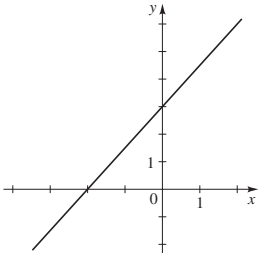
65. Undefined, none



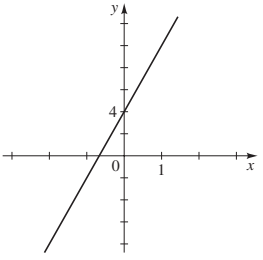
67. 2, -3



69. -2, 3

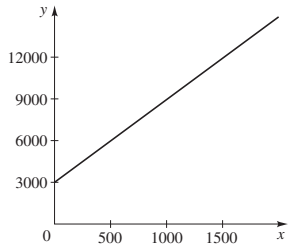


71. $-\frac{2}{3}$, 4



73. Parallel **75.** Perpendicular **77.** Neither
83. $x - y - 3 = 0$ **85. (b)** $4x - 3y - 24 = 0$
89. (a) 8.34; the slope represents an increase of 8.34 mg in dosage for each year of increase in age.
(b) 8.34 mg

91. **(a)**

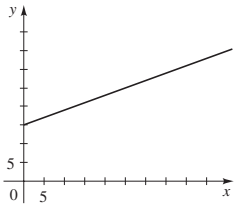


(b) The slope represents a cost of \$6 for each toaster oven produced, and the y-intercept represents monthly fixed costs of \$3000.

93. **(a)** $t = \frac{5}{24}n + 45$ **(b)** 76°F

95. **(a)** $P = 0.434d + 15$, where P is pressure in lb/in^2 and d is depth in feet

(b)



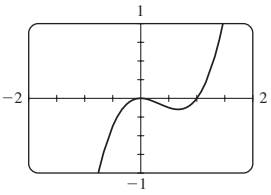
(c) The slope represents an increase of 0.434 lb/in^2 in pressure for each one foot increase in depth, and the d-intercept is the air pressure at the surface. **(d)** ≈196 ft

Section 1.11 ■ Page 122

1. x **2.** above **3.** **(a)** $x = -1, 0, 1, 3$ **(b)** $[-1, 0] \cup [1, 3]$

4. **(a)** $x = 1, 4$ **(b)** $(1, 4)$

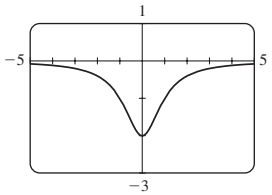
5. **(a)**



(b) x-intercepts 0, 1
y-intercept 0

(c) No symmetry

7. **(a)**



(b) No x-intercept
y-intercept -2

(c) Symmetry with respect to y-axis

9. No **11.** Yes; 2 **13.** 3 **15.** $\frac{5}{14} \approx 0.36$ **17.** $\pm\sqrt{2} \approx \pm 1.41$

19. No solution **21.** $\pm\frac{4}{3} \approx 1.33$

23. $5 + 2\sqrt[4]{5} \approx 7.99$, $5 - 2\sqrt[4]{5} \approx 2.01$ **25.** 5, 6

27. 1.00, 2.00, 3.00 **29.** 1.62 **31.** −1.00, 0.00, 1.00

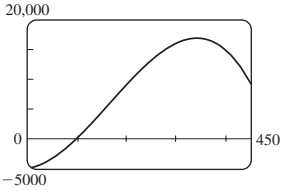
33. 4 **35.** 4 **37.** 2.55 **39.** −2.05, 0, 1.05

41. $[-2.00, 5.00]$ **43.** $(-\infty, 1.00] \cup [2.00, 3.00]$

45. $(-1.00, 0) \cup (1.00, \infty)$ **47.** $(-\infty, 0)$ **49.** $(-1, 4)$

51. $(-\infty, -5] \cup \{-3\} \cup [2, \infty)$ **53.** 2.27

55. **(a)**



(b) 101 cooktops

(c) $279 < x < 400$

Section 1.12 ■ Page 128

1. directly proportional; proportionality **2.** inversely proportional; proportionality **3.** directly proportional; inversely proportional **4.** $\frac{1}{2}xy$

5. **(a)** Directly proportional **(b)** Not proportional

6. **(a)** Not proportional **(b)** Inversely proportional

7. $T = kx$ **9.** $v = k/z$ **11.** $y = ks/t$ **13.** $z = k\sqrt{y}$

15. $V = klwh$ **17.** $R = \dfrac{kP^2t^2}{b^3}$ **19.** $y = 4x$ **21.** $A = \dfrac{75}{r}$

23. $A = \dfrac{18x}{t}$ **25.** $W = 216/r^2$ **27.** $C = 16lwh$

29. $R = \dfrac{27.5}{\sqrt{x}}$ **31.** **(a)** $z = k\dfrac{x^3}{y^2}$ **(b)** $\frac{27}{4}$

33. **(a)** $z = kx^3y^5$ **(b)** 864 **35.** **(a)** $F = kx$ **(b)** 7.5 N/cm **(c)** 45 N **37.** **(a)** $P = ks^3$ **(b)** 0.012 W/(mi/h)^3 **(c)** 324 W

39. ≈46 mi/h **41.** ≈5.3 mi/h **43.** **(a)** $P = kT/V$ **(b)** 8.3 **(c)** ≈51.9 kPa **45.** **(a)** $L = k/d^2$ **(b)** 7000 **(c)** $\frac{1}{4}$ **(d)** 4

47. **(a)** $R = kL/d^2$ **(b)** $0.002916\overline{6}$ **(c)** $R \approx 137$ ohms **(d)** $\frac{3}{4}$

49. **(a)** 160,000 **(b)** 1,930,670,340

51. **(a)** $f = k/L$ **(b)** Halves it **53.** 296 km; 781 km

55. 3.47×10^{-14} W/m^2

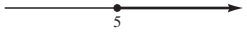
Chapter 1 Review ■ Page 135

1. Commutative Property of Addition

3. Distributive Property

5. $-2 \le x < 6$

7. $[5, \infty)$



9. 3 **11.** 4 **13.** $\frac{1}{6}$ **15.** 11 **17.** **(a)** b^{14} **(b)** $12xy^8$

19. **(a)** x^2y^2 **(b)** $w^4|z|^5$ **21.** 7.825×10^{10}

23. 1.65×10^{-32} **25.** $(x + 7)(x - 2)$

27. $(x - 1)^2(x + 1)^2$ **29.** $-4(t - 2)(t + 2)$

31. $(x - 1)(x^2 + x + 1)(x + 1)(x^2 - x + 1)$

33. $x^{-1/2}(5x - 3)(x + 1)$ **35.** $(x + 3)(5x^2 - 1)$

37. $(a + b - 5)(a + b + 2)$ **39.** $4y^2 - 49$

41. $2x^3 - 6x^2 + 4x$ **43.** $\dfrac{x + 6}{x + 5}$ **45.** $\dfrac{3x^2 - 7x + 8}{x(x - 2)^2}$

47. $-\dfrac{1}{2x}$ **49.** $\dfrac{x + 4 - 4\sqrt{x}}{x - 4}$ **51.** $\dfrac{\sqrt{11}}{11}$ **53.** $5\sqrt{2} - 5$

55. 5 **57.** No solution **59.** 2, 7 **61.** $-1, \frac{1}{2}$ **63.** $0, \pm\frac{5}{2}$

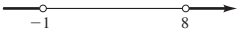
65. $\dfrac{-2 \pm \sqrt{7}}{3}$ **67.** −5 **69.** 2, 7 **71.** 3, 11 **73.** **(a)** $3 + i$ **(b)** $8 - i$ **75.** **(a)** $\frac{6}{5} + \frac{8}{5}i$ **(b)** 2 **77.** $\pm 4i$ **79.** $-3 \pm i$

81. $\pm 4, \pm 4i$ **83.** 20 lb raisins, 30 lb nuts

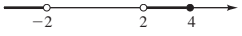
85. $\frac{1}{4}(\sqrt{329} - 3) \approx 3.78$ mi/h **87.** 1 h 50 min

89. $(-3, \infty)$

91. $(-\infty, -1) \cup (8, \infty)$

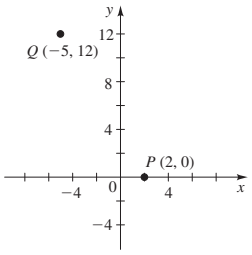


93. $(-\infty, -2) \cup (2, 4]$



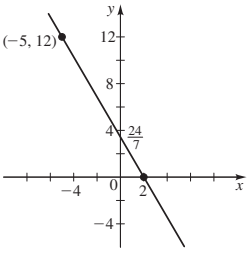
95. $[2, 8]$

97. (a)

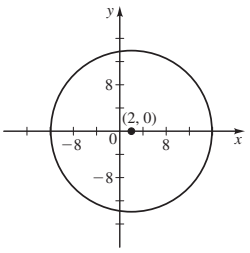


(b) $\sqrt{193}$ **(c)** $\left(-\frac{3}{2}, 6\right)$

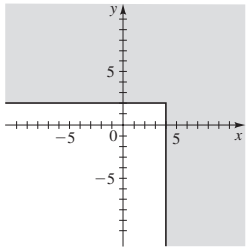
(d) $y = -\frac{12}{7}x + \frac{24}{7}$



(e) $(x - 2)^2 + y^2 = 193$



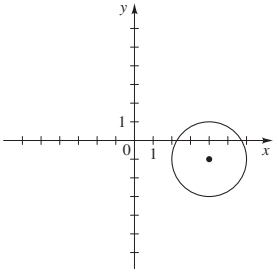
99.



101. B **103.** $(x + 5)^2 + (y + 1)^2 = 26$

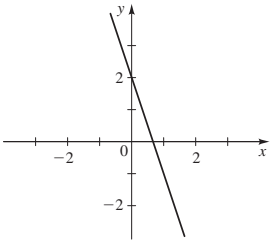
105. (a) Circle

(b) Center $(4, -1)$, radius 2

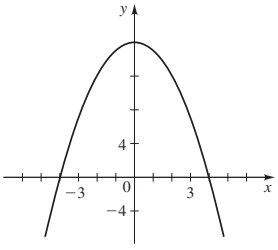


107. (a) No graph

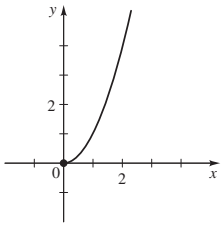
109.



111.



113.



115. (a) Symmetric with respect to x-axis

(b) x-intercept 16; y-intercepts -4, 4

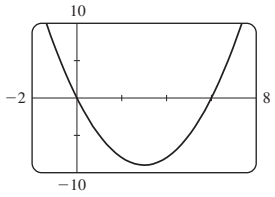
117. (a) Symmetric with respect to y-axis

(b) x-intercepts -3, 3; y-intercept -1

119. (a) Symmetric with respect to origin

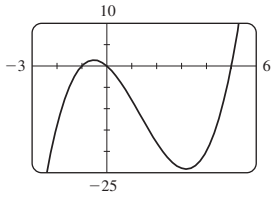
(b) x-intercepts -1, 1; y-intercepts -1, 1

121. (a)



(b) x-intercepts 0, 6; y-intercept 0

123. (a)

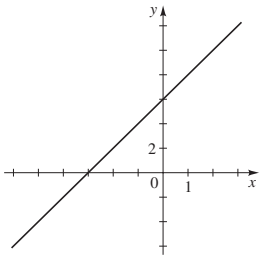


(b) x-intercepts -1, 0, 5; y-intercept 0

125. (a) $y = 2x + 6$

(b) $2x - y + 6 = 0$

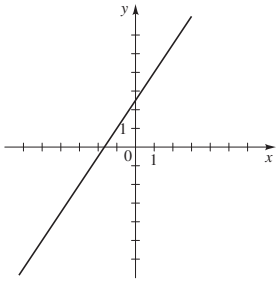
(c)



127. (a) $y = \frac{3}{2}x + \frac{5}{2}$

(b) $3x - 2y + 5 = 0$

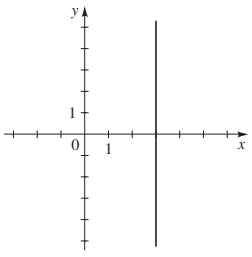
(c)



129. (a) $x = 3$

(b) $x - 3 = 0$

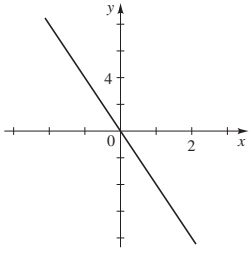
(c)



131. (a) $y = -4x$

(b) $4x + y = 0$

(c)



133. (a) The slope represents a stretch of 0.3 in. for each one-pound increase in weight. The s-intercept represents the unstretched length of the spring. **(b)** 4 in.

135. $-1, 6$ **137.** $[-1, 6]$ **139.** $(-\infty, 0] \cup [4, \infty)$

141. $-1, 7$ **143.** $-2.72, -1.15, 1.00, 2.87$

145. $(-\infty, -6) \cup (2, \infty)$ **147.** $(-1.85, -0.60) \cup (0.45, 2.00)$

149. $x^2 + y^2 = 169$, $5x - 12y + 169 = 0$

151. $M = 8z$ **153. (a)** $I = k/d^2$ **(b)** 64,000

(c) 160 candles **155.** 11.0 mi/h **157.** 1460 m/s

159. 2.4×10^5 km/s; $\approx$11,538 Mly

160. **(a)** III **(b)** V **(c)** II **(d)** IV **(e)** I **(f)** VII **(g)** VIII **(h)** VI

Chapter 1 Test ■ Page 139

1. **(a)** 

(b) $(-\infty, 3], [-1, 4)$ **(c)** 16 **2.** **(a)** 81 **(b)** -81 **(c)** $\frac{1}{81}$ **(d)** 27 **(e)** $\frac{9}{4}$ **(f)** $\frac{1}{8}$ **3.** **(a)** 1.86×10^{11} **(b)** 3.965×10^{-7}

4. **(a)** $6\sqrt{2}$ **(b)** $48a^5b^7$ **(c)** $\dfrac{y^2}{2x^4}$

5. **(a)** $3z$ **(b)** $4x^2 + 7x - 15$ **(c)** $a - b$ **(d)** $4x^2 + 12x + 9$ **(e)** $x^3 + 6x^2 + 12x + 8$

6. **(a)** $(2x - 5)(2x + 5)$ **(b)** $(2x - 3)(x + 4)$ **(c)** $(x - 3)(x - 2)(x + 2)$ **(d)** $x(x + 3)(x^2 - 3x + 9)$ **(e)** $2x^{-1/2}(x + 5)(x - 1)$ **(f)** $x^2y^2(x - 3)(x + 3)$

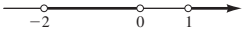
7. **(a)** $\dfrac{w + 3}{w - 3}$ **(b)** $\dfrac{1}{x - 2}$ **(c)** $-(x + y)$ **8.** $\dfrac{1 + 2\sqrt{2}}{7}$

9. **(a)** 6 **(b)** 1 **(c)** $-3, 4$ **(d)** $-1 \pm \dfrac{\sqrt{2}}{2}$ **(e)** No real solution **(f)** $\pm 1, \pm\sqrt{2}$ **(g)** $\frac{2}{3}, \frac{22}{3}$

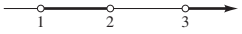
10. **(a)** $7 + i$ **(b)** $-1 - 5i$ **(c)** $18 + i$ **(d)** $\frac{6}{25} - \frac{17}{25}i$ **(e)** 1 **(f)** $6 - 2i$

11. $-1 \pm \dfrac{\sqrt{2}}{2}i$ **12.** 120 mi **13.** 50 ft by 120 ft

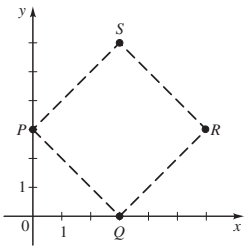
14. **(a)** $[-4, 3)$ 

(b) $(-2, 0) \cup (1, \infty)$ 

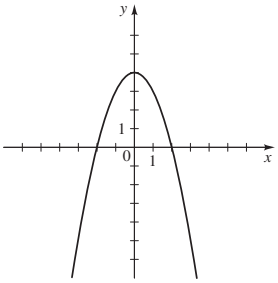
(c) $(1, 7)$ 

(d) $(1, 2) \cup (3, \infty)$ 

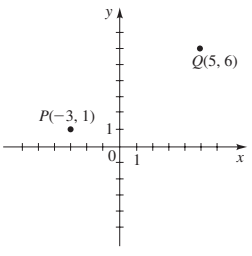
15. Between 41°F and 50°F **16.** $0 \le x \le 6$

17. **(a)** $S(3, 6)$ 

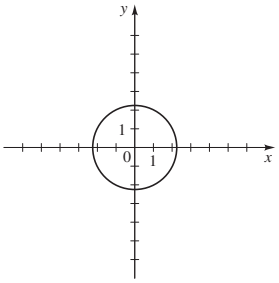
(b) 18

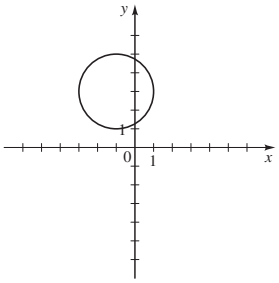
18. **(a)** 

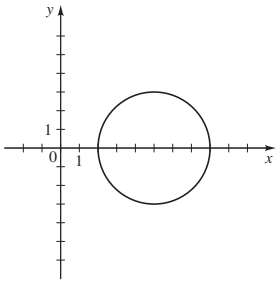
(b) x-intercepts -2, 2
y-intercept 4
(c) Symmetric with respect to y-axis

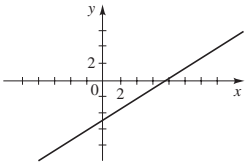
19. **(a)** 

(b) $\sqrt{89}$ **(c)** $\left(1, \frac{7}{2}\right)$ **(d)** $(x - 1)^2 + \left(y - \frac{7}{2}\right)^2 = \frac{89}{4}$

20. **(a)** $C(0, 0)$; $r = \sqrt{5}$ 

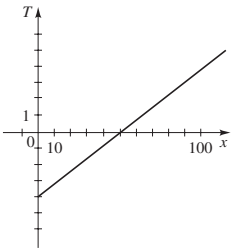
(b) $C(-1, 3)$; $r = 2$ 

(c) $C(5, 0)$; $r = 3$ 

21. $y = \frac{2}{3}x - 5$ 

slope $\frac{2}{3}$;
y-intercept -5

22. **(a)** $2x - y - 5 = 0$ **(b)** $3x + y - 3 = 0$ **(c)** $2x + 3y - 12 = 0$

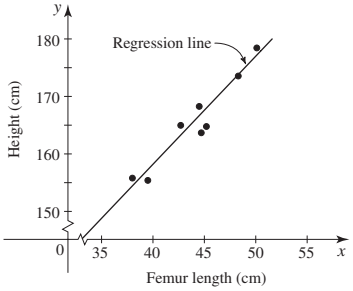
23. **(a)** 4°C **(b)** 

(c) The slope represents an increase of 0.08°C for each one-centimeter increase in depth, the x-intercept is the depth at which the temperature is 0°C, and the T-intercept is the temperature at ground level.

24. **(a)** $-2.94, -0.11, 3.05$ **(b)** $[-1, 2]$

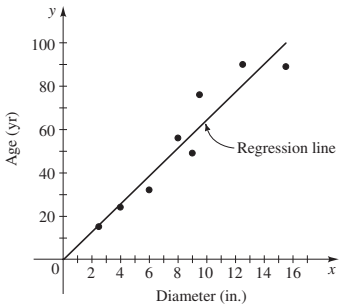
25. **(a)** $M = kwh^2/L$ **(b)** 400 **(c)** 12,000 lb

Focus on Modeling ■ Page 144

1. **(a)** $y = 1.8807x + 82.65$ 

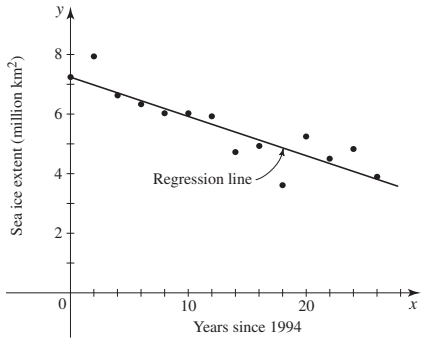
(b) 191.7 cm

3. (a) $y = 6.451x - 0.1523$



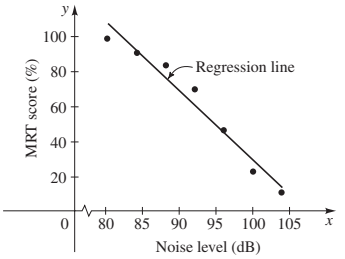
(b) 116 years

5. (a) $y = -0.13198x + 7.2514$



(b) 3.95 million km^2 **(c)** Unlikely to be accurate far into the future

7. (a) $y = -3.9018x + 419.7$



(b) The correlation coefficient is -0.98, so a linear model is appropriate. **(c)** 53%

Chapter 2

Section 2.1 ■ Page 155

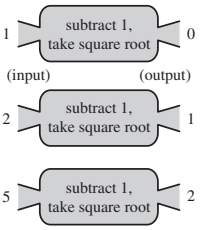
1. (a) $f(-1) = 0$ **(b)** $f(2) = 9$ **(c)** $f(2) - f(-1) = 9$
2. domain, range **3. (a)** f and g **(b)** $f(5) = 10, g(5) = 0$
4. (a) square, add 3

(b)

x	0	2	4	6
$f(x)$	19	7	3	7

5. one; (b) **6. (a)** 4, 4 **(b)** Yes **7.** Yes **8.** No
9. $f(x) = 3x - 5$ **11.** $f(x) = \sqrt{x^2 + 1}$
13. Multiply by 5, then add 1
15. Take the square root, subtract 4, then divide by 3

17.



19.

x	$f(x)$
-1	8
0	2
1	0
2	2
3	8

21. 13, 13, 1, $\frac{4}{3}$, 16 **23.** $\frac{3}{5}, \frac{1}{5}, -\frac{1}{5}, \frac{1+a}{5}, \frac{1-x^2}{5}, \frac{3-a}{5}$

25. $0, 15, 3, a^2 + 2a, x^2 - 2x, \frac{1}{a^2} + \frac{2}{a}$

27. $-\frac{1}{3}$, undefined, $\frac{1}{3}, \frac{1-a}{1+a}, \frac{2-a}{a}, \frac{2-x^2}{x^2}$

29. $5, 1, 11, 16 - \sqrt{5}, 3a^2 - 7a + 5, 3x^4 - x^2 + 1$
31. $6, 2, 1, 2, 2|x|, 2(x^2 + 1)$ **33.** $-14, 1, 2, 24, 35$
35. $8, -\frac{3}{4}, -1, 0, -1$ **37.** $x^2 + 4x + 5, x^2 + 6$
39. $x^2 + 4, x^2 + 8x + 16$ **41.** 12 **43.** -21
45. $3 - a, 3 - a - h, -1$ **47.** 5, 5, 0

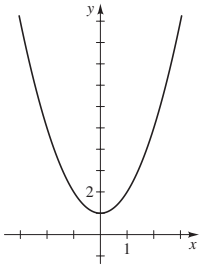
49. $\frac{a}{a+1}, \frac{a+h}{a+h+1}, \frac{1}{(a+h+1)(a+1)}$

51. $3 - 5a + 4a^2, 3 - 5a - 5h + 4a^2 + 8ah + 4h^2, -5 + 8a + 4h$ **53.** $(-\infty, \infty), (-\infty, \infty)$ **55.** $(-\infty, \infty), [3, \infty)$
57. $[-2, 6], [-6, 18]$ **59.** $\{x \mid x \neq -3\}$ **61.** $\{x \mid x \neq \pm 1\}$
63. $(-\infty, 2]$ **65.** $(-\infty, \infty)$ **67.** $(-\infty, -5] \cup [5, \infty)$
69. $[-2, 3) \cup (3, \infty)$ **71.** $(-\infty, 0] \cup [6, \infty)$
73. $(-\infty, 2)$ **75.** $(\frac{1}{2}, \infty)$
77. (a) $f(x) = x^2 + 1$

(b)

x	$f(x)$
-2	5
-1	2
0	1
1	2
2	5

(c)

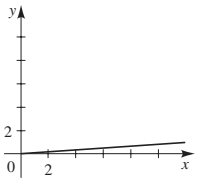


79. (a) $T(x) = 0.08x$

(b)

x	$T(x)$
2	0.16
4	0.32
6	0.48
8	0.64

(c)



81. $(-\infty, \infty), \{1, 5\}$
83. (a) 50, 0 **(b)** $V(0)$ is the volume of the full tank, and $V(20)$ is the volume of the empty tank, 20 min later.

(c)

x	$V(x)$
0	50
5	28.125
10	12.5
15	3.125
20	0

(d) -50 gal

85. **(a)** 8.66 m, 6.61 m, 4.36 m **(b)** The object will appear to get shorter.

87. **(a)** 2 mm, 1.66 mm, 1.48 mm

(b)

x	$R(x)$
1	2
10	1.66
100	1.48
200	1.44
500	1.41
1000	1.39

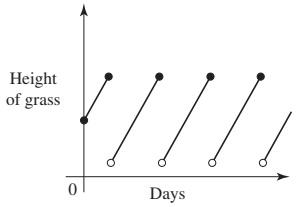
(c) -0.18 mm

89. **(a)** 28.1 mi, 39.8 mi **(b)** 41.3 mi **(c)** 235.6 mi **(d)** 194.3 mi **91.** **(a)** 0, 160, 1550 **(b)** The amount of tax paid on incomes of 5000, 12,000, and 25,000 dollars

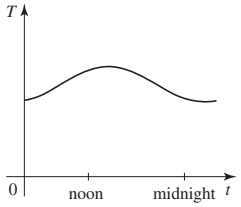
93. **(a)** $T(x) = \begin{cases} 114x & \text{if } 0 \le x \le 2 \\ 228 + 99(x-2) & \text{if } x > 2 \end{cases}$

(b) \$228, \$327, \$525 **(c)** Total cost of staying at the hotel

95.



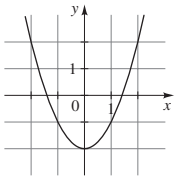
97.



Section 2.2 ■ Page 168

1. $f(x)$, $x^2 - 2$, 7, 7

x	$y = f(x)$	(x, y)
-2	2	$(-2, 2)$
-1	-1	$(-1, -1)$
0	-2	$(0, -2)$
1	-1	$(1, -1)$
2	2	$(2, 2)$



2. 10 **3.** 7 **4.** **(a)** IV **(b)** II **(c)** I **(d)** III

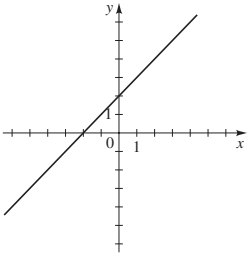
5. The input 1 has two different outputs, 1 and 2.

6. There are 2 different y-values that correspond to an x-value. For instance, $x = 1$ corresponds to $y = \frac{1}{2}$ and to $y = -\frac{1}{2}$.

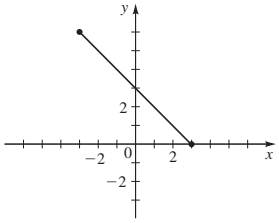
7. The input 10 is mapped to two different outputs, 10 and 15.

8. The curve does not pass the Vertical Line Test.

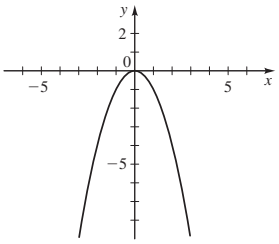
9.



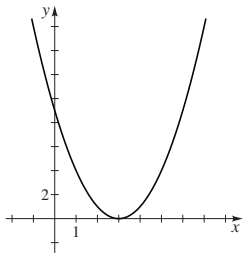
11.



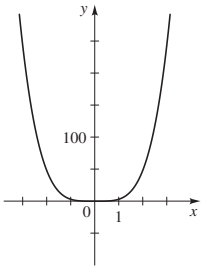
13.



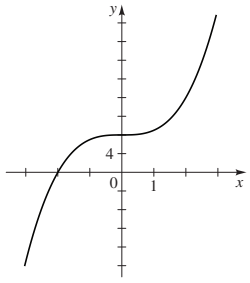
15.



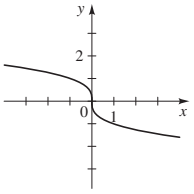
17.



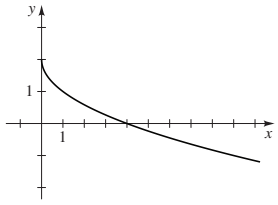
19.



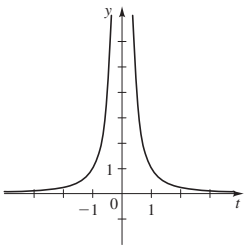
21.



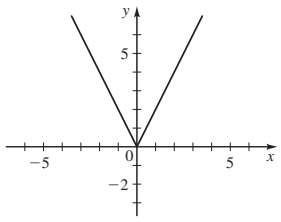
23.



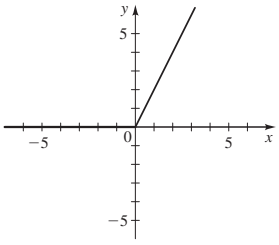
25.



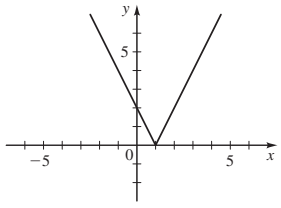
27.



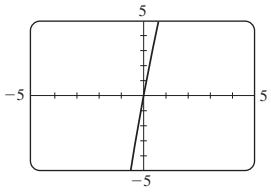
29.



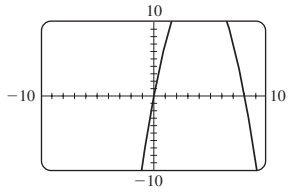
31.



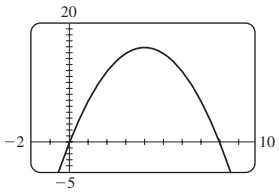
33. **(a)**



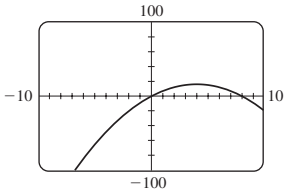
(b)



(c)

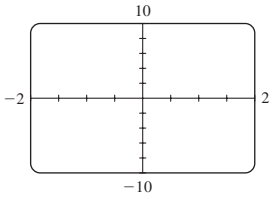


(d)

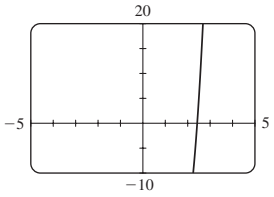


Graph (c) is the most appropriate.

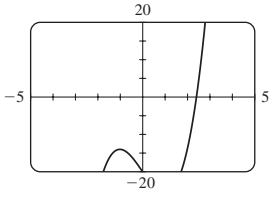
35. (a)



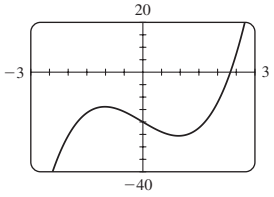
(b)



(c)

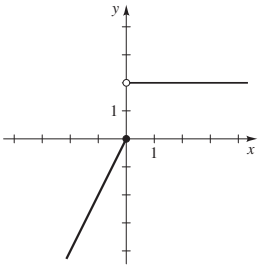


(d)

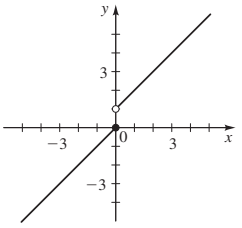


Graph (d) is the most appropriate.

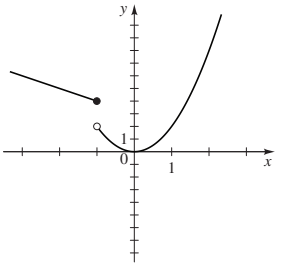
37.



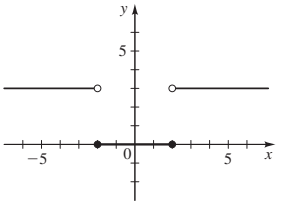
39.



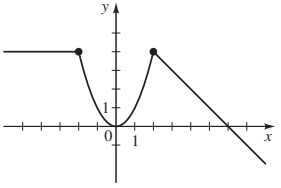
41.



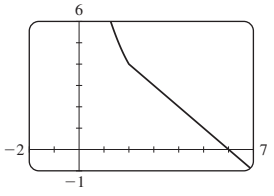
43.



45.

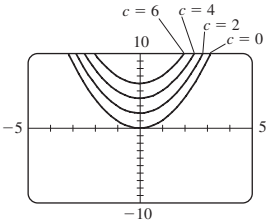


47.

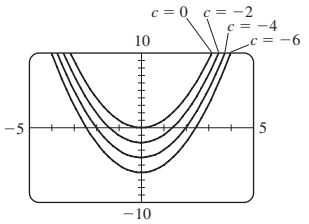


49. $f(x) = \begin{cases} -2 & \text{if } x < -2 \\ x & \text{if } -2 \le x \le 2 \\ 2 & \text{if } x > 2 \end{cases}$

51. **(a)** Yes **(b)** No **(c)** Yes **(d)** No **53.** Yes
55. Yes **57.** No **59.** No **61.** No **63.** Yes **65.** Yes
67. Not a function; domain $\{0, 1, 4, 5, 6\}$, range $\{1, 2, 3\}$
69. Function
71. **(a)**

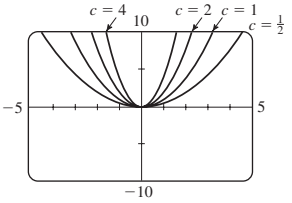


(b)

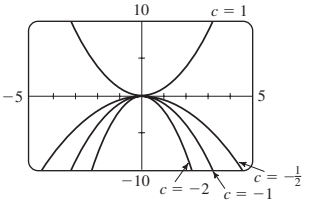


(c) If $c > 0$, then the graph of $f(x) = x^2 + c$ is the same as the graph of $y = x^2$ shifted upward c units. If $c < 0$, then the graph of $f(x) = x^2 + c$ is the same as the graph of $y = x^2$ shifted downward c units.

73. **(a)**



(b)

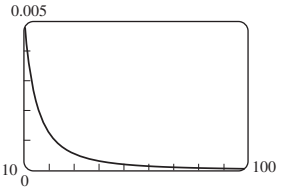


(c) As $|c|$ increases, the graph of $f(x) = cx^2$ is stretched vertically. As $|c|$ decreases, the graph of f is flattened. When $c < 0$, the graph is reflected about the x-axis.

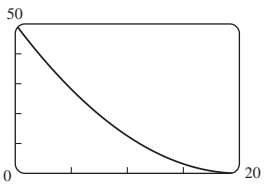
75. $f(x) = -\frac{7}{6}x - \frac{4}{3}$, $-2 \le x \le 4$

77. $f(x) = \sqrt{9 - x^2}$, $-3 \le x \le 3$

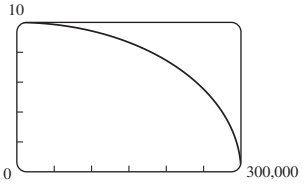
79.



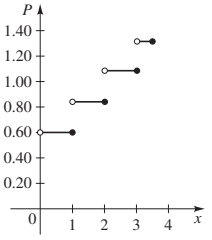
81.



83.



85. $P(x) = \begin{cases} 0.60 & \text{if } 0 < x \le 1 \\ 0.84 & \text{if } 1 < x \le 2 \\ 1.08 & \text{if } 2 < x \le 3 \\ 1.32 & \text{if } 3 < x \le 3.5 \end{cases}$



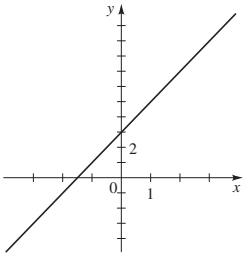
Section 2.3 ■ Page 180

1. a, 4, 6, $f(5) - f(3) = 2$ **2.** x, y, $[1, 7]$, $[0, 7]$
3. **(a)** increase, $(1, 2)$, $(4, 5)$ **(b)** decrease, $(2, 4)$, $(5, 7)$
4. **(a)** largest, 7, 6, 5 **(b)** smallest, 2, 4 **5.** x; x; 1, 7, $[1, 7]$
6. **(a)** $2x + 1$, $-x + 4$; 1 **(b)** $2x + 1$, $-x + 4$, higher; $(-\infty, 1)$

7. **(a)** 1, −1, 3, 4 **(b)** Domain $[-3, 4]$, range $[-1, 4]$ **(c)** $-3, 2, 4$ **(d)** $-3 \le x \le 2$ and $x = 4$ **(e)** 1 **9.** **(a)** $f(0)$ **(b)** $f(-1)$ **(c)** $-2, 2$ **(d)** $\{x \mid -4 \le x \le -2 \text{ or } 2 \le x \le 4\}$ **(e)** $\{x \mid -2 < x < 2\}$ **11.** Domain $(-3, 3]$, range $[-2, 3]$

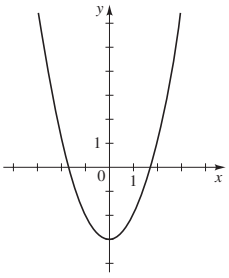
13. Domain $[-3, 3]$, range $\{-3, -2, 3\}$

15. **(a)**



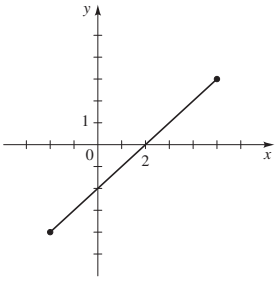
(b) $(-\infty, \infty)$, $(-\infty, \infty)$

17. **(a)**



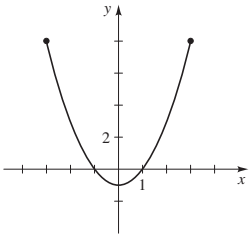
(b) $(-\infty, \infty)$, $[-3, \infty)$

19. **(a)**



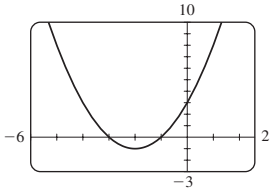
(b) $[-2, 5]$, $[-4, 3]$

21. **(a)**



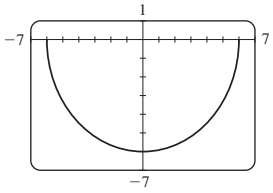
(b) $[-3, 3]$, $[-1, 8]$

23. **(a)**



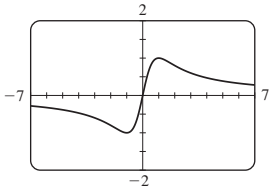
(b) $(-\infty, \infty)$, $[-1, \infty)$

25. **(a)**



(b) $[-6, 6]$, $[-6, 0]$

27. **(a)**



(b) $(-\infty, \infty)$, $[-1, 1]$

29. **(a)** $x = 2$ **(b)** $x < 2$

31. **(a)** $x = -2, 1$ **(b)** $-2 \le x \le 1$

33. **(a)** $x \approx -4.32, -1.12, 1.44$

(b) $-4.32 \le x \le -1.12$ or $x \ge 1.44$

35. **(a)** $x = -1, -0.25, 0.25$

(b) $-1 \le x \le -0.25$ or $x \ge 0.25$

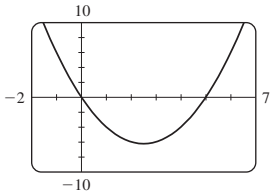
37. **(a)** Domain $[-1, 4]$, range $[-1, 3]$

(b) Increasing on $(-1, 1)$ and $(2, 4)$, decreasing on $(1, 2)$

39. **(a)** Domain $[-3, 3]$, range $[-2, 2]$

(b) Increasing on $(-2, -1)$ and $(1, 2)$, decreasing on $(-3, -2)$, $(-1, 1)$, and $(2, 3)$

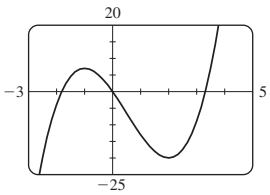
41. **(a)**



(b) Domain $(-\infty, \infty)$, range $[-6.25, \infty)$

(c) Increasing on $(2.5, \infty)$; decreasing on $(-\infty, 2.5)$

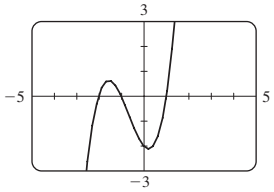
43. **(a)**



(b) Domain $(-\infty, \infty)$, range $(-\infty, \infty)$

(c) Increasing on $(-\infty, -1)$, $(2, \infty)$; decreasing on $(-1, 2)$

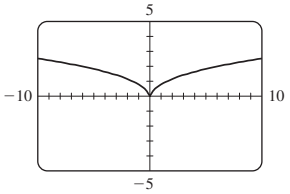
45. **(a)**



(b) Domain $(-\infty, \infty)$, range $(-\infty, \infty)$

(c) Increasing on $(-\infty, -1.55)$, $(0.22, \infty)$; decreasing on $(-1.55, 0.22)$

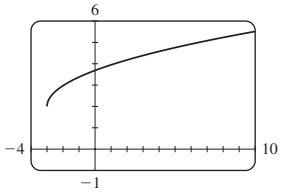
47. **(a)**



(b) Domain $(-\infty, \infty)$, range $[0, \infty)$

(c) Increasing on $(0, \infty)$; decreasing on $(-\infty, 0)$

49. **(a)**



(b) Domain $[-3, \infty)$, range $[2, \infty)$ **(c)** Increasing on $(-3, \infty)$

51. **(a)** Local maximum 3 when $x = -1$, local maximum 4 when $x = 3$; local minimum -3 when $x = 1$ **(b)** Increasing on $(-\infty, -1), (1, 3)$; decreasing on $(-1, 1), (3, \infty)$

53. **(a)** Local maximum 3 when $x = 0$; local minimum -1 when $x = -2$, local minimum 1 when $x = 1$ **(b)** Increasing on $(-2, 0), (1, \infty)$; decreasing on $(-\infty, -2), (0, 1)$

55. **(a)** Local maximum ≈ 0.38 when $x \approx -0.58$; local minimum ≈ -0.38 when $x \approx 0.58$ **(b)** Increasing on $(-\infty, -0.58), (0.58, \infty)$; decreasing on $(-0.58, 0.58)$

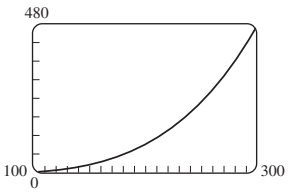
57. **(a)** Local maximum ≈ 0 when $x = 0$; local minimum ≈ -13.61 when $x \approx -1.71$, local minimum ≈ -73.32 when $x \approx 3.21$ **(b)** Increasing on $(-1.71, 0), (3.21, \infty)$; decreasing on $(-\infty, -1.71), (0, 3.21)$ **59.** **(a)** Local maximum ≈ 5.66 when $x \approx 4.00$ **(b)** Increasing on $(-\infty, 4.00)$; decreasing on $(4.00, 6.00)$ **61.** **(a)** Local maximum ≈ 0.38 when $x \approx -1.73$; local minimum ≈ -0.38 when $x \approx 1.73$

(b) Increasing on $(-\infty, -1.73), (1.73, \infty)$; decreasing on $(-1.73, 0), (0, 1.73)$ **63.** **(a)** $\approx$11 gigawatts, $\approx$14 gigawatts **(b)** $\approx$3:00 to 4:30 A.M.; $\approx$7:00 P.M. **(c)** $\approx$3 gigawatts

65. **(a)** Increasing on $\approx(0, 30)$, $\approx(32, 68)$; decreasing on $\approx(30, 32)$ **(b)** The person went on a crash diet and lost weight, only to regain it again later. **(c)** $\approx$100 lb **67.** **(a)** Increasing on $\approx(0, 150)$, $\approx(300, 365)$; decreasing on $\approx(150, 300)$

(b) Local maximum when $x = 150$; local minimum when $x = 300$ **(c)** -50 ft **69.** Runner A won the race. All runners finished. Runner B fell but got up again to finish second.

71. (a)



(b) Increases **73.** ≈7.5 mi/h

Section 2.4 ■ Page 190

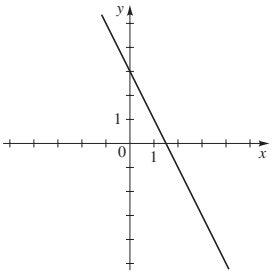
1. $\frac{100 \text{ mi}}{2 \text{ h}} = 50$ mi/h **2.** $\frac{f(b) - f(a)}{b - a}$ **3.** $\frac{25 - 1}{5 - 1} = 6$

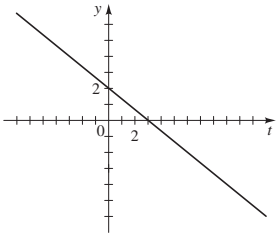
4. (a) secant **(b)** 3 **5. (a)** Yes **(b)** Yes **6. (a)** No **(b)** No
7. (a) 2 **(b)** $\frac{2}{3}$ **9. (a)** -4 **(b)** $-\frac{4}{5}$ **11. (a)** 15 **(b)** 5
13. (a) -8 **(b)** $-\frac{1}{2}$ **15. (a)** 26 **(b)** 13 **17. (a)** 600
(b) 60 **19.** $8a + 4h$ **21.** $-\frac{1}{a(a+h)}$ **23.** $\frac{1}{\sqrt{a} + \sqrt{a+h}}$

25. (a) $\frac{1}{2}$ **27.** f; g; 0, 1.5 **29. (a)** -0.25 ft/day; on average, the water level was decreasing at a rate of 0.25 ft/day between $x = 100$ and $x = 200$. **(b)** Answers may vary. For instance, on the interval [200, 350] the average rate of change is 0.
31. (a) 376.5 persons/year **(b)** -341.75 persons/year **(c)** 2002–2012 **(d)** 2012–2020 **33. (a)** 248.3 cakes/year **(b)** -404 cakes/year **(c)** 507 cakes/year **(d)** 2016–2017, 2015–2016 **35.** First 20 minutes: -4.05°F/min, next 20 minutes: -1.5°F/min; first interval **37. (a)** All 10 m/s **(b)** Skier A started quickly and slowed down, skier B maintained a constant speed, and skier C started slowly and sped up.

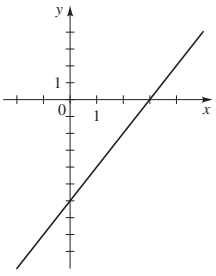
Section 2.5 ■ Page 198

1. (a) linear, a, b **(b)** line **2. (a)** -5 **(b)** line, -5, 7
3. 15 **4.** 15 gal/min **5.** Upward **6.** Yes, 0, 0 **7.** Yes, $f(x) = 2x + \sqrt{5}$ **9.** Yes, $f(x) = -\frac{1}{5}x + 4$ **11.** No **13.** No
15. -2 **17.** $-\frac{2}{3}$



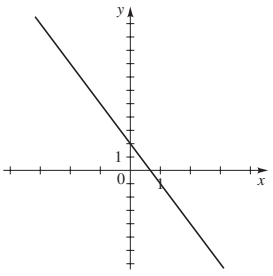


19. (a)



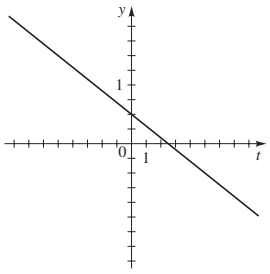
(b) 2 **(c)** 2

21. (a)



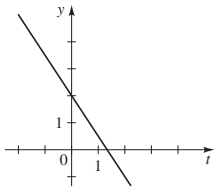
(b) -3 **(c)** -3

23. (a)



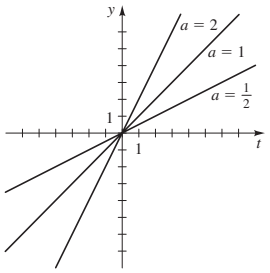
(b) $-\frac{1}{5}$ **(c)** $-\frac{1}{5}$

25. (a)



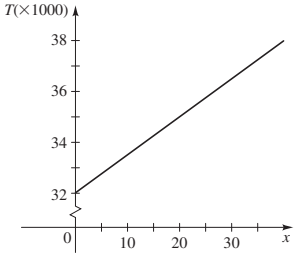
(b) $-\frac{3}{2}$ **(c)** $-\frac{3}{2}$

27. $f(x) = 5x + 10$ **29.** $f(x) = \frac{1}{2}x + 3$
31. (a) $\frac{3}{2}$ **(b)** $f(x) = \frac{3}{2}x + 7$
33. (a) 1 **(b)** $f(x) = x + 3$
35. (a) $-\frac{1}{2}$ **(b)** $f(x) = -\frac{1}{2}x + 2$
37.

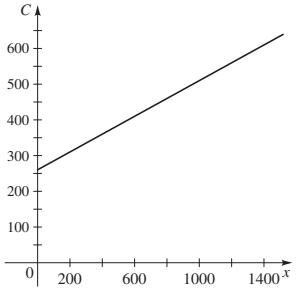


As a increases, the graph of f becomes steeper and the rate of change increases.

39. (a)



(b) 150
(c) 150,000 tons/year
41. (a) $V(t) = 0.5t + 2$ **(b)** 26 s
43. (a) $\frac{1}{12}$, $H(x) = \frac{1}{12}x$ **(b)** 12.5 in.
45. (a) Engineer **(b)** Manager: 60 mi/h; engineer: 70 mi/h
(c) Manager: $f(t) = t + 10$; Engineer $g(t) = \frac{7}{6}t$ **47.** 3.16 mi
49. $f(x) = -12x + 100$; ≈47 kPa
51. (a) $C(x) = \frac{1}{4}x + 260$
(b) $\frac{1}{4}$ **(c)** \$0.25/mi



Section 2.6 ■ Page 209

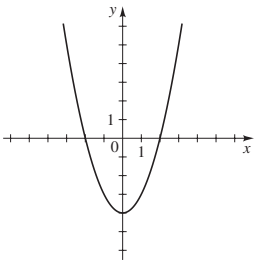
1. (a) upward **(b)** left **2. (a)** downward **(b)** right
3. (a) x-axis **(b)** y-axis **4. (a)** II **(b)** I **(c)** III **(d)** IV
5. Symmetry with respect to the y-axis **6.** Symmetric with respect to the origin **7. (a)** Shift upward 11 units **(b)** Shift 8 units to the left **9. (a)** Reflect about the y-axis, then shrink vertically by a factor of $\frac{1}{4}$ **(b)** Reflect about the x-axis, then stretch vertically by a factor of 5 **11. (a)** Shift 1 unit to the right, then downward 5 units **(b)** Shift 2 units to the left, then downward 4 units **13. (a)** Reflect about the y-axis, then shift upward 5 units **(b)** Shift 2 units to the left, shrink vertically by a factor of $\frac{1}{2}$, reflect about the x-axis, then shift upward 3 units

15. **(a)** Shrink horizontally by a factor of $\frac{1}{5}$, reflect about the x-axis, then shift upward 2 units **(b)** Stretch horizontally by a factor of 2, shift 1 unit to the left, then shift upward 1 unit

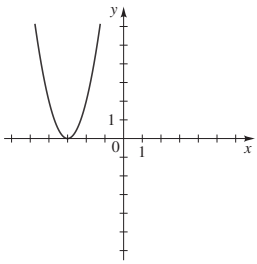
17. **(a)** Shift to the left 2 units **(b)** Shift upward 2 units

19. **(a)** Shift to the left 2 units, then shift downward 2 units **(b)** Shift to the right 2 units, then shift upward 2 units

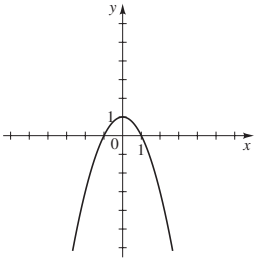
21. **(a)**



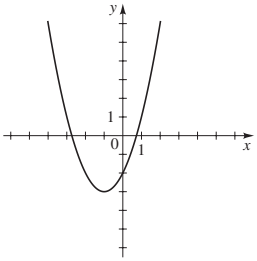
(b)



(c)

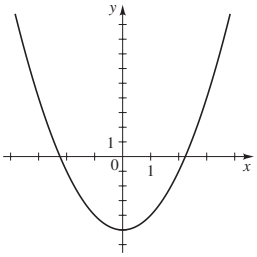


(d)

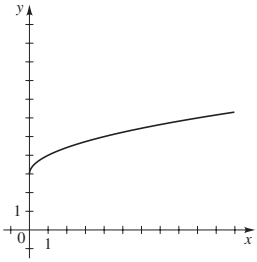


23. II; range $[0, \infty)$ **25.** I; range $[-1, \infty)$

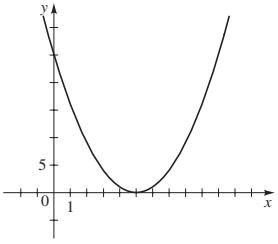
27.



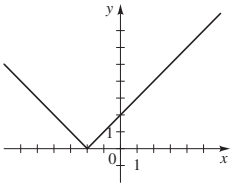
29.



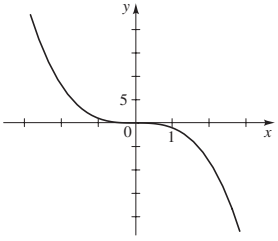
31.



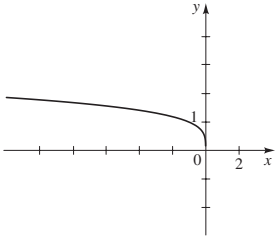
33.



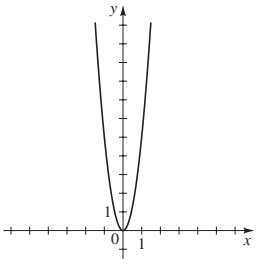
35.



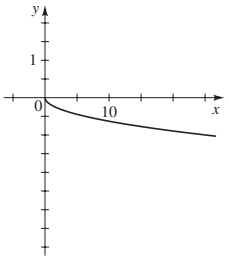
37.



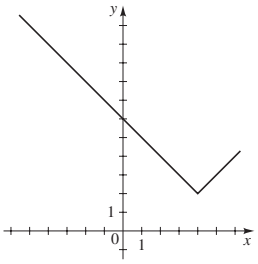
39.



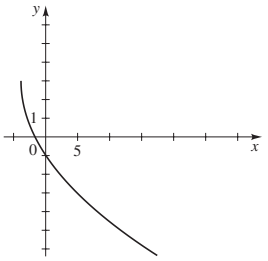
41.



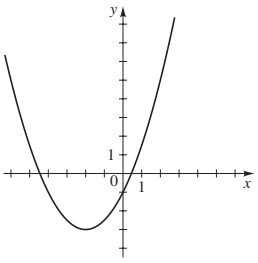
43.



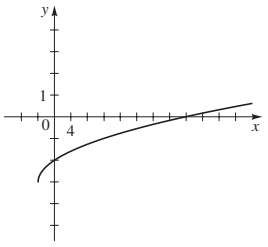
45.



47.



49.



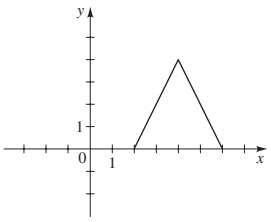
51. $y = x^2 + 10$ **53.** $y = (x - 3)^4$ **55.** $y = |x + 2| - 5$

57. $y = \sqrt[4]{-x} + 1$ **59.** $y = 2(x - 3)^2 - 2$

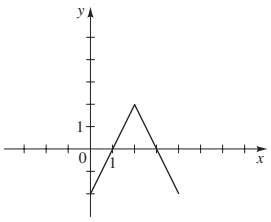
61. $g(x) = (x - 2)^2$ **63.** $g(x) = |x + 1| + 2$

65. $g(x) = -\sqrt{x + 2}$ **67.** **(a)** 3 **(b)** 1 **(c)** 2 **(d)** 4

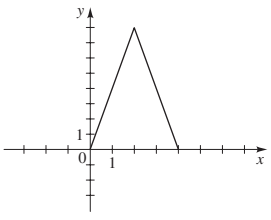
69. **(a)**



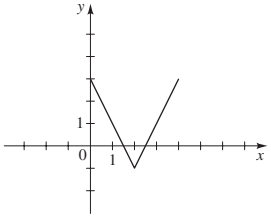
(b)



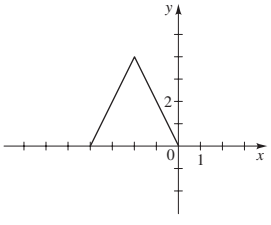
(c)



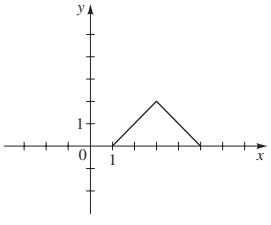
(d)



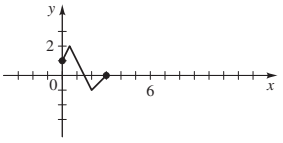
(e)



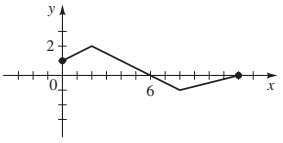
(f)



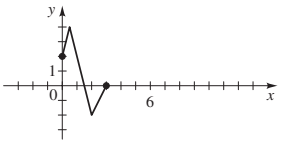
71. **(a)**



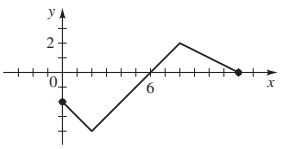
(b)



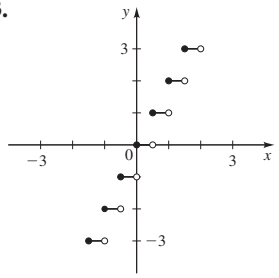
(c)



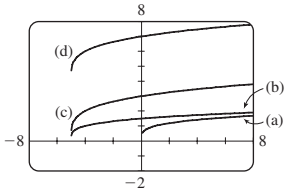
(d)



73.

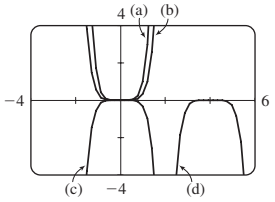


75.



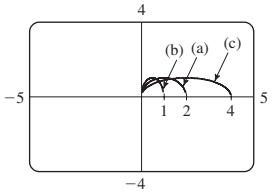
For part (b) shift the graph in (a) 5 units to the left; for part (c) shift the graph in (a) 5 units to the left and stretch vertically by a factor of 2; for part (d) shift the graph in (a) 5 units to the left, stretch vertically by a factor of 2, and then shift upward 4 units.

77.



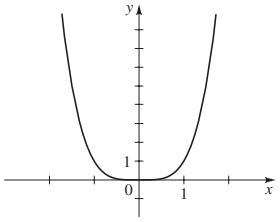
For part (b) shrink the graph in (a) vertically by a factor of $\frac{1}{3}$; for part (c) shrink the graph in (a) vertically by a factor of $\frac{1}{3}$ and reflect about the x-axis; for part (d) shift the graph in (a) 4 units to the right, shrink vertically by a factor of $\frac{1}{3}$, and then reflect about the x-axis.

79.



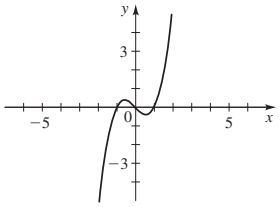
The graph in part (b) is shrunk horizontally by a factor of $\frac{1}{2}$ and the graph in part (c) is stretched horizontally by a factor of 2.

81. Even



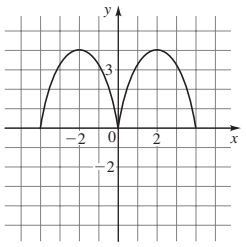
83. Neither

85. Odd

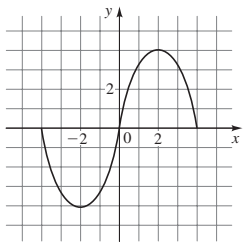


87. Neither

89. **(a)**

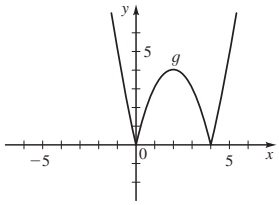


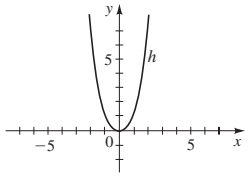
(b)



91. **(a)** To obtain the graph of g, reflect about the x-axis the part of the graph of f that is below the x-axis.

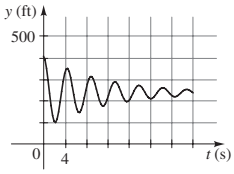
(b)





93. **(a)** The bungee jumper drops to 200 ft, bounces up and down, then settles at 350 ft.

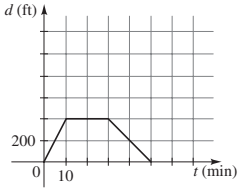
(b)



(c) Shift downward 100 ft; $H(t) = h(t) - 100$

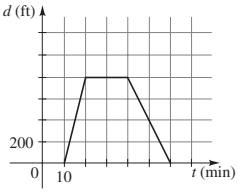
95. **(a)** 80 ft/min; 20 min; 800 ft

(b)



Shrunk vertically by a factor of 0.5; 40 ft/min; 400 ft

(c)

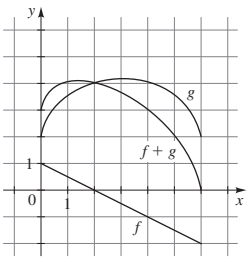


Shifted 10 min to the right; the class left 10 min later

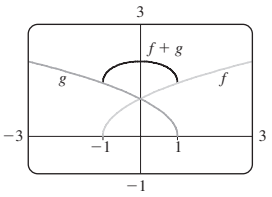
Section 2.7 ■ Page 220

1. $(f+g)(2)=8, (f-g)(2)=-2, (fg)(2)=15, \left(\frac{f}{g}\right)(2)=\frac{3}{5}$

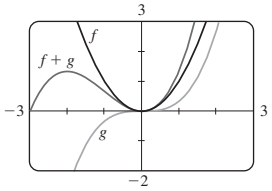
2. $f(g(x))$, 12 **3.** Multiply by 2, then add 1; Add 1, then multiply by 2 **4.** $f(x)=x+1, g(x)=2x, (f\circ g)(x)=2x+1,$ $(g\circ f)(x)=2(x+1)$ **5. (a)** f, g **(b)** f, g **(c)** $f, g, 0$
6. g, f **7.** $(f+g)(x)=2x+1, (-\infty,\infty);$
$(f-g)(x)=4x-1, (-\infty,\infty); (fg)(x)=3x-3x^2, (-\infty,\infty);$
$\left(\frac{f}{g}\right)(x)=\frac{3x}{1-x}, (-\infty,1)\cup(1,\infty)$
9. $(f+g)(x)=x^3+2x^2, (-\infty,\infty);$
$(f-g)(x)=x^3, (-\infty,\infty); (fg)(x)=x^5+x^4, (-\infty,\infty);$
$\left(\frac{f}{g}\right)(x)=x+1, (-\infty,0)\cup(0,\infty)$
11. $(f+g)(x)=x^2-4x+5, (-\infty,\infty);$
$(f-g)(x)=-x^2+2x+5, (-\infty,\infty);$
$(fg)(x)=-x^3+8x^2-15x, (-\infty,\infty);$
$\left(\frac{f}{g}\right)(x)=\frac{5-x}{x^2-3x}, (-\infty,0)\cup(0,3)\cup(3,\infty)$
13. $(f+g)(x)=\sqrt{25-x^2}+\sqrt{x+3}, [-3,5];$
$(f-g)(x)=\sqrt{25-x^2}-\sqrt{x+3}, [-3,5];$
$(fg)(x)=\sqrt{(25-x^2)(x+3)}, [-3,5];$
$\left(\frac{f}{g}\right)(x)=\sqrt{\frac{25-x^2}{x+3}}, (-3,5]$
15. $(f+g)(x)=\frac{4x+1}{x^2-x-2}, x\neq -1, x\neq 2;$
$(f-g)(x)=\frac{-2x-5}{x^2-x-2}, x\neq -1, x\neq 2;$
$(fg)(x)=\frac{3}{x^2-x-2}, x\neq -1, x\neq 2;$
$\left(\frac{f}{g}\right)(x)=\frac{x-2}{3x+3}, x\neq -1, x\neq 2$
17. $[0,3]$ **19.** $(3,\infty)$
21.



23.



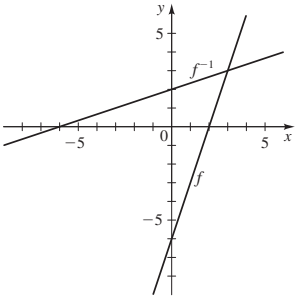
25.



27. **(a)** 17 **(b)** 83 **29.** **(a)** 29 **(b)** 3
31. **(a)** $4x^2+13$ **(b)** $16x^2+40x+27$ **33.** 4
35. 5 **37.** 4 **39.** 6 **41.** 3 **43.** 1 **45.** 3
47. $(f\circ g)(x)=8x+1, (-\infty,\infty)$;
$(g\circ f)(x)=8x+11, (-\infty,\infty); (f\circ f)(x)=4x+9, (-\infty,\infty);$
$(g\circ g)(x)=16x-5, (-\infty,\infty)$
49. $(f\circ g)(x)=(x+1)^2, (-\infty,\infty);$
$(g\circ f)(x)=x^2+1, (-\infty,\infty); (f\circ f)(x)=x^4, (-\infty,\infty);$
$(g\circ g)(x)=x+2, (-\infty,\infty)$
51. $(f\circ g)(x)=\frac{1}{x}+1, (0,\infty);$
$(g\circ f)(x)=\frac{1}{\sqrt{x^2+1}}, (-\infty,\infty);$
$(f\circ f)(x)=x^4+2x^2+2, (-\infty,\infty); (g\circ g)(x)=\sqrt[4]{x}, (0,\infty)$
53. $(f\circ g)(x)=\frac{2x-1}{2x}, x\neq 0;$
$(g\circ f)(x)=\frac{2x}{x+1}-1, x\neq -1;$
$(f\circ f)(x)=\frac{x}{2x+1}, x\neq -1, x\neq -\frac{1}{2};$
$(g\circ g)(x)=4x-3, (-\infty,\infty)$
55. $(f\circ g)(x)=\frac{2x+4}{x}, x\neq -2, x\neq 0;$
$(g\circ f)(x)=\frac{1}{1+x}, \ x\neq -1, x\neq 0;$
$(f\circ f)(x) = x, x\neq 0;$
$(g\circ g)(x) = \frac{x}{3x+4}, x\neq -2, x\neq -\frac{4}{3}$
57. $(f\circ g)(x)=\frac{1}{\sqrt{x^2-4x}}, (-\infty,0)\cup(4,\infty);$
$(g\circ f)(x)=\frac{1}{x}-\frac{4}{\sqrt{x}}, (0,\infty); (f\circ f)(x) = \sqrt[4]{x}, (0,\infty);$
$(g\circ g)(x)=x^4-8x^3+12x^2+16x, (-\infty,\infty)$
59. $(f\circ g)(x)=1-\sqrt[6]{x}, [0,\infty);$
$(g\circ f)(x)=\sqrt[3]{1-\sqrt{x}}, [0,\infty);$
$(f\circ f)(x)=1-\sqrt{1-\sqrt{x}}, [0,1]; (g\circ g)(x)=\sqrt[9]{x}, (-\infty,\infty)$
61. $(f\circ g\circ h)(x)=\sqrt{x-1}-1$
63. $(f\circ g\circ h)(x)=(\sqrt{x}-5)^4+1$
For Exercises 65–78, there are many possible answers,
65. $g(x)=x-9, f(x)=x^5$ **67.** $g(x)=x^2, f(x)=x/(x+4)$
69. $g(x)=1-x^3, f(x)=|x|$
71. $g(x)=x^3+1, f(x)=1-\sqrt{x}$
73. $h(x)=x^2, g(x)=x+1, f(x)=1/x$
75. $h(x)=\sqrt[3]{x}, g(x)=4+x, f(x)=x^9$
77. $h(x)=\sqrt{x}, g(x)=\frac{x}{x-1}, f(x)=x^3$
79. Yes; m_1m_2 **81.** $R(x)=0.15x-0.000002x^2$
83. **(a)** $g(t)=60t$ **(b)** $f(r)=\pi r^2$ **(c)** $(f\circ g)(t)=3600\pi t^2$; area as a function of time **85.** $A(t)=16\pi t^2$
87. **(a)** $f(x)=0.80x$ **(b)** $g(x)=x-50$
(c) $(f\circ g)(x)=0.80x-40$; $(g\circ f)(x)=0.80x-50$; applying the 20% discount, then \$50 coupon $(g\circ f)$ gives the lower price
89. **(a)** $s=\sqrt{1+d^2}$ **(b)** $d=350t$
(c) $s(t)=\sqrt{1+122{,}500t^2}$

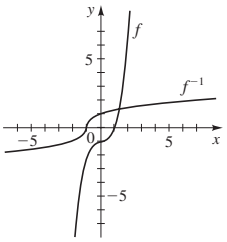
Section 2.8 ■ Page 231

1. different, Horizontal Line **2. (a)** one-to-one, $g(x) = x^3$ **(b)** $g^{-1}(x) = x^{1/3}$ **3. (a)** Take the cube root, subtract 5, then divide the result by 3. **(b)** $f(x) = (3x + 5)^3$, $f^{-1}(x) = \dfrac{\sqrt[3]{x} - 5}{3}$ **4.** Yes, 4, 5 **5.** $(4, 3)$ **6. (a)** False **(b)** True **7.** No **9.** Yes **11.** No **13.** Yes **15.** Yes **17.** No **19.** No **21.** Yes **23.** No **25. (a)** 5 **(b)** 10 **27.** 1 **29. (a)** 6 **(b)** 2 **(c)** 0 **31.** 4 **33.** 1 **35.** 2 **49.** $f^{-1}(x) = \frac{1}{3}x - 5$ **51.** $f^{-1}(x) = \frac{4}{3}x + 16$ **53.** $f^{-1}(x) = \sqrt[3]{\frac{1}{4}(5 - x)}$ **55.** $f^{-1}(x) = \dfrac{1}{x} - 2$ **57.** $f^{-1}(x) = \dfrac{2x}{x + 1}$ **59.** $f^{-1}(x) = \dfrac{7x + 5}{x - 2}$ **61.** $f^{-1}(x) = \dfrac{x - 3}{5x + 2}$ **63.** $f^{-1}(x) = \sqrt[3]{3x - 1}$ **65.** $f^{-1}(x) = (x - 2)^3$ **67.** $f^{-1}(x) = (x - 1)^{2/3}$ **69. (a), (b)**



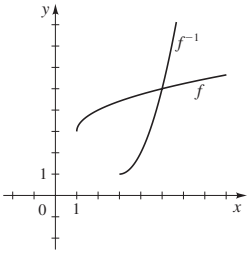
(c) $f^{-1}(x) = \frac{1}{3}(x + 6)$

71. (a), (b)



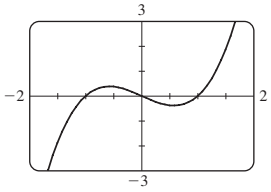
(c) $f^{-1}(x) = \sqrt[3]{x + 1}$

73. (a), (b)

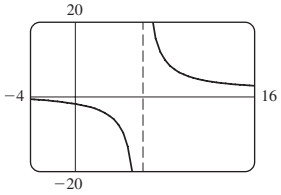


(c) $f^{-1}(x) = (x - 3)^2 + 1, x \geq 3$

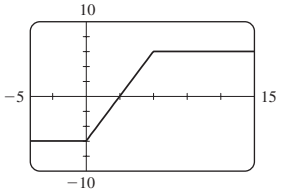
75. Not one-to-one



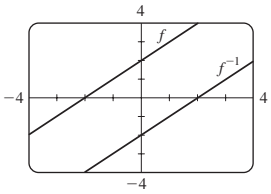
77. One-to-one



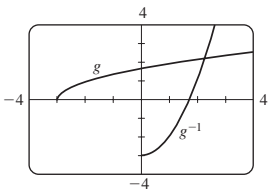
79. Not one-to-one



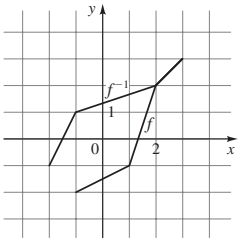
81. (a) $f^{-1}(x) = x - 2$ **(b)**



83. (a) $g^{-1}(x) = x^2 - 3, x \geq 0$ **(b)**

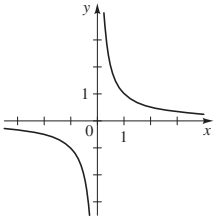


85. $x \geq 0, f^{-1}(x) = \sqrt{4 - x}$ **87.** $x \geq -2, h^{-1}(x) = \sqrt{x} - 2$ **89.**



91. (a) $f^{-1}(x) = \sqrt{x + 9}, x \geq -9$

93. (a) $f^{-1}(x) = \dfrac{1}{\sqrt[4]{x}}, x > 0$ **95. (a)** $f^{-1}(x) = x^2, 0 \leq x \leq 3$ **97. (a)**



(b) Yes **(c)** $f^{-1}(x) = \dfrac{1}{x}$

99. (a) $f(n) = 16 + 1.5n$ **(b)** $f^{-1}(x) = \frac{2}{3}(x - 16)$; the number of toppings on a pizza that costs x dollars **(c)** 6 **101. (a)** $f^{-1}(V) = 40 - 4\sqrt{V}$, time elapsed when V gal of water remain **(b)** ≈24.5 min; in 24.5 min the tank has 15 gal of water remaining **103. (a)** $f^{-1}(D) = 50 - \frac{1}{3}D$; the price associated with the demand D **(b)** \$40; when the demand is 30 units, the price is \$40 **105. (a)** $f(x) = 0.79x$ **(b)** $f^{-1}(x) = 1.265823x$; the Canadian dollar value of x US dollars **(c)** \$15,506.33 Canadian **107. (a)** $f(x) = 0.85x$ **(b)** $g(x) = x - 1000$ **(c)** $H(x) = 0.85x - 850$ **(d)** $H^{-1}(x) = 1.176x + 1000$, the original sticker price for a given discounted price **(e)** \$16,288, the original price of the car when the discounted price (\$1000 rebate, then 15% off) is \$13,000

Chapter 2 Review ■ Page 236

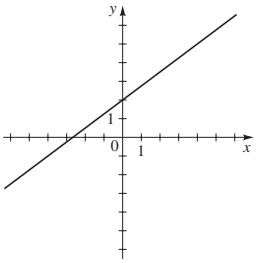
1. $f(x) = x^2 - 5$ **3.** Add 10, then multiply by 3.

5.

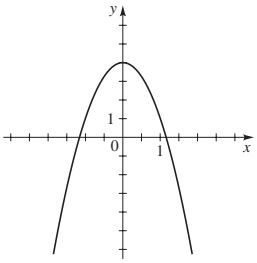
x	$g(x)$
−1	5
0	0
1	−3
2	−4
3	−3

7. **(a)** $C(1000) = \$34{,}000$, $C(10{,}000) = \$205{,}000$
(b) The costs of printing 1000 and 10,000 copies of the book
(c) $C(0) = \$5000$; fixed costs **(d)** \$171,000; \$19/copy
9. $6, 2, 18, a^2 - 4a + 6, a^2 + 4a + 6, x^2 - 2x + 3, 4x^2 - 8x + 6$
11. $a^2 + 8, a^2 + 2ah + h^2 + 8, 2a + h$
13. **(a)** Not a function **(b)** Function **(c)** Function, one-to-one
(d) Not a function **15.** Domain $[5, \infty)$, range $[0, \infty)$
17. $(-\infty, \infty)$ **19.** $(-\infty, \infty)$ **21.** $\{x \mid x \neq -2, -1, 0\}$
23. $(-\infty, -1] \cup [1, 4]$

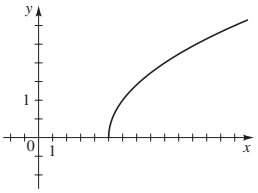
25.



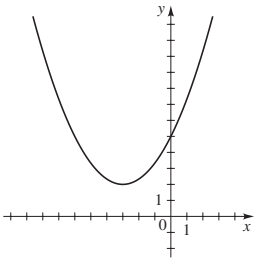
27.



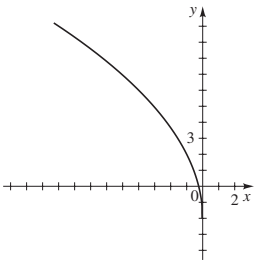
29.



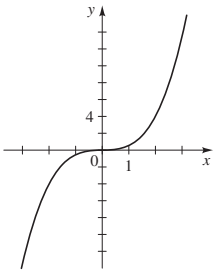
31.



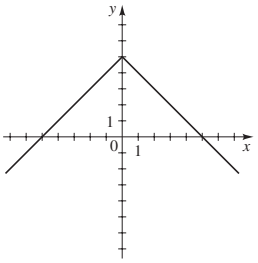
33.



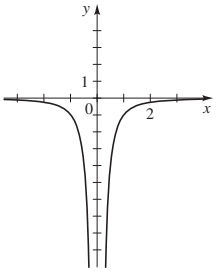
35.



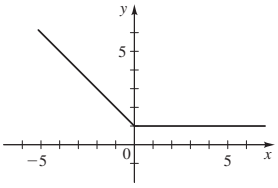
37.



39.

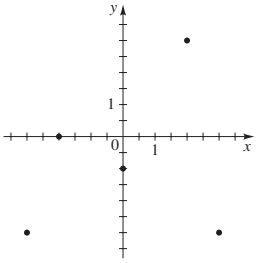


41.

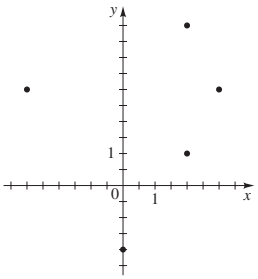


43. No **45.** Yes

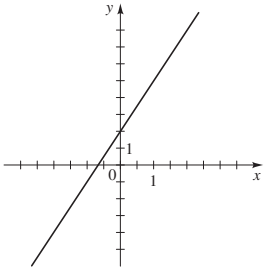
47. **(a)** $(-3, -3), (-2, 0), (0, -1), (2, 3), (3, -3)$



Yes, y is a function of x; domain $\{-3, -2, 0, 2, 3\}$, range $\{-3, -1, 0, 3\}$
(b) $(-3, 3), (2, 1), (0, -2), (2, 5), (3, 3)$

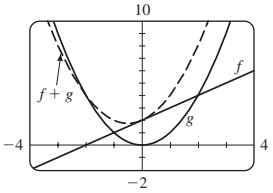


No, y is not a function of x; domain $\{-3, 0, 2, 3\}$, range $\{-2, 1, 3, 5\}$
49. **(a)** Domain $[-3, 3]$, range $[0, 3]$ **(b)** $x = \pm 3$
(c) $(-2.83, 2.83)$
51. **(a)** Domain $[-2.11, 0.25] \cup [1.86, \infty)$, range $[0, \infty)$
(b) $x \approx -2.11, 0.25, 1.86$ **(c)** $(-2, 0) \cup (2, \infty)$
53. **(a)** Local minimum $= 3$ when $x = 1$ **(b)** Increasing on $(1, \infty)$, decreasing on $(-\infty, 1)$
55. **(a)** Local maximum ≈ 2.81 when $x \approx -0.46$, local minimum ≈ 3.79 when $x \approx 0.46$ **(b)** Increasing on $(-0.46, 0.46)$, decreasing on $(-\infty, -0.46), (0.46, \infty)$
57. **(a)** Local maximum ≈ 3.175 when $x \approx 4.00$, local minimum $= 0$ when $x \approx 0$ **(b)** Increasing on $(0, 4)$, decreasing on $(-\infty, 0), (4, \infty)$ **59.** $-4, -1$ **61.** $4, \frac{4}{3}$ **63.** $9, 3$ **65.** No
67. **(a)**

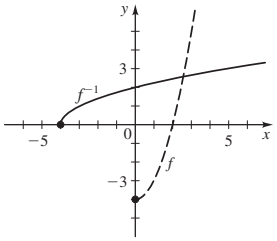


(b) 3 **(c)** 3
69. $f(x) = -2x + 3$ **71.** $f(x) = 2x + 3$
73. $f(x) = -\frac{1}{2}x + 4$ **75.** **(a)** $\frac{1}{2}, \frac{1}{2}$ **(b)** Yes **(c)** Yes, $\frac{1}{2}$
77. **(a)** $0, 63$ **(b)** No **(c)** No
79. **(a)** **(i)** Shift upward 8 units **(ii)** $y = x^3 + 8$ **(b)** **(i)** Shift left 8 units **(ii)** $y = (x + 8)^3$ **(c)** **(i)** Stretch vertically by a factor of 2, then shift upward 1 unit **(ii)** $y = 1 + 2x^3$
(d) **(i)** Shift right 2 units, then shift downward 2 units
(ii) $y = (x - 2)^3 - 2$ **(e)** **(i)** Reflect about the y-axis
(ii) $y = -x^3$ **(f)** **(i)** Reflect about the y-axis, then about the x-axis **(ii)** $y = x^3$ **(g)** **(i)** Reflect about the x-axis
(ii) $y = -x^3$ **(h)** **(i)** Reflect about the line $y = x$ **(ii)** $y = \sqrt[3]{x}$

81. **(a)** Neither **(b)** Odd **(c)** Even **(d)** Neither
83. **(a)** Graph ② **(b)** Graph ⑤ **(c)** Graph ④ **(d)** Graph ③ **(e)** Graph ① **(f)** Graph ③ **(g)** Graph ①, ②, ④
85. **(a)** $g(t) = 1.6t$ **(b)** $g(t) = 0.8(t - 4), t \geq 4$ **(c)** $g(t) = 5 + 0.8t$
87. **(a)** $w^{-1}(x) = 3960\left(\frac{12}{\sqrt{x}} - 1\right)$; height above the earth as a function of the astronaut's weight **(b)** 1980 mi; if the astronaut weighs 64 lb, then the astronaut's height above the earth is 1980 mi
89.



91. **(a)** $(f + g)(x) = x^2 - 6x + 6$ **(b)** $(f - g)(x) = x^2 - 2$
(c) $(fg)(x) = -3x^3 + 13x^2 - 18x + 8$
(d) $(f/g)(x) = (x^2 - 3x + 2)/(4 - 3x)$
(e) $(f \circ g)(x) = 9x^2 - 15x + 6$
(f) $(g \circ f)(x) = -3x^2 + 9x - 2$
93. $(f \circ g)(x) = \sqrt{x - x^2} + 1, [0, 1]$;
$(g \circ f)(x) = -(\sqrt{x} + x), [0, \infty)$;
$(f \circ f)(x) = \sqrt{\sqrt{x} + 1} + 1, [0, \infty)$;
$(g \circ g)(x) = -x^4 + 2x^3 - 2x^2 + x, (-\infty, \infty)$
95. $(f \circ g \circ h)(x) = 1 + \sqrt{x}$ **97.** Yes **99.** No **101.** No
103. $f^{-1}(x) = \frac{x + 2}{3}$ **105.** $f^{-1}(x) = \sqrt[3]{x} - 1$ **107.** Yes, 1, 3
109. **(a), (b)**



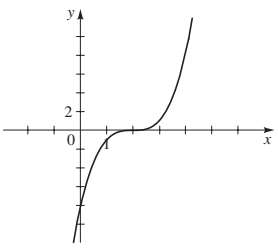
(c) $f^{-1}(x) = \sqrt{x + 4}$
111. **(a)** VI, yes **(b)** IV, yes **(c)** V, no **(d)** I, yes **(e)** VIII, no **(f)** III, yes **(g)** VII, yes **(h)** II, yes

Chapter 2 Test ■ Page 241

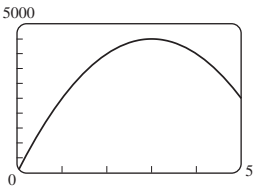
1. (a) and (b) are graphs of functions, (a) is one-to-one
2. **(a)** $0, \frac{\sqrt{2}}{3}, \frac{\sqrt{a + 2}}{a + 3}$ **(b)** $[0, \infty)$
(c) $\frac{3\sqrt{10} - 11\sqrt{2}}{264} \approx -0.023$
3. **(a)** $f(x) = (x - 2)^3$
(b)

x	$f(x)$
−1	−27
0	−8
1	−1
2	0
3	1
4	8

(c)

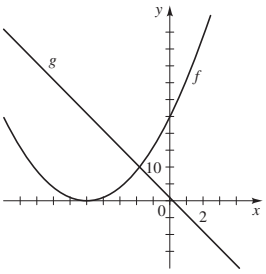


(d) By the Horizontal Line Test; take the cube root, then add 2
(e) $f^{-1}(x) = \sqrt[3]{x} + 2$
4. **(a)** $-2, 3$ **(b)** 5, 1 **(c)** Domain $[-5, 5]$, range $[-4, 4]$ **(d)** Increasing on $(-5, -4), (-1, 3)$, decreasing on $(-4, -1), (3, 5)$ **(e)** Local maximum $= -1$ when $x = -4$, local maximum $= 4$ when $x = 3$; local minimum $= -4$ when $x = -1$ **(f)** No. The function f does not pass the Horizontal Line Test.
5. **(a)** $R(2) = \$4000, R(4) = \$4000$; total sales revenue with prices of \$2 and \$4
(b)

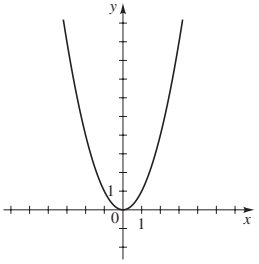


Revenue increases until price reaches \$3, then decreases

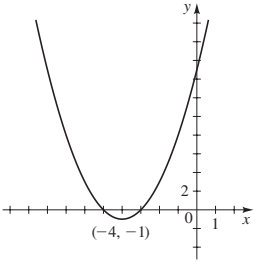
(c) \$4500; \$3 **6.** $2h + h^2, 2 + h$
7. **(a)** g; f is not linear because it has a squared term
(b)



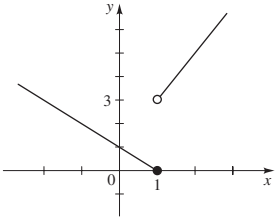
(c) -5
8. **(a)**



(b)



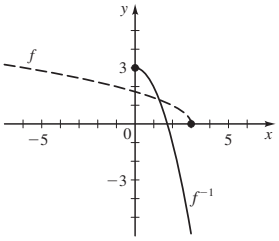
9. **(a)** Shift 3 units right, then shift upward 2 units
(b) $y = \sqrt{x - 3} + 2$
10. **(a)** Reflect about the y-axis **(b)** $y = \sqrt{-x}$
11. **(a)** 3, 0
(b)



12. **(a)** $x^2 + 2x - 2$ **(b)** $x^2 + 4$ **(c)** $x^2 - 5x + 7$ **(d)** $x^2 + x - 2$ **(e)** 1 **(f)** 4 **(g)** $x - 9$
13. **(a)** Yes **(b)** No **15.** $f^{-1}(x) = -\frac{5x + 3}{2x - 1}$

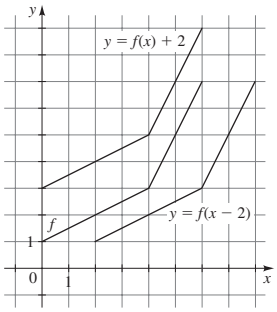
16. **(a)** $f^{-1}(x) = 3 - x^2, x \geq 0$

(b)



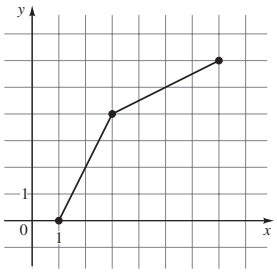
17. Domain $[0, 6]$, range $[1, 7]$ **18.** 1, 3

19.

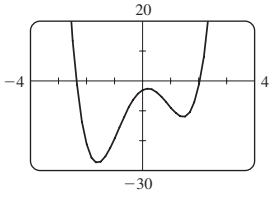


20. $5, \frac{5}{4}$ **21.** 0, 4

22.



23. **(a)**



(b) No

(c) local maximum ≈ -2.55 when $x \approx 0.18$;
Local minimum ≈ -27.18 when $x \approx -1.61$,
local minimum ≈ -11.93 when $x \approx 1.43$;
(d) $[-27.18, \infty)$ **(e)** Increasing on $(-1.61, 0.18), (1.43, \infty)$;
decreasing on $(-\infty, -1.61), (0.18, 1.43)$

Focus on Modeling ■ Page 246

1. $A(w) = 3w^2, w > 0$ **3.** $V(w) = \frac{1}{2}w^3, w > 0$

5. $A(x) = 10x - x^2, 0 < x < 10$ **7.** $A(x) = (\sqrt{3}/4)x^2, x > 0$

9. $r(A) = \sqrt{A/\pi}, A > 0$ **11.** $S(x) = 2x^2 + \dfrac{240}{x}, x > 0$

13. $D(t) = 25t, t \geq 0$ **15.** $A(b) = b\sqrt{4 - b}, 0 < b < 4$

17. $A(h) = 2h\sqrt{100 - h^2}, 0 < h < 10$

19. **(b)** $p(x) = x(19 - x)$ **(c)** 9.5, 9.5

21. **(b)** $A(x) = x(2400 - 2x)$ **(c)** 600 ft by 1200 ft

23. **(a)** $f(x) = 8x + (7200/x)$ **(b)** length along road is 30 ft, width is 40 ft **(c)** 15 ft to 60 ft

25. **(a)** $A(x) = 15x - \left(\dfrac{\pi + 4}{8}\right)x^2$

(b) Width ≈ 8.40 ft, height of rectangular part ≈ 4.20 ft

27. **(a)** $A(x) = x^2 + \dfrac{48}{x}$

(b) Height ≈ 1.44 ft, width ≈ 2.88 ft

29. **(a)** $L(x) = 2x + \dfrac{200}{x}$ **(b)** 10 m by 10 m

31. **(a)** $T(x) = \frac{1}{2}\sqrt{x^2 - 14x + 53} + \frac{1}{5}x$ **(b)** $\approx$6.13 mi from B

33. **(b)** horizontal is $\approx$9.23, vertical is $\approx$13.00

Chapter 3

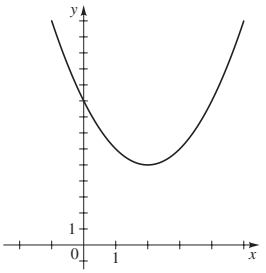
Section 3.1 ■ Page 257

1. square **2.** **(a)** (h, k) **(b)** upward, minimum
(c) downward, maximum **3.** upward, $(2, -6)$, -6, minimum
4. downward, $(2, -6)$, -6, maximum
5. **(a)** $(3, 4)$; x-intercepts 1, 5; y-intercept -5
(b) Maximum $f(3) = 4$ **(c)** $\mathbb{R}, (-\infty, 4]$

7. **(a)** $(1, -3)$; x-intercepts $\dfrac{2 \pm \sqrt{6}}{2}$; y-intercept -1

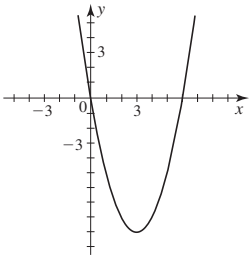
(b) Minimum $f(-1) = -3$ **(c)** $\mathbb{R}, [-3, \infty)$

9. **(a)** $f(x) = (x - 2)^2 + 5$
(b) Vertex $(2, 5)$
no x-intercept
y-intercept 9
(c)



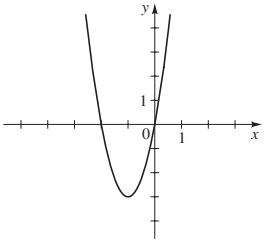
(d) $\mathbb{R}, [5, \infty)$

11. **(a)** $f(x) = (x - 3)^2 - 9$
(b) Vertex $(3, -9)$
x-intercepts 0, 6
y-intercept 0
(c)



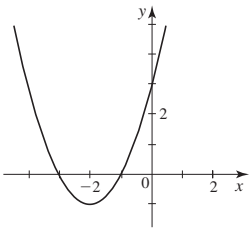
(d) $\mathbb{R}, [-9, \infty)$

13. **(a)** $f(x) = 3(x + 1)^2 - 3$
(b) Vertex $(-1, -3)$
x-intercepts -2, 0
y-intercept 0
(c)

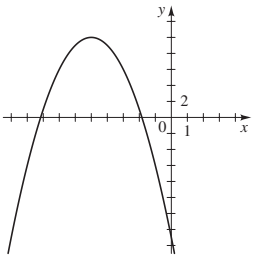


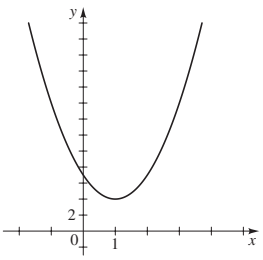
(d) $\mathbb{R}, [-3, \infty)$

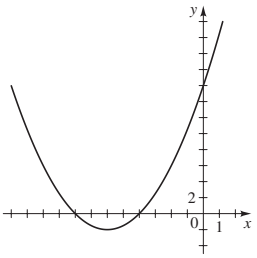
15. **(a)** $f(x) = (x + 2)^2 - 1$
(b) Vertex $(-2, -1)$
x-intercepts -1, -3
y-intercept 3
(c)

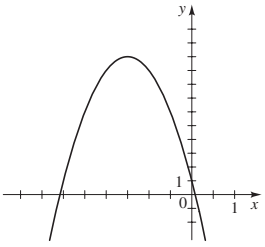


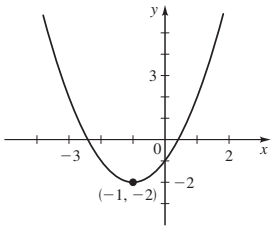
(d) $\mathbb{R}, [-1, \infty)$

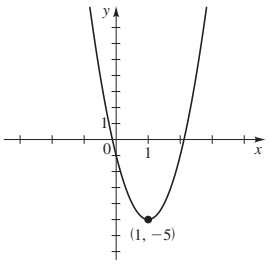
17. **(a)** $f(x) = -(x + 5)^2 + 10$
(b) Vertex $(-5, 10)$; x-intercepts $-5 \pm \sqrt{10}$; y-intercept -15
(c)

(d) $\mathbb{R}$, $(-\infty, 10]$

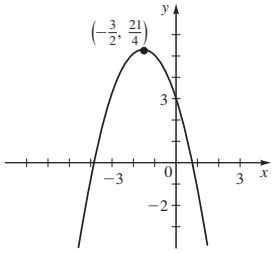
19. **(a)** $f(x) = 3(x - 1)^2 + 4$
(b) Vertex $(1, 4)$; no x-intercept; y-intercept 7
(c)

(d) $\mathbb{R}$, $[4, \infty)$

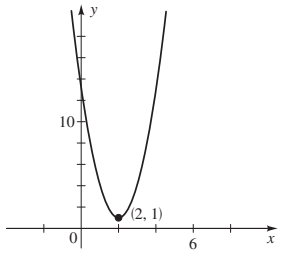
21. **(a)** $f(x) = 0.5(x + 6)^2 - 2$
(b) Vertex $(-6, -2)$; x-intercepts $-8, -4$; y-intercept 16
(c)

(d) $\mathbb{R}$, $[-2, \infty)$

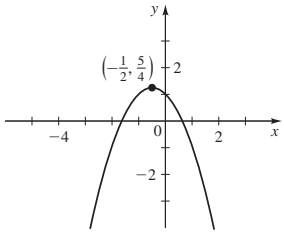
23. **(a)** $f(x) = -4\left(x + \frac{3}{2}\right)^2 + 10$
(b) Vertex $\left(-\frac{3}{2}, 10\right)$; x-intercepts $-\frac{3}{2} - \frac{\sqrt{10}}{2}, -\frac{3}{2} + \frac{\sqrt{10}}{2}$; y-intercept 1
(c)

(d) $\mathbb{R}$, $(-\infty, 10]$

25. **(a)** $f(x) = (x + 1)^2 - 2$
(b)

(c) Minimum $f(-1) = -2$

27. **(a)** $f(x) = 4(x - 1)^2 - 5$
(b)

(c) Minimum $f(1) = -5$

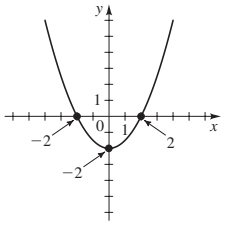
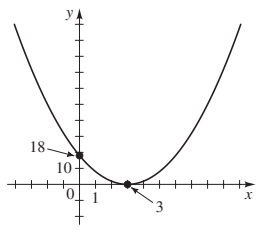
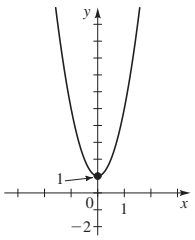
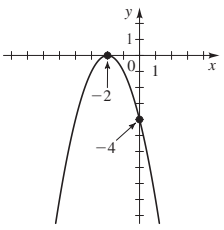
29. **(a)** $f(x) = -\left(x + \frac{3}{2}\right)^2 + \frac{21}{4}$
(b)

(c) Maximum $f\left(-\frac{3}{2}\right) = \frac{21}{4}$

31. **(a)** $f(x) = 3(x - 2)^2 + 1$
(b)

(c) Minimum $f(2) = 1$

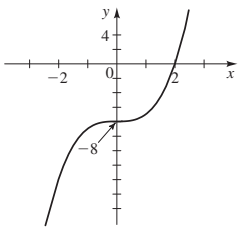
33. **(a)** $f(x) = -\left(x + \frac{1}{2}\right)^2 + \frac{5}{4}$
(b)

(c) Maximum $f\left(-\frac{1}{2}\right) = \frac{5}{4}$

35. Maximum $f(1) = 2$
37. Minimum $f(5) = 10$
39. Minimum $f(0.6) = 15.64$
41. Minimum $h(-2) = -8$
43. Maximum $f(-1) = \frac{7}{2}$
45. **(a)** $f(-0.90) \approx -4.01$ **(b)** $f(-0.895) = -4.011025$
47. $f(x) = 4(x - 2)^2 - 3$ **49.** 7 **51.** 25 ft
53. \$4000, 100 units **55.** 30 times
57. 50 trees/acre **59.** 600 ft by 1200 ft
61. Width $\frac{60}{4 + \pi} \approx 8.40$ ft, height of rectangular part $\frac{30}{4 + \pi} \approx 4.20$ ft
63. **(a)** $f(x) = x(1200 - x)$ **(b)** 600 ft by 600 ft
65. **(a)** $R(x) = x(57{,}000 - 3000x)$ **(b)** \$9.50 **(c)** \$19.00

Section 3.2 ■ Page 271

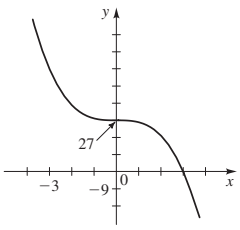
1. II **2.** **(a)** $-\infty, \infty$ **(b)** $-\infty, -\infty$
3. **(a)** 0 **(b)** factor **(c)** x **4.** (a)
5. **(a)**

Domain $(-\infty, \infty)$, range $[-2, \infty)$
(b)

Domain $(-\infty, \infty)$, range $[0, \infty)$
(c)

Domain $(-\infty, \infty)$, range $[1, \infty)$
(d)

Domain $(-\infty, \infty)$, range $(-\infty, 0]$

7. (a)



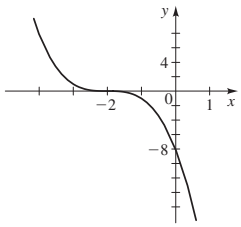
Domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

(b)



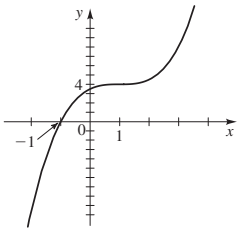
Domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

(c)



Domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

(d)



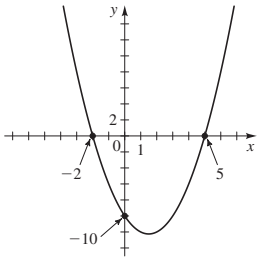
Domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

9. (a) $y \to \infty$ as $x \to \infty$, $y \to -\infty$ as $x \to -\infty$ **(b)** III

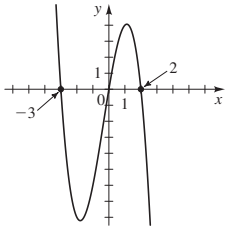
11. (a) $y \to -\infty$ as $x \to \infty$, $y \to \infty$ as $x \to -\infty$ **(b)** V

13. (a) $y \to \infty$ as $x \to \infty$, $y \to \infty$ as $x \to -\infty$ **(b)** VI

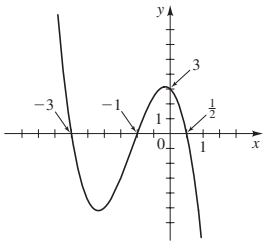
15.



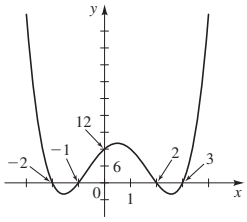
17.



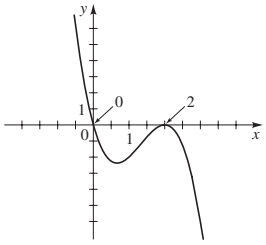
19.



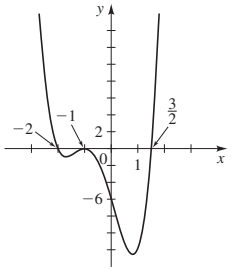
21.



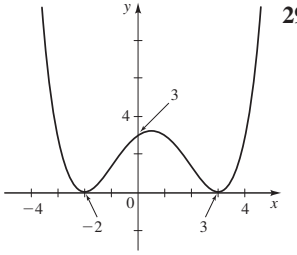
23.



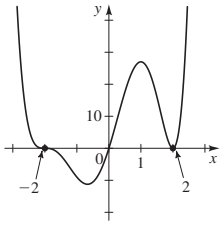
25.



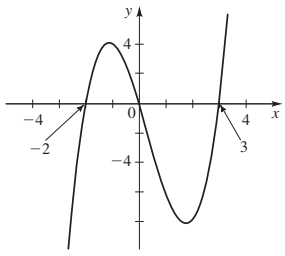
27.



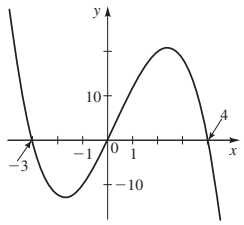
29.



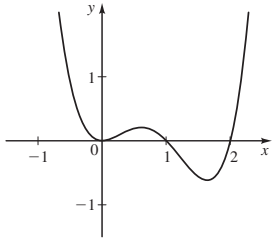
31. $P(x) = x(x + 2)(x - 3)$



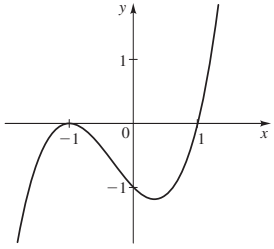
33. $P(x) = -x(x + 3)(x - 4)$



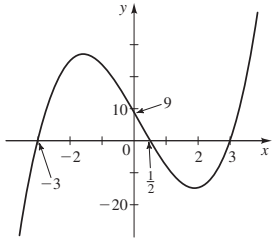
35. $P(x) = x^2(x - 1)(x - 2)$



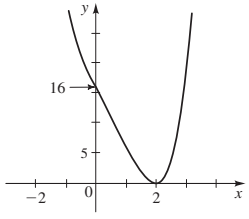
37. $P(x) = (x + 1)^2(x - 1)$



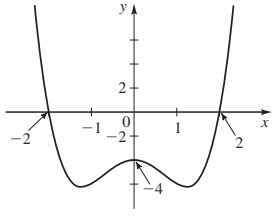
39. $P(x) = (2x - 1)(x + 3)(x - 3)$



41. $P(x) = (x - 2)^2(x^2 + 2x + 4)$



43. $P(x) = (x^2 + 1)(x + 2)(x - 2)$



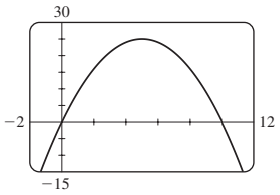
45. $y \to \infty$ as $x \to \infty$, $y \to -\infty$ as $x \to -\infty$

47. $y \to \infty$ as $x \to \pm\infty$

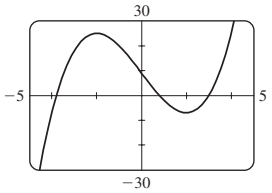
49. $y \to \infty$ as $x \to \infty$, $y \to -\infty$ as $x \to -\infty$

51. (a) x-intercepts 0, 4; y-intercept 0 **(b)** Local maximum $(2, 4)$ **(c)** $(-\infty, \infty)$, $(-\infty, 4]$

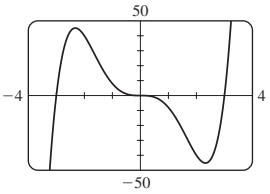
53. (a) x-intercepts -2, 1; y-intercept -1 **(b)** Local minimum $(-1, -2)$, local maximum $(1, 0)$ **(c)** $(-\infty, \infty)$, $(-\infty, \infty)$

55. 

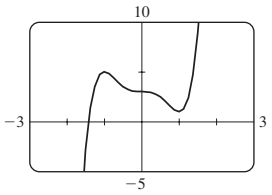
local maximum $(5, 25)$,
domain $(-\infty, \infty)$,
range $(-\infty, 25]$

57. 

local maximum $(-2, 25)$,
local minimum $(2, -7)$,
domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

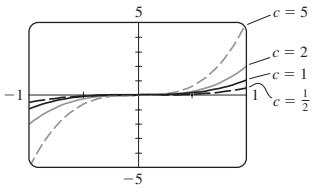
59. 

local minimum $(2.32, -45.17)$,
local maximum $(-2.32, 45.17)$,
domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

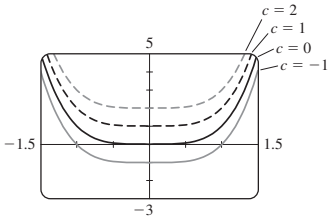
61. 

local maximum $(-1, 5)$,
local minimum $(1, 1)$,
domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

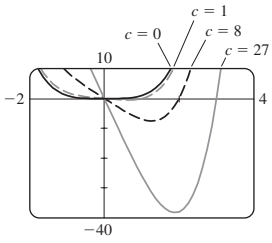
63. One local maximum, no local minimum
65. One local maximum, one local minimum
67. One local maximum, two local minimums
69. No local extrema
71. One local maximum, two local minimums

73. 

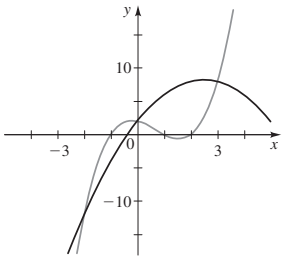
Increasing the value of c stretches the graph vertically.

75. 

Increasing the value of c shifts the graph upward.

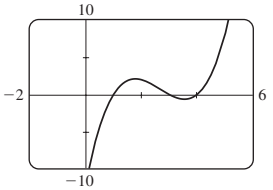
77. 

Increasing the value of c causes a deeper dip in the graph in the fourth quadrant and moves the positive x-intercept toward the right.

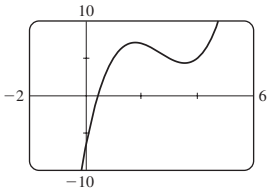
79. (a) 

(b) Three
(c) $(0, 2), (3, 8), (-2, -12)$

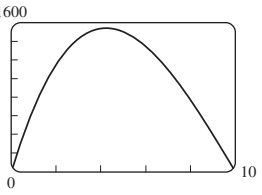
81. (d) $P(x) = P_O(x) + P_E(x)$, where $P_O(x) = x^5 + 6x^3 - 2x$ and $P_E(x) = -x^2 + 5$

83. (a) 

local maximum $(1.8, 2.1)$,
local minimum $(3.6, -0.6)$

(b) 

local maximum $(1.8, 7.1)$,
local minimum $(3.5, 4.4)$

85. 5; there are four local extrema
87. (a) 26 blenders **(b)** No; \$3276.22
89. (a) $V(x) = 4x^3 - 120x^2 + 800x$ **(b)** $0 < x < 10$
(c) 

maximum volume $\approx 1539.6\ \text{cm}^3$

Section 3.3 ■ Page 279

1. quotient, remainder **2. (a)** zero **(b)** k

3. $3x + 3 + \dfrac{13}{x - 3}$ **5.** $4x^2 - 8x + 5 - \dfrac{11}{3x + 2}$

7. $2x^2 - x + 1 + \dfrac{4x - 4}{x^2 + 4}$

9. $(x + 5)(3x^2 - 10x + 50) - 245$

11. $(2x - 3)(x^2 - 1) - 3$

13. $(2x^2 + 1)(4x^2 + 2x + 1) + (-2x - 1)$

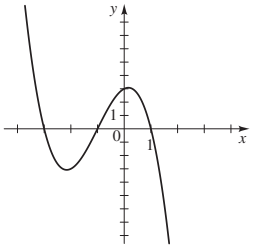
In answers 15–37 the first polynomial given is the quotient, and the second is the remainder.

15. $x - 1, 5$ **17.** $3x^2 - x, 1$ **19.** $4x - 2, 6x - 5$
21. $3x + 1, 7x - 5$ **23.** $x^4 + 1, 0$ **25.** $2x + 1, 6$
27. $3x - 2, 2$ **29.** $3x^2 + 4x + 9, 13$ **31.** $x^2 - 4x + 6, -11$
33. $x^4 + x^3 + 4x^2 + 4x + 4, -2$ **35.** $2x^2 + 4x, 1$
37. $x^2 + 3x + 9, 0$ **39.** 17 **41.** 12 **43.** -7 **45.** -483
47. 2159 **49.** $\frac{7}{3}$ **51.** -8.279 **57.** $2, 5$ **59.** $-1 \pm \sqrt{6}$
61. $\dfrac{5 \pm \sqrt{37}}{6}$ **63.** $x^3 - 3x^2 - x + 3$
65. $x^4 - 8x^3 + 14x^2 + 8x - 15$
67. $-2x^4 + 4x^3 + 10x^2 - 12x$ **69.** $3x^4 - 9x^2 + 6$
71. $(x + 1)(x - 1)(x - 2)$ **73.** $(x + 2)^2(x - 1)^2$

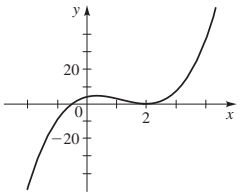
Section 3.4 ■ Page 289

1. $a_0, a_n, \pm 1, \pm\frac{1}{2}, \pm\frac{1}{3}, \pm\frac{1}{6}, \pm 2, \pm\frac{2}{3}, \pm 5, \pm\frac{5}{2}, \pm\frac{5}{3}, \pm\frac{5}{6}, \pm 10, \pm\frac{10}{3}$
2. 1, 3, 5; 0 **3.** True **4.** False **5.** $\pm 1, \pm 2, \pm 3, \pm 6$
7. $\pm\frac{1}{3}, \pm 1, \pm 3, \pm 9$ **9.** $\pm 1, \pm 5, \pm\frac{1}{2}, \pm\frac{5}{2}, \pm\frac{1}{3}, \pm\frac{5}{3}, \pm\frac{1}{6}, \pm\frac{5}{6}$

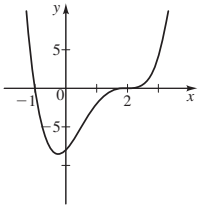
11. **(a)** $\pm 1, \pm\frac{1}{5}$ **(b)** $-1, 1, \frac{1}{5}$ **13.** **(a)** $\pm 1, \pm 3, \pm\frac{1}{2}, \pm\frac{3}{2}$ **(b)** $-\frac{1}{2}, 1, 3$ **15.** $-2, 1, 6$; $P(x) = (x+2)(x-1)(x-6)$
17. $-1, 3$; $P(x) = (x+1)(x-3)^2$
19. 2; $P(x) = (x-2)^3$
21. $-6, 3$; $P(x) = (x+6)(x-3)^2$
23. $-3, -1, 1$; $P(x) = (x+3)(x+1)(x-1)$
25. $\pm 1, \pm 2$; $P(x) = (x-2)(x+2)(x-1)(x+1)$
27. $-4, -2, -1, 1$; $P(x) = (x+4)(x+2)(x-1)(x+1)$
29. $\pm 3, \pm\frac{1}{3}$; $P(x) = (3x+1)(3x-1)(x+3)(x-3)$
31. $\pm 1, -\frac{3}{2}, \frac{1}{3}$; $P(x) = (2x+3)(3x-1)(x+1)(x-1)$
33. $-1, \pm\frac{1}{2}$; $P(x) = (x+1)(2x-1)(2x+1)$
35. $-\frac{3}{2}, \frac{1}{2}, 1$; $P(x) = (x-1)(2x+3)(2x-1)$
37. $-\frac{2}{3}, -\frac{1}{2}, \frac{3}{4}$; $P(x) = (3x+2)(2x+1)(4x-3)$
39. $-3, -\frac{3}{2}, \frac{1}{3}, 2$; $P(x) = (2x+3)(x+3)(3x-1)(x-2)$
41. $-3, -2, 1, 3$; $P(x) = (x+3)(x+2)^2(x-1)(x-3)$
43. $-1, -\frac{1}{3}, 2, 5$; $P(x) = (x+1)^2(x-2)(x-5)(3x+1)$
45. $-1, \dfrac{-1 \pm \sqrt{13}}{3}$ **47.** $-1, 4, \dfrac{3 \pm \sqrt{13}}{2}$
49. $3, \dfrac{1 \pm \sqrt{5}}{2}$ **51.** $\frac{1}{2}, \dfrac{1 \pm \sqrt{3}}{2}$ **53.** $-1, -\frac{1}{2}, -3 \pm \sqrt{10}$
55. **(a)** $-3, \pm 1$ **(b)**



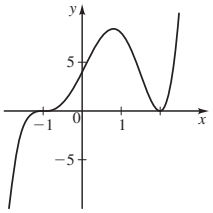
57. **(a)** $-\frac{1}{2}, 2$ **(b)**



59. **(a)** $-1, 2$ **(b)**



61. **(a)** $-1, 2$ **(b)**



63. 1 positive, 2 or 0 negative; 3 or 1 real **65.** 1 positive, 1 negative; 2 real **67.** 2 or 0 positive, 0 negative; 3 or 1 real (since 0 is a zero but is neither positive nor negative) **77.** $3, -2$
79. $3, -1$ **81.** $-2, \frac{1}{2}, \pm 1$ **83.** $\pm\frac{1}{2}, \pm\sqrt{5}$ **85.** $-2, 1, 3, 4$
91. $-2, 2, 3$ **93.** $-\frac{3}{2}, -1, 1, 4$ **95.** $-1.28, 1.53$ **97.** -1.50
99. 11.3 ft **101.** 2.76 m **103.** 88 in. (or 3.21 in.)

Section 3.5 ■ Page 299

1. $6; -7; 2, 3$ **2.** **(a)** $x - a$ **(b)** $(x-a)^m$ **3.** n **4.** $a - bi$; $3 - i$ **5.** **(a)** True **(b)** True **(c)** False, $x^4 + 1 > 0$ for all real x **6.** **(a)** False, $x^2 + 1$ has no real zeros **(b)** True **(c)** False, $x^2 + 1$ factors into linear factors with complex coefficients **7.** **(a)** $0, \pm 2i$ **(b)** $x^2(x-2i)(x+2i)$
9. **(a)** $0, 1 \pm i$ **(b)** $x(x-1-i)(x-1+i)$
11. **(a)** $\pm i$ **(b)** $(x-i)^2(x+i)^2$
13. **(a)** $\pm 2, \pm 2i$ **(b)** $(x-2)(x+2)(x-2i)(x+2i)$
15. **(a)** $-2, 1 \pm \sqrt{3}i$
(b) $(x+2)\big(x-1-\sqrt{3}i\big)\big(x-1+\sqrt{3}i\big)$
17. **(a)** $\pm 1, -\frac{1}{2} \pm \frac{\sqrt{3}}{2}i, \frac{1}{2} \pm \frac{\sqrt{3}}{2}i$
(b) $(x-1)(x+1)\big(x-\frac{1}{2}-\frac{\sqrt{3}}{2}i\big)\big(x-\frac{1}{2}+\frac{\sqrt{3}}{2}i\big) \times \big(x+\frac{1}{2}-\frac{\sqrt{3}}{2}i\big)\big(x+\frac{1}{2}+\frac{\sqrt{3}}{2}i\big)$

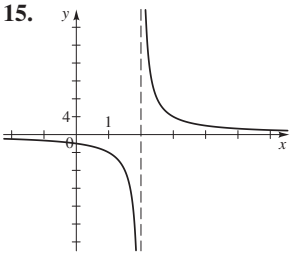
In answers 19–35 the factored form is given first, then the zeros are listed with the multiplicity of each in parentheses.

19. $x^2(x+4i)(x-4i)$; $0\,(2), \pm 4i\,(1)$
21. $x^4(x+1+i)(x+1-i)$; $0\,(4), -1 \pm i\,(1)$
23. $x(x-2i)(x+2i)$; $0\,(1), 2i\,(1), -2i\,(1)$
25. $(x-1)(x+1)(x-i)(x+i)$; $1\,(1), -1\,(1), i\,(1), -i\,(1)$
27. $16\big(x-\frac{3}{2}\big)\big(x+\frac{3}{2}\big)\big(x-\frac{3}{2}i\big)\big(x+\frac{3}{2}i\big)$; $\frac{3}{2}\,(1), -\frac{3}{2}\,(1), \frac{3}{2}i\,(1), -\frac{3}{2}i\,(1)$ **29.** $(x+1)(x-3i)(x+3i)$; $-1\,(1), 3i\,(1), -3i\,(1)$
31. $x^2(x+\sqrt{5}i)^2(x-\sqrt{5}i)^2$; $0\,(2), \pm\sqrt{5}i\,(2)$
33. $(x-1)(x+1)(x-2i)(x+2i)$; $1\,(1), -1\,(1), 2i\,(1), -2i\,(1)$
35. $x\big(x-\sqrt{3}i\big)^2\big(x+\sqrt{3}i\big)^2$; $0\,(1), \sqrt{3}i\,(2), -\sqrt{3}i\,(2)$
37. $P(x) = x^2 - 2x + 2$ **39.** $Q(x) = x^3 - 3x^2 + 4x - 12$
41. $P(x) = x^3 - 2x^2 + x - 2$
43. $R(x) = x^4 - 4x^3 + 10x^2 - 12x + 5$
45. $T(x) = 6x^4 - 12x^3 + 18x^2 - 12x + 12$ **47.** $2, -1 \pm i$
49. $1, \dfrac{1 \pm \sqrt{3}i}{2}$ **51.** $2, \dfrac{1 \pm \sqrt{3}i}{2}$ **53.** $-\frac{3}{2}, -1 \pm \sqrt{2}i$
55. $-2, 1, \pm 3i$ **57.** $1, \pm 2i, \pm\sqrt{3}i$ **59.** 3 (multiplicity 2), $\pm 2i$
61. $-\frac{1}{2}$ (multiplicity 2), $\pm i$ **63.** 1 (multiplicity 3), $\pm 3i$
65. **(a)** $(x-5)(x^2+4)$ **(b)** $(x-5)(x-2i)(x+2i)$
67. **(a)** $(x-1)(x+1)(x^2+9)$
(b) $(x-1)(x+1)(x-3i)(x+3i)$
69. **(a)** $(x-2)(x+2)(x^2-2x+4)(x^2+2x+4)$
(b) $(x-2)(x+2)\big[x-\big(1+\sqrt{3}i\big)\big]\big[x-\big(1-\sqrt{3}i\big)\big] \times \big[x+\big(1+\sqrt{3}i\big)\big]\big[x+\big(1-\sqrt{3}i\big)\big]$
71. **(a)** 4 real **(b)** 2 real, 2 non-real **(c)** 4 non-real

Section 3.6 ■ Page 314

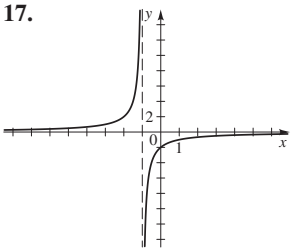
1. $-\infty, \infty$ **2.** 2 **3.** $-1, 2$ **4.** $\frac{1}{3}$ **5.** $-2, 3$ **6.** 1
7. Vertical asymptote $x = 3$; horizontal asymptote $y = 4$
8. Vertical asymptote $x = 2$; horizontal asymptote $y = -1$
9. **(a)** True **(b)** False **(c)** False **(d)** True **10.** True
11. **(a)** $-3, -19, -199, -1999$; $5, 21, 201, 2001$; $1.2500, 1.0417, 1.0204, 1.0020$; $0.8333, 0.9615, 0.9804, 0.9980$
(b) $r(x) \to -\infty$ as $x \to 2^-$; $r(x) \to \infty$ as $x \to 2^+$
(c) Horizontal asymptote $y = 1$
13. **(a)** $-22, -430, -40{,}300, -4{,}003{,}000$; $-10, -370, -39{,}700, -3{,}997{,}000$; $0.3125, 0.0608, 0.0302, 0.0030$; $-0.2778, -0.0592, -0.0298, -0.0030$
(b) $r(x) \to -\infty$ as $x \to 2^-$; $r(x) \to -\infty$ as $x \to 2^+$
(c) Horizontal asymptote $y = 0$

15.



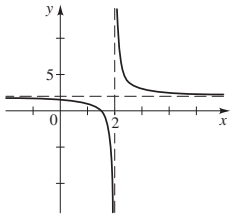
domain $\{x \mid x \neq 2\}$
range $\{y \mid y \neq 0\}$

17.



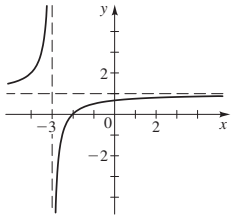
domain $\{x \mid x \neq -1\}$
range $\{y \mid y \neq 0\}$

19.



domain $\{x \mid x \neq 2\}$
range $\{y \mid y \neq 2\}$

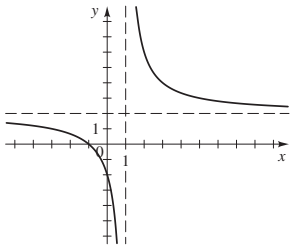
21.



domain $\{x \mid x \neq -3\}$
range $\{y \mid y \neq 1\}$

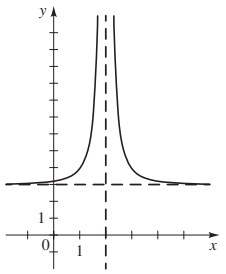
23. x-intercept 1, y-intercept $-\frac{1}{4}$ **25.** x-intercepts -1, 2; y-intercept $\frac{1}{3}$ **27.** x-intercepts -3, 3; no y-intercept
29. x-intercept 3, y-intercept 3, vertical $x = 2$; horizontal $y = 2$
31. x-intercepts -1, 1; y-intercept $\frac{1}{4}$; vertical $x = -2$, $x = 2$; horizontal $y = 1$ **33.** Vertical $x = 2$; horizontal $y = 0$
35. Horizontal $y = 0$ **37.** Vertical $x = 0$, $x = -1$, $x = 1$; horizontal $y = 10$ **39.** Vertical $x = -\frac{7}{4}$, $x = 2$; horizontal $y = \frac{1}{2}$
41. Vertical $x = 0$; horizontal $y = 3$ **43.** Vertical $x = 1$

45.



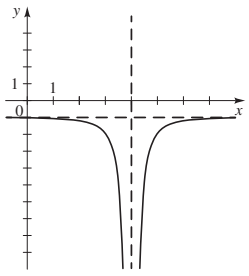
x-intercept -1
y-intercept -2
vertical $x = 1$
horizontal $y = 2$
domain $\{x \mid x \neq 1\}$
range $\{y \mid y \neq 2\}$

47.



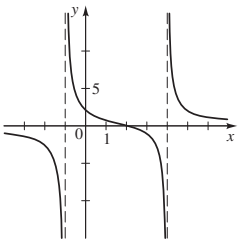
No x-intercept
y-intercept $\frac{13}{4}$
vertical $x = 2$
horizontal $y = 3$
domain $\{x \mid x \neq 2\}$
range $\{y \mid y > 3\}$

49.



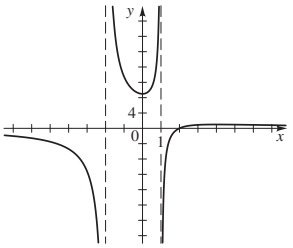
No x-intercept
y-intercept $-\frac{9}{8}$
vertical $x = 4$
horizontal $y = -1$
domain $\{x \mid x \neq 4\}$
range $\{y \mid y < -1\}$

51.



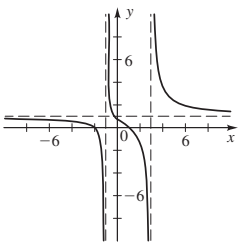
x-intercept 2
y-intercept 2
vertical $x = -1$, $x = 4$
horizontal $y = 0$
domain $\{x \mid x \neq -1, 4\}$
range $\mathbb{R}$

53.



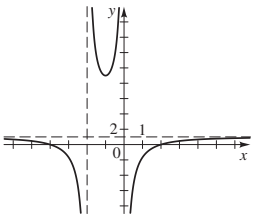
x-intercept 2
y-intercept 9
vertical $x = -2$, $x = 1$
horizontal $y = 0$
domain $\{x \mid x \neq -2, 1\}$
range $(-\infty, 1] \cup [9, \infty)$

55.



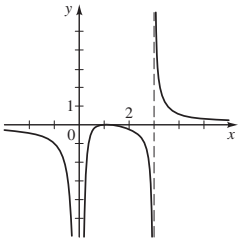
x-intercepts -2, 1
y-intercept $\frac{2}{3}$
vertical $x = -1$, $x = 3$
horizontal $y = 1$
domain $\{x \mid x \neq -1, 3\}$
range $\mathbb{R}$

57.



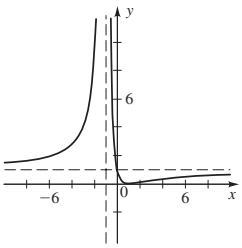
x-intercepts -4, 2
y-intercept none
vertical $x = -2$, $x = 0$
horizontal $y = 1$
domain $\{x \mid x \neq -2, 0\}$
range $\{y \mid y < 1 \text{ or } y \geq 9\}$

59.

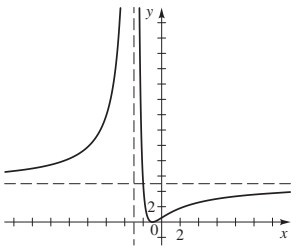


x-intercept 1
y-intercept none
vertical $x = 0$, $x = 3$
horizontal $y = 0$
domain $\{x \mid x \neq 0, 3\}$
range $\mathbb{R}$

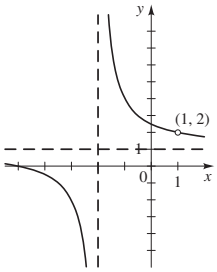
61.



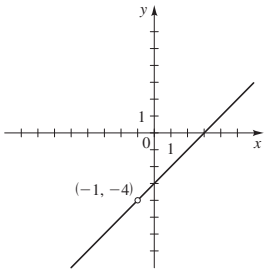
x-intercept 1
y-intercept 1
vertical $x = -1$
horizontal $y = 1$
domain $\{x \mid x \neq -1\}$
range $\{y \mid y \geq 0\}$

63. 

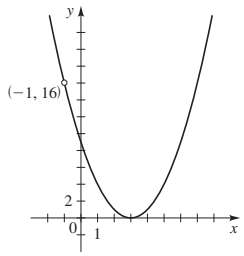
x-intercept -1
y-intercept $\frac{5}{9}$
vertical $x = -3$
horizontal $y = 5$
domain $\{x \mid x \neq -3\}$
range $\{y \mid y \geq 0\}$

65. 

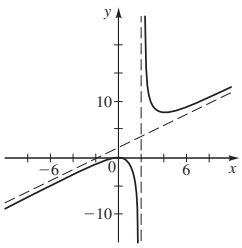
x-intercept -5
y-intercept $\frac{5}{2}$
vertical $x = -2$
horizontal $y = 1$
domain $\{x \mid x \neq -2, 1\}$
range $\{y \mid y \neq 1, 2\}$

67. 

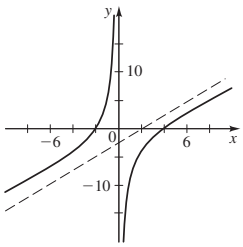
x-intercept 3
y-intercept -3
no asymptote
domain $\{x \mid x \neq -1\}$
range $\{y \mid y \neq -4\}$

69. 

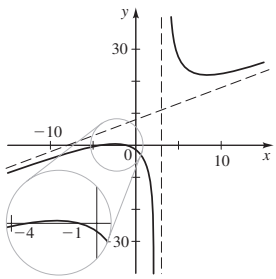
x-intercept 3
y-intercept 9
no asymptote
domain $\{x \mid x \neq -1\}$
range $\{y \mid y \geq 0\}$

71. 

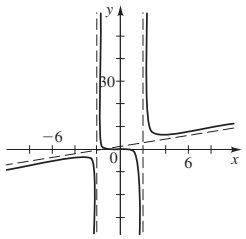
slant $y = x + 2$
vertical $x = 2$

73. 

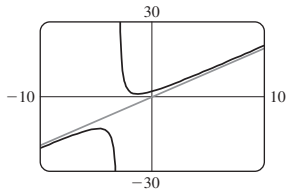
slant $y = x - 2$
vertical $x = 0$

75. 

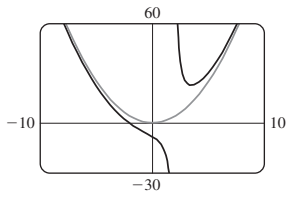
slant $y = x + 8$
vertical $x = 3$

77. 

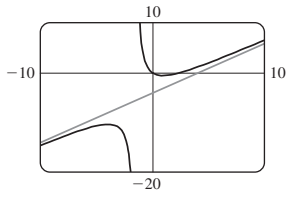
slant $y = x + 1$
vertical $x = 2$, $x = -2$

79. 

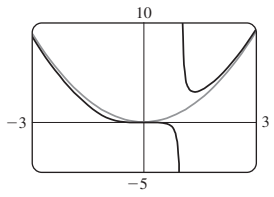
vertical $x = -3$

81. 

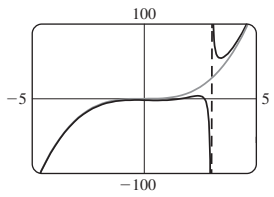
vertical $x = 2$

83. 

vertical $x = -1.5$
x-intercepts 0, 2.5
y-intercept 0, local
maximum $(-3.9, -10.4)$
local minimum $(0.9, -0.6)$
end behavior $y = x - 4$

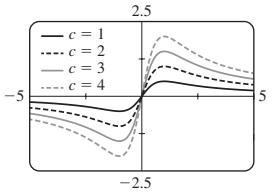
85. 

vertical $x = 1$
x-intercept 0
y-intercept 0
local minimum $(1.4, 3.1)$
end behavior $y = x^2$

87. 

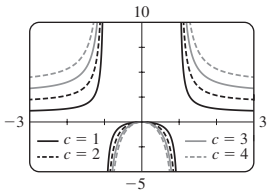
vertical $x = 3$
x-intercepts 1.6, 2.7
y-intercept -2
local maximums $(-0.4, -1.8)$,
$(2.4, 3.8)$,
local minimums $(0.6, -2.3)$,
$(3.4, 54.3)$
end behavior $y = x^3$

89.



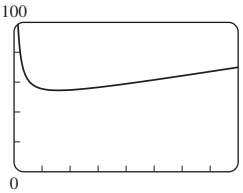
The graph of r has the same basic shape for all values of c. The larger the value of c, the more the graph is vertically stretched.

91.



The graph of r has the same basic shape, local maximum $r(0) = 0$, vertical asymptotes $x = \pm 1$, and horizontal asymptote $y = c$ for all values of c. The location of the horizontal asymptote changes as c changes.

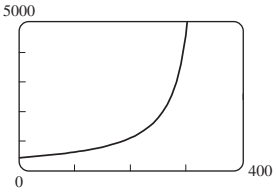
93. (b)



The local minimum $A(158) \approx 54.5$ tells us that the lowest average cost per purse is \$54.50, and this is achieved when 158 purses are produced.

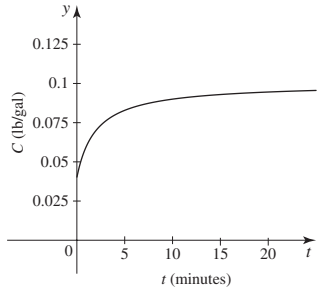
95. (a) 2.50 mg/L **(b)** The concentration decreases to 0. **(c)** ≈16.61 h

97.



If the speed of the train approaches the speed of sound, then the pitch increases indefinitely (a sonic boom).

99. (a) $C(t) = \dfrac{4 + 5t}{100 + 50t}$



(b) 0.09 lb/gal; 0.094 lb/gal **(c)** 0.1 lb/gal

Section 3.7 ■ Page 323

1. zeros; zeros; $[-2, 0]$, $[1, \infty)$

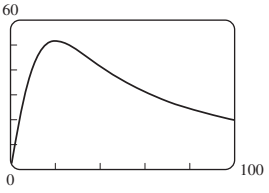
Sign of	−2	0	1	
x	−	−	+	+
$x + 2$	−	+	+	+
$x - 1$	−	−	−	+
$x(x + 2)(x - 1)$	−	+	−	+

2. zeros; zeros; cut points; $(-\infty, -4,)$, $[-2, 1]$, $(3, \infty)$

Sign of	−4	−2	1	3	
$x + 2$	−	−	+	+	+
$x - 1$	−	−	−	+	+
$x - 3$	−	−	−	−	+
$x + 4$	−	+	+	+	+
$\dfrac{(x + 2)(x - 1)}{(x - 3)(x + 4)}$	+	−	+	−	+

3. $(-\infty, -5) \cup \left(-\frac{5}{2}, 3\right)$ **5.** $(-\infty, -5) \cup (-5, -3) \cup (1, \infty)$
7. $[-4, -2] \cup [2, \infty)$ **9.** $(-\infty, \frac{1}{2})$ **11.** $(-3, 3)$
13. $[-5, 1] \cup [3, \infty)$ **15.** $(-\infty, -1) \cup (1, 7)$ **17.** $(1, 10)$
19. $\left[-8, -\frac{5}{2}\right)$ **21.** $\left(-\frac{5}{2}, 3\right]$ **23.** $\left(-7, -\frac{5}{2}\right] \cup (5, \infty)$
25. $(-5, 2)$ **27.** $(-1, 1) \cup (1, \infty)$
29. $(-\infty, -3) \cup \left(-\frac{2}{3}, 1\right) \cup (3, \infty)$ **31.** $(-4, 3]$
33. $(-\infty, -2) \cup (-1, 1) \cup (1, \infty)$
35. $[-2, -1) \cup [9, \infty)$ **37.** $[-2, 0) \cup (1, 3]$
39. $(-\infty, -2) \cup (-2, -1)$ **41.** $(-\infty, -2) \cup (5, \infty)$
43. $\left(-\frac{1}{2}, 0\right) \cup \left(\frac{1}{2}, \infty\right)$ **45.** $[-2, 3]$ **47.** $(-\infty, -1] \cup [1, \infty)$
49. $[-2, 1] \cup [3, \infty)$ **51.** $(-\infty, -1.37) \cup (0.37, 1)$
53. $(0, 1.60)$ **55.** $(0, 1]$ **57.** $(-\infty, a] \cup [b, c] \cup [d, \infty)$
59. More than 2.66 m

61.

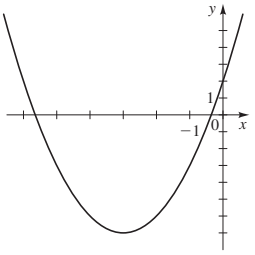


Between 9.5 and 42.3 mi/h

Chapter 3 Review ■ Page 327

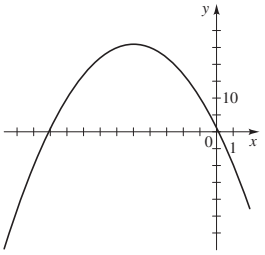
1. (a) $f(x) = (x + 3)^2 - 7$

(b)



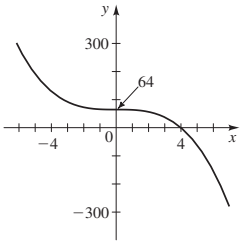
3. (a) $f(x) = -(x + 5)^2 + 26$

(b)



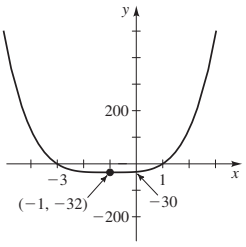
5. Maximum $f\left(\frac{3}{2}\right) = \frac{5}{4}$ **7.** 68 ft

9.



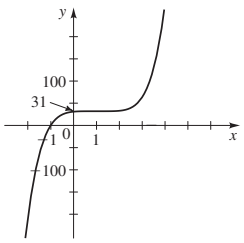
domain $(-\infty, \infty)$,
range $(-\infty, \infty)$

11.



domain $(-\infty, \infty)$,
range $[-32, \infty)$

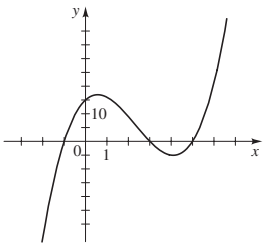
13.



domain $(-\infty, \infty)$, range $(-\infty, \infty)$

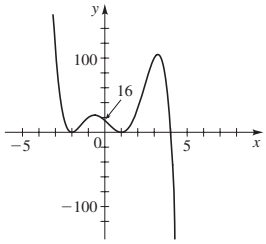
15. (a) $y \to \infty$ as $x \to \infty$, $y \to -\infty$ as $x \to -\infty$

(b)



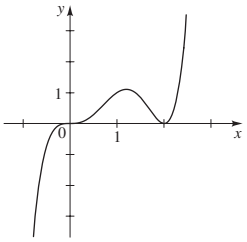
17. (a) $y \to -\infty$ as $x \to \infty$, $y \to \infty$ as $x \to -\infty$

(b)

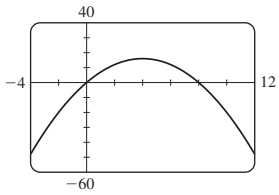


19. (a) 0 (multiplicity 3), 2 (multiplicity 2)

(b)

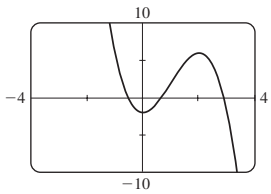


21.



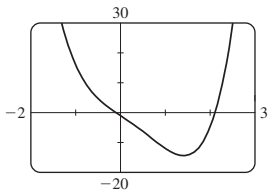
x-intercepts 0, 8
y-intercept 0
local maximum $(4, 16)$
end behavior $y \to -\infty$ as $x \to \infty$, $y \to -\infty$ as $x \to -\infty$

23.



x-intercepts -0.5, 0.7, 2.9
y-intercept -2
local maximum $(2, 6)$
local minimum $(0, -2)$
end behavior $y \to -\infty$ as $x \to \infty$, $y \to \infty$ as $x \to -\infty$

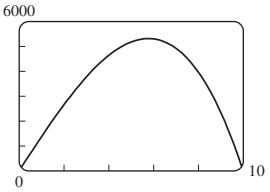
25.



x-intercepts -0.1, 2.1
y-intercept -1
local minimum $(1.4, -14.5)$
end behavior $y \to \infty$ as $x \to \infty$, $y \to \infty$ as $x \to -\infty$

27. (a) $S = 13.8x(100 - x^2)$ **(b)** $0 \le x \le 10$

(c)

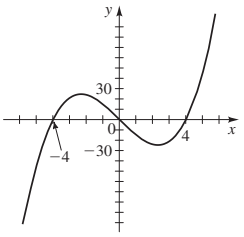


(d) ≈5.8 in.

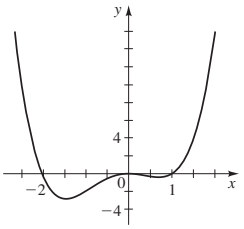
In answers 29–36 the first polynomial is the quotient, and the second is the remainder.

29. $x - 2, -4$ **31.** $2x^2 - 11x + 58, -294$
33. $x^3 - 5x^2 + 17x - 83, 422$ **35.** $2x - 3, 12$ **37.** 3 **39.** 8
43. (a) $\pm1, \pm2, \pm3, \pm6, \pm9, \pm18$ **(b)** 2 or 0 positive; 3 or 1 negative **45. (a)** $\pm1, \pm2, \pm4, \pm8, \pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{4}{3}, \pm\frac{8}{3}$
(b) 2 or 0 positive; 3 or 1 negative

47. (a) $-4, 0, 4$ **(b)**

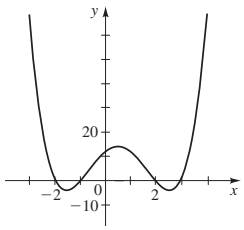


49. (a) $-2, 0$ (multiplicity 2), 1 **(b)**



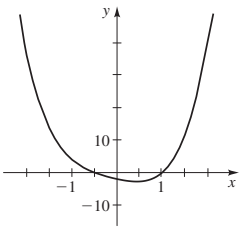
51. (a) $-2, -1, 2, 3$

(b)



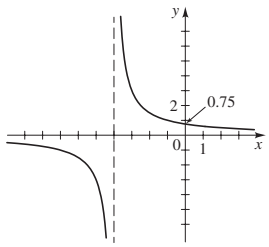
53. (a) $-\frac{1}{2}, 1$

(b)



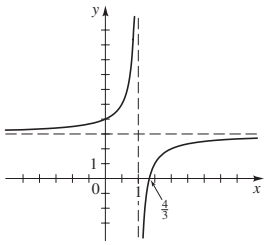
55. $P(x) = 4x^3 - 18x^2 + 14x + 12$
57. No; since the complex conjugates of imaginary zeros will also be zeros, the polynomial would have 8 zeros, contradicting the requirement that it have degree 4.
59. $1, \pm i$ **61.** $-3, 1, 5$ **63.** $-1 \pm 2i, -2$ (multiplicity 2)
65. $\pm2, 1$ (multiplicity 3) **67.** $\pm2, 1 \pm \sqrt{3}i, -1 \pm \sqrt{3}i$
69. $1, 3, \dfrac{-1 \pm \sqrt{7}i}{2}$ **71.** $x = -0.5, 3$ **73.** $x \approx -0.24, 4.24$
75. $2, P(x) = (x - 2)(x^2 + 2x + 2)$
77. (a) Vertical asymptote $x = -4$, horizontal asymptote $y = 0$, no x-intercept, y-intercept $\frac{3}{4}$, domain $\{x \mid x \neq -4\}$ range $\{y \mid y \neq 0\}$

(b)

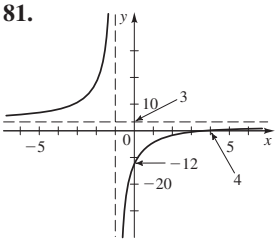


79. **(a)** Vertical asymptote $x = 1$, horizontal asymptote $y = 3$, x-intercept $\frac{4}{3}$, y-intercept 4, domain $\{x \mid x \neq 1\}$ range $\{y \mid y \neq 3\}$

(b)

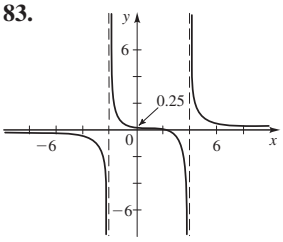


81.



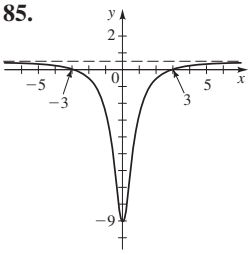
Domain $\{x \mid x \neq -1\}$, range $\{y \mid y \neq 3\}$

83.



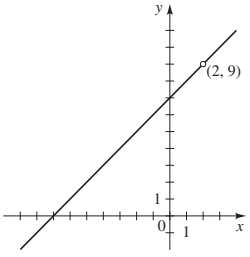
Domain $\{x \mid x \neq -2, 4\}$, range $(-\infty, \infty)$

85.



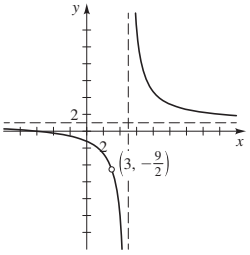
Domain $(-\infty, \infty)$, range $\{y \mid -9 \leq y < \frac{1}{2}\}$

87.



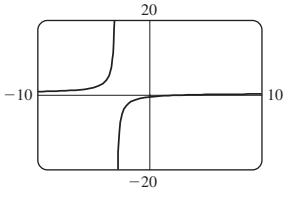
x-intercept -7
y-intercept 7
no asymptote
domain $\{x \mid x \neq 2\}$
range $\{y \mid y \neq 9\}$

89.



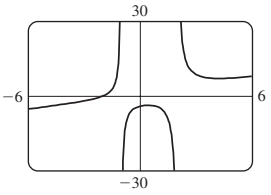
x-intercept -6
y-intercept $-\frac{6}{5}$
vertical $x = 5$
horizontal $y = 1$
domain $\{x \mid x \neq 3, 5\}$
range $\{y \mid y \neq 1, -\frac{9}{2}\}$

91.



x-intercept 3
y-intercept -0.5
vertical $x = -3$
horizontal $y = 0.5$
no local extrema

93.



x-intercept -2
y-intercept -4
vertical $x = -1$, $x = 2$
slant $y = x + 1$
local maximum $(0.425, -3.599)$
local minimum $(4.216, 7.175)$

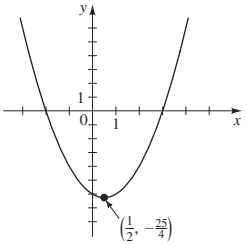
95. $(-\infty, -1] \cup [\frac{3}{2}, \infty)$ **97.** $(-3, 3)$

99. $(-\infty, -2) \cup (1, 2)$ **101.** $(-3, 0) \cup (2, \frac{9}{2}]$

103. $[-3, \frac{8}{3}]$ **105.** $[0.74, 1.95]$ **109.** **(a)** VII **(b)** V **(c)** III **(d)** I **(e)** IV **(f)** VIII **(g)** VI **(h)** II

Chapter 3 Test ■ Page 330

1. $f(x) = (x - \frac{1}{2})^2 - \frac{25}{4}$

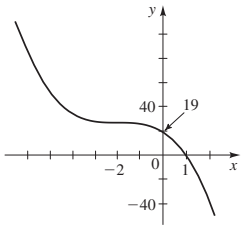


domain $(-\infty, \infty)$, range $[-\frac{25}{4}, \infty)$

2. Minimum $g(-\frac{3}{2}) = -\frac{3}{2}$

3. **(a)** 2500 ft **(b)** 1000 ft

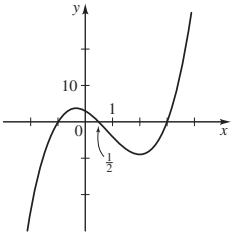
4.



5. **(a)** $x^3 + 2x^2 + 2, 9$ **(b)** $x^3 + 2x^2 + \frac{1}{2}, \frac{15}{2}$

6. **(a)** $\pm 1, \pm 3, \pm\frac{1}{2}, \pm\frac{3}{2}$ **(b)** $2(x - 3)(x - \frac{1}{2})(x + 1)$

(c) $-1, \frac{1}{2}, 3$ **(d)**

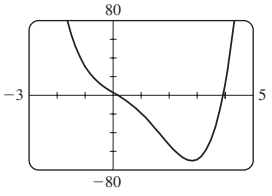


7. $3, -1 \pm i$ **8.** $P(x) = (x - 1)^2(x - 2i)(x + 2i)$

9. $P(x) = x^4 + 2x^3 + 10x^2 + 18x + 9$

10. **(a)** 4, 2, or 0 positive; 0 negative

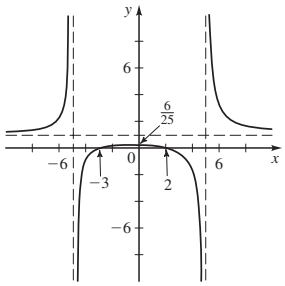
(c) 0.17, 3.93



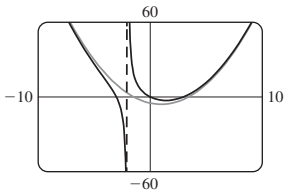
(d) Local minimum $(2.82, -70.31)$

11. **(a)** R **(b)** P **(c)** Q **(d)** T **(e)** S

12. **(a)** r, u **(b)** s **(c)** s, w **(d)** w
(e) Vertical $x = -1, x = 2$; horizontal $y = 0$
(f)



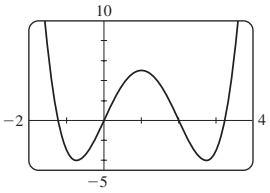
(g) $P(x) = x^2 - 2x - 5$



13. $\{x \mid x \le -1 \text{ or } \frac{5}{2} < x \le 3\}$

14. $\{x \mid -1 - \sqrt{5} < x < -1 + \sqrt{5}\}$

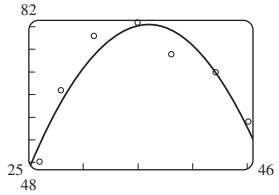
15. **(a)**



x-intercepts $-1.24, 0, 2, 3.24$; local maximum $P(1) = 5$; local minimums $P(-0.73) = P(2.73) = -4$
(b) $(-\infty, -1.24] \cup [0, 2] \cup [3.24, \infty)$

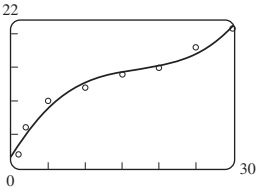
Focus on Modeling ■ Page 334

1. **(a)** $y = -0.275428x^2 + 19.7485x - 273.5523$, (where miles are measured in thousands)
(b)



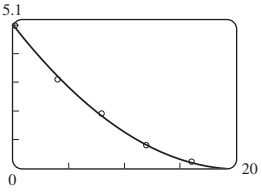
(c) 35.85 lb/in^2

3. **(a)** $y = 0.00203709x^3 - 0.104522x^2 + 1.966206x + 1.45576$
(b)



(c) 43 vegetables **(d)** 2.0 s

5. **(a)** $y = 0.0120536x^2 - 0.490357x + 4.96571$
(b)

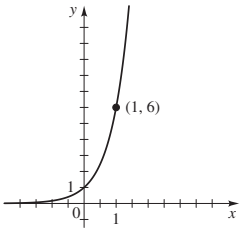


(c) 19.0 min

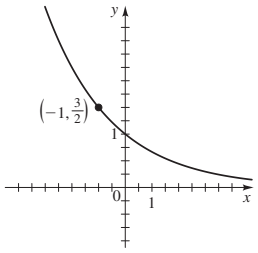
Chapter 4

Section 4.1 ■ Page 344

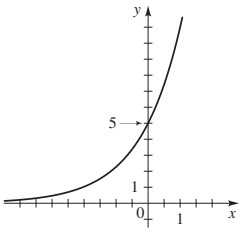
1. 5; $\frac{1}{25}$; 1; 25; 15,625 **2.** **(a)** III **(b)** I **(c)** II **(d)** IV
3. **(a)** downward **(b)** right **4.** principal, interest rate per year, number of times interest is compounded per year, number of years, amount accumulated after t years; \$112.65
5. horizontal, 0; 0 **6.** horizontal, 3; 3
7. 2.000, 22.195, 0.063, 1.516 **9.** 0.192, 0.070, 15.588, 1.552
11.



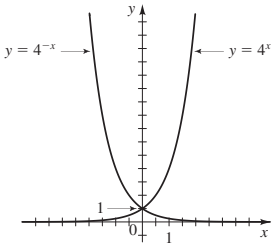
13.



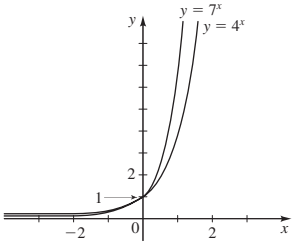
15.



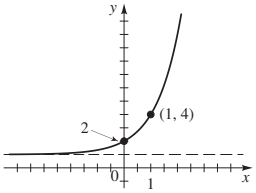
17.



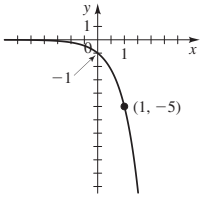
19.



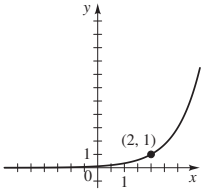
21. $f(x) = 3^x$ **23.** $f(x) = \left(\frac{1}{4}\right)^x$ **25.** II
27. y-intercept 2, $\mathbb{R}$, $(1, \infty)$, horizontal asymptote $y = 1$



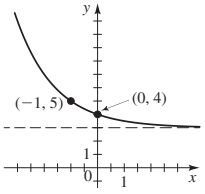
29. y-intercept -1, $\mathbb{R}$, $(-\infty, 0)$, horizontal asymptote $y = 0$



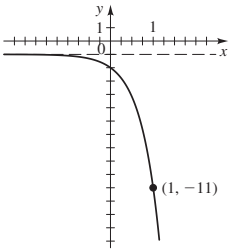
31. y-intercept $\frac{1}{9}$, $\mathbb{R}$, $(0, \infty)$, horizontal asymptote $y = 0$



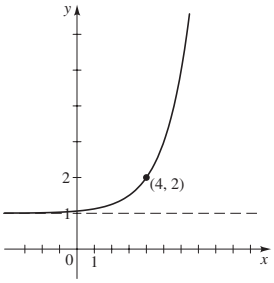
33. y-intercept 4, $\mathbb{R}$, $(3, \infty)$, horizontal asymptote $y = 3$



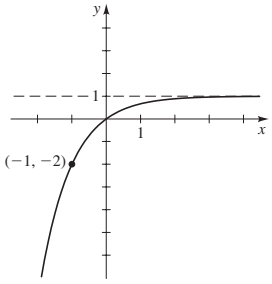
35. y-intercept -2, $\mathbb{R}$, $(-\infty, -1)$, horizontal asymptote $y = -1$



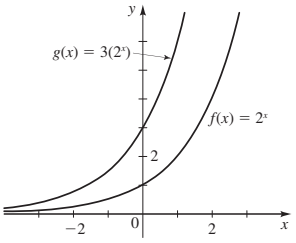
37. y-intercept $\frac{17}{16}$, $\mathbb{R}$, $(1, \infty)$, horizontal asymptote $y = 1$



39. y-intercept 0, $\mathbb{R}$, $(-\infty, 1)$, horizontal asymptote $y = 1$



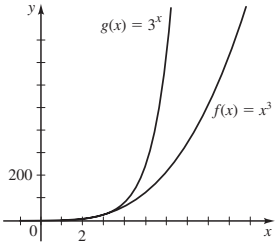
41. (a)



(b) The graph of g is steeper than that of f.

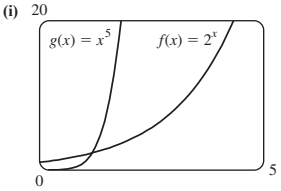
43.

x	0	1	2	3	4	6	8	10
$f(x)$	0	1	8	27	64	216	512	1000
$g(x)$	1	3	9	27	81	729	6561	59,049

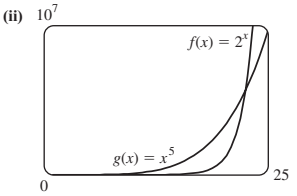


45. (a)

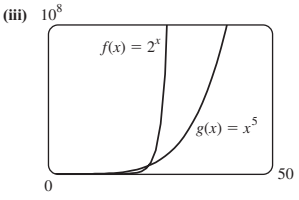
(i)



(ii)



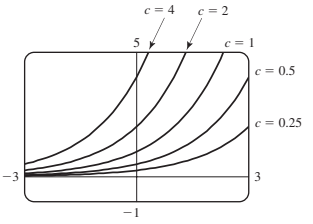
(iii)



The graph of f ultimately increases much more quickly than that of g.

(b) 1.2, 22.4

47.



The larger the value of c, the more rapidly the graph increases.

49. (a) Increasing on $(-\infty, 0.50)$; decreasing on $(0.50, \infty)$ **(b)** $(0, 1.78]$ **53. (a)** $N(t) = 1500 \cdot 2^t$ **(b)** $\approx 2.52 \times 10^{10}$

55. \$5203.71, \$5415.71, \$5636.36, \$5865.99, \$6104.98, \$6353.71

57. (a) \$10,882.52 **(b)** \$14,803.66 **(c)** \$20,137.65

59. (a) \$1233.34 **(b)** \$1267.61 **(c)** \$1578.35 **61.** \$7678.96

63. 8.30%

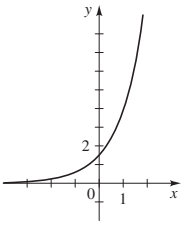
Section 4.2 ■ Page 349

1. natural; 2.71828 **2.** principal, interest rate per year, number of years, amount accumulated after t years; \$112.75

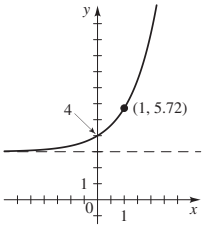
3. 2.718, 23.141, 0.050, 4.113

5.

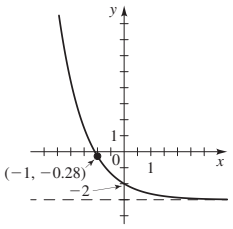
x	$y = f(x)$
−2	0.20
−1	0.55
−0.5	0.91
0	1.5
0.5	2.47
1	4.08
2	11.08



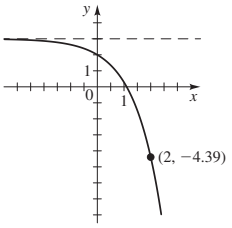
7. y-intercept 4, $\mathbb{R}$, $(3, \infty)$, horizontal asymptote $y = 3$



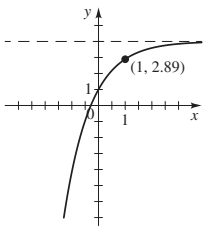
9. y-intercept -2, $\mathbb{R}$, $(-2, \infty)$, horizontal asymptote $y = -3$



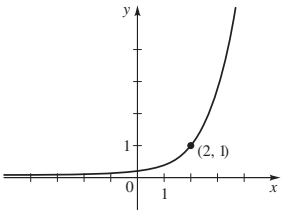
11. y-intercept 2, $\mathbb{R}$, $(-\infty, 3)$, horizontal asymptote $y = 3$



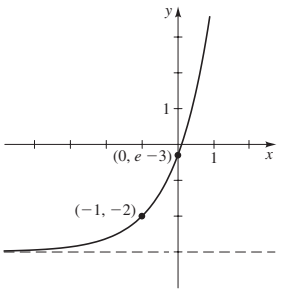
13. y-intercept 1, $\mathbb{R}$, $(-\infty, 4)$, horizontal asymptote $y = 4$



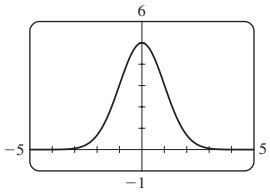
15. y-intercept $e^{-2} \approx 0.14$, $\mathbb{R}$, $(0, \infty)$, horizontal asymptote $y = 0$



17. y-intercept $e - 3 \approx -0.28$, $\mathbb{R}$, $(-3, \infty)$, horizontal asymptote $y = -3$

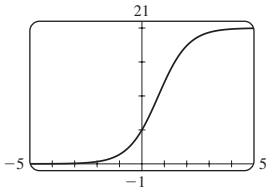


19.



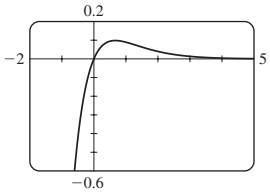
y-intercept 5;
horizontal asymptote $y = 0$,
local maximum $(0, 5)$

21.



y-intercept 5;
horizontal asymptotes $y = 0$ and $y = 20$,
no local extrema

23.



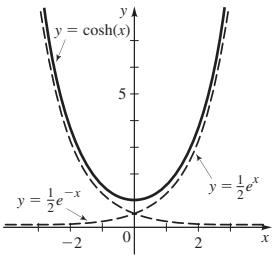
y-intercept 0;
horizontal asymptote $y = 0$,
local maximum $(0.67, 0.098)$

Answers to Exercises 25–27 will vary.

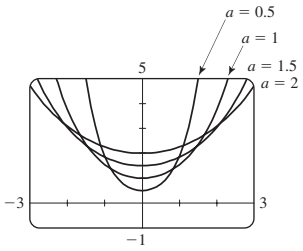
25. $g(x) = (x - 10)^2$, $f(x) = 2e^x$

27. $g(x) = 1 + e^x$, $f(x) = \sqrt{x}$

29. (a)



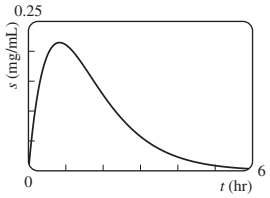
31. (a)



(b) As the value of a increases, the graph flattens out and the y-intercept increases.

33. Local minimum $(0.37, 0.69)$ **35.** 27.4 mg

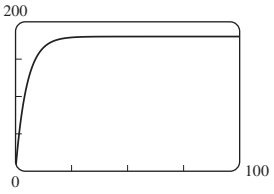
37. (a)



(b) $\approx$ 50 min **(c)** $\approx$ 4.86 h

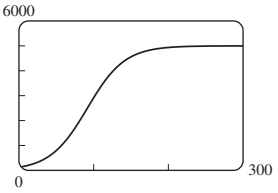
39. (a) 0 **(b)** 113.8 ft/s, 155.6 ft/s

(c)



(d) 180 ft/s

41. (a) 125 **(b)**



(c) 5000

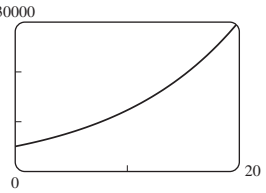
43. \$7213.18, \$7432.86, \$7659.22, \$7892.48, \$8132.84, \$8380.52

45. (a) \$2145.02 **(b)** \$2300.55 **(c)** \$3043.92

47. (a) \$768.05 **(b)** \$769.22 **(c)** \$769.82 **(d)** \$770.42

49. (a) is best.

51. (a) $A(t) = 5000e^{0.09t}$ **(b)**



(c) After 17.88 years

Section 4.3 ■ Page 359

1. x

x	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}	$10^{1/2}$
$\log x$	3	2	1	0	-1	-2	-3	$\frac{1}{2}$

2. 9; 1, 0, -1, 2, $\frac{1}{2}$ **3. (a)** $\log_5 125 = 3$ **(b)** $5^2 = 25$

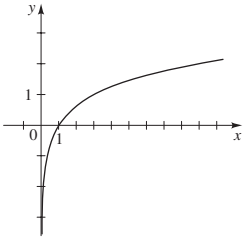
4. (a) III **(b)** II **(c)** I **(d)** IV **5.** vertical, 0 **6.** vertical, 1

7.

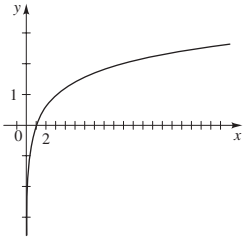
Logarithmic Form	Exponential Form
$\log_8 8 = 1$	$8^1 = 8$
$\log_8 64 = 2$	$8^2 = 64$
$\log_8 4 = \frac{2}{3}$	$8^{2/3} = 4$
$\log_8 512 = 3$	$8^3 = 512$
$\log_8\left(\frac{1}{8}\right) = -1$	$8^{-1} = \frac{1}{8}$
$\log_8\left(\frac{1}{64}\right) = -2$	$8^{-2} = \frac{1}{64}$

9. (a) $3^4 = 81$ (b) $\left(\frac{1}{3}\right)^0 = 1$ **11.** (a) $8^{1/3} = 2$ (b) $10^{-2} = 0.01$
13. (a) $3^x = 5$ (b) $\left(\frac{1}{6}\right)^3 = 2y$ **15.** (a) $e^{2y} = 10$
(b) $e^{-2} = 3x + 1$ **17.** (a) $\log_{10} 10{,}000 = 4$ (b) $\log_5\left(\frac{1}{25}\right) = -2$
19. (a) $\log_8\left(\frac{1}{8}\right) = -1$ (b) $\log_2\left(\frac{1}{8}\right) = -3$
21. (a) $\log_4 70 = x$ (b) $\log_{1/2} w = 3$ **23.** (a) $\ln 2 = x$
(b) $\ln y = 3$ **25.** (a) 1 (b) 0 (c) -1 **27.** (a) 2 (b) 2
(c) 10 **29.** (a) -3 (b) -3 (c) $\frac{1}{2}$ **31.** (a) 5 (b) 27
(c) 10 **33.** (a) $-\frac{2}{3}$ (b) 4 (c) -1 **35.** (a) 36 (b) -3
37. (a) e^3 (b) 2 **39.** (a) -3 (b) $\frac{1}{8}$ **41.** (a) -1
(b) $\frac{1}{1000}$ **43.** (a) 2 (b) 4 **45.** (a) 0.3010 (b) 1.5465
(c) -0.1761 **47.** (a) 1.6094 (b) 3.2308 (c) 1.0051

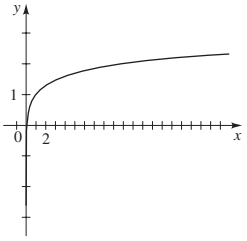
49.



51.

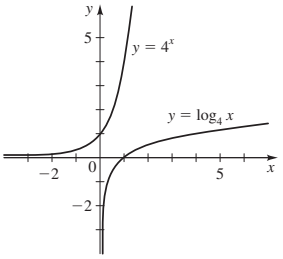


53.

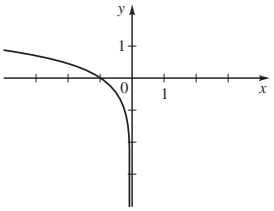


55. $y = \log_5 x$ **57.** $y = \log_9 x$ **59.** I

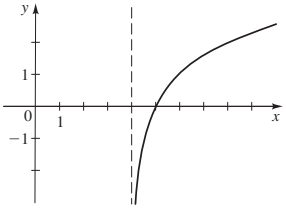
61.



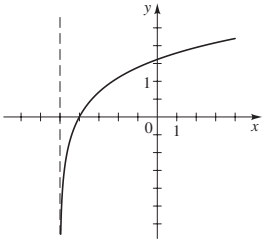
63. $(-\infty, 0), \mathbb{R}, x = 0$



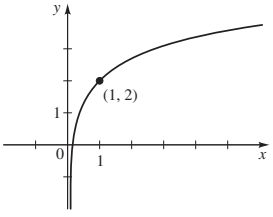
65. $(4, \infty), \mathbb{R}, x = 4$



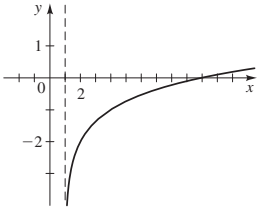
67. $(-5, \infty), \mathbb{R}, x = -5$



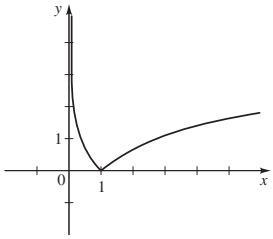
69. $(0, \infty), \mathbb{R}, x = 0$



71. $(1, \infty), \mathbb{R}, x = 1$

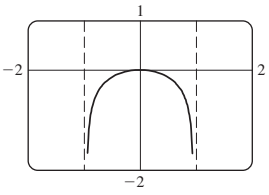


73. $(0, \infty), [0, \infty), x = 0$



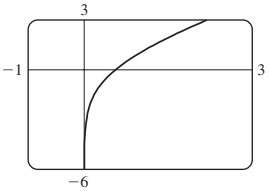
75. $(-3, \infty)$ **77.** $(-\infty, -1) \cup (1, \infty)$ **79.** $(0, 2)$

81.



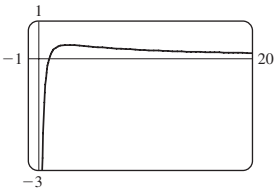
domain $(-1, 1)$
vertical asymptotes $x = 1$, $x = -1$
local maximum $(0, 0)$

83.



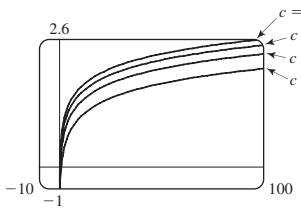
domain $(0, \infty)$
vertical asymptote $x = 0$
no maximum or minimum

85.



domain $(0, \infty)$
vertical asymptote $x = 0$
horizontal asymptote $y = 0$
local maximum
$\approx (2.72, 0.37)$

Answers to Exercises 87–89 will vary.
87. $g(x) = x^2 + 1, f(x) = \ln x$
89. $g(x) = 1 + |\ln x|, f(x) = \sqrt{x}$
91. $(f \circ g)(x) = 2^{x+1}, (-\infty, \infty); (g \circ f)(x) = 2^x + 1, (-\infty, \infty)$
93. $(f \circ g)(x) = \log_2(x - 2), (2, \infty)$;
$(g \circ f)(x) = (\log_2 x) - 2, (0, \infty)$
95. The graph of f grows more slowly than g.
97. (a)



(b) The graph of $f(x) = \log(cx)$ is the graph of $f(x) = \log(x)$ shifted upward $\log c$ units.

99. (a) $(1, \infty)$ (b) $f^{-1}(x) = 10^{2^x}$

101. (a) $f^{-1}(x) = \log_2\left(\dfrac{x}{1 - x}\right)$ (b) $(0, 1)$ **103.** 2602 years

105. 11.6 years, 9.9 years, 8.7 years **107.** 5.32, 4.32

Section 4.4 ■ Page 366

1. sum; $\log_5 25 + \log_5 125 = 2 + 3$
2. difference; $\log_5 25 - \log_5 125 = 2 - 3$
3. power; $10 \cdot \log_5 25 = 10 \cdot 2$ **4.** $2 \log x + \log y - \log z$

5. $\log\dfrac{x^2y}{z}$ **6. (a)** $\log_7 12 = \dfrac{\log 12}{\log 7} \approx 1.277$ **(b)** Yes

7. (a) False **(b)** True **8. (a)** True **(b)** False

9. 4 **11.** 2 **13.** 1 **15.** $\frac{1}{2}$ **17.** 3 **19.** 200

21. 4 **23.** $\log_3 8 + \log_3 x$ **25.** $\log_3 2 + \log_3 x + \log_3 y$

27. $3 \ln a$ **29.** $\frac{1}{2}(\log_3 x + \log_3 y + \log_3 z)$ **31.** $3 \ln a + 2 \ln b$

33. $2 + \log_2 a - \log_2 b$ **35.** $3 \log_8 a + 2 \log_8 b - \log_8 c$

37. $\frac{1}{2} + \frac{5}{2}\log_3 x - \log_3 y$ **39.** $3 \log x + 4 \log y - 6 \log z$

41. $\frac{1}{2}\ln(x^4 + 2)$ **43.** $\frac{1}{2}[\log(x + z) - \log y]$

45. $\frac{1}{3}[\ln(x^2 + y^2) - \ln(x + y)]$

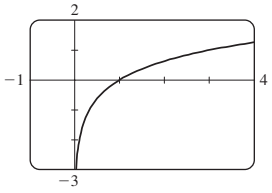
47. $\frac{1}{2}[\log(x^2 + 4) - \log(x^2 + 1) - 2\log(x^3 - 7)]$

49. $\log_4 294$ **51.** $\log\dfrac{x^2}{(x+1)^3}$ **53.** $\log\dfrac{x^2-1}{x^3}$

55. $\log_5\sqrt{\dfrac{x+2}{x^3+4x}}$ **57.** $\log\dfrac{x^2}{x-3}$ **59.** 1.430677

61. 0.630930 **63.** 0.493008 **65.** 3.482892

67.



73. (a) $P = c/W^k$ **(b)** 1866, 64

75. (a) $M = -2.5 \log B + 2.5 \log B_0$

Section 4.5 ■ Page 376

1. (a) $e^x = 25$ **(b)** $x = \ln 25$ **(c)** 3.219

2. (a) $\log 3(x-2) = \log x$ **(b)** $3(x-2) = x$ **(c)** 3 **3.** 5

5. $\frac{3}{2}$ **7.** -3 **9.** $-1, 1$ **11. (a)** $4 \ln 2$ **(b)** 2.772589

13. (a) $-\log 6$ **(b)** -0.778151 **15. (a)** $\dfrac{\ln 4}{\ln 3} - 5$

(b) -3.738140 **17. (a)** $1 - \dfrac{\ln 5}{\ln 6}$ **(b)** 0.101756

19. (a) $\dfrac{\ln 7.5}{4 \ln 1.02}$ **(b)** 25.437319 **21. (a)** $5 - \ln 4$

(b) 3.613706 **23. (a)** $\dfrac{10 \ln 0.3}{\ln 2}$ **(b)** -17.369656

25. (a) $\frac{1}{5}\log\left(\frac{5}{4}\right)$ **(b)** 0.019382 **27. (a)** $\dfrac{1 - \ln 12}{4}$

(b) -0.371227 **29. (a)** $\dfrac{\ln(50/3)}{2 \ln 2}$ **(b)** 2.029447

31. (a) $\dfrac{2}{\log 5 - 3}$ **(b)** -0.869176 **33. (a)** $\dfrac{3 \ln 3}{\ln 5 - 3 \ln 3}$

(b) -1.954364 **35. (a)** $-\ln 11.5$ **(b)** -2.442347 **37.** 0

39. $\frac{1}{2}\ln 3 \approx 0.5493$ **41.** 1 **43.** ± 1 **45.** $0, \frac{4}{3}$ **47.** 6

49. $2, 4$ **51.** 5 **53.** 10^9 **55.** $4 - e \approx 1.2817$ **57.** $\frac{14}{3}$

59. -7 **61.** 4 **63.** 6 **65.** $\frac{13}{12}$ **67.** 2.21 **69.** 0.00, 1.14

71. -0.57 **73.** 0.36 **75.** $2 < x < 4$ or $7 < x < 9$

77. $\log 2 < x < \log 5$ **79.** $f^{-1}(x) = \dfrac{\ln x}{2 \ln 2}$

81. $f^{-1}(x) = 2^x + 1$ **83.** $1/\sqrt{5} \approx 0.4472$ **85.** $0, \frac{1}{10}$

87. (a) \$5593.60 **(b)** about 30 years and 10 months

89. about 13 years and 6 months **91.** 8.15 years **93.** 13 days

95. (a) 7337 **(b)** 1.73 years **97. (a)** $P = P_0 e^{-h/k}$

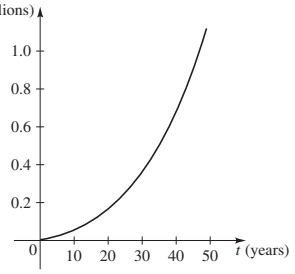
(b) 56.47 kPa **99. (a)** $t = -\frac{5}{13}\ln\left(1 - \frac{13}{60}I\right)$ **(b)** 0.218 s

Section 4.6 ■ Page 387

1. (a) $n(t) = 10 \cdot 2^{2t/3}$ **(b)** 1.06×10^8 **(c)** 14.9

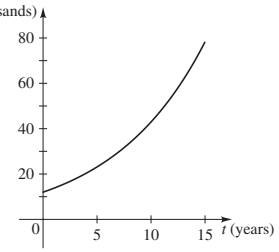
3. (a) 3125 **(b)** 317,480

(c)



5. (a) $n(t) = 12{,}800e^{0.12t}$ **(b)** 23,300 beavers **(c)** 11.35 years

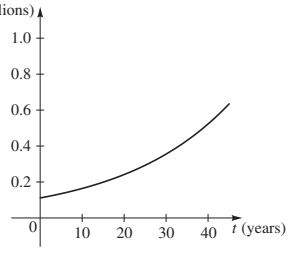
(d)



7. (a) 233 million **(b)** 181 million

9. (a) $n(t) = 112{,}000 \cdot 2^{t/18}$ **(b)** $n(t) = 112{,}000e^{0.0385t}$

(c)



(d) 38.9 years

11. (a) 20,000 **(b)** $n(t) = 20{,}000e^{0.1096t}$ **(c)** About 48,000

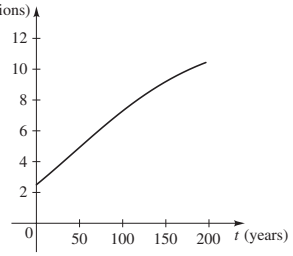
(d) 14.7 years

13. (a) $n(t) = 8600e^{0.1508t}$ **(b)** About 11,600 **(c)** 4.6 h

15. (a) $n(t) = 49e^{-0.00566t}$ million; 2059 **(b)** 122.5 years

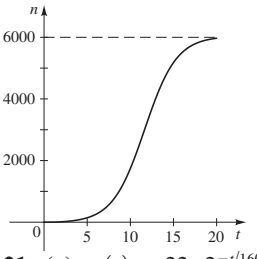
17. (a) $n(t) = \dfrac{11}{1 + 3.4e^{-0.0189t}}$ billion; 2136

(b)

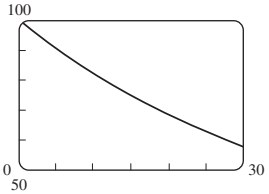


19. **(a)** $n(t) = \dfrac{6000}{1 + 749e^{-0.57t}}$

(b) About 19 days



21. **(a)** $m(t) = 22 \cdot 2^{-t/1600}$ **(b)** $m(t) = 22e^{-0.000433t}$
(c) 3.9 mg **(d)** 463.4 **23.** 18.67 years **25.** 149 h
27. 3560 years **29.** ≈1.45 billion years **31.** ≈139 years
33. **(a)** 210°F **(b)** 153°F **(c)** 28 min
35. 63°C

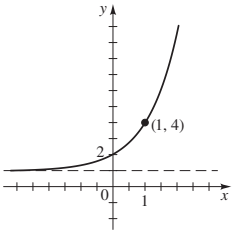


Section 4.7 ■ Page 395

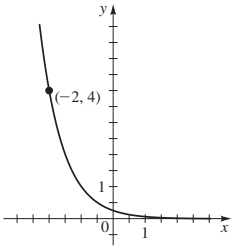
1. **(a)** 2.3 **(b)** 3.5 **(c)** 8.3 **3.** **(a)** 10^{-3} M **(b)** 3.2×10^{-7} M
5. $4.8 \le \text{pH} \le 6.4$ **7.** **(a)** 6.31×10^{-4} M, 1.26×10^{-3} M
(b) red wine **9.** **(a)** 5.49 **(b)** 6.3 **11.** $\log 20 \approx 1.3$
13. Six times as intense **15.** 73 dB **17.** 10^{-5} W/m^2
19. **(a)** 75 dB **(b)** 10^{-3} W/m^2 **(c)** 32.3

Chapter 4 Review ■ Page 398

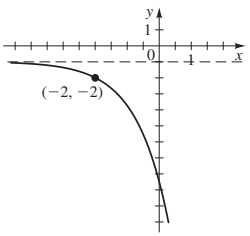
1. 0.089, 9.739, 55.902 **3.** 0.269, 1.472, 12.527
5. $\mathbb{R}$, $(1, \infty)$, horizontal asymptote $y = 1$



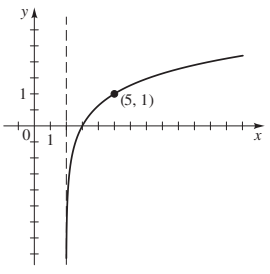
7. $\mathbb{R}$, $(0, \infty)$, horizontal asymptote $y = 0$



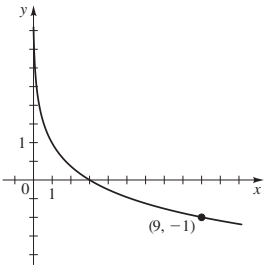
9. $\mathbb{R}$, $(-\infty, -1)$, horizontal asymptote $y = -1$



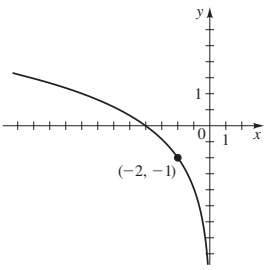
11. $(2, \infty)$, $\mathbb{R}$, vertical asymptote $x = 2$



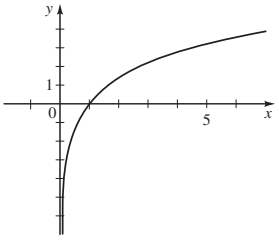
13. $(0, \infty)$, $\mathbb{R}$, vertical asymptote $x = 0$



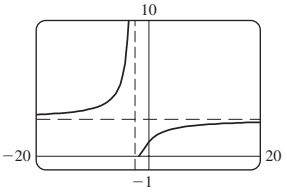
15. $(-\infty, 0)$, $\mathbb{R}$, vertical asymptote $x = 0$



17. $(0, \infty)$, $\mathbb{R}$, vertical asymptote $x = 0$

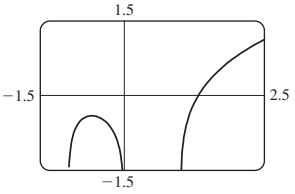


19. $\left(-\infty, \frac{1}{2}\right)$ **21.** $(-\infty, -2) \cup (2, \infty)$ **23.** $2^{10} = 1024$
25. $10^y = x$ **27.** $\log_2 64 = 6$ **29.** $\log 74 = x$ **31.** 7 **33.** 45
35. 6 **37.** −3 **39.** $\frac{1}{2}$ **41.** 2 **43.** 92 **45.** $\frac{2}{3}$
47. $\log A + 2 \log B + 3 \log C$
49. $\frac{1}{2}[\ln(x - 1) + \ln(x + 1) - \ln(x^2 + 1)]$
51. $2 \log_5 x + \frac{3}{2} \log_5(1 - 5x) - \frac{1}{2}[\log_5 x + \log_5(x - 1) + \log_5(x + 1)]$
53. $\log 96$ **55.** $\log_2 \dfrac{(x - y)^{3/2}}{(x^2 + y^2)^2}$ **57.** $\log \dfrac{x^2 - 4}{\sqrt{x^2 + 4}}$
59. 1 **61.** $\dfrac{1}{3}\left(\dfrac{\ln 2}{\ln 5} - 2\right) \approx -0.52$ **63.** $\dfrac{\ln(81/2)}{5 \ln 2 + \ln 3} \approx 0.81$
65. −2, 0, 3 **67.** 3 **69.** −15 **71.** 9 **73.** 0.430618
75. 2.303600
77.



vertical asymptote $x = -2$
horizontal asymptote $y \approx 2.72$
no maximum or minimum

79.



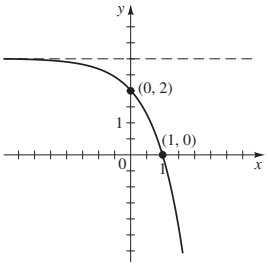
vertical asymptotes $x = -1, x = 0, x = 1$
local maximum $\approx(-0.58, -0.41)$

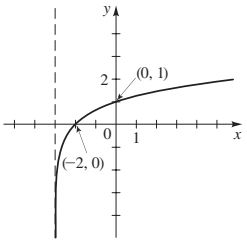
81. 2.42 **83.** $0.16 < x < 3.15$
85. Increasing on $(-\infty, 0)$ and $(1.10, \infty)$, decreasing on $(0, 1.10)$
87. 1.953445 **89.** −0.579352 **91.** $\log_4 258$
93. **(a)** \$16,081.15 **(b)** \$16,178.18 **(c)** \$16,197.64
(d) \$16,198.31 **95.** 1.83 years **97.** 4.341%
99. **(a)** $n(t) = 30e^{0.15t}$ **(b)** 55 **(c)** 19 years

101. **(a)** $n(t) = 150 \cdot 2^{-t/75{,}380}$ **(b)** 148.63 mg
(c) 119,474 years **103.** **(a)** 12 g
(b) $m(t) = 12e^{-0.173t} = 12 \cdot 2^{-t/4}$ **(c)** 7.1 g **(d)** 25 days
105. **(a)** 0.462 **(b)** $n(t) = \dfrac{1400}{1 + 13e^{-0.462t}}$ **(c)** 5.55 h
107. 7.9, basic **109.** 8.0 **111.** **(a)** VI **(b)** VIII **(c)** V
(d) III **(e)** II **(f)** VII **(g)** IV **(h)** I

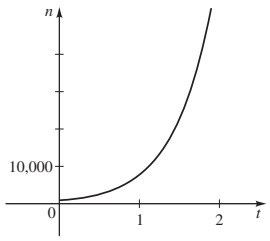
Chapter 4 Test ■ Page 402

1. **(a)** $\mathbb{R}, (-\infty, 3)$, horizontal asymptote $y = 3$ **(b)** $(-3, \infty), \mathbb{R}$, vertical asymptote $x = -3$





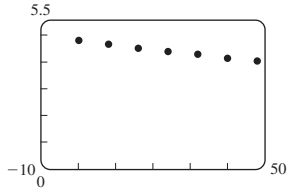
2. **(a)** $\left(\frac{3}{2}, \infty\right)$ **(b)** $(-\infty, -1) \cup (1, \infty)$
3. **(a)** $\log_6 25 = 2x$ **(b)** $e^3 = A$
4. **(a)** 36 **(b)** 3 **(c)** $\frac{3}{2}$ **(d)** 3 **(e)** $\frac{2}{3}$ **(f)** 2
5. **(a)** $\log x + 3 \log y - 2 \log z$ **(b)** $\frac{1}{2} \ln x - \frac{1}{2} \ln y$
(c) $\frac{1}{2}[\log(x^2 + 1) - 3 \log x - \log(x - 1)]$
6. **(a)** $\log(ab^2)$ **(b)** $\ln(x - 5)$ **(c)** $\log_3 \dfrac{xy^3}{(x + 1)^2}$
7. **(a)** 25 **(b)** 1, 2 **(c)** $\dfrac{\ln(9/5)}{3 \ln(2/3)} \approx -0.48$ **(d)** 5.39
8. **(a)** 500 **(b)** $\frac{2}{3}$ **(c)** $3 - e^{4/5} \approx 0.774$ **(d)** $\frac{19}{15}$
9. $\dfrac{\log 27}{\log 12}$ or $\dfrac{\ln 27}{\ln 12} \approx 1.326$
10. **(a)** $n(t) = 1000e^{2.07944t}$ **(b)** 22,600 **(c)** 1.3
(d)



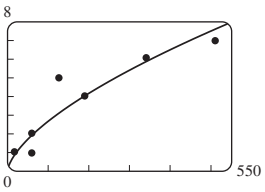
11. **(a)** $A(t) = 12{,}000\left(1 + \dfrac{0.056}{12}\right)^{12t}$ **(b)** \$14,195.06
(c) 9.12 years **12.** **(a)** $m(t) = 3 \cdot 2^{-t/10}$ **(b)** $m(t) = 3e^{-0.0693t}$
(c) 0.047 g **(d)** After 3.6 min **13.** 1995 times more intense

Focus on Modeling ■ Page 406

1. **(a)**



(b) $y = ab^t$, where $a = 4.79246$ and $b = 0.99642$ **(c)** 192.8 h
3. **(a)** $S = 0.14A^{0.64}$

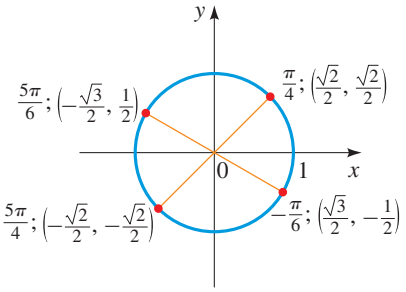


(b) 4 species
5. **(a)** $I = 306.9687 \cdot e^{-0.02999x}$, $k = 0.02999$
(b) Yes; according to the model, the light intensity in the twilight zone is at least 2.911×10^{-11} W/m^2.

Chapter 5

Section 5.1 ■ Page 415

1. **(a)** $(0, 0), 1$ **(b)** $x^2 + y^2 = 1$ **(c)** (i) 0 (ii) 0 (iii) 0
(iv) 0 **2.** **(a)** terminal **(b)** $(0, 1), (-1, 0), (0, -1), (1, 0)$
3. P; $\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right), \left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$
4.



Yes, the statement is true.
11. $-\frac{4}{5}$ **13.** $-2\sqrt{2}/3$ **15.** $3\sqrt{5}/7$ **17.** $P\left(\frac{5}{13}, -\frac{12}{13}\right)$
19. $P\left(-\sqrt{5}/3, \frac{2}{3}\right)$ **21.** $P\left(-\sqrt{2}/3, -\sqrt{7}/3\right)$
23. $t = \pi/4, \left(\sqrt{2}/2, \sqrt{2}/2\right)$; $t = \pi/2, (0, 1)$;
$t = 3\pi/4, \left(-\sqrt{2}/2, \sqrt{2}/2\right)$; $t = \pi, (-1, 0)$;
$t = 5\pi/4, \left(-\sqrt{2}/2, -\sqrt{2}/2\right)$; $t = 3\pi/2, (0, -1)$;
$t = 7\pi/4, \left(\sqrt{2}/2, -\sqrt{2}/2\right)$; $t = 2\pi, (1, 0)$
25. $(-1, 0)$ **27.** $(1, 0)$ **29.** $(0, -1)$ **31.** $(0, -1)$
33. $\left(-\sqrt{3}/2, \frac{1}{2}\right)$ **35.** $\left(-\sqrt{2}/2, -\sqrt{2}/2\right)$ **37.** $\left(\frac{1}{2}, \sqrt{3}/2\right)$
39. $\left(\sqrt{2}/2, -\sqrt{2}/2\right)$ **41.** $\left(-\sqrt{3}/2, -\frac{1}{2}\right)$
43. **(a)** $\pi/3$ **(b)** $\pi/3$ **(c)** $\pi/6$ **(d)** $3.5 - \pi \approx 0.36$
45. **(a)** $2\pi/7$ **(b)** $2\pi/9$ **(c)** $\pi - 3 \approx 0.14$
(d) $2\pi - 5 \approx 1.28$ **47.** **(a)** $\pi/4$ **(b)** $\left(-\sqrt{2}/2, \sqrt{2}/2\right)$
49. **(a)** $\pi/6$ **(b)** $\left(-\sqrt{3}/2, -\frac{1}{2}\right)$ **51.** **(a)** $\pi/6$ **(b)** $\left(\sqrt{3}/2, -\frac{1}{2}\right)$
53. **(a)** $\pi/4$ **(b)** $\left(-\sqrt{2}/2, -\sqrt{2}/2\right)$
55. **(a)** $\pi/6$ **(b)** $\left(-\sqrt{3}/2, \frac{1}{2}\right)$ **57.** **(a)** $\pi/3$ **(b)** $\left(\frac{1}{2}, \sqrt{3}/2\right)$
59. **(a)** $\pi/3$ **(b)** $\left(-\frac{1}{2}, -\sqrt{3}/2\right)$ **61.** $(0.5, 0.8)$ **63.** $(0.5, -0.9)$
65. **(a)** $\left(-\frac{3}{5}, \frac{4}{5}\right)$ **(b)** $\left(\frac{3}{5}, -\frac{4}{5}\right)$ **(c)** $\left(-\frac{3}{5}, -\frac{4}{5}\right)$ **(d)** $\left(\frac{3}{5}, \frac{4}{5}\right)$

Section 5.2 ■ Page 424

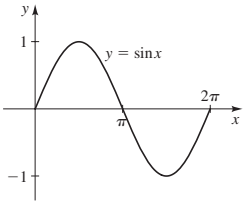
1. $y, x, y/x$ **2.** 1; 1;
$\cos t = \pm\sqrt{1 - \sin^2 t}$, $\sin t = \pm\sqrt{1 - \cos^2 t}$
3. $\sin t_3, \sin t_1, \sin t_2$ **4.** $\cos t_2, \cos t_3, \cos t_1$
5. $\pi/4, \cos t = \sqrt{2}/2, \sin t = \sqrt{2}/2$; $\pi/2, \cos t = 0, \sin t = 1$;
$3\pi/4, \cos t = -\sqrt{2}/2, \sin t = -\sqrt{2}/2$; $\pi, \cos t = -1, \sin t = 0$;
$5\pi/4, \cos t = -\sqrt{2}/2, \sin t = -\sqrt{2}/2$; $3\pi/2, \cos t = 0, \sin t = -1$;
$7\pi/4, \cos t = \sqrt{2}/2, \sin t = -\sqrt{2}/2$; $2\pi, \cos t = 1, \sin t = 0$

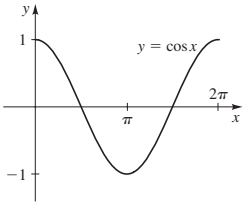
7. **(a)** $-\sqrt{3}/2$ **(b)** $\sqrt{2}/2$ **(c)** $-\sqrt{3}/3$
9. **(a)** $-\sqrt{2}/2$ **(b)** $-\sqrt{2}/2$ **(c)** $\sqrt{3}/3$
11. **(a)** $-\sqrt{2}/2$ **(b)** $-\sqrt{2}/2$ **(c)** $\sqrt{2}/2$
13. **(a)** $\sqrt{3}/2$ **(b)** $2\sqrt{3}/3$ **(c)** $\sqrt{3}/3$
15. **(a)** $\frac{1}{2}$ **(b)** 2 **(c)** $-\sqrt{3}/2$
17. **(a)** $\sqrt{3}/2$ **(b)** $-2\sqrt{3}/3$ **(c)** $-\sqrt{3}/3$
19. **(a)** -2 **(b)** $2\sqrt{3}/3$ **(c)** $\sqrt{3}$
21. **(a)** $-\sqrt{3}/2$ **(b)** $2\sqrt{3}/3$ **(c)** $-\sqrt{3}/3$
23. **(a)** 0 **(b)** 1 **(c)** 0
25. $\sin 0 = 0$, $\cos 0 = 1$, $\tan 0 = 0$, $\sec 0 = 1$, others undefined
27. $\sin \pi = 0$, $\cos \pi = -1$, $\tan \pi = 0$, $\sec \pi = -1$, others undefined
29. $\frac{3}{5}, -\frac{4}{5}, -\frac{3}{4}$ **31.** $\frac{1}{2}, -\sqrt{3}/2, -\sqrt{3}/3$
33. $\sqrt{13}/7, -\frac{6}{7}, -\sqrt{13}/6$ **35.** $-\frac{12}{13}, -\frac{5}{13}, \frac{12}{5}$ **37.** $\frac{21}{29}, -\frac{20}{29}, -\frac{21}{20}$
39. **(a)** 0.8 **(b)** 0.84147 **41.** **(a)** 0.9 **(b)** 0.93204
43. **(a)** 1 **(b)** 1.02964 **45.** **(a)** -0.6 **(b)** -0.57482
47. Negative **49.** Negative **51.** II **53.** II
55. $\cos t = -\sqrt{1 - \sin^2 t}$ **57.** $\sin t = \sqrt{1 - \cos^2 t}$
59. $\tan t = \dfrac{\sqrt{1 - \cos^2 t}}{\cos t}$ **61.** $\tan t = -\sqrt{\sec^2 t - 1}$
63. $\csc t = \sqrt{1 + \cot^2 t}$ **65.** $\tan^2 t = \dfrac{\sin^2 t}{1 - \sin^2 t}$
67. $\cos t = \frac{3}{5}$, $\tan t = -\frac{4}{3}$, $\csc t = -\frac{5}{4}$, $\sec t = \frac{5}{3}$, $\cot t = -\frac{3}{4}$
69. $\sin t = -2\sqrt{2}/3$, $\cos t = \frac{1}{3}$, $\tan t = -2\sqrt{2}$, $\csc t = -\frac{3}{4}\sqrt{2}$, $\cot t = -\sqrt{2}/4$
71. $\sin t = \frac{12}{13}$, $\cos t = -\frac{5}{13}$, $\csc t = \frac{13}{12}$, $\sec t = -\frac{13}{5}$, $\cot t = -\frac{5}{12}$
73. $\cos t = -\sqrt{15}/4$, $\tan t = \sqrt{15}/15$, $\csc t = -4$, $\sec t = -4\sqrt{15}/15$, $\cot t = \sqrt{15}$

For Exercises 75–81, there are many possible answers.
75. $g(x) = \cos x$, $f(x) = x^2$ **77.** $g(x) = 1 + \tan x$, $f(x) = \sqrt{x}$
79. $h(x) = \sin x$, $g(x) = x^2$, $f(x) = e^x$
81. $h(x) = \cos x$, $g(x) = x^2$, $f(x) = \ln x$ **83.** Odd
85. Odd **87.** Even **89.** Neither
91. $y(0) = 4$, $y(0.25) = -2.828$, $y(0.50) = 0$, $y(0.75) = 2.828$, $y(1.00) = -4$, $y(1.25) = 2.828$
93. **(a)** 0.499 amp **(b)** -0.171 amp

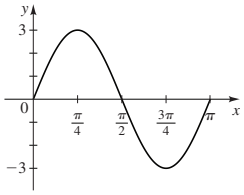
Section 5.3 ■ Page 439

1. $f(t)$; 2π, 1

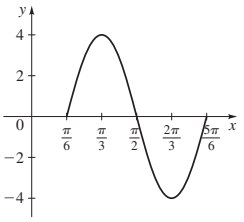




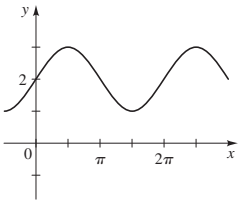
2. upward; x **3.** **(a)** $|a|, 2\pi/k$; 3, π; $[0, \pi]$
(b)



4. **(a)** $|a|, 2\pi/k, b$; 4, $2\pi/3$, $\pi/6$; $[\pi/6, 5\pi/6]$
(b)

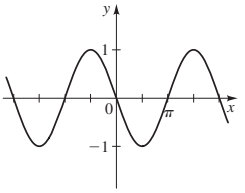


5.



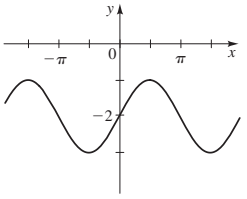
Domain $\mathbb{R}$, range $[1, 3]$

7.



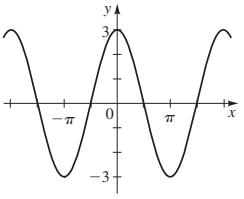
Domain $\mathbb{R}$, range $[-1, 1]$

9.



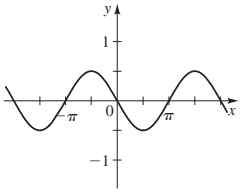
Domain $\mathbb{R}$, range $[-3, -1]$

11.



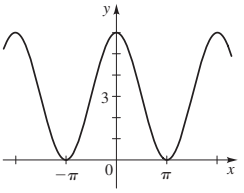
Domain $\mathbb{R}$, range $[-3, 3]$

13.



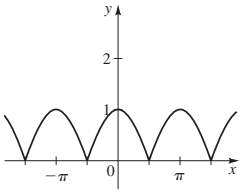
Domain $\mathbb{R}$, range $[-\frac{1}{2}, \frac{1}{2}]$

15.



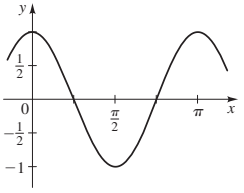
Domain $\mathbb{R}$, range $[0, 6]$

17.

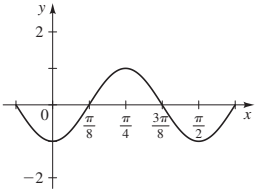


Domain $\mathbb{R}$, range $[0, 1]$

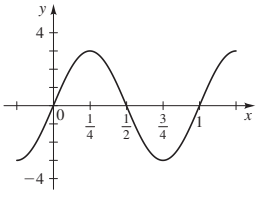
19. 1, π



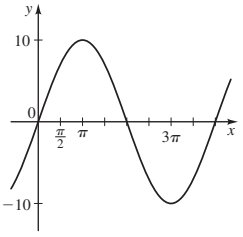
21. 1, $\pi/2$



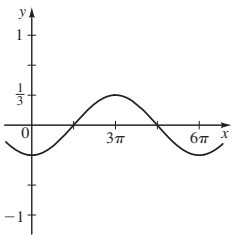
23. 3, 1



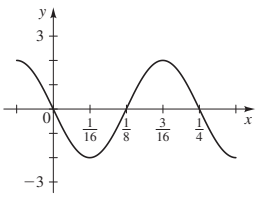
25. 10, 4π



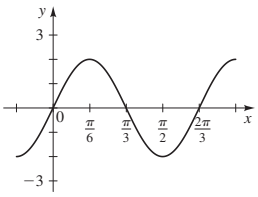
27. $\frac{1}{3}, 6\pi$



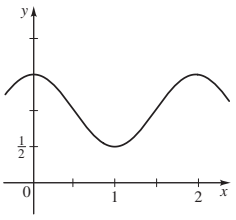
29. $2, \frac{1}{4}$



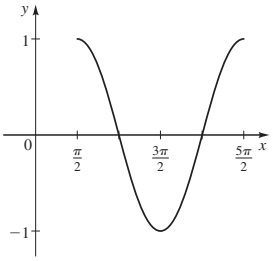
31. $2, 2\pi/3$



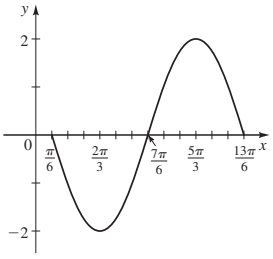
33. $\frac{1}{2}, 2$



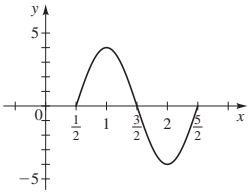
35. $1, 2\pi, \pi/2$



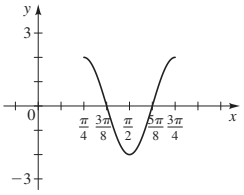
37. $2, 2\pi, \pi/6$



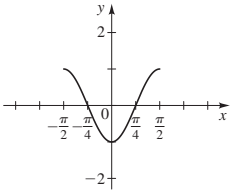
39. $4, 2, \frac{1}{2}$



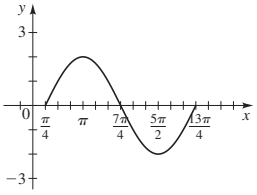
41. $2, \pi/2, \pi/4$



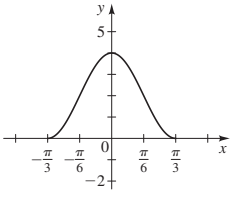
43. $1, \pi, -\pi/2$



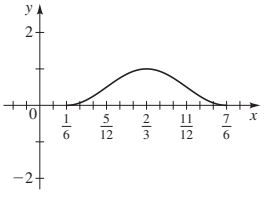
45. $2, 3\pi, \pi/4$



47. $2, 2\pi/3, -\pi/3$



49. $\frac{1}{2}, 1, \frac{1}{6}$



For Exercises 51–57, there are many possible answers.

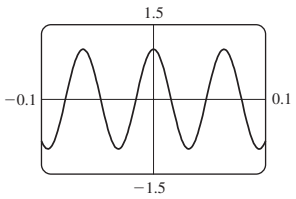
51. $4, 2\pi; y = 4 \sin x, y = 4 \cos\left(x - \frac{\pi}{2}\right)$

53. $\frac{3}{2}, 2\pi/3; y = \frac{3}{2} \sin 3\left(x + \frac{\pi}{6}\right), y = \frac{3}{2} \cos 3x$

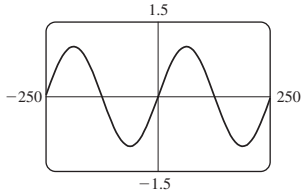
55. $\frac{1}{2}, \pi; y = -\frac{1}{2} \sin 2\left(x + \frac{7\pi}{12}\right), y = -\frac{1}{2} \cos 2\left(x + \frac{\pi}{3}\right)$

57. $1, \pi; y = 1 + \sin 2\left(x - \frac{\pi}{2}\right), y = 1 + \cos 2\left(x - \frac{3\pi}{4}\right)$

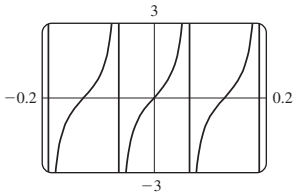
59.



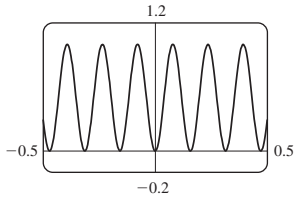
61.



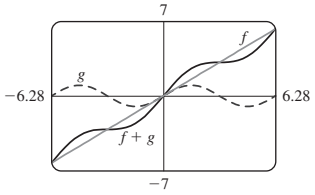
63.



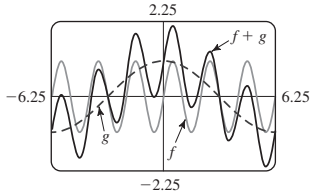
65.



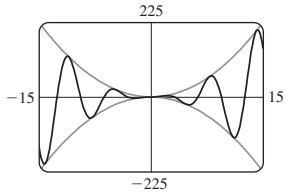
67.



69.

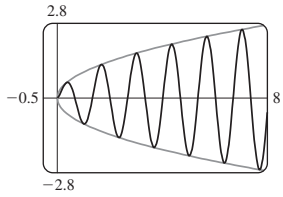


71.



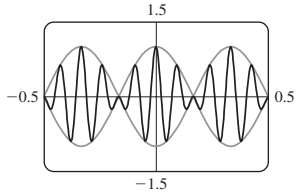
$y = x^2 \sin x$ is a sine curve that lies between the graphs of $y = x^2$ and $y = -x^2$

73.



$y = \sqrt{x} \sin 5\pi x$ is a sine curve that lies between the graphs of $y = \sqrt{x}$ and $y = -\sqrt{x}$

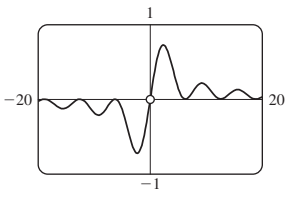
75.



$y = \cos 3\pi x \cos 21\pi x$ is a cosine curve that lies between the graphs of $y = \cos 3\pi x$ and $y = -\cos 3\pi x$

77. Maximum value 1.76 when $x \approx 0.94 + 2n\pi$, minimum value -1.76 when $x \approx -0.94 + 2n\pi$, n any integer.
79. Maximum value 3.00 when $x \approx 1.57 + 2n\pi$, minimum value -1.00 when $x \approx -1.57 + 2n\pi$, n any integer.
81. 1.16 **83.** 0.34, 2.80
85. (a) Odd **(b)** $\pm 2\pi, \pm 4\pi, \pm 6\pi, \ldots$

(c)

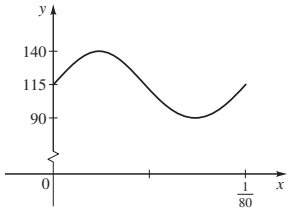


(d) $f(x)$ approaches 0
(e) $f(x)$ approaches 0

87. (a) 20 s **(b)** 6 ft

89. (a) $\frac{1}{80}$ min **(b)** 80

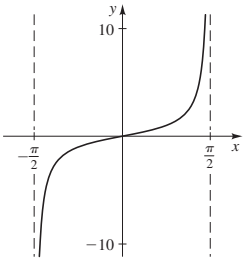
(c)



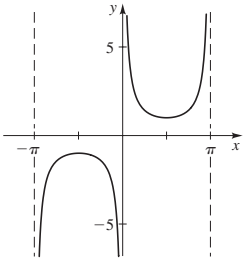
(d) $\frac{140}{90}$ mmHg; higher than normal

Section 5.4 ■ Page 449

1. π; $\frac{\pi}{2} + n\pi$, n an integer

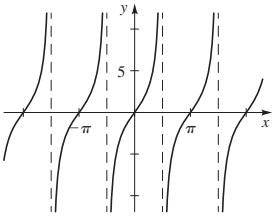


2. 2π; $n\pi$, n an integer

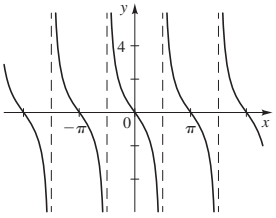


3. II **5.** VI **7.** IV

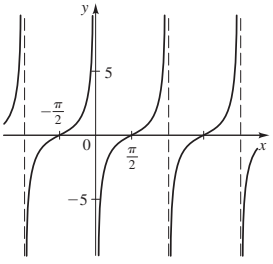
9. π



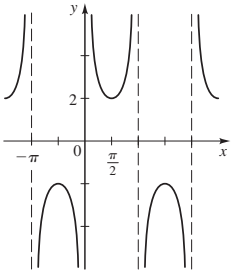
11. π



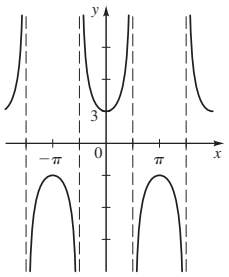
13. π



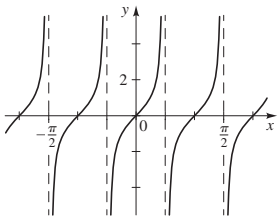
15. 2π



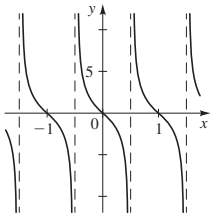
17. 2π



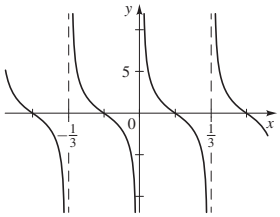
19. $\pi/3$



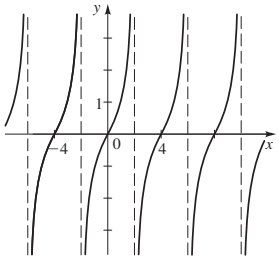
21. 1



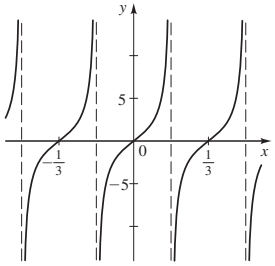
23. $\frac{1}{3}$



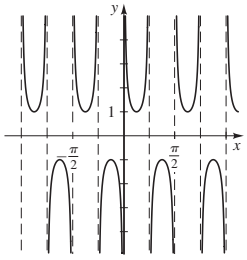
25. 4



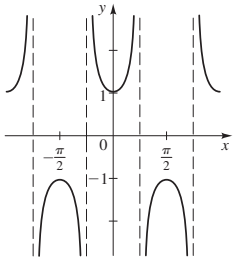
27. $\frac{1}{3}$



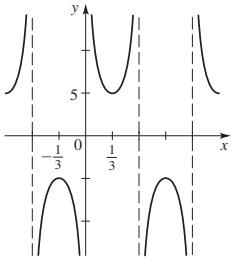
29. $\pi/2$



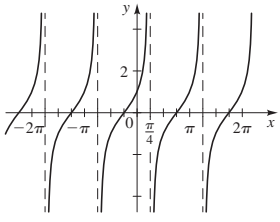
31. π



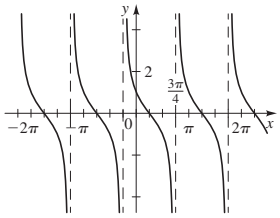
33. $\frac{4}{3}$



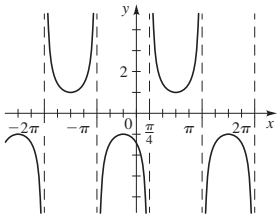
35. π



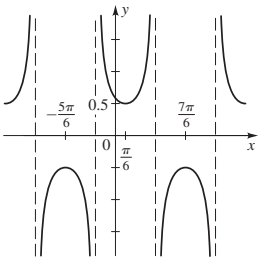
37. π



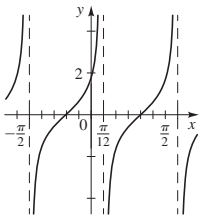
39. 2π



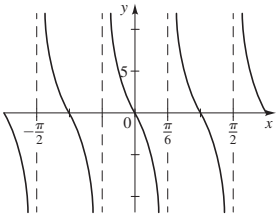
41. 2π



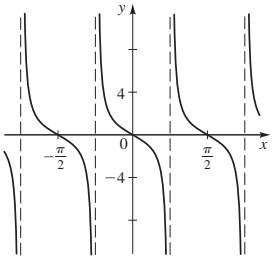
43. $\pi/2$



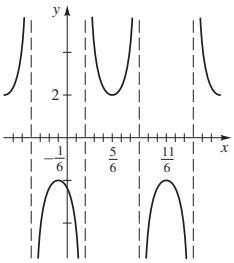
45. $\pi/3$



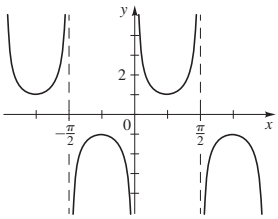
47. $\pi/2$



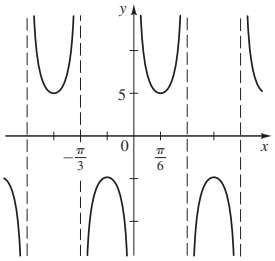
49. 2



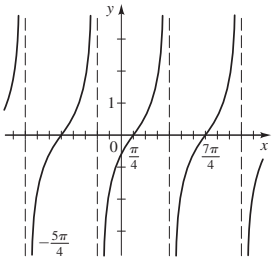
51. π



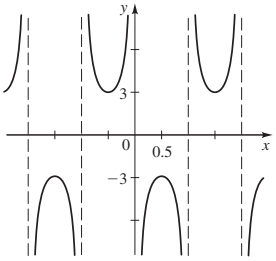
53. $2\pi/3$



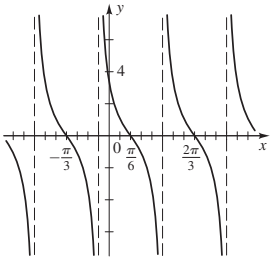
55. $3\pi/2$



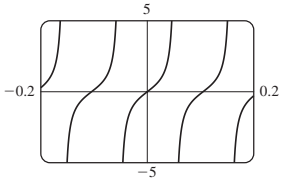
57. 2



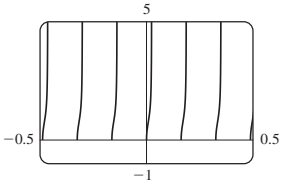
59. $\pi/2$



61.

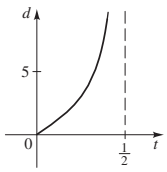


63.



65. **(a)** 1.53 mi, 3.00 mi, 18.94 mi

(b)



(c) $d(t)$ approaches ∞

Section 5.5 ■ Page 456

1. **(a)** $[-\pi/2, \pi/2]$, y, x, $\pi/6$, $\pi/6$, $\frac{1}{2}$
(b) $[0, \pi]$; y, x, $\pi/3$, $\pi/3$, $\frac{1}{2}$ **2.** **(a)** $[-\pi/2, \pi/2]$; $\frac{\pi}{4}$, $-\frac{\pi}{3}$
(b) $\sin^{-1}(\frac{1}{2}) = \frac{\pi}{6}$ **3.** **(a)** $\pi/2$ **(b)** $\pi/3$ **(c)** Undefined
5. **(a)** π **(b)** $\pi/3$ **(c)** $5\pi/6$ **7.** **(a)** $-\pi/4$ **(b)** $\pi/3$
(c) $\pi/6$ **9.** **(a)** $2\pi/3$ **(b)** $-\pi/4$ **(c)** $\pi/4$ **11.** 0.72973
13. 2.01371 **15.** 2.75876 **17.** 1.47113 **19.** 0.88998
21. −0.26005 **23.** $\frac{1}{4}$ **25.** 5 **27.** Undefined **29.** $-\frac{1}{5}$
31. $\pi/4$ **33.** $\pi/4$ **35.** $5\pi/6$ **37.** $5\pi/6$ **39.** $\pi/4$
41. $-\pi/3$ **43.** $\sqrt{3}/2$ **45.** 0 **47.** $2\sqrt{3}/3$ **49.** $\sqrt{2}$
51. $\sqrt{1 + x^2}$ **53.** $\dfrac{x}{\sqrt{1 - x^2}}$

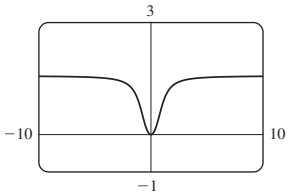
For Exercises 55–61, there are many possible answers.

55. $g(x) = \arcsin x$, $f(x) = e^x$ **57.** $g(x) = 1/x$, $f(x) = \sin^{-1}x$

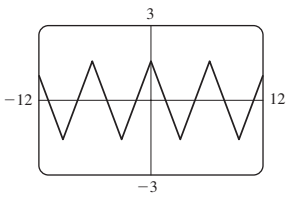
59. $h(x) = x^2$, $g(x) = \arcsin x$, $f(x) = e^x$

61. $h(x) = 1 - x^2$, $g(x) = e^x$, $f(x) = \tan^{-1}x$

63. **(a)** $\mathbb{R}$ **(b)**



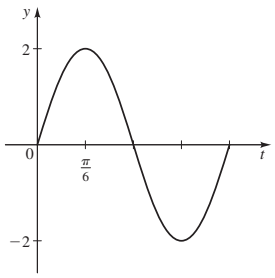
65. **(a)** $\mathbb{R}$ **(b)**



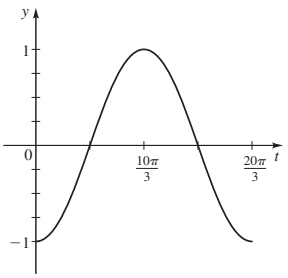
Section 5.6 ■ Page 467

1. **(a)** $a \sin \omega t$ **(b)** $a \cos \omega t$
2. **(a)** $ae^{-ct} \sin \omega t$ **(b)** $ae^{-ct} \cos \omega t$
3. **(a)** $|A|$, $2\pi/k$, b; $A \sin k(t - \frac{b}{k})$; b/k **(b)** 5, $\pi/2$, π, $\pi/4$
4. π, $\pi/2$; $\pi/2$, out of phase
5. **(a)** 2, $2\pi/3$, $3/(2\pi)$ **7.** **(a)** 1, $20\pi/3$, $3/(20\pi)$

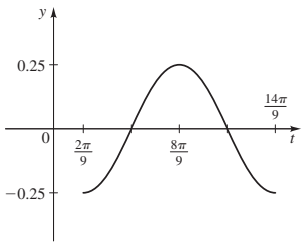
(b)



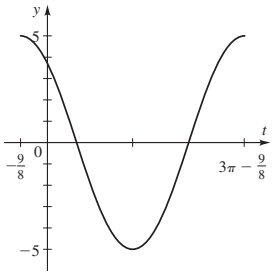
(b)



9. **(a)** $\frac{1}{4}$, $4\pi/3$, $3/(4\pi)$ **(b)**



11. **(a)** 5, 3π, $1/(3\pi)$ **(b)**

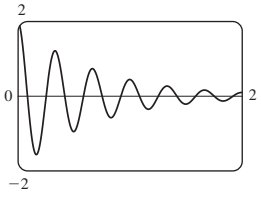


13. $y = 10 \sin\left(\frac{2\pi}{3}t\right)$ **15.** $y = 6 \sin(10t)$

17. $y = 60 \cos(4\pi t)$ **19.** $y = 2.4 \cos(1500\pi t)$

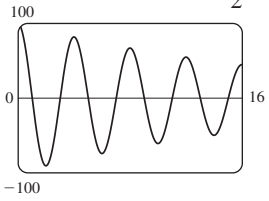
21. **(a)** $y = 2e^{-1.5t} \cos 6\pi t$

(b)



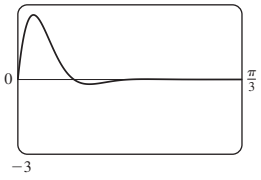
23. **(a)** $y = 100e^{-0.05t} \cos \frac{\pi}{2}t$

(b)



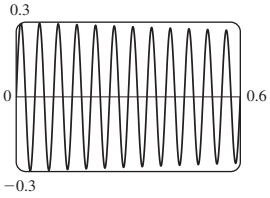
25. **(a)** $y = 7e^{-10t} \sin 12t$

(b)



27. **(a)** $y = 0.3e^{-0.2t} \sin(40\pi t)$

(b)



29. 5, π, $\pi/2$, $\pi/4$ **31.** 100, $2\pi/5$, $-\pi$, $-\pi/5$

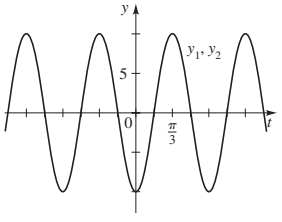
33. 20, π, $\pi/2$, $\pi/4$

35. **(a)** $\pi/2$, $5\pi/2$

(b) -2π

(c) In phase

(d)

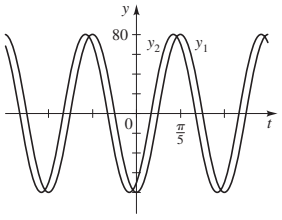


37. **(a)** $\pi/2$, $\pi/3$

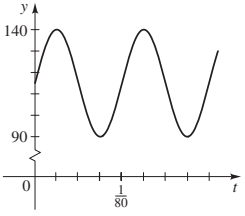
(b) $\pi/6$

(c) Out of phase

(d)



39. **(a)** 25, $\frac{1}{80}$, 80 **(b)**



(c) The period decreases and the frequency increases.

41. $d(t) = 5 \sin 5\pi t$

43. $y = 5 \cos 2\pi t$ **45.** $y = 11 + 10 \sin\left(\frac{\pi t}{10}\right)$

47. $y = 3.8 + 0.2 \sin\left(\frac{\pi}{5}t\right)$

49. $f(t) = 10 \sin\left(\frac{\pi}{12}(t - 8)\right) + 90$

51. **(a)** 45 V **(b)** 40 **(c)** 40 **(d)** $E(t) = 45 \cos 80\pi t$

53. $f(t) = e^{-0.9t} \sin \pi t$ **55.** $c = \frac{1}{3} \ln 4 \approx 0.46$

57. **(a)** $y = \sin 200\pi t$, $y = \sin\left(200\pi t + \frac{3\pi}{4}\right)$

(b) No; $3\pi/4$

Chapter 5 Review ■ Page 475

1. **(b)** $\frac{1}{2}$, $-\sqrt{3}/2$, $-\sqrt{3}/3$ **3.** **(a)** $\pi/3$ **(b)** $\left(-\frac{1}{2}, \sqrt{3}/2\right)$

(c) $\sin t = \sqrt{3}/2$, $\cos t = -\frac{1}{2}$, $\tan t = -\sqrt{3}$, $\csc t = 2\sqrt{3}/3$, $\sec t = -2$, $\cot t = -\sqrt{3}/3$

5. **(a)** $\pi/4$ **(b)** $(-\sqrt{2}/2, -\sqrt{2}/2)$

(c) $\sin t = -\sqrt{2}/2$, $\cos t = -\sqrt{2}/2$, $\tan t = 1$, $\csc t = -\sqrt{2}$, $\sec t = -\sqrt{2}$, $\cot t = 1$

7. **(a)** $\sqrt{2}/2$ **(b)** $-\sqrt{2}/2$ **9.** **(a)** 0.89121 **(b)** 0.45360

11. **(a)** 0 **(b)** Undefined **13.** **(a)** Undefined **(b)** 0

15. **(a)** $-\sqrt{3}/3$ **(b)** $-\sqrt{3}$ **17.** $\dfrac{\sin t}{1 - \sin^2 t}$ **19.** $\dfrac{\sin t}{\sqrt{1 - \sin^2 t}}$

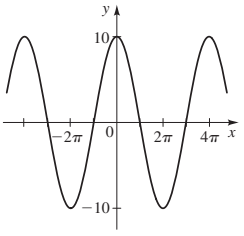
21. $\tan t = -\frac{5}{12}$, $\csc t = \frac{13}{5}$, $\sec t = -\frac{13}{12}$, $\cot t = -\frac{12}{5}$

23. $\sin t = 2\sqrt{5}/5$, $\cos t = -\sqrt{5}/5$, $\tan t = -2$, $\sec t = -\sqrt{5}$

25. $-\dfrac{\sqrt{17}}{4} + 4$ **27.** 3

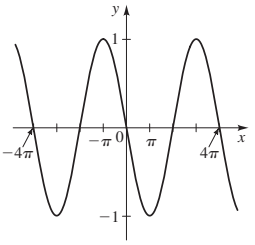
29. **(a)** 10, 4π, 0

(b)



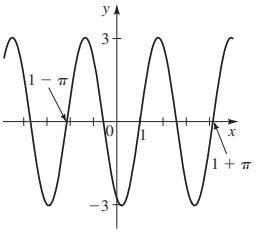
31. **(a)** 1, 4π, 0

(b)



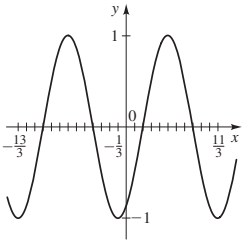
33. **(a)** 3, π, 1

(b)



35. **(a)** 1, 4, $-\frac{1}{3}$

(b)

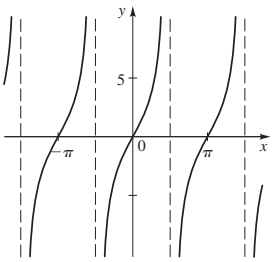


For Exercises 37–39, there are many possible answers.

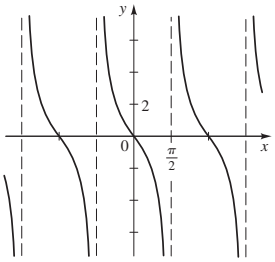
37. $y = 5 \sin 4x$, $y = 5 \cos 4\left(x - \frac{\pi}{8}\right)$

39. $y = \frac{1}{2} \sin 2\pi(x + \frac{1}{3})$, $y = \frac{1}{2} \cos 2\pi(x + \frac{1}{12})$

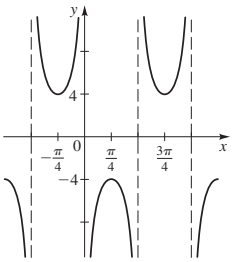
41. π



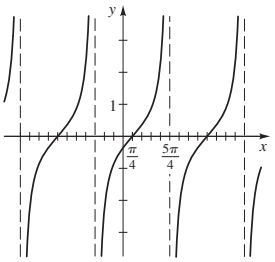
43. π



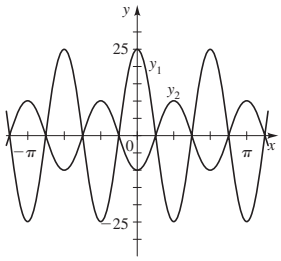
45. π



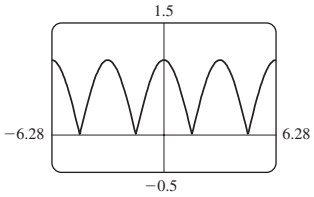
47. 2π



49. $\pi/2$ **51.** $\pi/6$ **53.** 100, $\pi/4$, $-\pi/2$, $-\pi/16$
55. **(a)** $3\pi/2$, $5\pi/2$ **(b)** $-\pi$ **(c)** Out of phase
(d)

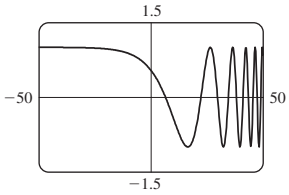


57. **(a)**



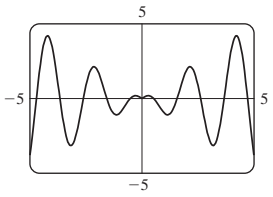
(b) Period π
(c) Even

59. **(a)**



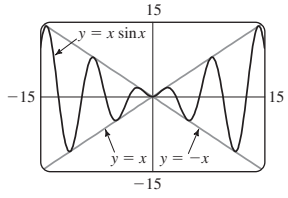
(b) Not periodic
(c) Neither

61. **(a)**



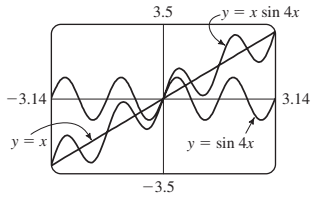
(b) Not periodic
(c) Even

63.



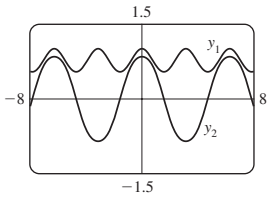
$y = x \sin x$ is a sine function whose graph lies between those of $y = x$ and $y = -x$

65.



The graphs are related by graphical addition.

67. 1.76, −1.76 **69.** 0.30, 2.84
71. **(a)**



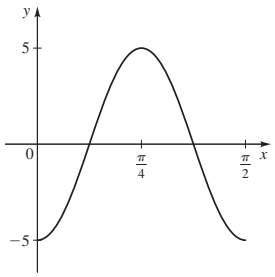
(b) y_1 has period π, y_2 has period 2π
(c) $\sin(\cos x) < \cos(\sin x)$, for all x
73. $y = -50 \cos 8\pi t$ **75.** **(a)** VII **(b)** I **(c)** V **(d)** III **(e)** VI **(f)** IV **(g)** II **(h)** VIII

Chapter 5 Test ■ Page 478

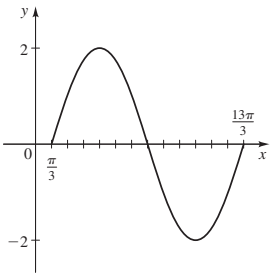
1. $y = -\frac{5}{6}$ **2.** **(a)** $\frac{4}{5}$ **(b)** $-\frac{3}{5}$ **(c)** $-\frac{4}{3}$ **(d)** $-\frac{5}{3}$
3. **(a)** $-\frac{1}{2}$ **(b)** $-\sqrt{2}/2$ **(c)** $\sqrt{3}$ **(d)** -1

4. $\tan t = -\dfrac{\sin t}{\sqrt{1 - \sin^2 t}}$ **5.** $-\frac{2}{15}$

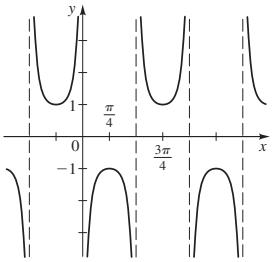
6. **(a)** 5, $\pi/2$, 0, 0
(b)



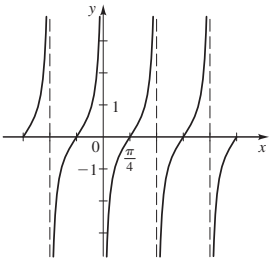
7. **(a)** 2, 4π, $\pi/6$, $\pi/3$
(b)



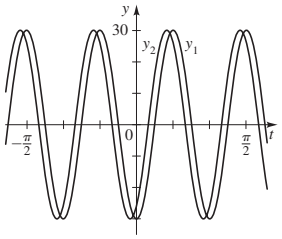
8. π



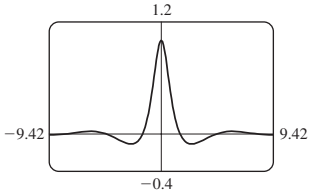
9. $\pi/2$



10. **(a)** $\pi/4$ **(b)** $5\pi/6$ **(c)** 0 **(d)** $\frac{1}{2}$
11. $y = 2 \sin 2(x + \pi/3)$
12. **(a)** $\pi/2$, $\pi/3$ **(b)** $\pi/6$ **(c)** Out of phase
(d)



13. **(a)**



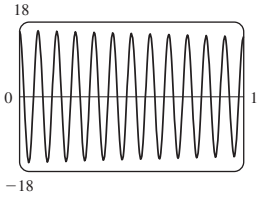
(b) Even

(c) Minimum value -0.11 when $x \approx \pm 2.54$, maximum value 1 when $x = 0$

14. $y = 5 \sin 4\pi t$

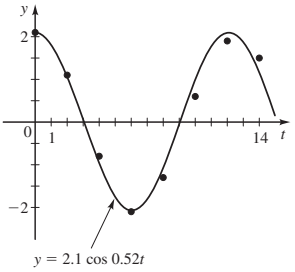
15. **(a)** $y = 16e^{-0.1t} \cos 24\pi t$

(b)



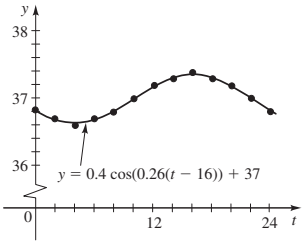
Focus on Modeling ■ Page 482

1. **(a)** $y = 2.1 \cos 0.52t$



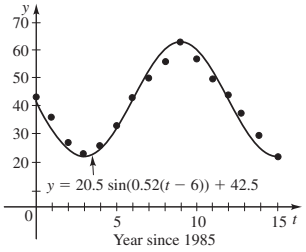
(b) $y = 2.05 \sin(0.50t + 1.55) - 0.01$. The formula reduces to $y = 2.05 \cos(0.50t - 0.02) - 0.01$. Same as (a), rounded to one decimal.

3. **(a)** $y = 0.4 \cos(0.26(t - 16)) + 37$, where y is the body temperature (°C) and t is hours since midnight



(b) $y = 0.37 \sin(0.26t - 2.62) + 37.0$

5. **(a)** $y = 20.5 \sin(0.52(t - 6)) + 42.5$, where y is the salmon population ($\times$ 1000), and t is years since 1985



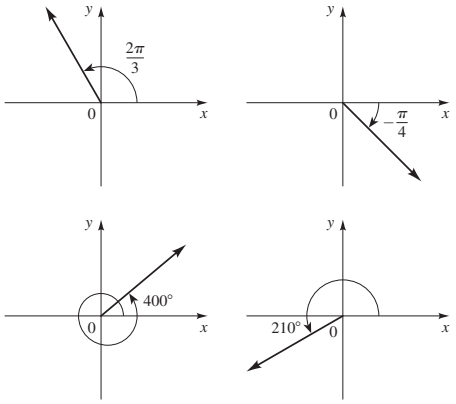
(b) $y = 17.8 \sin(0.52t + 3.11) + 42.4$

Chapter 6

Section 6.1 ■ Page 492

1. **(a)** arc, 1 **(b)** $\pi/180$ **(c)** $180/\pi$

(d) Vertex at the origin, initial side on the positive x-axis.



2. **(a)** $r\theta$ **(b)** $\frac{1}{2}r^2\theta$

3. **(a)** θ/t **(b)** s/t **(c)** $r\omega$ **4.** No, B **5.** $\pi/9 \approx 0.349$ rad

7. $3\pi/10 \approx 0.942$ rad **9.** $-\pi/4 \approx -0.785$ rad

11. $5\pi/9 \approx 1.745$ rad **13.** $50\pi/9 \approx 17.453$ rad

15. $-7\pi/18 \approx -1.222$ rad **17.** 210° **19.** 150°

21. $(540/\pi)° \approx 171.9°$ **23.** $(-630/\pi)° \approx -200.5°$

25. 18° **27.** −24° **29.** 410°, 770°, −310°, −670°

31. $11\pi/4$, $19\pi/4$, $-5\pi/4$, $-13\pi/4$

33. $7\pi/4$, $15\pi/4$, $-9\pi/4$, $-17\pi/4$ **35.** Yes **37.** Yes

39. Yes **41.** 40° **43.** 60° **45.** 280° **47.** $7\pi/6$

49. π **51.** $\pi/4$ **53.** $15\pi/2 \approx 23.6$

55. 2 rad $\approx 114.6°$ **57.** 8 cm **59.** $\frac{14}{9}$ rad, 89.1°

61. $18/\pi \approx 5.73$ m **63.** **(a)** $128\pi/9 \approx 44.68$ **(b)** 25

65. $24\pi \approx 75.4$ m^2 **67.** $9\sqrt{10\pi}/2\pi \approx 8.03$ m

69. $\frac{1}{2}$ rad **71.** $\pi/4$ ft^2 **73.** **(a)** $3\pi/2$ rad, $\pi/8$ rad

(b) $23\pi/2$ rad, $23\pi/24$ rad **75.** 13.9 mi **77.** 330π mi ≈ 1037 mi

79. 1.6 million mi **81.** 1.15 mi **83.** 360π in$^2 \approx 1130.97$ in^2

85. **(a)** 90π rad/min **(b)** 1440π in./min ≈ 4523.9 in./min

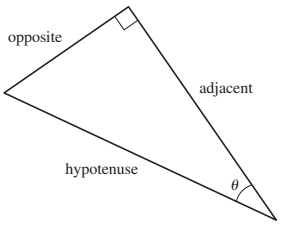
87. $32\pi/15$ ft/s ≈ 6.7 ft/s **89.** 1039.6 mi/h **91.** 2.1 m/s

93. **(a)** 10π cm ≈ 31.4 cm **(b)** 5 cm **(c)** 3.32 cm

(d) 86.8 cm^3

Section 6.2 ■ Page 501

1. **(a)**



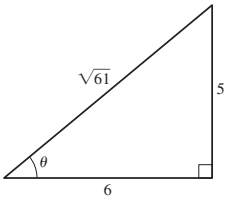
(b) $\frac{\text{opposite}}{\text{hypotenuse}}, \frac{\text{adjacent}}{\text{hypotenuse}}, \frac{\text{opposite}}{\text{adjacent}}$ **2.** similar

3. $\sin\theta, \cos\theta, \tan\theta$ **4.** **(a)** $x = r\cos\theta$, $y = r\sin\theta$ **(b)** $3\sqrt{3}, 3$

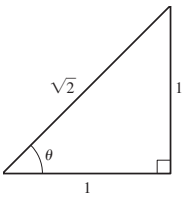
5. $\sin\theta = \frac{4}{5}$, $\cos\theta = \frac{3}{5}$, $\tan\theta = \frac{4}{3}$, $\csc\theta = \frac{5}{4}$, $\sec\theta = \frac{5}{3}$, $\cot\theta = \frac{3}{4}$

7. $\sin\theta = \frac{40}{41}$, $\cos\theta = \frac{9}{41}$, $\tan\theta = \frac{40}{9}$, $\csc\theta = \frac{41}{40}$, $\sec\theta = \frac{41}{9}$, $\cot\theta = \frac{9}{40}$

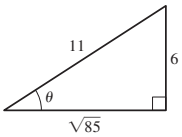
9. $\sin\theta = 2\sqrt{13}/13$, $\cos\theta = 3\sqrt{13}/13$, $\tan\theta = \frac{2}{3}$, $\csc\theta = \sqrt{13}/2$, $\sec\theta = \sqrt{13}/3$, $\cot\theta = \frac{3}{2}$
11. **(a)** $3\sqrt{34}/34$, $3\sqrt{34}/34$ **(b)** $\frac{3}{5}, \frac{3}{5}$ **(c)** $\sqrt{34}/5$, $\sqrt{34}/5$
13. **(a)** 0.37461 **(b)** 0.41421 **15.** **(a)** 1.85082 **(b)** 1.23490
17. $\frac{25}{2}$ **19.** $13\sqrt{3}/2$ **21.** 16.51658
23. $x = 28\cos\theta$, $y = 28\sin\theta$
25. $\sin\theta = 5\sqrt{61}/61$, $\cos\theta = 6\sqrt{61}/61$, $\csc\theta = \sqrt{61}/5$, $\sec\theta = \sqrt{61}/6$, $\cot\theta = \frac{6}{5}$



27. $\sin\theta = \sqrt{2}/2$, $\cos\theta = \sqrt{2}/2$, $\tan\theta = 1$, $\csc\theta = \sqrt{2}$, $\sec\theta = \sqrt{2}$

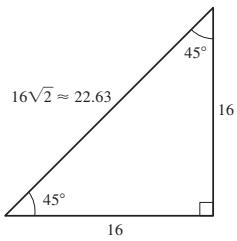


29. $\sin\theta = \frac{6}{11}$, $\cos\theta = \sqrt{85}/11$, $\tan\theta = 6\sqrt{85}/85$, $\sec\theta = 11\sqrt{85}/85$, $\cot\theta = \sqrt{85}/6$

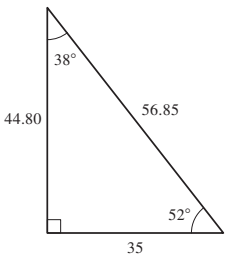


31. $(1 + \sqrt{3})/2$ **33.** 1 **35.** $\frac{1}{2}$ **37.** $\frac{3}{4} + (\sqrt{2}/2)$

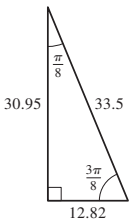
39.



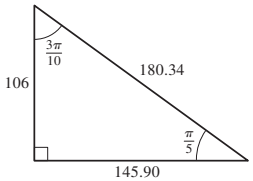
41.



43.



45.



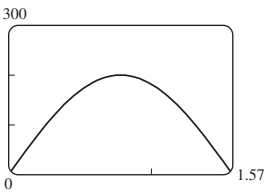
47. $\sin\theta \approx 0.44$, $\cos\theta \approx 0.89$, $\tan\theta = 0.50$, $\csc\theta \approx 2.25$, $\sec\theta \approx 1.125$, $\cot\theta = 2.00$ **49.** 230.9 **51.** 63.7
53. $x = 10\tan\theta\sin\theta$ **55.** 1026 ft
57. **(a)** 2100 mi **(b)** No **59.** 19 ft **61.** 345 ft
63. 415 ft, 152 ft **65.** 2570 ft **67.** 5808 ft
69. 91.7 million mi **71.** 3960 mi **73.** 0.723 AU

Section 6.3 ■ Page 513

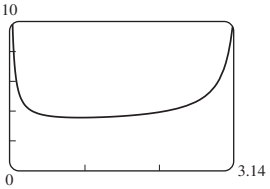
1. y/r, x/r, y/x **2.** quadrant; positive; negative; negative
3. **(a)** x-axis; 80°, 10° **(b)** 80°; 10° **4.** $\frac{1}{2}ab\sin\theta$; 7
5. **(a)** 45° **(b)** 15° **(c)** 60° **7.** **(a)** 70° **(b)** 55° **(c)** 80° **9.** **(a)** $3\pi/10$ **(b)** $\pi/8$ **(c)** $\pi/3$
11. **(a)** $2\pi/7$ **(b)** 0.4π **(c)** 1.4 **13.** $-\sqrt{3}/2$ **15.** -1
17. $-2\sqrt{3}/3$ **19.** $-\sqrt{2}/2$ **21.** 2 **23.** $\sqrt{3}$ **25.** -1
27. $-\sqrt{3}$ **29.** -2 **31.** 2 **33.** -1 **35.** Undefined
37. III **39.** IV **41.** $-\frac{1}{2}$ **43.** $-\sqrt{2}/2$ **45.** $\sqrt{13}/3$
47. $\sin\theta = \frac{4}{5}$, $\tan\theta = -\frac{4}{3}$, $\csc\theta = \frac{5}{4}$, $\sec\theta = -\frac{5}{3}$, $\cot\theta = -\frac{3}{4}$
49. $\sin\theta = -\sqrt{5}/5$, $\cos\theta = 2\sqrt{5}/5$, $\tan\theta = -\frac{1}{2}$, $\csc\theta = -\sqrt{5}$, $\sec\theta = \sqrt{5}/2$
51. $\cos\theta = -\sqrt{5}/3$, $\tan\theta = 2\sqrt{5}/5$, $\csc\theta = -\frac{3}{2}$, $\sec\theta = -3\sqrt{5}/5$, $\cot\theta = \sqrt{5}/2$
53. $\cos\theta = \sqrt{15}/4$, $\tan\theta = \sqrt{15}/15$, $\csc\theta = 4$, $\sec\theta = 4\sqrt{15}/15$, $\cot\theta = \sqrt{15}$
55. $\sin\theta = -3\sqrt{10}/10$, $\cos\theta = -\sqrt{10}/10$, $\csc\theta = -\sqrt{10}/3$, $\sec\theta = -\sqrt{10}$, $\cot\theta = \frac{1}{3}$
57. $\sin\theta = -\frac{1}{4}$, $\cos\theta = \sqrt{15}/4$, $\tan\theta = -\sqrt{15}/15$, $\sec\theta = 4\sqrt{15}/15$, $\cot\theta = -\sqrt{15}$
59. $\tan\theta = -\dfrac{\sqrt{1-\cos^2\theta}}{\cos\theta}$
61. $\cos\theta = \sqrt{1-\sin^2\theta}$ **63.** $\sec\theta = -\sqrt{1+\tan^2\theta}$
65. $\sqrt{3}/2$, $\sqrt{3}$ **67.** 30.0 **69.** $25\sqrt{3} \approx 43.3$
71. 10.9 in. **73.** $(4\pi/3) - \sqrt{3} \approx 2.46$ **75.** $\sqrt{3} - \pi/2 \approx 0.16$
77. **(b)**

θ	20°	60°	80°	85°
h	1922	9145	29,944	60,351

79. **(a)** $A(\theta) = 400\sin\theta\cos\theta$
(b)



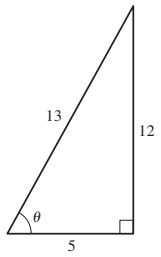
(c) Width = depth ≈ 14.14 in.
81. **(a)** $9\sqrt{3}/4 \approx 3.897$ ft, $\frac{9}{16} = 0.5625$ ft
(b) 23.982 ft, 3.462 ft
83. **(a)**



(b) 0.946 rad or 54°

Section 6.4 ■ Page 521

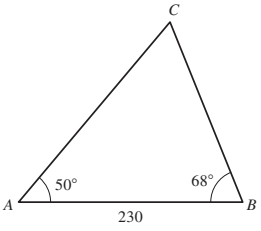
1. one-to-one; domain, $[-\pi/2, \pi/2]$
2. **(a)** $[-1, 1]$, $[-\pi/2, \pi/2]$ **(b)** $[-1, 1]$, $[0, \pi]$
(c) $\mathbb{R}$, $(-\pi/2, \pi/2)$ **3.** **(a)** $\frac{8}{10}$ **(b)** $\frac{6}{10}$ **(c)** $\frac{8}{6}$
4. $\frac{5}{13}, \frac{12}{5}$



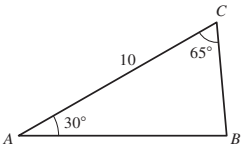
5. **(a)** $\pi/2$ **(b)** $\pi/2$ **(c)** $\pi/3$
7. **(a)** $-\pi/4$ **(b)** $3\pi/4$ **(c)** $-\pi/4$ **9.** 0.305, 17.458°
11. 1.231, 70.529° **13.** 1.249, 71.565° **15.** Undefined
17. 36.9° **19.** 34.7° **21.** 34.8° **23.** 36.9° **25.** −56.3°
27. 41.8°, 138.2° **29.** 113.6° **31.** 78.7° **33.** $\frac{3}{5}$ **35.** $\frac{13}{5}$
37. $-\frac{12}{13}$ **39.** $\sqrt{15}/4$ **41.** $\sqrt{1-x^2}$ **43.** $\dfrac{1}{x}$ **45.** $\sqrt{x^2+1}$
47. 72.5°, 19 ft **49.** **(a)** $h = 2\tan\theta$ **(b)** $\theta = \tan^{-1}(h/2)$
51. **(a)** $\theta = \sin^{-1}(h/680)$ **(b)** $\theta = 47.3°$
53. **(a)** $\theta = \cos^{-1}\left(\dfrac{3960}{h+3960}\right)$ **(b)** $s = 7920\theta$
(c) $s = 7920\cos^{-1}\left(\dfrac{3960}{h+3960}\right)$ **(d)** 1761.5 mi **(e)** 197.3 mi
55. 42°

Section 6.5 ■ Page 529

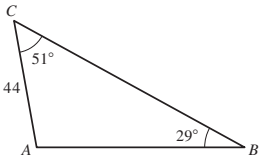
1. $\dfrac{\sin A}{a} = \dfrac{\sin B}{b} = \dfrac{\sin C}{c}$ **2.** **(a)** ASA, SSA **(b)** SSA
3. $\dfrac{\sin 40°}{6} = \dfrac{\sin 110°}{x}$, $x \approx 8.8$
4. $\dfrac{\sin\theta}{6} = \dfrac{\sin 50°}{5}$, $\theta \approx 66.8°$
5. 318.8 **7.** 24.8 **9.** 43.9°
11. $\angle C = 114°$, $a \approx 51.2$, $b \approx 24.3$
13. $\angle A = 44°$, $\angle B = 68°$, $a \approx 8.99$
15. $\angle C = 62°$, $a \approx 199.5$, $b \approx 241.5$



17. $\angle B = 85°$, $a \approx 5.0$, $c \approx 9.1$



19. $\angle A = 100°$, $a \approx 89.4$, $c \approx 70.5$



21. $\angle B \approx 30.2°$, $\angle C \approx 39.8°$, $c \approx 19.1$ **23.** No solution
25. $\angle A_1 \approx 124.5°$, $\angle C_1 \approx 30.5°$, $a_1 \approx 48.7$;
$\angle A_2 \approx 5.5°$, $\angle C_2 \approx 149.5°$, $a_2 \approx 5.6$
27. No solution
29. $\angle A \approx 122.8°$, $\angle B \approx 28.2°$, $b \approx 14.6$ **31.** 78.7°
33. **(a)** 91.1° **(b)** 14.4° **35.** **(a)** 1018 mi **(b)** 1017 mi
37. 219 ft **39.** 56 m **41.** 175 ft **43.** 192 m
45. 0.427 AU, 1.119 AU

Section 6.6 ■ Page 536

1. $a^2 + b^2 - 2ab\cos C$ **2.** SSS, SAS
3. $x^2 = 3^2 + 4^2 - 2\cdot 3\cdot 4\cdot\cos 35°$, $x \approx 2.3$
4. $3^2 = 6^2 + 5^2 - 2\cdot 6\cdot 5\cdot\cos\theta$, $\cos\theta = \frac{13}{15}$, $\theta \approx 29.9°$
5. 28.9 **7.** 47 **9.** 29.89° **11.** 15.1
13. $\angle A \approx 39.4°$, $\angle B \approx 20.6°$, $c \approx 24.6$
15. $\angle A \approx 47.5°$, $\angle B \approx 79.5°$, $c \approx 3.2$
17. $\angle A \approx 49.9°$, $\angle B \approx 72.9°$, $\angle C \approx 57.2°$
19. $\angle A_1 \approx 83.6°$, $\angle C_1 \approx 56.4°$, $a_1 \approx 193.2$;
$\angle A_2 \approx 16.4°$, $\angle C_2 \approx 123.6$, $a_2 \approx 55.0$
21. No such triangle **23.** 2.0 **25.** 25.4 **27.** 89.2°
29. 24.3 **31.** 54 **33.** 26.83 **35.** 5.33 **37.** 40.77
39. 3.85 cm^2 **41.** 2.30 mi **43.** 23.1 mi **45.** 2179 mi
47. **(a)** 62.6 mi **(b)** S 18.2° E **49.** 95.7° **51.** 211 ft
53. 3835 ft **55.** $165,554

Chapter 6 Review ■ Page 543

1. **(a)** $\pi/6$ **(b)** $5\pi/6$ **(c)** $-\pi/9$ **(d)** $-5\pi/4$
3. **(a)** 150° **(b)** −20° **(c)** −240° **(d)** 229.2°
5. $4\pi \approx 12.6$ m **7.** $90/\pi \approx 28.6$ ft **9.** 21,609 **11.** 25 m^2
13. 0.4 rad ≈ 22.9° **15.** 300π rad/min ≈ 942.5 rad/min,
7539.8 in./min = 628.3 ft/min
17. $\sin\theta = 5/\sqrt{74}$, $\cos\theta = 7/\sqrt{74}$, $\tan\theta = \frac{5}{7}$,
$\csc\theta = \sqrt{74}/5$, $\sec\theta = \sqrt{74}/7$, $\cot\theta = \frac{7}{5}$
19. $x \approx 3.83$, $y \approx 3.21$ **21.** $x \approx 2.92$, $y \approx 3.11$
23. $A = 70°$, $a \approx 2.819$, $b \approx 1.026$
25. $A \approx 16.3°$, $C \approx 73.7°$, $c = 24$
27. $a = \cot\theta$, $b = \csc\theta$ **29.** 48 m **31.** 1076 mi
33. $-\sqrt{2}/2$ **35.** 1 **37.** $-\sqrt{3}/3$ **39.** $-\sqrt{2}/2$
41. $2\sqrt{3}/3$ **43.** $-\sqrt{3}$
45. $\sin\theta = \frac{12}{13}$, $\cos\theta = -\frac{5}{13}$, $\tan\theta = -\frac{12}{5}$,
$\csc\theta = \frac{13}{12}$, $\sec\theta = -\frac{13}{5}$, $\cot\theta = -\frac{5}{12}$ **47.** 60°
49. $\tan\theta = \sqrt{1-\cos^2\theta}/\cos\theta$
51. $\tan^2\theta = \sin^2\theta/(1-\sin^2\theta)$
53. $\sin\theta = \sqrt{7}/4$, $\cos\theta = \frac{3}{4}$, $\csc\theta = 4\sqrt{7}/7$, $\cot\theta = 3\sqrt{7}/7$
55. $\cos\theta = -\frac{4}{5}$, $\tan\theta = -\frac{3}{4}$, $\csc\theta = \frac{5}{3}$, $\sec\theta = -\frac{5}{4}$,
$\cot\theta = -\frac{4}{3}$ **57.** $-\sqrt{5}/5$ **59.** 1 **61.** $\pi/3$ **63.** $2/\sqrt{21}$
65. $x/\sqrt{1+x^2}$ **67.** $\theta = \cos^{-1}(x/3)$ **69.** 5.32 **71.** 148.07
73. 9.17 **75.** 54.1° **77.** 80.4° **79.** 77.3 mi **81.** 3.9 mi
83. 32.12 **85.** **(a)** VII **(b)** III **(c)** I **(d)** VI
(e) V **(f)** VIII **(g)** II **(h)** IV

Chapter 6 Test ■ Page 547

1. $11\pi/6, -3\pi/4$ **2.** $240°, -74.5°$
3. **(a)** 240π rad/min ≈ 753.98 rad/min
(b) 12,063.7 ft/min = 137 mi/h **4.** **(a)** $\sqrt{2}/2$
(b) $\sqrt{3}/3$ **(c)** 2 **(d)** 1 **5.** $(26 + 6\sqrt{13})/39$
6. $a = 24 \sin\theta$, $b = 24 \cos\theta$ **7.** $(4 - 3\sqrt{2})/4$
8. $-\frac{13}{12}$ **9.** $\tan\theta = -\sqrt{\sec^2\theta - 1}$ **10.** 19.6 ft
11. **(a)** $\theta = \tan^{-1}(x/4)$ **(b)** $\theta = \cos^{-1}(3/x)$ **12.** $\frac{40}{41}$
13. 9.1 **14.** 250.5 **15.** 8.4 **16.** 19.5 **17.** 78.6° **18.** 40.2°
19. **(a)** 15.3 m^2 **(b)** 24.3 m **20.** **(a)** 129.9° **(b)** 44.9
21. 554 ft

Focus on Modeling ■ Page 550

1. 1.41 mi **3.** 14.3 m **5.** **(b)** 2350 ft **7.** 4194 ft

Chapter 7

Section 7.1 ■ Page 558

1. all; 1 **2.** $\cos(-x) = \cos x$ **3.** $\sin t$ **5.** $\tan\theta$ **7.** -1
9. $\cos y$ **11.** $\csc u$ **13.** $\tan\theta$ **15.** 1 **17.** $\cos t + 1$
19. $\cos x$ **21.** $\sin^2 x$ **23.** $\cos y$ **25.** $2 \sec u$ **27.** $1 - \sin x$
29. $2 \sec^2\alpha$

31. **(a)** LHS $= \dfrac{1 - \sin^2 x}{\sin x} =$ RHS

33. LHS $= \cos\alpha \dfrac{1}{\dfrac{1}{\cos\alpha}} = \cos\alpha \cos\alpha =$ RHS

35. LHS $= \cos u \cdot \dfrac{1}{\cos u} \cdot \cot u =$ RHS

37. LHS $= \cos^2\left(\dfrac{\pi}{2} - y\right)\dfrac{1}{\sin y} = \sin^2 y \cdot \dfrac{1}{\sin y} =$ RHS

39. LHS $= \sin^2 x + 2 \sin x \cos x + \cos^2 x =$ RHS

41. LHS $= \cos x - (-\sin x) =$ RHS

43. LHS $= \dfrac{\sec A - 1}{\sec A + 1} \cdot \dfrac{\cos A}{\cos A} = \dfrac{1 - \cos A}{1 + \cos A} =$ RHS

45. LHS $= 1 - \cos^2\beta = \sin^2\beta =$ RHS

47. LHS $= \dfrac{1}{\cos^2 y} = \sec^2 y =$ RHS

49. LHS $= \tan^2 x + 2 \tan x \cot x + \cot^2 x = \tan^2 x + 2 + \cot^2 x$
$= (\tan^2 x + 1) + (\cot^2 x + 1) =$ RHS

51. LHS $= (2 \cos^2 t)^2 + 4 \sin^2 t \cos^2 t$
$= 4 \cos^2 t \cdot (\cos^2 t + \sin^2 t) =$ RHS

53. LHS $= \dfrac{\cos^2 x}{\sin x} + \dfrac{\sin^2 x}{\sin x} = \dfrac{1}{\sin x} =$ RHS

55. LHS $= \dfrac{1/(\cos t) - \cos t}{1/(\cos t)} \cdot \dfrac{\cos t}{\cos t} = \dfrac{1 - \cos^2 t}{1} =$ RHS

57. LHS $= \cos^2 x - (1 - \cos^2 x) = 2 \cos^2 x - 1 =$ RHS

59. LHS $= (\sin^2\theta)^2 - (\cos^2\theta)^2$
$= (\sin^2\theta - \cos^2\theta)(\sin^2\theta + \cos^2\theta) =$ RHS

61. LHS $= \dfrac{\sin^2 t + 2 \sin t \cos t + \cos^2 t}{\sin t \cos t}$
$= \dfrac{\sin^2 t + \cos^2 t}{\sin t \cos t} + \dfrac{2 \sin t \cos t}{\sin t \cos t} = \dfrac{1}{\sin t \cos t} + 2$
$=$ RHS

63. LHS $= \dfrac{1 + \dfrac{\sin^2 u}{\cos^2 u}}{1 - \dfrac{\sin^2 u}{\cos^2 u}} \cdot \dfrac{\cos^2 u}{\cos^2 u} = \dfrac{\cos^2 u + \sin^2 u}{\cos^2 u - \sin^2 u} =$ RHS

65. LHS $= \dfrac{\frac{1}{\cos x} + \frac{1}{\sin x}}{\frac{\sin x}{\cos x} + \frac{\cos x}{\sin x}} \cdot \dfrac{\sin x \cos x}{\sin x \cos x} = \dfrac{\sin x + \cos x}{\sin^2 x + \cos^2 x} =$ RHS

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

69. LHS $= \dfrac{\sin^2 u}{\cos^2 u} - \dfrac{\sin^2 u \cos^2 u}{\cos^2 u} = \dfrac{\sin^2 u}{\cos^2 u} \cdot (1 - \cos^2 u) =$ RHS

71. LHS $= \dfrac{1 + \frac{\sin x}{\cos x}}{1 - \frac{\sin x}{\cos x}} \cdot \dfrac{\cos x}{\cos x} = \dfrac{\cos x + \sin x}{\cos x - \sin x} =$ RHS

73. LHS $= \dfrac{\sec x - \tan x + \sec x + \tan x}{(\sec x + \tan x)(\sec x - \tan x)}$
$= \dfrac{2 \sec x}{\sec^2 x - \tan^2 x} =$ RHS

75. LHS $= \dfrac{(1 + \sin x)^2 - (1 - \sin x)^2}{(1 - \sin x)(1 + \sin x)}$
$= \dfrac{1 + 2 \sin x + \sin^2 x - 1 + 2 \sin x - \sin^2 x}{1 - \sin^2 x}$
$= \dfrac{4 \sin x}{\cos^2 x} = 4 \dfrac{\sin x}{\cos x} \cdot \dfrac{1}{\cos x} =$ RHS

77. LHS $= \dfrac{(\sin x + \cos x)(\sin^2 x - \sin x \cos x + \cos^2 x)}{\sin x + \cos x}$
$= \sin^2 x - \sin x \cos x + \cos^2 x =$ RHS

79. LHS $= \dfrac{1 - \cos\alpha}{\sin\alpha} \cdot \dfrac{1 + \cos\alpha}{1 + \cos\alpha}$
$= \dfrac{1 - \cos^2\alpha}{\sin\alpha (1 + \cos\alpha)} = \dfrac{\sin^2\alpha}{\sin\alpha (1 + \cos\alpha)} =$ RHS

81. LHS $= \dfrac{\sin w}{\sin w + \cos w} \cdot \dfrac{\frac{1}{\cos w}}{\frac{1}{\cos w}} = \dfrac{\frac{\sin w}{\cos w}}{\frac{\sin w}{\cos w} + \frac{\cos w}{\cos w}} =$ RHS

83. LHS $= \dfrac{\sec x}{\sec x - \tan x} \cdot \dfrac{\sec x + \tan x}{\sec x + \tan x}$
$= \dfrac{\sec x (\sec x + \tan x)}{\sec^2 x - \tan^2 x} =$ RHS

85. LHS $= \dfrac{(\sin x + \cos x)^2}{(\sin x + \cos x)(\sin x - \cos x)} = \dfrac{\sin x + \cos x}{\sin x - \cos x}$
$= \dfrac{(\sin x + \cos x)(\sin x - \cos x)}{(\sin x - \cos x)(\sin x - \cos x)} =$ RHS

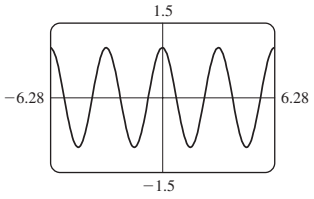
87. LHS $= \dfrac{1 - \sin x}{1 + \sin x} \cdot \dfrac{1 - \sin x}{1 - \sin x} = \dfrac{1 - 2 \sin x + \sin^2 x}{1 - \sin^2 x}$
$= \dfrac{1}{\cos^2 x} - \dfrac{2 \sin x}{\cos^2 x} + \dfrac{\sin^2 x}{\cos^2 x}$
$= \sec^2 x - 2 \sec x \tan x + \tan^2 x$
$= (\sec x - \tan x)^2 =$ RHS

89. $\text{LHS} = \dfrac{1}{\sin x} - \dfrac{\cos x}{\sin x} = \dfrac{(1 - \cos x)(1 + \cos x)}{\sin x\,(1 + \cos x)}$

$= \dfrac{\sin^2 x}{\sin x\,(1 + \cos x)} = \dfrac{1}{\frac{1}{\sin x} + \frac{\cos x}{\sin x}} = \text{RHS}$

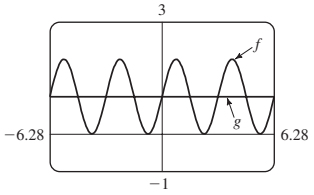
91. $\tan\theta$ **93.** $\tan\theta$ **95.** $3\cos\theta$

97.



Yes

99.



No

101. $\text{LHS} = \tan^2 x + 2\tan x\cot x + \cot^2 x$

$= \sec^2 x - 1 + 2 + \csc^2 x - 1 = \text{RHS}$

103. $\text{LHS} = \left(\sin\alpha - \dfrac{\sin\alpha}{\cos\alpha}\right)\left(\cos\alpha - \dfrac{\cos\alpha}{\sin\alpha}\right)$

$= \sin\alpha\left(1 - \dfrac{1}{\cos\alpha}\right)\cdot\cos\alpha\left(1 - \dfrac{1}{\sin\alpha}\right)$

$= \cos\alpha\left(1 - \dfrac{1}{\cos\alpha}\right)\cdot\sin\alpha\left(1 - \dfrac{1}{\sin\alpha}\right)$

$= (\cos\alpha - 1)(\sin\alpha - 1) = \text{RHS}$

105. $\text{RHS} = \dfrac{\sin^2 y - \tan^2 y}{\cos^2 y - \cot^2 y}\cdot\dfrac{\tan^2 y}{\tan^2 y}$

$= \dfrac{\sin^2 y\tan^2 y - \tan^4 y}{\sin^2 y - 1}$

$= \dfrac{\sin^2 y\tan^2 y - \tan^4 y}{-\cos^2 y}$

$= \dfrac{-\sin^2 y\tan^2 y}{\cos^2 y} + \dfrac{\tan^4 y}{\cos^2 y}$

$= -\tan^4 y + \dfrac{\tan^4 y}{\cos^2 y}$

$= \tan^4 y\,(-1 + \sec^2 y) = \text{LHS}$

107. $\text{LHS} = \ln|\tan x| + \ln|\sin x| = \ln\left|\dfrac{\sin x}{\cos x}\right| + \ln|\sin x|$

$= \ln|\sin x| + \ln\left|\dfrac{1}{\cos x}\right| + \ln|\sin x| = \text{RHS}$

109. $\text{LHS} = e^{1-\cos^2 x}e^{\sec^2 x - 1} = e^{1-\cos^2 x + \sec^2 x - 1} = \text{RHS}$

Section 7.2 ■ Page 567

1. Addition; $\sin x\cos y + \cos x\sin y$

2. Subtraction; $\cos x\cos y + \sin x\sin y$

3. $\dfrac{\sqrt{6} + \sqrt{2}}{4}$ **5.** $\dfrac{\sqrt{2} - \sqrt{6}}{4}$ **7.** $2 - \sqrt{3}$ **9.** $-\dfrac{\sqrt{6} + \sqrt{2}}{4}$

11. $\sqrt{3} - 2$ **13.** $-\dfrac{\sqrt{6} + \sqrt{2}}{4}$ **15.** $\cos 90° = 0$

17. $\sin\frac{\pi}{2} = 1$ **19.** $\tan 45° = 1$

21. $\text{LHS} = \dfrac{\sin\left(\frac{\pi}{2} - u\right)}{\cos\left(\frac{\pi}{2} - u\right)} = \dfrac{\sin\frac{\pi}{2}\cos u - \cos\frac{\pi}{2}\sin u}{\cos\frac{\pi}{2}\cos u + \sin\frac{\pi}{2}\sin u}$

$= \dfrac{\cos u}{\sin u} = \text{RHS}$

23. $\text{LHS} = \dfrac{1}{\cos\left(\frac{\pi}{2} - u\right)} = \dfrac{1}{\cos\frac{\pi}{2}\cos u + \sin\frac{\pi}{2}\sin u}$

$= \dfrac{1}{\sin u} = \text{RHS}$

25. $\text{LHS} = \sin x\cos\frac{\pi}{2} - \cos x\sin\frac{\pi}{2} = \text{RHS}$

27. $\text{LHS} = \sin x\cos\pi - \cos x\sin\pi = \text{RHS}$

29. $\text{LHS} = \dfrac{\tan x - \tan\pi}{1 + \tan x\tan\pi} = \text{RHS}$

31. $\text{LHS} = \sin\left(\dfrac{\pi}{2} - x\right) = \sin\dfrac{\pi}{2}\cos x - \cos\dfrac{\pi}{2}\sin x = \cos x$

$\text{RHS} = \sin\left(\dfrac{\pi}{2} + x\right) = \sin\dfrac{\pi}{2}\cos x + \cos\dfrac{\pi}{2}\sin x = \cos x$

33. $\text{LHS} = \dfrac{\tan x + \tan\frac{\pi}{3}}{1 - \tan x\tan\frac{\pi}{3}} = \text{RHS}$

35. $\text{LHS} = \sin x\cos y + \cos x\sin y$

$-(\sin x\cos y - \cos x\sin y) = \text{RHS}$

37. $\text{LHS} = \dfrac{1}{\tan(x - y)} = \dfrac{1 + \tan x\tan y}{\tan x - \tan y}$

$= \dfrac{1 + \frac{1}{\cot x}\frac{1}{\cot y}}{\frac{1}{\cot x} - \frac{1}{\cot y}}\cdot\dfrac{\cot x\cot y}{\cot x\cot y} = \text{RHS}$

39. $\text{LHS} = \dfrac{\sin x}{\cos x} - \dfrac{\sin y}{\cos y} = \dfrac{\sin x\cos y - \cos x\sin y}{\cos x\cos y} = \text{RHS}$

41. $\text{LHS} = \dfrac{(\tan x - \tan y)(\cos x\cos y)}{(1 - \tan x\tan y)(\cos x\cos y)}$

$= \dfrac{\sin x\cos y - \cos x\sin y}{\cos x\cos y - \sin x\sin y} = \text{RHS}$

43. $\text{LHS} = (\cos x\cos y - \sin x\sin y)(\cos x\cos y + \sin x\sin y)$

$= \cos^2 x\cos^2 y - \sin^2 x\sin^2 y$

$= \cos^2 x(1 - \sin^2 y) - (1 - \cos^2 x)\sin^2 y$

$= \cos^2 x - \sin^2 y\cos^2 x + \sin^2 y\cos^2 x - \sin^2 y = \text{RHS}$

45. $\text{LHS} = \sin((x + y) + z)$

$= \sin(x + y)\cos z + \cos(x + y)\sin z$

$= \cos z[\sin x\cos y + \cos x\sin y]$

$+ \sin z[\cos x\cos y - \sin x\sin y] = \text{RHS}$

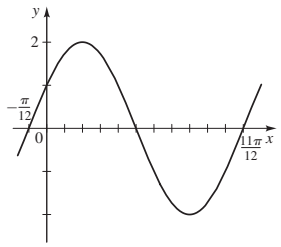
47. $\dfrac{\sqrt{1 - x^2} + xy}{\sqrt{1 + y^2}}$ **49.** $\dfrac{x - y}{\sqrt{1 + x^2}\sqrt{1 + y^2}}$

51. $\frac{1}{4}(\sqrt{6} + \sqrt{2})$ **53.** $\dfrac{3 - 2\sqrt{14}}{\sqrt{7} + 6\sqrt{2}}$ **55.** $-3\sqrt{10}/10$

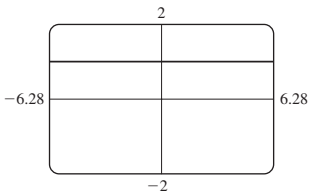
57. $2\sqrt{5}/65$ **59.** $2\sin\left(x + \dfrac{5\pi}{6}\right)$ **61.** $5\sqrt{2}\sin 2\left(x + \dfrac{7\pi}{8}\right)$

63. **(a)** $g(x) = 2\sin 2\left(x + \dfrac{\pi}{12}\right)$

(b)



67. **(a)**



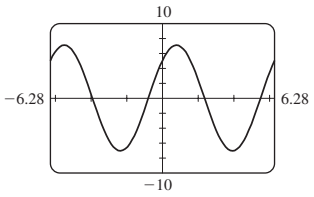
$$\sin^2\left(x + \frac{\pi}{4}\right) + \sin^2\left(x - \frac{\pi}{4}\right) = 1$$

71. $\text{LHS} = \tan^{-1}\left(\dfrac{\tan u + \tan v}{1 - \tan u \tan v}\right) = \tan^{-1}(\tan(u + v))$

$= u + v = \text{RHS}$

73. **(c)** $8.1°$

75. **(a)**



(b) $k = 5\sqrt{2}$, $\phi = \pi/4$

Section 7.3 ■ Page 576

1. Double-Angle; $2\sin x \cos x$

2. Half-Angle; $\pm\sqrt{(1 - \cos x)/2}$

3. $\frac{120}{169}, \frac{119}{169}, \frac{120}{119}$ **5.** $-\frac{24}{25}, \frac{7}{25}, -\frac{24}{7}$ **7.** $\frac{24}{25}, \frac{7}{25}, \frac{24}{7}$

9. $-\frac{3}{5}, \frac{4}{5}, -\frac{3}{4}$ **11.** $\frac{1}{2}\left(\frac{3}{4} - \cos 2x + \frac{1}{4}\cos 4x\right)$

13. $\frac{1}{16}(1 - \cos 2x - \cos 4x + \cos 2x \cos 4x)$

15. $\frac{1}{32}\left(\frac{3}{4} - \cos 4x + \frac{1}{4}\cos 8x\right)$

17. $\frac{1}{2}\sqrt{2 - \sqrt{3}}$ **19.** $\sqrt{2} - 1$ **21.** $-\frac{1}{2}\sqrt{2 + \sqrt{3}}$

23. $-\sqrt{2} - 1$ **25.** $\frac{1}{2}\sqrt{2 + \sqrt{3}}$ **27.** $-\frac{1}{2}\sqrt{2 - \sqrt{2}}$

29. **(a)** $\sin 32°$ **(b)** $\sin 8\theta$ **31.** **(a)** $\cos 42°$ **(b)** $\cos 18\theta$

33. **(a)** $\tan 4°$ **(b)** $\tan 2\theta$ **37.** $\sqrt{10}/10, 3\sqrt{10}/10, \frac{1}{3}$

39. $\sqrt{(3 + 2\sqrt{2})/6}, \sqrt{(3 - 2\sqrt{2})/6}, 3 + 2\sqrt{2}$

41. $\sqrt{6}/6, -\sqrt{30}/6, -\sqrt{5}/5$ **43.** $\frac{336}{625}$ **45.** $\frac{8}{7}$ **47.** $\dfrac{2x}{1 + x^2}$

49. $\sqrt{\dfrac{1 - x}{2}}$ **51.** $\frac{7}{25}$ **53.** $-8\sqrt{3}/49$ **55.** $\frac{1}{2}(\sin 9x + \sin x)$

57. $\frac{1}{2}(\sin 5x + \sin 3x)$ **59.** $\frac{3}{2}(\cos 11x + \cos 3x)$

61. $2\sin 6x \cos x$ **63.** $2\sin 5x \sin x$ **65.** $-2\cos\frac{9}{2}x \sin\frac{5}{2}x$

67. $(\sqrt{2} + \sqrt{3})/2$ **69.** $\frac{1}{4}(\sqrt{2} - 1)$ **71.** $\sqrt{2}/2$

73. $\text{LHS} = \cos(2 \cdot 5x) = \text{RHS}$

75. $\text{LHS} = \sin^2 x + 2\sin x \cos x + \cos^2 x$

$= 1 + 2\sin x \cos x = \text{RHS}$

77. $\text{LHS} = \dfrac{2\tan x}{\sec^2 x} = 2 \cdot \dfrac{\sin x}{\cos x}\cos^2 x = 2\sin x \cos x = \text{RHS}$

79. $\text{LHS} = \dfrac{1 - \cos x}{\sin x} + \cos x\left(\dfrac{1 - \cos x}{\sin x}\right)$

$= \dfrac{1 - \cos x + \cos x - \cos^2 x}{\sin x} = \dfrac{\sin^2 x}{\sin x} = \text{RHS}$

81. $\text{LHS} = \dfrac{2\sin 2x \cos 2x}{\sin x} = \dfrac{2(2\sin x \cos x)(\cos 2x)}{\sin x} = \text{RHS}$

83. $\text{LHS} = \dfrac{\cos^2 x - \sin^2 x}{(\sin^2 x + \cos^2 x) + 2\sin x \cos x}$

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

$= \dfrac{(\cos x - \sin x)}{(\cos x + \sin x)} \cdot \dfrac{\dfrac{1}{\cos x}}{\dfrac{1}{\cos x}} = \text{RHS}$

85. $\text{LHS} = \dfrac{1}{\tan 2x} = \dfrac{1}{\dfrac{2\tan x}{1 - \tan^2 x}} = \text{RHS}$

87. $\text{LHS} = \tan(2x + x) = \dfrac{\tan 2x + \tan x}{1 - \tan 2x \tan x}$

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

$= \dfrac{2\tan x + \tan x\,(1 - \tan^2 x)}{1 - \tan^2 x - 2\tan x \tan x} = \text{RHS}$

89. $\text{LHS} = \dfrac{2\sin 3x \cos 2x}{2\cos 3x \cos 2x} = \dfrac{\sin 3x}{\cos 3x} = \text{RHS}$

91. $\text{LHS} = \dfrac{2\sin 5x \cos 5x}{2\sin 5x \cos 4x} = \text{RHS}$

93. $\text{LHS} = \dfrac{2\sin\left(\dfrac{x + y}{2}\right)\cos\left(\dfrac{x - y}{2}\right)}{2\cos\left(\dfrac{x + y}{2}\right)\cos\left(\dfrac{x - y}{2}\right)}$

$= \dfrac{\sin\left(\dfrac{x + y}{2}\right)}{\cos\left(\dfrac{x + y}{2}\right)} = \text{RHS}$

95. $\text{LHS} = \dfrac{1 - \cos 2\left(\dfrac{x}{2} + \dfrac{\pi}{4}\right)}{1 + \cos 2\left(\dfrac{x}{2} + \dfrac{\pi}{4}\right)} = \dfrac{1 - \cos\left(x + \dfrac{\pi}{2}\right)}{1 + \cos\left(x + \dfrac{\pi}{2}\right)}$

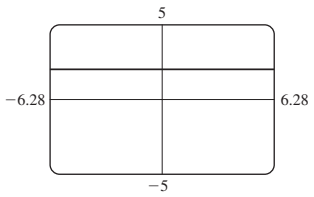
$= \dfrac{1 - (-\sin x)}{1 + (-\sin x)} = \text{RHS}$

101. LHS $= \dfrac{(\sin x + \sin 5x) + (\sin 2x + \sin 4x) + \sin 3x}{(\cos x + \cos 5x) + (\cos 2x + \cos 4x) + \cos 3x}$

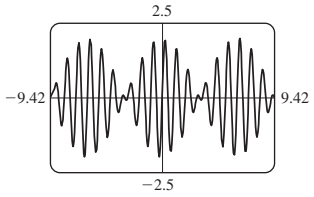
$= \dfrac{2 \sin 3x \cos 2x + 2 \sin 3x \cos x + \sin 3x}{2 \cos 3x \cos 2x + 2 \cos 3x \cos x + \cos 3x}$

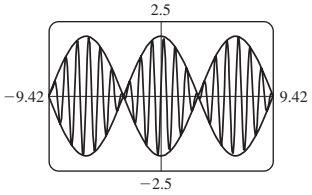
$= \dfrac{\sin 3x\,(2 \cos 2x + 2 \cos x + 1)}{\cos 3x\,(2 \cos 2x + 2 \cos x + 1)} = \text{RHS}$

103. RHS $= \cos^{-1}(1 - 2 \sin^2 u) = \cos^{-1}(\cos 2u) = 2u = \text{LHS}$

105. (a) 

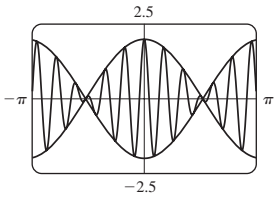
$\dfrac{\sin 3x}{\sin x} - \dfrac{\cos 3x}{\cos x} = 2$

107. (a) 

(c) 

The graph of $y = f(x)$ lies between the two other graphs.

109. (a) $P(t) = 8t^4 - 8t^2 + 1$ **(b)** $Q(t) = 16t^5 - 20t^3 + 5t$

115. (a) and **(c)** 

The graph of f lies between the graphs of $y = 2 \cos t$ and $y = -2 \cos t$. Thus, the loudness of the sound varies between $y = \pm 2 \cos t$.

Section 7.4 ■ Page 584

1. infinitely many **2.** no, infinitely many
3. 0.3; $x \approx -9.7, -6.0, -3.4, 0.3, 2.8, 6.6, 9.1$
4. (a) 0.30, 2.84 **(b)** 2π; $0.30 + 2k\pi$, $2.84 + 2k\pi$

5. $\dfrac{\pi}{3} + 2k\pi, \dfrac{2\pi}{3} + 2k\pi$

7. $(2k + 1)\pi$ **9.** $1.32 + 2k\pi, 4.97 + 2k\pi$

11. $3.61 + 2k\pi, 5.82 + 2k\pi$ **13.** $-\dfrac{\pi}{3} + k\pi$

15. $1.37 + k\pi$ **17.** $\dfrac{5\pi}{6} + 2k\pi, \dfrac{7\pi}{6} + 2k\pi$; $-7\pi/6, -5\pi/6, 5\pi/6, 7\pi/6, 17\pi/6, 19\pi/6$

19. $\dfrac{\pi}{4} + 2k\pi, \dfrac{3\pi}{4} + 2k\pi$; $-7\pi/4, -5\pi/4, \pi/4, 3\pi/4, 9\pi/4, 11\pi/4$

21. $1.29 + 2k\pi, 5.00 + 2k\pi$; $-5.00, -1.29, 1.29, 5.00, 7.57, 11.28$
23. $-1.47 + k\pi$; $-7.75, -4.61, -1.47, 1.67, 4.81, 7.95$

25. $(2k + 1)\pi$ **27.** $\dfrac{\pi}{6} + 2k\pi, \dfrac{11\pi}{6} + 2k\pi$

29. $1.23 + 2k\pi, 5.05 + 2k\pi$ **31.** $-\dfrac{\pi}{6} + k\pi, \dfrac{\pi}{6} + k\pi$

33. $\dfrac{\pi}{4} + k\pi, \dfrac{3\pi}{4} + k\pi$ **35.** $\pm 0.62 + k\pi$

37. $\dfrac{\pi}{4} + k\pi, \dfrac{3\pi}{4} + k\pi$

39. $-1.11 + k\pi, 1.11 + k\pi, \dfrac{2\pi}{3} + 2k\pi, \dfrac{4\pi}{3} + 2k\pi$

41. $\dfrac{\pi}{3} + 2k\pi, \dfrac{5\pi}{3} + 2k\pi$ **43.** $-1.11 + k\pi, 1.25 + k\pi$

45. $\dfrac{\pi}{3} + 2k\pi, \dfrac{5\pi}{3} + 2k\pi$ **47.** No solution **49.** $\dfrac{3\pi}{2} + 2k\pi$

51. $\dfrac{\pi}{2} + k\pi, \dfrac{7\pi}{6} + 2k\pi, \dfrac{11\pi}{6} + 2k\pi$ **53.** $\dfrac{\pi}{2} + k\pi$

55. $k\pi, 0.73 + 2k\pi, 2.41 + 2k\pi$ **57.** 44.95°
59. (a) 0° **(b)** 60°, 300° **(c)** 90°, 270° **(d)** 180°

Section 7.5 ■ Page 590

1. $\sin x = 0, k\pi$ **2.** $\sin x + 2 \sin x \cos x = 0$, $\sin x = 0$, $1 + 2 \cos x = 0$ **3.** $\dfrac{7\pi}{6} + 2k\pi, \dfrac{11\pi}{6} + 2k\pi, \dfrac{\pi}{2} + 2k\pi$

5. $\pi + 2k\pi, 1.23 + 2k\pi, 5.05 + 2k\pi$

7. $k\pi, \dfrac{\pi}{3} + 2k\pi, \dfrac{5\pi}{3} + 2k\pi$ **9.** $\dfrac{\pi}{6} + k\pi, \dfrac{5\pi}{6} + k\pi$

11. $\dfrac{\pi}{3} + 2k\pi, \dfrac{5\pi}{3} + 2k\pi, (2k + 1)\pi$

13. $(2k + 1)\pi, \dfrac{\pi}{2} + 2k\pi$ **15.** $2k\pi$

17. (a) $\dfrac{\pi}{9} + \dfrac{2k\pi}{3}, \dfrac{5\pi}{9} + \dfrac{2k\pi}{3}$ **(b)** $\pi/9, 5\pi/9, 7\pi/9, 11\pi/9, 13\pi/9, 17\pi/9$

19. (a) $\dfrac{\pi}{3} + k\pi, \dfrac{2\pi}{3} + k\pi$ **(b)** $\pi/3, 2\pi/3, 4\pi/3, 5\pi/3$

21. (a) $\dfrac{5\pi}{18} + \dfrac{k\pi}{3}$ **(b)** $5\pi/18, 11\pi/18, 17\pi/18, 23\pi/18, 29\pi/18, 35\pi/18$ **23. (a)** $4k\pi$ **(b)** 0

25. (a) $4\pi + 6k\pi, 5\pi + 6k\pi$ **(b)** None

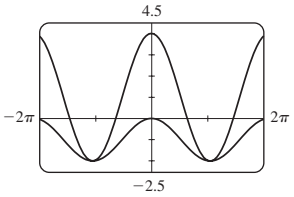
27. (a) $0.62 + \dfrac{k\pi}{2}$ **(b)** 0.62, 2.19, 3.76, 5.33

29. (a) $k\pi, \dfrac{\pi}{2} + 2k\pi$ **(b)** $0, \pi/2, \pi$

31. (a) $\dfrac{\pi}{6} + k\pi, \dfrac{\pi}{4} + k\pi, \dfrac{5\pi}{6} + k\pi$
(b) $\pi/6, \pi/4, 5\pi/6, 7\pi/6, 5\pi/4, 11\pi/6$

33. (a) $\dfrac{\pi}{6} + 2k\pi, \dfrac{5\pi}{6} + 2k\pi, \dfrac{3\pi}{4} + k\pi$
(b) $\pi/6, 3\pi/4, 5\pi/6, 7\pi/4$

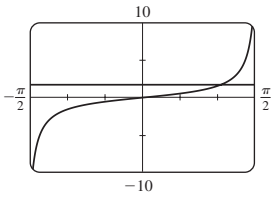
35. (a)



$(\pm 3.14, -2)$

(b) $((2k+1)\pi, -2)$

37. (a)



$(1.05, 1.73)$

(b) $\left(\frac{\pi}{3} + k\pi, \sqrt{3}\right)$

39. $\pi/8, 3\pi/8, 5\pi/8, 7\pi/8, 9\pi/8, 11\pi/8, 13\pi/8, 15\pi/8$
41. $\pi/3, 2\pi/3$ **43.** $\pi/2, 7\pi/6, 3\pi/2, 11\pi/6$ **45.** 0
47. $0, \pi$ **49.** $0, \pi/3, 2\pi/3, \pi, 4\pi/3, 5\pi/3$ **51.** $\pi/6, 3\pi/2$

53. $k\pi/2$ **55.** $\frac{\pi}{2} + k\pi, \frac{\pi}{9} + \frac{2k\pi}{3}, \frac{5\pi}{9} + \frac{2k\pi}{3}$

57. $0, \pm 0.95$ **59.** 1.92 **61.** ± 0.71

63. $\frac{\sqrt{17} - 3}{4}$ **65.** 0.95° or 89.1°

67. (a) 34th day (February 3), 308th day (November 4)
(b) 275 days

Chapter 7 Review ■ Page 594

1. $\text{LHS} = \sin\theta\left(\frac{\cos\theta}{\sin\theta} + \frac{\sin\theta}{\cos\theta}\right) = \cos\theta + \frac{\sin^2\theta}{\cos\theta}$
$= \frac{\cos^2\theta + \sin^2\theta}{\cos\theta} = \text{RHS}$

3. $\text{LHS} = (1 - \sin^2 x)\csc x - \csc x$
$= \csc x - \sin^2 x \csc x - \csc x$
$= -\sin^2 x \cdot \frac{1}{\sin x} = \text{RHS}$

5. $\text{LHS} = \frac{\cos^2 x}{\sin^2 x} - \frac{\tan^2 x}{\sin^2 x} = \cot^2 x - \frac{1}{\cos^2 x} = \text{RHS}$

7. $\text{LHS} = \frac{\cos x}{\frac{1}{\cos x}(1 - \sin x)} = \frac{\cos x}{\frac{1}{\cos x} - \frac{\sin x}{\cos x}} = \text{RHS}$

9. $\text{LHS} = \sin^2 x \cdot \frac{\cos^2 x}{\sin^2 x} + \cos^2 x \cdot \frac{\sin^2 x}{\cos^2 x} = \cos^2 x + \sin^2 x = \text{RHS}$

11. $\text{LHS} = \frac{2\sin x \cos x}{1 + 2\cos^2 x - 1} = \frac{2\sin x \cos x}{2\cos^2 x} = \frac{\sin x}{\cos x} = \text{RHS}$

13. $\text{LHS} = \csc x - \frac{1 - \cos x}{\sin x}$
$= \csc x - (\csc x - \cot x) = \text{RHS}$

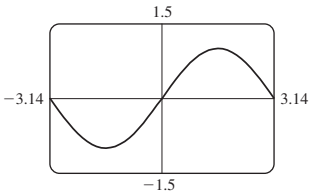
15. $\text{LHS} = \frac{2\sin x \cos x}{\sin x} - \frac{2\cos^2 x - 1}{\cos x}$
$= 2\cos x - 2\cos x + \frac{1}{\cos x} = \text{RHS}$

17. $\text{LHS} = \frac{\frac{1}{\cos x} - 1}{\sin x \cdot \frac{1}{\cos x}} = \left(\frac{1}{\cos x} - 1\right)\frac{\cos x}{\sin x}$
$= \frac{1 - \cos x}{\sin x} = \text{RHS}$

19. $\text{LHS} = \cos^2\frac{x}{2} - 2\sin\frac{x}{2}\cos\frac{x}{2} + \sin^2\frac{x}{2}$
$= 1 - \sin\left(2 \cdot \frac{x}{2}\right) = \text{RHS}$

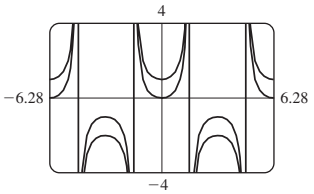
21. $\text{LHS} = \frac{2\sin\left(\frac{(x+y) + (x-y)}{2}\right)\cos\left(\frac{(x+y) - (x-y)}{2}\right)}{2\cos\left(\frac{(x+y) + (x-y)}{2}\right)\cos\left(\frac{(x+y) - (x-y)}{2}\right)}$
$= \frac{2\sin x \cos y}{2\cos x \cos y} = \text{RHS}$

23. (a)



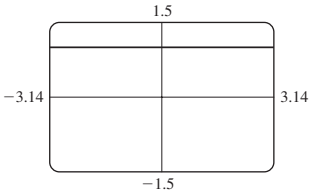
(b) Yes

25. (a)



(b) No

27. (a)



$2\sin^2 3x + \cos 6x = 1$

29. 0.85, 2.29 **31.** $0, \pi$ **33.** $\pi/6, 5\pi/6$ **35.** $\pi/3, 5\pi/3$
37. $2\pi/3, 4\pi/3$ **39.** $\pi/3, 2\pi/3, 3\pi/4, 4\pi/3, 5\pi/3, 7\pi/4$
41. $\pi/6, \pi/2, 5\pi/6, 7\pi/6, 3\pi/2, 11\pi/6$ **43.** $\pi/6$
45. 1.18 **47. (a)** 63.4° **(b)** No **(c)** 90°

49. $\frac{\sqrt{2} + \sqrt{6}}{4}$ or $\frac{1}{2}\sqrt{2 + \sqrt{3}}$ **51.** $\sqrt{2} - 1$ **53.** $\sqrt{2}/2$

55. $\sqrt{2}/2$ **57.** $\frac{\sqrt{2} + \sqrt{3}}{4}$ **59.** $\frac{2}{9}(\sqrt{10} + 1)$

61. $\frac{2}{3}(\sqrt{2} + \sqrt{5})$ **63.** $\sqrt{(3 + 2\sqrt{2})/6}$ **65.** $-\frac{12\sqrt{10}}{31}$

67. $\frac{2x}{1 - x^2}$ **69. (a)** $\theta = \tan^{-1}\left(\frac{10}{x}\right)$ **(b)** 286.4 ft

71. (a) VII **(b)** III **(c)** VI **(d)** II **(e)** IV **(f)** VIII
(g) I **(h)** V

Chapter 7 Test ■ Page 597

1. $\text{LHS} = \frac{\sin\theta}{\cos\theta} \cdot \sin\theta + \cos\theta = \frac{\sin^2\theta + \cos^2\theta}{\cos\theta} = \text{RHS}$

2. $\text{LHS} = \frac{\tan x}{1 - \cos x} \cdot \frac{1 + \cos x}{1 + \cos x} = \frac{\tan x\,(1 + \cos x)}{1 - \cos^2 x}$
$= \frac{\frac{\sin x}{\cos x}(1 + \cos x)}{\sin^2 x} = \frac{1}{\sin x} \cdot \frac{1 + \cos x}{\cos x} = \text{RHS}$

3. $\text{LHS} = \frac{2\tan x}{\sec^2 x} = \frac{2\sin x}{\cos x} \cdot \cos^2 x = 2\sin x \cos x = \text{RHS}$

4. LHS $= \sin x \tan\dfrac{x}{2} = \sin x \cdot \dfrac{1-\cos x}{\sin x} =$ RHS

5. LHS $= 2\left(\dfrac{1-\cos 6x}{2}\right) =$ RHS

6. LHS $= 1 - 2\sin^2 2x = 1 - 2(2\sin x \cos x)^2$
$= 1 - 8\sin^2 x\,(1 - \sin^2 x) =$ RHS

7. LHS $= \sin^2\left(\dfrac{x}{2}\right) + 2\sin\dfrac{x}{2}\cos\dfrac{x}{2} + \cos^2\left(\dfrac{x}{2}\right)$
$= 1 + \sin\left[2\cdot\left(\dfrac{x}{2}\right)\right] =$ RHS

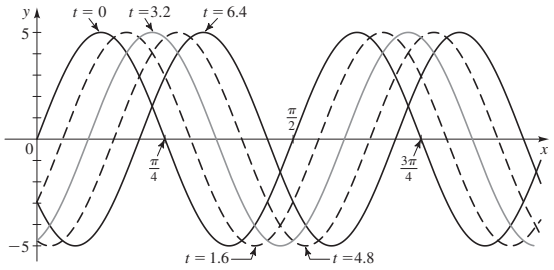
8. $\tan\theta$ **9. (a)** $\frac{1}{2}$ **(b)** $\dfrac{\sqrt{2}+\sqrt{6}}{4}$ or $\frac{1}{2}\sqrt{2+\sqrt{3}}$
(c) $\dfrac{\sqrt{6}-\sqrt{2}}{4}$ or $\frac{1}{2}\sqrt{2-\sqrt{3}}$

10. $(10 - 2\sqrt{5})/15$
11. $\frac{1}{2}(\sin 8x - \sin 2x)$ **12.** $-2\cos\frac{7}{2}x\sin\frac{3}{2}x$ **13.** -2
14. 0.34, 2.80 **15.** $\pi/3, \pi/2, 5\pi/3$ **16.** $2\pi/3, 4\pi/3$
17. $\pi/6, \pi/2, 5\pi/6, 3\pi/2$ **18.** 0.58, 2.56, 3.72, 5.70
19. $\pi/3, 2\pi/3, 4\pi/3, 5\pi/3$ **20.** $\pi/3, 5\pi/3$
21. $\frac{1519}{1681}$ **22.** $\dfrac{\sqrt{1-x^2}-xy}{\sqrt{1+y^2}}$

Focus on Modeling ■ Page 601

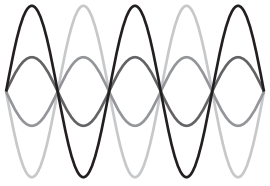
1. (a) $y = -5\sin\dfrac{\pi}{8}t$

(b)

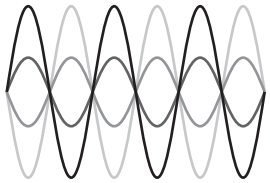


Yes, it is a traveling wave.

(c) $v = \pi/32$
3. $y(x, t) = 2.7\sin(0.68x - 4.10t)$
5. $y(x, t) = 0.6\sin\pi x\cos 40\pi t$
7. (a) 1, 2, 3, 4
(b) 5:



6:

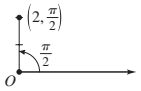


(c) 880π **(d)** $y(x, t) = \sin x\cos 880\pi t$;
$y(x, t) = \sin 2x\cos 880\pi t$; $y(x, t) = \sin 3x\cos 880\pi t$;
$y(x, t) = \sin 4x\cos 880\pi t$

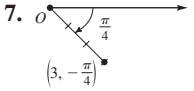
Chapter 8

Section 8.1 ■ Page 608

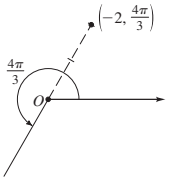
1. coordinate; $(1, 1), (\sqrt{2}, \pi/4)$ **2. (a)** $r\cos\theta, r\sin\theta$
(b) $x^2 + y^2, y/x$ **3.** Yes
4. No; adding a multiple of 2π to θ gives the same point
5.



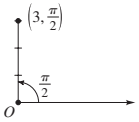
7.



9.

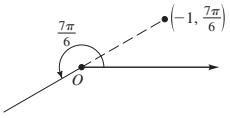


11.



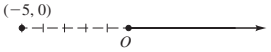
$\left(-3, \dfrac{3\pi}{2}\right), \left(3, \dfrac{5\pi}{2}\right)$

13.



$\left(-1, -\dfrac{5\pi}{6}\right), \left(1, \dfrac{\pi}{6}\right)$

15.

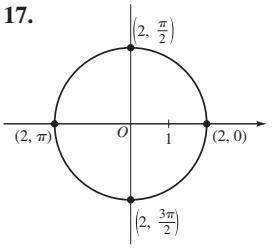


$(-5, 2\pi), (5, \pi)$

17. Q **19.** Q **21.** P **23.** P **25.** $(3\sqrt{2}, 3\pi/4)$
27. $\left(-\dfrac{5}{2}, -\dfrac{5\sqrt{3}}{2}\right)$ **29.** $(0, 3)$ **31.** $(1, -1)$ **33.** $(-5, 0)$
35. $(3/2, -\sqrt{3}/2)$ **37.** $(\sqrt{2}, 3\pi/4)$ **39.** $(4, \pi/4)$
41. $(5, \tan^{-1}(\frac{4}{3}))$ **43.** $(6, \pi)$ **45.** $\theta = \pi/4$
47. $r = \cot\theta\csc\theta$ **49.** $r = 4\sec\theta$ **51.** $r = \sin\theta$
53. $x^2 + y^2 = 49$ **55.** $x = 0$ **57.** $x = 6$ **59.** $x^2 + y^2 = 4y$
61. $x^2 + y^2 = (x^2 + y^2 - x)^2$ **63.** $(x^2 + y^2 - 2y)^2 = x^2 + y^2$
65. $y - x = 1$ **67.** $x^2 - 3y^2 + 16y - 16 = 0$
69. $x^2 + y^2 = \dfrac{y}{x}$ **71.** $y^2 - 3x^2 = 0$

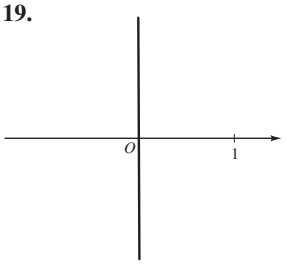
Section 8.2 ■ Page 616

1. circles, rays **2. (a)** satisfy **(b)** circle, 3, pole; line, pole, 1
3. VI **5.** II **7.** I **9.** Symmetric about $\theta = \pi/2$
11. Symmetric about the polar axis
13. Symmetric about $\theta = \pi/2$
15. All three types of symmetry
17.



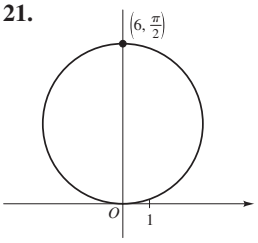
$x^2 + y^2 = 4$

19.



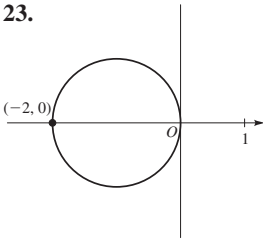
$x = 0$

21.

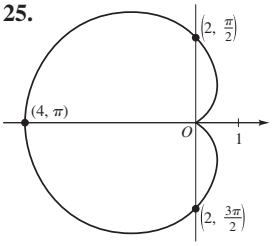


$x^2 + (y - 3)^2 = 9$

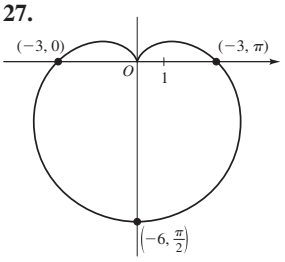
23.



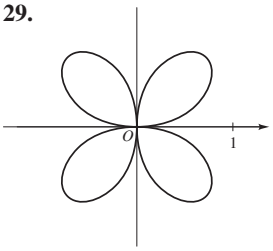
25.



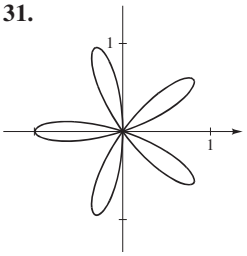
27.



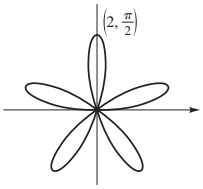
29.



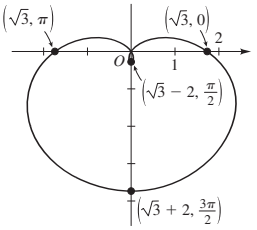
31.



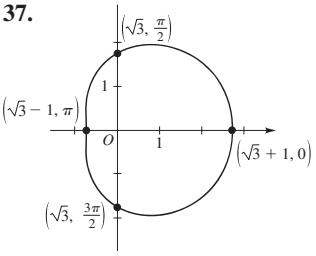
33.



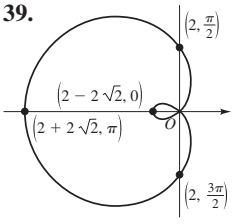
35.



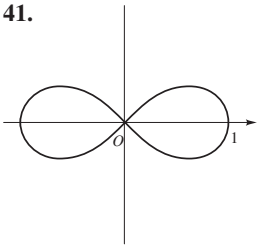
37.



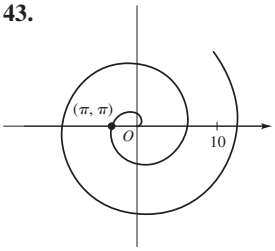
39.



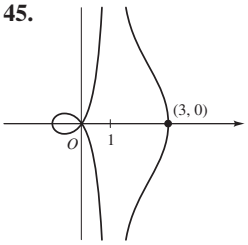
41.



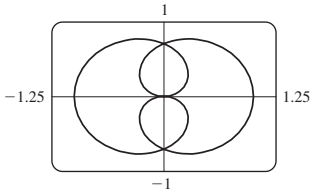
43.



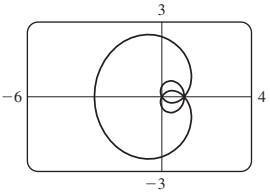
45.



47. $0 \le \theta \le 4\pi$



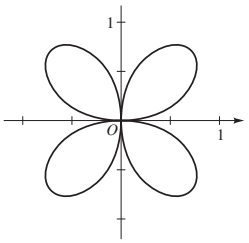
49. $0 \le \theta \le 4\pi$



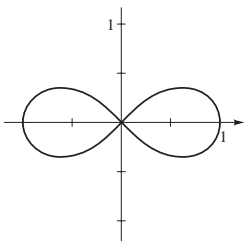
51. The graph of $r = 1 + \sin n\theta$ has n loops.

53. IV **55.** III

57.



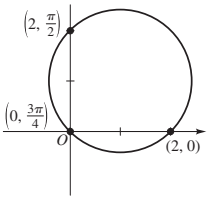
59.



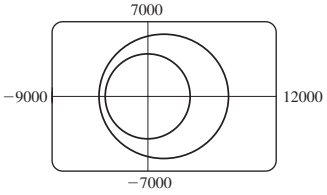
61. (a) $\left(x - \frac{a}{2}\right)^2 + \left(y - \frac{b}{2}\right)^2 = \frac{a^2 + b^2}{4}$

$\left(\frac{a}{2}, \frac{b}{2}\right), \frac{1}{2}\sqrt{a^2 + b^2}$

(b)



63. (a) Elliptical



(b) π; 540 mi

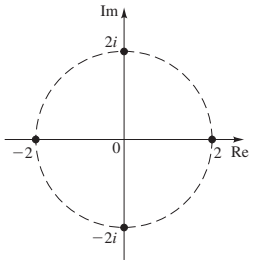
Section 8.3 ■ Page 625

1. real, imaginary, (a, b) **2. (a)** $\sqrt{a^2 + b^2}$, b/a
(b) $r(\cos\theta + i \sin\theta)$

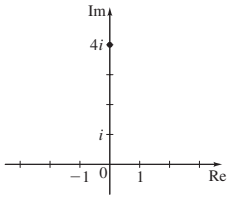
3. (a) $\sqrt{2}\left(\cos\frac{3\pi}{4} + i \sin\frac{3\pi}{4}\right)$ **(b)** $\sqrt{3} + i$

(c) $1 + i$, $\sqrt{2}\left(\cos\frac{\pi}{4} + i \sin\frac{\pi}{4}\right)$

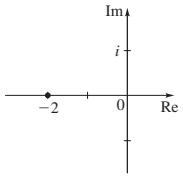
4. n; four; $2, 2i, -2, -2i$; 2



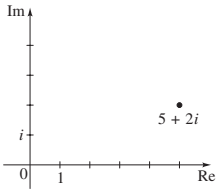
5. 4



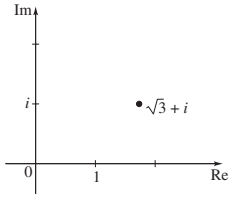
7. 2



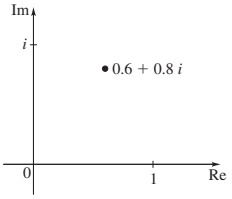
9. $\sqrt{29}$



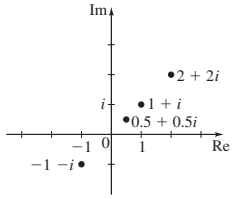
11. 2



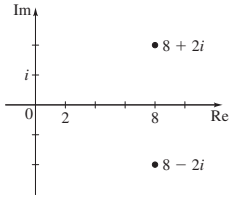
13. 1



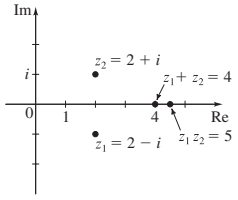
15.



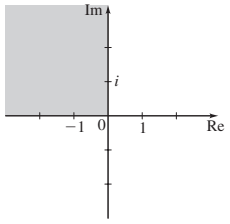
17.



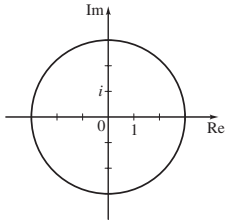
19.



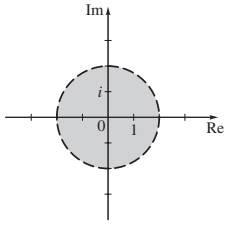
21.



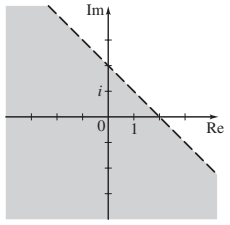
23.



25.



27.



29. $\sqrt{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$ **31.** $2\sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

33. $2\left(\cos\frac{7\pi}{6} + i\sin\frac{7\pi}{6}\right)$ **35.** $4\left(\cos\frac{11\pi}{6} + i\sin\frac{11\pi}{6}\right)$

37. $2\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$ **39.** $3(\cos\pi + i\sin\pi)$

41. $2\sqrt{2}\left(\cos\frac{5\pi}{6} + i\sin\frac{5\pi}{6}\right)$

43. $5\left[\cos\left(\tan^{-1}\left(\frac{3}{4}\right)\right) + i\sin\left(\tan^{-1}\left(\frac{3}{4}\right)\right)\right]$

45. $8\left(\cos\frac{11\pi}{6} + i\sin\frac{11\pi}{6}\right)$ **47.** $3\sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

49. $z_1z_2 = 6\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right), \frac{z_1}{z_2} = \frac{3}{2}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

51. $z_1z_2 = 4\left(\cos\frac{7\pi}{6} + i\sin\frac{7\pi}{6}\right), \frac{z_1}{z_2} = \frac{1}{2}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

53. $z_1z_2 = 8(\cos 150° + i\sin 150°)$

$z_1/z_2 = 2(\cos 90° + i\sin 90°)$

55. $z_1z_2 = 100(\cos 350° + i\sin 350°)$

$z_1/z_2 = \frac{4}{25}(\cos 50° + i\sin 50°)$

57. $z_1 = 2\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

$z_2 = 2\left(\cos\frac{\pi}{3} + i\sin\frac{\pi}{3}\right)$

$z_1z_2 = 4\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$

$\frac{z_1}{z_2} = \cos\left(-\frac{\pi}{6}\right) + i\sin\left(-\frac{\pi}{6}\right)$

$\frac{1}{z_1} = \frac{1}{2}\left[\cos\left(-\frac{\pi}{6}\right) + i\sin\left(-\frac{\pi}{6}\right)\right]$

59. $z_1 = 4\left(\cos\frac{11\pi}{6} + i\sin\frac{11\pi}{6}\right)$

$z_2 = \sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

$z_1z_2 = 4\sqrt{2}\left(\cos\frac{7\pi}{12} + i\sin\frac{7\pi}{12}\right)$

$\frac{z_1}{z_2} = 2\sqrt{2}\left(\cos\frac{13\pi}{12} + i\sin\frac{13\pi}{12}\right)$

$\frac{1}{z_1} = \frac{1}{4}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

61. $z_1 = 5\sqrt{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

$z_2 = 4(\cos 0 + i\sin 0)$

$z_1z_2 = 20\sqrt{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

$\frac{z_1}{z_2} = \frac{5\sqrt{2}}{4}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

$\frac{1}{z_1} = \frac{\sqrt{2}}{10}\left[\cos\left(-\frac{\pi}{4}\right) + i\sin\left(-\frac{\pi}{4}\right)\right]$

63. $z_1 = 20(\cos \pi + i \sin \pi)$

$z_2 = 2\left(\cos \dfrac{\pi}{6} + i \sin \dfrac{\pi}{6}\right)$

$z_1 z_2 = 40\left(\cos \dfrac{7\pi}{6} + i \sin \dfrac{7\pi}{6}\right)$

$\dfrac{z_1}{z_2} = 10\left(\cos \dfrac{5\pi}{6} + i \sin \dfrac{5\pi}{6}\right)$

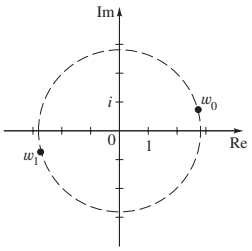
$\dfrac{1}{z_1} = \dfrac{1}{20}(\cos \pi + i \sin \pi)$

65. -64 **67.** $16\sqrt{2} + 16\sqrt{2}i$ **69.** -1 **71.** 4096

73. $8(-1 + i)$ **75.** $\frac{1}{2048}(-\sqrt{3} - i)$

77. $2\sqrt{2}\left(\cos \dfrac{\pi}{12} + i \sin \dfrac{\pi}{12}\right)$,

$2\sqrt{2}\left(\cos \dfrac{13\pi}{12} + i \sin \dfrac{13\pi}{12}\right)$

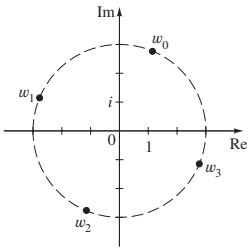


79. $3\left(\cos \dfrac{3\pi}{8} + i \sin \dfrac{3\pi}{8}\right)$,

$3\left(\cos \dfrac{7\pi}{8} + i \sin \dfrac{7\pi}{8}\right)$,

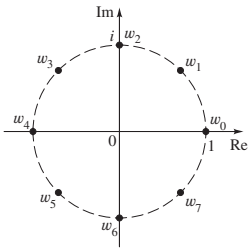
$3\left(\cos \dfrac{11\pi}{8} + i \sin \dfrac{11\pi}{8}\right)$,

$3\left(\cos \dfrac{15\pi}{8} + i \sin \dfrac{15\pi}{8}\right)$

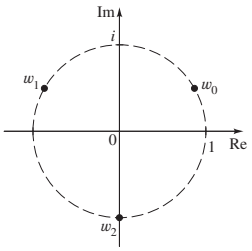


81. $\pm 1, \pm i, \dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i,$

$-\dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i$

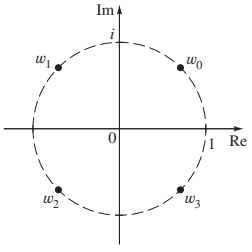


83. $\dfrac{\sqrt{3}}{2} + \dfrac{1}{2}i, -\dfrac{\sqrt{3}}{2} + \dfrac{1}{2}i, -i$



85. $\dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i,$

$-\dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i$



87. $\dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i, -\dfrac{\sqrt{2}}{2} \pm \dfrac{\sqrt{2}}{2}i$

89. $2\left(\cos \dfrac{\pi}{18} + i \sin \dfrac{\pi}{18}\right), 2\left(\cos \dfrac{13\pi}{18} + i \sin \dfrac{13\pi}{18}\right),$

$2\left(\cos \dfrac{25\pi}{18} + i \sin \dfrac{25\pi}{18}\right)$

91. $2^{1/6}\left(\cos \dfrac{5\pi}{12} + i \sin \dfrac{5\pi}{12}\right), 2^{1/6}\left(\cos \dfrac{13\pi}{12} + i \sin \dfrac{13\pi}{12}\right),$

$2^{1/6}\left(\cos \dfrac{21\pi}{12} + i \sin \dfrac{21\pi}{12}\right)$

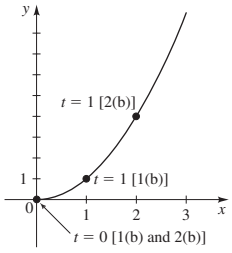
93. $\dfrac{1 \pm \sqrt{5}}{2}i$ **95.** $1 + i, -1 + i$

Section 8.4 ■ Page 633

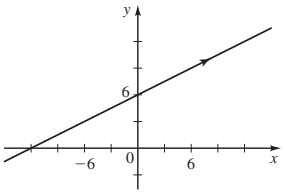
1. (a) parameter **(b)** $(0, 0), (1, 1)$ **(c)** x^2; parabola

2. (a) True **(b)** $(0, 0), (2, 4)$

(c) x^2; path

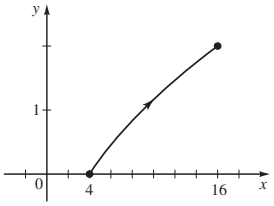


3. (a)



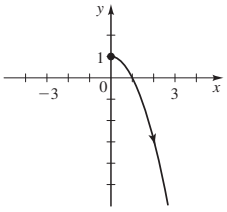
(b) $x - 2y + 12 = 0$

5. (a)



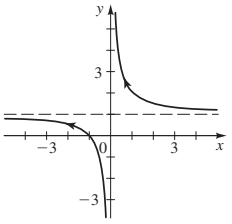
(b) $x = (y + 2)^2$

7. (a)



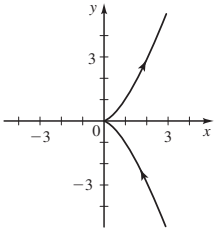
(b) $x = \sqrt{1 - y}$

9. (a)



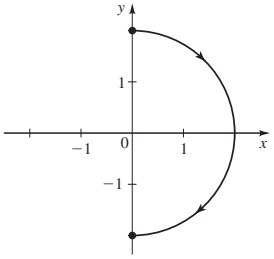
(b) $y = \dfrac{1}{x} + 1$

11. (a)



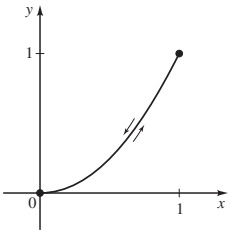
(b) $x^3 = y^2$

13. (a)



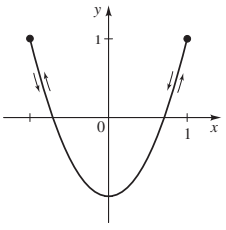
(b) $x^2 + y^2 = 4, x \geq 0$

15. (a)



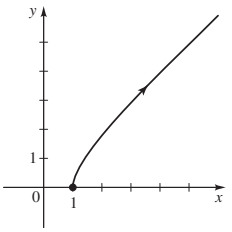
(b) $y = x^2,\ 0 \le x \le 1$

17. (a)



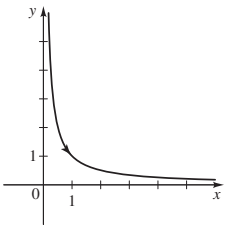
(b) $y = 2x^2 - 1,\ -1 \le x \le 1$

19. (a)



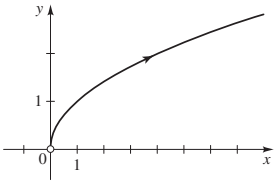
(b) $x^2 - y^2 = 1,\ x \ge 1,\ y \ge 0$

21. (a)



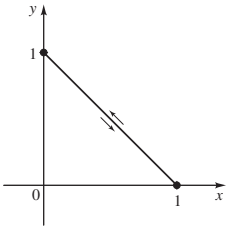
(b) $y = 1/x,\ x > 0$

23. (a)



(b) $x = y^2,\ y > 0$

25. (a)



(b) $x + y = 1,\ 0 \le x \le 1$

27. 3, (3, 0), counterclockwise, 2π

29. 1, (0, 1), clockwise, π

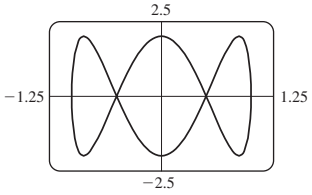
Answers to #31-35 will vary.

31. $x = 5 \sin \frac{1}{2}t,\ y = 5 \cos \frac{1}{2}t$

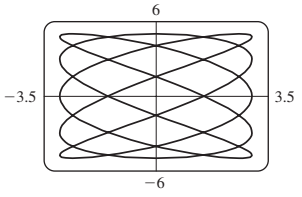
33. $x = 4 + t,\ y = -1 + \frac{1}{2}t$

35. $x = a \cos t,\ y = a \sin t$

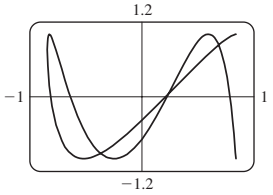
39.



41.

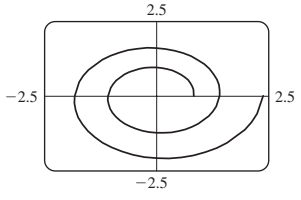


43.



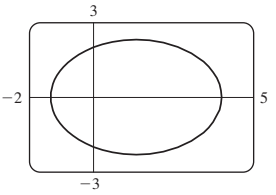
45. (a) $x = 2^{t/12} \cos t,\ y = 2^{t/12} \sin t$

(b)



47. (a) $x = \dfrac{4 \cos t}{2 - \cos t},\ y = \dfrac{4 \sin t}{2 - \cos t}$

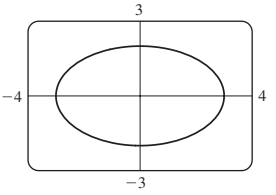
(b)



49. III **51.** II

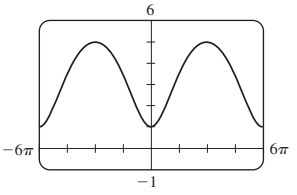
53. (a) $x = a \cos \theta,\ y = b \sin \theta$

(b)



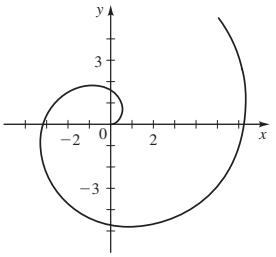
(c) $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1$

55. (b)

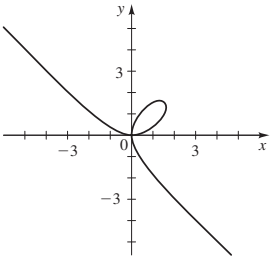


57. $\dfrac{y^2}{b^2} - \dfrac{x^2}{a^2} = 1$

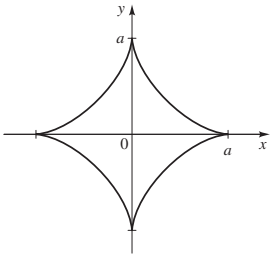
59.



61.



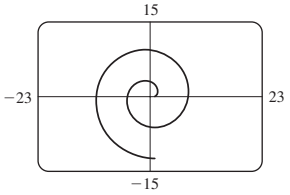
63. (b) $x^{2/3} + y^{2/3} = a^{2/3}$



65. $x = a(\sin \theta \cos \theta + \cot \theta),\ y = a(1 + \sin^2 \theta)$

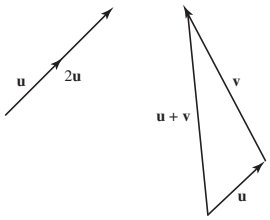
67. $y = a - a \cos\left(\dfrac{x + \sqrt{2ay - y^2}}{a}\right)$

69. (b)



Section 8.5 ■ Page 644

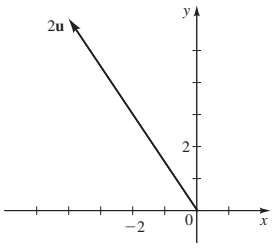
1. **(a)** *A, B*



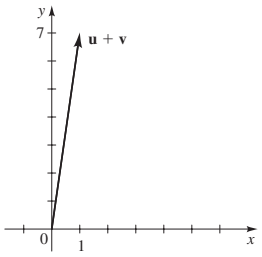
(b) $(2, 1), (4, 3), \langle 2, 2\rangle, \langle -3, 6\rangle, \langle 4, 4\rangle, \langle -1, 8\rangle$

2. **(a)** $\sqrt{a_1^2 + a_2^2}, 2\sqrt{2}$ **(b)** $\langle |\mathbf{w}| \cos\theta, |\mathbf{w}| \sin\theta\rangle$

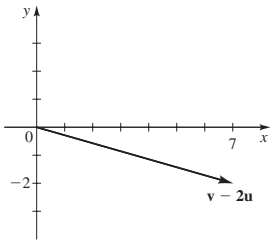
3.



5.

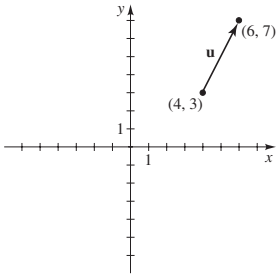


7.

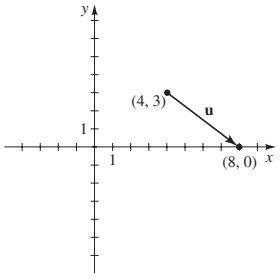


9. $\langle 3, 3\rangle$ **11.** $\langle 3, -1\rangle$ **13.** $\langle 3, 2\rangle$ **15.** $\langle -4, -3\rangle$ **17.** $\langle 0, 2\rangle$

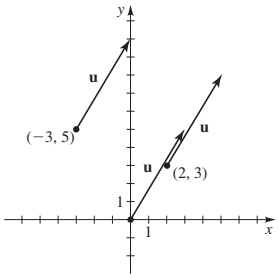
19.



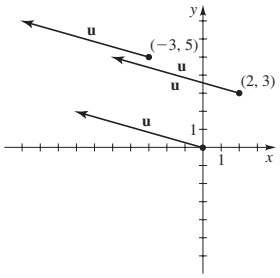
21.



23.



25.



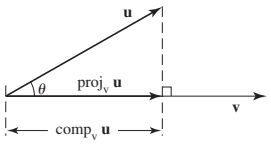
27. $2\mathbf{i} + 3\mathbf{j}$ **29.** $-2\mathbf{j}$ **31.** $\langle 2, 8\rangle, \langle 3, -6\rangle, \langle 0, 6\rangle, \langle 7, 4\rangle$
33. $\langle 0, -2\rangle, \langle 6, 0\rangle, \langle -2, -1\rangle, \langle 8, -3\rangle$
35. $4\mathbf{i} - 2\mathbf{j}, -3\mathbf{j}, 2\mathbf{i}, 6\mathbf{i} - 7\mathbf{j}$
37. $\sqrt{10}, \sqrt{13}, 2\sqrt{10}, \sqrt{13}/2, \sqrt{29}, \sqrt{17}, \sqrt{10} - \sqrt{13}$
39. $\sqrt{101}, 2\sqrt{2}, 2\sqrt{101}, \sqrt{2}, \sqrt{73}, \sqrt{145}, \sqrt{101} - 2\sqrt{2}$
41. $5\mathbf{i} + 5\sqrt{3}\mathbf{j}$ **43.** $-\dfrac{\sqrt{2}}{2}\mathbf{i} - \dfrac{\sqrt{2}}{2}\mathbf{j}$
45. $4\cos 10°\mathbf{i} + 4\sin 10°\mathbf{j} \approx 3.94\mathbf{i} + 0.69\mathbf{j}$
47. 5, 53.13° **49.** 13, 157.38° **51.** 2, 60° **53.** $15\sqrt{3}, -15$
55. $2\mathbf{i} - 3\mathbf{j}$ **57.** $\left(\dfrac{5\sqrt{2}}{2} + 3\right)\mathbf{i} + \left(\dfrac{5\sqrt{2}}{2}\right)\mathbf{j}$ **59.** **(a)** $40\mathbf{j}$
(b) $425\mathbf{i}$ **(c)** $425\mathbf{i} + 40\mathbf{j}$ **(d)** 427 mi/h, N 84.6° E
61. N 2.1° W **63.** **(a)** $10\mathbf{i}$ **(b)** $10\mathbf{i} + 10\sqrt{3}\mathbf{j}$
(c) $20\mathbf{i} + 10\sqrt{3}\mathbf{j}$ **(d)** 26.5 mi/h, N 49.1° E
65. **(a)** $22.8\mathbf{i} + 7.4\mathbf{j}$ **(b)** 7.4 mi/h, 22.8 mi/h
67. **(a)** $\langle 5, -3\rangle$ **(b)** $\langle -5, 3\rangle$ **69.** **(a)** $-4\mathbf{j}$ **(b)** $4\mathbf{j}$
71. **(a)** $\langle -7.57, 10.61\rangle$ **(b)** $\langle 7.57, -10.61\rangle$
73. $\mathbf{T}_1 \approx -56.5\mathbf{i} + 67.4\mathbf{j}$, $\mathbf{T}_2 \approx 56.5\mathbf{i} + 32.6\mathbf{j}$

Section 8.6 ■ Page 653

1. $a_1b_1 + a_2b_2$; real number or scalar

2. $\dfrac{\mathbf{u}\cdot\mathbf{v}}{|\mathbf{u}||\mathbf{v}|}$; perpendicular; $\dfrac{\langle -4, 3\rangle\cdot\langle 3, 2\rangle}{|\langle -4, 3\rangle||\langle 3, 2\rangle|} = \dfrac{-6}{5\sqrt{13}}$; 109°

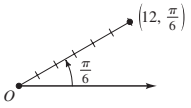
3. **(a)** $\dfrac{\mathbf{u}\cdot\mathbf{v}}{|\mathbf{v}|}$ **(b)** $\left(\dfrac{\mathbf{u}\cdot\mathbf{v}}{|\mathbf{v}|^2}\right)\mathbf{v}$



4. $\mathbf{F}\cdot\mathbf{D}$ **5.** **(a)** 2 **(b)** 45° **7.** **(a)** 1 **(b)** 60°
9. **(a)** -1 **(b)** 97° **11.** **(a)** $5\sqrt{3}$ **(b)** 30°
13. **(a)** 1 **(b)** 86° **15.** **(a)** -2 **(b)** 120° **17.** Yes
19. No **21.** Yes **23.** 9 **25.** -5 **27.** $-\frac{12}{5}$ **29.** -24
31. **(a)** $\langle 1, 1\rangle$ **(b)** $\mathbf{u}_1 = \langle 1, 1\rangle, \mathbf{u}_2 = \langle -3, 3\rangle$
33. **(a)** $\langle -\frac{1}{2}, \frac{3}{2}\rangle$ **(b)** $\mathbf{u}_1 = \langle -\frac{1}{2}, \frac{3}{2}\rangle, \mathbf{u}_2 = \langle \frac{3}{2}, \frac{1}{2}\rangle$
35. **(a)** $\langle -\frac{18}{5}, \frac{24}{5}\rangle$ **(b)** $\mathbf{u}_1 = \langle -\frac{18}{5}, \frac{24}{5}\rangle, \mathbf{u}_2 = \langle \frac{28}{5}, \frac{21}{5}\rangle$
37. -28 **39.** 25 **47.** 16 ft-lb **49.** 8660 ft-lb
51. **(a)** 2822 lb **(b)** 2779 lb **53.** 23.6°

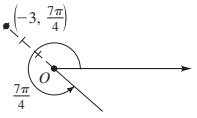
Chapter 8 Review ■ Page 657

1. **(a)**



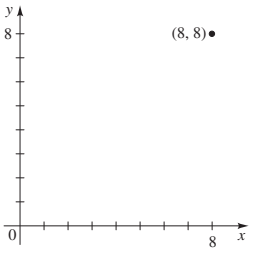
(b) $(6\sqrt{3}, 6)$

3. **(a)**



(b) $\left(\dfrac{-3\sqrt{2}}{2}, \dfrac{3\sqrt{2}}{2}\right)$

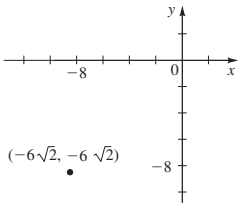
5. **(a)**



(b) $\left(8\sqrt{2}, \dfrac{\pi}{4}\right)$

(c) $\left(-8\sqrt{2}, \dfrac{5\pi}{4}\right)$

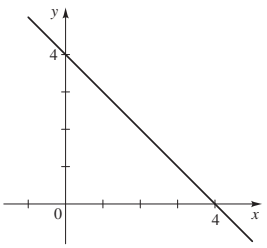
7. **(a)**



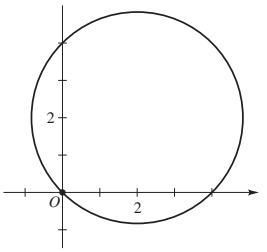
(b) $\left(12, \dfrac{5\pi}{4}\right)$

(c) $\left(-12, \dfrac{\pi}{4}\right)$

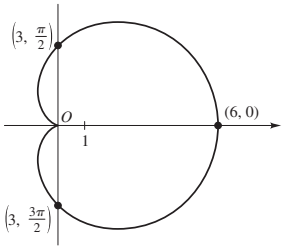
9. (a) $r = \dfrac{4}{\cos\theta + \sin\theta}$ **(b)**



11. (a) $r = 4(\cos\theta + \sin\theta)$ **(b)**

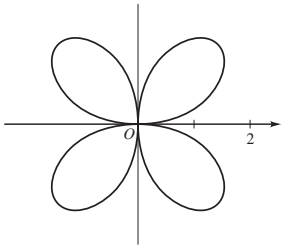


13. (a)



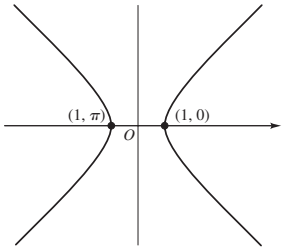
(b) $(x^2 + y^2 - 3x)^2 = 9(x^2 + y^2)$

15. (a)



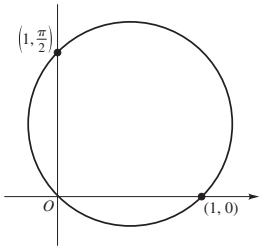
(b) $(x^2 + y^2)^3 = 16x^2y^2$

17. (a)



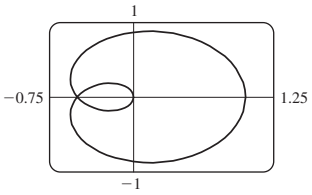
(b) $x^2 - y^2 = 1$

19. (a)

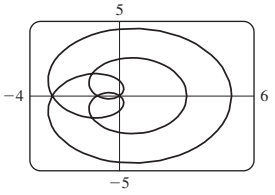


(b) $x^2 + y^2 = x + y$

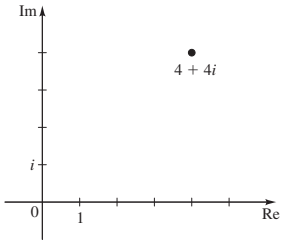
21. $0 \le \theta \le 3\pi$



23. $0 \le \theta \le 6\pi$

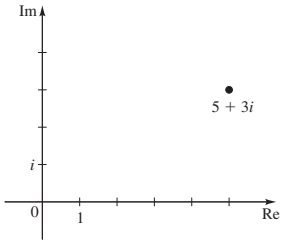


25. (a)



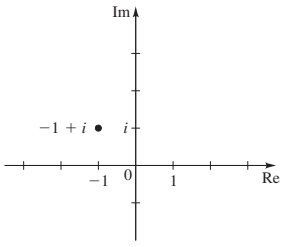
(b) $4\sqrt{2}, \dfrac{\pi}{4}$ **(c)** $4\sqrt{2}\left(\cos\dfrac{\pi}{4} + i\sin\dfrac{\pi}{4}\right)$

27. (a)



(b) $\sqrt{34}, \tan^{-1}\left(\frac{3}{5}\right)$ **(c)** $\sqrt{34}[\cos(\tan^{-1}\left(\frac{3}{5}\right)) + i\sin(\tan^{-1}\left(\frac{3}{5}\right))]$

29. (a)



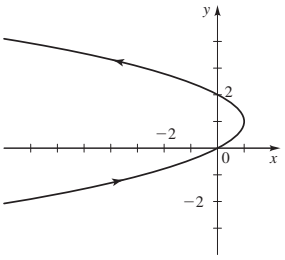
(b) $\sqrt{2}, \dfrac{3\pi}{4}$ **(c)** $\sqrt{2}\left(\cos\dfrac{3\pi}{4} + i\sin\dfrac{3\pi}{4}\right)$

31. $8(-1 + i\sqrt{3})$ **33.** $-\frac{1}{32}(1 + i\sqrt{3})$

35. $2\sqrt{2}(-1 + i), 2\sqrt{2}(1 - i)$

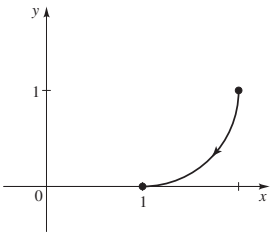
37. $\pm 1, \dfrac{1}{2} \pm \dfrac{\sqrt{3}}{2}i, -\dfrac{1}{2} \pm \dfrac{\sqrt{3}}{2}i$

39. (a)



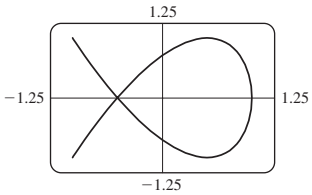
(b) $x = 2y - y^2$

41. (a)



(b) $(x - 1)^2 + (y - 1)^2 = 1$, $(1 \le x \le 2, 0 \le y \le 1)$

43.



45. $x = \frac{1}{2}(1 + \cos\theta), y = \frac{1}{2}(\sin\theta + \tan\theta)$

47. $\sqrt{13}, \langle 6, 4\rangle, \langle -10, 2\rangle, \langle -4, 6\rangle, \langle -22, 7\rangle$

49. $\langle 3, -4\rangle$ **51.** 4, 120° **53.** $\langle 10, 10\sqrt{3}\rangle$

55. (a) $10^4(4.8\mathbf{i} + 0.4\mathbf{j})$ **(b)** 4.8×10^4 lb, N 85.2° E

57. 5, 25, 60 **59.** $2\sqrt{2}$, 8, 0 **61.** Yes **63.** No, 45°

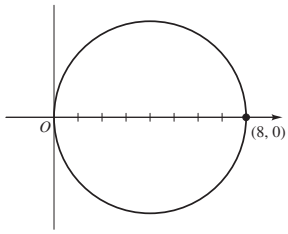
65. (a) $\frac{17\sqrt{37}}{37}$ **(b)** $\left\langle \frac{102}{37}, -\frac{17}{37}\right\rangle$ **(c)** $\mathbf{u}_1 = \left\langle \frac{102}{37}, -\frac{17}{37}\right\rangle, \mathbf{u}_2 = \left\langle \frac{9}{37}, \frac{54}{37}\right\rangle$

67. 6 ft-lb

Chapter 8 Test ■ Page 659

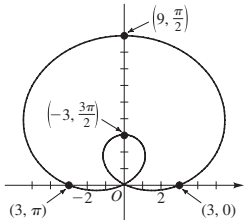
1. (a) $(-4\sqrt{2}, -4\sqrt{2})$ **(b)** $(4\sqrt{3}, 5\pi/6), (-4\sqrt{3}, 11\pi/6)$

2. (a) Circle

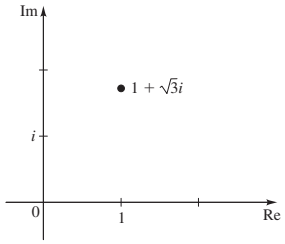


(b) $(x - 4)^2 + y^2 = 16$

3. Limaçon



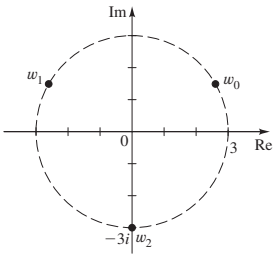
4. (a)



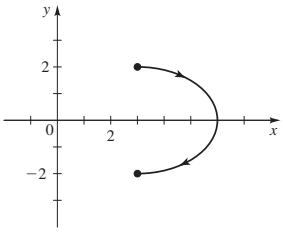
(b) $2\left(\cos\frac{\pi}{3} + i\sin\frac{\pi}{3}\right)$

(c) -512 **5.** $-8, \sqrt{3} + i$

6. $-3i, 3\left(\pm\frac{\sqrt{3}}{2} + \frac{1}{2}i\right)$



7. (a)

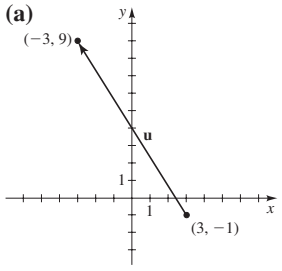


(b) $\frac{(x - 3)^2}{9} + \frac{y^2}{4} = 1\ (x \ge 3)$

8. $x = 3 + t, y = 5 + 2t$

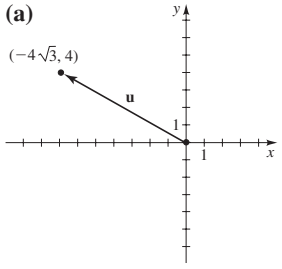
9. (a) 3, (0, 3), clockwise, π **(b)** $x = 3\sin 4t, y = 3\cos 4t$
(c) $x^2 + y^2 = 9$ **(d)** $r = 3$

10. (a) **(b)** $-6\mathbf{i} + 10\mathbf{j}$ **(c)** $2\sqrt{34}$



11. (a) $\langle 19, -3\rangle$ **(b)** $5\sqrt{2}$ **(c)** 0 **(d)** Yes

12. (a) **(b)** 8, 150°



13. **(a)** $14\mathbf{i} + 6\sqrt{3}\mathbf{j}$ **(b)** 17.4 mi/h, N 53.4° E

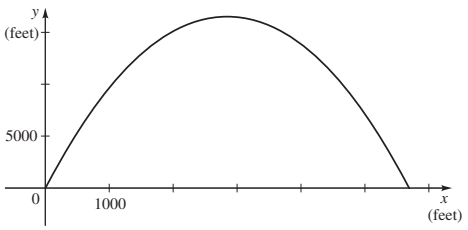
14. **(a)** 45° **(b)** $\frac{\sqrt{26}}{2}$ **(c)** $\frac{5}{2}\mathbf{i} - \frac{1}{2}\mathbf{j}$ **15.** 90 ft-lb

Focus on Modeling ■ Page 663

1. $y = -\left(\frac{g}{2v_0^2\cos^2\theta}\right)x^2 + (\tan\theta)x$

3. **(a)** 62.26 s **(b)** 15,500 ft **(c)** 5426 ft

(d)



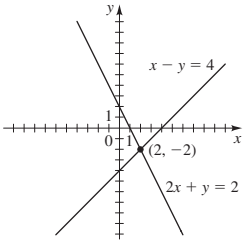
7. No, $\theta \approx 23°$

Chapter 9

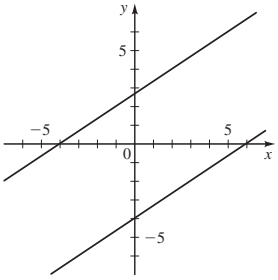
Section 9.1 ■ Page 674

1. x, y; equation; $(2, 1)$ **2.** substitution, elimination, graphical **3.** no, infinitely many **4.** infinitely many; $1 - t$; $(1, 0), (-3, 4), (5, -4)$ **5.** $(4, -2)$ **7.** $(-1, -4)$ **9.** $(5, 1)$ **11.** $(-3, 2)$ **13.** $(-2, 3)$

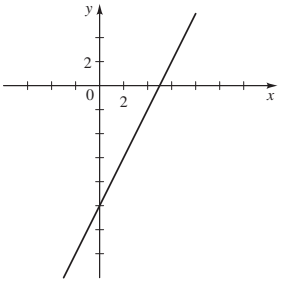
15. $(2, -2)$



17. No solution



19. Infinitely many solutions



21. $(3, 1)$ **23.** $(3, -1)$ **25.** $(2, 1)$ **27.** $(3, 5)$ **29.** $(1, 3)$ **31.** $(6, -6)$ **33.** $(10, -9)$ **35.** $(2, 1)$ **37.** No solution **39.** $\left(t, \frac{1}{3}t - \frac{5}{3}\right)$ **41.** $\left(t, 3 - \frac{3}{2}t\right)$ **43.** $(-3, -7)$ **45.** $\left(t, 5 - \frac{5}{6}t\right)$ **47.** $(5, 10)$ **49.** No solution **51.** $(3.87, 2.74)$ **53.** $(61.00, 20.00)$ **55.** $\left(-\frac{1}{a-1}, \frac{1}{a-1}\right)$ **57.** $\left(\frac{1}{a+b}, \frac{1}{a+b}\right)$ **59.** 22, 12 **61.** 5 dimes, 9 quarters **63.** 125 gallons of regular gas, 60 gallons of premium gas **65.** Plane's speed 120 mi/h, wind speed 30 mi/h **67.** 200 g of A, 40 g of B **69.** 25% in first solution, 10% in second solution **71.** \$14,000 at 5%, \$6,000 at 8% **73.** Truck $2\frac{1}{4}$ h, SUV $2\frac{1}{2}$ h **75.** 25

Section 9.2 ■ Page 683

1. $x + 3z = 1$ **2.** -3; $4y - 5z = -4$ **3.** Linear **5.** Nonlinear **7.** $(3, -2, 4)$ **9.** $(4, 0, 3)$ **11.** $(5, 2, -\frac{1}{2})$

13. $\begin{cases} 3x + y + z = 4 \\ -y + z = -1 \\ x - 2y - z = -1 \end{cases}$ **15.** $\begin{cases} 2x + y - 3z = 5 \\ 2x + 3y + z = 13 \\ -8y + 8z = -8 \end{cases}$

17. $(2, -1, 3)$ **19.** $(2, -1, 0)$ **21.** $(1, 2, 1)$ **23.** $(5, 0, 1)$ **25.** $(0, 1, 2)$ **27.** $(\frac{1}{4}, \frac{1}{2}, -\frac{1}{2})$ **29.** No solution **31.** No solution **33.** $(3 - t, -3 + 2t, t)$ **35.** $(2 - 2t, -\frac{2}{3} + \frac{4}{3}t, t)$ **37.** $(1, -1, 1, 2)$ **39.** \$30,000 in short-term, \$30,000 in intermediate-term, \$40,000 in long-term **41.** 250 acres corn, 500 acres wheat, 450 acres soybeans **43.** No solution **45.** 50 Midnight Mango, 60 Tropical Torrent, 30 Pineapple Power **47.** 1500 shares of A, 1200 shares of B, 1000 shares of C

Section 9.3 ■ Page 695

1. dependent, inconsistent

2. $\begin{bmatrix} 1 & 1 & -1 & 1 \\ 1 & 0 & 2 & -3 \\ 0 & 2 & -1 & 3 \end{bmatrix}$

3. **(a)** x and y **(b)** dependent **(c)** $x = 3 + t, y = 5 - 2t, z = t$

4. **(a)** $x = 2, y = 1, z = 3$ **(b)** $x = 2 - t, y = 1 - t, z = t$ **(c)** No solution **5.** 3×2 **7.** 2×1 **9.** 1×3

11. $\begin{bmatrix} 3 & 1 & -1 & 2 \\ 2 & -1 & 0 & 1 \\ 1 & 0 & -1 & 3 \end{bmatrix}$

13. **(a)** Yes **(b)** Yes **(c)** $\begin{cases} x = -3 \\ y = 5 \end{cases}$

15. **(a)** Yes **(b)** No **(c)** $\begin{cases} x + 2y + 8z = 0 \\ y + 3z = 2 \\ 0 = 0 \end{cases}$

17. **(a)** No **(b)** No **(c)** $\begin{cases} x = 0 \\ 0 = 0 \\ y + 5z = 1 \end{cases}$

19. **(a)** Yes **(b)** Yes **(c)** $\begin{cases} x + 3y - w = 0 \\ z + 2w = 0 \\ 0 = 1 \\ 0 = 0 \end{cases}$

21. $\begin{bmatrix} -1 & 1 & 2 & 0 \\ 0 & 4 & 7 & 4 \\ 1 & -2 & -1 & -1 \end{bmatrix}$ **23.** $\begin{bmatrix} 2 & 1 & -3 & 5 \\ 2 & 3 & 1 & 13 \\ 0 & -8 & 8 & -8 \end{bmatrix}$

25. **(a)** $\begin{cases} x - 2y + 4z = 3 \\ y + 2z = 7 \\ z = 2 \end{cases}$ **(b)** $(1, 3, 2)$

27. **(a)** $\begin{cases} x + 2y + 3z - w = 7 \\ y - 2z = 5 \\ z + 2w = 5 \\ w = 3 \end{cases}$ **(b)** $(7, 3, -1, 3)$

29. $(1, 1, 2)$ **31.** $(2, 0, -1)$ **33.** $(1, -3, 2)$ **35.** $(-1, 5, 0)$
37. $(10, 3, -2)$ **39.** No solution **41.** $(2 - 3t, 3 - 5t, t)$
43. No solution **45.** $(-2t + 5, t - 2, t)$
47. $\left(-\frac{1}{2}s + t + 6, s, t\right)$ **49.** $(-2, 1, 3)$ **51.** No solution
53. $(-9, 2, 0)$ **55.** $(5 - t, -3 + 5t, t)$ **57.** $(0, -3, 0, -3)$
59. $(-1, 0, 0, 1)$ **61.** $\left(\frac{1}{3}s - \frac{2}{3}t, \frac{1}{3}s + \frac{1}{3}t, s, t\right)$
63. $\left(\frac{7}{4} - \frac{7}{4}t, -\frac{7}{4} + \frac{3}{4}t, \frac{9}{4} + \frac{3}{4}t, t\right)$
65. $x = 1.25, y = -0.25, z = 0.75$
67. $x = 1.2, y = 3.4, z = -5.2, w = -1.3$
69. 2 VitaMax, 1 Vitron, 2 VitaPlus **71.** 5-mile run, 2-mile swim, 30-mile cycle **73.** Impossible

Section 9.4 ■ Page 705

1. dimension **2.** **(a)** columns, rows **(b)** (ii), (iii) **3.** (i), (ii)

4. $\begin{bmatrix} 4 & 9 & -7 \\ 7 & -7 & 0 \\ 4 & -5 & -5 \end{bmatrix}$ **5.** No **7.** $a = -5, b = 3$

9. $\begin{bmatrix} 1 & 3 \\ 1 & 5 \end{bmatrix}$ **11.** $\begin{bmatrix} 3 & 6 \\ 12 & -3 \\ 3 & 0 \end{bmatrix}$ **13.** Impossible

15. $\begin{bmatrix} 5 & 2 & 1 \\ 7 & 10 & -7 \end{bmatrix}$ **17.** $\begin{bmatrix} -1 & -\frac{1}{2} \\ 1 & 2 \end{bmatrix}$ **19.** Impossible

21. $\begin{bmatrix} 0 & -5 \\ -25 & -20 \\ -10 & 10 \end{bmatrix}$ **23.** **(a)** $\begin{bmatrix} 5 & -2 & 5 \\ 1 & 1 & 0 \end{bmatrix}$ **(b)** Impossible

25. **(a)** $\begin{bmatrix} 10 & -25 \\ 0 & 35 \end{bmatrix}$ **(b)** Impossible

27. **(a)** Impossible **(b)** $\begin{bmatrix} 14 & -14 \end{bmatrix}$

29. **(a)** $\begin{bmatrix} -4 & 7 \\ 14 & -7 \end{bmatrix}$ **(b)** $\begin{bmatrix} 6 & -8 \\ 4 & -17 \end{bmatrix}$

31. **(a)** $\begin{bmatrix} 5 & -3 & 10 \\ 6 & 1 & 0 \\ -5 & 2 & 2 \end{bmatrix}$ **(b)** $\begin{bmatrix} -1 \\ 8 \\ -1 \end{bmatrix}$

33. **(a)** $\begin{bmatrix} 4 & -45 \\ 0 & 49 \end{bmatrix}$ **(b)** $\begin{bmatrix} 8 & -335 \\ 0 & 343 \end{bmatrix}$

35. **(a)** $\begin{bmatrix} 13 \\ -7 \end{bmatrix}$ **(b)** Impossible **37.** $\begin{bmatrix} 1.56 & -5.62 \\ 1.28 & -0.88 \\ -1.09 & 0.97 \end{bmatrix}$

39. $\begin{bmatrix} -0.35 & 0.03 & 0.33 \\ -0.55 & -1.05 & 1.05 \\ -2.41 & -4.31 & 4.46 \end{bmatrix}$ **41.** Impossible

43. $x = 2, y = -1$ **45.** $x = 1, y = -2$

47. $\begin{bmatrix} 2 & -5 \\ 3 & 2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 7 \\ 4 \end{bmatrix}$

49. $\begin{bmatrix} 3 & 2 & -1 & 1 \\ 1 & 0 & -1 & 0 \\ 0 & 3 & 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 5 \\ 4 \end{bmatrix}$

51. Only ACB is defined. $ACB = \begin{bmatrix} -3 & -21 & 27 & -6 \\ -2 & -14 & 18 & -4 \end{bmatrix}$

53. **(a)** $\begin{bmatrix} 5 \\ 22 \\ 7 \end{bmatrix}$

(b) Five members have no postsecondary education, 22 have 1 to 4 years, and seven have more than 4 years.

55. **(a)** $\begin{bmatrix} 353.75 \\ 656.25 \\ 892.50 \end{bmatrix}$ **(b)** \$353.75 **(c)** \$1902.50

57. **(a)** $\begin{bmatrix} \$32{,}000 & \$18{,}000 \\ \$42{,}000 & \$26{,}800 \\ \$44{,}000 & \$26{,}800 \end{bmatrix}$ **(b)** \$42,000 **(c)** \$71,600

59. **(a)** $\begin{bmatrix} 97.00 \\ 46.50 \\ 41.00 \end{bmatrix}$ Ashton's stand sold \$97 of produce on Saturday. Bryn's stand sold \$46.50. Cimeron's stand sold \$41.

(b) $\begin{bmatrix} 70.00 \\ 33.50 \\ 48.50 \end{bmatrix}$ Ashton's stand sold \$70 of produce on Sunday. Bryn's stand sold \$33.50. Cimeron's stand sold \$48.50.

(c) $\begin{bmatrix} 220 & 110 & 90 \\ 75 & 45 & 50 \\ 120 & 55 & 50 \end{bmatrix}$ This represents the total numbers of melons, squash, and tomatoes sold during the weekend.

(d) $\begin{bmatrix} 167.00 \\ 80.00 \\ 89.50 \end{bmatrix}$ During the weekend Ashton's stand sold \$167, Bryn's stand sold \$80, and Cimeron's stand sold \$89.50 of produce.

Section 9.5 ■ Page 715

1. **(a)** identity **(b)** A, A **(c)** inverse

2. **(a)** $\underset{A}{\begin{bmatrix} 5 & 3 \\ 3 & 2 \end{bmatrix}} \underset{X}{\begin{bmatrix} x \\ y \end{bmatrix}} = \underset{B}{\begin{bmatrix} 4 \\ 3 \end{bmatrix}}$ **(b)** $\begin{bmatrix} 2 & -3 \\ -3 & 5 \end{bmatrix}$

(c) $\underset{A^{-1}}{\begin{bmatrix} 2 & -3 \\ -3 & 5 \end{bmatrix}} \underset{B}{\begin{bmatrix} 4 \\ 3 \end{bmatrix}} = \begin{bmatrix} -1 \\ 3 \end{bmatrix}$ **(d)** $x = -1, y = 3$

7. $\begin{bmatrix} 1 & -2 \\ -\frac{3}{2} & \frac{7}{2} \end{bmatrix}$ **9.** $\begin{bmatrix} \frac{1}{3} & -\frac{1}{2} \\ 2 & 2 \end{bmatrix}$ **11.** $\begin{bmatrix} 9 & -2 \\ -13 & 3 \end{bmatrix}$

13. $\begin{bmatrix} 13 & 5 \\ -5 & -2 \end{bmatrix}$ **15.** No inverse **17.** $\begin{bmatrix} 1 & 2 \\ -\frac{1}{2} & \frac{2}{3} \end{bmatrix}$

19. $\begin{bmatrix} -4 & -4 & 5 \\ 1 & 1 & -1 \\ 5 & 4 & -6 \end{bmatrix}$ **21.** No inverse

23. $\begin{bmatrix} -\frac{9}{2} & -1 & 4 \\ 3 & 1 & -3 \\ \frac{7}{2} & 1 & -3 \end{bmatrix}$ **25.** $\begin{bmatrix} 0 & 0 & -2 & 1 \\ -1 & 0 & 1 & 1 \\ 0 & 1 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}$

27. $\begin{bmatrix} \frac{2}{3} & \frac{4}{3} & 3 \\ 1 & 1 & 3 \\ \frac{1}{3} & \frac{2}{3} & 1 \end{bmatrix}$ **29.** $\begin{bmatrix} -2 & 3 & -1 & -2 \\ 0 & -1 & 0 & \frac{1}{2} \\ -2 & 2 & -1 & -2 \\ -1 & -1 & -1 & 0 \end{bmatrix}$

31. $\begin{bmatrix} 1 & -\frac{7}{2} & \frac{1}{6} \\ 0 & \frac{1}{2} & -\frac{1}{6} \\ 0 & 0 & \frac{1}{3} \end{bmatrix}$ **33.** $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \frac{1}{2} & 0 & 0 \\ 0 & 0 & \frac{1}{4} & 0 \\ 0 & 0 & 0 & \frac{1}{7} \end{bmatrix}$

35. $\begin{bmatrix} -\frac{1}{4} & \frac{3}{4} & \frac{3}{4} \\ -\frac{7}{16} & -\frac{23}{16} & -\frac{3}{16} \\ \frac{7}{8} & -\frac{1}{8} & -\frac{5}{8} \end{bmatrix}$ **37.** $\begin{bmatrix} -7 & -3 & -4 \\ \frac{22}{7} & -\frac{2}{7} & \frac{16}{7} \\ \frac{50}{7} & \frac{26}{7} & \frac{37}{7} \end{bmatrix}$

39. $x = 3, y = -4$ **41.** $x = 126, y = -50$
43. $x = -38, y = 9, z = 47$ **45.** $x = -20, y = 10, z = 16$
47. $x = 3, y = 2, z = 1$ **49.** $x = 3, y = -2, z = 2$
51. $x = 8, y = 1, z = 0, w = 3$

53. $\begin{bmatrix} 7 & 2 & 3 \\ 10 & 3 & 5 \end{bmatrix}$ **55.** $\frac{1}{2a}\begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix}$

57. $\begin{bmatrix} 1 & -\frac{1}{x} \\ -\frac{1}{x} & \frac{2}{x^2} \end{bmatrix}$; inverse does not exist for $x = 0$

59. $\frac{1}{2}\begin{bmatrix} 1 & e^{-x} & 0 \\ e^{-x} & -e^{-2x} & 0 \\ 0 & 0 & 1 \end{bmatrix}$; inverse exists for all x

61. (a) $\begin{bmatrix} 0 & 1 & -1 \\ -2 & \frac{3}{2} & 0 \\ 1 & -\frac{3}{2} & 1 \end{bmatrix}$ **(b)** 1 oz type A, 1 oz type B, 2 oz type C

(c) 2 oz type A, 0 oz type B, 1 oz type C **(d)** No

63. (a) $\begin{cases} 9x + 11y + 8z = 740 \\ 13x + 15y + 16z = 1204 \\ 8x + 7y + 14z = 828 \end{cases}$

(b) $\begin{bmatrix} 9 & 11 & 8 \\ 13 & 15 & 16 \\ 8 & 7 & 14 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 740 \\ 1204 \\ 828 \end{bmatrix}$

(c) $A^{-1} = \begin{bmatrix} \frac{7}{4} & -\frac{7}{4} & 1 \\ -\frac{27}{28} & \frac{31}{28} & -\frac{5}{7} \\ -\frac{29}{56} & \frac{25}{56} & -\frac{1}{7} \end{bmatrix}$

The commission is \$16 on a standard model, \$28 on a deluxe model, and \$36 on a super-deluxe model.

Section 9.6 ■ Page 726

1. True **2.** True **3.** True **4. (a)** $2\cdot 4 - 1\cdot(-3) = 11$
(b) $+1(2\cdot 4 - 1\cdot(-3)) - 0(3\cdot 4 - 1\cdot 0)$
$+ 2(3\cdot(-3) - 2\cdot 0) = -7$
5. 6 **7.** 0 **9.** -4 **11.** Does not exist **13.** $\frac{1}{8}$ **15.** 20, 20
17. -12, 12 **19.** 0, 0 **21.** 4, has an inverse
23. 5000, has an inverse **25.** 0, does not have an inverse
27. -4, has an inverse **29.** -6, has an inverse
31. -12, has an inverse **33.** 0, does not have an inverse
35. -18 **37.** 120 **39. (a)** -2 **(b)** -2 **(c)** Yes
41. $(-2, 5)$ **43.** $(0.6, -0.4)$ **45.** $(4, -1)$ **47.** $(4, 2, -1)$
49. $(1, 3, 2)$ **51.** $(0, -1, 1)$ **53.** $\left(\frac{189}{29}, -\frac{108}{29}, \frac{88}{29}\right)$
55. $\left(\frac{1}{2}, \frac{1}{4}, \frac{1}{4}, -1\right)$ **57.** 21 **59.** $\frac{63}{2}$ **61.** *abcde* **63.** 0, 1, 2
65. 1, -1 **69. (a)** 0 **(b)** (i) Yes, (ii) No

71. (a) $\begin{cases} x + y + z = 18 \\ 75x + 90y + 60z = 1380 \\ -75x + 90y + 60z = 180 \end{cases}$

(b) 8 lb apples, 6 lb peaches, 4 lb pears
73. 7 million ft^2

Section 9.7 ■ Page 734

1. (iii) **2.** (ii) **3.** $\frac{A}{x-1} + \frac{B}{x+2}$

5. $\frac{A}{x-2} + \frac{B}{(x-2)^2} + \frac{C}{x+4}$

7. $\frac{A}{x-3} + \frac{Bx+C}{x^2+4}$ **9.** $\frac{Ax+B}{x^2+1} + \frac{Cx+D}{x^2+2}$

11. $\frac{A}{x} + \frac{B}{2x-5} + \frac{C}{(2x-5)^2} + \frac{D}{(2x-5)^3} + \frac{Ex+F}{x^2+2x+5} + \frac{Gx+H}{(x^2+2x+5)^2}$

13. $\frac{1}{x-1} - \frac{1}{x+1}$ **15.** $\frac{1}{x-1} - \frac{1}{x+4}$

17. $\frac{2}{x-3} - \frac{2}{x+3}$ **19.** $\frac{1}{x-2} - \frac{1}{x+2}$

21. $\frac{3}{x-4} - \frac{2}{x+2}$ **23.** $\frac{-\frac{1}{2}}{2x-1} + \frac{\frac{3}{2}}{4x-3}$

25. $\frac{2}{x-2} + \frac{3}{x+2} - \frac{1}{2x-1}$ **27.** $\frac{2}{x+1} - \frac{1}{x} + \frac{1}{x^2}$

29. $\frac{1}{2x+3} - \frac{3}{(2x+3)^2}$ **31.** $\frac{2}{x} - \frac{1}{x^3} - \frac{2}{x+2}$

33. $\frac{4}{x+2} - \frac{4}{x-1} + \frac{2}{(x-1)^2} + \frac{1}{(x-1)^3}$

35. $\frac{3}{x+2} - \frac{1}{(x+2)^2} - \frac{1}{(x+3)^2}$ **37.** $\frac{x+1}{x^2+3} - \frac{1}{x}$

39. $\frac{2x-5}{x^2+x+2} + \frac{5}{x^2+1}$ **41.** $\frac{1}{x^2+1} - \frac{x+2}{(x^2+1)^2} + \frac{1}{x}$

43. $x^2 + \frac{3}{x-2} - \frac{x+1}{x^2+1}$ **45.** $A = \frac{a+b}{2}$, $B = \frac{a-b}{2}$

Section 9.8 ■ Page 738

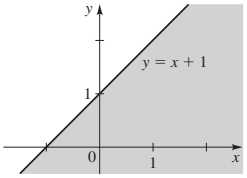
1. $(4, 8), (-2, 2)$ **3.** $(4, 16), (-3, 9)$ **5.** $(2, -2), (-2, 2)$
7. $(-25, 5), (-25, -5)$ **9.** $(-3, 4)\ (3, 4)$
11. $(-2, -1), (-2, 1), (2, -1), (2, 1)$
13. $(-1, \sqrt{2}), (-1, -\sqrt{2}), \left(\frac{1}{2}, \sqrt{\frac{7}{2}}\right), \left(\frac{1}{2}, -\sqrt{\frac{7}{2}}\right)$
15. $(2, 4), \left(-\frac{5}{2}, \frac{7}{4}\right)$ **17.** $(0, 0), (1, -1), (-2, -4)$
19. $(4, 0)$ **21.** $(-2, -2)$ **23.** $(6, 2), (-2, -6)$
25. No solution
27. $(\sqrt{5}, 2), (\sqrt{5}, -2), (-\sqrt{5}, 2), (-\sqrt{5}, -2)$
29. $\left(3, -\frac{1}{2}\right), \left(-3, -\frac{1}{2}\right)$ **31.** $\left(\frac{1}{5}, \frac{1}{3}\right)$
33. $(2.00, 20.00), (-8.00, 0)$
35. $(-4.51, 2.17), (4.91, -0.97)$

37. $(1.23, 3.87), (-0.35, -4.21)$
39. $(-2.30, -0.70), (0.48, -1.19)$ **41.** $(\sqrt{10}, 10)$
43. $(-5, -8), (8, 5)$ **45.** 12 cm by 15 cm
47. Length 15, width 20 **49.** $(400.50, 200.25)$, 447.77 m
51. $(12, 8)$

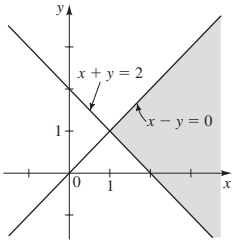
Section 9.9 ■ Page 747

1. 2, 3; yes
2. equation; $y = x + 1$; test

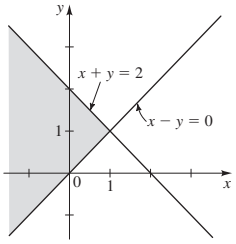
Test Point	Inequality $y \le x + 1$	Conclusion
$(0, 0)$	$0 \stackrel{?}{\le} 0 + 1$ ✓	Part of graph
$(0, 2)$	$2 \stackrel{?}{\le} 0 + 1$ ✗	Not part of graph



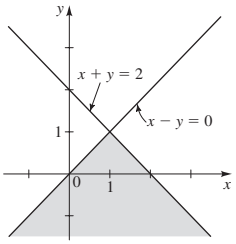
3. 2, 3; yes
4. **(a)**



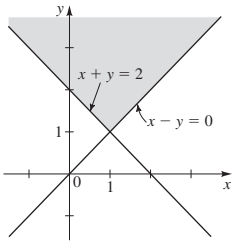
(b)



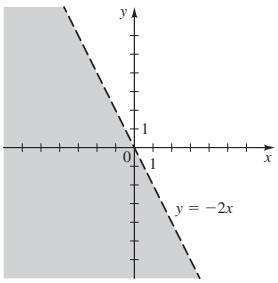
(c)



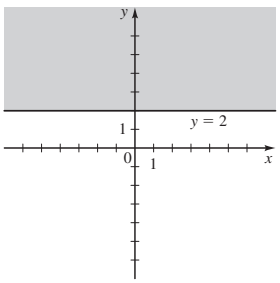
(d)



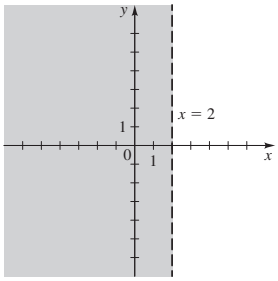
5. $(-1, -2), (1, -2)$ **7.** $(1, 2), (1, 1)$
9.



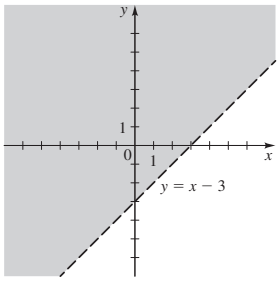
11.



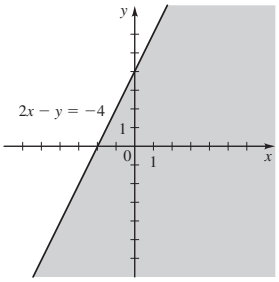
13.



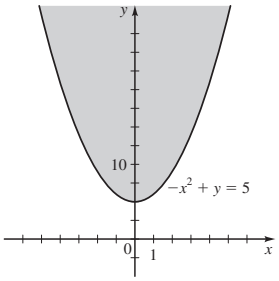
15.



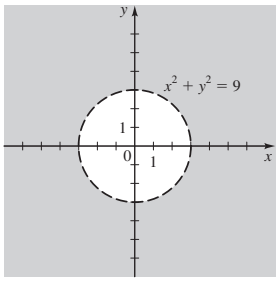
17.



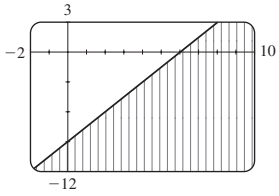
19.



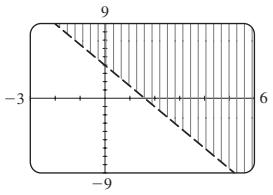
21.



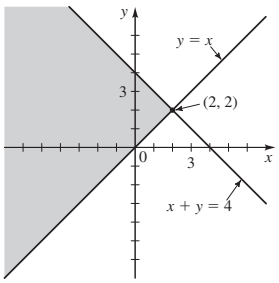
23.



25.

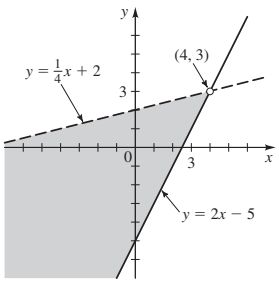


27. $y \le \frac{1}{2}x - 1$ **29.** $x^2 + y^2 > 4$
31.



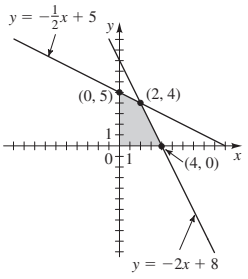
Not bounded

33.



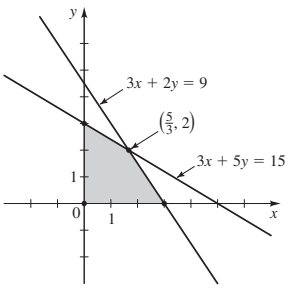
Not bounded

35.



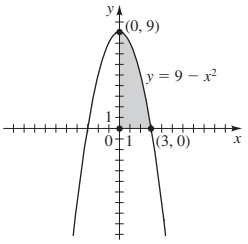
Bounded

37.



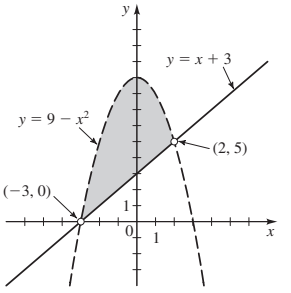
Bounded

39.



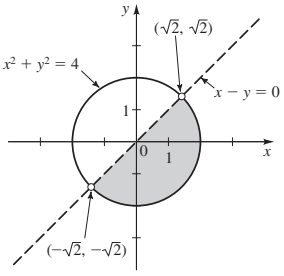
Bounded

41.



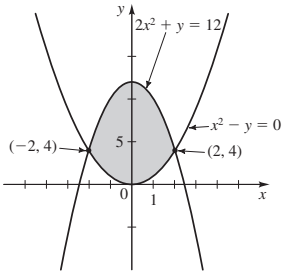
Bounded

43.



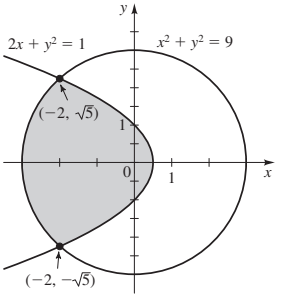
Bounded

45.



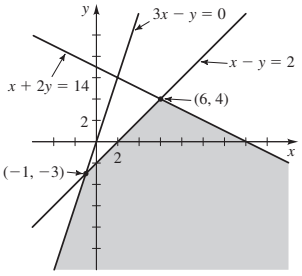
Bounded

47.



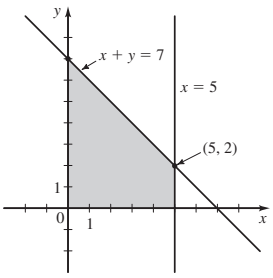
Bounded

49.



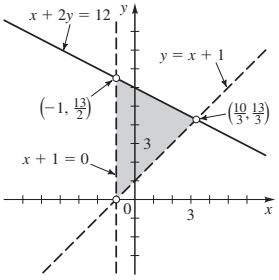
Not bounded

51.



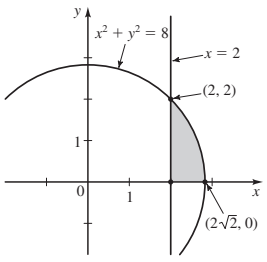
Bounded

53.



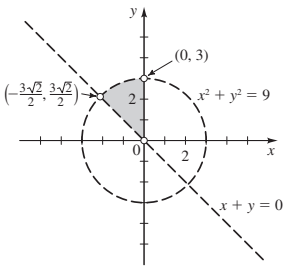
Bounded

55.



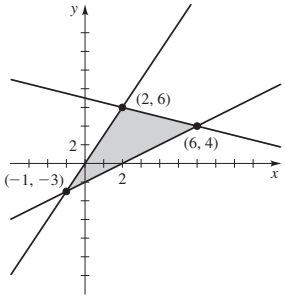
Bounded

57.



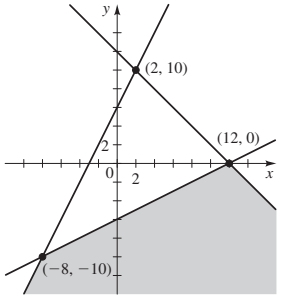
Bounded

59.



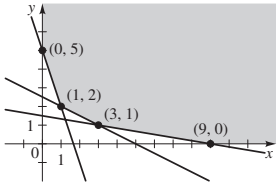
Bounded

61.



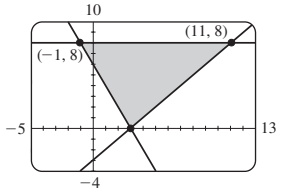
Not bounded

63.

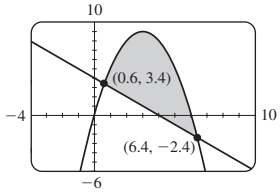


Not bounded

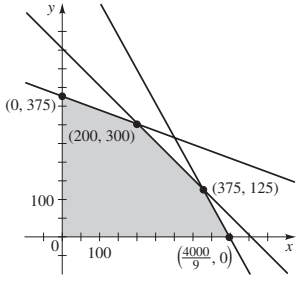
65.



67.



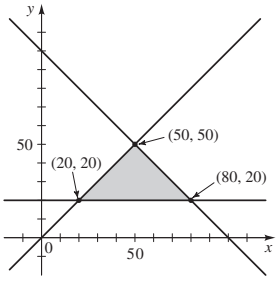
69. **(a)**
$$\begin{cases} x + \quad y \le 500 \\ 90x + 50y \le 40{,}000 \\ 30x + 80y \le 30{,}000 \\ x \ge 0, \quad y \ge 0 \end{cases}$$



(b) Yes **(c)** No

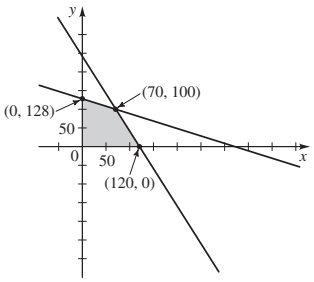
71. x = number of fiction books
y = number of nonfiction books

$$\begin{cases} x + y \le 100 \\ 20 \le y, \quad x \ge y \\ x \ge 0, \quad y \ge 0 \end{cases}$$



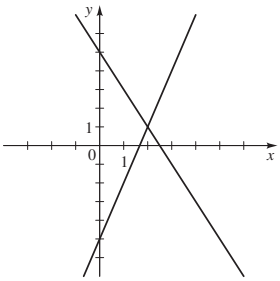
73. x = number of Standard packages
y = number of Deluxe packages

$$\begin{cases} \frac{1}{4}x + \frac{5}{8}y \le 80 \\ \frac{3}{4}x + \frac{3}{8}y \le 90 \\ x \ge 0, \quad y \ge 0 \end{cases}$$

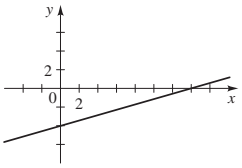


Chapter 9 Review ■ Page 754

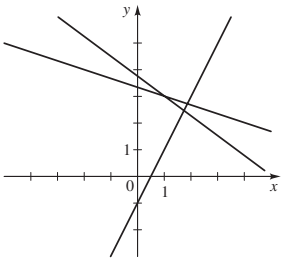
1. $(2, 1)$



3. x = any number t
$y = \frac{2}{7}t - 4$



5. No solution



7. $(-3, 3), (2, 8)$ **9.** $\left(\frac{16}{7}, -\frac{14}{3}\right)$ **11.** $(21.41, -15.93)$
13. $(11.94, -1.39), (12.07, 1.44)$
15. **(a)** 2×3 **(b)** Yes **(c)** No
(d) $\begin{cases} x + 2y = -5 \\ y = 3 \end{cases}$
17. **(a)** 3×4 **(b)** Yes **(c)** Yes
(d) $\begin{cases} x + 8z = 0 \\ y + 5z = -1 \\ 0 = 0 \end{cases}$
19. **(a)** 3×4 **(b)** No **(c)** No
(d) $\begin{cases} y - 3z = 4 \\ x + y = 7 \\ x + 2y + z = 2 \end{cases}$
21. $(1, 1, 2)$ **23.** No solution **25.** $(0, 1, 2)$ **27.** No solution
29. $(1, 0, 1, -2)$ **31.** $(-4t + 1, -t - 1, t)$
33. $(6 - 5t, \frac{1}{2}(7 - 3t), t)$ **35.** $\left(-\frac{4}{3}t + \frac{4}{3}, \frac{5}{3}t - \frac{2}{3}, t\right)$
37. $(s + 1, 2s - t + 1, s, t)$ **39.** No solution
41. $(1, t + 1, t, 0)$ **43.** \$3000 at 6%, \$6000 at 7%
45. \$2500 in bank A, \$40,000 in bank B, \$17,500 in bank C
47. Impossible

49. $\begin{bmatrix} 4 & 18 \\ 4 & 0 \\ 2 & 2 \end{bmatrix}$ **51.** $\begin{bmatrix} 10 & 0 & -5 \end{bmatrix}$ **53.** $\begin{bmatrix} -\frac{7}{2} & 10 \\ 1 & -\frac{9}{2} \end{bmatrix}$

55. $\begin{bmatrix} 30 & 22 & 2 \\ -9 & 1 & -4 \end{bmatrix}$ **57.** $\begin{bmatrix} -\frac{1}{2} & \frac{11}{2} \\ \frac{15}{4} & -\frac{3}{2} \\ -\frac{1}{2} & 1 \end{bmatrix}$ **61.** $\frac{1}{3}\begin{bmatrix} -1 & -3 \\ -5 & 2 \end{bmatrix}$

63. $\begin{bmatrix} \frac{7}{2} & -2 \\ 0 & 8 \end{bmatrix}$ **65.** $\begin{bmatrix} 2 & -2 & 6 \\ -4 & 5 & -9 \end{bmatrix}$ **67.** $1, \begin{bmatrix} 9 & -4 \\ -2 & 1 \end{bmatrix}$

69. 0, no inverse **71.** $-1, \begin{bmatrix} 3 & 2 & -3 \\ 2 & 1 & -2 \\ -8 & -6 & 9 \end{bmatrix}$

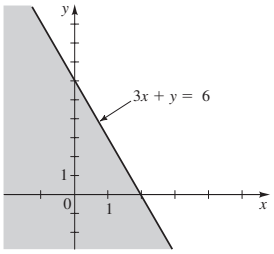
73. $24, \begin{bmatrix} 1 & 0 & 0 & -\frac{1}{4} \\ 0 & \frac{1}{2} & 0 & -\frac{1}{4} \\ 0 & 0 & \frac{1}{3} & -\frac{1}{4} \\ 0 & 0 & 0 & \frac{1}{4} \end{bmatrix}$ **75.** $(65, 154)$ **77.** $\left(-\frac{1}{12}, \frac{1}{12}, \frac{1}{12}\right)$

79. $\left(\frac{1}{5}, \frac{9}{5}\right)$ **81.** $\left(-\frac{87}{26}, \frac{21}{26}, \frac{3}{2}\right)$ **83.** 11 **85.** $\dfrac{2}{x-5} + \dfrac{1}{x+3}$

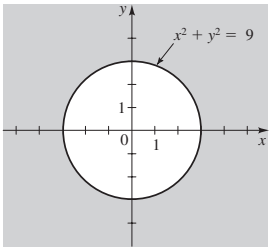
87. $\dfrac{-4}{x} + \dfrac{4}{x-1} + \dfrac{-2}{(x-1)^2}$ **89.** $\dfrac{-1}{x} + \dfrac{x+2}{x^2+1}$

91. $(2, 1)$ **93.** $\left(-\frac{1}{2}, \frac{7}{4}\right), (2, -2)$ **95.** $x + y^2 \le 4$

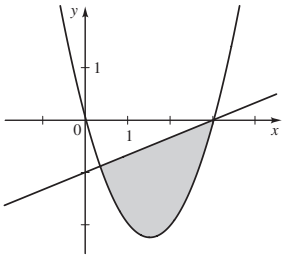
97.



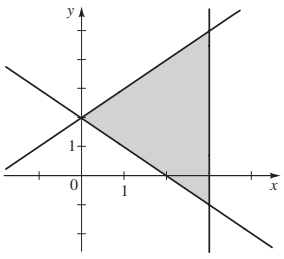
99.



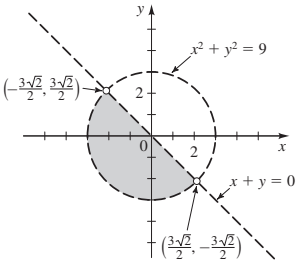
101.



103.

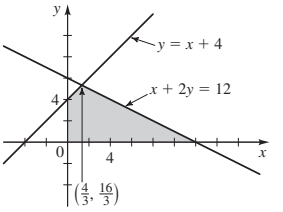


105.



Bounded

107.



Bounded

109. $x = \dfrac{b+c}{2}, y = \dfrac{a+c}{2}, z = \dfrac{a+b}{2}$ **111.** 2, 3

Chapter 9 Test ■ Page 757

1. **(a)** Linear **(b)** $(-2, 3)$ **2.** **(a)** Nonlinear
(b) $(1, -2), \left(\frac{5}{3}, 0\right)$
3. $(-0.55, -0.78), (0.43, -0.29), (2.12, 0.56)$
4. Wind 60 km/h, airplane 300 km/h
5. **(a)** Row-echelon form **(b)** Reduced row-echelon form
(c) Neither **6.** **(a)** $\left(\frac{5}{2}, \frac{5}{2}, 0\right)$ **(b)** No solution
7. $\left(-\frac{3}{5} + \frac{2}{5}t, \frac{1}{5} + \frac{1}{5}t, t\right)$
8. Coffee \$1.50, juice \$1.75, donut \$0.75
9. **(a)** Incompatible dimensions
(b) Incompatible dimensions

(c) $\begin{bmatrix} 6 & 10 \\ 3 & -2 \\ -3 & 9 \end{bmatrix}$ **(d)** $\begin{bmatrix} 36 & 58 \\ 0 & -3 \\ 18 & 28 \end{bmatrix}$ **(e)** $\begin{bmatrix} 2 & -\frac{3}{2} \\ -1 & 1 \end{bmatrix}$

(f) B is not square **(g)** B is not square **(h)** -3

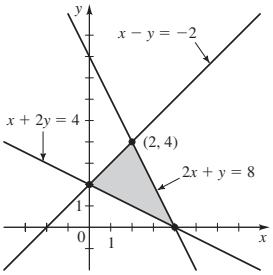
10. **(a)** $\begin{bmatrix} 4 & -3 \\ 3 & -2 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 10 \\ 30 \end{bmatrix}$ **(b)** $(70, 90)$

11. $|A| = 0, |B| = 2, B^{-1} = \begin{bmatrix} 1 & -2 & 0 \\ 0 & \frac{1}{2} & 0 \\ 3 & -6 & 1 \end{bmatrix}$

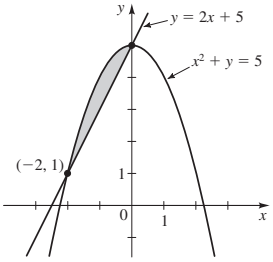
12. $(5, -5, -4)$

13. **(a)** $\dfrac{1}{x-1} + \dfrac{1}{(x-1)^2} - \dfrac{1}{x+2}$ **(b)** $-\dfrac{1}{x} + \dfrac{x+2}{x^2+3}$

14. **(a)**



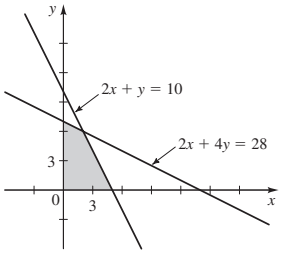
(b)



Focus on Modeling ■ Page 762

1. 198, 195

3.



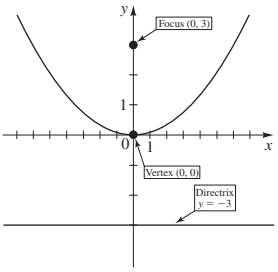
maximum 161
minimum 135

5. 3 tables, 34 chairs **7.** 30 grapefruit crates, 30 orange crates
9. 15 Pasadena to Santa Monica, 3 Pasadena to El Toro,
0 Long Beach to Santa Monica, 16 Long Beach to El Toro
11. 90 standard, 40 deluxe **13.** \$7500 in municipal bonds,
\$2500 in bank certificates, \$2000 in high-risk bonds
15. 4 games, 32 educational, 0 utility

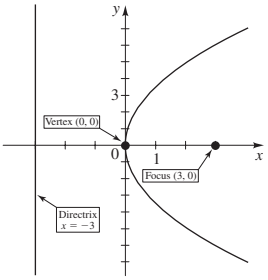
Chapter 10

Section 10.1 ■ Page 772

1. focus, directrix **2.** $F(0, p)$, $y = -p$, vertical, $F(0, 3)$, $y = -3$
3. $F(p, 0)$, $x = -p$, horizontal, $F(3, 0)$, $x = -3$
4. **(a)**



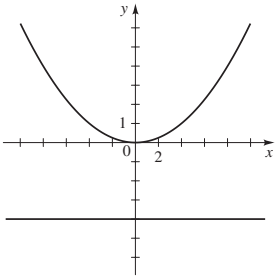
(b)



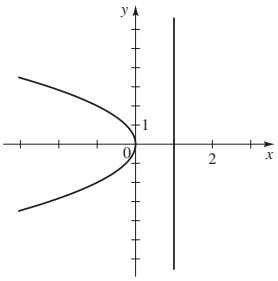
5. III **7.** II **9.** VI

Order of answers for 11–23, part (a): focus; directrix; focal diameter

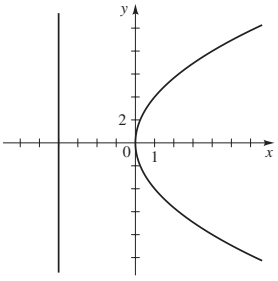
11. **(a)** $F(0, 4)$; $y = -4$; 16 **(b)**



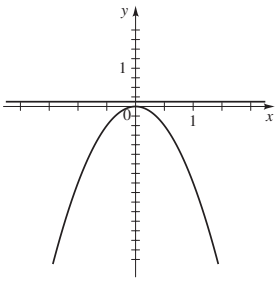
13. **(a)** $F(-1, 0)$; $x = 1$; 4 **(b)**



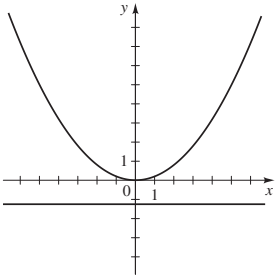
15. **(a)** $F(4, 0)$; $x = -4$; 16 **(b)**



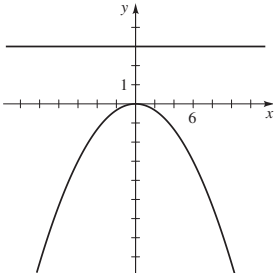
17. **(a)** $F\left(0, -\frac{1}{8}\right)$; $y = \frac{1}{8}$; $\frac{1}{2}$ **(b)**



19. **(a)** $F\left(0, \frac{5}{4}\right)$; $y = -\frac{5}{4}$; 5 **(b)**

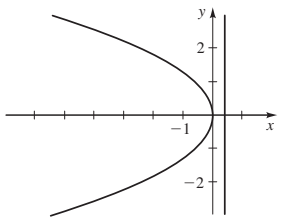


21. **(a)** $F(0, -3)$; $y = 3$; 12 **(b)**

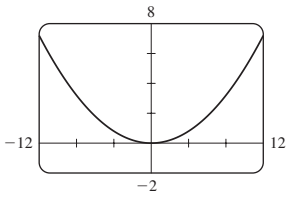


23. **(a)** $F\left(-\frac{5}{12}, 0\right)$; $x = \frac{5}{12}$; $\frac{5}{3}$

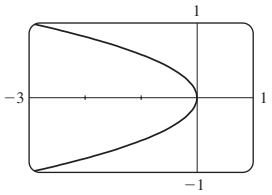
(b)



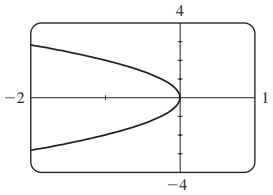
25.



27.



29.



31. $x^2 = 12y$ **33.** $y^2 = -32x$ **35.** $x^2 = -3y$ **37.** $y^2 = 8x$

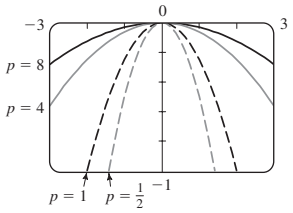
39. $x^2 = -\frac{2}{5}y$ **41.** $y^2 = -\frac{1}{5}x$ **43.** $y^2 = 4x$ **45.** $x^2 = -40y$

47. $x^2 = -24y$ **49.** $x^2 = 24y$ **51.** $y^2 = -16x$

53. $y^2 = -3x$ **55.** $x = y^2$ **57.** $x^2 = -4\sqrt{2}y$

59. **(a)** $x^2 = -4py$, $p = \frac{1}{2}$, 1, 4, and 8

(b) The closer the directrix to the vertex, the steeper the parabola.



61. **(a)** $y^2 = 12x$ **(b)** $8\sqrt{15} \approx 31$ cm **63.** $x^2 = 600y$

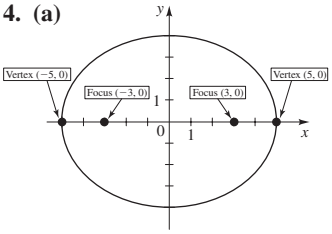
Section 10.2 ■ Page 781

1. sum; foci

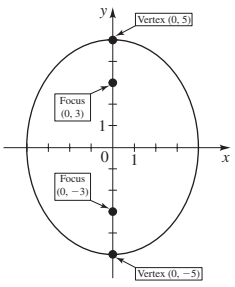
2. horizontal, $(a, 0), (-a, 0)$; $c = \sqrt{a^2 - b^2}$; $(5, 0), (-5, 0), (3, 0), (-3, 0)$

3. vertical, $(0, a), (0, -a)$; $c = \sqrt{a^2 - b^2}$; $(0, 5), (0, -5), (0, 3), (0, -3)$

4. **(a)**



(b)



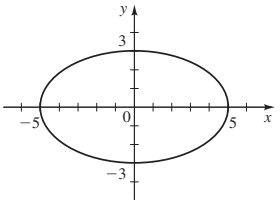
5. II **7.** I

Order of answers for 9–27 part (a): vertices; foci; eccentricity

9. **(a)** $V(\pm 5, 0)$; $F(\pm 4, 0)$; $\frac{4}{5}$

(b) 10, 6

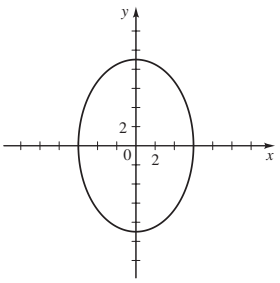
(c)



11. **(a)** $V(0, \pm 9)$; $F(0, \pm 3\sqrt{5})$; $\sqrt{5}/3$

(b) 18, 12

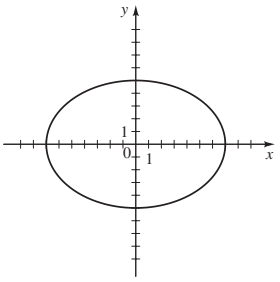
(c)



13. **(a)** $V(\pm 7, 0)$; $F(\pm 2\sqrt{6}, 0)$; $2\sqrt{6}/7$

(b) 14, 10

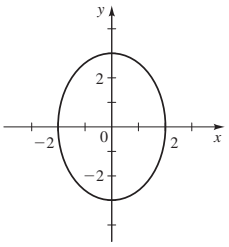
(c)



15. **(a)** $V(0, \pm 3)$; $F(0, \pm\sqrt{5})$; $\sqrt{5}/3$

(b) 6, 4

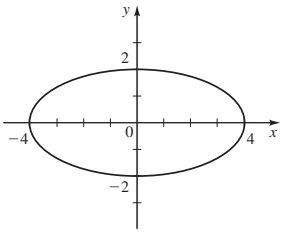
(c)



17. **(a)** $V(\pm 4, 0)$; $F(\pm 2\sqrt{3}, 0)$; $\sqrt{3}/2$

(b) 8, 4

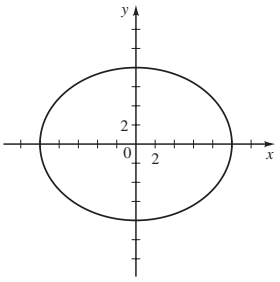
(c)



19. **(a)** $V(\pm 10, 0)$; $F(\pm 6, 0)$; $\frac{3}{5}$

(b) 20, 16

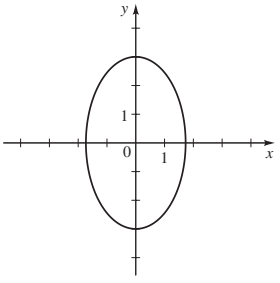
(c)



21. **(a)** $V(0, \pm 3)$; $F(0, \pm\sqrt{6})$; $\sqrt{6}/3$

(b) $6, 2\sqrt{3}$

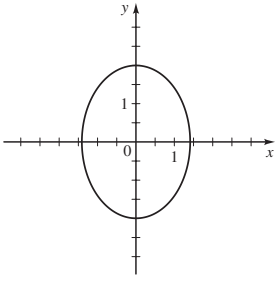
(c)



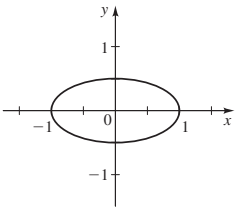
23. **(a)** $V(0, \pm 2)$; $F(0, \pm\sqrt{2})$; $\sqrt{2}/2$

(b) $4, 2\sqrt{2}$

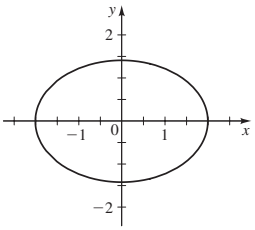
(c)



25. **(a)** $V(\pm 1, 0)$; $F(\pm\sqrt{3}/2, 0)$; $\sqrt{3}/2$
(b) 2, 1
(c)

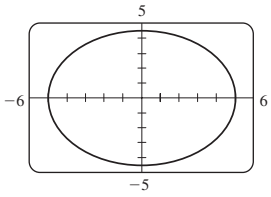


27. **(a)** $V(\pm 2, 0)$; $F(\pm\sqrt{2}, 0)$; $\sqrt{2}/2$
(b) $4, 2\sqrt{2}$
(c)

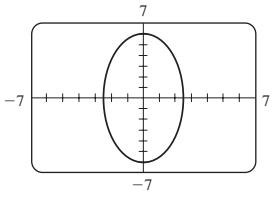


29. $\dfrac{x^2}{25} + \dfrac{y^2}{16} = 1$ **31.** $\dfrac{x^2}{4} + \dfrac{y^2}{8} = 1$ **33.** $\dfrac{x^2}{256} + \dfrac{y^2}{48} = 1$

35.



37.

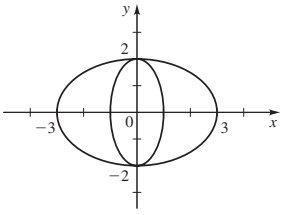


39. $\dfrac{x^2}{25} + \dfrac{y^2}{9} = 1$ **41.** $\dfrac{x^2}{4} + \dfrac{y^2}{3} = 1$ **43.** $\dfrac{x^2}{39} + \dfrac{y^2}{49} = 1$

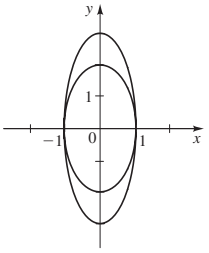
45. $x^2 + \dfrac{y^2}{4} = 1$ **47.** $\dfrac{x^2}{9} + \dfrac{y^2}{13} = 1$ **49.** $\dfrac{x^2}{100} + \dfrac{y^2}{91} = 1$

51. $\dfrac{x^2}{25} + \dfrac{y^2}{5} = 1$ **53.** $\dfrac{x^2}{32} + \dfrac{y^2}{36} = 1$ **55.** $x^2 + \dfrac{y^2}{4} = 1$

57. $(0, \pm 2)$



59. $(\pm 1, 0)$



61. **(a)** $x^2 + y^2 = 4$

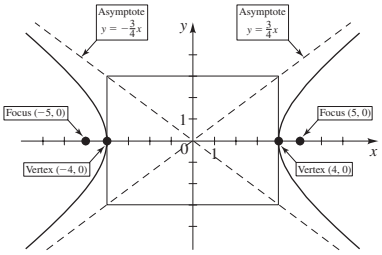
65. $\dfrac{x^2}{2.2500 \times 10^{16}} + \dfrac{y^2}{2.2491 \times 10^{16}} = 1$

67. $\dfrac{x^2}{1{,}455{,}642} + \dfrac{y^2}{1{,}451{,}610} = 1$ **69.** $5\sqrt{39}/2 \approx 15.6$ in.

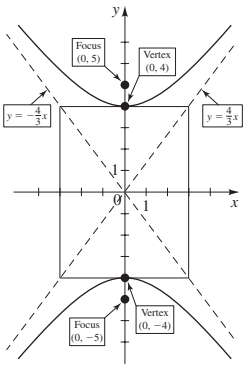
Section 10.3 ■ Page 789

1. difference; foci
2. horizontal; $(-a, 0), (a, 0)$; $\sqrt{a^2 + b^2}$; $(-4, 0), (4, 0), (-5, 0), (5, 0)$
3. vertical; $(0, -a), (0, a)$; $\sqrt{a^2 + b^2}$; $(0, -4), (0, 4), (0, -5), (0, 5)$

4. **(a)**



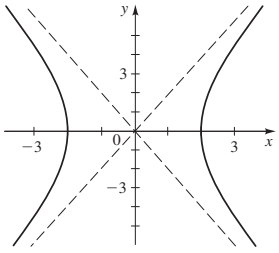
(b)



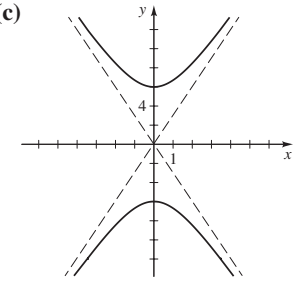
5. III **7.** II

Order of answers for 9–25, part (a): vertices; foci; asymptotes

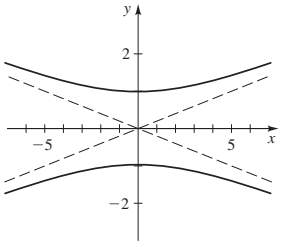
9. **(a)** $V(\pm 2, 0)$; $F(\pm 2\sqrt{5}, 0)$; $y = \pm 2x$
(b) 4
(c)



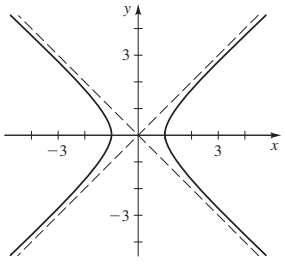
11. **(a)** $V(0, \pm 6)$; $F(0, \pm 2\sqrt{10})$; $y = \pm 3x$
(b) 12
(c)



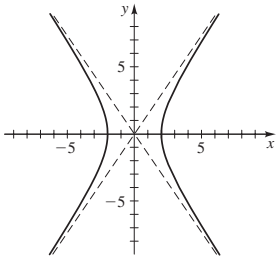
13. **(a)** $V(0, \pm 1)$; $F(0, \pm\sqrt{26})$; $y = \pm\frac{1}{5}x$
(b) 2
(c)



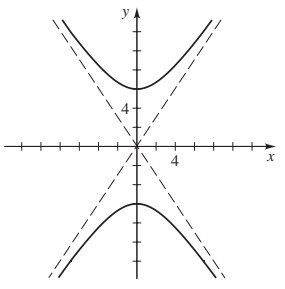
15. **(a)** $V(\pm 1, 0)$; $F(\pm\sqrt{2}, 0)$; $y = \pm x$
(b) 2
(c)



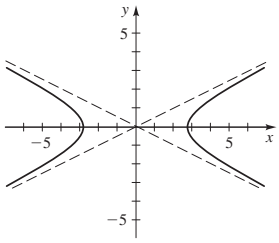
17. **(a)** $V(\pm 2, 0)$; $F(\pm\sqrt{13}, 0)$; $y = \pm\frac{3}{2}x$
(b) 4
(c)



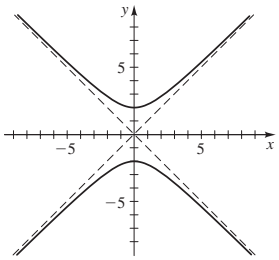
19. **(a)** $V(0, \pm 6)$; $F(0, \pm 2\sqrt{13})$; $y = \pm\frac{3}{2}x$
(b) 12
(c)



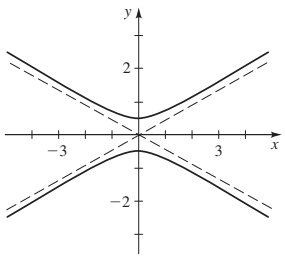
21. **(a)** $V(\pm 2\sqrt{2}, 0)$; $F(\pm\sqrt{10}, 0)$; $y = \pm\frac{1}{2}x$ **(b)** $4\sqrt{2}$ **(c)**



23. **(a)** $V(0, \pm 2)$; $F(0, \pm 2\sqrt{2})$; $y = \pm x$ **(b)** 4 **(c)**

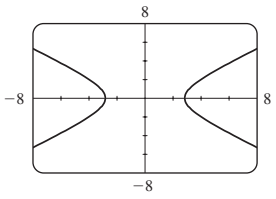


25. **(a)** $V(0, \pm\frac{1}{2})$; $F(0, \pm\sqrt{5}/2)$; $y = \pm\frac{1}{2}x$ **(b)** 1 **(c)**

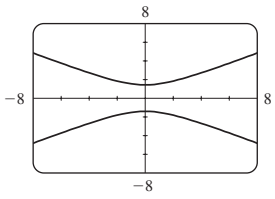


27. $\dfrac{x^2}{4} - \dfrac{y^2}{12} = 1$ **29.** $\dfrac{y^2}{16} - \dfrac{x^2}{16} = 1$ **31.** $\dfrac{y^2}{9} - x^2 = 1$

33.



35.

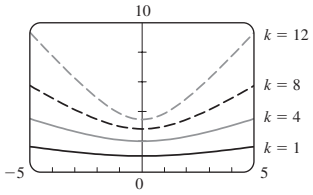


37. $\dfrac{x^2}{9} - \dfrac{y^2}{16} = 1$ **39.** $y^2 - \dfrac{x^2}{3} = 1$ **41.** $x^2 - \dfrac{y^2}{25} = 1$

43. $\dfrac{y^2}{36} - \dfrac{x^2}{20} = 1$ **45.** $\dfrac{x^2}{16} - \dfrac{y^2}{16} = 1$ **47.** $\dfrac{y^2}{8} - x^2 = 1$

49. $\dfrac{x^2}{9} - \dfrac{y^2}{16} = 1$ **51.** **(b)** $x^2 - y^2 = c^2/2$

55. **(b)**



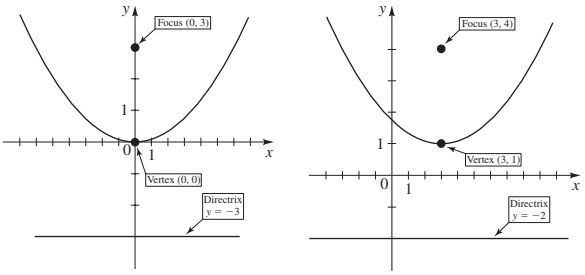
As k increases, the asymptotes get steeper.

57. $x^2 - y^2 = 2.3 \times 10^{19}$

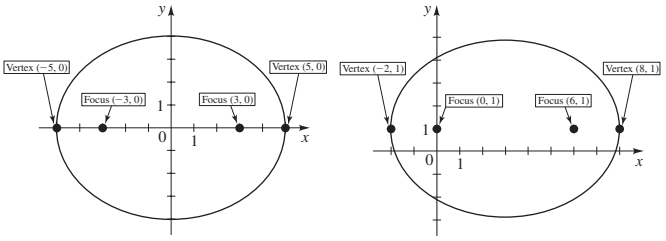
Section 10.4 ■ Page 799

1. **(a)** right; left **(b)** upward; downward

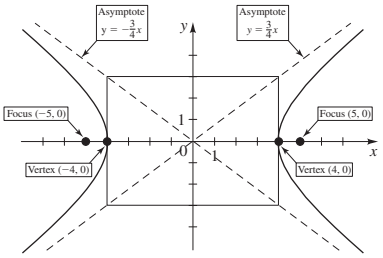
2.

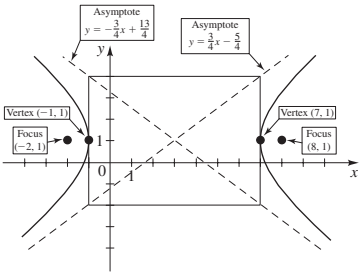


3.

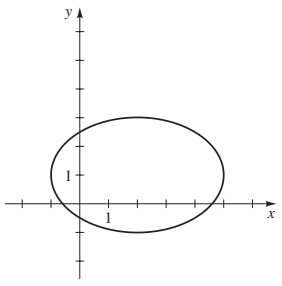


4.

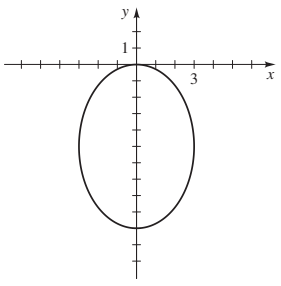




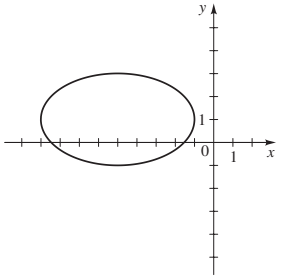
5. **(a)** $C(2, 1)$; $V_1(-1, 1)$, $V_2(5, 1)$; $F(2 \pm \sqrt{5}, 1)$ **(b)** 6, 4 **(c)**



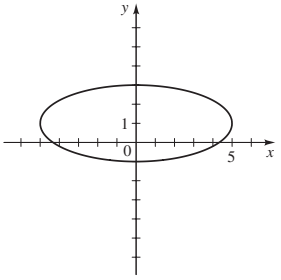
7. **(a)** $C(0, -5)$; $V_1(0, -10)$, $V_2(0, 0)$; $F_1(0, -9)$, $F_2(0, -1)$ **(b)** 10, 6 **(c)**



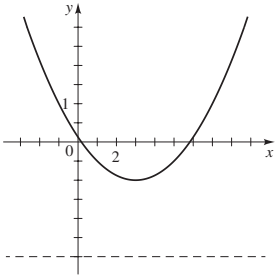
9. (a) $C(-5, 1)$; $V_1(-9, 1)$, $V_2(-1, 1)$; $F(-5 \pm 2\sqrt{3}, 1)$
(b) 8, 4
(c)



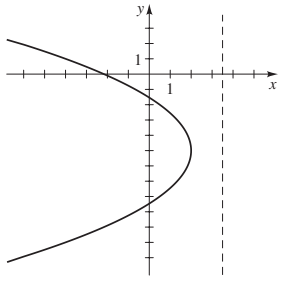
11. (a) $C(0, 1)$; $V(\pm 5, 1)$; $F(\pm\sqrt{21}, 1)$
(b) 10, 4
(c)



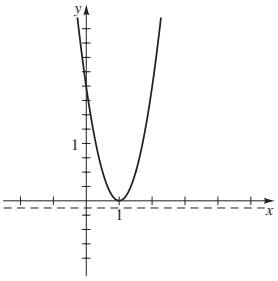
13. (a) $V(3, -1)$; $F(3, 1)$; directrix $y = -3$
(b)



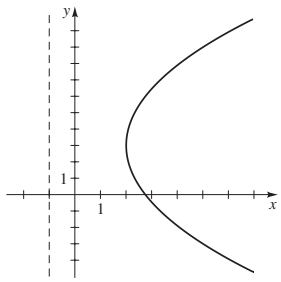
15. (a) $V(2, -5)$; $F\left(\frac{1}{2}, -5\right)$; directrix $x = \frac{7}{2}$
(b)



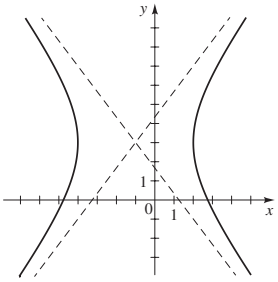
17. (a) $V(1, 0)$; $F\left(1, \frac{1}{8}\right)$; directrix $y = -\frac{1}{8}$
(b)



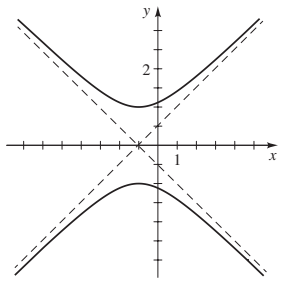
19. (a) $V(2, 3)$; $F(5, 3)$; directrix $x = -1$
(b)



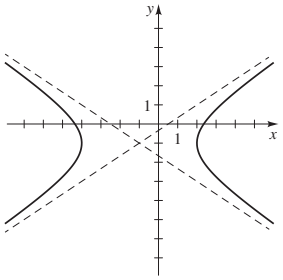
21. (a) $C(-1, 3)$; $V_1(-4, 3)$, $V_2(2, 3)$; $F_1(-6, 3)$, $F_2(4, 3)$; asymptotes $y = \frac{4}{3}x + \frac{13}{3}$ and $y = -\frac{4}{3}x + \frac{5}{3}$
(b)



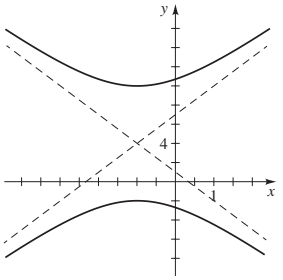
23. (a) $C(-1, 0)$; $V(-1, \pm 1)$; $F(-1, \pm\sqrt{5})$; asymptotes $y = \frac{1}{2}x + \frac{1}{2}$ and $y = -\frac{1}{2}x - \frac{1}{2}$
(b)



25. (a) $C(-1, -1)$; $V_1(-4, -1)$, $V_2(2, -1)$; $F(-1 \pm \sqrt{13}, -1)$; asymptotes $y = \frac{2}{3}x - \frac{1}{3}$ and $y = -\frac{2}{3}x - \frac{5}{3}$
(b)



27. (a) $C(-1, 4)$; $V_1(-1, -2)$, $V_2(-1, 10)$; $F(-1, 4 \pm 2\sqrt{10})$; asymptotes $y = 3x + 7$ and $y = -3x + 1$
(b)



29. $x^2 = -\frac{1}{4}(y - 4)$ **31.** $\dfrac{(x-5)^2}{25} + \dfrac{y^2}{16} = 1$

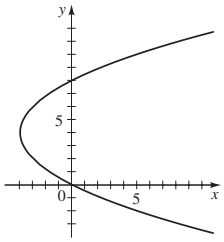
33. $(y - 1)^2 - x^2 = 1$ **35.** $\dfrac{(x-2)^2}{100} + \dfrac{(y+3)^2}{64} = 1$

37. $\dfrac{(y-4)^2}{49} - \dfrac{(x+1)^2}{32} = 1$ **39.** $(x + 3)^2 = 12(y - 5)$

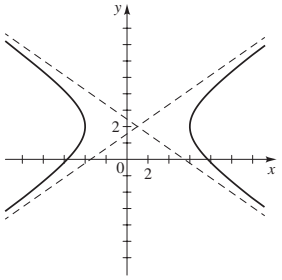
41. $\dfrac{y^2}{16} - \dfrac{(x-1)^2}{9} = 1$ **43.** $\dfrac{(x-3)^2}{29} + \dfrac{(y+4)^2}{25} = 1$

45. $(y - 2)^2 = \frac{1}{7}(x + 1)$

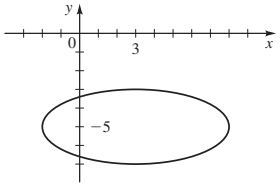
47. Parabola; $V(-4, 4)$; $F(-3, 4)$; directrix $x = -5$



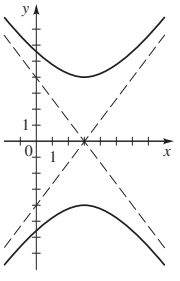
49. Hyperbola; $C(1, 2)$; $F(1 \pm \sqrt{30}, 2)$; $V_1(-4, 2)$, $V_2(6, 2)$; asymptotes $y = \pm\dfrac{\sqrt{5}}{5}(x - 1) + 2$



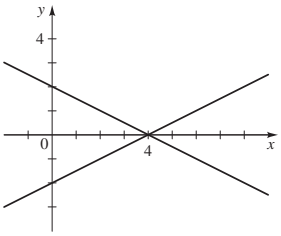
51. Ellipse; $C(3, -5)$; $F(3 \pm \sqrt{21}, -5)$; $V_1(-2, -5)$, $V_2(8, -5)$; major axis 10, minor axis 4



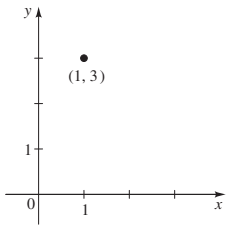
53. Hyperbola; $C(3, 0)$; $F(3, \pm 5)$; $V(3, \pm 4)$; asymptotes $y = \pm\frac{4}{3}(x - 3)$



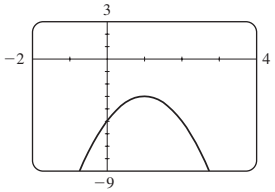
55. Degenerate conic (pair of lines), $y = \pm\frac{1}{2}(x - 4)$



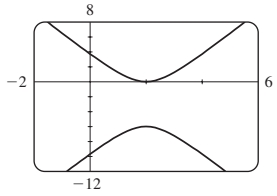
57. Point $(1, 3)$



59.

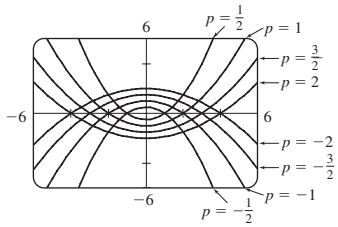


61.



63. **(a)** $F < 17$ **(b)** $F = 17$ **(c)** $F > 17$

65. **(a)**



(c) The parabolas become narrower.

67. $\dfrac{(x + 150)^2}{18{,}062{,}500} + \dfrac{y^2}{18{,}040{,}000} = 1$

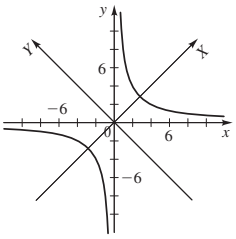
Section 10.5 ■ Page 808

1. $x = X\cos\phi - Y\sin\phi$, $y = X\sin\phi + Y\cos\phi$, $X = x\cos\phi + y\sin\phi$, $Y = -x\sin\phi + y\cos\phi$ **2.** **(a)** conic section **(b)** $(A - C)/B$ **(c)** $B^2 - 4AC$, a parabola, an ellipse, a hyperbola **3.** $(\sqrt{2}, 0)$ **5.** $(0, -2\sqrt{3})$ **7.** $(1.6383, 1.1472)$ **9.** $X^2 + \sqrt{3}XY + 2 = 0$ **11.** $7Y^2 - 48XY - 7X^2 - 40X - 30Y = 0$ **13.** $X^2 - Y^2 = 2$

15. **(a)** Hyberbola

(b) $X^2 - Y^2 = 16$

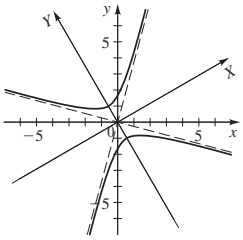
(c) $\phi = 45°$



17. **(a)** Hyberbola

(b) $Y^2 - X^2 = 1$

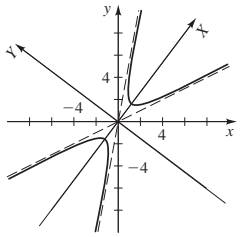
(c) $\phi = 30°$



19. **(a)** Hyberbola

(b) $\dfrac{X^2}{4} - Y^2 = 1$

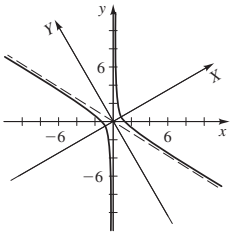
(c) $\phi \approx 53°$



21. **(a)** Hyberbola

(b) $3X^2 - Y^2 = 2\sqrt{3}$

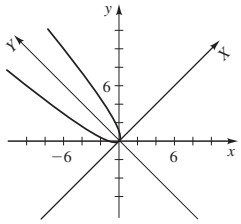
(c) $\phi = 30°$



23. **(a)** Parabola

(b) $Y = \sqrt{2}X^2$

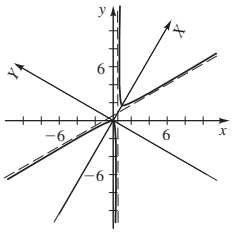
(c) $\phi = 45°$



25. **(a)** Hyberbola

(b) $(X - 1)^2 - 3Y^2 = 1$

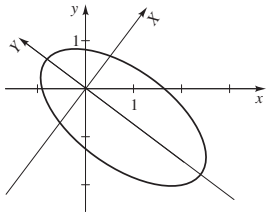
(c) $\phi = 60°$



27. **(a)** Ellipse

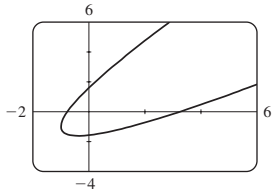
(b) $X^2 + \dfrac{(Y + 1)^2}{4} = 1$

(c) $\phi \approx 53°$



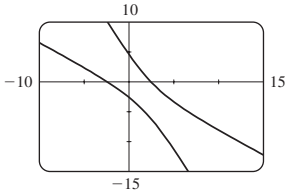
29. **(a)** Parabola

(b)



31. **(a)** Hyperbola

(b)



33. **(a)** $(X - 5)^2 - Y^2 = 1$

(b) XY-coordinates: $C(5, 0)$; $V_1(6, 0)$, $V_2(4, 0)$; $F(5 \pm \sqrt{2}, 0)$; xy-coordinates:

$C(4, 3)$; $V_1\left(\frac{24}{5}, \frac{18}{5}\right)$, $V_2\left(\frac{16}{5}, \frac{12}{5}\right)$; $F_1\left(4 + \frac{4}{5}\sqrt{2}, 3 + \frac{3}{5}\sqrt{2}\right)$, $F_2\left(4 - \frac{4}{5}\sqrt{2}, 3 - \frac{3}{5}\sqrt{2}\right)$

(c) $Y = \pm(X - 5)$; $7x - y - 25 = 0$, $x + 7y - 25 = 0$

35. $X = x\cos\phi + y\sin\phi$; $Y = -x\sin\phi + y\cos\phi$

Section 10.6 ■ Page 814

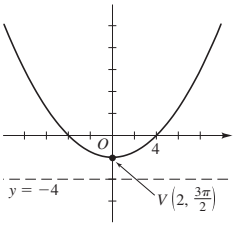
1. focus, directrix; $\dfrac{\text{distance from } P \text{ to } F}{\text{distance from } P \text{ to } \ell}$, conic section; parabola, ellipse, hyperbola, eccentricity

2. $\dfrac{ed}{1 \pm e\cos\theta}, \dfrac{ed}{1 \pm e\sin\theta}$ **3.** $r = 6/(3 + 2\cos\theta)$

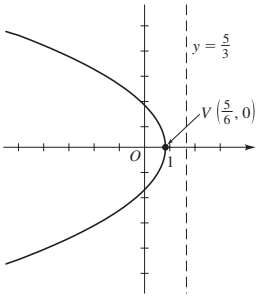
5. $r = 2/(1 + \sin\theta)$ **7.** $r = 20/(1 + 4\cos\theta)$

9. $r = 10/(1 + \sin\theta)$ **11.** II **13.** VI **15.** IV

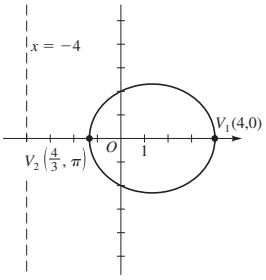
17. (a), (b)



19. (a), (b)

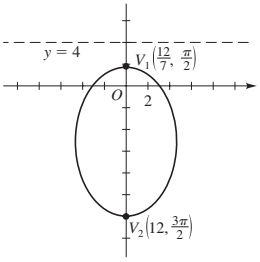


21. (a), (b)



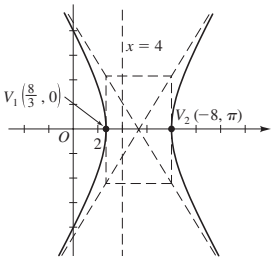
(c) $C\left(\frac{4}{3}, 0\right)$, major axis: $\frac{16}{3}$, minor axis: $\frac{8\sqrt{3}}{3}$

23. (a), (b)



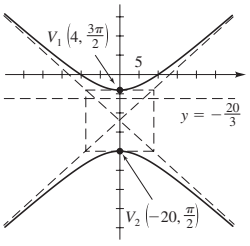
(c) $C\left(\frac{36}{7}, \frac{3\pi}{2}\right)$, major axis: $\frac{96}{7}$, minor axis: $\frac{24\sqrt{7}}{7}$

25. (a), (b)



(c) $\left(\frac{16}{3}, 0\right)$

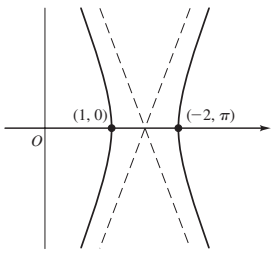
27. (a), (b)



(c) $\left(12, \frac{3\pi}{2}\right)$

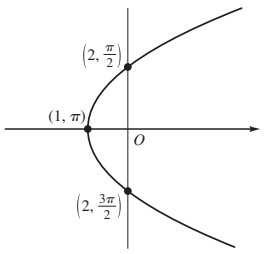
29. (a) 3, hyperbola

(b)



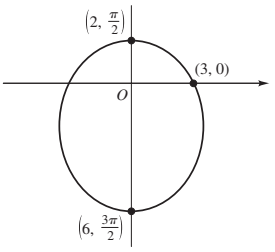
31. (a) 1, parabola

(b)



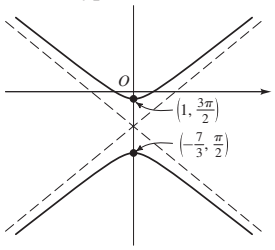
33. (a) $\frac{1}{2}$, ellipse

(b)



35. (a) $\frac{5}{2}$, hyperbola

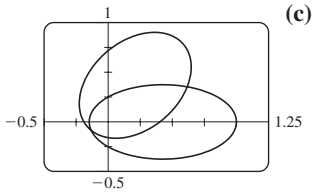
(b)



37. (a) Eccentricity $\frac{3}{4}$, directrix $x = -\frac{1}{3}$

(b) $r = \dfrac{1}{4 - 3\cos\left(\theta - \frac{\pi}{3}\right)}$

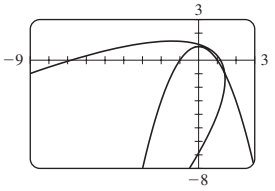
(c)



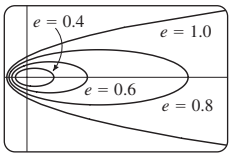
39. (a) Eccentricity 1, directrix $y = 2$

(b) $r = \dfrac{2}{1 + \sin\left(\theta + \frac{\pi}{4}\right)}$

(c)



41. The ellipse is nearly circular when e is close to 0 and becomes more elongated as $e \to 1^-$. At $e = 1$ the curve becomes a parabola.

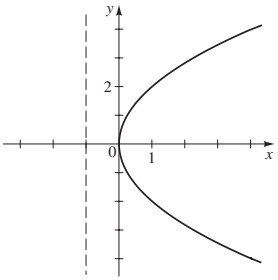


43. (b) $r = (1.49 \times 10^8)/(1 - 0.017\cos\theta)$ **45.** 0.25

Chapter 10 Review ■ Page 818

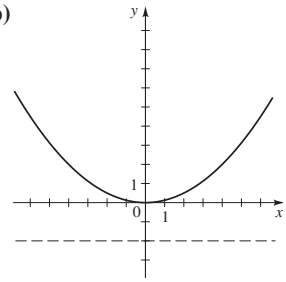
1. (a) $V(0, 0)$; $F(1, 0)$; directrix $x = -1$

(b)



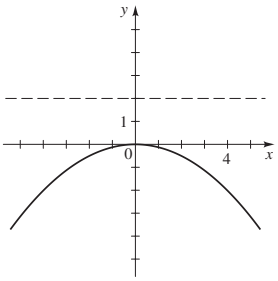
3. (a) $V(0, 0)$; $F(0, 2)$; directrix $y = -2$

(b)



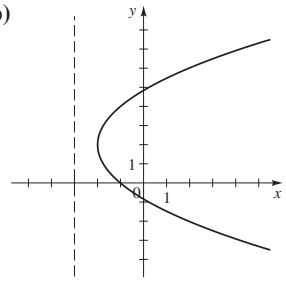
5. (a) $V(0, 0)$; $F(0, -2)$; directrix $y = 2$

(b)



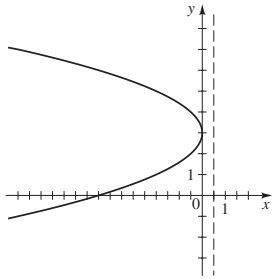
7. (a) $V(-2, 2)$; $F(-1, 2)$; directrix $x = -3$

(b)



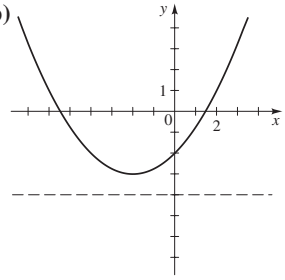
9. **(a)** $V(0, 3)$; $F\left(-\frac{1}{2}, 3\right)$; directrix $x = \frac{1}{2}$

(b)



11. **(a)** $V(-2, -3)$; $F(-2, -2)$; directrix $y = -4$

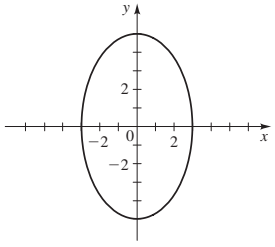
(b)



13. **(a)** $C(0, 0)$; $V(0, \pm 5)$; $F(0, \pm 4)$

(b) 10, 6

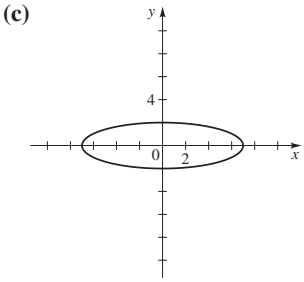
(c)



15. **(a)** $C(0, 0)$; $V(\pm 7, 0)$; $F(\pm 3\sqrt{5}, 0)$

(b) 14, 4

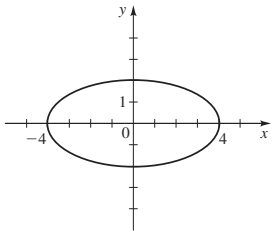
(c)



17. **(a)** $C(0, 0)$; $V(\pm 4, 0)$; $F\left(\pm 2\sqrt{3}, 0\right)$

(b) 8, 4

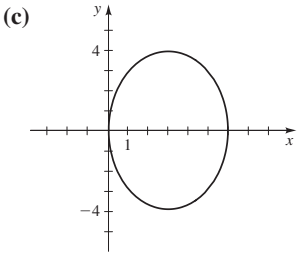
(c)



19. **(a)** $C(3, 0)$; $V(3, \pm 4)$; $F\left(3, \pm\sqrt{7}\right)$

(b) 8, 6

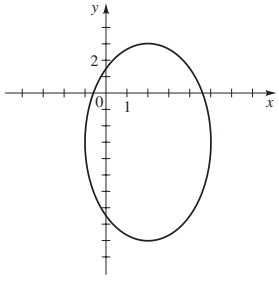
(c)



21. **(a)** $C(2, -3)$; $V_1(2, -9)$, $V_2(2, 3)$; $F(2, -3 \pm 3\sqrt{3})$

(b) 12, 6

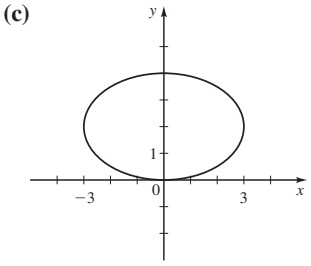
(c)



23. **(a)** $C(0, 2)$; $V(\pm 3, 2)$; $F\left(\pm\sqrt{5}, 2\right)$

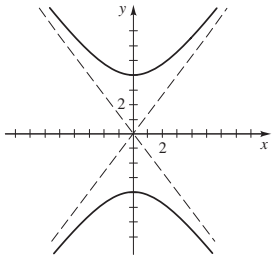
(b) 6, 4

(c)



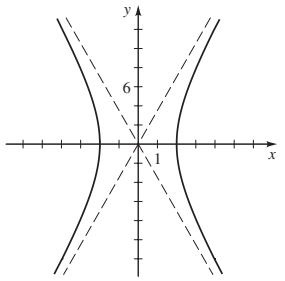
25. **(a)** $C(0, 0)$; $V(0, \pm 4)$; $F(0, \pm 5)$; asymptotes $y = \pm\frac{4}{3}x$

(b)



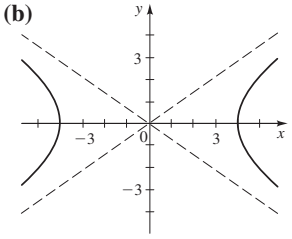
27. **(a)** $C(0, 0)$; $V(\pm 2, 0)$; $F(\pm\sqrt{53}, 0)$; asymptotes $y = \pm\frac{7}{2}x$

(b)



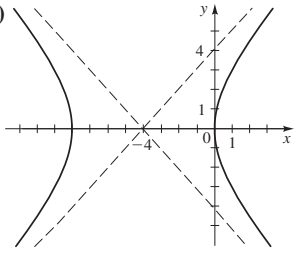
29. **(a)** $C(0, 0)$; $V(\pm 4, 0)$; $F\left(\pm 2\sqrt{6}, 0\right)$; asymptotes $y = \pm\dfrac{1}{\sqrt{2}}x$

(b)



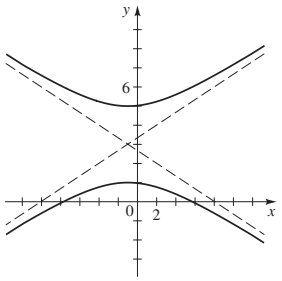
31. **(a)** $C(-4, 0)$; $V_1(-8, 0)$, $V_2(0, 0)$; $F\left(-4 \pm 4\sqrt{2}, 0\right)$; asymptotes $y = \pm(x + 4)$

(b)



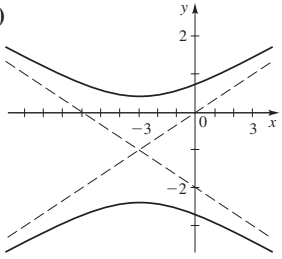
33. **(a)** $C(-1, 3)$; $V_1(-1, 1)$, $V_2(-1, 5)$; $F(-1, 3 \pm 2\sqrt{10})$; asymptotes $y = \frac{1}{3}x + \frac{10}{3}$ and $y = -\frac{1}{3}x + \frac{8}{3}$

(b)



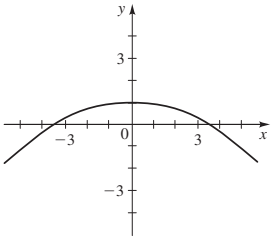
35. **(a)** $C(-3, -1)$; $V\left(-3, -1 \pm \sqrt{2}\right)$; $F\left(-3, -1 \pm 2\sqrt{5}\right)$; asymptotes $y = \frac{1}{3}x$, $y = -\frac{1}{3}x - 2$

(b)

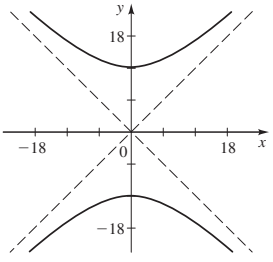


37. $y^2 = 8x$ **39.** $\dfrac{y^2}{16} - \dfrac{x^2}{9} = 1$ **41.** $\dfrac{(x-4)^2}{16} + \dfrac{(y-2)^2}{4} = 1$

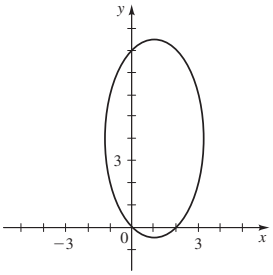
43. Parabola; $V(0, 1)$; $F(0, -2)$; directrix $y = 4$



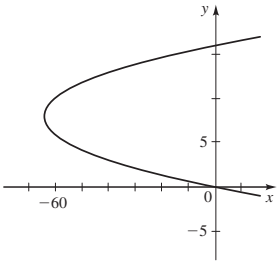
45. Hyperbola; $C(0, 0)$; $F(0, \pm 12\sqrt{2})$; $V(0, \pm 12)$; asymptotes $y = \pm x$



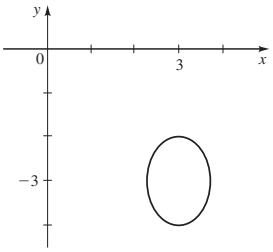
47. Ellipse; $C(1, 4)$;
$F(1, 4 \pm \sqrt{15})$;
$V(1, 4 \pm 2\sqrt{5})$



49. Parabola; $V(-64, 8)$;
$F\left(-\frac{255}{4}, 8\right)$; directrix $x = -\frac{257}{4}$



51. Ellipse; $C(3, -3)$;
$F\left(3, -3 \pm \frac{\sqrt{2}}{2}\right)$;
$V_1(3, -4)$, $V_2(3, -2)$



53. Has no graph

55. $x^2 = 4y$ **57.** $\dfrac{x^2}{4} + \dfrac{y^2}{25} = 1$

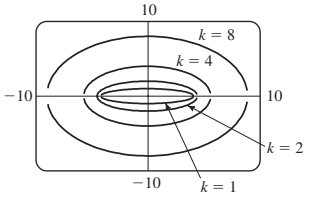
59. $\dfrac{x^2}{9} + \dfrac{(y-4)^2}{25} = 1$

61. $\dfrac{(x-1)^2}{3} + \dfrac{(y-2)^2}{4} = 1$

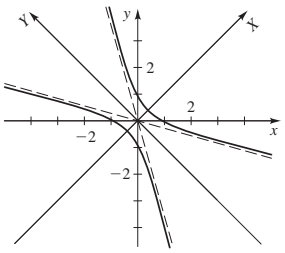
63. $\dfrac{4(x-7)^2}{225} + \dfrac{(y-2)^2}{100} = 1$

65. **(a)** 91,419,000 mi **(b)** 94,581,000 mi

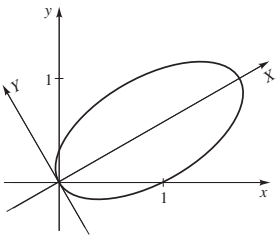
67. **(a)**



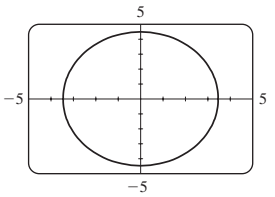
69. **(a)** Hyperbola **(b)** $3X^2 - Y^2 = 1$
(c) $\phi = 45°$



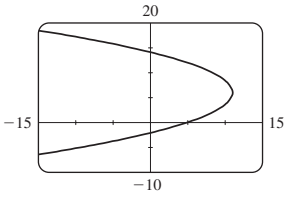
71. **(a)** Ellipse
(b) $(X-1)^2 + 4Y^2 = 1$
(c) $\phi = 30°$



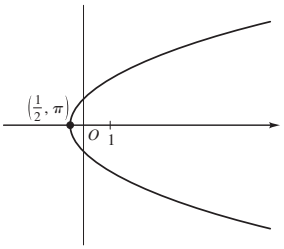
73. Ellipse



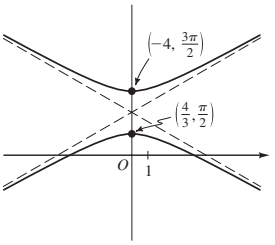
75. Parabola



77. **(a)** $e = 1$, parabola
(b)



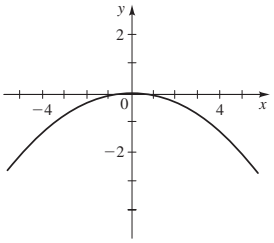
79. **(a)** $e = 2$, hyperbola
(b)



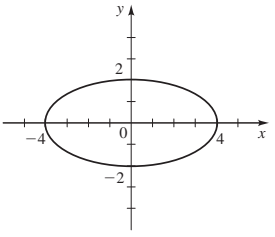
81. **(a)** IV **(b)** III **(c)** II **(d)** VIII **(e)** I **(f)** VII **(g)** VI **(h)** V

Chapter 10 Test ■ Page 821

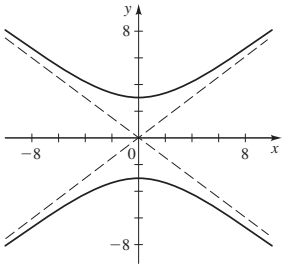
1. $F(0, -3)$, $y = 3$



2. $V(\pm 4, 0)$; $F(\pm 2\sqrt{3}, 0)$; 8, 4



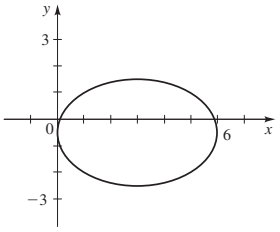
3. $V(0, \pm 3)$; $F(0, \pm 5)$; $y = \pm\frac{3}{4}x$



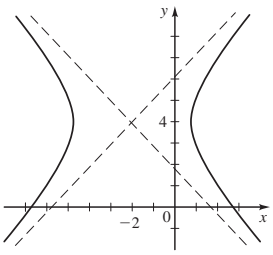
4. $y^2 = 16x$ **5.** $\dfrac{x^2}{16} + \dfrac{y^2}{7} = 1$ **6.** $\dfrac{y^2}{9} - \dfrac{x^2}{16} = 1$

7. $y^2 = -x$ **8.** $\dfrac{x^2}{16} + \dfrac{(y-3)^2}{9} = 1$ **9.** $(x-2)^2 - \dfrac{y^2}{3} = 1$

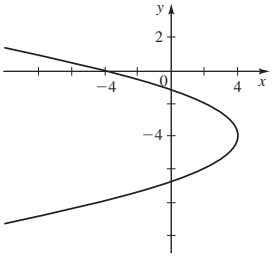
10. Ellipse; $C\left(3, -\frac{1}{2}\right)$; $F\left(3 \pm \sqrt{5}, -\frac{1}{2}\right)$; $V_1\left(0, -\frac{1}{2}\right)$, $V_2\left(6, -\frac{1}{2}\right)$



11. Hyperbola; $C(-2, 4)$, $F(-2 \pm \sqrt{17}, 4)$, $V(-2 \pm 2\sqrt{2}, 4)$, asymptotes $y - 4 = \pm\dfrac{3\sqrt{2}}{4}(x+2)$



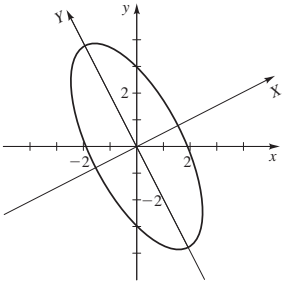
12. Parabola; $V(4, -4)$; $F\left(\frac{7}{2}, -4\right)$; directrix $x = \frac{9}{2}$



13. $\dfrac{(x-2)^2}{7} + \dfrac{y^2}{16} = 1$ **14.** $(x-2)^2 = 8(y-2)$ **15.** $\frac{3}{4}$ in.

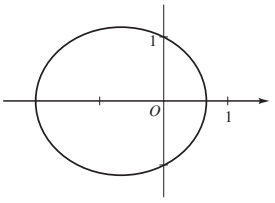
16. **(a)** Ellipse **(b)** $\dfrac{X^2}{3} + \dfrac{Y^2}{18} = 1$

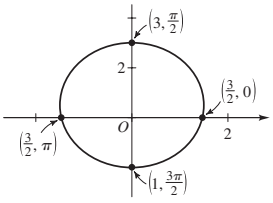
(c) $\phi \approx 27°$



(d) $\left(-3\sqrt{2/5}, 6\sqrt{2/5}\right), \left(3\sqrt{2/5}, -6\sqrt{2/5}\right)$

17. **(a)** $r = \dfrac{1}{1 + 0.5\cos\theta}$ **(b)** Ellipse





Focus on Modeling ■ Page 824

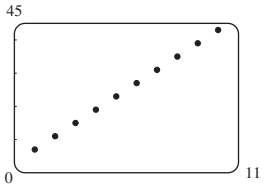
5. **(c)** $x^2 - mx + (ma - a^2) = 0$, discriminant $m^2 - 4ma + 4a^2 = (m-2a)^2$, $m = 2a$

Chapter 11

Section 11.1 ■ Page 836

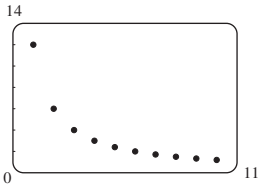
1. the natural numbers **2.** n; $1^2 + 2^2 + 3^2 + 4^2 = 30$
3. $-2, -1, 0, 1$; 97 **5.** $-1, \frac{1}{2}, \frac{1}{5}, \frac{1}{8}; \frac{1}{296}$ **7.** 3, 9, 27, 81; 3^{100}
9. $-1, \frac{1}{4}, -\frac{1}{9}, \frac{1}{16}; \frac{1}{10{,}000}$ **11.** 0, 2, 0, 2; 2
13. 1, 4, 27, 256; 100^{100} **15.** 4, 14, 34, 74, 154
17. 1, 3, 7, 15, 31 **19.** 1, 2, 3, 5, 8
21. **(a)** 7, 11, 15, 19, 23, 27, 31, 35, 39, 43

(b)



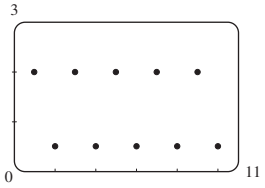
23. **(a)** 12, 6, 4, 3, $\frac{12}{5}$, 2, $\frac{12}{7}$, $\frac{3}{2}$, $\frac{4}{3}$, $\frac{6}{5}$

(b)



25. **(a)** 2, $\frac{1}{2}$, 2, $\frac{1}{2}$, 2, $\frac{1}{2}$, 2, $\frac{1}{2}$, 2, $\frac{1}{2}$

(b)

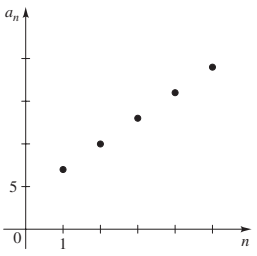


27. $a_n = 2n$ **29.** $a_n = (-3)^n$ **31.** $a_n = 5n - 1$
33. $a_n = (-1)^{n+1}5^n$ **35.** $a_n = (2n-1)/n^2$
37. $a_n = 1 + (-1)^n$ **39.** 2, 6, 12, 20, 30, 42
41. $\frac{1}{3}, \frac{4}{9}, \frac{13}{27}, \frac{40}{81}, \frac{121}{243}, \frac{364}{729}$ **43.** $\frac{2}{3}, \frac{8}{9}, \frac{26}{27}, \frac{80}{81}$; $S_n = 1 - \dfrac{1}{3^n}$
45. $1 - \sqrt{2}, 1 - \sqrt{3}, -1, 1 - \sqrt{5}$; $S_n = 1 - \sqrt{n+1}$
47. 10 **49.** $\frac{25}{36}$ **51.** 8 **53.** 31 **55.** 385 **57.** 46,438
59. 22 **61.** $1^3 + 2^3 + 3^3 + 4^3$
63. $\sqrt{4} + \sqrt{5} + \sqrt{6} + \sqrt{7} + \sqrt{8} + \sqrt{9} + \sqrt{10}$
65. $x^3 + x^4 + \cdots + x^{100}$ **67.** $\displaystyle\sum_{k=1}^{12} 4k$ **69.** $\displaystyle\sum_{k=1}^{10} k^2$
71. $\displaystyle\sum_{k=1}^{999} \frac{1}{k(k+1)}$ **73.** $\displaystyle\sum_{k=0}^{100} x^k$ **75.** $2^{(2^n-1)/2^n}$
77. **(a)** 2004.00, 2008.01, 2012.02, 2016.05, 2020.08, 2024.12 **(b)** \$2149.16 **79.** **(a)** 35,700; 36,414; 37,142; 37,885; 38,643 **(b)** 42,665 **81.** **(b)** 6898 **83.** **(a)** $A_n = A_{n-1} + 2000$, $A_1 = 45{,}000$ **(b)** \$53,000

Section 11.2 ■ Page 842

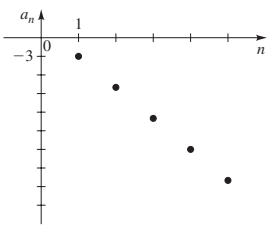
1. difference **2.** common difference; 2, 5 **3.** True **4.** True
5. **(a)** 7, 10, 13, 16, 19 **(b)** 3

(c)

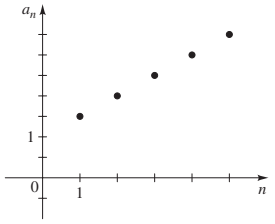


7. **(a)** $-3, -8, -13, -18, -23$ **(b)** -5

(c)



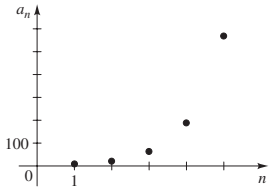
9. **(a)** 1.5, 2, 2.5, 3, 3.5
(b) 0.5
(c)



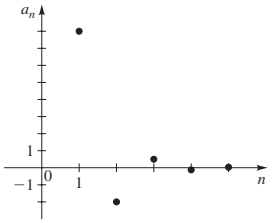
11. $a_n = -10 + 6(n - 1)$, $a_{10} = 44$
13. $a_n = 0.6 - (n - 1)$, $a_{10} = -8.4$
15. $a_n = \frac{5}{2} - \frac{1}{2}(n - 1)$, $a_{10} = -2$ **17.** Yes, 6 **19.** No
21. No **23.** Yes, $-\frac{3}{2}$ **25.** Yes, 1.7
27. 11, 18, 25, 32, 39; 7; $a_n = 11 + 7(n - 1)$
29. $\frac{1}{3}, \frac{1}{5}, \frac{1}{7}, \frac{1}{9}, \frac{1}{11}$; not arithmetic
31. -4, 2, 8, 14, 20; 6; $a_n = -4 + 6(n - 1)$
33. 2, $a_5 = 14$, $a_n = 6 + 2(n - 1)$, $a_{100} = 204$
35. -18, $a_5 = -43$, $a_n = 29 - 18(n - 1)$, $a_{100} = -1753$
37. 5, $a_5 = 24$, $a_n = 4 + 5(n - 1)$, $a_{100} = 499$
39. 4, $a_5 = 4$, $a_n = -12 + 4(n - 1)$, $a_{100} = 384$
41. 1.5, $a_5 = 31$, $a_n = 25 + 1.5(n - 1)$, $a_{100} = 173.5$
43. s, $a_5 = 2 + 4s$, $a_n = 2 + (n - 1)s$, $a_{100} = 2 + 99s$
45. 706, 712 **47.** $a_1 = -\frac{5}{12}$, $a_n = -\frac{5}{12} + \frac{1}{12}(n - 1)$
49. 33rd **51.** 1010 **53.** 870 **55.** -255 **57.** 20,301
59. 1735 **61.** 832.3 **63.** 46.75 **65.** 50 **69.** Yes
71. \$1250 **73.** \$540,000 **75.** 20 **77.** 78

Section 11.3 ■ Page 850

1. ratio **2.** common ratio; 2, 5 **3.** True **4.** **(a)** $a\left(\dfrac{1 - r^n}{1 - r}\right)$
(b) geometric; converges, $a/(1 - r)$; diverges
5. **(a)** 7, 21, 63, 189, 567
(b) 3
(c)



7. **(a)** 8, -2, $\frac{1}{2}$, $-\frac{1}{8}$, $\frac{1}{32}$
(b) $-\frac{1}{4}$
(c)



9. $a_n = 7(4)^{n-1}$, $a_4 = 448$ **11.** $a_n = 5(-3)^{n-1}$, $a_4 = -135$
13. Yes, 2 **15.** No **17.** Yes, $\frac{1}{2}$ **19.** No **21.** Yes, 1.1
23. 6, 18, 54, 162, 486; geometric, common ratio 3; $a_n = 6 \cdot 3^{n-1}$
25. $\frac{1}{4}, \frac{1}{16}, \frac{1}{64}, \frac{1}{256}, \frac{1}{1024}$; geometric, common ratio $\frac{1}{4}$; $a_n = \frac{1}{4}\left(\frac{1}{4}\right)^{n-1}$
27. 0, ln 5, 2 ln 5, 3 ln 5, 4 ln 5; not geometric
29. 3, $a_5 = 162$, $a_n = 2 \cdot 3^{n-1}$
31. -0.3, $a_5 = 0.00243$, $a_n = (0.3)(-0.3)^{n-1}$
33. $-\frac{1}{12}$, $a_5 = \frac{1}{144}$, $a_n = 144\left(-\frac{1}{12}\right)^{n-1}$
35. $3^{2/3}$, $a_5 = 3^{11/3}$, $a_n = 3^{(2n+1)/3}$
37. $s^{2/7}$, $a_5 = s^{8/7}$, $a_n = s^{2(n-1)/7}$ **39.** $a_4 = \frac{16}{49}$
41. $a_1 = -\frac{1}{27}$, $a_2 = \frac{1}{9}$ **43.** $a_1 = -\frac{9}{32}$, $a_n = -\frac{9}{32}(-8)^{n-1}$
45. $a_1 = 1728$, $a_2 = 1296$, $a_3 = 972$ **47.** Ninth **49.** 315
51. 441 **53.** 3280 **55.** -645 **57.** 13,888,888.75
59. $\frac{93}{16}$ **61.** -105 **63.** $\frac{211}{27}$ **65.** $\frac{3}{2}$ **67.** $\frac{3}{4}$
69. Divergent **71.** 2 **73.** Divergent **75.** $\sqrt{2} + 1$
77. 1 **79.** $\frac{1}{33}$ **81.** $\frac{112}{999}$ **83.** 10, 20, 40 **85.** **(a)** Neither
(b) Arithmetic, 3 **(c)** Geometric, $9\sqrt{3}$ **(d)** Arithmetic, 3
87. **(a)** $V_n = 160{,}000(0.80)^{n-1}$ **(b)** 4th year **89.** 19 ft, $80\left(\frac{3}{4}\right)^n$
91. $\frac{64}{25}, \frac{1024}{625}, 5\left(\frac{4}{5}\right)^n$ **93.** **(a)** $17\frac{8}{9}$ ft **(b)** $18 - \left(\frac{1}{3}\right)^{n-3}$
95. 2801 **97.** 3 m **99.** **(a)** 2 **(b)** $8 + 4\sqrt{2}$ **101.** 1

Section 11.4 ■ Page 857

1. natural; $P(1)$ **2.** (ii)

3. Let $P(n)$ denote the statement
$2 + 4 + 6 + \cdots + 2n = n(n + 1)$.

Step 1 $P(1)$ is true, since $2 = 1(1 + 1)$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} 2 + 4 + 6 + \cdots + 2k + 2(k + 1) &= k(k + 1) + 2(k + 1) && \text{Induction hypothesis} \\ &= (k + 1)(k + 2) \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

5. Let $P(n)$ denote the statement

$$5 + 8 + 11 + \cdots + (3n + 2) = \frac{n(3n + 7)}{2}.$$

Step 1 $P(1)$ is true, since $5 = \dfrac{1(3 \cdot 1 + 7)}{2}$

Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} 5 + 8 + 11 + \cdots + (3k + 2) + [3(k + 1) + 2] &= \frac{k(3k + 7)}{2} + (3k + 5) && \text{Induction hypothesis} \\ &= \frac{3k^2 + 13k + 10}{2} \\ &= \frac{(k + 1)[3(k + 1) + 7]}{2} \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

7. Let $P(n)$ denote the statement

$$1 \cdot 2 + 2 \cdot 3 + \cdots + n(n + 1) = \frac{n(n + 1)(n + 2)}{3}.$$

Step 1 $P(1)$ is true, since $1 \cdot 2 = \dfrac{1 \cdot (1 + 1) \cdot (1 + 2)}{3}$.

Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} 1 \cdot 2 + 2 \cdot 3 + \cdots + k(k + 1) + (k + 1)(k + 2) &= \frac{k(k + 1)(k + 2)}{3} + (k + 1)(k + 2) && \text{Induction hypothesis} \\ &= \frac{(k + 1)(k + 2)(k + 3)}{3} \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

9. Let $P(n)$ denote the statement

$$1^3 + 2^3 + 3^3 + \cdots + n^3 = \frac{n^2(n+1)^2}{4}.$$

Step 1 $P(1)$ is true, since $1^3 = \dfrac{1^2 \cdot (1+1)^2}{4}$.

Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} &1^3 + 2^3 + 3^3 + \cdots + k^3 + (k+1)^3 \\ &= \frac{k^2(k+1)^2}{4} + (k+1)^3 && \text{Induction hypothesis} \\ &= \frac{(k+1)^2[k^2 + 4(k+1)]}{4} \\ &= \frac{(k+1)^2(k+2)^2}{4} \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

11. Let $P(n)$ denote the statement

$$2^3 + 4^3 + 6^3 + \cdots + (2n)^3 = 2n^2(n+1)^2.$$

Step 1 $P(1)$ is true, since $2^3 = 2 \cdot 1^2(1+1)^2$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} &2^3 + 4^3 + 6^3 + \cdots + (2k)^3 + [2(k+1)]^3 \\ &= 2k^2(k+1)^2 + [2(k+1)]^3 && \text{Induction hypothesis} \\ &= (k+1)^2(2k^2 + 8k + 8) \\ &= 2(k+1)^2(k+2)^2 \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

13. Let $P(n)$ denote the statement

$$1 \cdot 2 + 2 \cdot 2^2 + \cdots + n \cdot 2^n = 2[1 + (n-1)2^n].$$

Step 1 $P(1)$ is true, since $1 \cdot 2 = 2[1 + 0]$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} &1 \cdot 2 + 2 \cdot 2^2 + 3 \cdot 2^3 + \cdots + k \cdot 2^k + (k+1) \cdot 2^{k+1} \\ &= 2[1 + (k-1)2^k] + (k+1) \cdot 2^{k+1} && \text{Induction hypothesis} \\ &= 2 + (k-1)2^{k+1} + (k+1) \cdot 2^{k+1} \\ &= 2 + 2k2^{k+1} = 2(1 + k2^{k+1}) \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

15. Let $P(n)$ denote the statement $n^2 + n$ is divisible by 2.

Step 1 $P(1)$ is true, since $1^2 + 1$ is divisible by 2.
Step 2 Suppose $P(k)$ is true. Now

$$\begin{aligned} (k+1)^2 + (k+1) &= k^2 + 2k + 1 + k + 1 \\ &= (k^2 + k) + 2(k+1) \end{aligned}$$

But $k^2 + k$ is divisible by 2 (by the induction hypothesis), and $2(k+1)$ is clearly divisible by 2, so $(k+1)^2 + (k+1)$ is divisible by 2. So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

17. Let $P(n)$ denote the statement $n^2 - n + 41$ is odd.

Step 1 $P(1)$ is true, since $1^2 - 1 + 41$ is odd.
Step 2 Suppose $P(k)$ is true. Now

$$(k+1)^2 - (k+1) + 41 = (k^2 - k + 41) + 2k$$

But $k^2 - k + 41$ is odd (by the induction hypothesis), and $2k$ is clearly even, so their sum is odd. So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

19. Let $P(n)$ denote the statement $8^n - 3^n$ is divisible by 5.

Step 1 $P(1)$ is true, since $8^1 - 3^1$ is divisible by 5.
Step 2 Suppose $P(k)$ is true. Now

$$\begin{aligned} 8^{k+1} - 3^{k+1} &= 8 \cdot 8^k - 3 \cdot 3^k \\ &= 8 \cdot 8^k - (8-5) \cdot 3^k = 8 \cdot (8^k - 3^k) + 5 \cdot 3^k \end{aligned}$$

which is divisible by 5 because $8^k - 3^k$ is divisible by 5 (by the induction hypothesis) and $5 \cdot 3^k$ is clearly divisible by 5. So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

21. Let $P(n)$ denote the statement $n < 2^n$.

Step 1 $P(1)$ is true, since $1 < 2^1$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} k+1 &< 2^k + 1 && \text{Induction hypothesis} \\ &< 2^k + 2^k && \text{Because } 1 < 2^k \\ &= 2 \cdot 2^k = 2^{k+1} \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

23. Let $P(n)$ denote the statement $(1+x)^n \geq 1 + nx$ for $x > -1$.

Step 1 $P(1)$ is true, since $(1+x)^1 \geq 1 + 1 \cdot x$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} (1+x)^{k+1} &= (1+x)(1+x)^k \\ &\geq (1+x)(1+kx) && \text{Induction hypothesis} \\ &= 1 + (k+1)x + kx^2 \\ &\geq 1 + (k+1)x \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

25. Let $P(n)$ denote the statement $a_n = 5 \cdot 3^{n-1}$.

Step 1 $P(1)$ is true, since $a_1 = 5 \cdot 3^0 = 5$.
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} a_{k+1} &= 3 \cdot a_k && \text{Definition of } a_{k+1} \\ &= 3 \cdot 5 \cdot 3^{k-1} && \text{Induction hypothesis} \\ &= 5 \cdot 3^k \end{aligned}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

27. Let $P(n)$ denote the statement $x - y$ is a factor of $x^n - y^n$.

Step 1 $P(1)$ is true, since $x - y$ is a factor of $x^1 - y^1$.
Step 2 Suppose $P(k)$ is true. Now

$$\begin{aligned} x^{k+1} - y^{k+1} &= x^{k+1} - x^k y + x^k y - y^{k+1} \\ &= x^k(x - y) + (x^k - y^k)y \end{aligned}$$

But $x^k(x - y)$ is clearly divisible by $x - y$, and $(x^k - y^k)y$ is divisible by $x - y$ (by the induction hypothesis), so their sum is divisible by $x - y$. So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

29. Let $P(n)$ denote the statement F_{3n} is even.

Step 1 $P(1)$ is true, since $F_{3\cdot 1} = 2$, which is even.
Step 2 Suppose $P(k)$ is true. Now, by the definition of the Fibonacci sequence,

$$\begin{aligned} F_{3(k+1)} &= F_{3k+3} = F_{3k+2} + F_{3k+1} \\ &= F_{3k+1} + F_{3k} + F_{3k+1} \\ &= F_{3k} + 2 \cdot F_{3k+1} \end{aligned}$$

But F_{3k} is even (by the induction hypothesis), and $2 \cdot F_{3k+1}$ is clearly even, so $F_{3(k+1)}$ is even. So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

31. Let $P(n)$ denote the statement
$F_1^2 + F_2^2 + F_3^2 + \cdots + F_n^2 = F_n \cdot F_{n+1}$.

Step 1 $P(1)$ is true, since $F_1^2 = F_1 \cdot F_2$ (because $F_1 = F_2 = 1$).
Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} &F_1^2 + F_2^2 + F_3^2 + \cdots + F_k^2 + F_{k+1}^2 \\ &= F_k \cdot F_{k+1} + F_{k+1}^2 && \text{Induction hypothesis} \\ &= F_{k+1}(F_k + F_{k+1}) && \text{Definition of the} \\ &= F_{k+1} \cdot F_{k+2} && \text{Fibonacci sequence} \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

33. Let $P(n)$ denote the statement

$$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}^n = \begin{bmatrix} F_{n+1} & F_n \\ F_n & F_{n-1} \end{bmatrix}.$$

Step 1 $P(2)$ is true, since

$$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}^2 = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} F_3 & F_2 \\ F_2 & F_1 \end{bmatrix}.$$

Step 2 Suppose $P(k)$ is true. Then

$$\begin{aligned} \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}^{k+1} &= \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}^k \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix} \\ &= \begin{bmatrix} F_{k+1} & F_k \\ F_k & F_{k-1} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix} && \text{Induction hypothesis} \\ &= \begin{bmatrix} F_{k+1} + F_k & F_{k+1} \\ F_k + F_{k-1} & F_k \end{bmatrix} \\ &= \begin{bmatrix} F_{k+2} & F_{k+1} \\ F_{k+1} & F_k \end{bmatrix} && \text{Definition of the} \\ & && \text{Fibonacci sequence} \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all $n \geq 2$.

35. Let $P(n)$ denote the statement $F_n \geq n$.

Step 1 $P(5)$ is true, since $F_5 \geq 5$ (because $F_5 = 5$).
Step 2 Suppose $P(k)$ is true. Now

$$\begin{aligned} F_{k+1} &= F_k + F_{k-1} && \text{Definition of the Fibonacci sequence} \\ &\geq k + F_{k-1} && \text{Induction hypothesis} \\ &\geq k + 1 && \text{Because } F_{k-1} \geq 1 \end{aligned}$$

So $P(k + 1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all $n \geq 5$.

Section 11.5 ■ Page 866

1. binomial **2.** Pascal's; 1, 4, 6, 4, 1

3. $\dfrac{n!}{k!(n-k)!}$; $\dfrac{4!}{3!(4-3)!} = 4$

4. Binomial; $\binom{4}{0}, \binom{4}{1}, \binom{4}{2}, \binom{4}{3}, \binom{4}{4}$

5. $x^6 + 6x^5y + 15x^4y^2 + 20x^3y^3 + 15x^2y^4 + 6xy^5 + y^6$

7. $x^4 + 4x^2 + 6 + \dfrac{4}{x^2} + \dfrac{1}{x^4}$

9. $x^5 - 5x^4 + 10x^3 - 10x^2 + 5x - 1$
11. $x^{10}y^5 - 5x^8y^4 + 10x^6y^3 - 10x^4y^2 + 5x^2y - 1$
13. $8x^3 - 36x^2y + 54xy^2 - 27y^3$

15. $\dfrac{1}{x^5} - \dfrac{5}{x^{7/2}} + \dfrac{10}{x^2} - \dfrac{10}{x^{1/2}} + 5x - x^{5/2}$

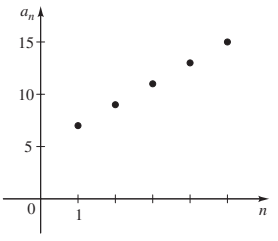
17. 15 **19.** 4950 **21.** 18 **23.** 32
25. $x^4 + 8x^3y + 24x^2y^2 + 32xy^3 + 16y^4$

27. $1 + \dfrac{6}{x} + \dfrac{15}{x^2} + \dfrac{20}{x^3} + \dfrac{15}{x^4} + \dfrac{6}{x^5} + \dfrac{1}{x^6}$

29. x^{20}, $40x^{19}y$, $760x^{18}y^2$ **31.** $25a^{26/3}$, $a^{25/3}$
33. $48{,}620x^{18}$ **35.** $300a^2b^{23}$ **37.** $100y^{99}$ **39.** $13{,}440x^4y^6$
41. $495a^8b^8$ **43.** $(x + y)^4$ **45.** $(2a + b)^3$
47. $3x^2 + 3xh + h^2$

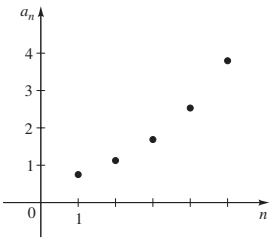
Chapter 11 Review ■ Page 869

1. $\frac{1}{2}, \frac{4}{3}, \frac{9}{4}, \frac{16}{5}, \frac{100}{11}$ **3.** $0, \frac{1}{4}, 0, \frac{1}{32}, \frac{1}{500}$
5. 1, 3, 15, 105; 654,729,075
7. 1, 4, 9, 16, 25, 36, 49
9. 1, 3, 5, 11, 21, 43, 85
11. **(a)** 7, 9, 11, 13, 15
(b)



(c) 55
(d) Arithmetic, common difference 2

13. **(a)** $\frac{3}{4}, \frac{9}{8}, \frac{27}{16}, \frac{81}{32}, \frac{243}{64}$
(b)



(c) $\frac{633}{64}$
(d) Geometric, common ratio $\frac{3}{2}$

15. Arithmetic, 7 **17.** Arithmetic, $t + 1$ **19.** Geometric, $\frac{1}{t}$

21. Geometric, $\frac{4}{27}$ **23.** $2i$ **25.** $a_2 = 5$ **27.** $a_5 = \frac{81}{4}$

29. $A_n = 52{,}000(1.04)^{n-1}$; Salary: \$52,000; \$54,080; \$56,243.20; \$58,492.93; \$60,832.65; \$63,265.95

31. 12,288 **35. (a)** 9 **(b)** $\pm 6\sqrt{2}$ **37.** 126

39. 384 **41.** $0^2 + 1^2 + 2^2 + \cdots + 9^2$

43. $\frac{3}{2^2} + \frac{3^2}{2^3} + \frac{3^3}{2^4} + \cdots + \frac{3^{50}}{2^{51}}$ **45.** $\sum_{k=1}^{33} 3k$ **47.** $\sum_{k=1}^{100} k2^{k+2}$

49. Geometric; 4.68559 **51.** Arithmetic, $5050\sqrt{5}$

53. Geometric, 9831 **55.** $\frac{5}{7}$ **57.** Divergent

59. Divergent **61.** 13 **63.** 65,534

65. Let $P(n)$ denote the statement

$$\frac{1}{1\cdot 3} + \frac{1}{3\cdot 5} + \cdots + \frac{1}{(2n-1)(2n+1)} = \frac{n}{2n+1}.$$

Step 1 $P(1)$ is true, since $\frac{1}{1\cdot 3} = \frac{1}{2\cdot 1 + 1}$.

Step 2 Suppose $P(k)$ is true. Then

$$\frac{1}{1\cdot 3} + \frac{1}{3\cdot 5} + \cdots + \frac{1}{(2k-1)(2k+1)} + \frac{1}{(2k+1)(2k+3)}$$

$$= \frac{k}{2k+1} + \frac{1}{(2k+1)(2k+3)} \qquad \text{Induction hypothesis}$$

$$= \frac{2k^2 + 3k + 1}{(2k+1)(2k+3)} = \frac{k+1}{2k+3}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

67. Let $P(n)$ denote the statement that $7^n - 1$ is divisible by 6.

Step 1 $P(1)$ is true, since $7^1 - 1 = 6$.
Step 2 Suppose $P(k)$ is true. We have

$$7^{k+1} - 1 = 7(7^k - 1) + 6$$

Now $7^k - 1$ is divisible by 6 (induction hypothesis), and so is 6, and hence $7(7^k - 1) + 6$ is also divisible by 6. So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

69. Let $P(n)$ denote the statement $a_n = 2 \cdot 3^n - 2$.

Step 1 $P(1)$ is true, since $a_1 = 2 \cdot 3^1 - 2 = 4$.
Step 2 Suppose $P(k)$ is true. Then

$$a_{k+1} = 3a_k + 4$$

$$= 3(2 \cdot 3^k - 2) + 4 \qquad \text{Induction hypothesis}$$

$$= 2 \cdot 3^{k+1} - 2$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

71. 255 **73.** 12,870

75. $x^5 + 10x^4 + 40x^3 + 80x^2 + 80x + 32$

77. $16x^4 + 32x^3y + 24x^2y^2 + 8xy^3 + y^4$

79. $b^{-40/3}$, $20b^{-37/3}$, $190b^{-34/3}$

Chapter 11 Test ■ Page 871

1. 1, 6, 15, 28, 45, 66; 161 **2.** 2, 5, 13, 36, 104, 307

3. (a) 3 **(b)** $a_n = 2 + (n-1)3$ **(c)** 104

4. (a) $\frac{1}{4}$ **(b)** $a_n = 12\left(\frac{1}{4}\right)^{n-1}$ **(c)** $3/4^8$

5. (a) $r = \frac{1}{5}$, $a_5 = \frac{1}{25}$ **(b)** $\frac{5^8 - 1}{12{,}500}$

6. (a) $d = -\frac{8}{9}$, $a_{100} = -78$ **(b)** 60

8. (a) $(1 - 1^2) + (1 - 2^2) + (1 - 3^2) + (1 - 4^2) + (1 - 5^2) = -50$

(b) $(-1)^3 2^1 + (-1)^4 2^2 + (-1)^5 2^3 + (-1)^6 2^4 = 10$

9. (a) $\frac{58{,}025}{59{,}049}$ **(b)** $2 + \sqrt{2}$

10. Let $P(n)$ denote the statement

$$1^2 + 2^2 + 3^2 + \cdots + n^2 = \frac{n(n+1)(2n+1)}{6}.$$

Step 1 $P(1)$ is true, since $1^2 = \frac{1(1+1)(2\cdot 1 + 1)}{6}$.

Step 2 Suppose $P(k)$ is true. Then

$$1^2 + 2^2 + 3^2 + \cdots + k^2 + (k+1)^2$$

$$= \frac{k(k+1)(2k+1)}{6} + (k+1)^2 \qquad \text{Induction hypothesis}$$

$$= \frac{k(k+1)(2k+1) + 6(k+1)^2}{6}$$

$$= \frac{(k+1)[k(2k+1) + 6(k+1)]}{6}$$

$$= \frac{(k+1)(2k^2 + 7k + 6)}{6}$$

$$= \frac{(k+1)[(k+1)+1][2(k+1)+1]}{6}$$

So $P(k+1)$ follows from $P(k)$. Thus, by the Principle of Mathematical Induction, $P(n)$ holds for all n.

11. $32x^5 + 80x^4y^2 + 80x^3y^4 + 40x^2y^6 + 10xy^8 + y^{10}$

12. $\binom{10}{3}(3x)^3(-2)^7 = -414{,}720x^3$

13. (a) $a_n = (0.85)(1.24)^n$ **(b)** 3.09 lb **(c)** Geometric

Focus on Modeling ■ Page 874

1. (a) $A_n = 1.0001A_{n-1}$, $A_0 = 275{,}000$ **(b)** $A_0 = 275{,}000$, $A_1 = 275{,}027.50$, $A_2 = 275{,}055.00$, $A_3 = 275{,}082.51$, $A_4 = 275{,}110.02$, $A_5 = 275{,}137.53$, $A_6 = 275{,}165.04$, $A_7 = 275{,}192.56$ **(c)** $A_n = 1.0001^n(275{,}000)$

3. (a) $A_n = 1.0025A_{n-1} + 100$, $A_0 = 100$ **(b)** $A_0 = 100$, $A_1 = 200.25$, $A_2 = 300.75$, $A_3 = 401.50$, $A_4 = 502.51$

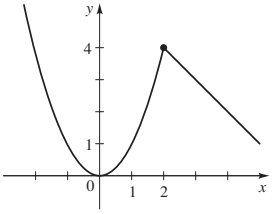
(c) $A_n = 100[(1.0025^{n+1} - 1)/0.0025]$ **(d)** \$6580.83

5. (b) In the 32nd year

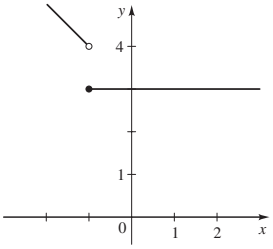
Chapter 12

Section 12.1 ■ Page 884

1. L, a; 5, 1 **2.** limit, left, L; less; left, right, equal
3. 10 **5.** $\frac{1}{4}$ **7.** $\frac{1}{3}$ **9.** 1 **11.** -1 **13.** 0.51 **15.** $\frac{1}{2}$
17. **(a)** 2 **(b)** 3 **(c)** Does not exist **(d)** 4 **(e)** Not defined
19. **(a)** -1 **(b)** -2 **(c)** Does not exist **(d)** 2 **(e)** 0
(f) Does not exist **(g)** 1 **(h)** 3 **21.** -8
23. Does not exist **25.** Does not exist **27.** Does not exist
29. **(a)** 4 **(b)** 4 **(c)** 4

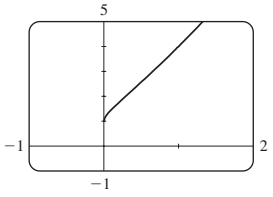


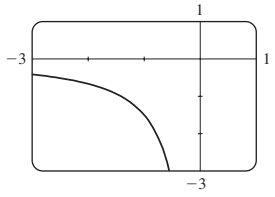
31. **(a)** 4 **(b)** 3 **(c)** Does not exist



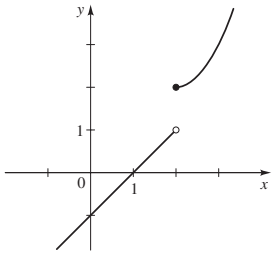
Section 12.2 ■ Page 893

1. $\lim_{x\to a} f(x) + \lim_{x\to a} g(x)$, $\lim_{x\to a} f(x) \cdot \lim_{x\to a} g(x)$; sum, product
2. $f(a)$ **3.** **(a)** 2 **(b)** Does not exist **(c)** 0
(d) Does not exist **(e)** 16 **(f)** 2
5. 5 **7.** 12 **9.** 75 **11.** $\frac{1}{2}$ **13.** -174 **15.** $\frac{4}{9}$ **17.** 7 **19.** 5
21. Does not exist **23.** $\frac{6}{5}$ **25.** 4 **27.** $\frac{1}{6}$ **29.** $-\frac{1}{16}$ **31.** $-\frac{1}{9}$
33. 4 **35.** $-\frac{3}{2}$

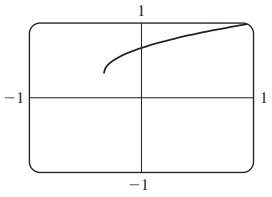




37. 0 **39.** Does not exist **41.** Does not exist
43. **(a)** 1, 2 **(b)** Does not exist
(c)



45. **(a)** 0.667



(b) 0.667

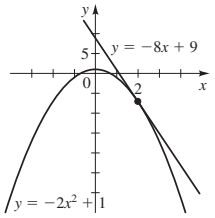
x	$f(x)$
0.1	0.71339
0.01	0.67163
0.001	0.66717
0.0001	0.66672

x	$f(x)$
−0.1	0.61222
−0.01	0.66163
−0.001	0.66617
−0.0001	0.66662

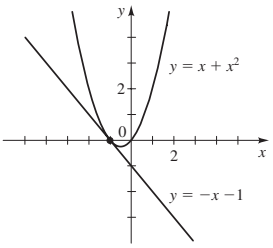
(c) $\frac{2}{3}$

Section 12.3 ■ Page 901

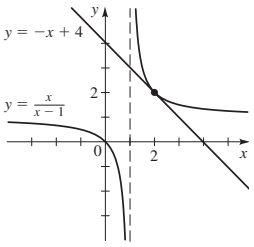
1. $\dfrac{f(a+h)-f(a)}{h}$; slope, $(a, f(a))$
2. $\dfrac{f(x)-f(a)}{x-a}$, instantaneous, a **3.** 3 **5.** -11 **7.** 24 **9.** $-\frac{1}{5}$
11. $y = -8x + 9$



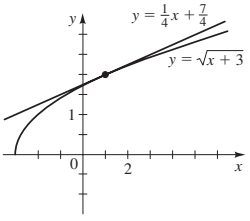
13. $y = -x - 1$



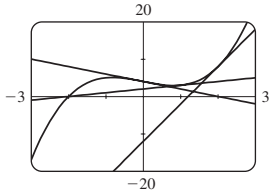
15. $y = -x + 4$



17. $y = \frac{1}{4}x + \frac{7}{4}$



19. $f'(2) = -12$ **21.** $f'(-1) = 7$ **23.** $f'(2) = -\frac{1}{9}$
25. $F'(4) = -\frac{1}{16}$ **27.** **(a)** $2a + 2$ **(b)** 8, 10
29. **(a)** $\dfrac{1}{(a+1)^2}$ **(b)** $\frac{1}{16}, \frac{1}{25}$
31. **(a)** $f'(a) = 3a^2 - 2$
(b) $y = -2x + 4$, $y = x + 2$, $y = 10x - 12$
(c)



33. $f(x) = x^{10}$, $a = 1$ **35.** $f(t) = \sqrt{t+1}$, $a = 1$ **37.** -24 ft/s

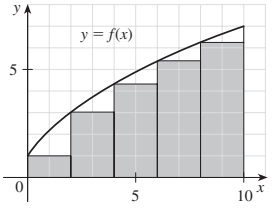
39. $12a^2 + 6$ m/s, 18 m/s, 54 m/s, 114 m/s
41. -0.8°F/min **43. (a)** -38.8 gal/min, -27.8 gal/min **(b)** -33.3 gal/min

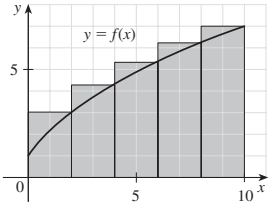
Section 12.4 ■ Page 910

1. L, x; horizontal asymptote; 0, 0
2. L, large; converges, diverges
3. (a) (i) -1 (ii) 2 **(b)** $y = -1$, $y = 2$ **5.** 0
7. $\frac{2}{5}$ **9.** $\frac{4}{3}$ **11.** 2 **13.** Does not exist **15.** 7
17. Does not exist **19.** $-\frac{1}{4}$ **21.** 0 **23.** 0
25. Divergent **27.** 0 **29.** Divergent **31.** $\frac{3}{2}$ **33.** 8
35. $f(x) = \dfrac{x^2}{(x-1)(x-3)}$ [Other answers are possible.]
37. Within 0.01 **39. (b)** approaches 30 g/L

Section 12.5 ■ Page 918

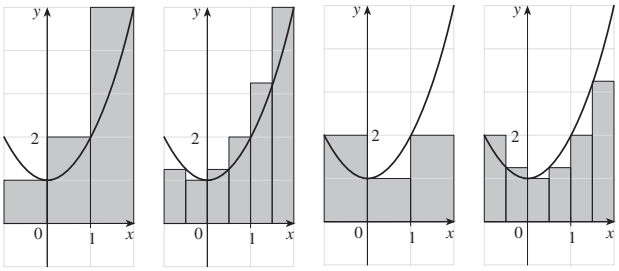
1. rectangles;
$f(x_1)(x_1 - a) + f(x_2)(x_2 - x_1) + f(x_3)(x_3 - x_2) + f(b)(b - x_3)$
2. $\displaystyle\sum_{k=1}^{n} f(x_k)\,\Delta x$
3. (a) 40, 52





(b) 43, 49
5. 5.25 **7.** $\frac{223}{35}$
9. (a) $\frac{77}{60}$, underestimate **(b)** $\frac{25}{12}$, overestimate

11. (a) 8, 6.875 **(b)** 5, 5.375



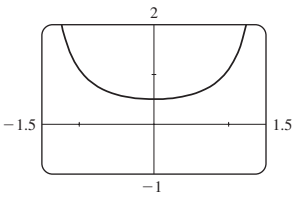
13. 37.5 **15.** 8 **17.** 166.25 **19.** 133.5

Chapter 12 Review ■ Page 922

1. 1 **3.** 0.69 **5.** Does not exist
7. (a) Does not exist **(b)** 2.4 **(c)** 2.4 **(d)** 2.4 **(e)** 0.5
(f) 1 **(g)** 2 **(h)** 0 **9.** -3 **11.** 7 **13.** 2 **15.** -1 **17.** 2
19. Does not exist **21.** $f'(4) = 3$ **23.** $f'(16) = \frac{1}{8}$
25. (a) $f'(a) = -2$ **(b)** -2, -2
27. (a) $f'(a) = 1/\left(2\sqrt{a+6}\right)$ **(b)** $1/\left(4\sqrt{2}\right)$, $1/4$
29. $y = 2x + 1$ **31.** $y = 2x$ **33.** $y = -\frac{1}{4}x + 1$
35. (a) -64 ft/s **(b)** $-32a$ ft/s **(c)** $\sqrt{40} \approx 6.32$ s
(d) -202.4 ft/s **37.** $\frac{1}{5}$ **39.** $\frac{1}{2}$ **41.** Divergent **43.** 3.83
45. 10 **47.** $\frac{5}{6}$

Chapter 12 Test ■ Page 924

1. (a) $\frac{1}{2}$ **(b)**



2. (a) 1 **(b)** 1 **(c)** 1 **(d)** 0 **(e)** 0 **(f)** 0 **(g)** 4 **(h)** 2
(i) Does not exist
3. (a) 6 **(b)** -2 **(c)** Does not exist
(d) Does not exist **(e)** $\frac{1}{4}$ **(f)** 2
4. (a) $f'(a) = 2a - 2$ **(b)** -4, 0, 2
5. $y = \frac{1}{6}x + \frac{3}{2}$ **6. (a)** 0 **(b)** Does not exist
7. (a) 3.56 **(b)** $\frac{11}{3}$

Focus on Modeling ■ Page 927

1. 57,333$\frac{1}{3}$ ft-lb **3. (b)** Area under the graph of $p(x) = 375x$ between $x = 0$ and $x = 4$ **(c)** 3000 lb **(d)** 1500 lb
5. (a) 1625.28 heating degree-hours **(b)** 70°F
(c) 1488 heating degree-hours **(d)** 75°F
(e) The day in part (a)

Appendix A ■ Page 936

1. Congruent, ASA **2.** Congruent, SSS
3. Not necessarily congruent **4.** Congruent, SAS
5. Similar **6.** Similar **7.** Similar **8.** Not similar
9. $x = 125$ **10.** $y = 30$ **11.** $x = 6$, $y = \dfrac{21}{4}$
12. $x = 4$ **13.** $x = \dfrac{ac}{a+b}$ **14.** $x = \dfrac{ac}{b} - a$
17. $x = 10$ **18.** $x = 48$ **19.** $x = \sqrt{3}$
20. $x = 2\sqrt{10}$ **21.** $x = 40$ **22.** $x = 144$ **23.** Yes
24. Yes **25.** No **26.** No **27.** Yes **28.** Yes **29.** 61 cm
30. 119 ft by 120 ft **31.** No **32.** 12
33. (b)

m	n	(a, b, c)
2	1	(3, 4, 5)
3	1	(8, 6, 10)
3	2	(5, 12, 13)
4	1	(15, 8, 17)
4	2	(12, 16, 20)
4	3	(7, 24, 25)
5	1	(24, 10, 26)
5	2	(21, 20, 29)
5	3	(16, 30, 34)
5	4	(9, 40, 41)

34. $h = 6$ ft
35. 140° **36.** 30° **37.** 30° **38.** 20° **39.** 20° **40.** 25°