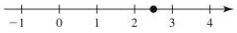
Student Answer Appendix

CHAPTER R

Exercises R.1, pp. 10–12

1. proper subset; element **3.** positive; negative, 7, -7; principal
5. Order of operations requires multiplication before addition.
7. a. $\{1, 2, 3, 4, 5\}$ **b.** $\{\ \}$ **9.** True **11.** True **13.** True
15. 1.3

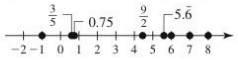
17. $2.\overline{5}$



19. ≈ 2.65

21. ≈ 1.73

23. a. i. $\{8, 7, 6\}$ **ii.** $\{8, 7, 6\}$ **iii.** $(-1, 8, 7, 6)$
iv. $\{-1, 8, 0.75, \frac{9}{2}, 5, 6, 7, \frac{3}{5}, 6\}$ **v.** $\{\ \}$
vi. $\{-1, 8, 0.75, \frac{9}{2}, 5.\overline{6}, 7, \frac{3}{5}, 6\}$ **b.** $\{-1, \frac{3}{5}, 0.75, \frac{9}{2}, 5.\overline{6}, 6, 7, 8\}$
c.



25. a. i. $\{\sqrt{49}, 2, 6, 4\}$ **ii.** $\{\sqrt{49}, 2, 6, 0, 4\}$
iii. $\{-5, \sqrt{49}, 2, -3, 6, -1, 0, 4\}$ **iv.** $\{-5, \sqrt{49}, 2, -3, 6, -1, 0, 4\}$
v. $\{\sqrt{3}, \pi\}$ **vi.** $\{-5, \sqrt{49}, 2, -3, 6, -1, \sqrt{3}, 0, 4, \pi\}$
b. $\{-5, -3, -1, 0, \sqrt{3}, 2, \pi, 4, 6, \sqrt{49}\}$
c.

27. False; not all real numbers are irrational. **29.** False; not all rational numbers are integers. **31.** False; $\sqrt{25} = 5$ is not irrational. **33.** c IV
35. a VI **37.** d III **39.** Let a represent Kylie's age: $a \geq 6$ years.
41. Let n represent the number of incorrect words: $n \leq 2$ incorrect.
43. 2.75 **45.** -4 **47.** $\frac{1}{2}$ **49.** $\frac{3}{4}$ **51.** 10 **53.** $-8, 2$ **55.** negative
57. $-n$ **59.** undefined, since $12 \div 0 = k$ implies $k \cdot 0 = 12$
61. undefined, since $7 \div 0 = k$ implies $k \cdot 0 = 7$ **63. a.** positive
b. negative **c.** negative **d.** negative **65.** $-\frac{11}{6}$ **67.** -2
69. $9^2 = 81$ is closest **71.** 7 **73.** -2.185 **75.** $4\frac{1}{3}$ **77.** $-\frac{29}{12}$ or $-2\frac{5}{12}$
79. 0 **81.** -5 **83.** $-\frac{1}{10}$ **85.** $-\frac{7}{8}$ **87.** -4 **89.** $\frac{-11}{12}$ **91.** 64
93. 4489.70 **95.** $D \approx 4.3$ cm **97.** 32°F **99.** 179°F
101. Tsu Ch'ung-chih: $\frac{355}{113}$ **103.** negative

Exercises R.2, pp. 18–21

1. constant **3.** coefficient **5.** $-5 + 5 = 0$, $-5 \cdot (-\frac{1}{5}) = 1$
7. two; 3 and -5 **9.** two; 2 and $\frac{1}{4}$ **11.** three; -2, 1, and -5
13. one; -1 **15.** $n - 7$ **17.** $n + 4$ **19.** $(n - 5)^2$ **21.** $2n - 13$
23. $n^2 + 2n$ **25.** $\frac{2}{3}n - 5$ **27.** $3(n + 5) - 7$ **29.** Let w represent the width. Then $2w$ represents twice the width and $2w - 3$ represents three meters less than twice the width. **31.** Let b represent the speed of the bus. Then $b + 15$ represents 15 mph more than the speed of the bus.
33. $h = b + 150$ **35.** $L = 2W + 20$ **37.** $M = 2.5N$
39. $T = 12.50g + 50$ **41.** 14 **43.** 19 **45.** 0 **47.** 16 **49.** -36
51. 51 **53.** 2 **55.** 144 **57.** $\frac{-41}{5}$ **59.** 24
61.

x	Output
-3	14
-2	6
-1	0
0	-4
1	-6
2	-6
3	-4

-1 has an output of 0.

63.

x	Output
-3	-18
-2	-15
-1	-12
0	-9
1	-6
2	-3
3	0

3 has an output of 0.

65.

x	Output
-3	-5
-2	8
-1	9
0	4
1	-1
2	0
3	13

2 has an output of 0.

67. a. $7 + (-5) = 2$ **b.** $n + (-2)$ **c.** $a + (-4.2) + 13.6 = a + 9.4$
d. $x + 7 - 7 = x$ **69. a.** 3.2 **b.** $\frac{5}{6}$ **71.** $-5x + 13$
73. $-\frac{2}{15}p + 6$ **75.** $-2a$ **77.** $\frac{17}{12}x$ **79.** $-2a^2 + 2a$ **81.** $6x^2 - 3x$
83. $2a + 3b + 2c$ **85.** $\frac{29}{8}n + \frac{38}{5}$ **87.** $7a^2 - 13a - 5$ **89.** 10 ohms
91. a. $t = \frac{1}{2}j$ **b.** $t = 225$ mph **93. a.** $L = 2W + 3$ **b.** 107 ft
95. $t = c + 22$; 37¢ **97.** $C = 25t + 43.50$; \$81
99. a. positive odd integer

Exercises R.3, pp. 31–34

1. power **3.** $20x$; 0 **5. a.** cannot be simplified, unlike terms
b. can be simplified, like bases **7.** $14n^7$ **9.** $-12p^5q^4$ **11.** $a^{14}b^7$
13. $216p^3q^6$ **15.** $32.768h^3k^6$ **17.** $\frac{p^2}{4q^2}$ **19.** $49c^{14}d^4$ **21.** $\frac{9}{16}x^6y^2$
23. $\frac{9}{4}x^3y^2$ **25. a.** $V = 27x^6$ **b.** 1728 units^3 **27.** $3w^3$ **29.** $-3ab$
31. $\frac{27}{8}$ **33.** $2h^3$ **35.** $\frac{-1}{8}$ **37.** -8 **39.** $\frac{4p^8}{q^6}$ **41.** $\frac{8x^6}{27y^9}$ **43.** $\frac{25m^4n^6}{4r^8}$
45. $\frac{25p^2q^2}{4}$ **47.** $\frac{3p^2}{-4q^2}$ **49.** $\frac{5}{3h^7}$ **51.** $\frac{1}{a^3}$ **53.** $\frac{a^{12}}{b^4c^8}$ **55.** $\frac{-12}{5x^4}$
57. $\frac{-2b^7}{27a^9c^3}$ **59.** 2 **61.** $\frac{7}{10}$ **63.** $\frac{13}{9}$ **65.** -4 **67.** 6.6×10^9
69. 0.000 000 006 5 **71.** 26,571 hrs; 1,107 days **73.** polynomial, none of these, degree 3 **75.** nonpolynomial because exponents are not whole numbers, NA, NA **77.** polynomial, binomial, degree 3
79. $-w^3 - 3w^2 + 7w + 8.2$; -1 **81.** $c^3 + 2c^2 - 3c + 6$; 1
83. $\frac{-2}{3}x^2 + 12$; $\frac{-2}{3}$ **85.** $3p^3 - 3p^2 - 12$ **87.** $7.85b^2 - 0.6b - 1.9$
89. $\frac{1}{4}x^2 - 8x + 6$ **91.** $q^6 + q^5 - q^4 + 2q^3 - q^2 - 2q$
93. $-3x^3 + 3x^2 + 18x$ **95.** $3r^2 - 11r + 10$ **97.** $x^3 - 27$
99. $b^3 - b^2 - 34b - 56$ **101.** $21v^2 - 47v + 20$ **103.** $9 - m^2$
105. $p^2 + 1.1p - 9$ **107.** $x^2 + \frac{3}{4}x + \frac{1}{8}$ **109.** $m^2 - \frac{9}{16}$
111. $6x^2 + 11xy - 10y^2$ **113.** $12c^2 + 23cd + 5d^2$
115. $2x^4 - x^2 - 15$ **117.** $4m + 3$; $16m^2 - 9$
119. $7x + 10$; $49x^2 - 100$ **121.** $6 - 5k$; $36 - 25k^2$

123. $x - \sqrt{6}; x^2 - 6$ **125.** $x^2 + 8x + 16$ **127.** $16g^2 + 24g + 9$
129. $16p^2 - 24pq + 9q^2$ **131.** $16 - 8\sqrt{x} + x$
133. $xy + 2x - 3y - 6$ **135.** $k^3 + 3k^2 - 28k - 60$
137. a. 340 mg, 292.5 mg **b.** Less, amount is decreasing. **c.** after 5 hr
139 $F = kPQd^{-2}$ **141.** $5x^{-3} + 3x^{-2} + 2x^{-1} + 4$ **143.** $15 **145.** 6

Exercises R.4, pp. 42–45

1. product **3.** binomial; conjugate **5.** Answers will vary.
7. a. $-17(x^2 - 3)$ **b.** $7b(3b^2 - 2b + 8)$ **c.** $-3a^2(a^2 + 2a - 3)$
9. a. $(a + 2)(2a + 3)$ **b.** $(b^2 + 3)(3b + 2)$ **c.** $(n + 7)(4m - 11)$
11. a. $(3q + 2)(3q^2 + 5)$ **b.** $(h - 12)(h^4 - 3)$ **c.** $(k^2 - 7)(k^3 - 5)$
13. a. $-1(p - 7)(p + 2)$ **b.** $(q - 9)(q + 5)$ **c.** $(n - 4)(n - 5)$
15. a. $(3p + 2)(p - 5)$ **b.** $(4q - 5)(q + 3)$ **c.** $(5u + 3)(2u - 5)$
17. a. $(2x + 5)(2x - 5)$ **b.** $(3x + 7)(3x - 7)$ **c.** $2(5x + 6)(5x - 6)$
d. $(11h + 12)(11h - 12)$ **e.** $(b + \sqrt{5})(b - \sqrt{5})$
19. a. $(a - 3)^2$ **b.** $(b + 5)^2$ **c.** $(2m - 5)^2$ **d.** $(3n - 7)^2$
21. a. $(2p - 3)(4p^2 + 6p + 9)$ **b.** $(m + \frac{1}{2})(m^2 - \frac{1}{2}m + \frac{1}{4})$
c. $(g - 0.3)(g^2 + 0.3g + 0.09)$ **d.** $-2t(t - 3)(t^2 + 3t + 9)$
23. a. $(x + 3)(x - 3)(x + 1)(x - 1)$ **b.** $(x^2 + 9)(x^2 + 4)$
c. $(x - 2)(x^2 + 2x + 4)(x + 1)(x^2 - x + 1)$
25. a. $(n + 1)(n - 1)$ **b.** $(n - 1)(n^2 + n + 1)$
c. $(n + 1)(n^2 - n + 1)$ **d.** $7x(2x + 1)(2x - 1)$ **27.** $(a + 5)(a + 2)$
29. $2(x - 2)(x - 10)$ **31.** $-1(3m + 8)(3m - 8)$ **33.** $(r - 3)(r - 6)$
35. $(2h + 3)(h + 2)$ **37.** $(3k - 4)^2$ **39.** $-3x(2x - 7)(x - 3)$
41. $4m(m + 5)(m - 2)$ **43.** $(a + 5)(a - 12)$ **45.** $(2x - 5)(4x^2 + 10x + 25)$
47. prime **49.** $(x - 5)(x + 3)(x - 3)$ **51. a.** H **b.** E **c.** C **d.** F
e. B **f.** A **g.** I **h.** D **i.** G **53.** $2\pi r(r + h)$, 7000π cm^2; 21,991 cm^2
55. $V = \frac{1}{3}\pi h(R + r)(R - r)$; 6π cm^3; 18.8 cm^3
57. $V = x(x + 5)(x + 3)$ **a.** 3 in. **b.** 5 in.
c. $V = 24(29)(27) = 18{,}792$ in^3
59. $L = L_0\sqrt{\left(1 + \frac{v}{c}\right)\left(1 - \frac{v}{c}\right)}$ $L = 12\sqrt{(1 + 0.75)(1 - 0.75)}$
$= 3\sqrt{7}$ in. ≈ 7.94 in. **61. a.** $\frac{1}{8}(4x^4 + x^3 - 6x^2 + 32)$
b. $\frac{1}{18}(12b^5 - 3b^3 + 8b^2 - 18)$ **63.** $2x(16x - 27)(6x + 5)$
65. $(x + 3)(x - 3)(x^2 + 9)$
67. $(p + 1)(p^2 - p + 1)(p - 1)(p^2 + p + 1)$
69. $(q + 5)(q - 5)(q + \sqrt{3})(q - \sqrt{3})$

Exercises R.5, pp. 51–54

1. 1; -1 **3.** common denominator **5.** F; numerator should be -1
7. a. $-\frac{1}{3}$ **b.** $\frac{x + 3}{2x(x - 2)}$ **9. a.** simplified **b.** $\frac{a - 4}{a - 7}$
11. a. -1 **b.** -1 **13. a.** $-3ab^9$ **b.** $\frac{x + 3}{9}$ **c.** $-1(y + 3)$ **d.** $\frac{-1}{m}$
15. a. $\frac{2n + 3}{n}$ **b.** $\frac{3x + 5}{2x + 3}$ **c.** $x + 2$ **d.** $n - 2$
17. $\frac{(a - 2)(a + 1)}{(a + 3)(a + 2)}$ **19.** 1 **21.** $\frac{(p - 4)^2}{p^2}$ **23.** $\frac{-15}{4}$ **25.** $\frac{3}{2}$
27. $\frac{8(a - 7)}{a - 5}$ **29.** $\frac{y}{x}$ **31.** $\frac{m}{m - 4}$ **33.** $\frac{y + 3}{3y(y + 4)}$ **35.** $\frac{x + 0.3}{x - 0.2}$
37. $\frac{n + \frac{1}{5}}{n + \frac{2}{3}}$ **39.** $\frac{3(a^2 + 3a + 9)}{2}$ **41.** $\frac{2n + 1}{n}$ **43.** $\frac{3 + 20x}{8x^2}$
45. $\frac{14y - x}{8x^2y^4}$ **47.** $\frac{2}{p + 6}$ **49.** $\frac{-3m - 16}{(m + 4)(m - 4)}$ **51.** $\frac{-5m + 37}{m - 7}$
53. $\frac{-y + 11}{(y + 6)(y - 5)}$ **55.** $\frac{2a - 5}{(a + 4)(a - 5)}$ **57.** $\frac{1}{y + 1}$
59. $\frac{m^2 - 6m + 21}{(m + 3)^2(m - 3)}$ **61.** $\frac{y^2 + 26y - 1}{(5y + 1)(y + 3)(y - 2)}$
63. a. $\frac{1}{p^2} - \frac{5}{p}; \frac{1 - 5p}{p^2}$ **b.** $\frac{1}{x^2} + \frac{2}{x^3}; \frac{x + 2}{x^3}$ **65.** $\frac{4a}{a + 20}$ **67.** $p - 1$
69. $\frac{x}{9x - 12}$ **71.** $\frac{-2}{y + 31}$ **73. a.** $\frac{1 + \frac{3}{m}}{1 - \frac{3}{m}}; \frac{m + 3}{m - 3}$ **b.** $\frac{1 + \frac{2}{x^2}}{1 - \frac{2}{x^2}}; \frac{x^2 + 2}{x^2 - 2}$
75. $\frac{f_2 + f_1}{f_1 f_2}$ **77.** $\frac{-a}{x(x + h)}$ **79.** $\frac{-(2x + h)}{2x^2(x + h)^2}$
81. a. \$300 million; \$2550 million **b.** It would require many resources. **c.** No

P	$\frac{450P}{100 - P}$
40	300
60	675
80	1800
90	4050
93	5979
95	8550
98	22050
100	ERROR

83. Price rises rapidly for first four days, then begins a gradual decrease. Yes, on the 35th day of trading.

Day	Price
0	10
1	16.67
2	32.76
3	47.40
4	53.51
5	52.86
6	49.25
7	44.91
8	40.75
9	37.03
10	33.81

85. $t = 8$ weeks **87. b.** $20 \cdot n \div 10 \cdot n = 2n^2$, all others equal 2
89. $\frac{6}{23}; \frac{ac}{ad + bc}$

Exercises R.6, pp. 64–68

1. even **3.** $(16^{\frac{1}{4}})^3$ **5.** Answers will vary. **7.** 9 **9. a.** $7|p|$ **b.** $|x - 3|$
c. $9m^2$ **d.** $|x - 3|$ **11. a.** 4 **b.** $-5x$ **c.** $6z^4$ **d.** $\frac{v}{-2}$
13. a. 2 **b.** not a real number **c.** $3x^2$ **d.** $-3x$ **e.** $k - 3$ **f.** $|h + 2|$
15. a. -5 **b.** $-3|n^3|$ **c.** not a real number **d.** $\frac{7|v^5|}{6}$ **17. a.** 4
b. $\frac{64}{125}$ **c.** $\frac{125}{8}$ **d.** $\frac{9p^4}{4q^2}$ **19. a.** -1728 **b.** not a real number
c. $\frac{1}{9}$ **d.** $\frac{-256}{81x^4}$ **21. a.** $\frac{32n^{10}}{p^2}$ **b.** $\frac{1}{2y^{\frac{1}{2}}}$ **23. a.** $3m\sqrt{2}$ **b.** $10pq^2\sqrt[3]{q}$
c. $\frac{3}{2}mn\sqrt[5]{n^2}$ **d.** $4pq^3\sqrt{2p}$ **e.** $-3 + \sqrt{7}$ **f.** $\frac{9}{2} - \sqrt{2}$
25. a. $15a^2$ **b.** $-4b\sqrt{b}$ **c.** $\frac{x^4\sqrt{y}}{3}$ **d.** $3u^2v\sqrt[3]{v}$ **27. a.** $2m^2$
b. $3n$ **c.** $\frac{3\sqrt{5}}{4x}$ **d.** $\frac{18\sqrt[3]{3}}{z^3}$ **29. a.** $2x^2y^3$ **b.** $x^2\sqrt[4]{x}$ **c.** $\sqrt[12]{b}$
d. $\frac{1}{\sqrt[6]{6}} = \frac{\sqrt[6]{6^5}}{6}$ **e.** $b^{\frac{1}{2}}$ **31. a.** $9\sqrt{2}$ **b.** $14\sqrt{3}$ **c.** $16\sqrt{2m}$
d. $-5\sqrt{7p}$ **33. a.** $-x\sqrt[3]{2x}$ **b.** $2 - \sqrt{3x} + 3\sqrt{5}$
c. $6x\sqrt{2x} + 5\sqrt{2} - \sqrt{7x} + 3\sqrt{3}$ **35. a.** 98 **b.** $\sqrt{15} + \sqrt{21}$
c. $n^2 - 5$ **d.** $39 - 12\sqrt{3}$ **37. a.** -19
b. $\sqrt{10} + \sqrt{65} - 2\sqrt{7} - \sqrt{182}$
c. $12\sqrt{5} + 2\sqrt{14} + 36\sqrt{15} + 6\sqrt{42}$ **39.** Verified
41. Verified **43. a.** $\frac{\sqrt{3}}{2}$ **b.** $\frac{2\sqrt{15x}}{9x^2}$ **c.** $\frac{3\sqrt{6b}}{10b}$ **d.** $\frac{\sqrt[3]{2p^2}}{2p}$
e. $\frac{5\sqrt[3]{a^2}}{a}$ **45. a.** $-12 + 4\sqrt{11}$; 1.27 **b.** $\frac{6\sqrt{x} + 6\sqrt{2}}{x - 2}$
47. a. $\sqrt{30} - 2\sqrt{5} - 3\sqrt{3} + 3\sqrt{2}$; 0.05
b. $\frac{7 + 7\sqrt{2} + \sqrt{6} + 2\sqrt{3}}{-3}$; -7.60 **49.** 8.33 ft **51. a.** $8\sqrt{10}$ m;
b. about 25.3 m **53. a.** 365.02 days **b.** 688.69 days **c.** 87.91 days
55. a. 36 mph **b.** 46.5 mph **57.** $12\pi\sqrt{34} \approx 219.82$ m^2
59. a. $(x + \sqrt{5})(x - \sqrt{5})$ **b.** $(n + \sqrt{19})(n - \sqrt{19})$
61. a. $13\sqrt{3x} + 39\sqrt{x}$ **b.** Answers will vary. **63.** $\frac{3\sqrt{2}}{2}$

Practice Test, pp. 70–71

1. a. True **b.** True **c.** False; $\sqrt{2}$ cannot be expressed as a ratio of two integers. **d.** True **2. a.** 11 **b.** -5 **c.** not a real number **d.** 20 **3. a.** $\frac{9}{8}$ **b.** $\frac{-7}{6}$ **c.** 0.5 **d.** -4.6 **4. a.** $\frac{28}{3}$ **b.** 0.9 **c.** 4 **d.** -7 **5. a.** ≈ 4439.28 **b.** 0 **b.** undefined **7. a.** 3; $-2, 6, 5$ **b.** $2; \frac{1}{3}, 1$ **8. a.** -13 **b.** ≈ 7.29 **9. a.** $x^3 - (2x - 9)$ **b.** $2n - 3\left(\frac{n}{2}\right)^2$ **10. a.** Let r represent Earth's radius. Then $11r - 119$ represents Jupiter's radius. **b.** Let e represent this year's earnings. Then $4e + 1.2$ million represents last year's earnings. **11. a.** $9v^2 + 3v - 7$ **b.** $-7b + 8$ **c.** $x^2 + 6x$ **12. a.** $(3x + 4)(3x - 4)$ **b.** $v(2v - 3)^2$ **c.** $(x + 5)(x + 3)(x - 3)$ **13. a.** $5b^3$ **b.** $4a^{12}b^{12}$ **c.** $\frac{m^6}{8n^3}$ **d.** $\frac{25}{4}p^2q^2$ **14. a.** $-4ab$ **b.** $6.4 \times 10^{-2} = 0.064$ **c.** $\frac{a^{12}}{b^4c^8}$ **d.** -6 **15. a.** $9x^4 - 25y^2$ **b.** $4a^2 + 12ab + 9b^2$ **16. a.** $7a^4 - 5a^3 + 8a^2 - 3a - 18$ **b.** $-7x^4 + 4x^2 + 5x$ **17. a.** -1 **b.** $\frac{2 + n}{2 - n}$ **c.** $x - 3$ **d.** $\frac{x - 5}{3x - 2}$ **e.** $\frac{x - 5}{3x + 1}$ **f.** $\frac{3(m + 7)}{5(m + 4)(m - 3)}$ **18. a.** $|x + 11|$ **b.** $\frac{-2}{3v}$ **c.** $\frac{64}{125}$ **d.** $-\frac{1}{2} + \frac{\sqrt{2}}{2}$ **e.** $11\sqrt{10}$ **f.** $x^2 - 5$ **g.** $\frac{\sqrt{10x}}{5x}$ **h.** $2(\sqrt{6} + \sqrt{2})$ **19.** $-0.5x^2 + 10x + 1200$; **a.** 10 decreases of 0.50 or \$5.00 **b.** Maximum revenue is \$1250. **20.** 58 cm

CHAPTER 1

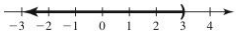
Exercises 1.1, pp. 82–85

1. identity; unknown **3.** literal; two **5.** Answers will vary. **7.** $x = 3$ **9.** $v = -11$ **11.** $b = \frac{6}{5}$ **13.** $b = -15$ **15.** $m = -\frac{27}{4}$ **17.** $x = 12$ **19.** $x = 12$ **21.** $p = -56$ **23.** $a = -3.6$ **25.** $v = -0.5$ **27.** $n = \frac{20}{21}$ **29.** $p = \frac{12}{5}$ **31.** contradiction; $\{\ \}$ **33.** conditional; $n = -\frac{11}{10}$ **35.** identity; $\{x|x \in \mathbb{R}\}$ **37.** $C = \frac{P}{1 + M}$ **39.** $r = \frac{C}{2\pi}$ **41.** $T_2 = \frac{T_1P_2V_2}{P_1V_1}$ **43.** $h = \frac{3V}{4\pi r^2}$ **45.** $n = \frac{2S_n}{a_1 + a_n}$ **47.** $P = \frac{2(S - B)}{S}$ **49.** $y = -\frac{A}{B}x + \frac{C}{B}$ **51.** $y = \frac{-20}{9}x + \frac{16}{3}$ **53.** $y = \frac{-4}{5}x - 5$ **55.** $a = 3; b = 2; c = -19; x = -7$ **57.** $a = -6; b = 1; c = 33; x = \frac{-16}{3}$ **59.** $a = 7; b = -13; c = -27; x = -2$ **61.** $h = 17$ cm **63.** 510 ft **65.** 56 in. **67.** 3084 ft **69.** 48; 50 **71.** 5; 7 **73.** 11:30 A.M. **75.** 36 min **77.** 4 quarts; 50% O.J. **79.** 16/lb; \$1.80/lb **81.** 12 lb **83.** 16 lb **85.** Answers will vary **87.** 69 **89.** -3 **91. a.** $(2x + 3)(2x - 3)$ **b.** $(x - 3)(x^2 + 3x + 9)$

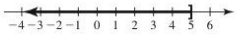
Exercises 1.2, pp. 92–95

1. set; interval **3.** intersection; union **5.** Answers will vary. **7.** $w \geq 45$ **9.** $250 < T < 450$

11.

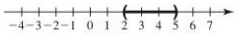


13.



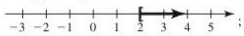
15.

17.



19. $\{x|x \geq -2\}; [-2, \infty)$ **21.** $\{x|-2 \leq x \leq 1\}; [-2, 1]$

23. $\{a|a \geq 2\}$;

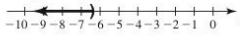


; $a \in [2, \infty)$

25. $\{n|n \geq 1\}$;

; $n \in [1, \infty)$

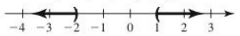
27. $\{x|x < \frac{-32}{5}\}$;



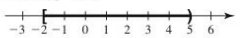
; $x \in (-\infty, \frac{-32}{5})$

29. $\{\ \}$ **31.** $\{x|x \in \mathbb{R}\}$ **33.** $\{x|x \in \mathbb{R}\}$ **35.** $\{2\}$; $\{-3, -2, -1, 0, 1, 2, 3, 4, 6, 8\}$ **37.** $\{\}$; $\{-3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7\}$ **39.** $\{4, 6\}$; $\{2, 4, 5, 6, 7, 8\}$

41. $x \in (-\infty, -2) \cup (1, \infty)$;

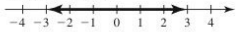


43. $x \in [-2, 5)$;

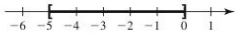


45. no solution

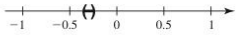
47. $x \in (-\infty, \infty)$;



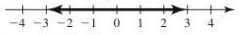
49. $x \in [-5, 0]$;



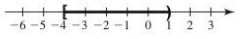
51. $x \in (\frac{-1}{3}, \frac{-1}{4})$;



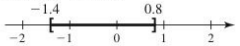
53. $x \in (-\infty, \infty)$;



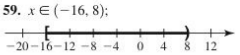
55. $x \in [-4, 1)$;



57. $x \in [-1.4, 0.8]$;



59. $x \in (-16, 8)$;



61. $m \in (-\infty, 0) \cup (0, \infty)$ **63.** $y \in (-\infty, -7) \cup (-7, \infty)$ **65.** $a \in (-\infty, \frac{1}{2}) \cup (\frac{1}{2}, \infty)$ **67.** $x \in (-\infty, 4) \cup (4, \infty)$ **69.** $x \in [2, \infty)$ **71.** $n \in [4, \infty)$ **73.** $b \in [\frac{4}{3}, \infty)$ **75.** $y \in (-\infty, 2]$ **77. a.** $W = \frac{BH^2}{704}$ **b.** $W < 177.34$ lb **79.** $x \geq 81\%$ **81.** $b \geq \$2000$ **83.** $0 < w < 7.5$ m **85.** $7.2° < C < 29.4°$ **87.** $h > 6$ **89.** Answers may vary. **91.** $<$ **93.** $<$ **95.** $<$ **97.** $>$ **99.** $2n - 8$ **101.** $\frac{17}{18}x - 5$

Exercises 1.3, pp. 101–103

1. reverse **3.** $-7; 7$ **5.** no solution; answers will vary. **7.** $\{-4, 6\}$ **9.** $\{2, -12\}$ **11.** $\{-3.35, 0.85\}$ **13.** $\left\{-\frac{8}{7}, 2\right\}$ **15.** $\left\{-\frac{1}{2}, \frac{1}{2}\right\}$ **17.** $\{\ \}$ **19.** $\{-10, -6\}$ **21.** $\{3.5, 11.5\}$ **23.** $\{-1.6, 1.6\}$ **25.** $[-5, 9]$ **27.** $\varnothing$ **29.** $\left(-1, \frac{3}{5}\right)$ **31.** $(-5, -3)$ **33.** $\left[\frac{8}{3}, \frac{14}{3}\right]$

35. $\varnothing$ **37.** $\left[-\frac{7}{4}, 0\right]$ **39.** $(-\infty, -10) \cup (4, \infty)$

41. $(-\infty, -3] \cup [3, \infty)$ **43.** $\left(-\infty, -\frac{7}{3}\right] \cup \left[\frac{7}{3}, \infty\right)$

45. $\left(-\infty, \frac{3}{7}\right] \cup [1, \infty)$ **47.** $(-\infty, \infty)$ **49.** $(-\infty, 0) \cup (5, \infty)$

51. $(-\infty, -0.75] \cup [3.25, \infty)$ **53.** $\left(-\infty, -\frac{7}{15}\right) \cup (1, \infty)$

55. $45 \le d \le 51$ in. **57.** in feet: [32,500, 37,600]; yes
59. in feet: $d < 210$ or $d > 578$ **61. a.** $|s - 37.58| \le 3.35$
b. [34.23, 40.93] **63. a.** $|s - 125| \le 23$ **b.** [102, 148]
65. a. $|d - 42.7| < 0.03$ **b.** $|d - 73.78| < 1.01$
c. $|d - 57.150| < 0.127$ **d.** $|d - 2171.05| < 12.05$

e. golf: $t \approx 0.0014$ **67. a.** $x = 4$ **b.** $\left[\frac{4}{3}, 4\right]$ **c.** $x = 0$ **d.** $\left(-\infty, \frac{3}{5}\right]$

e. $\{\ \}$ **69.** $3x(2x + 5)(3x - 4)$ **71.** $\frac{-3 + \sqrt{3}}{6} \approx -0.21$

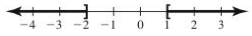
Mid-Chapter Check, pp. 103–104

1. a. $r = -9$ **b.** $x = -6$ **c.** identity; $m \in \mathbb{R}$ **d.** $y = \frac{50}{13}$

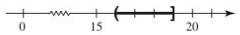
e. contradiction: $\{\ \}$ **f.** $x = 5.5$ **2.** $v_0 = \frac{H + 16t^2}{t}$

3. $x = \sqrt{\frac{S}{\pi(2 + y)}}$

4. a. $x \ge 1$ or $x \le -2$



b. $16 < x \le 19$



5. a. $x \in \left(-\infty, \frac{5}{2}\right) \cup \left(\frac{5}{2}, \infty\right)$ **b.** $x \in \left(-\infty, \frac{17}{6}\right]$

6. a. $\{-4, 14\}$ **b.** $\{\ \}$ **7. a.** $q \in (-8, 0)$ **b.** $\{-6\}$

8. a. $d \in (-\infty, 0] \cup [4, \infty)$ **b.** $y \in \left(-\infty, -\frac{19}{2}\right) \cup \left(\frac{23}{2}, \infty\right)$

c. $k \in (-\infty, \infty)$ **9.** 1 hr, 20 min **10.** $w \in [8, 26]$; yes

Reinforcing Basic Concepts pp. 104

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

Exercises 1.4, pp. 111–114

1. $3 - 2i$ **3.** $2; 3\sqrt{2}$ **5.** (b) is correct. **7. a.** $4i$ **b.** $7i$ **c.** $3\sqrt{3}$
d. $6\sqrt{2}$ **9. a.** $-3i\sqrt{2}$ **b.** $-5i\sqrt{2}$ **c.** $15i$ **d.** $6i$ **11. a.** $i\sqrt{19}$
b. $i\sqrt{31}$ **c.** $\frac{2\sqrt{3}}{5}i$ **d.** $\frac{3\sqrt{2}}{8}i$ **13. a.** $1 + i$; $a = 1, b = 1$
b. $2 + \sqrt{3}i$; $a = 2, b = \sqrt{3}$ **15. a.** $4 + 2i$; $a = 4, b = 2$
b. $2 - \sqrt{2}i$; $a = 2, b = -\sqrt{2}$ **17. a.** $5 + 0i$; $a = 5, b = 0$
b. $0 + 3i$; $a = 0, b = 3$ **19. a.** $18i$; $a = 0, b = 18$
b. $\frac{\sqrt{2}}{2}i$; $a = 0, b = \frac{\sqrt{2}}{2}$ **21. a.** $4 + 5\sqrt{2}i$; $a = 4, b = 5\sqrt{2}$
b. $-5 + 3\sqrt{3}i$; $a = -5, b = 3\sqrt{3}$
23. a. $\frac{7}{4} + \frac{7\sqrt{2}}{8}i$; $a = \frac{7}{4}, b = \frac{7\sqrt{2}}{8}$ **b.** $\frac{1}{2} + \frac{\sqrt{10}}{2}i$; $a = \frac{1}{2}, b = \frac{\sqrt{10}}{2}$
25. a. $19 + i$ **b.** $2 - 4i$ **c.** $9 + 10\sqrt{3}i$ **27. a.** $-3 + 2i$ **b.** 8
c. $2 - 8i$ **29. a.** $2.7 + 0.2i$ **b.** $15 + \frac{1}{12}i$ **c.** $-2 - \frac{1}{8}i$
31. a. 15 **b.** 16 **33. a.** $-21 - 35i$ **b.** $-42 - 18i$
35. a. $-12 - 5i$ **b.** $1 + 5i$ **37. a.** $4 - 5i$; 41 **b.** $3 + i\sqrt{2}$; 11
39. a. $-7i$; 49 **b.** $\frac{1}{2} + \frac{2}{3}i$; $\frac{25}{36}$ **41. a.** 41 **b** 74 **43. a.** 11 **b** $\frac{17}{36}$
45. a. $-5 + 12i$ **b** $-7 - 24i$ **47. a.** $-21 - 20i$ **b** $7 + 6\sqrt{2}i$
49. no **51.** yes **53.** yes **55.** yes **57.** yes **59.** Answers will vary.

61. a. 1 **b.** -1 **c.** $-i$ **d.** i **63. a.** $\frac{2}{7}i$ **b.** $\frac{-4}{5}i$

65. a. $\frac{21}{13} - \frac{14}{13}i$ **b.** $\frac{-10}{13} - \frac{15}{13}i$ **67. a.** $1 - \frac{3}{4}i$ **b.** $-1 - \frac{2}{3}i$
69. a. $\sqrt{13}$ **b.** 5 **c.** $\sqrt{11}$ **71.** $A + B = 10$ $AB = 40$
73. $7 - 5i\ \Omega$ **75.** $25 + 5i$ V **77.** $\frac{7}{4} + i\ \Omega$ **79. a.** $(x + 6i)(x - 6i)$
b. $(m + i\sqrt{3})(m - i\sqrt{3})$ **c.** $(n + 2i\sqrt{3})(n - 2i\sqrt{3})$
d. $(2x + 7i)(2x - 7i)$ **81.** $-8 - 6i$ **83. a.** $P = 4s$; $A = s^2$
b. $P = 2L + 2W$; $A = LW$ **85.** John

Exercises 1.5, pp. 124–128

1. descending; 0 **3.** quadratic; 1 **5.** GCF factoring: $x = 0, x = \frac{5}{4}$
7. $a = -1; b = 2; c = -15$ **9.** not quadratic
11. $a = \frac{1}{4}; b = -6; c = 0$ **13.** $a = 2; b = 0; c = 7$ **15.** not quadratic
17. $a = 1; b = -1; c = -5$ **19.** $x = 5$ or $x = -3$ **21.** $m = 4$
23. $p = 0$ or $p = 2$ **25.** $h = 0$ or $h = \frac{-1}{2}$ **27.** $a = 3$ or $a = -3$
29. $g = -9$ **31.** $m = -5$ or $m = -3$ or $m = 3$ **33.** $c = -3$ or $c = 15$
35. $r = 8$ or $r = -3$ **37.** $t = -13$ or $t = 2$ **39.** $x = 5$ or $x = -3$
41. $w = -\frac{1}{2}$ or $w = 3$ **43.** $m = \pm 4$ **45.** $y = \pm 2\sqrt{7}$; $y \approx \pm 5.29$
47. no real solutions **49.** $x = \pm\frac{\sqrt{21}}{4}$; $x \approx \pm 1.15$ **51.** $n = 9$; $n = -3$
53. $w = -5 \pm \sqrt{3}$; $w \approx -3.27$ or $w \approx -6.73$ **55.** no real solutions
57. $m = 2 \pm \frac{3\sqrt{2}}{7}$; $m \approx 2.61$ or $m \approx 1.39$ **59.** $9; (x + 3)^2$
61. $\frac{9}{4}; (n + \frac{3}{2})^2$ **63.** $\frac{1}{9}; (p + \frac{1}{3})^2$ **65.** $x = -1; x = -5$
67. $p = 3 \pm \sqrt{6}$; $p \approx 5.45$ or $p \approx 0.55$
69. $p = -3 \pm \sqrt{5}$; $p \approx -0.76$ or $p \approx -5.24$
71. $m = \frac{-3}{2} \pm \frac{\sqrt{13}}{2}$; $m \approx 0.30$ or $m \approx -3.30$
73. $n = \frac{5}{2} \pm \frac{3\sqrt{5}}{2}$; $n \approx 5.85$ or $n \approx -0.85$
75. $x = \frac{1}{2}$ or $x = -4$ **77.** $n = 3$ or $n = \frac{-3}{2}$
79. $p = \frac{3}{8} \pm \frac{\sqrt{41}}{8}$; $p \approx 1.18$ or $p \approx -0.43$
81. $m = \frac{7}{2} \pm \frac{\sqrt{33}}{2}$; $m \approx 6.37$ or $m \approx 0.63$
83. $x = 6$ or $x = -3$ **85.** $m = \pm\frac{5}{2}$
87. $n = \frac{2 \pm \sqrt{5}}{2}$; $n \approx 2.12$ or $n \approx -0.12$ **89.** $w = \frac{2}{3}$ or $w = \frac{-1}{2}$
91. $m = \frac{3}{2} \pm \frac{\sqrt{6}}{2}i$; $m \approx 1.5 \pm 1.12i$ **93.** $n = \pm\frac{3}{2}$
95. $w = \frac{-4}{3}$ or $w = 2$ **97.** $a = \frac{1}{6} \pm \frac{\sqrt{23}}{6}i$; $a \approx 0.16 \pm 0.80i$
99. $p = \frac{3 \pm 2\sqrt{6}}{5}$; $p \approx 1.58$ or $p \approx -0.38$
101. $w = \frac{1 \pm \sqrt{21}}{10}$; $w \approx 0.56$ or $w \approx -0.36$
103. $a = \frac{3}{4} \pm \frac{\sqrt{31}}{4}i$; $a \approx 0.75 \pm 1.39i$
105. $p = 1 \pm \frac{3\sqrt{2}}{2}i$; $p \approx 1 \pm 2.12i$
107. $w = \frac{-1}{3} \pm \frac{\sqrt{2}}{3}$; $w \approx 0.14$ or $w \approx -0.80$
109. $a = \frac{-6 \pm 3\sqrt{2}}{2}$; $a \approx -0.88$ or $a \approx -5.12$
111. $p = \frac{4 \pm \sqrt{394}}{6}$; $p \approx 3.97$ or $p \approx -2.64$
113. two rational; factorable **115.** two complex **117.** two rational; factorable **119.** two complex **121.** two irrational **123.** one repeated; factorable **125.** $x = \frac{1}{2} \pm \frac{1}{2}i$ **127.** $x = -\frac{1}{2} \pm \frac{i\sqrt{3}}{2}$

129. $x = \frac{5}{4} \pm \frac{3i\sqrt{7}}{4}$ **131.** $t = \frac{v \pm \sqrt{v^2 - 64h}}{32}$

133. $t = \frac{6 + \sqrt{138}}{2}$ sec, $t \approx 8.87$ sec **135.** 30,000 ovens
137. a. $P = -x^2 + 120x - 2000$ **b.** 10,000 **139.** $t = 2.5$ sec, 6.5 sec
141. $x \approx 13.5$, or the year 2008 **143.** 36 ft, 78 ft
145. a. $7x^2 + 6x - 16 = 0$ **b.** $6x^2 + 5x - 14 = 0$

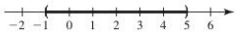
c. $5x^2 - x - 6 = 0$ **147.** $x = -2i$; $x = 5i$ **149.** $x = \frac{-3}{4}i$; $x = 2i$

151. $x = -1 - i$; $x = -13 - i$ **153. a.** $P = 2L + 2W$, $A = LW$
b. $P = 2\pi r$, $A = \pi r^2$ **c.** $A = \frac{1}{2}h(b_1 + b_2)$, $P = c + h + b_1 + b_2$
d. $A = \frac{1}{2}bh$, $P = a + b + c$ **155.** 700 $30 tickets; 200 $20 tickets

Exercises 1.6, pp. 137–142

1. excluded **3.** extraneous **5.** Answers will vary.
7. $x = -2, x = 0, x = 11$ **9.** $x = -3, x = 0, x = \frac{2}{3}$
11. $x = -\frac{3}{2}, x = 0, x = 3$ **13.** $x = 0, x = 2, x = -1 \pm i\sqrt{3}$

15. $x = \pm 2, x = 5$ **17.** $x = 3, x = \pm 2i$ **19.** $x = \pm\sqrt{5}, x = 6$
21. $x = 0, x = 7, x = \pm 2i$ **23.** $x = \pm 3, x = \pm 3i$
25. $x = \pm 4, x = \pm 4i$ **27.** $x = \pm\sqrt{2}, x = \pm 1, \pm i$
29. $x = \pm 1, x = 2, x = -1 \pm i\sqrt{3}$
31. $x = -\frac{1}{2} \pm \frac{i\sqrt{3}}{2}, x = \frac{1}{2} \pm \frac{i\sqrt{3}}{2}, x = \pm 1$ **33.** $x = 1$ **35.** $a = \frac{3}{2}$
37. $y = 12$ **39.** $x = 3$; $x = 7$ is extraneous **41.** $n = 7$
43. $a = -1, a = -8$ **45.** $f = \dfrac{f_1 f_2}{f_1 + f_2}$ **47.** $r = \dfrac{E - IR}{I}$ or $\dfrac{E}{I} - R$
49. $h = \dfrac{3V}{\pi r^2}$ **51.** $r^3 = \dfrac{3V}{4\pi}$ **53. a.** $x = \frac{14}{3}$
b. $x = 8, x = 1$ is extraneous **55. a.** $m = 3$ **b.** $x = 5$ **c.** $m = -64$
d. $x = -16$ **57. a.** $x = 25$ **b.** $x = 7$; $x = -2$ is extraneous
c. $x = 2, x = 18$ **d.** $x = 6$; $x = 0$ is extraneous **59.** $x = -32$
61. $x = 9$ **63.** $x = -32, x = 22$ **65.** $x = -27, 125$
67. $x = \pm 5, x = \pm i$ **69.** $x = \pm 1, \pm 2$ **71.** $x = -1, \frac{1}{4}$
73. $x = \pm\frac{1}{3}, \pm\frac{1}{2}$ **75.** $x = -4, 45$
77. $x = -6$; $x = \frac{-74}{9}$ is extraneous **79. a.** $h = \sqrt{\left(\dfrac{S}{\pi r}\right)^2 - r^2}$
b. $S = 12\pi\sqrt{34}\ \text{m}^2$ **81.** $x = \pm 3, x = -2$ **83.** $x = 2, 4, 6$ or $x = -2, 0, 2$ **85.** 11 in. by 13 in. **87.** $r = 3$ m; $r = 0$ and $r = 12$ m do not fit the context **89.** either \$50 or \$30 **91. a.** 32 ft, $(h = -32)$
b. 11 sec **c.** pebble is at canyon's rim **93.** 12 min **95.** $v = 6$ mph
97. $P \approx 52.1\%$ **99. a.** 36 million mi **b.** 67 million mi
c. 93 million mi **d.** 142 million mi **e.** 484 million mi
f. 887 million mi **101.** The constant "3" was not multiplied by the LCD, $3x(x + 3) - 8x = x + 3$; $x = -1, 1$ **103.** $x \in [1, 2) \cup (2, \infty)$
105. a. $x = -5, -3, 5, 7$ **b.** $x = -2, -1, 6, 7$ **c.** $x = -2, 1, 3$
d. $x = -4, -2, 3$ **e.** $x = -1, 1, 7$ **f.** $x = -1, 1, 2, 7$
107. $2\sqrt{11}$ cm **109.** $-1 < x < 5$;



Summary and Concept Review, pp. 142–146

1. a. yes **b.** yes **c.** yes **2.** $b = 6$ **3.** $n = 4$ **4.** $m = -1$
5. $x = \frac{1}{6}$ **6.** no solution **7.** $g = 10$ **8.** $h = \dfrac{V}{\pi r^2}$ **9.** $L = \frac{P - 2W}{2}$
10. $x = \frac{c - b}{a}$ **11.** $y = \frac{2}{3}x - 2$ **12.** 8 gal **13.** $12 + \frac{9}{8}\pi\ \text{ft}^2 \approx 15.5\ \text{ft}^2$
14. $\frac{2}{3}$ hr $= 40$ min **15.** $a \geq 35$ **16.** $a < 2$ **17.** $s \leq 65$
18. $c \geq 1200$ **19.** $(5, \infty)$ **20.** $(-10, \infty)$ **21.** $(-\infty, 2]$
22. $(-9, 9]$ **23.** $(-6, \infty)$ **24.** $\left(-\infty, \frac{-8}{5}\right) \cup \left(\frac{23}{10}, \infty\right)$
25. a. $(-\infty, 3) \cup (3, \infty)$ **b.** $\left(-\infty, \frac{3}{2}\right) \cup \left(\frac{3}{2}, \infty\right)$ **c.** $(-5, \infty)$
d. $(-\infty, 6]$ **26.** $x \geq 96\%$ **27.** $\{-4, 10\}$ **28.** $\{-7, 3\}$ **29.** $\{-5, 8\}$
30. $\{-4, -1\}$ **31.** $(-\infty, -6) \cup (2, \infty)$ **32.** $[4, 32]$ **33.** $\{\ \}$ **34.** $\{\ \}$
35. $(-\infty, \infty)$ **36.** $[-2, 6]$ **37.** $(-\infty, -2] \cup [\frac{10}{3}, \infty)$
38. a. $|r - 2.5| \leq 1.7$ **b.** highest: 4.2 in., lowest: 0.8 in. **39.** $6\sqrt{2}i$
40. $24\sqrt{3}i$ **41.** $-2 + \sqrt{2}i$ **42.** $3\sqrt{2}i$ **43.** i **44.** $21 + 20i$
45. $-2 + i$ **46.** $-5 + 7i$ **47.** 13 **48.** $-20 - 12i$
49. $(5i)^2 - 9 = -34$ $\quad$ $(-5i)^2 - 9 = -34$
$25i^2 - 9 = -34$ $\quad$ $25i^2 - 9 = -34$
$-25 - 9 = -34$✓ $\quad$ $-25 - 9 = -34$✓
50. $(2 + i\sqrt{5})^2 - 4(2 + i\sqrt{5}) + 9 = 0$
$(2 - i\sqrt{5})^2 - 4(2 - i\sqrt{5}) + 9 = 0$
$4 + 4i\sqrt{5} + 5i^2 - 8 - 4i\sqrt{5} + 9 = 0$
$4 - 4i\sqrt{5} + 5i^2 - 8 + 4i\sqrt{5} + 9 = 0$
$5 + (-5) = 0$✓ $\quad 5 + (-5) = 0$✓
51. a. $2x^2 + 3 = 0$; $a = 2, b = 0, c = 3$ **b.** not quadratic
c. $x^2 - 8x - 99 = 0$; $a = 1, b = -8, c = -99$
d. $x^2 + 16 = 0$; $a = 1, b = 0, c = 16$ **52. a.** $x = 5$ or $x = -2$
b. $x = -5$ or $x = 5$ **c.** $x = -\frac{5}{3}$ or $x = 3$ **d.** $x = -2$ or $x = 2$ or $x = 3$
53. a. $x = \pm 3$ **b.** $x = 2 \pm \sqrt{5}$ **c.** $x = \pm\sqrt{5}i$ **d.** $x = \pm 5$
54. a. $x = 3$ or $x = -5$ **b.** $x = -8$ or $x = 2$
c. $x = 1 \pm \frac{\sqrt{10}}{2}$; $x \approx 2.58$ or $x \approx -0.58$ **d.** $x = 2$ or $x = \frac{1}{3}$
55. a. $x = 2 \pm \sqrt{5}\,i$; $x \approx 2 \pm 2.24i$ **b.** $x = \frac{3 \pm \sqrt{2}}{2}$; $x \approx 2.21$ or $x \approx 0.79$ **c.** $x = \frac{3}{2} \pm \frac{1}{2}i$ **56. a.** 1.3 sec **b.** 4.7 sec **c.** 6 sec
57. a. 0.8 sec **b.** 3.2 sec **c.** 5 sec **58.** \$3.75; 3000 **59.** 6 hr
60. $x = \pm\sqrt{3}, x = 7$ **61.** $x = -2, x = 0, x = \frac{1}{3}$
62. $x = 0, x = 2, x = -1 \pm \sqrt{3}i$ **63.** $x = \pm\frac{1}{2}, x = \pm\frac{1}{2}i$ **64.** $x = \frac{-1}{2}$
65. $h = -\frac{5}{3}, h = 2$ **66.** $n = 13$; $n = -2$ is extraneous
67. $x = -3$; $x = 3$ **68.** $x = -4$; $x = 5$
69. $x = -1$; $x = 7$ is extraneous **70.** $x = \frac{5}{2}$ **71.** $x = -5.8$; $x = 5$
72. $x = -2, x = -1, x = 4, x = 5$
73. $x = -3, x = 3, x = -i\sqrt{2}, x = i\sqrt{2}$ **74. a.** 12,000 kilocalories
b. 810 kg **75.** width, 6 in.; length, 9 in. **76.** 1 sec; 244 ft; 8 sec
77. \$24 per load; \$42 per load

Mixed Review, pp. 147–147

1. a. $x \in (8, \infty)$ **b.** $x \in (-\infty, \frac{-4}{3}) \cup (\frac{-4}{3}, \infty)$ **3. a.** $x = 2, x = \pm 5i$
b. $x = 0, x = -5, x = \frac{5}{2} \pm \frac{5i\sqrt{3}}{2}$ **c.** $x = -\frac{7}{3}, x = \frac{5}{3}$
d. $(-\infty, 3] \cup [27, \infty)$ **e.** $v = \pm 27$ **f.** $x = 80$ **5.** $y = \frac{-3}{4}x - 3$
7. a. $x = -2$ **b.** $n = 5$ **9.** $x = 7, 11$ **11.** $x = -\sqrt{6}, \sqrt{6}$
13. $x = \frac{4}{5}$ **15.** $x = \pm\sqrt{5}, \pm i\sqrt{5}$ **17. a.** $v = 6, 2$ is extraneous
b. $x = -5$; $x = 4$ **c.** $x = 2$; $x = 18$ is extraneous **19.** $6'10''$

Practice Test, pp. 147

1. a. $x = 27$ **b.** $x = 2$ **c.** $C = \frac{P}{1 + k}$ **d.** $x = -4, x = -1$
2. 30 gal **3. a.** $x > -30$ **b.** $-5 \leq x < 4$ **c.** $x \in \mathbb{R}$
d. $x = 2, x = 4$ **e.** $x < -4$ or $x > 2$ **4.** $S \geq 177$
5. $z = -3, z = 10$ **6.** $x = \pm 5i$ **7.** $x = 1 \pm i\sqrt{3}$
8. $x = \pm 1, x = \pm 4$ **9.** $x = \frac{2}{3}, x = 6$ **10.** $x = -2, x = \pm\frac{3}{2}$
11. $x = 6, x = -2$ is extraneous **12.** $x = -\frac{3}{2}, x = 2$
13. $x = 16, x = 4$ is extraneous **14.** $x = -11, x = 5$
15. a. \$4.50 per tin **b.** 90 tins **16. a.** $t = 5$ (May) **b.** $t = 9$ (Sept.)
c. July; \$3000 more **17.** $-\frac{4}{3} \pm \frac{i\sqrt{5}}{3}$ **18.** $-i$ **19. a.** 1 **b.** $i\sqrt{3}$
c. 1 **20.** $-\frac{3}{2} + \frac{3}{2}i$ **21.** 34 **22.** $(2 - 3i)^2 - 4(2 - 3i) + 13 = 0$
$-5 - 12i - 8 + 12i + 13 = 0$ $\quad 0 = 0$✓ **23. a.** $x = 5 \pm \frac{\sqrt{2}}{2}$
b. $x = \frac{5}{4} \pm \frac{i\sqrt{7}}{4}$ **24. a.** $x = \frac{3 \pm \sqrt{3}}{3}$ **b.** $x = 1 \pm 3i$
25. a. $F \approx 64.8$ g **b.** $W \approx 256$ g

Strengthening Core Skills pp. 149–150

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

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

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

CHAPTER 2

Exercises 2.1, pp. 161–164

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

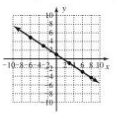
7.

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

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

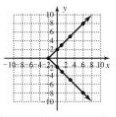
11. $D = \{4, -1, 2, -3\}$; $R = \{0, 5, 4, 2, 3\}$

13.



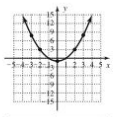
x	y
-6	5
-3	3
0	1
3	-1
6	-3
8	$\frac{-13}{3}$

15.



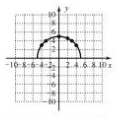
x	y
-2	0
0	$2, -2$
1	$3, -3$
3	$5, -5$
6	$8, -8$
7	$9, -9$

17.



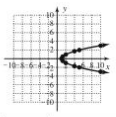
x	y
-3	8
-2	3
0	-1
2	3
3	8
4	15

19.



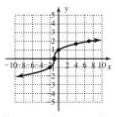
x	y
-4	3
-3	4
0	5
2	$\sqrt{21}$
3	4
4	3

21.



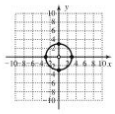
x	y
10	$3, -3$
5	$2, -2$
4	$\sqrt{3}, -\sqrt{3}$
2	$1, -1$
1.25	$0.5, -0.5$
1	0

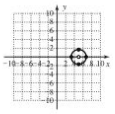
23.



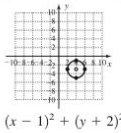
x	y
-9	-2
-2	-1
-1	0
0	1
4	$\sqrt[3]{5}$
7	2

25. (3, 1) **27.** $(-0.7, -0.3)$ **29.** $\left(\frac{1}{20}, \frac{1}{24}\right)$ **31.** $(0, -1)$
33. $(-1, 0)$ **35.** $2\sqrt{34}$ **37.** 10 **39.** not a right triangle
41. not a right triangle **43.** right triangle
45. $x^2 + y^2 = 9$ **47.** $(x - 5)^2 + y^2 = 3$

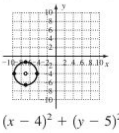




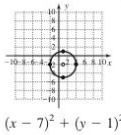
49. $(x - 4)^2 + (y + 3)^2 = 4$



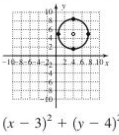
51. $(x + 7)^2 + (y + 4)^2 = 7$



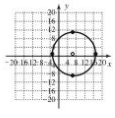
53. $(x - 1)^2 + (y + 2)^2 = 9$



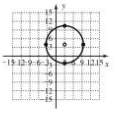
55. $(x - 4)^2 + (y - 5)^2 = 12$



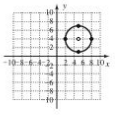
57. $(x - 7)^2 + (y - 1)^2 = 100$



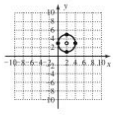
59. $(x - 3)^2 + (y - 4)^2 = 41$



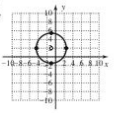
61. $(x - 5)^2 + (y - 4)^2 = 9$



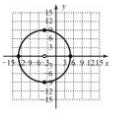
63. $(2, 3)$, $r = 2$, $x \in [0, 4]$, $y \in [1, 5]$



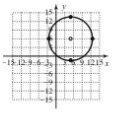
65. $(-1, 2)$, $r = 2\sqrt{3}$, $x \in [-1 - 2\sqrt{3}, -1 + 2\sqrt{3}]$, $y \in [2 - 2\sqrt{3}, 2 + 2\sqrt{3}]$



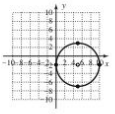
67. $(-4, 0)$, $r = 9$, $x \in [-13, 5]$, $y \in [-9, 9]$



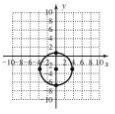
69. $(x - 5)^2 + (y - 6)^2 = 57$, $(5, 6)$, $r = \sqrt{57}$



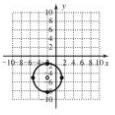
71. $(x - 5)^2 + (y + 2)^2 = 25$, $(5, -2)$, $r = 5$



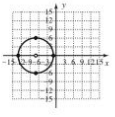
73. $x^2 + (y + 3)^2 = 14$, $(0, -3)$, $r = \sqrt{14}$



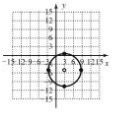
75. $(x + 2)^2 + (y + 5)^2 = 11$, $(-2, -5)$, $r = \sqrt{11}$



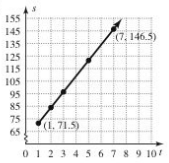
77. $(x + 7)^2 + y^2 = 37$, $(-7, 0)$, $r = \sqrt{37}$



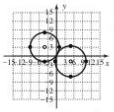
79. $(x - 3)^2 + (y + 5)^2 = 32$, $(3, -5)$, $r = 4\sqrt{2}$



81. **a.** (1, 71.5), (2, 84), (3, 96.5), (5, 121.5), (7, 146.5); yes **b.** \$159
c. 2011 **d.**



83. **a.** $(x-5)^2+(y-12)^2=625$ **b.** no
85. Red: $(x-2)^2+(y-2)^2=4$;
Blue: $(x-2)^2+y^2=16$;
Area blue $= 12\pi$ units^2
87.



No, distance between centers is less than sum of radii. **89.** Answers will vary.

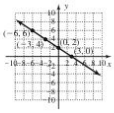
91. **a.** center: $(6,-2)$; $r=0$ (degenerate case) **b.** center: $(1,4)$; $r=5$
c. $r^2=-1$; degenerate case
93. **a.** 0 **b.** not possible **c.** 0.3; many answers possible
d. not possible **e.** not possible **f.** $\sqrt{3}$; many answers possible
95. $n=1$ is a solution, $n=-2$ is extraneous

Exercises 2.2, pp. 174–177

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

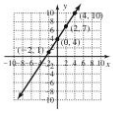
7.

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



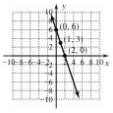
9.

x	y
-2	1
0	4
2	7
4	10

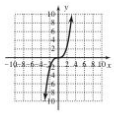


11. $-0.5 = \frac{3}{2}(-3)+4$
$-0.5 = -\frac{9}{2}+4$
$-0.5 = -0.5$ ✓
$\frac{19}{4} = \frac{3}{2}(\frac{1}{2})+4$
$\frac{19}{4} = \frac{3}{4}+4$
$\frac{19}{4} = \frac{19}{4}$ ✓

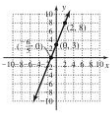
13.



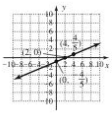
15.



17.



19.



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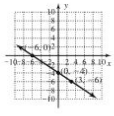

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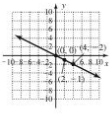

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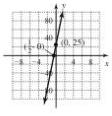

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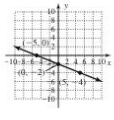

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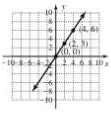

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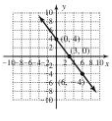
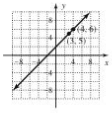
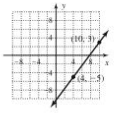


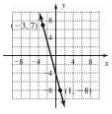
33. $m=1$; $(2,4)$ and $(1,3)$



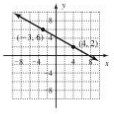
35. $m=\frac{4}{3}$; $(7,-1)$ and $(1,-9)$



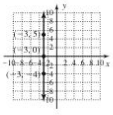
37. $m=\frac{-15}{4}$; $(1,-8)$ and $(-1,-\frac{1}{2})$



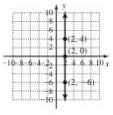
39. $m=\frac{-4}{7}$; $(-10,10)$ and $(11,-2)$



41. **a.** $m=125$, cost increased \$125,000 per 1000 sq ft **b.** \$375,000
43. **a.** $m=22.5$, distance increases 22.5 mph **b.** about 186 mi
45. **a.** $m=\frac{23}{6}$, a person weighs 23 lb more for each additional 6 in. in height **b.** 3.8
47. In inches: $(0,-6)$ and $(576,-18)$: $m=\frac{1}{48}$. The sewer line is 1 in. deeper for each 48 in. in length.
49.



51.



53. L_1: $x=2$; L_2: $y=4$; point of intersection $(2,4)$
55. **a.** For any two points chosen $m=0$, indicating there has been no increase or decrease in the number of supreme court justices.
b. For any two points chosen $m=\frac{1}{10}$, which indicates that over the last 5 decades, one nonwhite or nonfemale justice has been added to the court every 10 yr.
57. parallel **59.** neither **61.** parallel **63.** not a right triangle
65. not a right triangle **67.** right triangle
69. **a.** 76.4 yr **b.** 2010
71. $v=-1250t+8500$
a. \$3500
b. 5 yr
73. $h=-3t+300$ **a.** 273 in. **b.** 20 months
75. Yes they will meet, the two roads are not parallel: $\frac{38}{12} \neq \frac{30}{9.5}$.
77. **a.** \$3789 **b.** 2012 **79.** **a.** 23% **b.** 2005
81. $a=-6$ **83.** **a.** 142 **b.** -83 **c.** 9 **d.** $\frac{27}{2}$
85. perimeter of a rectangle, volume of a rectangular prism, volume of a right circular cylinder, circumference of a circle
87. 2 hr

Exercises 2.3, pp. 186–190

1. $\frac{-7}{4}$; $(0,3)$ **3.** 2.5 **5.** Answers will vary

7. $y=\frac{-4}{5}x+2$

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

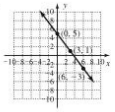
9. $y=2x+7$

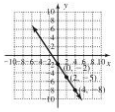
x	y
-5	-3
-2	3
0	7
1	9
3	13

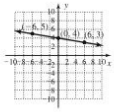
11. $y=\frac{-5}{3}x-5$

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

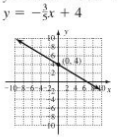
13. $y=2x-3$: 2, -3 **15.** $y=\frac{-5}{3}x-7$: $\frac{-5}{3}$, -7
17. $y=\frac{-35}{6}x-4$: $\frac{-35}{6}$, -4

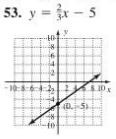
19. 

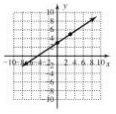
21. 

23. 

25. a. $\frac{-3}{4}$ **b.** $y = \frac{-3}{4}x + 3$ **c.** The coeff. of x is the slope and the constant is the y-intercept.
27. a. $\frac{2}{5}$ **b.** $y = \frac{2}{5}x - 2$ **c.** The coeff. of x is the slope and the constant is the y-intercept.
29. a. $\frac{4}{5}$ **b.** $y = \frac{4}{5}x + 3$ **c.** The coeff. of x is the slope and the constant is the y-intercept. **31.** $y = \frac{-2}{3}x + 2$, $m = \frac{-2}{3}$, y-intercept $(0, 2)$
33. $y = \frac{-5}{4}x + 5$, $m = \frac{-5}{4}$, y-intercept $(0, 5)$ **35.** $y = \frac{1}{3}x$, $m = \frac{1}{3}$, y-intercept $(0, 0)$ **37.** $y = \frac{-3}{4}x + 3$, $m = \frac{-3}{4}$, y-intercept $(0, 3)$
39. $y = \frac{2}{3}x + 1$ **41.** $y = 3x + 3$ **43.** $y = 3x + 2$
45. $y = 250x + 500$ **47.** $y = \frac{75}{2}x + 150$ **49.** $y = 2x - 13$
51. $y = -\frac{3}{5}x + 4$ **53.** $y = \frac{2}{3}x - 5$ **55.**







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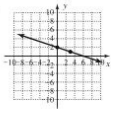

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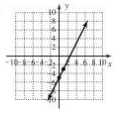
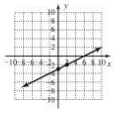
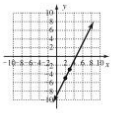
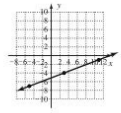


61.

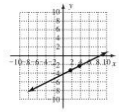


63. $y = \frac{2}{5}x + 4$ **65.** $y = \frac{-5}{3}x + 7$ **67.** $y = \frac{-12}{5}x - \frac{29}{5}$
69. $y = 5$ **71.** perpendicular **73.** neither **75.** neither
77. a. $y = \frac{-3}{4}x - \frac{5}{2}$ **b.** $y = \frac{4}{3}x - \frac{20}{3}$
79. a. $y = \frac{4}{9}x + \frac{31}{9}$ **b.** $y = \frac{-9}{4}x + \frac{3}{4}$
81. a. $y = \frac{-1}{2}x - 2$ **b.** $y = 2x - 2$
83. $y + 5 = 2(x - 2)$ **85.** $y + 4 = \frac{3}{8}(x - 3)$





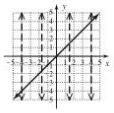
87. $y + 3.1 = 0.5(x - 1.8)$



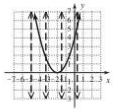
89. $y - 2 = \frac{6}{5}(x - 4)$; For each 5000 additional sales, income rises \$6000.
91. $y - 100 = \frac{-20}{1}(x - 0.5)$; For every hour of television, a student's final grade falls 20%. **93.** $y - 10 = \frac{35}{2}(x - \frac{1}{2})$; Every 2 in. of rainfall increases the number of cattle raised per acre by 35. **95.** C **97.** A
99. B **101.** D **103.** $m = \frac{-a}{b}$, y-intercept $= \frac{c}{b}$ **a.** $m = \frac{-3}{4}$, y-intercept $(0, 2)$ **b.** $m = \frac{-2}{5}$, y-intercept $(0, -3)$ **c.** $m = \frac{5}{6}$, y-intercept $(0, 2)$
d. $m = \frac{5}{3}$, y-intercept $(0, 3)$ **105. a.** As the temperature increases 5°C, the velocity of sound waves increases 3 m/s. At a temperature of 0°C, the velocity is 331 m/s. **b.** 343 m/s **c.** 50°C **107. a.** $V = \frac{20}{3}t + 150$ **b.** Every 3 yr the value of the coin increases by \$20; the initial value was \$150.
c. \$223.33 **d.** 15 years, in 2013 **e.** 3 yr **109. a.** $N = 7t + 9$
b. Every 1 yr the number of homes with Internet access increases by 7 million. **c.** 1993 **d.** 86 million **e.** 13 yr **f.** 2010
111. a. $P = 58{,}000t + 740{,}000$ **b.** Each year, the prison population increases by 58,000. **c.** 1,726,000 **113.** Answers will vary.
115. **(1)** d **(2)** a **(3)** c **(4)** b **(5)** f **(6)** h
117. $x = \frac{5 \pm 2\sqrt{13}}{3}$; $x \approx -0.74$ or $x \approx 4.07$ **119.** 113.10 yd^2

Exercises 2.4, pp. 200–205

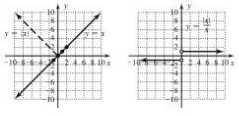
1. first **3.** range **5.** Answers will vary. **7.** function **9.** Not a function. The Shaq is paired with two heights. **11.** Not a function; 4 is paired with 2 and −5. **13.** function **15.** function **17.** Not a function; −2 is paired with 3 and −4. **19.** function **21.** function **23.**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



33. function



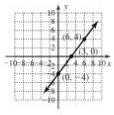
35. function, $x \in [-4, 5]$, $y \in [-2, 3]$ **37.** function, $x \in [-4, \infty)$, $y \in [-4, \infty)$ **39.** function, $x \in [-4, 4]$, $y \in [-5, -1]$ **41.** function, $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$ **43.** Not a function, $x \in [-3, 5]$, $y \in [-3, 3]$ **45.** Not a function, $x \in (-\infty, 3]$, $y \in (-\infty, \infty)$
47. $x \in (-\infty, 5) \cup (5, \infty)$ **49.** $x \in [\frac{-5}{3}, \infty)$
51. $x \in (-\infty, -5) \cup (-5, 5) \cup (5, \infty)$
53. $v \in (-\infty, -3\sqrt{2}) \cup (-3\sqrt{2}, 3\sqrt{2}) \cup (3\sqrt{2}, \infty)$
55. $x \in (-\infty, \infty)$ **57.** $x \in (-\infty, \infty)$ **59.** $x \in (-\infty, \infty)$
61. $x \in (-\infty, -2) \cup (-2, 5) \cup (5, \infty)$ **63.** $x \in [2, \frac{5}{2}) \cup (\frac{5}{2}, \infty)$
65. $x \in (2, \infty)$ **67.** $x \in (-4, \infty)$ **69.** $f(-6) = 0, f(\frac{3}{2}) = \frac{15}{4}, f(2c) = c + 3$, $f(c + 1) = \frac{1}{2}c + \frac{7}{2}$ **71.** $f(-6) = 132, f(\frac{3}{2}) = \frac{3}{4}, f(2c) = 12c^2 - 8c$, $f(c + 1) = 3c^2 + 2c - 1$ **73.** $h(3) = 1, h(\frac{-2}{3}) = \frac{-9}{2}, h(3a) = \frac{1}{a}$, $h(a - 2) = \frac{3}{a - 2}$ **75.** $h(3) = 5, h(\frac{-2}{3}) = -5, h(3a) = -5$ if $a < 0$ or 5 if $a > 0$, $h(a - 2) = 5\left(\frac{|a - 2|}{a - 2}\right)$
77. $g(4) = 8\pi, g\left(\frac{3}{2}\right) = 3\pi, g(2c) = 4\pi c, g(c + 3) = 2\pi(c + 3)$
79. $g(4) = 16\pi, g\left(\frac{3}{2}\right) = \frac{9}{4}\pi, g(2c) = 4\pi c^2, g(c + 3) = (c^2 + 6c + 9)\pi$
81. $p(5) = \sqrt{13}, p\left(\frac{3}{2}\right) = \sqrt{6}, p(3a) = \sqrt{6a + 3}, p(a - 1) = \sqrt{2a + 1}$
83. $p(5) = \frac{14}{5}, p\left(\frac{3}{2}\right) = \frac{7}{9}, p(3a) = \frac{27a^2 - 5}{9a^2}$, $p(a - 1) = \frac{3a^2 - 6a - 2}{a^2 - 2a + 1}$
85. a. $D = \{-1, 0, 1, 2, 3, 4, 5\}$ **b.** $R = \{-2, -1, 0, 1, 2, 3, 4\}$ **c.** 1 **d.** −1 **87. a.** $D = [-5, 5]$ **b.** $y \in [-3, 4]$ **c.** −2 **d.** −4 and 0
89. a. $D = [-3, \infty)$ **b.** $y \in (-\infty, 4]$ **c.** 2 **d.** −2 and 2
91. a. 186.5 lb **b.** 37 lb **93.** $A = \frac{1}{2}(8) + 22 - 1 = 25$ units^2
95. a. $N(g) = 2.5g$ **b.** $g \in [0, 5]$; $N \in [0, 12.5]$ **97. a.** $[0, \infty)$
b. 750π **c.** 800 **99. a.** $c(t) = 42.50t + 50$ **b.** \$156.25 **c.** 5 hr
d. $t \in [0, 10.6]$; $c \in [0, 500]$ **101. a.** Yes. Each x is paired with exactly one y. **b.** 10 P.M. **c.** 0.9 m **d.** 7 P.M. and 1 A.M.
103. a. $\frac{\Delta \text{fertility}}{\Delta \text{time}} = \frac{-1}{20}$, negative, fertility is decreasing by one child every 20 yr **b.** 1940 to 1950: $\frac{\Delta f}{\Delta t} = \frac{0.8}{10}$; positive, fertility is increasing by less than one child every 10 yr **c.** 1940 to 1950: $\frac{\Delta f}{\Delta t} = \frac{0.8}{10}$; 1980 to 1990: $\frac{\Delta f}{\Delta t} = \frac{0.2}{10}$, the fertility rate was increasing four times as fast from 1940 to 1950.
105. negative outputs become positive



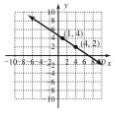
107. a. $x \in (-\infty, -2) \cup (2, \infty)$; $x = \frac{2y+3}{1-y}$; $y \in (-\infty, 1) \cup (1, \infty)$
b. $x \in \mathbb{R}$ $x = \pm\sqrt{y+3}$; $y \in [-3, \infty)$ **109. a.** $19\sqrt{6}$ **b.** 1
111. a. $(x-3)(x-5)(x+5)$ **b.** $(2x+3)(x-8)$
c. $(2x-5)(4x^2+10x+25)$

Mid-Chapter Check, p. 205

1.



2. $\frac{-18}{7}$ **3.** positive, loss is decreasing (profit is increasing); $m = \frac{3}{2}$, yes; $\frac{1.5}{1}$, each year Data.com's loss decreases by 1.5 million.
4.

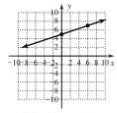


$y = \frac{3}{2}x + \frac{5}{2}$

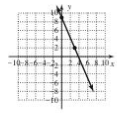
5. $x = -3$; no; input -3 is paired with more than one output.
6. $y = \frac{-4}{3}x + 4$; yes **7. a.** 0 **b.** $x \in [-3, 5]$ **c.** -1
d. $y \in [-4, 5]$ **8.** from $x = 1$ to $x = 2$; steeper line → greater slope
9. $F(p) = \frac{3}{4}p + \frac{5}{4}$, For every 4000 pheasants, the fox population increases by 300: 1625. **10. a.** $x \in \{-3, -2, -1, 0, 1, 2, 3, 4\}$
$y \in \{-3, -2, -1, 0, 1, 2, 3, 4\}$ **b.** $x \in [-3, 4]$ $y \in [-3, 4]$
c. $x \in (-\infty, \infty)$ $y \in (-\infty, \infty)$

Reinforcing Basic Concepts, p. 206

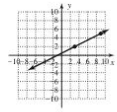
1. a. $\frac{1}{3}$, increasing **b.** $y - 5 = \frac{1}{3}(x - 0)$ **c.** $y = \frac{1}{3}x + 5$
d. $x - 3y = -15$ **e.** $(0, 5), (-15, 0)$



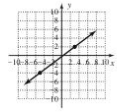
2. a. $\frac{-7}{3}$, decreasing **b.** $y - 9 = \frac{-7}{3}(x - 0)$ **c.** $y = \frac{-7}{3}x + 9$
d. $7x + 3y = 27$ **e.** $(0, 9), (\frac{27}{7}, 0)$



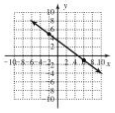
3. a. $\frac{1}{2}$, increasing **b.** $y - 2 = \frac{1}{2}(x - 3)$ **c.** $y = \frac{1}{2}x + \frac{1}{2}$
d. $x - 2y = -1$ **e.** $(0, \frac{1}{2}), (-1, 0)$



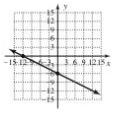
4. a. $\frac{3}{4}$, increasing **b.** $y + 4 = \frac{3}{4}(x + 5)$ **c.** $y = \frac{3}{4}x - \frac{1}{4}$
d. $3x - 4y = 1$ **e.** $(0, \frac{-1}{4}), (\frac{1}{3}, 0)$



5. a. $\frac{-3}{4}$, decreasing **b.** $y - 5 = \frac{-3}{4}(x + 2)$ **c.** $y = \frac{-3}{4}x + \frac{7}{2}$
d. $3x + 4y = 14$ **e.** $(0, \frac{7}{2}), (\frac{14}{3}, 0)$

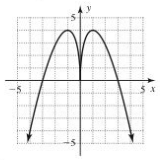


6. a. $\frac{-1}{2}$, decreasing **b.** $y + 7 = \frac{-1}{2}(x - 2)$ **c.** $y = \frac{-1}{2}x - 6$
d. $x + 2y = -12$ **e.** $(0, -6), (-12, 0)$

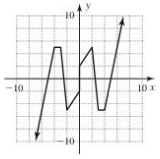


Exercises 2.5, pp. 218–224

1. linear; bounce **3.** increasing **5.** Answers will vary.
7.



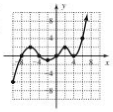
9. even **11.** even
13.



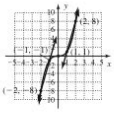
15. odd **17.** not odd **19.** neither **21.** odd **23.** neither
25. $x \in [-1, 1] \cup [3, \infty)$ **27.** $x \in (-\infty, -1) \cup (-1, 1) \cup (1, \infty)$
29. $p(x) \geq 0$ for $x \in [2, \infty)$ **31.** $f(x) \leq 0$ for $x \in (-\infty, 2]$
33. $V(x)\uparrow$: $x \in (-3, 1) \cup (4, 6)$ $V(x)\downarrow$: $x \in (-\infty, -3) \cup (1, 4)$
constant: none **35.** $f(x)\uparrow$: $x \in (1, 4)$ $f(x)\downarrow$: $x \in (-2, 1) \cup (4, \infty)$
constant: $x \in (-\infty, -2)$ **37. a.** $p(x)\uparrow$: $x \in (-\infty, \infty)$ $p(x)\downarrow$: none
b. down, up **39. a.** $f(x)\uparrow$: $x \in (-3, 0) \cup (3, \infty)$
$f(x)\downarrow$: $x \in (-\infty, -3) \cup (0, 3)$ **b.** up, up
41. a. $x \in (-\infty, \infty)$, $y \in (-\infty, 5)$ **b.** $x = 1, 3$
c. $H(x) \geq 0$: $x \in [1, 3]$ $H(x) \leq 0$: $x \in (-\infty, 1] \cup [3, \infty)$
d. $H(x)\uparrow$: $x \in (-\infty, 2)$ $H(x)\downarrow$: $x \in (2, \infty)$ **e.** local max: $y = 5$ at $(2, 5)$
43. a. $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$ **b.** $x = -1, 5$
c. $g(x) \geq 0$: $x \in [-1, \infty)$ $g(x) \leq 0$: $x \in (-\infty, -1] \cup [0, 3.5]$
d. $g(x)\uparrow$: $x \in (-\infty, 1) \cup (5, \infty)$ $g(x)\downarrow$: $x \in (1, 5)$ **e.** local max: $y = 6$ at $(1, 6)$; local min: $y = 0$ at $(5, 0)$ **45. a.** $x \in [-4, \infty)$, $y \in (-\infty, 3]$
b. $x = -4, 2$ **c.** $Y_1 \geq 0$: $x \in [-4, 2]$ $Y_1 \leq 0$: $x \in [2, \infty]$
d. $Y_1\uparrow$: $x \in (-4, -2)$ $Y_1\downarrow$: $x \in (-2, \infty)$ **e.** local max: $y = 3$ at $(-2, 3)$
47. a. $x \in \mathbb{R}$, $y \in \mathbb{R}$ **b.** $x = -4$ **c.** $p(x) \geq 0$: $x \in [-4, \infty)$; $p(x) \leq 0$: $x \in (-\infty, -4]$ **d.** $p(x)\uparrow$: $x \in (-\infty, -3) \cup (-3, \infty)$; $p(x)\downarrow$: never decreasing **e.** local max: none; local min: none
49. a. $x \in (-\infty, -3] \cup [3, \infty)$, $y \in [0, \infty)$ **b.** $(-3, 0), (3, 0)$
c. $f(x)\uparrow$: $x \in (3, \infty)$ $f(x)\downarrow$: $x \in (-\infty, -3)$ **d.** even
51. a. $x \in [0, 260]$, $y \in [0, 80]$ **b.** 80 ft **c.** 120 ft **d.** yes **e.** $(0, 120)$
f. $(120, 260)$ **53. a.** $x \in (-\infty, \infty)$; $y \in [-1, \infty)$ **b.** $(-1, 0), (1, 0)$
c. $f(x) \geq 0$: $x \in (-\infty, -1] \cup [1, \infty)$; $f(x) < 0$: $x \in (-1, 1)$;
d. $f(x)\uparrow$: $x \in (0, \infty)$, $f(x)\downarrow$: $x \in (-\infty, 0)$ **e.** min: $(0, -1)$

55. a. $t \in [72, 96]$, $I \in [7.25, 16]$
b. $I(t)\uparrow$: $t \in (72, 74) \cup (77, 81) \cup (83, 84) \cup (93, 94)$
$I(t)\downarrow$: $t \in (74, 75) \cup (81, 83) \cup (84, 86) \cup (90, 93) \cup (94, 95)$ $I(t)$ constant: $t \in (75, 77) \cup (86, 90) \cup (95, 96)$ **c.** max: (74, 9.25), (81, 16) (global max), (84, 13), (94, 8.5), min: (72, 7.5), (83, 12.75), (93, 7.25)
d. Increase: 80 to 81; Decrease: 82 to 83 or 85 to 86

57. zeroes: $(-8, 0)$, $(-4, 0)$, $(0, 0)$, $(4, 0)$; min: $(-2, -1)$, $(4, 0)$; max: $(-6, 2)$, $(2, 2)$



59. a. 7 **b.** 7 **c.** They are the same. **d.** Slopes are equal.

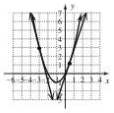


61. a. 176 ft **b.** 320 ft **c.** 144 ft/sec **d.** -144 ft/sec; The arrow is going down. **63. a.** 17.89 ft/sec; 25.30 ft/sec **b.** 30.98 ft/sec; 35.78 ft/sec **c.** Between 5 and 10. **d.** 1.482 ft/sec, 0.96 ft/sec **65.** 2

67. $2x + h$ **69.** $2x + 2 + h$ **71.** $\dfrac{-2}{x(x+h)}$

73. a. $\dfrac{\Delta g}{\Delta x} = 2x + 2 + h$ **b.** $\dfrac{\Delta g}{\Delta x} = -3.9$ **c.** $\dfrac{\Delta g}{\Delta x} = 3.01$

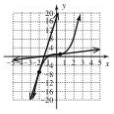
d.



The rates of change have opposite sign, with the secant line to the left being slightly more steep.

75. a. $\dfrac{\Delta g}{\Delta x} = 3x^2 + 3xh + h^2$ **b.** $\dfrac{\Delta g}{\Delta x} \approx 12.61$ **c.** $\dfrac{\Delta g}{\Delta x} \approx 0.49$

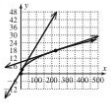
d.



Both lines have a positive slope, but the line at $x = -2$ is much steeper.

77. a. $\dfrac{\Delta d}{\Delta h} \approx 0.25$ **b.** $\dfrac{\Delta d}{\Delta h} \approx 0.05$

c.



As height increases you can see farther, the sight distance is increasing much slower.

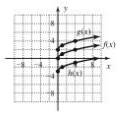
79. no; no; Answers will vary. **81.** Answers will vary.

83. $x = -2, x = 10$ **85.** $y = \dfrac{2}{3}x - 1$

Exercises 2.6, pp. 234–239

1. stretch; compression **3.** $(-5, -9)$; upward **5.** Answers will vary.
7. a. quadratic; **b.** up/up, $(-2, -4)$, $x = -2$, $(-4, 0)$, $(0, 0)$, $(0, 0)$; **c.** D: $x \in \mathbb{R}$, R: $y \in [-4, \infty)$ **9. a.** quadratic; **b.** up/up, $(1, -4)$, $x = 1$, $(-1, 0)$, $(3, 0)$, $(0, -3)$; **c.** D: $x \in \mathbb{R}$, R: $y \in [-4, \infty)$
11. a. quadratic; **b.** up/up, $(2, -9)$, $x = 2$, $(-1, 0)$, $(5, 0)$, $(0, -5)$; **c.** D: $x \in \mathbb{R}$, R: $y \in [-9, \infty)$ **13. a.** square root; **b.** up to the right, $(-4, -2)$, $(-3, 0)$, $(0, 2)$; **c.** D: $x \in [-4, \infty)$, R: $y \in [-2, \infty)$
15. a. square root; **b.** down to the left, $(4, 3)$, $(3, 0)$, $(0, -3)$; **c.** D: $x \in (-\infty, 4]$, R: $y \in (-\infty, 3]$ **17. a.** square root; **b.** up to the left, $(4, 0)$, $(4, 0)$, $(0, 4)$; **c.** D: $x \in (-\infty, 4]$, R: $y \in [0, \infty)$
19. a. absolute value; **b.** up/up, $(-1, -4)$, $x = -1$, $(-3, 0)$, $(1, 0)$, $(0, -2)$; **c.** D: $x \in \mathbb{R}$, R: $y \in [-4, \infty)$ **21. a.** absolute value; **b.** down/down, $(-1, 6)$, $x = -1$, $(-4, 0)$, $(2, 0)$, $(0, 4)$; **c.** D: $x \in \mathbb{R}$, R: $y \in (-\infty, 6]$
23. a. absolute value; **b.** down/down, $(0, 6)$, $x = 0$, $(-2, 0)$, $(2, 0)$, $(0, 6)$; **c.** D: $x \in \mathbb{R}$, R: $y \in (-\infty, 6]$ **25. a.** cubic; **b.** up/down, $(1, 0)$, $(1, 0)$, $(0, 1)$; **c.** D: $x \in \mathbb{R}$, R: $y \in \mathbb{R}$ **27. a.** cubic; **b.** down/up, $(0, 1)$, $(-1, 0)$, $(0, 1)$; **c.** D: $x \in \mathbb{R}$, R: $y \in \mathbb{R}$ **29. a.** cube root; **b.** down/up, $(1, -1)$, $(2, 0)$, $(0, -2)$; **c.** D: $x \in \mathbb{R}$, R: $y \in \mathbb{R}$ **31.** square root function; y-int $(0, 2)$; x-int $(-3, 0)$; initial point $(-4, -2)$; up on right; D: $x \in [-4, \infty)$, R: $y \in [-2, \infty)$ **33.** cubic function; y-int $(0, -2)$; x-int $(-2, 0)$; inflection point $(-1, -1)$; up, down; D: $x \in \mathbb{R}$, R: $y \in \mathbb{R}$

35.



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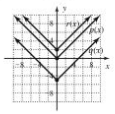

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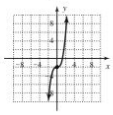

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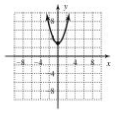
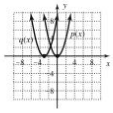


43.



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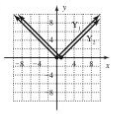
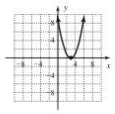
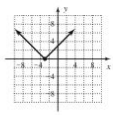


47.



49.



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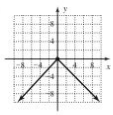

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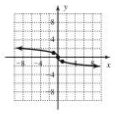

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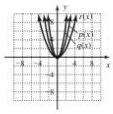

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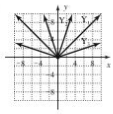

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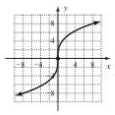

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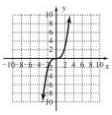
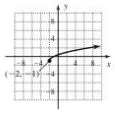


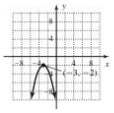
63. g **65.** i **67.** e **69.** j **71.** l **73.** c

75.



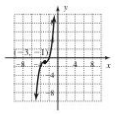
left 2, down 1

77.



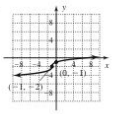
left 3, reflected across x-axis, down 2

79.



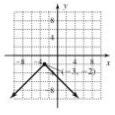
left 3, down 1

81.

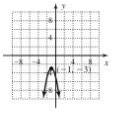


left 1, down 2

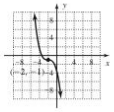
83. left 3, reflected across x-axis, down 2



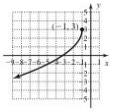
85. left 1, reflected across x-axis, stretched vertically, down 3



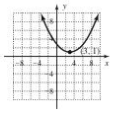
87. left 2, reflected across x-axis, compressed vertically down 1,



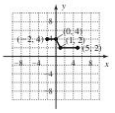
89. left 1, reflected across y-axis, reflected across x-axis, stretched vertically up 3,



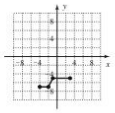
91. right 3, compressed vertically up 1



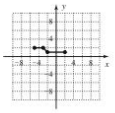
93. a.



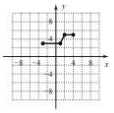
b.



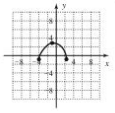
c.



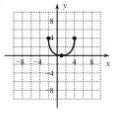
d.



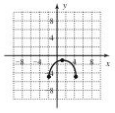
95. a.



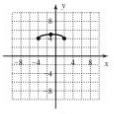
b.



c.

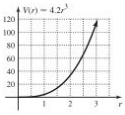


d.



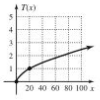
97. $f(x) = -(x-2)^2$ **99.** $p(x) = 1.5\sqrt{x+3}$

101. $f(x) = \frac{4}{5}|x+4|$ **103.**



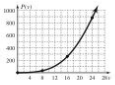
≈ -4.2, about 65 units^3, 65.4 units^3, yes

105.



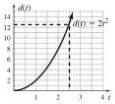
compressed vertically, 2.25 sec

107.



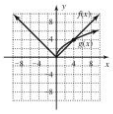
a. compressed vertically, **b.** 216 W, **c.** ≈15.6, 161.5, power increases dramatically at higher windspeeds

109.



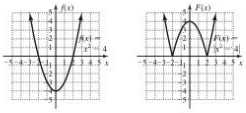
a. vertical stretch by a factor of 2, **b.** 12.5 ft, **c.** 5, 13, distance fallen by unit time increases very fast

111.



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

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



115. $p = 140$ in. $A = 1168$ in^2

117. $f(x)\downarrow: x \in (-\infty, 4)$ $f(x)\uparrow: x \in (4, \infty)$

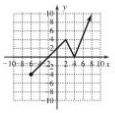
Exercises 2.7, pp. 248–253

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

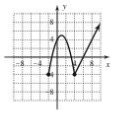
7. a. $f(x) = \begin{cases} x^2 - 6x + 10 & 0 \le x \le 5 \\ \frac{3}{2}x - \frac{5}{2} & 5 < x \le 9 \end{cases}$ **b.** $y \in [1, 11]$

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

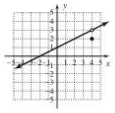
13. D: $x \in [-6, \infty)$; R: $y \in [-4, \infty)$



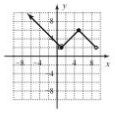
15. D: $x \in (-2, \infty)$; R: $y \in (-4, \infty)$



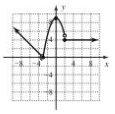
17. D: $x \in (-\infty, \infty)$; R: $y \in (-\infty, 3), \cup (3, \infty)$



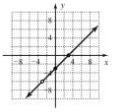
19. $x \in (-\infty, 9)$; $y \in [2, \infty)$



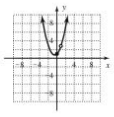
21. $x \in (-\infty, \infty)$; $y \in [0, \infty)$



23. $x \in (-\infty, \infty)$; $y \in (-\infty, -6) \cup (-6, \infty)$; discontinuity at $x = -3$, redefine $f(x) = -6$ at $x = -3$; $c = -6$



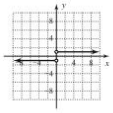
25. $x \in (-\infty, \infty)$; $y \in [0.75, \infty)$; discontinuity at $x = 1$, redefine $f(x) = 3$ at $x = 1$; $c = 3$



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

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

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



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

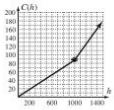
35. a.

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

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

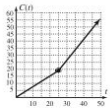
37. $C(h) = \begin{cases} 0.09h & 0 \le h \le 1000 \\ 0.18h - 90 & h > 1000 \end{cases}$

$C(1200) = \$126$

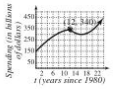


39. $C(t) = \begin{cases} 0.75t & 0 \le t \le 25 \\ 1.5t - 18.75 & t > 25 \end{cases}$

$C(45) = \$48.75$



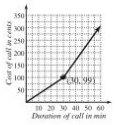
41. $S(t) = \begin{cases} -1.35t^2 + 31.9t + 152 & 0 \le t \le 12 \\ 2.5t^2 - 80.6t + 950 & 12 < t \le 22 \end{cases}$



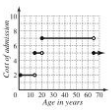
$498 billion, $653 billion, $782 billion

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

$2.11



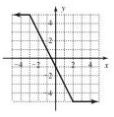
45. $C(a) = \begin{cases} 0 & a < 2 \\ 2 & 2 \le a < 13 \\ 5 & 13 \le a < 20 \\ 7 & 20 \le a < 65 \\ 5 & a \ge 65 \end{cases}$



$38

47. a. $C(w - 1) = 17[w - 1] + 80$, **b.** $0 < w \le 13$; **c.** 80¢, **d.** 165¢, **e.** 165¢, **f.** 165¢, **g.** 182¢

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



51. Y_1 has a removable discontinuity at $x = -2$; Y_2 has a discontinuity at $x = -2$ **53.** $x = -7$, $x = 4$ **55. a.** $4\sqrt{5}$ cm **b.** $16\sqrt{5}$ cm^2 **c.** $V = 320\sqrt{5}$ cm^3

Exercises 2.8, pp. 264–270

1. $(f + g)(x)$; $A \cap B$ **3.** intersection; $g(x)$ **5.** Answers will vary. **7. a.** $x \in \mathbb{R}$ **b.** $f(-2) - g(-2) = 13$ **9. a.** $h(x) = x^2 - 6x - 3$ **b.** $h(-2) = 13$ **c.** they are identical **11. a.** $x \in [3, \infty)$ **b.** $h(x) = \sqrt{x - 3} + 2x^3 - 54$ **c.** $h(4) = 75$, 2 is not in the domain of h. **13. a.** $x \in [-5, 3]$ **b.** $r(x) = \sqrt{x + 5} + \sqrt{3 - x}$ **c.** $2(7) = \sqrt{7} + 1$, 4 is not in the domain of r. **15. a.** $x \in [-4, \infty)$ **b.** $h(x) = \sqrt{x + 4}(2x + 3)$ **c.** $h(-4) = 0$, $h(21) = 225$ **17. a.** $x \in [-1, 7]$ **b.** $r(x) = \sqrt{-x^2 + 6x + 7}$ **c.** 15 is not in the domain of r, $r(3) = 4$ **19. a.** $x \in (-\infty, -4) \cup (-4, \infty)$ **b.** $h(x) = x - 4$, $x \ne -4$ **21. a.** $x \in (-\infty, -4) \cup (-4, \infty)$ **b.** $h(x) = x^2 - 2$, $x \ne -4$ **23. a.** $x \in (-\infty, 1) \cup (1, \infty)$ **b.** $h(x) = x^2 - 6x$, $x \ne 1$ **25. a.** $x \in (-\infty, 5) \cup (5, \infty)$ **b.** $h(x) = \frac{x + 1}{x - 5}$, $x \ne 5$ **27. a.** $x \in (-\infty, -2)$ **b.** $r(x) = \frac{2x - 3}{\sqrt{-2 - x}}$ **c.** 6 is not in the domain of r. $r(-6) = -\frac{15}{2}$ **29. a.** $x \in (5, \infty)$ **b.** $r(x) = \frac{x - 5}{\sqrt{x - 5}}$ **c.** $r(6) = 1$; -6 is not in the domain of r. **31. a.** $x \in \left(-\frac{13}{2}, \infty\right)$ **b.** $r(x) = \frac{x^2 - 36}{\sqrt{2x + 13}}$ **c.** $r(6) = 0$, $r(-6) = 0$ **33. a.** $h(x) = \frac{2x + 4}{x - 3}$ **b.** $x \in (-\infty, 3) \cup (3, \infty)$ **c.** $x \ne -2$, $x \ne 0$ **35.** sum: $3x + 1$, $x \in (-\infty, \infty)$; difference: $x + 5$, $x \in (-\infty, \infty)$; product: $2x^2 - x - 6$, $x \in (-\infty, \infty)$; quotient: $\frac{2x + 3}{x - 2}$, $x \in (-\infty, 2) \cup (2, \infty)$ **37.** sum: $x^2 + 3x + 5$, $x \in (-\infty, \infty)$; difference: $x^2 - 3x + 9$, $x \in (-\infty, \infty)$; product: $3x^3 - 2x^2 + 21x - 14$, $x \in (-\infty, \infty)$; quotient: $\frac{x^2 + 7}{3x - 2}$, $x \in \left(-\infty, \frac{2}{3}\right) \cup \left(\frac{2}{3}, \infty\right)$ **39.** sum: $x^2 + 3x - 4$, $x \in (-\infty, \infty)$; difference: $x^2 + x - 2$, $x \in (-\infty, \infty)$; product: $x^3 + x^2 - 5x + 3$, $x \in (-\infty, \infty)$; quotient: $x + 3$, $x \in (-\infty, 1) \cup (1, \infty)$ **41.** sum: $3x + 1 + \sqrt{x - 3}$, $x \in [3, \infty)$; difference: $3x + 1 - \sqrt{x - 3}$, $x \in [3, \infty)$; product: $(3x + 1)\sqrt{x - 3}$, $x \in [3, \infty)$; quotient: $\frac{3x + 1}{\sqrt{x - 3}}$, $x \in (3, \infty)$ **43.** sum: $2x^2 + \sqrt{x + 1}$, $x \in [-1, \infty)$; difference: $2x^2 - \sqrt{x + 1}$, $x \in [-1, \infty)$; product: $2x^2\sqrt{x + 1}$, $x \in [-1, \infty)$; quotient: $\frac{2x^2}{\sqrt{x + 1}}$, $x \in (-1, \infty)$ **45.** sum: $\frac{7x - 11}{(x - 3)(x + 2)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; difference: $\frac{-3x + 19}{(x - 3)(x + 2)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; product: $\frac{10}{(x^2 - x - 6)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$; quotient: $\frac{2x + 4}{(5x - 15)}$, $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$

47. 0; 0; $4a^2 - 10a - 14$ $a^2 - 9a$ **49. a.** $h(x) = \sqrt{2x - 2}$ **b.** $H(x) = 2\sqrt{x + 3} - 5$ **c.** D of $h(x)$: $x \in [1, \infty)$; D of $H(x)$: $x \in [-3, \infty)$ **51. a.** $h(x) = \sqrt{3x + 1}$ **b.** $H(x) = 3\sqrt{x - 3} + 4$ **c.** D of $h(x)$: $x \in [-\frac{1}{3}, \infty)$ D of $H(x)$: $x \in [3, \infty)$

53. a. $h(x) = x^2 + x - 2$ **b.** $H(x) = x^2 - 3x + 2$ **c.** D of $h(x)$: $x \in (-\infty, \infty)$ D of $H(x)$: $x \in (-\infty, \infty)$ **55. a.** $h(x) = x^2 + 7x + 8$ **b.** $H(x) = x^2 + x - 1$ **c.** D of $h(x)$: $x \in (-\infty, \infty)$ D of $H(x)$: $x \in (-\infty, \infty)$ **57. a.** $h(x) = |-3x + 1| - 5$ **b.** $H(x) = -3|x| + 16$ **c.** D of $h(x)$: $x \in (-\infty, \infty)$ D of $H(x)$: $x \in (-\infty, \infty)$

59. a. $(f \circ g)(x)$: For $g(x)$ to be defined, $x \neq 0$.

For $f[g(x)] = \dfrac{2g(x)}{g(x) + 3}$, $g(x) \neq -3$ so $x \neq -\dfrac{5}{3}$.

domain: $\left\{x \mid x \neq 0, x \neq -\dfrac{5}{3}\right\}$

b. $(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq -3$.

For $g[f(x)] = \dfrac{5}{f(x)}$, $f(x) \neq 0$ so $x \neq 0$.

domain: $\{x \mid x \neq 0, x \neq -3\}$

c. $(f \circ g)(x) = \dfrac{10}{5 + 3x}$; $(g \circ f)(x) = \dfrac{5x + 15}{2x}$;

the domain of a composition cannot always be determined from the composed form

61. a. $(f \circ g)(x)$: For $g(x)$ to be defined, $x \neq 5$.

For $f[g(x)] = \dfrac{4}{g(x)}$, $g(x) \neq 0$ and $g(x)$ is never zero

domain: $\{x \mid x \neq 5\}$

b. $(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq 0$.

For $g[f(x)] = \dfrac{1}{f(x) - 5}$, $f(x) \neq 5$ so $x \neq \dfrac{4}{5}$.

domain: $\left\{x \mid x \neq 0, x \neq \dfrac{4}{5}\right\}$

c. $(f \circ g)(x) = 4x - 20$; $(g \circ f)(x) = \dfrac{x}{4 - 5x}$; the domain of a composition cannot always be determined from the composed form

63. a. 41 **b.** 41 **65.** $g(x) = \sqrt{x - 2} + 1, f(x) = x^3 - 5$ **67.** $p(x) = 2(x + 4)^2 - 3, q(x) = (2x + 7)^2 - 1$ **69. a.** 6000 **b.** 3000 **c.** 8000 **d.** $C(9) - T(9)$; 4000 **71. a.** \$1 billion **b.** \$5 billion **c.** 2003, 2007, 2010 **d.** $t \in (2000, 2003) \cup (2007, 2010)$ **e.** $t \in [2003, 2007]$ **f.** $R(5) - C(5)$; \$4 billion **73. a.** 4 **b.** 0 **c.** 2 **d.** 3 **e.** $-\dfrac{1}{3}$ **f.** 6 **g.** -3 **h.** 1 **i.** 1 **j.** undefined **k.** 0.5 **l.** 2

75. $h(x) = -\dfrac{2}{3}x + 4$ **77.** $h(x) = 4x - x^2$

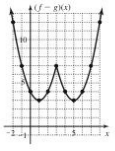
79. $A = 2\pi r(20 + r)$; $f(r) = 2\pi r$, $g(r) = 20 + r$; $A(5) = 250\pi$ units^2

81. a. $P(x) = 12{,}000x - 108{,}000$; **b.** nine boats must be sold

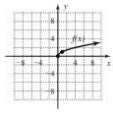
83. a. $p(n) = 11.45n - 0.1n^2$ **b.** \$123 **c.** \$327 **d.** $C(115) > R(115)$ **85.** $h(x) = x - 2.5$; 10.5 **87. a.** 4160 **b.** 45,344 **c.** $M(x) = 453.44x$; yes **89. a.** 6 ft **b.** 36π ft^2 **c.** $A(t) = 9\pi t^2$; yes **91. a.** 1995 to 1996; 1999 to 2004 **b.** 30; 1995 **c.** 20 seats; 1997 **d.** The total number in the senate (50); the number of additional seats held by the majority **93.** Answers will vary.

95. no, yes

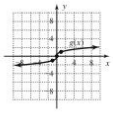
x	$f(x)$	$g(x)$	$(f - g)(x)$
-2	27	15	12
-1	18	11	7
0	11	7	4
1	6	3	3
2	3	-1	4
3	2	-5	7
4	3	-1	4
5	6	3	3
6	11	7	4
7	18	11	7
8	27	15	12



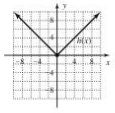
97. a.



b.



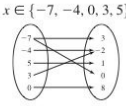
c.



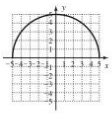
99. $y = -\dfrac{3}{2}x$

Summary and Concept Review, pp. 270–277

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

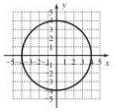


2. $x \in [-5, 5]$ $y \in [0, 5]$

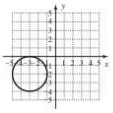


x	y
-5	0
-4	3
-2	$\sqrt{21} \approx 4.58$
0	5
2	$\sqrt{21} \approx 4.58$
4	3
5	0

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

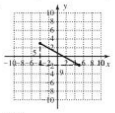


6.

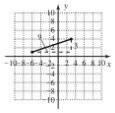


7. $(x + 1.5)^2 + (y - 2)^2 = 6.25$

8. a.



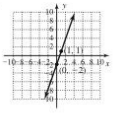
b.



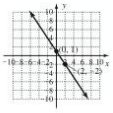
$\dfrac{-5}{9}$, $(14, -7)$ $\frac{1}{3}$, $(0, 3)$

9. a. parallel **b.** perpendicular

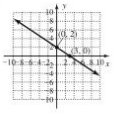
10. a.



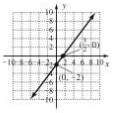
b.



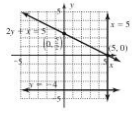
11. a.

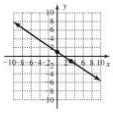
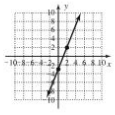
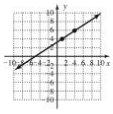
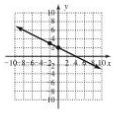
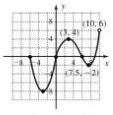
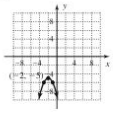
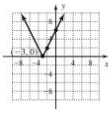


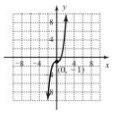
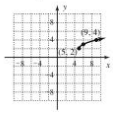
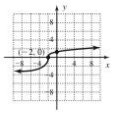
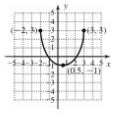
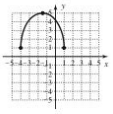
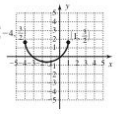
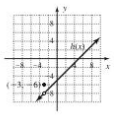
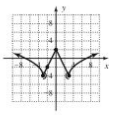
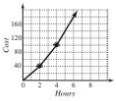
b.



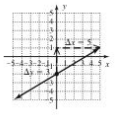
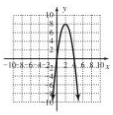
12. a. vertical
b. horizontal
c. neither



13. yes **14.** $m = \frac{2}{3}$, y-intercept (0, 2) when the rodent population increases by 3000, the hawk population increases by 200.
15. a. $y = \frac{-4}{3}x + 4$, $m = \frac{-4}{3}$, y-intercept (0, 4) **b.** $y = \frac{5}{3}x - 5$, $m = \frac{5}{3}$, y-intercept (0, −5)
16. a.  **b.** 
17. a.  **b.** 
18. $y = 5$, $x = -2$; $y = 5$ **19.** $y = \frac{-3}{4}x + \frac{11}{4}$ **20.** $f(x) = \frac{4}{3}x$
21. $m = \frac{2}{5}$, y-intercept (0, 2), $y = \frac{2}{5}x + 2$. When the rabbit population increases by 500, the wolf population increases by 200.
22. a. $y - 90 = \frac{-15}{2}(x - 2)$ **b.** (14, 0), (0, 105) **c.** $f(x) = \frac{-15}{2}x + 105$
d. $f(20) = -45$, $x = 12$ **23. a.** $x \in [-\frac{5}{4}, \infty)$
b. $x \in (-\infty, -2) \cup (-2, 3) \cup (3, \infty)$ **24.** 14; $\frac{26}{9}$; $18a^2 - 9a$ **25.** It is a function. **26. I. a.** $D = \{-1, 0, 1, 2, 3, 4, 5\}$, $R = \{-2, 1, 0, 1, 2, 3, 4\}$ **b.** 1 **c.** 2 **II. a.** $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$ **b.** −1 **c.** 3 **III. a.** $x \in [-3, \infty)$, $y \in [-4, \infty)$ **b.** −1 **c.** −3 or 3 **27.** D: $x \in (-\infty, \infty)$, R: $y \in [-5, \infty)$, $f(x)\uparrow$: $x \in (2, \infty)$, $f(x)\downarrow$: $x \in (-\infty, 2)$, $f(x) > 0$: $x \in (-\infty, -1) \cup (5, \infty)$, $f(x) < 0$: $x \in (-1, 5)$ **28.** D: $x \in [-3, \infty)$, R: $y \in (-\infty, 0)$, $f(x)\uparrow$: none, $f(x)\downarrow$: $x \in (-3, \infty)$, $f(x) > 0$: none, $f(x) < 0$: $x \in (-3, \infty)$
29. D: $x \in (-\infty, \infty)$, R: $y \in (-\infty, \infty)$, $f(x)\uparrow$: $x \in (-\infty, -3) \cup (1, \infty)$, $f(x)\downarrow$: $x \in (-3, 1)$, $f(x) > 0$: $x \in (-5, -1) \cup (4, \infty)$, $f(x) < 0$: $x \in (-\infty, -5) \cup (-1, 4)$
30. a. odd **b.** even **c.** neither **d.** odd **31. a.** $\frac{1}{4}$; the graph is rising to the right. **b.** $2x - 1 + h$; 3.01
32.  zeroes: −6, 0), (0, 0), (6, 0) (9, 0) min: (−3, −8), (7.5 −2) max: (−6, 0), (3, 4)
33. squaring function **a.** up on left/up on the right; **b.** x-intercepts: (−4, 0), (0, 0); y-intercept: (0, 0) **c.** vertex (−2, −4) **d.** $x \in (-\infty, \infty)$, $y \in [-4, \infty)$ **34.** square root function **a.** down on the right; **b.** x-intercept: (0,0); y-intercept: (0, 0) **c.** initial point (−1, 2); **d.** $x \in [-1, \infty)$, $y \in (-\infty, 2]$ **35.** cubing function **a.** down on left/up on the right **b.** x-intercepts: (−2, 0), (1, 0), (4, 0); y-intercept: (0, 2) **c.** inflection point: (1, 0) **d.** $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$
36. absolute value function **a.** down on left/down on the right **b.** x-intercepts: (−1, 0), (3, 0); y-intercept: (0, 1) **c.** vertex: (1, 2); **d.** $x \in [-\infty, \infty)$, $y \in (-\infty, 2]$ **37.** cube root **a.** up on left, down on right **b.** x-intercept: (1, 0); y-intercept: (0, 1) **c.** inflection point: (1,0) **d.** $x \in (-\infty, \infty)$, $y \in (-\infty, \infty)$
38. quadratic  **39.** absolute value 

40. cubic  **41.** square root  **42.** cube root 
43. a.  **b.**  **c.** 
44. a. $f(x) = \begin{cases} 5 & x \le -3 \\ -x + 1 & -3 < x \le 3 \\ 3\sqrt{x - 3} - 1 & x > 3 \end{cases}$ **b.** R: $y \in [-2, \infty)$
45.  D: $x \in (-\infty, \infty)$, R: $y \in (-\infty, -8) \cup (-8, \infty)$, discontinuity at $x = -3$; define $h(x) = -8$ at $x = -3$
46. −4, −4, −4.5, −4.99, $3\sqrt{3} - 9$, $3\sqrt{3.5} - 9$
47. D: $x \in (-\infty, \infty)$ R: $y \in [-4, \infty)$ 
48. $\begin{cases} 20x & x \le 2 \\ 30x - 20 & 2 < x \le 4 \\ 40x - 60 & x > 4 \end{cases}$ For 5 hrs the total cost is $140. 
49. $a^2 + 7a - 2$ **50.** 147 **51.** $x \in (-\infty, \frac{2}{3}) \cup (\frac{3}{2}, \infty)$
52. $4x^2 + 8x - 3$ **53.** 99 **54.** x; x
55. $f(x) = \sqrt{x} + 1$; $g(x) = 3x - 2$
56. $f(x) = x^2 - 3x - 10$; $g(x) = x^{\frac{1}{2}}$ **57.** $A(t) = \pi(2t + 3)^2$ **58. a.** 4 **b.** 7 **c.** 6 **d.** $\frac{-1}{5}$ **e.** 14

Mixed Review, pp. 277–278

1. $y = -\frac{4}{3}x + 4$ **3. a.** $(-\infty, 1) \cup (1, 4) \cup (4, \infty)$ **b.** $\left(\frac{3}{2}, \infty\right)$
5. $y = -\frac{3}{2}x - 2$ **7.** (2, 2); $(x - 2)^2 + (y - 2)^2 = 50$
9. 
11. a.  rate of change is positive in $[-2, -1]$ since p is increasing in $(-\infty, 2)$; less; $\frac{\Delta y}{\Delta x} = \frac{14}{1}$ in $[-2, -1]$; $\frac{\Delta y}{\Delta x} = \frac{2}{1}$ in [1, 2]

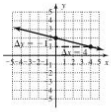
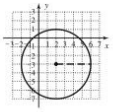
b. In the interval [15, 15.01], $\frac{\Delta A}{\Delta t} \approx 200.1$

13. $\frac{1}{3x^2 - 4x + 1}$; $\left(-\infty, \frac{1}{3}\right) \cup \left(\frac{1}{3}, 1\right) \cup (1, \infty)$

15. $\frac{\Delta f}{\Delta x} = 2x + h$, $\frac{\Delta g}{\Delta x} = 3$; For small h, $2x + h = 3$ when $x \approx \frac{3}{2}$.

17. D: $x \in (-\infty, 6]$; R: $y \in (-\infty, 3]$ $g(x)\uparrow$: $x \in (-\infty, -6) \cup (3, 6)$ $g(x)\downarrow$: $x \in (-3, 3)$ $g(x)$ constant: $x \in (-6, -3)$ $g(x) > 0$: $x \in (-7, -1)$ $g(x) < 0$: $x \in (-\infty, -7) \cup (-1, 6)$ max: $y = 3$ for $x \in (-6, -3)$; $y = 0$ at $(6, 0)$ min: $y = -3$ at $(3, -3)$ **19.** $f(x) = -2x^2 + x + 3$

Practice Test, pp. 279–280

1. a. a and c are nonfunctions, they do not pass the vertical line test
2. neither **3.**  **4.** $(2, -3)$; $r = 4$ 

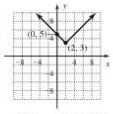
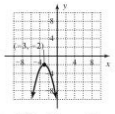
5. $y = -\frac{6}{5}x + \frac{2}{5}$ **6. a.** (7.5, 1.5), **b.** ≈61.27 mi

7. L_1: $x = -3$ L_2: $y = 4$ **8. a.** $x \in \{-4, -2, 0, 2, 4, 6\}$ $y \in \{-2, -1, 0, 1, 2, 3\}$ **b.** $x \in [-2, 6]$ $y \in [1, 4]$ **9. a.** 300 **b.** 30 **c.** $W(h) = \frac{25}{2}h$ **d.** Wages are $12.50 per hr. **e.** $h \in [0, 40]$; $w \in [0, 500]$ **10. I. a.** square root **b.** $x \in [-4, \infty)$, $y \in [-3, \infty)$ **c.** $(-2, 0)$, $(0, 1)$ **d.** up on right **e.** $x \in (-2, \infty)$ **f.** $x \in [-4, -2)$ **II. a.** cubic **b.** $x \in (-\infty, \infty)$ $y \in (-\infty, \infty)$ **c.** $(2, 0)$, $(0, -1)$ **d.** down on left, up on right **e.** $x \in (2, \infty)$ **f.** $x \in (-\infty, 2)$ **III. a.** absolute value **b.** $x \in (-\infty, \infty)$ $y \in (-\infty, 4]$ **c.** $(-1, 0)$, $(3, 0)$, $(0, 2)$ **d.** down/down **e.** $x \in (-1, 3)$ **f.** $x \in (-\infty, -1) \cup (3, \infty)$ **IV. a.** quadratic **b.** $x \in (-\infty, \infty)$; $y \in [-5.5, \infty)$ **c.** $(0, 0)$, $(5, 0)$, $(0, 0)$ **d.** up/up **e.** $x \in (-\infty, 0) \cup (5, \infty)$ **f.** $x \in (0, 5)$

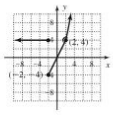
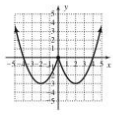
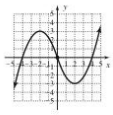
11. a. $\frac{7}{2}$ **b.** $\frac{-a^2 - 6a - 7}{a^2 + 6a + 9}$ **c.** $-\frac{31}{25} - \frac{8}{25}i$

12. $3x + 1$; $x \in [\frac{1}{3}, \infty)$ **13. a.** No, new company and sales should be growing **b.** 19 for [5, 6]; 23 for [6, 7]

c. $\frac{\Delta s}{\Delta t} = 4t - 3 + 2h$. For small h, sales volume is approximately $\frac{37{,}000 \text{ units}}{1 \text{ mo}}$ in month 10, $\frac{69{,}000 \text{ units}}{1 \text{ mo}}$ in month 18, and $\frac{93{,}000 \text{ units}}{1 \text{ mo}}$ in month 24

14.  **15.** 

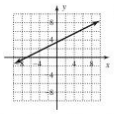
16. a. $V(t) = \frac{4}{4}\pi(\sqrt{t})^3$ **b.** 36π in^3 **17. a.** D: $x \in [-4, \infty)$; R: $y \in (-3, \infty)$ **b.** $f(-1) \approx 2.2$ **c.** $f(x) < 0$: $x \in (-4, -3)$ $f(x) > 0$: $x \in (-3, \infty)$ **d.** $f(x)\uparrow$: $x \in (-4, \infty)$ $f(x)\downarrow$: none **e.** $f(x) = 3\sqrt{x + 4} - 3$ **18. a.** 4, −4, 6.25

b.  **19.**  **20.** 

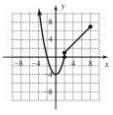
Strengthening Core Skills, p. 281

Exercise 1: $h(x) = x^2 - 28$; $x = 4 \pm 2\sqrt{7}$
Exercise 2: $h(x) = x^2 + 1$; $x = -2 \pm i$
Exercise 3: $h(x) = 2x^2 - \frac{3}{2}$; $x = \frac{5}{2} \pm \frac{\sqrt{3}}{2}$

Cumulative Review, p. 282

1. $x^2 + 2$ **3.** 29.45 cm **5.** $x = 1$ **7. a.** $\frac{-1}{3}$ **b.** $\frac{3}{5}$
9.  $y = \frac{1}{2}x + \frac{7}{2}$ **11.** $(f \cdot g)(x) = 3x^3 - 12x^2 + 12x$; $\left(\frac{f}{g}\right)(x) = 3x$, $x \neq 2$; $(g \circ f) = 22$

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



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

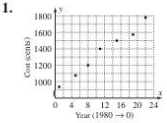
17. a. False; $\mathbb{Z} \not\subset \mathbb{W}$ **b.** False; $\mathbb{W} \not\subset \mathbb{N}$ **c.** True **d.** False; $\mathbb{R} \not\subset \mathbb{Z}$

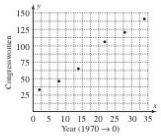
19. $x = -5 \pm \frac{\sqrt{2}}{2}$, $x \approx -5.707$; $x \approx -4.293$

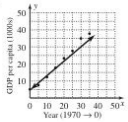
21. $W = 31$ cm, $L = 47$ cm **23. a.** $x = \frac{-4}{3}, \frac{5}{2}$ **b.** $x = -5, -\sqrt{3}, \sqrt{3}$
25. $p = 15 + \sqrt{97}$ units ≈ 24.8 units. No, it is not a right triangle. $5^2 + (\sqrt{97})^2 \neq 10^2$

MODELING WITH TECHNOLOGY I

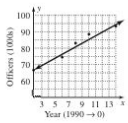
Exercises, pp. 288–292

1.  positive

3.  **a.** linear **b.** positive

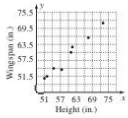
5. a.  **b.** positive **c.** $m \approx 1$

7. a.



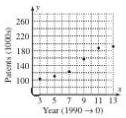
b. positive **c.** $y = 2.4x + 69.4$, 74,200, 112,600

9. a.



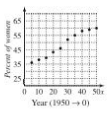
b. linear **c.** positive
d. $y = 0.96x + 1.55$, 63.95 in.

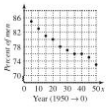
11. a.



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

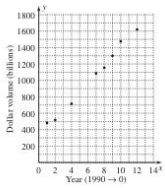
13. a.





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

15.



a. linear **b.** $y = 108.2x + 330.2$
c. $1736.8 billion; about $2602.4 billion

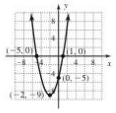
17. a. $h(t) = -14.5t^2 + 90t$ **b.** $v = 90$ ft/sec **c.** Venus

CHAPTER 3

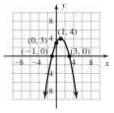
Exercises 3.1, pp. 300–304

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

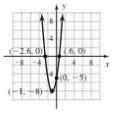
7. left 2, down 9



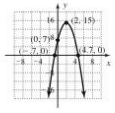
9. right 1, reflected across x-axis, up 4



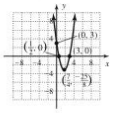
11. left 1, stretched vertically, down 8



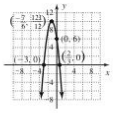
13. right 2, stretched vertically, reflected across x-axis, up 15



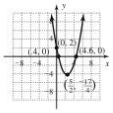
15. right $\frac{7}{4}$, stretched vertically, down $\frac{25}{8}$



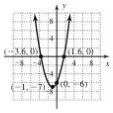
17. left $\frac{7}{6}$, stretched vertically, reflected across x-axis, up $\frac{121}{12}$



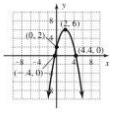
19. right $\frac{5}{2}$, down $\frac{17}{4}$



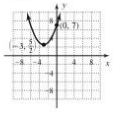
21. left 1, down 7



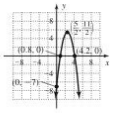
23. right 2, reflected across x-axis, up 6



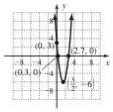
25. left 3, compressed vertically, up $\frac{5}{2}$



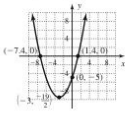
27. right $\frac{5}{2}$, reflected across x-axis, stretched vertically, up $\frac{11}{2}$



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



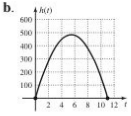
31. left 3, compressed vertically, down $\frac{19}{2}$



33. $y = 1(x - 2)^2 - 1$ **35.** $y = -1(x + 2)^2 + 4$

37. $y = -\frac{3}{2}(x + 2)^2 + 3$ **39. i.** $x = -3 \pm \sqrt{5}$ **ii.** $x = 4 \pm \sqrt{3}$ **iii.** $x = -4 \pm \frac{\sqrt{14}}{2}$ **iv.** $x = 2 \pm \sqrt{2}$ **v.** $t = -2.7, t = 1.3$ **vi.** $t = -1.4, t = 2.6$ **41. a.** $(0, -66{,}000)$; when no cars are produced, there is a loss of \$66,000. **b.** (20, 0), (330, 0); no profit will be made if less than 20 or more than 330 cars are produced. **c.** 175 **d.** \$240,250 **43. a.** 6 mi **b.** 3600 ft **c.** 3200 ft **d.** 12 mi **45. a.** $(0, -3300)$; if no appliances are sold, the loss will be \$3300. **b.** (20, 0), (330, 0); if less than 20 or more than 330 appliances are made and sold, there will be no profit. **c.** $0 \le x \le 200$; maximum capacity is 200 **d.** 175, \$12,012.50

47. a. 288 ft **b.**



c. 484 ft; 5.5 sec **d.** 11 sec

49. a. $h(t) = -16t^2 + 32t + 5$ **b.** (i) 17 ft (ii) 17 ft **c.** it must occur between $t = 0.5$ and $t = 1.5$ **d.** $t = 1$ sec **e.** $h(1) = 21$ ft **f.** 2 sec **51.** 155,000; \$16,625 **53. a.** 96 ft × 48 ft **b.** 32 ft × 48 ft **55.** $f(x) = x^2 - 4x + 13$

57. **a.** radicand will be negative—two complex zeroes. **b.** radicand will be positive—two real zeroes. **c.** radicand is zero—one real zero. **d.** two real, rational zeroes. **e.** two real, irrational zeroes. **59.** $\frac{x-2}{x-5}$ **61.** $x \in [-3, \frac{2}{3}]$

Exercises 3.2, pp. 312–315

1. synthetic; zero **3.** $P(c)$; remainder **5.** Answers will vary.
7. $x^3 - 5x^2 - 4x + 21 = (x-2)(x^2 - 3x - 10) + 3$
9. $2x^3 + 5x^2 + 4x + 17 = (x+3)(2x^2 - x + 7) - 4$
11. $x^3 - 8x^2 + 11x + 20 = (x-5)(x^2 - 3x - 4) + 0$
13. **a.** $\frac{2x^2 - 5x - 3}{x-3} = (2x+1) + \frac{0}{x-3}$
b. $2x^2 - 5x - 3 = (x-3)(2x+1) + 0$
15. **a.** $\frac{x^3 - 3x^2 - 14x - 8}{x-2} = (x^2 - 5x - 4) + \frac{0}{x+2}$
b. $x^3 - 3x^2 - 14x - 8 = (x+2)(x^2 - 5x - 4) + 0$
17. **a.** $\frac{x^3 - 5x^2 - 4x + 23}{x-2} = (x^2 - 3x - 10) + \frac{3}{x-2}$
b. $x^3 - 5x^2 - 4x + 23 = (x-2)(x^2 - 3x - 10) + 3$
19. **a.** $\frac{2x^3 - 5x^2 - 11x - 17}{x-4} = (2x^2 + 3x + 1) + \frac{-13}{x-4}$
b. $2x^3 - 5x^2 - 11x - 17 = (x-4)(2x^2 + 3x + 1) - 13$
21. $x^3 + 5x^2 + 7 = (x+1)(x^2 + 4x - 4) + 11$
23. $x^3 - 13x - 12 = (x-4)(x^2 + 4x + 3) + 0$
25. $3x^3 - 8x + 12 = (x-1)(3x^2 + 3x - 5) + 7$
27. $n^3 + 27 = (n+3)(n^2 - 3n + 9) + 0$
29. $x^4 + 3x^3 - 16x - 8 = (x-2)(x^3 + 5x^2 + 10x + 4) + 0$
31. $(2x+7) + \frac{-7x+5}{x^2+3}$ **33.** $-(x^2 - 4) + \frac{-4x+3}{x^2-1}$
35. **a.** -30 **b.** 12 **37.** **a.** -2 **b.** -22 **39.** **a.** -1 **b.** 3
41. **a.** 31 **b.** 0 **43.** **a.** -10 **b.** 0 **45.** **a.** yes **b.** yes **47.** **a.** no **b.** yes **49.** **a.** yes **b.** yes

51.
$$\begin{array}{r|cccc} -3 & 1 & 2 & -5 & -6 \\ & & -3 & 3 & 6 \\ \hline & 1 & -1 & -2 & 0 \end{array}$$

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

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

57. $P(x) = (x+2)(x-3)(x+5)$, $P(x) = x^3 + 4x^2 - 11x - 30$
59. $P(x) = (x+2)(x-\sqrt{3})(x+\sqrt{3})$, $P(x) = x^3 + 2x^2 - 3x - 6$
61. $P(x) = (x+5)(x-2\sqrt{3})(x+2\sqrt{3})$, $P(x) = x^3 + 5x^2 - 12x - 60$
63. $P(x) = (x-1)(x+2)(x-\sqrt{10})(x+\sqrt{10})$,
$P(x) = x^4 + x^3 - 12x^2 - 10x + 20$ **65.** $P(x) = (x+2)(x-3)(x-4)$
67. $p(x) = (x+3)^2(x-3)(x-1)$ **69.** $f(x) = 2(x - \frac{3}{2})(x+2)(x+5)$
71. $p(x) = (x+3)(x-3)^2$ **73.** $p(x) = (x-2)^3$
75. $p(x) = (x+3)(x-3)^3$ **77.** $p(x) = (x+3)(x-3)^2(x+4)^2$
79. 4-in. squares; 16 in. $\times$ 10 in. $\times$ 4 in. **81.** **a.** week 10, 22.5 thousand **b.** one week before closing, 36 thousand **c.** week 9
83. **a.** 198 ft^3 **b.** 2 ft **c.** about 7 ft **85.** $k = 10$ **87.** $k = -3$
89. The theorems also apply to complex zeroes of polynomials.
91. $S_3 = 36$; $S_5 = 225$ **93.** yes, John wins.
95. $G(t) = 1400t + 5000$

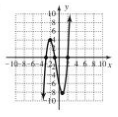
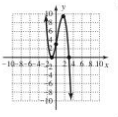
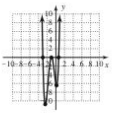
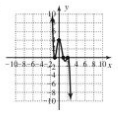
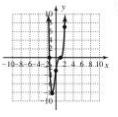
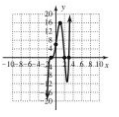
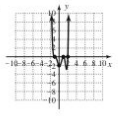
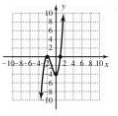
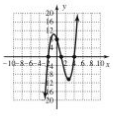
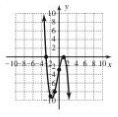
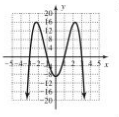
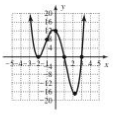
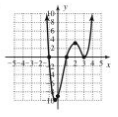
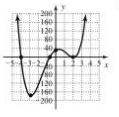
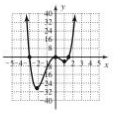
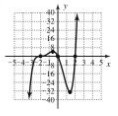
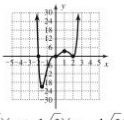
Exercises 3.3, pp. 325–330

1. coefficients **3.** $a - bi$ **5.** b; 4 is not a factor of 6
7. $P(x) = (x+2)(x-2)(x+3i)(x-3i)$
$x = -2, x = 2, x = 3i, x = -3i$
9. $Q(x) = (x+2)(x-2)(x+2i)(x-2i)$
$x = -2, x = 2, x = 2i, x = -2i$ **11.** $P(x) = (x+1)(x+1)(x-1)$
$x = -1, x = -1, x = 1$ **13.** $P(x) = (x-5)(x+5)(x-5)$
$x = 5, x = -5, x = 5$
15. $(x-5)^3(x+9)^2$; $x = 5$, multiplicity 3; $x = -9$, multiplicity 2
17. $(x-7)^2(x+2)^2(x+7)$; $x = 7$, multiplicity 2; $x = -2$, multiplicity 2; $x = -7$, multiplicity 1
19. $P(x) = x^3 - 3x^2 + 4x - 12$ **21.** $P(x) = x^4 - x^3 - x^2 - x - 2$
23. $P(x) = x^4 - 6x^3 + 13x^2 - 24x + 36$
25. $P(x) = x^4 + 2x^2 + 8x + 5$ **27.** $P(x) = x^4 + 4x^3 + 27$
29. **a.** yes **b.** yes **31.** **a.** yes **b.** yes
33. $\{\pm 1, \pm 15, \pm 3, \pm 5, \pm \frac{1}{4}, \pm \frac{15}{4}, \pm \frac{3}{4}, \pm \frac{5}{4}, \pm \frac{1}{2}, \pm \frac{15}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}\}$
35. $\{\pm 1, \pm 15, \pm 3, \pm 5, \pm \frac{1}{2}, \pm \frac{15}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}\}$
37. $\{\pm 1, \pm 28, \pm 2, \pm 14, \pm 4, \pm 7, \pm \frac{1}{6}, \pm \frac{14}{3}, \pm \frac{1}{3}, \pm \frac{7}{3}, \pm \frac{2}{3}, \pm \frac{7}{6}, \pm \frac{1}{2}, \pm \frac{7}{2}, \pm \frac{28}{3}, \pm \frac{4}{3}\}$
39. $\{\pm 1, \pm 3, \pm \frac{1}{32}, \pm \frac{1}{2}, \pm \frac{1}{16}, \pm \frac{1}{4}, \pm \frac{1}{8}, \pm \frac{3}{32}, \pm \frac{3}{2}, \pm \frac{3}{16}, \pm \frac{3}{4}, \pm \frac{3}{8}\}$
41. $(x+4)(x-1)(x-3)$, $x = -4, 1, 3$
43. $(x+3)(x+2)(x-5)$, $x = -3, -2, 5$
45. $(x+3)(x-1)(x-4)$, $x = -3, 1, 4$
47. $(x+2)(x-3)(x-5)$, $x = -2, 3, 5$
49. $(x+4)(x+1)(x-2)(x-3)$, $x = -4, -1, 2, 3$
51. $(x+7)(x+2)(x+1)(x-3)$, $x = -7, -2, -1, 3$
53. $(2x+3)(2x-1)(x-1)$; $x = -\frac{3}{2}, \frac{1}{2}, 1$
55. $(2x+3)^2(x-1)$; $x = -\frac{3}{2}, 1$
57. $(x+2)(x-1)(2x-5)$; $x = -2, 1, \frac{5}{2}$
59. $(x+1)(2x+1)(x-\sqrt{5})(x+\sqrt{5})$; $x = -1, -\frac{1}{2}, \sqrt{5}, -\sqrt{5}$
61. $(x-1)(3x-2)(x-2i)(x+2i)$; $x = 1, \frac{2}{3}, 2i, -2i$
63. $x = 1, 2, 3, \frac{-3}{2}$ **65.** $x = -2, 1, \frac{-2}{3}$ **67.** $x = -2, -\frac{3}{2}, 4$
69. $x = 3, -1, \frac{5}{3}$ **71.** $x = 1, 2, -3, \pm\sqrt{7}\,i$ **73.** $x = -2, \frac{2}{3}, 1, \pm\sqrt{3}\,i$
75. $x = 1, 2, 4, -2$ **77.** $x = -3, 1, \pm\sqrt{2}$ **79.** $x = -1, \frac{3}{2}, \pm\sqrt{3}\,i$
81. $x = \frac{1}{2}, 1, 2, \pm\sqrt{3}\,i$ **83.** **a.** possible roots: $\{\pm 1, \pm 8, \pm 2, \pm 4\}$; **b.** neither -1 nor 1 is a root; **c.** 3 or 1 positive roots, 1 negative root; **d.** roots must lie between -2 and 2 **85.** **a.** possible roots: $\{\pm 1, \pm 2\}$; **b.** -1 is a root; **c.** 2 or 0 positive roots, 3 or 1 negative roots; **d.** roots must lie between -3 and 2 **87.** **a.** possible roots: $\{\pm 1, \pm 12, \pm 2, \pm 6, \pm 3, \pm 4\}$; **b.** $x = 1$ and $x = -1$ are roots; **c.** 4, 2, or 0 positive roots, 1 negative root; **d.** roots must lie between -1 and 4 **89.** **a.** possible roots: $\pm 1, \pm 20, \pm 2, \pm 10, \pm 4, \pm 5, \pm \frac{1}{2}, \pm \frac{5}{2}$; **b.** $x = 1$ is a root; **c.** 1 positive root, 1 negative root; **d.** roots must lie between -2 and 1
91. $(x-4)(2x-3)(2x+3)$; $x = 4, \frac{3}{2}, -\frac{3}{2}$
93. $(2x+1)(3x-2)(x-12)$; $x = -\frac{1}{2}, \frac{2}{3}, 12$
95. $(x-2)(2x-1)(2x+1)(x+12)$; $x = 2, \frac{1}{2}, -\frac{1}{2}, -12$
97. **a.** 5 **b.** 13 **c.** 2 **99.** yes **101.** yes
103. **a.** 4 cm $\times$ 4 cm $\times$ 4 cm **b.** 5 cm $\times$ 5 cm $\times$ 5 cm
105. length 10 in., width 5 in., height 3 in.
107. 1994, 1998, 2002, about 5 yr **109.** **a.** 8.97 m, 11.29 m, 12.05 m, 12.94 m; **b.** 9.7 m, +3.7 **111.** **a.** yes, **b.** no, **c.** about 14.88
113A. **a.** $(x+5i)(x-5i)$ **b.** $(x+3i)(x-3i)$
c. $(x+i\sqrt{7})(x-i\sqrt{7})$ **113B.** **a.** $x = -\sqrt{7}, \sqrt{7}$
b. $x = -2\sqrt{3}, 2\sqrt{3}$ **c.** $x = -3\sqrt{2}, 3\sqrt{2}$
115. **a.** $C(z) = (z-4i)(z+3)(z-2)$
b. $C(z) = (z-9i)(z+4)(z+1)$
c. $C(z) = (z-3i)(z-1-2i)(z-1+2i)$
d. $C(z) = (z-i)(z-2-5i)(z-2+5i)$
e. $C(z) = (z-6i)(z-1-\sqrt{3}\,i)(z-1+\sqrt{3}\,i)$
f. $C(z) = (z+4i)(z-3-\sqrt{2}\,i)(z-3+\sqrt{2}\,i)$
g. $C(z) = (z-2+i)(z-3i)(z+i)$
h. $C(z) = (z-2+3i)(z-5i)(z+2i)$ **117.** **a.** $w = 150$ ft, $l = 300$; **b.** $A = 15{,}000$ ft^2 **119.** $r(x) = 2\sqrt{x+4} - 2$

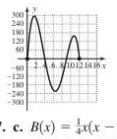
Exercises 3.4, pp. 340–343

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

d. $x \in \mathbb{R}, y \in (-\infty, 25]$ **27. a.** odd **b.** -1 even, 3 odd
c. $f(x) = -(x+1)^2(x-3)$, deg 3 **d.** $x \in \mathbb{R}, y \in \mathbb{R}$
29. degree 6; up/up; $(0, -12)$ **31.** degree 5; up/down; $(0, -24)$
33. degree 6; up/up; $(0, -192)$ **35.** degree 5; up/down; $(0, 2)$
37. b **39.** e **41.** c

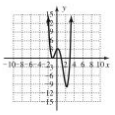
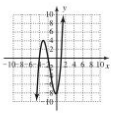
43. 
45. 
47. 
49. 
51. 
53. 
55. 
57. 
59. 
61. 
63. 
65. 
67. 
69. 
71. 
73. 
75. 

77. $h(x) = (x+4)(x-\sqrt{3})(x+\sqrt{3})(x-\sqrt{3}i)(x+\sqrt{3}i)$
79. $f(x) = 2(x+\frac{5}{2})(x-\sqrt{2})(x+\sqrt{2})(x-\sqrt{3})(x+\sqrt{3})$
81. $P(x) = \frac{1}{6}(x+4)(x-1)(x-3)$, $P(x) = \frac{1}{6}(x^3 - 13x + 12)$
83. $P(x) = x^4 - 2x^3 - 13x^2 + 14x + 24$
85. a. 280 vehicles above average, 216 vehicles below average, 154 vehicles below average **b.** 6:00 A.M. ($t = 0$), 10:00 A.M. ($T = 4$), 3:00 P.M. ($t = 9$), 6:00 P.M. ($t = 12$)
c. max: about 300 vehicles above average at 7:30 A.M.;
min: about 220 vehicles below average at 12 noon



87. c. $B(x) = \frac{1}{4}x(x-4)(x-9)$, $-\$80{,}000$
89. a. $f(x) \to \infty, f(x) \to -\infty$ **b.** $g(x) \to \infty, g(x) \to \infty$; $x^4 \geq 0$ for all x
91. verified **93.** $h(x) = \dfrac{1-2x}{x^2}$; $D: x \in \{x | x \neq 0\}$; $H(x) = \dfrac{1}{x^2 - 2x}$; $D: x \in \{x | x \neq 0, x \neq 2\}$ **95. a.** $x = 2$ **b.** $x = 8$ **c.** $x = 4, x = -6$

Mid Chapter, p. 344

1. a. $x^3 + 8x^2 + 7x - 14 = (x^2 + 6x - 5)(x+2) - 4$
b. $\dfrac{x^3 + 8x^2 + 7x - 14}{x+2} = x^2 + 6x - 5 - \dfrac{4}{x+2}$
2. $f(x) = (2x+3)(x+1)(x-1)(x-2)$ **3.** $f(-2) = 7$
4. $f(x) = x^3 - 2x + 4$ **5.** $g(2) = -8$ and $g(3) = 5$ have opposite signs
6. $f(x) = (x-2)(x+1)(x+2)(x+4)$
7. $x = -2, x = 1, x = -1 \pm 3i$
8. 
9. 

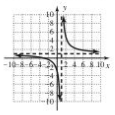
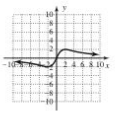
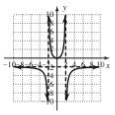
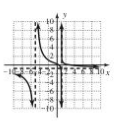
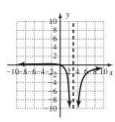
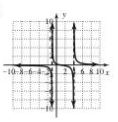
10. a. degree 4; three turning points **b.** 2 sec
c. $A(t) = (t-1)^2(t-3)(t-5)$ $A(t) = t^4 - 10t^3 + 32t^2 - 38t + 15$
$A(2) = 3$; altitude is 300 ft above hard-deck $A(4) = -9$; altitude is 900 ft below hard-deck

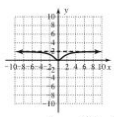
Reinforcing Basic Concepts, pp. 344–345

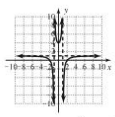
Exercise 1: 1.532
Exercise 2: -2.152, 1.765

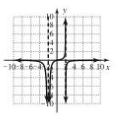
Exercises 3.5, pp. 356–362

1. as $x \to -\infty, y \to 2$ **3.** denominator; numerator **5.** about $x = 98$
7. a. as $x \to -\infty, y \to 2$
as $x \to \infty, y \to 2$
b. as $x \to 1^-, y \to -\infty$
as $x \to 1^+, y \to \infty$
9. a. as $x \to -\infty, y \to 1$
as $x \to \infty, y \to 1$
b. as $x \to -2^-, y \to \infty$
as $x \to -2^+, y \to \infty$
11. reciprocal quadratic, $S(x) = \dfrac{1}{(x+1)^2} - 2$
13. reciprocal function, $Q(x) = \dfrac{1}{x+1} - 2$
15. reciprocal quadratic, $v(x) = \dfrac{1}{(x+2)^2} - 5$
17. $\to -2$ **19.** $\to -\infty$ **21.** -1; $\pm\infty$
23. $x = 3, x \in (-\infty, 3) \cup (3, \infty)$
25. $x = 3, x = -3, x \in (-\infty, -3) \cup (-3, 3) \cup (3, \infty)$
27. $x = \frac{-5}{2}, x = 1, x \in (-\infty, -\frac{5}{2}) \cup (-\frac{5}{2}, 1) \cup (1, \infty)$
29. No V.A., $x \in (-\infty, \infty)$ **31.** $x = 3$, yes; $x = -2$, yes
33. $x = 3$, no **35.** $x = 2$, yes; $x = -2$, no **37.** $y = 0$, crosses at $(\frac{3}{2}, 0)$
39. $y = 4$, crosses at $(-\frac{21}{4}, 4)$ **41.** $y = 3$, does not cross
43. (0, 0) cross, (3, 0) cross **45.** $(-4, 0)$ cross, (0, 4)
47. (0, 0) cross, (3, 0) bounce

49. 
51. 
53. 
55. 
57. 
59. 

61. 

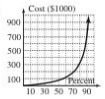
63. 

65. 

67. $f(x) = \dfrac{(x-4)(x+1)}{(x+2)(x-3)}$ **69.** $f(x) = \dfrac{x^2-4}{9-x^2}$

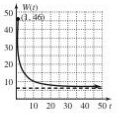
71. a. Population density approaches zero far from town. **c.** 4.5 mi, 704 people per square mi

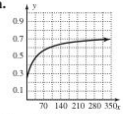
73. a. \$20,000, \$80,000, \$320,000; cost increases dramatically

b. 

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

75. a. 5 hr; about 0.28 **b.** $-0.019, -0.005$; As the number of hours increases, the rate of change decreases. **c.** $h \to \infty$, $C \to 0^+$; horizontal asymptote

77. 

79. a. 

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

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

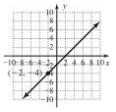
83. a. 5 **b.** 18 **c.** The horizontal asymptote at $y = 95$ means her average grade will approach 95 as the number of tests taken increases; no **d.** 6 **85. a.** 16.0 28.7 65.8 277.8 **b.** 12.7, 37.1, 212.0 **c. a.** 22.4, 40.2, 92.1, 388.9 **b.** 17.8, 51.9, 296.8; answers will vary.

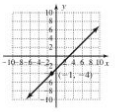
87. a. $q(x) = 3$, horizontal asymptote at $y = 3$; $r(x) = -7x + 10$, graph crosses HA at $x = \dfrac{10}{7}$ **b.** $q(x) = -2$, horizontal asymptote at $y = -2$; $r(x) = 7$, no zeroes—graph will not cross

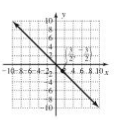
89. $y = \dfrac{-4}{3}x - \dfrac{1}{3}$ **91.** $39, \frac{3}{2}, 1$

Exercises 3.6, pp. 371–375

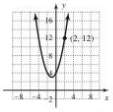
1. nonremovable **3.** two **5.** Answers will vary.

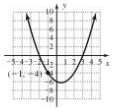
7. $F(x) = \begin{cases} \dfrac{x^2-4}{x+2} & x \neq -2 \\ -4 & x = -2 \end{cases}$ 

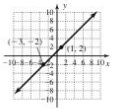
9. $G(x) = \begin{cases} \dfrac{x^2-2x-3}{x+1} & x \neq -1 \\ -4 & x = -1 \end{cases}$ 

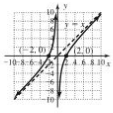
11. $H(x) = \begin{cases} \dfrac{3x-2x^2}{2x-3} & x \neq \dfrac{3}{2} \\ \dfrac{-3}{2} & x = \dfrac{3}{2} \end{cases}$ 

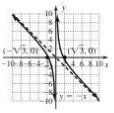
13. $P(x) = \begin{cases} \dfrac{x^3-8}{x-2} & x \neq 2 \\ 12 & x = 2 \end{cases}$ **15.** $q(x) = \begin{cases} \dfrac{x^3-7x-6}{x+1} & x \neq -1 \\ -4 & x = -1 \end{cases}$

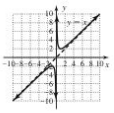


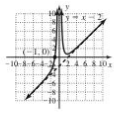


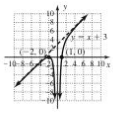
17. $R(x) = \begin{cases} \dfrac{x^3+3x^2-x-3}{x^2+2x-3} & x \neq -3, x \neq 1 \\ -2 & x = -3 \\ 2 & x = 1 \end{cases}$ 

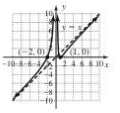
19. 

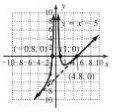
21. 

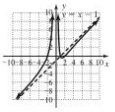
23. 

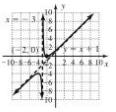
25. 

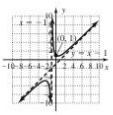
27. 

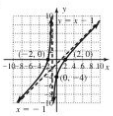
29. 

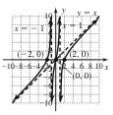
31. 

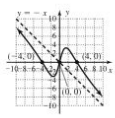
33. 

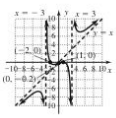
35. 

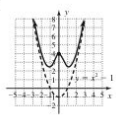
37. 

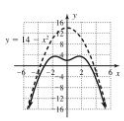
39. 

41. 

43. 

45. 

47. 

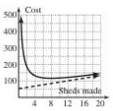
49. 

51. 119.1

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

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

b. cost: \$307, \$372, \$445, Avg. cost: \$307, \$186, \$148.33 **c.** 8, \$116.25

d. 

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

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

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

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

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

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

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

67. $y = \frac{3}{4}x - 4$, $m = \frac{3}{4}$, $(0, -4)$ **69. a.** $P = 30$ cm, **b.** $\overline{CD} = \frac{60}{13}$ cm,

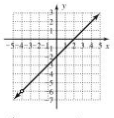
c. 30 cm^2, **d.** $A = \frac{750}{169}$ cm^2, and $A = \frac{4320}{169}$ cm^2

Exercises 3.7, pp. 384–388

1. vertical; multiplicity **3.** empty **5.** Answers will vary.
7. $x \in (0, 4)$ **9.** $x \in (-\infty, -5] \cup [1, \infty)$ **11.** $x \in (-1, \frac{7}{2})$
13. $x \in [-\sqrt{7}, \sqrt{7}]$ **15.** $x \in [-\frac{3}{2} - \frac{\sqrt{33}}{2}, -\frac{3}{2} + \frac{\sqrt{33}}{2}]$
17. $x \in (-\infty, -\frac{5}{3}] \cup [1, \infty)$ **19.** $x \in (-\infty, \infty)$ **21.** $\{\ \}$
23. $x \in (-\infty, 5) \cup (5, \infty)$ **25.** $\{\ \}$ **27.** $x \in (-\infty, \infty)$
29. $x \in (-\infty, \infty)$ **31.** $x \in (-\infty, -5] \cup [5, \infty)$
33. $x \in (-\infty, 0] \cup [5, \infty)$ **35.** $\{\ \}$ **37.** $x \in (-3, 5)$
39. $x \in [4, \infty) \cup \{-1\}$ **41.** $x \in (-\infty, -2] \cup \{2\} \cup [4, \infty)$
43. $x \in (-2 - \sqrt{3}, -2 + \sqrt{3})$ **45.** $x \in [-\infty, -3] \cup -\{1\}$
47. $x \in (-3, 1) \cup (2, \infty)$ **49.** $x \in (-\infty, -3) \cup (-1, 1) \cup (3, \infty)$
51. $x \in (-\infty, -2) \cup (-2, 1) \cup (3, \infty)$ **53.** $x \in [-1, 1] \cup \{3\}$
55. $x \in [-3, 2)$ **57.** $x \in (-\infty, -2) \cup (-2, -1)$
59. $x \in (-\infty, -2) \cup [2, 3)$ **61.** $x \in (-\infty, -5) \cup (0, 1) \cup (2, \infty)$
63. $x \in (-4, -2] \cup (1, 2] \cup (3, \infty)$ **65.** $x \in (-7, -3) \cup (2, \infty)$
67. $x \in (-\infty, -2] \cup (0, 2)$ **69.** $x \in (-\infty, -17) \cup (-2, 1) \cup (7, \infty)$
71. $x \in (-3, \frac{-7}{4}] \cup (2, \infty)$ **73.** $x \in (-2, \infty)$ **75.** $x \in (-1, \infty)$
77. $(-\infty, -3) \cup (3, \infty)$ **79.** $x \in (-\infty, -3] \cup [5, \infty)$
81. $x \in [-3, 0] \cup [3, \infty)$ **83.** $x \in (-\infty, -2) \cup (2, 3)$
85. $x \in (-\infty, -2] \cup (-1, 1) \cup [3, \infty)$ **87.** b **89.** b **91. a.** verified
b. $D = -4(p + \frac{3}{4})(p + 3)^2$, $p = -3$, $q = -2$; $p = \frac{-3}{4}$, $q = \frac{1}{4}$
c. $(-\infty, -3) \cup (-3, \frac{-3}{4})$ **d.** verified
93. $d(x) = k(x^3 - 192x + 1024)$ **a.** $x \in (5, 8]$ **b.** 320 units
c. $x \in [0, 3)$ **d.** 2 ft **95. a.** verified **b.** horizontal: $r_2 = 20$, as r_1 increases, r_2 decreases to maintain $R = 40$ vertical: $r_1 = 20$, as r_1 decreases, r_2 increases to maintain $R = 40$ **97.** $R(t) = 0.01t^2 + 0.1t + 30$
a. $[0°, 30°)$ **b.** $(20°, \infty)$ **c.** $(50°, \infty)$ **99. a.** $n \geq 4$ **b.** $n \leq 9$
c. 13 **101. a.** yes, $x^2 \geq 0$ **b.** yes, $\dfrac{x^2}{x^2 + 1} \geq 0$

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

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

107. $F(x) = \begin{cases} f(x) & x \neq -4 \\ -6 & x = -4 \end{cases}$ 

109.

Exercises 3.8, pp. 394–399

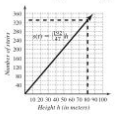
1. constant **3.** $y = \frac{k}{x^2}$ **5.** Answers will vary. **7.** $d = kr$ **9.** $F = ka$

11. $y = 0.025\,x$

x	y
500	12.5
650	16.25
750	18.75

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

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

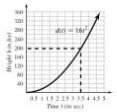
b.  **c.** 330 stairs **d.** $S = 331$; yes

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

21. $k = 0.112$; $p = 0.112\,q^2$

q	p
45	226.8
55	338.8
70	548.8

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

25. a. $k = 16$ $d = 16t^2$ **b.** 

c. about 3.5 sec **d.** 3.5 sec; yes **e.** 2.75 sec **27.** $F = \frac{k}{d^2}$ **29.** $S = \frac{k}{L}$

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

Z	Y
37	9
74	2.25
111	1

33. $w = \dfrac{3{,}072{,}000{,}000}{r^2}$; 48 kg **35.** $l = krt$

37. $A = kh(B + b)$ **39.** $V = ktr^2$

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

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

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

45. cube root family; answers will vary; 0.054 or 5.4%

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

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

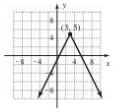
51. $D = 21.6\sqrt{S}$; ≈ 144.9 ft **53.** $C = 8.5LD$; \$76.50

55. $C \approx (4.4 \times 10^{-4})\frac{P_1P_2}{d^2}$; about 223 calls **57. a.** about 23.39 cm^3, **b.** about 191% **59. a.** $M = kwh^2(\frac{1}{2})$ **b.** 180 lb

61. For f: $\frac{\Delta y}{\Delta x} = \frac{-10}{3}$ For g: $\frac{\Delta y}{\Delta x} = \frac{-110}{9}$; less; for both f and g, as $x \to \infty$, $y \to 0$ **63. a.** about 3.5 ft **b.** about 6.9 ft

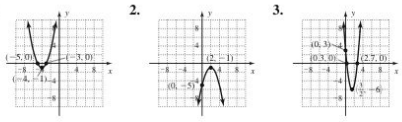
65. $x = 0, x = -2 \pm 2i$

67.



Summary and Concept Review, pp. 399–404

1. **2.** **3.**



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

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

7.

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

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

8. $x^3 - 4x + 5 = (x - 2)(x^2 + 2x) + 5$ **9.** $(x + 4)(x + 1)(x - 3)$

10. $h(x) = (x - 1)(x - 4)(x^2 + 2x + 2)$

11.

$\frac{1}{2}$	4	8	-3	-1
		2	5	1
	4	10	2	0

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

12.

$3i$	1		-2	9	-18
			$3i$	$-9 - 6i$	18
	1	$-2 + 3i$		$-6i$	0

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

13.

-7	1	9	13	-10
		-7	-14	7
	1	2	-1	-3

$h(-7) = -3$

14. $P(x) = x^3 - x^2 - 5x + 5$ **15.** $C(x) = x^4 - 2x^3 + 5x^2 - 8x + 4$

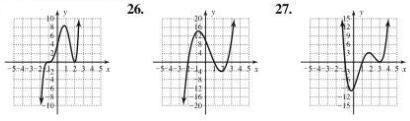
16. a. $C(0) = 350$ customers **b.** more at 2 P.M., 170 **c.** busier at 1 P.M., $760 > 710$

17. $\{\pm 1, \pm\frac{1}{2}, \pm\frac{1}{4}, \pm 5, \pm 10, \pm\frac{5}{2}, \pm\frac{5}{4}, \pm 2\}$ **18.** $x = -\frac{1}{2}, 2, \frac{5}{2}$

19. $p(x) = (2x + 3)(x - 4)(x + 1)$ **20.** only possibilities are $\pm 1, \pm 3$, none give a remainder of zero **21.** [1, 2], [4, 5]; verified **22.** one sign change for $g(x) \to 1$ positive zero; three sign changes for $g(-x) \to 3$ or 1 negative zeroes; 1 positive, 3 negative, 0 complex, or 1 positive, 1 negative, 2 complex; verified **23.** degree 5; up/down; $(0, -4)$

24. degree 4; up/up; $(0, 8)$

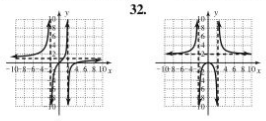
25. **26.** **27.**



28. a. even **b.** $x = -2$, odd; $x = -1$, even; $x = 1$, odd **c.** deg 6: $P(x) = (x + 2)(x + 1)^2(x - 1)^3$

29. a. $\{x | x \in \mathbb{R}; x \neq -1, 4\}$ **b.** HA: $y = 1$; VA: $x = -1, x = 4$ **c.** $V(0) = \frac{9}{4}$ (y-intercept); $x = -3, 3$ (x-intercepts) **d.** $V(1) = \frac{4}{3}$

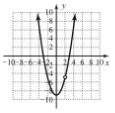
31. **32.**



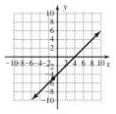
33. $V(x) = \frac{x^2 - x - 12}{x^2 - x - 6}$; $V(0) = 2$

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

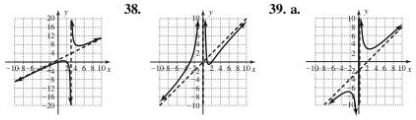
35. removable discontinuity at $(2, -5)$;



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

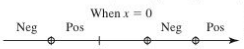


37. **38.** **39. a.**



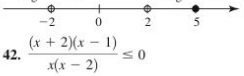
b. about 2450 favors **c.** about \$2.90 ea.

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



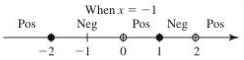
outputs are positive for $x \in (-4, 1) \cup (2, \infty)$

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



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

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



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

43. $k = 17.5$; $y = 17.5\sqrt[3]{x}$ **44.** $k = 0.72$; $z = \frac{0.72v}{w^2}$

x	y
216	105
0.343	12.25
729	157.5

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

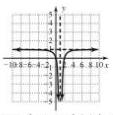
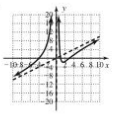
45. $t = 160$ **46.** 4.5 sec

Mixed Review, pp. 404–405

1. $y = -2(x - \frac{1}{2})^2 + \frac{9}{2}$ **3.** 80 GB, \$40.00

5. $q(x) = x^3 - 2x^2 + x + 3$; $R = -7$ **7. a.** $P(-1) = 42$ **b.** $P(1) = -26$ **c.** $P(5) = 6$ **9. a.** $x = 9$; $x = \frac{8}{3}$

b. $P(x) = (x - 2)(x + 1)(x^2 + 9)$; $x = 2, x = -1, x = -3i, x = 3i$

11.  **13.** 

15. $x \in (-\infty, 3) \cup (-2, 2)$

17. a. $V(x) = (24 - 2x)(16 - 2x)(x) = 4x^3 - 80x^2 + 384x$

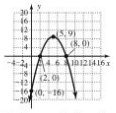
b. $512 = 4x^3 - 80x^2 + 384x\ 0 = x^3 - 20x^2 + 96x - 128$

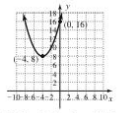
c. for $0 < x < 8$, possible rational zeroes are 1, 2, and 4

d. $x = 4$ **e.** $x = 8 - 4\sqrt{2} \approx 2.34$ in. **19.** $R = kL(\frac{1}{A})$

Practice Test, pp. 405–406

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





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

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

6.

−3	1	0	−15	−10	24
		−3	9	18	−24
	1	−3	−6	8	0

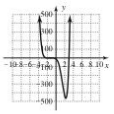
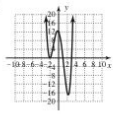
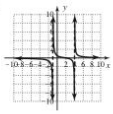
$R = 0$ ✓

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

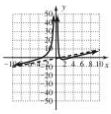
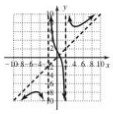
9. $Q(x) = (x - 2)^2(x - 1)^2(x + 1)$, 2 mult 2, 1 mult 2, -1 mult 1

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

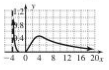
11. a. 1992, 1994, 1998 **b.** 4 yr **c.** surplus of $2.5 million

12.  **13.**  **14.** 

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

16. a.  **b.** 

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

19. a.  **b.** $h = -\sqrt[3]{55}$; no **c.** 28.6% 29.6% **d.** ≈11.7 hr **e.** 4 hr 43.7% **f.** The amount of the chemical in the bloodstream becomes neglible.

20. 520 lb

Strengthening Core Skills, pp. 407–408

Exercise 1: $x \in (-\infty, 3]$

Exercise 2: $x \in (-2, -1) \cup (2, \infty)$

Exercise 3: $x \in (-\infty, -4) \cup (1, 3)$

Exercise 4: $x \in [-2, \infty)$

Exercise 5: $x \in (-\infty, -2) \cup (2, \infty)$

Exercise 6: $x \in [-3, 1] \cup [3, \infty)$

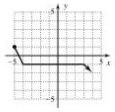
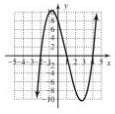
Cumulative Review chapter R–3, pp. 408–409

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

b. $(x - 3)(x + 2)(x - 2)$ **5.** all reals **7.** verified

9. $y = \dfrac{11}{60}x + \dfrac{1009}{60}$; 39 min, driving time increases 11 min every 60 days

11. Month 9 **13.** $f^{-1}(x) = \dfrac{x^3 + 3}{2}$

15.  **17.** $X = 63$ **19.** 

CHAPTER 4

Exercises 4.1, pp. 420–424

1. second; one **3.** $(-11, -2), (-5, 0), (1, 2), (19, 4)$ **5.** False, answers will vary. **7.** one-to-one **9.** one-to-one **11.** not a function **13.** one-to-one **15.** not one-to-one, fails horizontal line test: $x = -3$ and $x = 3$ are paired with $y = 1$ **17.** not one-to-one, $y = 7$ is paired with $x = -2$ and $x = 2$ **19.** one-to-one **21.** one-to-one **23.** not one-to-one; $p(t) > 5$, corresponds to two x-values **25.** one-to-one **27.** one-to-one

29. $f^{-1}(x) = \{(1, -2), (4, -1), (5, 0), (9, 2), (15, 5)\}$

31. $v^{-1}(x) = \{(3, -4), (2, -3), (1, 0), (0, 5), (-1, 12), (-2, 21), (-3, 32)\}$

33. $f^{-1}(x) = x - 5$ **35.** $p^{-1}(x) = \dfrac{-5}{4}x$ **37.** $f^{-1}(x) = \dfrac{x - 3}{4}$

39. $Y_1^{-1} = x^3 + 4$ **41.** $f^{-1}(x) = x^3 + 2$ **43.** $f^{-1}(x) = \sqrt[3]{x - 1}$

45. $f^{-1}(x) = \dfrac{8}{x} - 2$ **47.** $f^{-1}(x) = \dfrac{x}{1 - x}$ **49. a.** $x \geq -5, y \geq 0$

b. $f^{-1}(x) = \sqrt{x} - 5, x \geq 0, y \geq -5$ **51. a.** $x > 3, y > 0$

b. $v^{-1}(x) = \sqrt{\dfrac{8}{x}} + 3, x > 0, y > 3$ **53 a.** $x \geq -4, y \geq -2$

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

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

59. $(f \circ g)(x) = x, (g \circ f)(x) = x$ **61.** $(f \circ g)(x) = x, (g \circ f)(x) = x$

63. $f^{-1}(x) = \dfrac{x + 5}{3}$ **65.** $f^{-1}(x) = 2x + 5$ **67.** $f^{-1}(x) = 2x + 6$

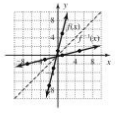
69. $f^{-1}(x) = \sqrt[3]{x - 3}$ **71.** $f^{-1}(x) = \dfrac{x^3 - 1}{2}$ **73.** $f^{-1}(x) = 2\sqrt[3]{x} + 1$

75. $f^{-1}(x) = \dfrac{x^2 - 2}{3}, x \geq 0; y \in \left[-\dfrac{2}{3}, \infty\right)$

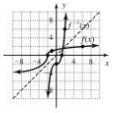
77. $p^{-1}(x) = \dfrac{x^2}{4} + 3, x \geq 0; y \in [3, \infty)$

79. $v^{-1}(x) = \sqrt{x - 3}, x \geq 3; y \in [0, \infty)$

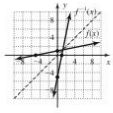
81.



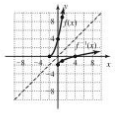
83.

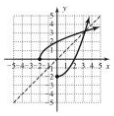


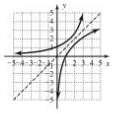
85.

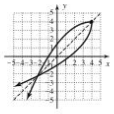


87.



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

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

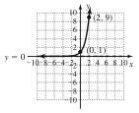
93.  D: $x \in (-\infty, 4]$, R: $y \in (-\infty, 4]$; D: $x \in (-\infty, 4]$, R: $y \in (-\infty, 4]$

95. a. 31.5 cm **b.** The result is 80 cm. It gives the distance of the projector from the screen. **97. a.** $-63.5°$F **b.** $f^{-1}(x) = \frac{-2}{7}(x - 59)$; independent: temperature, dependent: altitude **c.** 22,000 ft **99. a.** 144 ft **b.** $f^{-1}(x) = \frac{\sqrt{x}}{4}$, independent: distance fallen, dependent: time fallen **c.** 7 sec **101. a.** 28,260 ft^3 **b.** $f^{-1}(x) = \sqrt[3]{\frac{3x}{\pi}}$, independent: volume, dependent: height **c.** 9 ft **103.** Answers will vary. **105.** d **107.** $x \in [-1, 2]$ **109. a.** $P = 2l + 2w$ **b.** $A = \pi r^2$ **c.** $V = \pi r^2 h$ **d.** $V = \frac{1}{3}\pi r^2 h$ **e.** $C = 2\pi r$ **f.** $A = \frac{1}{2}bh$ **g.** $A = \frac{1}{2}(b_1 + b_2)h$ **h.** $V = \frac{4}{3}\pi r^3$ **i.** $a^2 + b^2 = c^2$

Exercises 4.2, pp. 432–436

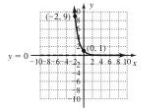
1. b^x; b; b; x **3.** a; 1 **5.** False; for $|b| < 1$ and $x_2 > x_1$, $b^{x_2} < b^{x_1}$ so function is decreasing **7.** 40,000; 5000; 20,000; 27,589.162 **9.** 500; 1.581; 2.321; 221.168 **11.** 10,000; 1975.309; 1487.206; 1316.872

13. increasing



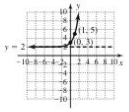
increasing

15. decreasing

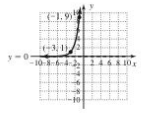


decreasing

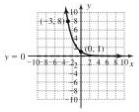
17. up 2



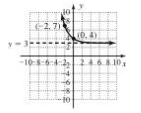
19. left 3



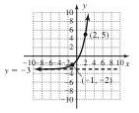
21. reflect across y-axis



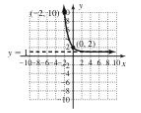
23. reflect across y-axis, up 3



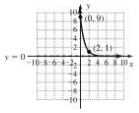
25. left 1, down 3



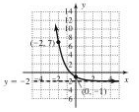
27. up 1



29. right 2

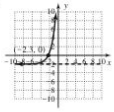


31. down 2

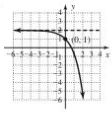


33. e **35.** a **37.** b **39.** 2.718282 **41.** 7.389056 **43.** 4.481689 **45.** 4.113250

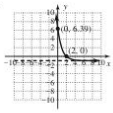
47.



49.

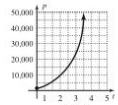


51.



53. 3 **55.** $\frac{3}{2}$ **57.** $-\frac{1}{3}$ **59.** 4 **61.** -3 **63.** 3 **65.** 2 **67.** -2 **69.** 2 **71.** 3

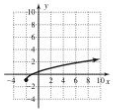
73. a. 1732, 3000, 5196, 9000 **b.** yes **c.** as $t \to \infty$, $P \to \infty$



75. no, they will have to wait about 10 min **77. a.** \$100,000 **b.** 3 yr **79. a.** ≈ \$86,806 **b.** 3 yr **81. a.** \$40 million **b.** 7 yr **83.** 32% transparent **85.** 17% transparent **87.** ≈ \$32,578 **89. a.** 8 g **b.** 48 min **91.** 9.5×10^{-7}; answers will vary **93.** 9 **95.** $\frac{3}{2}$

97. a. $\frac{\Delta y}{\Delta x} = 0.3842, 0.056, 0.011, 0.003$; the rate of growth seems to be approaching zero **b.** 16,608 **c.** yes, the secant lines are becoming virtually horizontal

99.

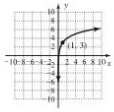


101. a. volume of a sphere **b.** area of a triangle **c.** volume of a rectangular prism **d.** Pythagorean theorem

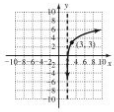
Exercises 4.3, pp. 445–449

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

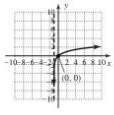
59. shift up 3



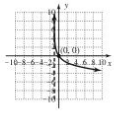
61. shift right 2, up 3



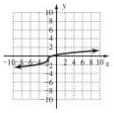
63. shift left 1



65. reflect across x-axis, shift left 1



67. II **69.** VI **71.** V **73.** $x \in (-\infty, -1) \cup (3, \infty)$ **75.** $x \in (\frac{3}{2}, \infty)$ **77.** $x \in (-3, 3)$ **79.** pH ≈ 4.1; acid **81. a.** ≈ 4.7 **b.** ≈ 4.9 **83.** about 3.2 times **85. a.** ≈ 2.4 **b.** ≈ 1.2 **87. a.** 20 dB **b.** 120 dB **89.** about 3162 times **91.** 6,194 m **93. a.** about 5434 m **b.** 4000 m **95. a.** 2225 items **b.** 2732 items **c.** \$117,000 **d.** verified **97. a.** about 58.6 cfm **b.** about 1605 ft^2 **99. a.** 95% **b.** 67% **c.** 39% **101.** ≈ 4.3; acid **103.** Answers will vary. **a.** 0 dB **b.** 90 dB **c.** 15 dB **d.** 120 dB **e.** 100 dB **f.** 140 dB **105. a.** $\frac{-2}{3}$ **b.** $\frac{-3}{2}$ **c.** $\frac{-5}{2}$ **107.** D: $x \in \mathbb{R}$ R: $y \in \mathbb{R}$



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

Mid-Chapter Check, pp. 449–450

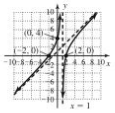
1. a. $\frac{2}{3} = \log_{27} 9$ **b.** $\frac{5}{4} = \log_{81} 243$ **2. a.** $8^{\frac{1}{3}} = 32$ **b.** $1296^{0.25} = 6$ **3. a.** $x = 5$ **b.** $b = \frac{5}{4}$ **4. a.** $x = 3$ **b.** $b = 5$ **5. a.** \$71,191.41 **b.** 6 yr **6.** $F(x) = 4 \cdot 5^{x-3} + 2$ **7.** $f^{-1}(x) = (x - 1)^2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

Reinforcing Basic Concepts p. 450

Exercise 1: about 158 times
Exercise 2: about 501 times
Exercise 3: about 12,589 times
Exercise 4: about 398 times
Exercise 5: about 39,811 times

Exercises 4.4, pp. 462–466

1. e **3.** extraneous **5.** 2.316566275 **7.** $x \approx 29.964$ **9.** $x \approx 1.778$ **11.** $x \approx 2.200$ **13.** $x \approx 1.260$ **15.** $x \approx 4.7881$ **17.** $x \approx -3.1079$ **19.** $x = -\dfrac{\ln 2.32}{0.75}$, $x \approx -1.1221$ **21.** $x = e^3 - 4$, $x \approx 10.3919$ **23.** $x = 5 - 10^{1.25}$, $x \approx -12.7828$ **25.** $x = \dfrac{e^{0.4} - 5}{2}$, $x \approx -1.7541$ **27.** $\ln(2x^2 - 14x)$ **29.** $\log(x^2 - 1)$ **31.** $\log_3 4$ **33.** $\log\left(\dfrac{x}{x+1}\right)$ **35.** $\ln\left(\dfrac{x-5}{x}\right)$ **37.** $\ln(x - 2)$ **39.** $\log_2 42$ **41.** $\log_5(x - 2)$ **43.** $(x + 2) \log 8$ **45.** $(2x - 1) \ln 5$ **47.** $\frac{1}{2} \log 22$ **49.** $4 \log_5 3$ **51.** $3 \log a + \log b$ **53.** $\ln x + \frac{1}{4} \ln y$ **55.** $2 \ln x - \ln y$ **57.** $\frac{1}{2}[\log(x - 2) - \log x]$ **59.** $\ln 7 + \ln x + \frac{1}{2} \ln(3 - 4x) - \ln 2 - 3 \ln(x - 1)$ **61.** $\dfrac{\ln 60}{\ln 7}$; 2.104076884 **63.** $\dfrac{\ln 152}{\ln 5}$; 3.121512475 **65.** $\dfrac{\log 1.73205}{\log 3}$; 0.499999576 **67.** $\dfrac{\log 0.125}{\log 0.5}$; 3 **69.** $f(x) = \dfrac{\log(x)}{\log(3)}$; $f(5) \approx 1.4650$; $f(15) \approx 2.4650$; $f(45) \approx 3.4650$; outputs increase by 1; $f(3^3 \cdot 5) = 4.465$ **71.** $h(x) = \dfrac{\log(x)}{\log(9)}$; $h(2) \approx 0.3155$; $h(4) \approx 0.6309$; $h(8) \approx 0.9464$; outputs are multiples of 0.3155; $h(2^4) = 4(0.3155) \approx 1.2619$ **73.** $x = 32$ **75.** $x = 6.4$ **77.** $x = 20, -5$ is extraneous **79.** $x = 2, -\frac{5}{2}$ is extraneous **81.** $x = 0$ **83.** $x = \frac{5}{2}$ **85.** $x = \frac{2}{3}$ **87.** $x = \frac{3}{2}$ **89.** $x = \frac{-19}{9}$ **91.** $x = \dfrac{e^2 - 63}{9}$ **93.** $x = 2$; -9 is extraneous **95.** $x = 3e^3 - \frac{1}{2}$; $x \approx 59.75661077$ **97.** no solution **99.** $t = -\frac{1}{2}$; -4 is extraneous **101.** $x = 2 + \sqrt{3}$, $x = 2 - \sqrt{3}$ is extraneous **103.** $x = \dfrac{\ln 231}{\ln 7} - 2$; $x \approx 0.7968$ **105.** $x = \dfrac{\ln 128{,}965}{3 \ln 5} + \dfrac{2}{3}$; $x \approx 3.1038$ **107.** $x = \dfrac{\ln 2}{\ln 3 - \ln 2}$; $x \approx 1.7095$ **109.** $x = \dfrac{\ln 9 - \ln 5}{2 \ln 5 - \ln 9}$; $x \approx 0.5753$ **111.** $x \approx 46.2$ **113.** $t = \dfrac{\ln\left(\frac{\frac{C}{P} - 1}{a}\right)}{-k}$, $t \approx 55.45$ **115. a.** 30 fish **b.** about 37 months **117.** about 3.2 cmHg **119.** about 50.2 min **121.** \$15,641 **123.** 6 hr, 18.0% **125.** $M_f = 52.76$ tons **127. a.** 26 planes **b.** 9 days **129. a.** $\log_3 4 + \log_3 5 = 2.7268$ **b.** $\log_3 4 - \log_3 5 = -0.203$ **c.** $2 \log_3 5 = 2.9298$ **131. a.** d **b.** e **c.** b **d.** f **e.** a **f.** c **133.** $x = 0.69314718$ **135. a.** $(f \circ g)(x) = 3^{(\log_3 x + 2) - 2} = 3^{\log_3 x} = x$; $(g \circ f)(x) = \log_3(3^{x-2}) + 2 = x - 2 + 2 = x$ **b.** $(f \circ g)(x) = e^{(\ln x + 1) - 1} = e^{\ln x} = x$; $(g \circ f)(x) = \ln e^{x-1} + 1 = x - 1 + 1 = x$ **137. a.** $y = e^{x \ln 2} = e^{\ln 2^x} = 2^x$; $y = 2^x \Rightarrow \ln y = x \ln 2$, $e^{\ln y} = e^{x \ln 2} \Rightarrow y = e^{x \ln 2}$ **b.** $y = b^x$, $\ln y = x \ln b$, $e^{\ln y} = e^{x \ln b}$, $y = e^{xr}$ for $r = \ln b$ **139.** Answers will vary. **141.** b **143.**

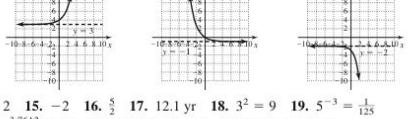


Exercises 4.5, pp. 475–480

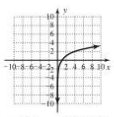
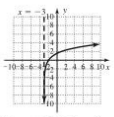
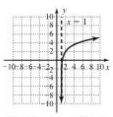
1. Compound **3.** $Q_0 e^{-rt}$ **5.** Answers will vary. **7.** \$4896 **9.** 250% **11.** \$2152.47 **13.** 5.25 yr **15.** 80% **17.** 4 yr **19.** 16 yr **21.** \$7561.33 **23.** about 5 yr **25.** 7.5 yr **27.** no **29. a.** no **b.** 9.12% **31.** 7.9 yr **33.** 7.5 yr **35. a.** no **b.** 9.4% **37. a.** no **b.** approx 13,609 euros **39.** No; \$234,612.01 **41.** about 7 yr **43.** 23 yr **45. a.** no **b.** \$302.25 **47. a.** $t = \dfrac{A - P}{pr}$ **b.** $p = \dfrac{A}{1 + rt}$ **49. a.** $r = n\left(\sqrt[nt]{\dfrac{A}{p}} - 1\right)$ **b.** $t = \dfrac{\ln\left(\frac{A}{p}\right)}{n \ln\left(1 + \frac{r}{n}\right)}$ **51. a.** $Q_0 = \dfrac{Q(t)}{e^{rt}}$ **b.** $t = \dfrac{\ln\left(\frac{Q(t)}{Q_0}\right)}{r}$ **53.** \$709.74 **55. a.** 5.78% **b.** 91.67 hr **57.** 0.65 g **59.** 816 yr **61.** about 12.4% **63.** \$17,027,502.21 **65.** 7.93% **67.** 2548.8 m **69.** $P(x) = x^4 - 4x^3 + 6x^2 - 4x - 15$

Summary and Concept Review, pp. 480–484

1. no **2.** no **3.** yes **4.** $f^{-1}(x) = \frac{x-2}{-3}$ **5.** $f^{-1}(x) = \sqrt{x + 2}$ **6.** $f^{-1}(x) = x^2 + 1$; $x \geq 0$ **7.** $f(x)$: D: $x \in [-4, \infty)$, R: $y \in [0, \infty)$; $f^{-1}(x)$: D: $x \in [0, \infty)$, R: $y \in [-4, \infty)$ **8.** $f(x)$: D: $x \in (-\infty, \infty)$, R: $y \in (-\infty, \infty)$; $f^{-1}(x)$: D: $(-\infty, \infty)$, R: $y \in (-\infty, \infty)$ **9.** $f(x)$: D: $x \in (-\infty, \infty)$, R: $y \in (0, \infty)$; $f^{-1}(x)$: D: $x \in (0, \infty)$, R: $y \in (-\infty, \infty)$ **10. a.** \$3.05 **b.** $f^{-1}(t) = \frac{t-2}{0.15}$ $f^{-1}(3.05) = 7$ **c.** 12 days **11.** **12.** **13.**



14. 2 **15.** -2 **16.** $\frac{5}{2}$ **17.** 12.1 yr **18.** $3^2 = 9$ **19.** $5^{-3} = \frac{1}{125}$ **20.** $e^{3.7612} \approx 43$ **21.** $\log_5 25 = 2$ **22.** $\ln 0.7788 \approx -0.25$ **23.** $\log_3 81 = 4$ **24.** 5 **25.** -1 **26.** $\frac{1}{2}$

27.  **28.**  **29.** 

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

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

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

c. $x = \dfrac{10^3}{3}$, $x \approx 33.3333$ **d.** $x = e^{-2.75}$, $x \approx 0.0639$ **35. a.** $\ln 42$

b. $\log_9 30$ **c.** $\ln\left(\frac{x+3}{x-1}\right)$ **d.** $\log(x^2 + x)$ **36. a.** $2\log_5 9$ **b.** $2\log_7 4$

c. $(2x - 1)\ln 5$ **d.** $(3x + 2)\ln 10$ **37. a.** $\ln x + \frac{1}{4}\ln y$

b. $\frac{1}{3}\ln p + \ln q$ **c.** $\frac{5}{3}\log x + \frac{4}{3}\log y - \frac{5}{2}\log x - \frac{3}{2}\log y$

d. $\log 4 + \frac{5}{3}\log p + \frac{4}{3}\log q - \frac{3}{2}\log p - \log q$ **38. a.** $\dfrac{\log 45}{\log 6} \approx 2.215$

b. $\dfrac{\log 128}{\log 3} \approx 4.417$ **c.** $\dfrac{\ln 124}{\ln 2} \approx 6.954$ **d.** $\dfrac{\ln 0.42}{\ln 5} \approx -0.539$

39. $x = \dfrac{\ln 7}{\ln 2}$ **40.** $x = \dfrac{\ln 5}{\ln 3} - 1$ **41.** $x = \dfrac{2}{1 - \ln 3}$ **42.** $x \approx 6.389$

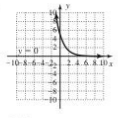
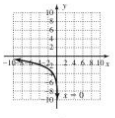
43. $x = 5$; -2 is extraneous **44.** $x = 4.25$ **45. a.** 17.77%

b. 23.98 days **46.** 38.6 cmHg **47.** 18.5% **48.** Almost, she needs \$42.15 more. **49. a.** no **b.** \$268.93 **50.** 55.0%

Mixed Review, pp. 484–485

1. a. $\dfrac{\log 30}{\log 2} \approx 4.9069$ **b.** -1.5 **c.** $\frac{1}{3}$ **3. a.** $2\log_{10} 20$ **b.** $0.05x$

c. $(x - 3)\ln 2$

5.  **7.**  **9. a.** $5^4 = 625$

b. $e^{0.45} = 0.15x$ **c.** $10^7 = 0.1 \times 10^8$ **11. a.** $x \in [1, \infty)$, $y \in [2, \infty)$

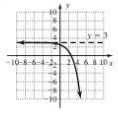
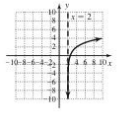
b. $g^{-1}(x) = (x - 2)^2 + 1$, $x \in [2, \infty)$, $y \in [1, \infty)$ **c.** Answers will vary. **13.** $6 + \log 2$ **15.** $\frac{9}{4} + \frac{\sqrt{129}}{4}$ **17.** $I \approx 6.3 \times 10^{17}$

19. 1.6 m, 1.28 m, 1.02 m, 0.82 m, 0.66 m, 0.52 m

Practice Test, pp. 485–486

1. $3^4 = 81$ **2.** $\log_{2.5} 5 = \frac{1}{2}$ **3.** $\frac{5}{2}\log_b x + 3\log_b y - \log_b z$

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

9.  **10.**  **11. a.** 4.19 **b.** -0.81

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

13. $x = 1 + \dfrac{\ln 89}{\ln 3}$ **14.** $x = 1$, $x = -5$ is extraneous **15.** ≈5 yr

16. ≈8.7 yr **17.** 19.1 months **18.** 7% compounded semi-annually

19. a. no **b.** \$54.09 **20. a.** 10.2 lb **b.** 19 weeks

Strengthening Core Skills, p. 488

Exercise 1: Answers will vary.

Exercise 2: **a.** $\log(x^2 + 3x)$ **b.** $\ln(x^2 - 4)$ **c.** $\log_{\frac{x}{x+3}}$

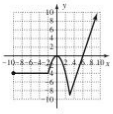
Exercise 3: Answers will vary.

Exercise 4: **a.** $x \log 3$ **b.** $5 \ln x$ **c.** $(3x - 1)\ln 2$

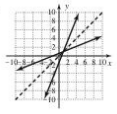
Cumulative Review chapters 1–4, pp. 488–489

1. $x = 2 \pm 7i$ **3.** $(4 + 5i)^2 - 8(4 + 5i) + 41 = 0$ **5.** $f(g(x)) = x$ $g(f(x)) = x$ Since $(f \circ g)(x) = (g \circ f)(x)$, they are inverse functions.

7. a. $T(t) = 455t + 2645$ $(1991 \rightarrow \text{year } 1)$ **b.** $\dfrac{\Delta T}{\Delta t} = \dfrac{455}{1}$, triple births increase by 455 each year **c.** $T(6) = 5375$ sets of triplets, $T(17) = 10{,}380$ sets of triplets

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

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

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

17. $x = 5$, $x = -6$ is an extraneous root **19. a.** ≈88 hp for sport wagon, ~81 hp for minivan **b.** ≈3294 rpm **c.** minivan, 208 hp at 5800 rpm

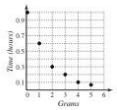
MODELING WITH TECHNOLOGY II

Modeling with Technology Exercises, pp. 495–502

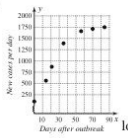
1. e **3.** a **5.** d **7.** linear **9.** exponential **11.** logistic

13. exponential

15. As time increases, the amount of radioactive material decreases but will never truly reach 0 or become negative. Exponential with $b < 1$ and $k > 0$ is the best choice. $y \approx (1.042)0.5626^x$



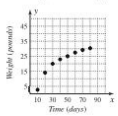
17. Sales will increase rapidly, then level off as the market is saturated with ads and advertising becomes less effective, possibly modeled by a logarithmic function. $y \approx 120.4938 + 217.2705 \ln(x)$

19. a.  **b.** about 1750 **c.** $y \approx \dfrac{1719}{1 + 10.2e^{-0.11x}}$ logistic

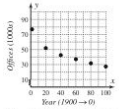
21. 4.95 **23.** 6.25 **25.** 5.75 **27.** 6.84

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

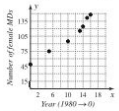
a. 9.2 lb **b.** 29 days **c.** 34.8 lb



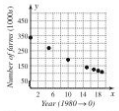
31. logarithmic, $y = 78.8 - 10.3 \ln x$
a. 51,000 **b.** 1977 **c.** 30,400



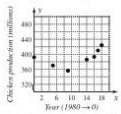
33. exponential, $y = 50.21(1.07)^x$
a. 86,270 **b.** 272,511 **c.** 1990



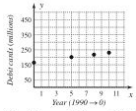
35. exponential, $y = 346.79(0.94)^x$
a. 155,142 **b.** 78,548 **c.** 1993



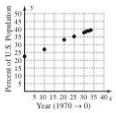
37. quadratic $y \approx 0.576x^2 - 8.879x + 394$
a. 360 million **b.** about 513 million
c. from 1984 to 1990



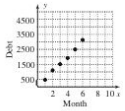
39. linear, $y \approx 6.555x + 165.308$
a. 224 million **b.** 264 million **c.** 2010



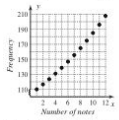
41. linear, $P(t) = 0.51t + 22.51$, 2005: 40.4%, 2010: 43%



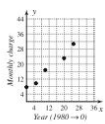
43. linear, $y \approx 509.18x - 7.96$; about \$6100; the next July ($x \approx 19.7$)



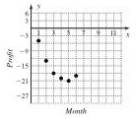
45. exponential, $y \approx 103.83\,(1.0595)^x$
a. 220 **b.** The 22nd note, or F sharp
c. frequency doubles, yes



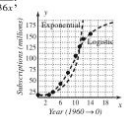
47. exponential, $y \approx 8.02\,(1.0564)^x$
\$41.59/mo, \$54.72/mo



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

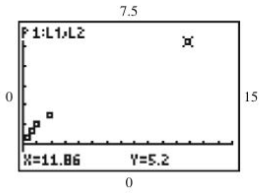


51. logistic, $y \approx \dfrac{222.133}{1 + 32.280e^{-0.336x}}$;



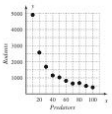
about 55 million, about 184 million, about 214 million; 2014

53.



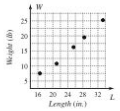
power regression,
a. $y \approx x^{0.665}$, 9.5 AU;
b. 84.8 yr

55.



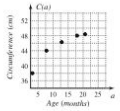
a. power regression, $y \approx 58555.89(x^{-1.056})$;
b. about 295 rodents **c.** about 17 predators

57. a.



linear, $W = 1.24L - 15.83$, 32.5 lb, 35.3 in.

57. b.



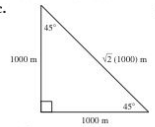
logarithmic, $C(a) \approx 37.9694 + 3.4229 \ln (a)$, about 49.3 cm, about 34 mo

CHAPTER 5

Exercises 5.1, pp. 513–518

1. Complementary; 180°; less; greater1. **3.** $r\theta$, $\frac{1}{2}r^2\theta$, radians
5. Answers will vary. **7. a.** 77.5° **b.** 30.8° **9.** 53° **11.** 42.5°
13. 67.555° **15.** 285.0025° **17.** 45.7625° **19.** 20° 15′ 00″
21. 67° 18′ 25.2″ **23.** 275° 19′ 48″ **25.** 5° 27′ 9″ **27.** No, $19 + 16 < 40$ **29.** 69° **31.** 25° **33.** 62.5 m
35. $41\sqrt{2}$ ft $\approx$ 58 ft + 10 ft = 68 ft **37.** −645°, −285°, 435°, 795°
39. −765°, −405°, 315°, 675° **41.** s = 980 m **43.** θ = 0.75 rad
45. $r \approx$ 1760 yd **47.** $s = \frac{8\pi}{3}$ mi **49.** θ = 0.2575 rad
51. $r \approx$ 9.4 km **53.** A = 115.6 km^2 **55.** θ = 0.6 rad
57. $r \approx$ 3 m **59.** θ = 1.5 rad; s = 7.5 cm; r = 5 cm; A = 18.75 cm^2
61. θ = 4.3 rad s = 43 m; r = 10 m; A = 215 m^2
63. θ = 3 rad; A = 864 mm^2; s = 72 mm; r = 24 mm
65. 2π rad **67.** $\frac{\pi}{4}$ rad **69.** $\frac{7\pi}{6}$ rad **71.** $\frac{-2\pi}{3}$ rad **73.** 0.4712 rad
75. 3.9776 rad **77.** 60° **79.** 30° **81.** 120° **83.** 720° **85.** 165°

87. 186.4° **89.** 171.9° **91.** −143.2°
93. $h \approx 7.06$ cm; $m \approx 3.76$ cm; $n \approx 13.24$ cm
95. 960.7 mi apart **97.** **a.** ≈50.3 m² **b.** ≈80° **c.** ≈17 m
99. **a.** 1.5π rad/sec **b.** about 15 mi/hr
101. **a.** 40π rad/min **b.** $\frac{\pi}{6}$ ft/sec ≈ 0.52 ft/sec **c.** about 11.5 sec
103. **a.** 1000 m **b.** 1000 m
c. $1000\sqrt{2}$ m ≈ 1414.2 m



105. $50\sqrt{2}$ or about 70.7 mi apart
107. **a.** ≈50.3°/day; ≈0.8788 rad/day **b.** ≈0.0366 rad/hr **c.** ≈6.67 mi/sec
109. Answers will vary. **111.** **a.** ≈192 yd **b.** ≈86.7 rpm
113. ≈8.14% **115.** $y = \frac{1}{4}(x-2)^2 - 4$

Exercises 5.2, pp. 525–531

1. $\theta = \tan^{-1} x$ **3.** opposite; hypotenuse
5. To find the measure of all three angles and all three sides
7. $\sin\theta = \frac{12}{13}$, $\csc\theta = \frac{13}{12}$, $\sec\theta = \frac{13}{5}$, $\tan\theta = \frac{12}{5}$, $\cot\theta = \frac{5}{12}$
9. $\cos\theta = \frac{13}{85}$, $\sec\theta = \frac{85}{13}$, $\cot\theta = \frac{13}{84}$, $\sin\theta = \frac{84}{85}$, $\csc\theta = \frac{85}{84}$
11. $\sin\theta = \frac{11}{5\sqrt{3}}$, $\tan\theta = \frac{11}{2}$, $\csc\theta = \frac{5\sqrt{3}}{11}$, $\cos\theta = \frac{2}{5\sqrt{3}}$, $\sec\theta = \frac{5\sqrt{3}}{2}$
13.

Angles	Sides
$A = 30°$	$a = 98$ cm
$B = 60°$	$b = 98\sqrt{3}$ cm
$C = 90°$	$c = 196$ cm

15.

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

17.

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

verified

19.

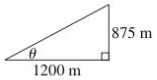
Angles	Sides
$A = 32°$	$a = 5.6$ mi
$B = 58°$	$b \approx 8.96$ mi
$C = 90°$	$c \approx 10.57$ mi

verified

21.

Angles	Sides
$A = 65°$	$a = 625$ mm
$B = 25°$	$b \approx 291.44$ mm
$C = 90°$	$c \approx 689.61$ mm

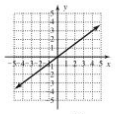
23. 0.4540 **25.** 0.8391 **27.** 1.3230 **29.** 0.9063 **31.** 27° **33.** 40°
35. 40.9° **37.** 65° **39.** 44.7° **41.** 20.2° **43.** 18.4° **45.** 46.2°
47. 61.6° **49.** 21.98 mm **51.** 3.04 mi **53.** 177.48 furlongs
55. They have like values. **57.** They have like values.
59. 43° **61.** 21° **63.** $\frac{1}{2}, \frac{\sqrt{3}}{2}, \frac{\sqrt{3}}{3}, \frac{\sqrt{3}}{2}, \frac{1}{2}, \sqrt{3}, 2, \frac{2\sqrt{3}}{3}, \sqrt{3}$
65. $6 + 2\sqrt{3}$ **67.** $7 + 4\sqrt{3}$ **69.** $\theta \approx 11.0°$, $\beta \approx 23.9°$, $\gamma \approx 145.1°$
71. approx. 300.6 m **73.** approx. 1483.8 ft **75.** approx. 118.1 mph
77. **a.** approx. 250.0 yd **b.** approx. 351.0 yd **c.** approx. 23.1 yd
79. approx. 1815.2 ft; approx. 665.3 ft **81.** approx. 386.0 Ω
83. **a.** 875 m **b.** 1200 m
c. 1485 m; 36.1°



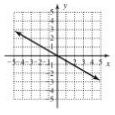
85. approx. 450 ft **87.** **a.** approx. 20.2 cm for each side **b.** approx. 35.3°
89. $\cot u = \frac{x}{h}$
$x = h \cot u$
$\cot v = \frac{x-d}{h}$
$\cot v = \frac{h\cot u - d}{h}$
$h\cot v = h\cot u - d$
$d = h\cot u - h\cot v$
$h = \frac{d}{\cot u - \cot v}$
91. **a.** approx. 3055.6 mi **b.** approx. 9012.8 mi **c.** approx. 7 hr, 13 min
93. **a.** local max: (−5, 2), (2, 3);
local min: (−2, −1), (−7, −2), (6, −3)
b. zeroes: $x = -6, -3, -1, 4$
c. $T(x)\downarrow$: $x \in (-5, -2) \cup (2, 6)$; $T(x)\uparrow$: $x \in (-7, -5) \cup (-2, 2)$
d. $T(x) > 0$: $x \in (-6, -3) \cup (-1, 4)$;
$T(x) < 0$: $x \in [-7, -6) \cup (-3, -1) \cup (4, 6]$
95. $d \approx 53.74$ in.
$D \approx 65.82$ in.

Exercises 5.3, pp. 538–541

1. origin; x-axis **3.** positive; clockwise **5.** Answers will vary.
7. slope $= \sqrt{3}$, equation: $y = \sqrt{3}x$,
$\sin 60° = \frac{\sqrt{3}}{2}$, $\cos 60° = \frac{1}{2}$, $\tan 60° = \sqrt{3}$
9. QI/III;



(4, 3): $\sin\theta = \frac{3}{5}$; (−4, −3): $\sin\theta = -\frac{3}{5}$
$\cos\theta = \frac{4}{5}$ $\cos\theta = -\frac{4}{5}$
$\tan\theta = \frac{3}{4}$ $\tan\theta = \frac{3}{4}$
11. QII/QIV;



$(-3, \sqrt{3})$: $\sin\theta = \frac{1}{2}$; $(3, -\sqrt{3})$: $\sin\theta = -\frac{1}{2}$
$\cos\theta = -\frac{\sqrt{3}}{2}$ $\cos\theta = \frac{\sqrt{3}}{2}$
$\tan\theta = -\frac{1}{\sqrt{3}}$ $\tan\theta = -\frac{1}{\sqrt{3}}$
13. $\sin\theta = \frac{15}{17}$, $\csc\theta = \frac{17}{15}$, $\cos\theta = \frac{8}{17}$, $\sec\theta = \frac{17}{8}$, $\tan\theta = \frac{15}{8}$, $\cot\theta = \frac{8}{15}$
15. $\sin\theta = \frac{21}{29}$, $\csc\theta = \frac{29}{21}$, $\cos\theta = \frac{-20}{29}$, $\sec\theta = \frac{-29}{20}$, $\tan\theta = \frac{-21}{20}$, $\cot\theta = \frac{-20}{21}$
17. $\sin\theta = \frac{-\sqrt{2}}{2}$, $\csc\theta = \frac{-2}{\sqrt{2}}$, $\cos\theta = \frac{\sqrt{2}}{2}$, $\sec\theta = \frac{2}{\sqrt{2}}$, $\tan\theta = -1$, $\cot\theta = -1$
19. $\sin\theta = \frac{1}{2}$, $\csc\theta = 2$, $\cos\theta = \frac{\sqrt{3}}{2}$, $\sec\theta = \frac{2}{\sqrt{3}}$, $\tan\theta = \frac{1}{\sqrt{3}}$, $\cot\theta = \sqrt{3}$
21. $\sin\theta = \frac{4}{\sqrt{17}}$, $\csc\theta = \frac{\sqrt{17}}{4}$, $\cos\theta = \frac{1}{\sqrt{17}}$, $\sec\theta = \sqrt{17}$, $\tan\theta = 4$, $\cot\theta = \frac{1}{4}$

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

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

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

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

31. 60° **33.** 45° **35.** 45° **37.** 68° **39.** 40° **41.** 11.6°

43. QII **45.** QII

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

49. $\sin\theta = \frac{-\sqrt{2}}{2}; \cos\theta = \frac{\sqrt{2}}{2}; \tan\theta = -1$

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

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

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

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

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

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

63. $52° + 360°k$ **65.** $87.5° + 360°k$ **67.** $225° + 360°k$

69. $-107° + 360°k$ **71.** $\frac{\sqrt{3}}{2}, \frac{-1}{2}, -\sqrt{3}$ **73.** $-\frac{1}{2}, \frac{\sqrt{3}}{2}, \frac{1}{\sqrt{3}}$

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

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

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

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

83. QIV, neg., −0.0175 **85.** QIV, neg., −1.6643

87. QIV, neg., −1.5890 **89.** QI, pos., 0.0872

91. a. approx. 144.78 units^2 **b.** 53° **c.** The parallelogram is a rectangle whose area is $A = ab$. **d.** $A = \frac{ab}{2}\sin\theta$

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

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

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

99. $\theta = 113.0° + 360°k$ and $\theta = 293.0° + 360°k$

101. 1890°; $90° + 360°k$ **103.** head first; 900°

105. approx. 701.6° **107.** 343.12 in^2 **109.** Answers will vary.

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

113. about 555.4 ft **115.** $y = -\frac{5}{4}x + 2$

Exercises 5.4, pp. 550–555

1. x; y; origin **3.** x; y; $\frac{y}{x}$, $\sec t$; $\csc t$; $\cot t$ **5.** Answers will vary.

7. (−0.6, −0.8) **9.** $\left(\frac{5}{13}, \frac{-12}{13}\right)$ **11.** $\left(\frac{\sqrt{11}}{6}, \frac{5}{6}\right)$ **13.** $\left(\frac{-\sqrt{11}}{4}, \frac{\sqrt{5}}{4}\right)$

15. (−0.9769, −0.2137) **17.** (−0.9928, 0.1198)

19. $\left(\frac{-\sqrt{3}}{2}, \frac{-1}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right), \left(\frac{\sqrt{3}}{2}, \frac{-1}{2}\right)$

21. $\left(\frac{-\sqrt{11}}{6}, \frac{-5}{6}\right), \left(\frac{-\sqrt{11}}{6}, \frac{5}{6}\right), \left(\frac{\sqrt{11}}{6}, \frac{5}{6}\right)$

23. (−0.3325, 0.9431), (−0.3325, −0.9431), (0.3325, −0.9431)

25. (0.9937, 0.1121), (−0.9937, 0.1121), (−0.9937, −0.1121)

27. $\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$ is on unit circle **29.** $\frac{\pi}{4}, \left(\frac{-\sqrt{2}}{2}, \frac{-\sqrt{2}}{2}\right)$

31. $\frac{\pi}{6}, \left(\frac{-\sqrt{3}}{2}, \frac{-1}{2}\right)$ **33.** $\frac{\pi}{4}, \left(\frac{-\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right)$ **35.** $\frac{\pi}{6}, \left(\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

37. a. $\frac{\sqrt{2}}{2}$ **b.** $\frac{\sqrt{2}}{2}$ **c.** $\frac{-\sqrt{2}}{2}$ **d.** $\frac{-\sqrt{2}}{2}$ **e.** $\frac{\sqrt{2}}{2}$ **f.** $\frac{-\sqrt{2}}{2}$ **g.** $\frac{\sqrt{2}}{2}$ **h.** $\frac{-\sqrt{2}}{2}$ **39. a.** −1 **b.** 1 **c.** 0 **d.** 0

41. a. $\frac{\sqrt{3}}{2}$ **b.** $\frac{-\sqrt{3}}{2}$ **c.** $\frac{-\sqrt{3}}{2}$ **d.** $\frac{\sqrt{3}}{2}$ **e.** $\frac{\sqrt{3}}{2}$ **f.** $\frac{\sqrt{3}}{2}$ **g.** $\frac{-\sqrt{3}}{2}$ **h.** $\frac{\sqrt{3}}{2}$ **43. a.** 0 **b.** 0 **c.** undefined **d.** undefined

45. $\sin t = 0.6, \cos t = -0.8, \tan t = -0.75, \csc t = 1.\overline{6}, \sec t = -1.25, \cot t = -1.3\overline{3}$

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

49. $\sin t = \frac{\sqrt{11}}{6}, \cos t = \frac{5}{6}, \tan t = \frac{\sqrt{11}}{5}, \csc t = \frac{6\sqrt{11}}{11}, \sec t = \frac{6}{5}, \cot t = \frac{5\sqrt{11}}{11}$

51. $\sin t = \frac{\sqrt{21}}{5}, \cos t = \frac{-2}{5}, \tan t = \frac{-\sqrt{21}}{2}, \csc t = \frac{5\sqrt{21}}{21}, \sec t = \frac{-5}{2}, \cot t = \frac{-2\sqrt{21}}{21}$

53. $\sin t = \frac{-2\sqrt{2}}{3}, \cos t = \frac{-1}{3}, \tan t = 2\sqrt{2}, \csc t = \frac{-3\sqrt{2}}{4}, \sec t = -3, \cot t = \frac{\sqrt{2}}{4}$

55. $\sin t = \frac{\sqrt{3}}{2}, \cos t = \frac{1}{2}, \tan t = \sqrt{3}, \csc t = \frac{2\sqrt{3}}{3}, \sec t = 2, \cot t = \frac{\sqrt{3}}{3}$

57. $\sin t = \frac{\sqrt{2}}{2}, \cos t = \frac{-\sqrt{2}}{2}, \tan t = -1, \csc t = \sqrt{2}, \sec t = -\sqrt{2}, \cot t = -1$

59. QI, 0.7 **61.** QIV, 0.7 **63.** QI, 1 **65.** QII, 1.1

67. QII, −0.4 **69.** QIV, −3.1 **71.** $\frac{2\pi}{3}$ **73.** $\frac{7\pi}{6}$ **75.** $\frac{2\pi}{3}$ **77.** $\frac{\pi}{2}$

79. $\frac{3\pi}{4}, \frac{5\pi}{4}$ **81.** $\frac{\pi}{2}, \frac{3\pi}{2}$ **83.** $\frac{3\pi}{4}, \frac{5\pi}{4}$ **85.** $0, \pi$ **87. a.** $\left(\frac{3}{4}, \frac{4}{5}\right)$ **b.** $\left(\frac{-3}{4}, \frac{4}{5}\right)$

89. 2.3416 **91.** 1.7832 **93.** 3.5416

95. a. $\left(\frac{5}{13}, \frac{12}{13}, 1\right), \left(\frac{5}{13}\right)^2 + \left(\frac{12}{13}\right)^2 = \frac{25}{169} + \frac{144}{169} = \frac{169}{169} = 1$; $\sin t = \frac{12}{13}$, $\cos t = \frac{5}{13}$, $\tan t = \frac{12}{5}$, $\csc t = \frac{13}{12}$, $\sec t = \frac{13}{5}$, $\cot t = \frac{5}{12}$

b. $(\frac{7}{25}, \frac{24}{25}, 1)$, $(\frac{7}{25})^2 + (\frac{24}{25})^2 = \frac{49}{625} + \frac{576}{625} = \frac{625}{625} = 1$; $\sin t = \frac{24}{25}$, $\cos t = \frac{7}{25}$, $\tan t = \frac{24}{7}$, $\csc t = \frac{25}{24}$, $\sec t = \frac{25}{7}$, $\cot t = \frac{7}{24}$

c. $(\frac{12}{37}, \frac{35}{37}, 1)$, $(\frac{12}{37})^2 + (\frac{35}{37})^2 = \frac{144}{1369} + \frac{1225}{1369} = \frac{1369}{1369} = 1$; $\sin t = \frac{35}{37}$, $\cos t = \frac{12}{37}$, $\tan t = \frac{35}{12}$, $\csc t = \frac{37}{35}$, $\sec t = \frac{37}{12}$, $\cot t = \frac{12}{35}$

d. $(\frac{9}{41}, \frac{40}{41}, 1)$, $(\frac{9}{41})^2 + (\frac{40}{41})^2 = \frac{81}{1681} + \frac{1600}{1681} = \frac{1681}{1681} = 1$; $\sin t = \frac{40}{41}$, $\cos t = \frac{9}{41}$, $\tan t = \frac{40}{9}$, $\csc t = \frac{41}{40}$, $\sec t = \frac{41}{9}$, $\cot t = \frac{9}{40}$

97. **a.** 5 rad **b.** 30 rad **99.** **a.** 5 dm **b.** ≈6.28 dm
101. **a.** 2.5 AU **b.** ≈6.28 AU **103.** yes
105. range of $\sin t$ and $\cos t$ is $[-1, 1]$
107. **a.** $2t \approx 2.2$ **b.** QI **c.** $\cos t \approx 0.5$ **d.** No
109. **a.** $d = 10$ **b.** midpoint: $(1, -1)$ **c.** $m = \frac{3}{4}$
111. **a.** $x = -6, 4$ **b.** $x = 24$

Mid-Chapter Check, p. 555

1. **a.** 36.11°N, 115.08°W **b.** 2495.7 mi
2. $\theta = 4.3$; $A = 860\ \text{cm}^2$ **3.** **a.** $\frac{1}{\sqrt{3}}$ **b.** $\frac{-\sqrt{2}}{2}$
4. **a.** ≈1.0353 **b.** ≈8.9152
5. $y = \frac{-2}{3}$, $\sin\theta = \frac{-2}{3}$, $\csc\theta = \frac{-3}{2}$, $\cos\theta = \frac{-\sqrt{5}}{3}$, $\sec\theta = \frac{-3}{\sqrt{5}}$, $\tan\theta = \frac{2}{\sqrt{5}}$, $\cot\theta = \frac{\sqrt{5}}{2}$
6. 221.8°, 3.8711 **7.** $b = 7\sqrt{3}$ cm, $c = 14$ cm
8. approximately 367 ft **9.** **a.** QIV **b.** $2\pi - 5.94 \approx 0.343$ **c.** $\sin t$, $\tan t$
10. approximately 3 ft 5.6 in.

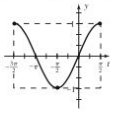
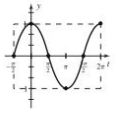
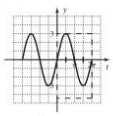
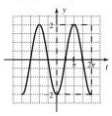
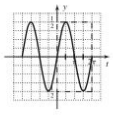
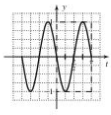
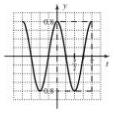
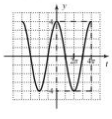
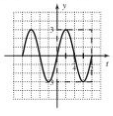
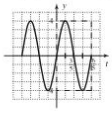
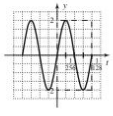
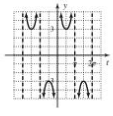
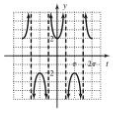
Reinforcing Basic Concepts, p. 556

1. $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$, $\cos t = -\frac{1}{2}$, $\sin t = \frac{\sqrt{3}}{2}$ **2.** $t = \frac{5\pi}{6}$, negative since $x < 0$
3. QIV, negative since $y < 0$ **4.** QI, $\cos t = \frac{1}{2}$, $\sin t = \frac{\sqrt{3}}{2}$, $t = \frac{\pi}{3}$

Exercises 5.5, pp. 568–573

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

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

9. **a.** II **b.** V **c.** IV **d.** I **e.** III
11. 
13. 
15. $|A| = 3$, $P = 2\pi$ 
17. $|A| = 2$, $P = 2\pi$ 
19. $|A| = \frac{1}{2}$, $P = 2\pi$ 
21. $|A| = 1$, $P = \pi$ 
23. $|A| = 0.8$, $P = \pi$ 
25. $|A| = 4$, $P = 4\pi$ 
27. $|A| = 3$, $P = \frac{1}{2}$ 
29. $|A| = 4$, $P = \frac{6}{5}$ 
31. $|A| = 2$, $P = \frac{1}{128}$ 
33. 
35. 
37. $|A| = 2$, $P = \frac{\pi}{2}$, k

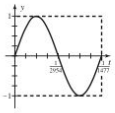
39. $|A| = 3$, $P = \pi$, f **41.** $P = 4\pi$, h **43.** $|A| = \frac{3}{4}$, $P = 5\pi$, b
45. $P = \frac{1}{4}$, j **47.** $|A| = 4$, $P = \frac{1}{72}$, d **49.** $y = -\frac{3}{4}\cos(8t)$
51. $y = -0.2\csc(\frac{1}{2}t)$ **53.** $y = 6\cos\left(\frac{2\pi}{3}t\right)$
55. red: $y = -\cos x$; blue: $y = \sin x$; $x = \frac{3\pi}{4}, \frac{7\pi}{4}$
57. red: $y = -2\cos x$; blue: $y = 2\sin(3x)$; $x = \frac{3\pi}{8}, \frac{3\pi}{4}, \frac{7\pi}{8}, \frac{11\pi}{8}, \frac{7\pi}{4}, \frac{15\pi}{8}$
59. $\cos t = \frac{112}{113}$, (15, 112, 113)
61. **a.** 3 ft **b.** 80 mi **c.** $h = 1.5\cos\left(\frac{\pi}{40}x\right)$
63. **a.** $D = -4\cos\left(\frac{\pi}{12}t\right)$ **b.** $D \approx 3.86$ **c.** 72°
65. **a.** $D = 15\cos(\pi t)$ **b.** at center **c.** Swimming leisurely. One complete cycle in 2 sec **67.** **a.** Graph a **b.** 76 days **c.** 96 days
69. **a.** 480 nm → blue **b.** 620 nm → orange
71. $I = 30\sin(50\pi t)$, $I \approx 21.2$ amps

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

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

avg. value = 3; shifted up 3 units; avg. value = 1; amplitude is "centered" on average value.

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



77. distance $= \frac{200}{\sqrt{3}}$ yd $\approx$ 115.5 yd

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

Exercises 5.6, pp. 582–587

1. π; $P = \frac{\pi}{|B|}$ **3.** odd, $-f(t)$; -0.268 **5. a.** use $\frac{\cos t}{\sin t}$ **b.** use reciprocals of $\tan t$ **7.** 0, $\frac{1}{\sqrt{3}}$, 1, $\sqrt{3}$, und.

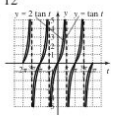
9. 1.6, 0.8, 0.5, 1.4, 0.7, 1.2 **11. a.** -1 **b.** $\sqrt{3}$ **c.** -1 **d.** $\sqrt{3}$

13. a. $\frac{7\pi}{4}$ **b.** $\frac{7\pi}{6}$ **c.** $\frac{5\pi}{3}$ **d.** $\frac{3\pi}{4}$ **15.** und., $\sqrt{3}$, 1, $\frac{1}{\sqrt{3}}$, 0

17. $\frac{-13\pi}{24}, \frac{35\pi}{24}, \frac{59\pi}{24}$ **19.** $-1.6, 4.6, 7.8$ **21.** $\frac{\pi}{10} + \pi k, k \in Z$

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

25.



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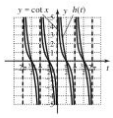

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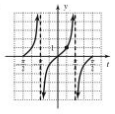

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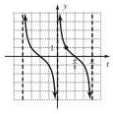

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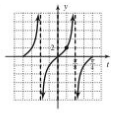

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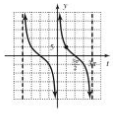

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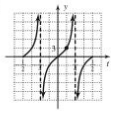

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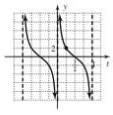


41. $y = 3 \tan\left(\frac{1}{2}t\right)$ **43.** $y = 2 \cot\left(\frac{2\pi}{3}t\right)$ **45.** $\frac{\pi}{8}, \frac{3\pi}{8}$

47. about 137.8 ft

49. $y = 5.2 \tan\left(\frac{\pi}{12}x\right)$; $P = 12$; asymptotes at $x = 6 + 12k, k \in \mathbb{Z}$; using (3, 5.2), $|A| = 5.2$; at $x = 2$, model gives $y \approx 3.002$; at $x = -2$, model gives $y \approx -3.002$; answers will vary.

51. Answers will vary; $y = 11.95 \tan \theta$; $P = 180°$; asymptotes at $\theta = 90° + 180°k$; $|A| = 11.95$ from (30°, 6.9 cm); pen is $\approx$ 12 cm long

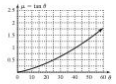
53. a. 20π cm $\approx$ 62.8 cm **b.** 80 cm; it is a square

c.

n	P
10	64.984
20	63.354
30	63.063
100	62.853

getting close to 20π

55.



a. no; $\approx 35°$ **b.** 1.05

c. Angles will be greater than 68.2°; soft rubber on sandstone

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

d. The closer θ gets to 90°, the longer the line segment gets.

59. $[2, 3] \rightarrow \approx 7.1$ m/sec; $[3, 3.5] \rightarrow \approx 26.1$ m/sec; $[3.5, 3.8] \rightarrow \approx 128$ m/sec. The velocity of the beam is increasing dramatically, $[3.9, 3.99] \rightarrow \approx 12{,}733$ m/sec

61. a. x-intercepts: (0, 0), (3, 0); y-intercept: (0, 0); vertical asymptotes: $x = -2$, $x = 2$; horizontal asymptote: $y = \frac{3}{2}$

b. x-intercept: $(-1, 0)$; y-intercept: none; vertical asymptotes: $x = 0$, $x = 4$; horizontal asymptote: $y = 0$

c. x-intercepts: $(-1, 0)$, (1, 0); y-intercept: $\left(0, -\frac{1}{2}\right)$; vertical asymptote: $x = -2$, slant asymptote: $y = x - 2$

63. $\approx$7.37 hr

Exercises 5.7, pp. 596–600

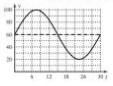
1. $y = A \sin(Bt + C) + D$; $y = A \cos(Bt + C) + D$

3. $0 \le Bt + C < 2\pi$ **5.** Answers will vary.

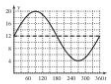
7. a. $|A| = 50$, $P = 24$ **b.** ≈ -25 **c.** [1.6, 10.4]

9. a. $|A| = 200$, $P = 3$ **b.** -175 **c.** [1.75, 2.75]

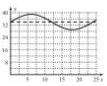
11. $y = 40 \sin\left(\frac{\pi}{15}t\right) + 60$



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



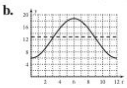
15. a. $y = 5 \sin\left(\frac{\pi}{12}t\right) + 34$ **b.**



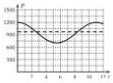
c. $\approx$ 1:30 A.M., 10:30 A.M.

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

b.



c. $\approx$134 days

19. **a.** $P = 11$ yr **b.**  **c.** max = 1200, min = 700 **d.** about 2 yr.

21. $P(t) = 250\cos\left[\frac{2\pi}{11}(t - 2.75)\right] + 950$; $P(t) = 250\sin\left(\frac{2\pi}{11}t\right) + 950$

23. $|A| = 120$; $P = 24$; HS: 6 units right; VS: (none); PI: $6 \le t < 30$

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

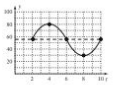
27. $|A| = 1$; $P = 8$; HS: $\frac{2}{3}$ unit right; VS: (none); PI: $\frac{2}{3} \le t < \frac{26}{3}$

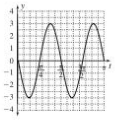
29. $|A| = 24.5$; $P = 20$; HS: 2.5 units right; VS: 15.5 units up; PI: $2.5 \le t < 22.5$

31. $|A| = 28$; $P = 12$; HS: $\frac{5}{2}$ units right; VS: 92 units up; PI: $\frac{5}{2} \le t < \frac{29}{2}$

33. $|A| = 2500$; $P = 8$; HS: $\frac{1}{3}$ unit left; VS: 3150 units up; PI: $-\frac{1}{3} \le t < \frac{23}{3}$

35. $y = 250\sin\left(\frac{\pi}{12}t\right) + 350$ **37.** $y = 5\sin\left(\frac{\pi}{50}t + \frac{\pi}{2}\right) + 13$

39. $y = 4\sin\left(\frac{\pi}{180}t + \frac{\pi}{4}\right) + 7$ **41.** 

43. 

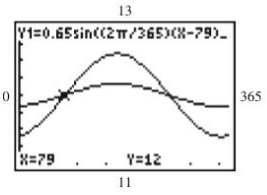
45. $P = \frac{2\pi}{B}$, $B = \frac{2\pi}{P}$; $f = \frac{1}{P}$, $P = \frac{1}{f}$; $B = \frac{2\pi}{1/f} = 2\pi f$.
$A\sin(Bt) = A\sin[(2\pi f)t]$

47. **a.** $P = 4$ sec, $f = \frac{1}{4}$ cycle/sec **b.** -4.24 cm, moving away **c.** -4.24 cm, moving toward **d.** about 1.76 cm. avg. vel. = 3.52 cm/sec, greater, still gaining speed

49. $d(t) = 15\cos\left(\frac{5\pi}{4}t\right)$ **51.** red $\rightarrow D_3$; blue $\rightarrow A\#_3$

53. D_3: $y = \sin[146.84\,(2\pi t)]$; $P \approx 0.0068$ sec;
G_4: $y = \sin[392\,(2\pi t)]$; $P \approx 0.00255$ sec

55. **a.** Caracas: ≈11.4 hr, Tokyo: ≈9.9 hr
b. (i) Same # of hours on 79th day & 261st day
(ii) Caracas: ≈81 days, Tokyo: ≈158 days



57. **a.** Adds 12 hr. The sinusoidal behavior is actually based on hours more/less than an average of 12 hr of light.
b. Means 12 hr of light and dark on March 20, day 79 (Solstice!).
c. Additional hours of deviation from average. In the north, the planet is tilted closer toward the Sun or farther from Sun, depending on date. Variations will be greater!

59. QIII; $3.7 - \pi \approx 0.5584$

61. sum: -2, difference: $2i\sqrt{5}$, product: 6, quotient: $\frac{-2}{3} - \frac{i\sqrt{5}}{3}$

Summary and Concept Review, pp. 601–608

1. $147.61\overline{3}$ **2.** $32°52'12''$ **3.** $10.125 \times 13.5 \times 16.875$

4. approx. 692.82 yd **5.** 120° **6.** $\frac{7\pi}{6}$ **7.** approx. 4.97 units **8.** $-\frac{1}{2}$

9. $s = 25.5$ cm, $A = 191.25$ cm^2 **10.** $r \approx 41.74$ in., $A \approx 2003.48$ in^2

11. $\theta = 4.75$ rad, $s = 38$ m **12.** **a.** approx. 9.4248 rad/sec **b.** approx. 3.9 ft/sec **c.** about 15.4 sec **13.** **a.** $A \approx 0.80$ **b.** $A \approx 64.3°$

14. **a.** cot 32.6° **b.** cos(70°29′45″)

15.

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

16.

Angles	Sides
$A \approx 43.6°$	$a = 20$ m
$B \approx 46.4°$	$c = 21$ m
$C = 90°$	$c = 29$ m

17. approx. 5.18 m **18.** **a.** approx. 239.32 m **b.** approx. 240.68 m apart

19. approx. 54.5° and 35.5° **20.** $207° + 360°k$; answers will vary.

21. 28°, 19°, 30°

22. **a.** $\sin\theta = \frac{35}{37}$, $\csc\theta = \frac{37}{35}$, $\cos\theta = \frac{-12}{37}$, $\sec\theta = \frac{-37}{12}$, $\tan\theta = \frac{-35}{12}$, $\cot\theta = \frac{-12}{35}$
b. $\sin\theta = \frac{-3}{\sqrt{13}}$, $\csc\theta = \frac{-\sqrt{13}}{3}$, $\cos\theta = \frac{2}{\sqrt{13}}$, $\sec\theta = \frac{\sqrt{13}}{2}$, $\tan\theta = \frac{-3}{2}$, $\cot\theta = \frac{-2}{3}$

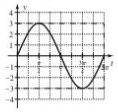
23. **a.** $x = 4$, $y = -3$, $r = 5$; QIV; $\sin\theta = -\frac{3}{5}$, $\csc\theta = -\frac{5}{3}$, $\cos\theta = \frac{4}{5}$, $\sec\theta = \frac{5}{4}$, $\tan\theta = \frac{-3}{4}$, $\cot\theta = \frac{-4}{3}$
b. $x = 5$, $y = -12$, $r = 13$; QIV; $\sin\theta = \frac{-12}{13}$, $\csc\theta = \frac{-13}{12}$, $\cos\theta = \frac{5}{13}$, $\sec\theta = \frac{13}{5}$, $\tan\theta = \frac{-12}{5}$, $\cot\theta = \frac{-5}{12}$

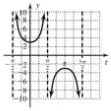
24. **a.** $\theta = 135° + 180°k$ **b.** $\theta = 30° + 360°k$ or $\theta = 330° + 360°k$
c. $\theta \approx 76.0° + 180°k$ **d.** $\theta \approx -27.0° + 360°k$ or $\theta = 207.0° + 360°k$

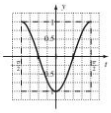
25. $y = -\frac{6}{7}$, $\left(-\frac{\sqrt{13}}{7}, \frac{6}{7}\right)$, $\left(-\frac{\sqrt{13}}{7}, -\frac{6}{7}\right)$, and $\left(\frac{\sqrt{13}}{7}, \frac{6}{7}\right)$

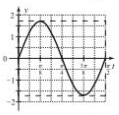
26. $\sin t = -\frac{\sqrt{7}}{4}$, $\csc t = -\frac{4}{\sqrt{7}}$ $\cos t = \frac{3}{4}$, $\sec t = \frac{4}{3}$, $\tan t = -\frac{\sqrt{7}}{3}$, $\cot t = -\frac{3}{\sqrt{7}}$

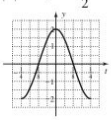
27. $\frac{\pi}{3}$ and $\frac{2\pi}{3}$ **28.** $t \approx 2.44$ **29.** **a.** approx. 19.67 rad **b.** 25 rad

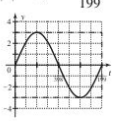
30. $|A| = 3$, $P = 2\pi$ 

31. $P = 2\pi$ 

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

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

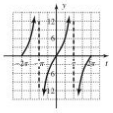
34. $|A| = 2$, $P = \frac{1}{2}$ 

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

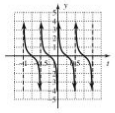
36. $y = 0.75\sin(6t)$ **37.** $y = 4\csc(3\pi t)$ **38.** green, red

39. $\tan\left(\frac{7\pi}{4}\right) = -1$; $\cot\left(\frac{\pi}{3}\right) = \frac{1}{\sqrt{3}}$ **40.** $\theta = \frac{2\pi}{3}$; $\theta = \frac{2\pi}{3}$

41.



42.

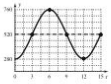


43. $1.55 + k\pi$ radians; $k \in Z$ **44.** 3.5860 **45.** ≈ 151.14 m

46. $y = 5.2\tan\left(\frac{\pi}{12}x\right)$; period $= 12$; $A = 5.2$; asymptotes $x = -6$, $x = 6$

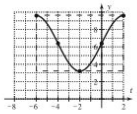
47. a. $|A| = 240$, $P = 12$, HS: 3 units right, VS: 520 units up

b.



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

b.



49. $|A| = 125$, $P = 24$, HS: 3 units right, VS: 175 units up,

$y = 125\cos\left[\frac{\pi}{12}(t-3)\right] + 175$

50. $A = 75$, $P = \frac{3\pi}{8}$, HS: (none), VS: 105 units up,

$y = 75\sin\left(\frac{16}{3}t\right) + 105$ **51. a.** $P(t) = 0.91\sin\left(\frac{\pi}{6}t\right) + 1.35$

b. August: 1.81 in., Dec: 0.44 in.

Mixed Review, pp. 607–609

1. a. $A = 10$ **b.** $D = 15$ **c.** $P = 6$ **d.** $f(4) = 20$

3. $t = \frac{2\pi}{3}$ and $t = \frac{4\pi}{3}$ **5.** 220°48′50″

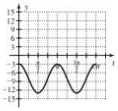
7. $12\sqrt{2}$ in.; $60\sqrt{2} \approx 84.9$ in.

9. arc length: $\frac{28}{3}\pi \approx 29.3$ units; area: $\frac{112\pi}{3} \approx 117.3$ units^2 **11.** 86.915°

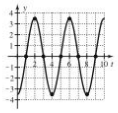
13. $\sin\theta = \frac{-8}{17}$, $\sec\theta = \frac{17}{15}$, $\cos\theta = \frac{15}{17}$,

$\csc\theta = \frac{-17}{8}$, $\tan\theta = \frac{-8}{15}$, $\cot\theta = \frac{-15}{8}$ **15.** 60°

17. a. $|A| = 5$; $P = \pi$; HS: (none); **b.** $|A| = \frac{7}{2}$; $P = 4$; HS: 1 unit right; VS: 8 units down; PI: $0 \le t < \pi$

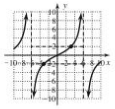


VS: (none); PI: $1 \le t < 5$

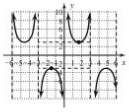


19. a. 6π rad/sec **b.** $20(6\pi)$ cm/sec ≈ 377 cm/sec

c. $|A|$: NA; $P = 4\pi$; HS: none; VS: none; PI: $(-2\pi, 2\pi)$



d. $|A|$: NA; $P = 2\pi$; HS: $\frac{\pi}{2}$ to the right; VS: none; PI: $(-\pi, \pi)$



Practice Test, pp. 609–610

1. complement: 55°; supplement: 145° **2. a.** 45° **b.** 30° **c.** $\frac{\pi}{6}$ **d.** $\frac{\pi}{3}$

3. $30° + 360°k$; $k \in Z$ **4. a.** 100.755° **b.** 48°12′45″

5. a. 430 mi **b.** $215\sqrt{3} \approx 372$ mi

6.

t	$\sin t$	$\cos t$	$\tan t$	$\csc t$	$\sec t$	$\cot t$
0	0	1	0	undefined	1	undefined
$\frac{2\pi}{3}$	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$	$\frac{2\sqrt{3}}{3}$	-2	$\frac{-\sqrt{3}}{3}$
$\frac{7\pi}{6}$	$-\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$	-2	$\frac{-2\sqrt{3}}{3}$	$\sqrt{3}$
$\frac{5\pi}{4}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{2}}{2}$	1	$-\sqrt{2}$	$-\sqrt{2}$	1
$\frac{5\pi}{3}$	$-\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$-\sqrt{3}$	$-\frac{2\sqrt{3}}{3}$	2	$\frac{-\sqrt{3}}{3}$
$\frac{13\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$	2	$\frac{2\sqrt{3}}{3}$	$\sqrt{3}$

7. $\sec\theta = \frac{5}{2}$, $\sin\theta = \frac{-\sqrt{21}}{5}$, $\tan\theta = \frac{-\sqrt{21}}{2}$, $\csc\theta = \frac{-5}{\sqrt{21}}$,

$\cot\theta = \frac{-2}{\sqrt{21}}$

8. $\left(\frac{1}{3}\right)^2 + \left(\frac{-2\sqrt{2}}{3}\right)^2 = \frac{1}{9} + \frac{8}{9} = 1$; $\cos t = \frac{1}{3}$, $\sin t = \frac{2\sqrt{2}}{3}$, $\tan t = 2\sqrt{2}$,

$\sec t = 3$, $\csc t = \frac{3\sqrt{2}}{4}$, $\cot t = \frac{\sqrt{2}}{4}$

9. a. ≈ 225.8 ft or 225 ft 9.6 in. **b.** $\frac{23\pi}{480} \approx 0.1505$ rad/sec

c. 11.29 ft/sec ≈ 7.7 mph

10.

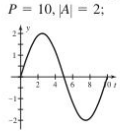
Angles	Sides
$A = 33°$	$a \approx 8.2$ cm
$B = 57°$	$b \approx 12.6$ cm
$C = 90°$	$c = 15.0$ cm

11. about 67 cm, 49.6° **12.** 57.9 m **13. a.** $\frac{7\pi}{6}$ **b.** $\frac{11\pi}{6}$ **c.** $\frac{3\pi}{4}$

14. a. $W(t) = 18.4\sin\left(\frac{\pi}{12}t\right) + 34.1$

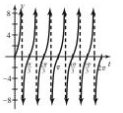
b. 433,000 gal; 249,000 gal

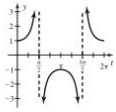
15. a. D: $t \in R$, R: $y \in [-2, 2]$, $P = 10$, $|A| = 2$;



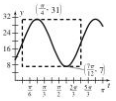
b. D: $t \neq \frac{\pi}{2}(2k+1)$ for $k \in Z$,
R: $y \in (-\infty, -1] \cup [1, +\infty)$, $P = 2\pi$

c. D: $t \neq \frac{\pi}{6}(2k+1)$ for $k \in Z$, R: $y \in R$, $P = \frac{\pi}{3}$



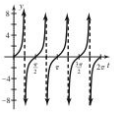


16. $|A| = 12$, $P = \frac{2\pi}{3}$, HS: $\frac{\pi}{12}$ units right, VS: 19 units up
PI: $\frac{\pi}{12} \le t < \frac{3\pi}{4}$

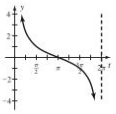


17. 1260°

18. a. D: $t \neq \frac{\pi}{4}(2k+1)$, $k \in Z$; R: $y \in R$; $P = \frac{\pi}{2}$;



b. D: $t \neq 2\pi k$, $k \in Z$; R: $y \in R$, $P = 2\pi$,



19. $y = 7.5 \sin\left(\frac{\pi}{6}t - \frac{\pi}{2}\right) + 12.5$ **20. a.** $t \approx 4$ **b.** $t \approx 2.3$

Strengthening Core Skills, pp. 612–613

Exercise 1:

t	$\mathbf{0}$	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$
$\sin t = y$	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
$\cos t = x$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0
$\tan t = \frac{y}{x}$	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$	—
$\frac{2\pi}{3}$	$\frac{3\pi}{4}$	$\frac{5\pi}{6}$	π	$\frac{7\pi}{6}$	$\frac{5\pi}{4}$
$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$\frac{-1}{2}$	$\frac{-\sqrt{2}}{2}$
$\frac{-1}{2}$	$\frac{-\sqrt{2}}{2}$	$\frac{-\sqrt{3}}{2}$	-1	$\frac{-\sqrt{3}}{2}$	$\frac{-\sqrt{2}}{2}$
$-\sqrt{3}$	-1	$\frac{-\sqrt{3}}{3}$	0	$\frac{\sqrt{3}}{3}$	1

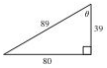
Exercise 2:
a. $t = \frac{4\pi}{3}, \frac{5\pi}{3}$ **b.** $t = \frac{\pi}{4}, \frac{7\pi}{4}$ **c.** $t = \frac{\pi}{6}, \frac{7\pi}{6}$ **d.** $t = \frac{\pi}{4}, \frac{7\pi}{4}$

Exercise 3:
a. no solution **b.** $t \approx 1.2310$, $t \approx 5.0522$ **c.** $t \approx 6.0382$, $t \approx 2.8966$
d. $t \approx 1.9823$, $t \approx 4.3009$

Cumulative Review Chapters 1–5, pp. 613–614

1. $-5 < x < 3$

3.



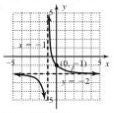
hyp = 89; $\theta \approx 64°$; $90 - \theta = 26°$

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

7. a. D: $x \in \left[\frac{3}{2}, \infty\right)$, R: $y \in [0, \infty)$
b. D: $x \in (-\infty, -7) \cup (-7, 7) \cup (7, \infty)$, R: $y \in (-\infty, \infty)$

9. a. max: $(-2, 4)$, endpoint max: $(4, 0)$
min: $(2, -4)$, endpoint min: $(-4, 0)$
b. $f(x) \ge 0$: $x \in [-4, 0] \cup \{4\}$
$f(x) < 0$: $x \in (0, 4)$
c. $f(x)\uparrow$: $x \in (-4, -2) \cup (2, 4)$
$f(x)\downarrow$: $x \in (-2, 2)$
d. function is odd: $f(-x) = -f(x)$

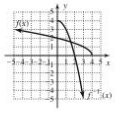
11. ≈ 114.3 ft **13.**



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

17. $S = 18$ m; $A = 135$ m^2 **19.** $y = \frac{3}{2}\sin\left(4t - \frac{\pi}{2}\right) + \frac{1}{2}$

21.



23. $y = \frac{3}{4}x - 2$, $m = \frac{3}{4}$, y-intercept $(0, -2)$

25. about 6.85%

CHAPTER 6

Exercises 6.1, pp. 620–623

1. $\sin\theta$; $\sec\theta$; $\cos\theta$. **3.** one, false **5.** $\frac{1-\sin^2 x}{\sin x \sec x}$; Answers will vary.
7. Answers may vary;
$\tan x = \frac{\sec x}{\csc x}; \frac{\sin x}{\cos x} = \frac{\sec x}{\csc x}; \frac{1}{\cot x} = \frac{\sec x}{\csc x}; \frac{1}{\cot x} = \frac{\sin x}{\cos x}$
9. $1 = \sec^2 x - \tan^2 x$; $\tan^2 x = \sec^2 x - 1$;
$1 = (\sec x + \tan x)(\sec x - \tan x)$; $\tan x = \pm\sqrt{\sec^2 x - 1}$

11. $\sin x \cot x = \cancel{\sin x}\frac{\cos x}{\cancel{\sin x}} = \cos x$

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

15. $\cos x(\sec x - \cos x) = \cos x \sec x - \cos^2 x =$
$\cos x\frac{1}{\cos x} - \cos^2 x = 1 - \cos^2 x = \sin^2 x$

17. $\sin x(\csc x - \sin x) = 1 - \sin^2 x = \cos^2 x$

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

21. $\tan^2 x \csc^2 x - \tan^2 x = \tan^2 x(\csc^2 x - 1) = 1$; $\tan^2 x(\cot^2 x) = 1$

23. $\frac{\sin x \cos x + \sin x}{\cos x + \cos^2 x} = \frac{\sin x(\cancel{\cos x + 1})}{\cos x(\cancel{1 + \cos x})} = \tan x$; $\frac{\sin x}{\cos x} = \tan x$

25. $\frac{1 + \sin x}{\cos x + \cos x \sin x} = \frac{(1)(\cancel{1 + \sin x})}{(\cos x)(\cancel{1 + \sin x})} = \frac{1}{\cos x} = \sec x$

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

29. $\frac{(\sin x + \cos x)^2}{\cos x} = \frac{\sin^2 x + 2\sin x \cos x + \cos^2 x}{\cos x} =$
$\frac{\sin^2 x + \cos^2 x + 2\sin x \cos x}{\cos x} = \frac{1 + 2\sin x \cos x}{\cos x} =$
$\frac{1}{\cos x} + \frac{2\sin x \cos x}{\cos x} = \sec x + 2\sin x$

31. $(1 + \sin x)[1 + \sin(-x)] = (1 + \sin x)(1 - \sin x) = 1 - \sin^2 x = \cos^2 x$

33. $\frac{(\csc x - \cot x)(\csc x + \cot x)}{\tan x} = \frac{\csc^2 x - \cot^2 x}{\tan x} = \frac{1}{\tan x} = \cot x$

35. $\frac{\cos^2 x}{\sin x} + \frac{\sin x}{1} = \frac{\cos^2 x + \sin^2 x}{\sin x} = \frac{1}{\sin x} = \csc x$

37. $\frac{\tan x}{\csc x} - \frac{\sin x}{\cos x} = \frac{\tan x \cos x - \sin x \csc x}{\csc x \cos x} = \frac{\frac{\sin x}{\cancel{\cos x}}\cancel{\cos x} - 1}{\frac{1}{\sin x}\cos x} = \frac{\sin x - 1}{\cot x}$

39. $\frac{\sec x}{\sin x} - \frac{\csc x}{\sec x} = \frac{\sec^2 x - \sin x \csc x}{\sin x \sec x} = \frac{\sec^2 x - 1}{\sin x \frac{1}{\cos x}} = \frac{\tan^2 x}{\cancel{\tan x}} = \tan x$

41. $\frac{\sin x}{\pm\sqrt{1 - \sin^2 x}}$ **43.** $\pm\sqrt{\frac{1}{\cot^2 x} + 1}$ **45.** $\frac{\pm\sqrt{1 - \sin^2 x}}{\sin x}$

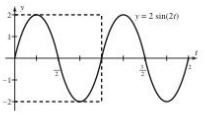
47. $\sin\theta = \frac{21}{29}, \tan\theta = -\frac{21}{20}, \sec\theta = -\frac{29}{20}, \csc\theta = \frac{29}{21}, \cot\theta = -\frac{20}{21}$

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

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

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

55. $\sin\theta = \frac{4\sqrt{2}}{9}, \cos\theta = -\frac{7}{9}, \tan\theta = -\frac{4\sqrt{2}}{7}$,
$\csc\theta = \frac{9}{4\sqrt{2}}, \cot\theta = -\frac{7}{4\sqrt{2}}$ **57.** Answers will vary.
59. Answers will vary. **61.** Answers will vary.
63. a. $A = \frac{nx^2}{4}\cot\left(\frac{\pi}{n}\right)$ **b.** $A = \frac{\cancel{4}(8\text{ m})^2}{\cancel{4}}\cot\left(\frac{\pi}{4}\right) = 64\text{ m}^2 \cdot 1 = 64\text{ m}^2$
c. $A \approx 119.62\text{ in}^2$
65. $\cos^3 x = (\cos x)(\cos^2 x) = (\cos x)(1 - \sin^2 x)$
67. $\tan x + \tan^3 x = (\tan x)(1 + \tan^2 x) = (\tan x)(\sec^2 x)$
69. $\tan^2 x \sec x - 4\tan^2 x = (\tan^2 x)(\sec x - 4)$
$= (\sec x - 4)(\tan^2 x) = (\sec x - 4)(\sec^2 - 1)$
$= (\sec x - 4)(\sec x - 1)(\sec x + 1)$
71. $\cos^2 x \sin x - \cos^2 x = (\cos^2 x)(\sin x - 1)$
$= (1 - \sin^2 x)(\sin x - 1)$
$= (1 + \sin x)(1 - \sin x)(\sin x - 1)$
$= (1 + \sin x)(1 - \sin x)(-1)(1 - \sin x)$
$= (-1)(1 + \sin x)(1 - \sin x)^2$
73. a. $A = nr^2\tan\left(\frac{\pi}{n}\right)$ **b.** $A = 4 \cdot 4^2\tan\left(\frac{\pi}{4}\right) = 64\text{ m}^2$
c. $A \approx 51.45\text{ m}^2$ **75.** $\tan\theta = \frac{1 + m_1 m_2}{m_2 - m_1}$ **77.** $\theta = 45°$
79. $0, \frac{\pi}{3}, \frac{\pi}{2}, \frac{2\pi}{3}, \pi, \frac{3\pi}{2}$ **81.** about 1148 ft
83.



Exercises 6.2, pp. 627–630

1. substituted **3.** complicated; simplify; build
5. Because we don't know if the equation is true. **7.** $\frac{1 + \sin x}{\cos x}$
9. $\cos x$ **11.** $\frac{1 - \cos x}{\sin x}$

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

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

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

19. $\sec\theta + \tan\theta = \dfrac{1}{\cos\theta} + \dfrac{\sin\theta}{\cos\theta}$

$= \dfrac{1+\sin\theta}{\cos\theta}$

$= \dfrac{(1+\sin\theta)(1-\sin\theta)}{\cos\theta(1-\sin\theta)}$

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

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

$= \dfrac{\cos\theta}{1-\sin\theta}$

21. $\dfrac{1-\sin x}{\cos x} = \dfrac{(1-\sin x)(1+\sin x)}{\cos x(1+\sin x)}$

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

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

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

23. $\dfrac{\csc x}{\cos x} - \dfrac{\cos x}{\csc x} = \dfrac{\csc^2 x - \cos^2 x}{\cos x \csc x}$

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

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

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

25. $\dfrac{\sin x}{1+\sin x} - \dfrac{\sin x}{1-\sin x} = \dfrac{\sin x(1-\sin x) - \sin x(1+\sin x)}{(1+\sin x)(1-\sin x)}$

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

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

$= -2\tan^2 x$

27. $\dfrac{\cot x}{1+\csc x} - \dfrac{\cot x}{1-\csc x} = \dfrac{\cot x(1-\csc x) - \cot x(1+\csc x)}{(1+\csc x)(1-\csc x)}$

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

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

$= \dfrac{2\csc x}{\cot x}$

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

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

$= 2\sec x$

29. $\dfrac{\sec^2 x}{1+\cot^2 x} = \dfrac{\sec^2 x}{\csc^2 x}$

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

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

$= \tan^2 x$

31. $\sin^2 x(\cot^2 x - \csc^2 x) = \sin^2 x \cot^2 x - \sin^2 x \csc^2 x$

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

$= \cos^2 x - 1$

$= -\sin^2 x$

33. $\cos x \cot x + \sin x = \cos x \dfrac{\cos x}{\sin x} + \sin x$

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

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

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

$= \csc x$

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

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

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

$= \sin x$

37. $\dfrac{\sin x - \csc x}{\csc x} = \dfrac{\sin x}{\csc x} - \dfrac{\csc x}{\csc x}$

$= \sin^2 x - 1$

$= -\cos^2 x$

39. $\dfrac{1}{\csc x - \sin x} = \dfrac{1}{(\csc x - \sin x)} \dfrac{\sin x}{\sin x}$

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

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

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

$= \tan x \sec x$

41. $\dfrac{1+\sin x}{1-\sin x} = \dfrac{(1+\sin x)(1+\sin x)}{(1-\sin x)(1+\sin x)}$

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

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

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

$= \sec^2 x + 2\tan x \sec x + \tan^2 x$

$= (\sec x + \tan x)^2$

$= (\tan x + \sec x)^2$

43. $\dfrac{\cos x - \sin x}{1-\tan x} = \dfrac{(\cos x - \sin x)}{(1-\tan x)} \dfrac{(\cos x + \sin x)}{(\cos x + \sin x)}$

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

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

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

$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{\cos x(1-\tan x)(1+\tan x)}$

$= \dfrac{(\cos x - \sin x)(\cos x + \sin x)}{(\cos x - \sin x)(1+\tan x)}$

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

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

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

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

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

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

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

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

59. a. $d^2 = (20 + x \cos\theta)^2 + (20 - x \sin\theta)^2$
$= 400 + 40x \cos\theta + x^2\cos^2\theta + 400 - 40x \sin\theta + x^2\sin^2\theta$
$= 800 + 40x(\cos\theta - \sin\theta) + x^2(\cos^2\theta + \sin^2\theta)$
$= 800 + 40x(\cos\theta - \sin\theta) + x^2$

b. ≈42.2 ft

61. a. $h = \sqrt{\cot x + \tan x}$;
$h \approx 3.76$

b. $\cot x + \tan x = \dfrac{\cos x}{\sin x} + \dfrac{\sin x}{\cos x}$
$= \dfrac{\cos^2 x + \sin^2 x}{\sin x \cos x}$
$= \dfrac{1}{\sin x \cos x}$
$= \csc x \sec x$;
$h = \sqrt{\csc x \sec x}$
$h \approx 3.76$; yes

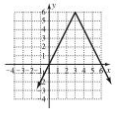
63. $D^2 = 400 + 40x \cos\theta + x^2$
$D \approx 40.5$ ft

65. $\sin\alpha = \cos\theta$ **67.** Answers will vary.

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

71. $\sin t = \dfrac{3}{4}$, $\cos t = \dfrac{\sqrt{7}}{4}$, $\tan t = \dfrac{3}{\sqrt{7}}$

73.



Exercises 6.3, pp. 635–639

1. false; QII **3.** repeat; opposite **5.** Answers will vary.

7. $\dfrac{\sqrt{2} - \sqrt{6}}{4}$ **9.** $\dfrac{\sqrt{2} - \sqrt{6}}{4}$

11. a. $\cos(45° + 30°) = \cos 45° \cos 30° - \sin 45° \sin 30° = \dfrac{\sqrt{6} - \sqrt{2}}{4}$

b. $\cos(120° - 45°) = \cos 120° \cos 45° + \sin 120° \sin 45° = \dfrac{-\sqrt{2} + \sqrt{6}}{4} = \dfrac{\sqrt{6} - \sqrt{2}}{4}$

13. $\cos(5\theta)$ **15.** $\dfrac{\sqrt{3}}{2}$ **17.** $\dfrac{-16}{65}$ **19.** $\sin 33°$ **21.** $\cot\left(\dfrac{\pi}{12}\right)$

23. $\cos\left(\dfrac{\pi}{3} + \theta\right)$ **25.** $\sin(8x)$ **27.** $\tan(3\theta)$ **29.** 1 **31.** $\sqrt{3}$

33. a. $\dfrac{-304}{425}$ **b.** $\dfrac{-304}{297}$ **35.** $\dfrac{\sqrt{6} + \sqrt{2}}{4}$ **37.** $\dfrac{\sqrt{6} + \sqrt{2}}{4}$

39. $-\dfrac{1}{\sqrt{3}} = -\dfrac{\sqrt{3}}{3}$ **41.** $-\sqrt{3}$

43. a. $\sin(45° - 30°) = \sin 45° \cos 30° - \cos 45° \sin 30° = \dfrac{\sqrt{6} - \sqrt{2}}{4}$

b. $\sin(135° - 120°) = \sin 135° \cos 120° - \cos 135° \sin 120°$
$= \left(\dfrac{\sqrt{2}}{2}\right)\left(-\dfrac{1}{2}\right) - \left(\dfrac{-\sqrt{2}}{2}\right)\left(\dfrac{\sqrt{3}}{2}\right)$
$= \dfrac{-\sqrt{2}}{4} + \dfrac{\sqrt{6}}{4}$
$= \dfrac{\sqrt{6} - \sqrt{2}}{4}$

45. $\dfrac{-\sqrt{2} - \sqrt{6}}{4}$ **47. a.** $\dfrac{319}{481}$ **b.** $\dfrac{480}{481}$ **c.** $-\dfrac{319}{360}$

49. a. $\dfrac{3416}{4505}$ **b.** $\dfrac{-1767}{4505}$ **c.** $\dfrac{3416}{2937}$

51. a. $\dfrac{12 + 5\sqrt{3}}{26}$ **b.** $\dfrac{12\sqrt{3} - 5}{26}$ **c.** $\dfrac{12 + 5\sqrt{3}}{12\sqrt{3} - 5}$

53. $(90° - \alpha) + \theta + (90° - \beta) = 180°$ **a.** $\dfrac{247}{265}$ **b.** $\dfrac{96}{265}$ **c.** $\dfrac{247}{96}$

55. $\sin(\pi - \alpha) = \sin\pi\cos\alpha - \cos\pi\sin\alpha$
$= 0 - (-1)\sin\alpha$
$= \sin\alpha$

57. $\cos\left(x+\frac{\pi}{4}\right)=\cos x\cos\left(\frac{\pi}{4}\right)-\sin x\sin\left(\frac{\pi}{4}\right)=$
$\cos x\left(\frac{\sqrt{2}}{2}\right)-\sin x\left(\frac{\sqrt{2}}{2}\right)=\frac{\sqrt{2}}{2}(\cos x-\sin x)$

59. $\tan\left(x+\frac{\pi}{4}\right)=\dfrac{\tan x+\tan\left(\frac{\pi}{4}\right)}{1-\tan x\tan\left(\frac{\pi}{4}\right)}=\dfrac{\tan x+1}{1-\tan x}=\dfrac{1+\tan x}{1-\tan x}$

61. $\cos(\alpha+\beta)+\cos(\alpha-\beta)=$
$\cos\alpha\cos\beta-\cancel{\sin\alpha\sin\beta}+\cos\alpha\cos\beta+\cancel{\sin\alpha\sin\beta}=$
$2\cos\alpha\cos\beta$

63. $\cos(2t)=\cos(t+t)$
$=\cos t\cos t-\sin t\sin t$
$=\cos^2 t-\sin^2 t$

65. $\sin(3t)=\sin(2t+t)$
$=\sin(2t)\cos t+\cos(2t)\sin t$
$=2\sin t\cos t\cos t+(\cos^2 t-\sin^2 t)\sin t$
$=2\sin t\cos^2 t+\sin t\cos^2 t-\sin^3 t$
$=3\sin t\cos^2 t-\sin^3 t$
$=3\sin t(1-\sin^2 t)-\sin^3 t$
$=3\sin t-3\sin^3 t-\sin^3 t$
$=-4\sin^3 t+3\sin t$

67. $\cos\left(x-\frac{\pi}{4}\right)=\cos x\cos\left(\frac{\pi}{4}\right)+\sin x\sin\left(\frac{\pi}{4}\right)$
$=\cos x\left(\frac{\sqrt{2}}{2}\right)+\sin x\left(\frac{\sqrt{2}}{2}\right)$
$=\frac{\sqrt{2}}{2}(\cos x+\sin x)$

69. $F=\dfrac{Wk}{c}\dfrac{1-\sqrt{3}}{1+\sqrt{3}}$

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

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

75. verified using sum identity for sine

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

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

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

85. $P=16$ **87.** about 19.3 ft

Exercises 6.4, pp. 648–652

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

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

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

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

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

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

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

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

21. $\sin(3\theta)=\sin(2\theta+\theta)$
$=\sin(2\theta)\cos\theta+\cos(2\theta)\sin\theta$
$=(2\sin\theta\cos\theta)\cos\theta+(1-2\sin^2\theta)\sin\theta$
$=2\sin\theta\cos^2\theta+\sin\theta-2\sin^3\theta$
$=2\sin\theta(1-\sin^2\theta)+\sin\theta-2\sin^3\theta$
$=2\sin\theta-2\sin^3\theta+\sin\theta-2\sin^3\theta$
$=3\sin\theta-4\sin^3\theta$

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

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

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

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

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

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

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

45. $\frac{\sqrt{2-\sqrt{2+\sqrt{2}}}}{2}$ **47.** $\frac{\sqrt{2-\sqrt{2+\sqrt{3}}}}{2}$ **49.** $\cos 15^\circ$

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

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

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

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

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

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

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

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

75. $2\sin\left(\frac{55}{2}k\right)\cos\left(\frac{27}{2}k\right)$ **77.** $-2\sin x \sin\left(\frac{x}{6}\right)$

79. $2\cos\left(\frac{2061}{2}\pi t\right)\cos\left(\frac{357}{2}\pi t\right)$ **81.** $\frac{-\sqrt{2}}{2}$

83.
$$\frac{2\sin x\cos x}{\cos^2 x - \sin^2 x} = \frac{\sin(2x)}{\cos(2x)} = \tan(2x)$$

85.
$$\begin{aligned}(\sin x + \cos x)^2 &= \sin^2 x + 2\sin x\cos x + \cos^2 x\\ &= \sin^2 x + \cos^2 x + 2\sin x\cos x\\ &= 1 + 2\sin x\cos x\\ &= 1 + \sin(2x)\end{aligned}$$

87.
$$\begin{aligned}\cos(8\theta) &= \cos(2\cdot 4\theta)\\ &= \cos^2(4\theta) - \sin^2(4\theta)\end{aligned}$$

89.
$$\begin{aligned}\frac{\cos(2\theta)}{\sin^2\theta} &= \frac{\cos^2\theta - \sin^2\theta}{\sin^2\theta}\\ &= \frac{\cos^2\theta}{\sin^2\theta} - \frac{\sin^2\theta}{\sin^2\theta}\\ &= \cot^2\theta - 1\end{aligned}$$

91.
$$\begin{aligned}\tan(2\theta) &= \frac{2\tan\theta}{1-\tan^2\theta}\\ &= \frac{(2\tan\theta)\frac{1}{\tan\theta}}{(1-\tan^2\theta)\frac{1}{\tan\theta}}\\ &= \frac{2}{\frac{1}{\tan\theta} - \tan\theta}\\ &= \frac{2}{\cot\theta - \tan\theta}\end{aligned}$$

93.
$$\begin{aligned}2\csc(2x) &= \frac{2}{\sin(2x)}\\ &= \frac{2}{2\sin x\cos x}\\ &= \frac{1}{\sin x\cos x}\\ &= \frac{\sin^2 x + \cos^2 x}{\sin x\cos x}\\ &= \frac{\sin^2 x}{\cancel{\sin x}\cos x} + \frac{\cos^2 x}{\sin x\cancel{\cos x}}\\ &= \frac{\sin x}{\cos x} + \frac{\cos x}{\sin x}\\ &= \tan x + \cot x\end{aligned}$$

95.
$$\begin{aligned}\cos^2\left(\frac{x}{2}\right) - \sin^2\left(\frac{x}{2}\right) &= \cos\left(2\cdot\frac{x}{2}\right)\\ &= \cos x\end{aligned}$$

97.
$$\begin{aligned}1 - 4\sin^2\theta + 4\sin^4\theta &= (1 - 2\sin^2\theta)^2\\ &= [\cos(2\theta)]^2\\ &= \cos^2(2\theta)\\ &= 1 - \sin^2(2\theta)\end{aligned}$$

99.
$$\frac{\sin(120\pi t) + \sin(80\pi t)}{\cos(120\pi t) - \cos(80\pi t)} = \frac{2\cancel{\sin(100\pi t)}\cos(20\pi t)}{-2\cancel{\sin(100\pi t)}\sin(20\pi t)} = -\frac{\cos(20\pi t)}{\sin(20\pi t)} = -\cot(20\pi t)$$

101.
$$\begin{aligned}&\sin^2\alpha + (1-\cos\alpha)^2 = \sin^2\alpha + 1 - 2\cos\alpha + \cos^2\alpha\\ &= \sin^2\alpha + \cos^2\alpha + 1 - 2\cos\alpha = 1 + 1 - 2\cos\alpha = 2 - 2\cos\alpha\\ &= 2(1-\cos\alpha) = 4\left(\frac{1-\cos\alpha}{2}\right) = 4\sin^2\left(\frac{\alpha}{2}\right) = \left[2\sin\left(\frac{\alpha}{2}\right)\right]^2\end{aligned}$$

103.
$$\begin{aligned}\sin(2\alpha) &= \sin(\alpha+\alpha)\\ &= \sin\alpha\cos\alpha + \cos\alpha\sin\alpha\\ &= \sin\alpha\cos\alpha + \sin\alpha\cos\alpha\\ &= 2\sin\alpha\cos\alpha\\ \tan(\alpha+\beta) &= \tan(\alpha+\alpha)\\ &= \frac{\tan\alpha + \tan\alpha}{1 - \tan\alpha\tan\alpha}\\ &= \tan(2\alpha) = \frac{2\tan\alpha}{1-\tan^2\alpha}\end{aligned}$$

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

107. a. $\mathcal{M} = \frac{2}{\sqrt{2-\sqrt{3}}}$, $\mathcal{M} \approx 3.9$

b. $\mathcal{M} = \frac{2}{\sqrt{2-\sqrt{2}}}$, $\mathcal{M} \approx 2.6$ **c.** $\theta = 60°$

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

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

113.
$$\begin{aligned}d(t) &= \left|6\sin\left(\frac{\pi t}{60}\right)\right|\\ &= \left|6\sin\left(\frac{1}{2}\cdot\frac{\pi t}{30}\right)\right|\\ &= \left|6\left(\pm\sqrt{\frac{1-\cos\left(\frac{\pi t}{30}\right)}{2}}\right)\right|\\ &= 6\sqrt{\frac{1-\cos\left(\frac{\pi t}{30}\right)}{2}}\\ &= \sqrt{36\frac{1-\cos\left(\frac{\pi t}{30}\right)}{2}}\\ &= \sqrt{18\left[1-\cos\left(\frac{\pi t}{30}\right)\right]}\end{aligned}$$

115. a.
$$\begin{aligned}&\sin(2\theta - 90°) + 1\\ &= \sin(2\theta)\cos 90° - \cos(2\theta)\sin 90° + 1\\ &= 0 - \cos(2\theta) + 1\\ &= 1 - \cos(2\theta)\end{aligned}$$

b.
$$\begin{aligned}2\sin^2\theta &= \sin^2\theta + \sin^2\theta\\ &= 1 - \cos^2\theta + \sin^2\theta\\ &= 1 - (\cos^2\theta - \sin^2\theta)\\ &= 1 - \cos(2\theta)\end{aligned}$$

c.
$$\begin{aligned}1 + \sin^2\theta - \cos^2\theta &= 1 - (\cos^2\theta - \sin^2\theta)\\ &= 1 - \cos(2\theta)\end{aligned}$$

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

117. a. ≈ 0.9659; ≈ 0.9659

b.
$$\left(\frac{\sqrt{2+\sqrt{3}}}{2}\right)^2 \stackrel{?}{=} \left(\frac{\sqrt{6}+\sqrt{2}}{4}\right)^2$$
$$\frac{2+\sqrt{3}}{4} \stackrel{?}{=} \frac{6+2\sqrt{12}+2}{16}$$
$$\frac{2+\sqrt{3}}{4} \stackrel{?}{=} \frac{8+4\sqrt{3}}{16}$$
$$\frac{2+\sqrt{3}}{4} = \frac{2+\sqrt{3}}{4}$$

119. Must be a unit circle with θ in radians. Must use a right triangle definition of tangent: $\text{tangent}\left(\frac{\theta}{2}\right) = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{\sin\theta}{1+\cos\theta}$.

121. $x = 1; x = -2; x = -\sqrt{6}; x = \sqrt{6}$

123. $\left(\frac{16}{65}\right)^2 + \left(\frac{63}{65}\right)^2 = \frac{256}{4224} + \frac{3969}{4225} = \frac{4225}{4225} = 1,$

$\tan\theta = \frac{63}{16}; \sec\theta = \frac{65}{16}$

$1 + \left(\frac{63}{16}\right)^2 = \left(\frac{65}{16}\right)^2$

$1 + \frac{3969}{256} = \frac{4225}{256}$

$\frac{256}{256} + \frac{3969}{256} = \frac{4225}{256}$

Mid-Chapter Check, pp. 652–653

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

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

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

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

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

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

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

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

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

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

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

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

Reinforcing Basic Concepts, pp. 653–654

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

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

Exercises 6.5, pp. 665–670

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

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

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

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

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

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

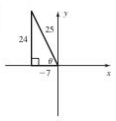
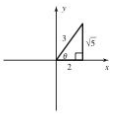
51. $0.9441, 54.1°$ **53.** $-\frac{\pi}{6}$ **55.** $\frac{\sqrt{3}}{3}$ **57.** $\sqrt{2}$ **59.** $-30°$

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

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

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

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

69. $\frac{24}{25}$  **71.** $\frac{\sqrt{5}}{3}$ 

73. $\frac{\sqrt{25-9x^2}}{3x}$  **75.** $\sqrt{\frac{12}{12+x^2}}$ 

77. 0; 2; 30°; -1; π **79.** $\frac{\pi}{6}$ **81.** $\frac{\pi}{6}$ **83.** 80.1° **85.** 67.8°

87. a. $F_N \approx 2.13$ N; $F_N \approx 1.56$ N **b.** $\theta \approx 63°$ for $F_N = 1$ N, $\theta \approx 24.9°$ for $F_N = 2$ N **89.** ≈30° **91.** $\theta \approx 72.3°$; straight line distance; ≈ 157.5 yd

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

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

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

97. a. $\theta \approx 15.5°$; $\theta \approx 0.2705$ rad **b.** ≈29 mi **99. a.** 413.6 ft away

b. −503 ft **c.** ≈651.2 ft **101.** $\sin(2\theta) = \frac{84}{85}$

103. $x \in (-\infty, -3] \cup [0, 3]$

Exercises 6.6, pp. 678–682

1. principal; $[0, 2\pi)$; real **3.** $\frac{\pi}{4}; \frac{\pi}{4}; \frac{3\pi}{4}; \frac{\pi}{4} + 2\pi k; \frac{3\pi}{4} + 2\pi k$

5. Answers will vary. **7. a.** QIV **b.** 2 roots **9. a.** QIV **b.** 2 roots

11.

θ	$\sin\theta$	$\cos\theta$	$\tan\theta$
0	0	1	0
$\frac{\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$
$\frac{\pi}{3}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$
$\frac{\pi}{2}$	1	0	und.
$\frac{2\pi}{3}$	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$
$\frac{5\pi}{6}$	$\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$-\frac{\sqrt{3}}{3}$
π	0	-1	0
$\frac{7\pi}{6}$	$-\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	$\frac{\sqrt{3}}{3}$
$\frac{4\pi}{3}$	$-\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$\sqrt{3}$

13. $\frac{\pi}{4}$ **15.** $-\frac{\pi}{4}$ **17.** $\frac{\pi}{6}$ **19.** $-\frac{\pi}{3}$ **21.** π **23.** $\frac{\pi}{3}$ **25.** $\frac{\pi}{6}$ **27.** $\frac{5\pi}{6}$

29. $\frac{\pi}{6}, \frac{5\pi}{6}$ **31.** $\frac{2\pi}{3}, \frac{5\pi}{3}$ **33.** $\frac{3\pi}{4}, \frac{7\pi}{4}$ **35.** $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$

37. $\frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}, \frac{5\pi}{3}$ **39.** $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$ **41.** $\frac{\pi}{2}, \frac{3\pi}{2}$

43. $\theta = 1.2310 + 2\pi k$ or $5.0522 + 2\pi k$

45. $x = \frac{\pi}{2} + \pi k$ or $\frac{\pi}{6} + 2\pi k$ or $\frac{5\pi}{6} + 2\pi k$

47. $x = \frac{2\pi}{3} + 2\pi k$ or $\frac{4\pi}{3} + 2\pi k$ or $1.4455 + 2\pi k$ or $4.8377 + 2\pi k$

49. $x = \frac{\pi}{6} + \pi k$ or $\frac{5\pi}{6} + \pi k$ **51.** $x = \frac{5\pi}{4} + 2\pi k$ or $\frac{7\pi}{4} + 2\pi k$

53. $x = \frac{3\pi}{4} + 2\pi k$ or $\frac{5\pi}{4} + 2\pi k$ **55.** $x = \frac{3\pi}{4} + \pi k$

57. $x = \frac{\pi}{3} + \pi k$ or $\frac{2\pi}{3} + \pi k$ **59.** $x = \frac{3\pi}{8} + \frac{\pi}{2}k$ **61.** $x = 3\pi + 6\pi k$

63. $x = \frac{\pi}{2} + \pi k$ **65.** $x = \frac{\pi}{6} + \frac{\pi}{3}k$ or $\frac{\pi}{12} + \pi k$ or $\frac{5\pi}{12} + \pi k$

67. a. $x \approx 1.2310$ **b.** $x \approx 1.2310 + 2\pi k$, $5.0522 + 2\pi k$

69. a. $x \approx 1.2094$ **b.** $x \approx 1.2094 + 2\pi k$, $5.0738 + 2\pi k$

71. a. $\theta \approx 0.3649$ **b.** $\theta \approx 0.3649 + \pi k$, $1.2059 + \pi k$

73. a. $\theta \approx 0.8861$ **b.** $\theta \approx 0.8861 + \pi k$, $2.2555 + \pi k$

75. $x = \frac{\pi}{6} + \pi k$ or $\frac{5\pi}{6} + \pi k$ **77.** $x = \frac{2\pi}{9} + \frac{4\pi}{3}k$ or $\frac{10\pi}{9} + \frac{4\pi}{3}k$

79. $\theta = \frac{\pi}{2}k$ **81.** $\theta \approx 0.3398 + 2\pi k$ or $2.8018 + 2\pi k$ **83.** $x \approx 0.7290$

85. $x \approx 2.6649$ **87.** $x \approx 0.4566$ **89.** 22.1° and 67.9°

91. 0°; the ramp is horizontal. **93.** 30.7°; smaller

95. $\alpha = 35°, \beta \approx 25.5°$ **97.** $k \approx 1.36, \alpha \approx 20.6°$ **99. a.** 7 in.

b. ≈1.05 in. and ≈5.24 in. **101.** 1.1547 **103.** $\frac{\pi}{2} + \pi k$, explanations will vary.

105. $f(2+i) = (2+i)^2 - 4(2+i) + 5$
$= 4 + 4i + i^2 - 8 - 4i + 5$
$= 4 + 4i - 1 - 8 - 4i + 5 = 0$

Exercises 6.7, pp. 687–690

1. $\sin^2 x + \cos^2 x = 1$; $1 + \tan^2 x = \sec^2 x$; $1 + \cot^2 x = \csc^2 x$

3. factor; grouping **5.** Answers will vary. **7.** $\frac{\pi}{12}, \frac{5\pi}{12}$ **9.** 0

11. 0.4456, 1.1252 **13.** $\frac{\pi}{4}, \frac{5\pi}{4}, \frac{\pi}{6}, \frac{5\pi}{6}$ **15.** $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$, 0.8411, 5.4421

17. $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$ **19.** $\frac{\pi}{6}, \frac{5\pi}{6}$, 0.7297, 2.4119 **21.** $\frac{2\pi}{3}$

23. $\frac{\pi}{9} + \frac{2\pi}{3}k, \frac{5\pi}{9} + \frac{2\pi}{3}k$; $k = 0, 1, 2$ **25.** $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$

27. $P = 12$; $x = 3$; $x = 11$ **29.** $P = 24$; $x \approx 0.4909$, $x \approx 5.5091$

31. $\frac{\pi}{12}, \frac{17\pi}{12}$ **33.** 0.3747, 5.9085, 2.7669, 3.5163

35. $\frac{\pi}{2}\left(\frac{3\pi}{2}\text{ is extraneous}\right)$ **37.** $\frac{3\pi}{4}, \frac{7\pi}{4}$ **39.** $\frac{\pi}{12}, \frac{5\pi}{12}, \frac{13\pi}{12}, \frac{17\pi}{12}$

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

c. verified

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

c. verified

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

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

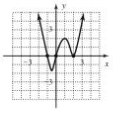
45. a. ≈78.53 m^3/sec **b.** during the months of August, September, October, and November **47. a.** ≈$3554.52 **b.** during the months of May, June, July, and August **49. a.** ≈12.67 in. **b.** during the months of April, May, June, July, and August **51. a.** ≈8.39 gal **b.** approx. day 214 to day 333 **53. a.** 68 bpm **b.** ≈176.2 bpm

c. from about 4.6 min to 7.4 min

55. a. $y = 19\cos\left(\pi - \frac{\pi}{6}x\right) + 53$ **b.** $y = -21\sin\left(\frac{2\pi}{365}x\right) + 29$

57. a. $L \approx 25.5$ cm. **b.** $\theta \approx 38.9°$ or $33.4°$, depending on what side you consider the base.

59. $(-1, 0)$, $(0, 0)$, $(2, 0)$ (multiplicity 2): up/up;



61. $\theta \approx 4.56°$

Summary and Concept Review, pp. 691–695

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

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

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

4. $\dfrac{\sec^2 x}{\csc x} - \sin x = \dfrac{\sec^2 x - \sin x \csc x}{\csc x}$
$= \dfrac{\sec^2 x - 1}{\csc x}$
$= \dfrac{\tan^2 x}{\csc x}$

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

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

7. $\dfrac{1 + \cos x}{\sin x}$; answers will vary. **8.** $\sec x - \tan x$; answers will vary.

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

10. $\dfrac{\cot x}{\sec x} - \dfrac{\csc x}{\tan x} = \cot x \dfrac{1}{\sec x} - \cot x \csc x$
$= \cot x \cos x - \cot x \csc x$
$= \cot x(\cos x - \csc x)$

11. $\dfrac{\sin^4 x - \cos^4 x}{\sin x \cos x} = \dfrac{(\sin^2 x - \cos^2 x)(\sin^2 x + \cos^2 x)}{\sin x \cos x}$
$= \dfrac{(\sin^2 x - \cos^2 x)(1)}{\sin x \cos x}$
$= \dfrac{\sin x \cancel{\sin x}}{\cancel{\sin x} \cos x} - \dfrac{\cancel{\cos x} \cos x}{\sin x \cancel{\cos x}}$
$= \dfrac{\sin x}{\cos x} - \dfrac{\cos x}{\sin x}$
$= \tan x - \cot x$

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

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

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

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

b. $\sin\left(\dfrac{-\pi}{12}\right) = \dfrac{\sqrt{2} - \sqrt{6}}{4}$ **15. a.** $\cos 180° = -1$ **b.** $\sin 120° = \dfrac{\sqrt{3}}{2}$

16. a. $\cos x$ **b.** $\sin\left(\dfrac{5x}{8}\right)$ **17. a.** $\cos 1170° = \cos 90° = 0$

b. $\sin\left(\dfrac{57\pi}{4}\right) = \sin\left(\dfrac{\pi}{4}\right) = \dfrac{\sqrt{2}}{2}$ **18. a.** $\cos\left(\dfrac{x}{8}\right) = \sin\left(\dfrac{\pi}{2} - \dfrac{x}{8}\right)$

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

19. $\tan(45° - 30°) = \dfrac{\tan 45° - \tan 30°}{1 + \tan 45° \tan 30°}$
$= \dfrac{1 - \dfrac{\sqrt{3}}{3}}{1 + 1 \cdot \dfrac{\sqrt{3}}{3}} = \dfrac{1 - \dfrac{\sqrt{3}}{3}}{1 + \dfrac{\sqrt{3}}{3}} = \dfrac{\dfrac{3 - \sqrt{3}}{3}}{\dfrac{3 + \sqrt{3}}{3}}$
$= \dfrac{3 - \sqrt{3}}{\cancel{3}} \cdot \dfrac{\cancel{3}}{3 + \sqrt{3}} = \dfrac{3 - \sqrt{3}}{3 + \sqrt{3}} = \dfrac{\cancel{\sqrt{3}}(\sqrt{3} - 1)}{\cancel{\sqrt{3}}(\sqrt{3} + 1)} = \dfrac{\sqrt{3} - 1}{\sqrt{3} + 1}$

$\tan(135° - 120°) = \dfrac{\tan 135° - \tan 120°}{1 + \tan 135° \tan 120°}$
$= \dfrac{-1 + \sqrt{3}}{1 + (-1)(-\sqrt{3})} = \dfrac{\sqrt{3} - 1}{1 + \sqrt{3}} = \dfrac{\sqrt{3} - 1}{\sqrt{3} + 1}$

20. $\cos\left(x + \dfrac{\pi}{6}\right) + \cos\left(x - \dfrac{\pi}{6}\right) = \sqrt{3}\cos x$
$= \cos x \cos\left(\dfrac{\pi}{6}\right) - \sin x \sin\left(\dfrac{\pi}{6}\right) + \cos x \cos\left(\dfrac{\pi}{6}\right) + \sin x \sin\left(\dfrac{\pi}{6}\right)$
$= 2\cos x \cos\left(\dfrac{\pi}{6}\right) + 0 = 2\cos x\left(\dfrac{\sqrt{3}}{2}\right) = \sqrt{3}\cos x$

21. a. $\sin(2\theta) = 2\left(\dfrac{-84}{85}\right)\left(\dfrac{13}{85}\right) = \dfrac{-2184}{7225}$
$\cos(2\theta) = \left(\dfrac{13}{85}\right)^2 - \left(\dfrac{84}{85}\right)^2 = \dfrac{-6887}{7225}$
$\tan(2\theta) = \dfrac{2184}{-7225}\left(\dfrac{7225}{-6887}\right) = \dfrac{2184}{6887}$

b. $\sin(2\theta) = 2\left(\dfrac{-20}{29}\right)\left(\dfrac{-21}{29}\right) = \dfrac{840}{841}$
$\cos(2\theta) = \left(\dfrac{-21}{29}\right)^2 - \left(\dfrac{-20}{29}\right)^2 = \dfrac{441 - 400}{841} = \dfrac{41}{841}$
$\tan(2\theta) = \dfrac{2\left(\dfrac{20}{21}\right)}{1 - \left(\dfrac{20}{21}\right)^2} = \dfrac{840}{41}$

22. a. $\sin\theta = \dfrac{21}{29}$, $\cos\theta = \dfrac{-20}{29}$, $\tan\theta = -\dfrac{21}{20}$,

b. $\sin\theta = \dfrac{7}{25}$ or $\sin\theta = \dfrac{24}{25}$, $\cos\theta = \dfrac{-24}{25}$ or $\cos\theta = \dfrac{-7}{25}$, $\tan\theta = \dfrac{-7}{24}$ or $\tan\theta = \dfrac{-24}{7}$

23. a. $\cos 45° = \dfrac{\sqrt{2}}{2}$ **b.** $\cos\left(\dfrac{\pi}{6}\right) = \dfrac{\sqrt{3}}{2}$

24. a. $\sin 67.5 = \sqrt{\frac{1-\cos 135^\circ}{2}} = \sqrt{\frac{1+\frac{\sqrt{2}}{2}}{2}} = \sqrt{\frac{2+\sqrt{2}}{4}} = \frac{\sqrt{2+\sqrt{2}}}{2}$

$\cos 67.5 = \sqrt{\frac{1+\cos 135^\circ}{2}} = \sqrt{\frac{1-\frac{\sqrt{2}}{2}}{2}} = \sqrt{\frac{2-\sqrt{2}}{4}} = \frac{\sqrt{2-\sqrt{2}}}{2}$

b. $\sin\left(\frac{5\pi}{8}\right) = \sqrt{\frac{1-\cos\left(\frac{5\pi}{4}\right)}{2}} = \sqrt{\frac{1+\frac{\sqrt{2}}{2}}{2}} = \sqrt{\frac{2+\sqrt{2}}{4}} = \frac{\sqrt{2+\sqrt{2}}}{2}$

$\cos\left(\frac{5\pi}{8}\right) = -\sqrt{\frac{1+\cos\left(\frac{5\pi}{4}\right)}{2}} = -\sqrt{\frac{1-\frac{\sqrt{2}}{2}}{2}} = -\sqrt{\frac{2-\sqrt{2}}{4}} = -\frac{\sqrt{2-\sqrt{2}}}{2}$

25. a. $\sin\left(\frac{\theta}{2}\right) = \sqrt{\frac{1-24/25}{2}} = \sqrt{\frac{25-24}{50}} = +\frac{1}{5\sqrt{2}}, \frac{\theta}{2}$ in QII

$\cos\left(\frac{\theta}{2}\right) = -\sqrt{\frac{1+24/25}{2}} = -\sqrt{\frac{25+24}{50}} = -\sqrt{\frac{49}{50}} = \frac{-7}{5\sqrt{2}}, \frac{\theta}{2}$ in QII

b. $\sin\left(\frac{\theta}{2}\right) = -\sqrt{\frac{1-56/65}{2}} = -\sqrt{\frac{65-56}{130}} = -\sqrt{\frac{9}{130}} = \frac{-3}{\sqrt{130}}, \frac{\theta}{2}$ in QIV

$\cos\left(\frac{\theta}{2}\right) = \sqrt{\frac{1+56/65}{2}} = \sqrt{\frac{65+56}{130}} = \sqrt{\frac{121}{130}} = +\frac{11}{\sqrt{130}}, \frac{\theta}{2}$ in QIV

26. $\frac{\cos(3\alpha)-\cos\alpha}{\cos(3\alpha)+\cos\alpha} = \frac{-2\sin(2\alpha)\sin\alpha}{2\cos(2\alpha)\cos\alpha} = \frac{-2\sin^2\alpha}{\cos^2\alpha-\sin^2\alpha} = \frac{2\sin^2\alpha}{\sin^2\alpha-\cos^2\alpha} = \frac{2\sin^2\alpha}{1-2\cos^2\alpha} = \frac{2\tan^2\alpha}{\sec^2\alpha-2}$

27. $\cos(3x)+\cos x = 0 \to 2\cos(2x)\cos x = 0$

$\cos(2x) = 0$: $x = \frac{\pi}{4} + \frac{\pi}{2}k; k \in \mathbb{Z}$

$\cos x = 0$: $x = \frac{\pi}{2} + \pi k; k \in \mathbb{Z}$

28. a. $A = 12^2\sin\left(\frac{30^\circ}{2}\right)\cos\left(\frac{30^\circ}{2}\right) = 144\sqrt{\frac{1-\cos 30^\circ}{2}}\sqrt{\frac{1+\cos 30^\circ}{2}} = 144\sqrt{\frac{1-\frac{\sqrt{3}}{2}}{2}}\sqrt{\frac{1+\frac{\sqrt{3}}{2}}{2}} = 144\sqrt{\frac{2-\sqrt{3}}{4}}\sqrt{\frac{2+\sqrt{3}}{4}} = \frac{144\sqrt{4-3}}{4} = 36\text{ cm}^2$; yes

b. $x^2\sin\left(\frac{\theta}{2}\right)\cos\left(\frac{\theta}{2}\right)$

Let $u = \frac{\theta}{2}$, then $x^2\sin u\cos u = \frac{1}{2}x^2(2\sin u\cos u) = \frac{1}{2}x^2\sin(2u)$

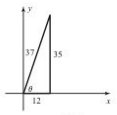
$= \frac{1}{2}x^2\sin\theta$; $A = \frac{1}{2}(12)^2\sin(30^\circ) = 72\left(\frac{1}{2}\right) = 36\text{ cm}^2$; yes

29. $\frac{\pi}{4}$ or 45° **30.** $\frac{\pi}{6}$ or 30° **31.** $\frac{5\pi}{6}$ or 150° **32.** 1.3431 or 77.0°

33. 1.0956 or 62.8° **34.** 0.5054 or 29.0° **35.** $\frac{1}{2}$ **36.** $\frac{\pi}{4}$

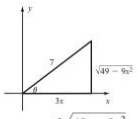
37. undefined **38.** 1.0245 **39.** 60° **40.** $\frac{3\pi}{4}$

41.



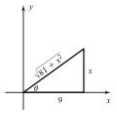
$\sin\theta = \frac{35}{37}$

42.



$\tan\theta = \frac{\sqrt{49-9x^2}}{3x}$

43.



$\cot\theta = \frac{9}{x}$

44. $\theta = \cos^{-1}\left(\frac{x}{5}\right)$ **45.** $\theta = \sec^{-1}\left(\frac{x}{7\sqrt{3}}\right)$

46. $\theta = \sin^{-1}\left(\frac{x}{4}\right) + \frac{\pi}{6}$

47. a. $\frac{\pi}{4}$ **b.** $\frac{\pi}{4}, \frac{3\pi}{4}$ **c.** $x = \frac{\pi}{4} + 2\pi k$ or $\frac{3\pi}{4} + 2\pi k, k \in \mathbb{Z}$

48. a. $\frac{2\pi}{3}$ **b.** $\frac{2\pi}{3}, \frac{4\pi}{3}$ **c.** $\frac{2\pi}{3} + 2\pi k$ or $\frac{4\pi}{3} + 2\pi k, k \in \mathbb{Z}$

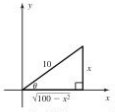
49. a. $-\frac{\pi}{3}$ **b.** $\frac{2\pi}{3}, \frac{5\pi}{3}$ **c.** $\frac{2\pi}{3} + \pi k, k \in \mathbb{Z}$

50. a. ≈1.1102 **b.** ≈1.1102, 5.1729 **c.** ≈1.1102 + $2\pi k$ or 5.1729 + $2\pi k, k \in \mathbb{Z}$ **51. a.** ≈0.3376 **b.** ≈0.3376, 1.2332, 3.4792, 4.3748 **c.** ≈0.3376 + πk or 1.2332 + $\pi k, k \in \mathbb{Z}$ **52. a.** ≈0.3614 **b.** ≈0.3614, 2.7802 **c.** ≈0.3614 + $2\pi k$ or 2.7802 + $2\pi k, k \in \mathbb{Z}$

Mixed Review, pp. 695–696

1. $\sin\theta = \frac{6}{\sqrt{117}}, \sec\theta = \frac{-\sqrt{117}}{9}, \tan\theta = \frac{-6}{9} = \frac{-2}{3}, \cos\theta = \frac{-9}{\sqrt{117}}, \csc\theta = \frac{\sqrt{117}}{6}, \cot\theta = \frac{-3}{2}$ **3.** $\sqrt{3}+2$

5.



$\tan\theta = \frac{x}{\sqrt{100-x^2}}$

7. $x = 0.4103$; $x = 4.9230$

9. a. $y = 5000\sin\left(\frac{\pi}{3}x + \pi\right) + 9000$ **b.** ≈$4670 **c.** mid-October

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

13. $\frac{3\pi}{4}$ or 135°

15. a. $\sin(2x) = \sin(x+x) = \sin x\cos x + \sin x\cos x = 2\sin x\cos x$

b. $\cos(2x) = \cos(x+x) = \cos x\cos x - \sin x\sin x = \cos^2 x - \sin^2 x$

17. $\theta = \csc^{-1}\left(\frac{x}{2\sqrt{2}}\right) + \frac{\pi}{4}$ **19. a.** $t \approx 0.7754$ **b.** $t \approx 0.7754$, 2.3662 **c.** $t \approx 0.7754 + 2\pi k$ or $2.3662 + 2\pi k$

Practice Test, pp. 697–698

1. $\frac{(\csc x - \cot x)(\csc x + \cot x)}{\sec x} = \frac{\csc^2 x + \csc x \cot x - \csc x \cot x - \cot^2 x}{\sec x}$
$= \frac{\csc^2 x - \cot^2 x}{\sec x}$
$= \frac{(1 + \cot^2 x) - \cot^2 x}{\sec x}$
$= \frac{1}{\sec x}$
$= \cos x$

2. $\frac{\sin^3 x - \cos^3 x}{1 + \cos x \sin x} = \frac{(\sin x - \cos x)(\sin^2 x + \sin x \cos x + \cos^2 x)}{1 + \cos x \sin x}$
$= \frac{(\sin x - \cos x)(1 + \sin x \cos x)}{1 + \cos x \sin x}$
$= \sin x - \cos x$

3. $\sin\theta = \frac{-55}{73}$, $\sec\theta = \frac{73}{48}$, $\cot\theta = \frac{-48}{55}$, $\tan\theta = \frac{-55}{48}$, $\csc\theta = \frac{-73}{55}$

4. $\frac{\sqrt{3} - 1}{\sqrt{3} + 1}$ **5.** $\frac{\sqrt{2}}{2}$ **6.** $\frac{-\sqrt{2}}{2}$

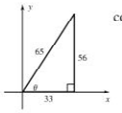
7. $\sin\left(x + \frac{\pi}{4}\right) - \sin\left(x - \frac{\pi}{4}\right)$
$= \sin x \cos\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right) - \sin x \cos\left(\frac{\pi}{4}\right) + \cos x \sin\left(\frac{\pi}{4}\right)$
$= \sin\left(\frac{\pi}{4}\right)\cos x + \sin\left(\frac{\pi}{4}\right)\cos x$
$= 2\sin\left(\frac{\pi}{4}\right)\cos x$
$= 2\frac{\sqrt{2}}{2}\cos x$
$= \sqrt{2}\cos x$

8. $\sin\theta = \frac{15}{17}$, $\cos\theta = \frac{8}{17}$, $\tan\theta = \frac{15}{8}$ **9.** $\frac{-\sqrt{3}}{2}$ **10.** $\frac{1}{\sqrt{37}}; \frac{6}{\sqrt{37}}$

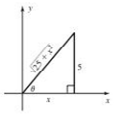
11. $20\sqrt{2 - \sqrt{2}}$ **12.** $\frac{\sqrt{6} - \sqrt{2}}{4} \approx 0.2588; \frac{\sqrt{6} + \sqrt{2}}{4} \approx 0.9659$

13. a. $y = 30°$ **b.** $f(x) = \frac{1}{2}$ **c.** $y = 30°$

14. a. $y = 0.8523$ rad or $y = 48.8°$ **b.** $y = 78.5°$ or $\frac{157\pi}{360}$ rad
c. $y = \frac{7\pi}{24}$ rad or 52.5°

15. 

$\cos\theta = \frac{33}{65}$

16. 

$\cot\theta = \frac{x}{5}$

17. I. a. $\cos^{-1}\left(\frac{-\sqrt{2}}{2}\right) = \frac{3\pi}{4}$ **b.** $x = \frac{3\pi}{4}, \frac{5\pi}{4}$
c. $x = \frac{3\pi}{4} + 2\pi k$ or $\frac{5\pi}{4} + 2\pi k, k \in \mathbb{Z}$ **II. a.** $\frac{\pi}{6}$ **b.** $x = \frac{\pi}{6}, \frac{11\pi}{6}$
c. $x = \frac{\pi}{6} + 2\pi k$ or $\frac{11\pi}{6} + 2\pi k, k \in \mathbb{Z}$ **18. I. a.** $x \approx 0.1922$
b. $x \approx 0.1922, 1.3786, 3.3338, 4.5202$ **c.** $x \approx 0.1922 + \pi k$ or $1.3786 + \pi k, k \in \mathbb{Z}$ **II. a.** $x \approx 0.9204$ **b.** $x \approx 0.9204, 2.2212, 4.0620, 5.3628$ **c.** $x \approx 0.9204 + \pi k$ or $2.2212 + \pi k, k \in \mathbb{Z}$

19. a. $x \approx -1.6875, -0.3413, 1.1321, 2.8967$ **b.** $x \approx 0.9671, 2.6110, 3.4538$ **20. a.** $x = 0, \pi, \frac{7\pi}{6}, \frac{11\pi}{6}$ **b.** $x = \frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$

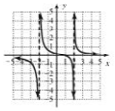
Strengthening Core Skills p. 699

Exercise 1: $x \in (0.6025, 2.5391)$
Exercise 2: $x \in [0, 0.7945] \cup [4.4415, 2\pi]$
Exercise 3: $x \in [0, 2.6154] \cup [9.3847, 12]$
Exercise 4: $x \subset (67.3927, 202.6073)$

Cumulative Review Chapters 1–6, p. 700

1. $\sin\theta = \frac{84}{85}$, $\csc\theta = \frac{85}{84}$, $\cos\theta = \frac{-13}{85}$, $\sec\theta = \frac{-85}{13}$, $\tan\theta = \frac{-84}{13}$, $\cot\theta = \frac{-13}{84}$

3. $g(2 + \sqrt{3}) = (2 + \sqrt{3})^2 - 4(2 + \sqrt{3}) + 1$
$= 4 + 4\sqrt{3} + 3 - 8 - 4\sqrt{3} + 1$
$= 0$

5. about 474 ft **7.** 

9. 50.89 km/hr **11.** $x \in \left[-\frac{9}{2}, \frac{11}{2}\right]$ **13. a.** $y = -\frac{1}{2}x + 31$ **b.** every 2 years, the amount of emissions decreases by 1 million tons.
c. 23.5 million tons; 11 million tons **15.** $x \in (1, 5)$ **17.** \$7

19. $\frac{\cos x}{\sec x - 1} = \frac{\cos x(\sec x + 1)}{(\sec x - 1)(\sec x + 1)}$
$= \frac{1 + \cos x}{\sec^2 x - 1}$
$= \frac{1 + \cos x}{\tan^2 x}$

21. $\frac{99}{101}$

23. a. $y = 5.4\sin\left(\frac{\pi}{6}x - \frac{2\pi}{3}\right) + 27.1$ **b.** from early May until late August

MODELING WITH TECHNOLOGY III

Modeling with Technology III Exercises, pp. 707–710

1. $y = 25\sin\left(\frac{\pi}{6}x\right) + 50$ **3.** $y = 2.25\sin\left(\frac{\pi}{12}x + \frac{\pi}{4}\right) + 5.25$

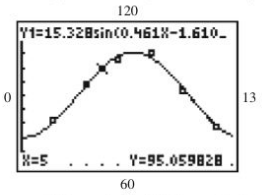
5. $y = 503\sin\left(\frac{\pi}{6}x + \frac{2\pi}{3}\right) + 782$

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

9. a. $T(x) = 0.4 \sin\left(\frac{\pi}{12}x + \frac{13\pi}{12}\right) + 98.6$ **b.** at 11 A.M. and 11 P.M.
c. from $x = 1$ to $x = 9$, about 8 hr

11. $P = 12$, $B = \frac{\pi}{12}$, $C = \frac{\pi}{2}$; using (4, 3) gives $A = -3\sqrt{3}$, so $f(x) = -3\sqrt{3} \tan\left(\frac{\pi}{12}x + \frac{\pi}{2}\right)$ **a.** $f(2.5) \approx 6.77$ **b.** $f(x) = 16$ for $x \approx 1.20$ **13. a.** using (18, 10) gives $A \approx 4.14$; $H(d) = 4.14 \tan\left(\frac{\pi}{48}d\right)$
b. ≈ 12.2 cm **c.** ≈ 21.9 mi

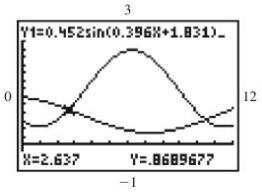
15. a. $y \approx 49.26 \sin(0.213x - 1.104) + 51.43$
b. $y \approx 49 \sin(0.203x - 0.963) + 51$ **c.** at day 31 ≈ 5.6
17. a. $y \approx 5.88 \sin(0.523x - 0.521) + 16.00$
b. $y \approx 6 \sin(0.524x - 0.524) + 16$ **c.** at month 9 ≈ 0.12
19. a. $T(m) \approx 15.328 \sin(0.461m - 1.610) + 85.244$



b.

Month	Temp. (°F)
1	71
3	82
5	95
7	101
9	94
11	80

c. max difference is about 1°F in months 6 and 8
21. a. Reno: $R(t) \approx 0.452 \sin(0.396t + 1.831) + 0.750$
b. The graphs intersect at $t \approx 2.6$ and $t \approx 10.5$. Reno gets more rainfall than Cheyenne for about 4 months of the year: $2.6 + (12 - 10.5) = 4.1$



23. a. $f(x) \approx 49.659 \sin(0.214x - 0.689) + 48.328$ **b.** about 26.8%
c. $g(x) = 49.5 \sin\left(\frac{2\pi}{31}x - \frac{7\pi}{62}\right) + 49.5$; values for A, B, and D are very close; some variation in C.

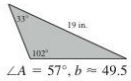
25. a. $D(t) = 2000 \cos\left(\frac{\pi}{60}t\right)$ **b.** 30 min **c.** north, 1258.6 mi.

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

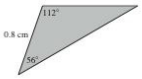
CHAPTER 7

Exercises 7.1, pp. 719–724

1. ambiguous **3.** I; II **5.** Answers will vary. **7.** $a \approx 8.98$
9. $C \approx 49.2°$ **11.** $C \approx 21.4°$ **13.** $\angle C = 78°$, $b \approx 109.5$ cm, $c \approx 119.2$ cm **15.** $\angle C = 90°$, $a = 10$ in., $c = 20$ in.
17.



19. $\angle C = 90°$, $a = 15$ mi, $b = 15$ mi
21. $\angle A = 57°$, $b \approx 49.5$ km, $c \approx 17.1$ km
23.



25. a. 10 cm **b.** 0 **c.** 2 **d.** 1
27. not possible **29.** $B = 60°$, $C = 90°$, $b = 12.9\sqrt{3}$ mi
31. $A \approx 39°$, $B \approx 82°$, $a \approx 42.6$ mi or $A \approx 23°$, $B \approx 98°$, $a \approx 26.4$ mi
33. $A \approx 39°$, $B \approx 82°$, $a \approx 42.6$ ft or $A \approx 23°$, $B \approx 98°$, $a \approx 26.4$ ft
35. not possible **37.** $A \approx 80.0°$, $B \approx 38.0°$, $b \approx 1.8 \times 10^{25}$ mi
39. $A_1 \approx 19.3°$, $A_2 \approx 160.7°$, $48° + 160.7° > 180°$; no second solution possible **41.** $C_1 \approx 71.3°$, $C_2 \approx 108.7°$, $57° + 108.7° < 180°$; two solutions possible
43. not possible, $\sin A > 1$ **45.** $\frac{\sqrt{2}}{2}$
47. 34.6 million miles or 119.7 million miles **49. a.** No **b.** ≈ 3.9 mi
51. $V \leftrightarrow S = 41.7$ km, $V \leftrightarrow P = 80.8$ km
53. a. No **b.** about 201.5 ft **c.** ≈15 sec
55. Two triangles

Angles	Sides
$A_1 \approx 41.1°$	$a = 12$ cm
$B = 26°$	$b = 8$ cm
$C_1 \approx 112.9°$	$c_1 \approx 16.8$ cm

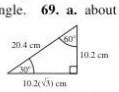
Angles	Sides
$A_2 \approx 138.9°$	$a = 12$ cm
$B = 26°$	$b = 8$ cm
$C_2 \approx 15.1°$	$c_2 \approx 4.8$ cm

57.

Angles	Sides
$A_1 \approx 47.0°$	$a = 9$ cm
$B_1 \approx 109.0°$	$b_1 \approx 11.6$ cm
$C \approx 24°$	$c = 5$ cm

Angles	Sides
$A_2 \approx 133.0°$	$a = 9$ cm
$B_2 = 23.0°$	$b_2 = 4.8$ cm
$C \approx 24°$	$c = 5$ cm

59. $a \approx 33.7$ ft, $c \approx 22.3$ ft **61.** Rhymes to Tarryson: 61.7 km, Sexton to Tarryson: 52.6 km **63.** ≈ 3.2 mi **65.** $h \approx 161.9$ yd
67. angle = 90°; sides ≈ 9.8 cm, 11 cm; diameter ≈ 11 cm; it is a right triangle. **69. a.** about 3187 m **b.** about 2613 m **c.** about 2368 m
71.



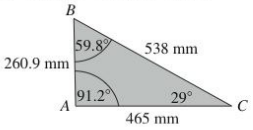
$\sqrt{3} = \frac{\sin 60°}{\sin 30°}$, $\sqrt{2} = \frac{\sin 90°}{\sin 45°}$
73. $A = 19°$, $B = 31°$, $C = 130°$, $a = 45$ cm, $b \approx 71.2$ cm, $c \approx 105.8$ cm
75. ≈12,564 mph
77.

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

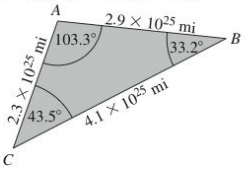
79. a. $y = \frac{5}{9}x - \frac{2}{9}$ **b.** $\sqrt{106}$ units

Exercises 7.2, pp. 731–736

1. cosines **3.** Pythagorean **5.** $B \approx 33.1°$, $C \approx 129.9°$, $a \approx 19.8$ m; law of sines **7.** yes **9.** no **11.** yes **13.** verified **15.** $B \approx 41.4°$
17. $a \approx 7.24$ **19.** $A \approx 41.6°$ **21.** $A \approx 120.4°$, $B \approx 21.6°$, $c \approx 53.5$ cm
23. $A \approx 23.8°$, $C \approx 126.2°$, $b \approx 16$ mi
25.



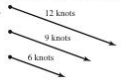
27. $A \approx 137.9°, B \approx 15.6°, C \approx 26.5°$
29. $A \approx 119.3°, B \approx 41.5°, C = 19.2°$
31.



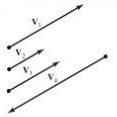
33. $A \approx 139.7°, B \approx 23.7°, C \approx 16.6°$
35. $C \approx 86.3°$ **37.** about 1688 mi **39.** $P \approx 27.7°$; heading 297.7°
41. It cannot be constructed (available length ≈ 10,703.6 ft)
43. 1678.2 mi **45.** $P \approx 22.4$ cm, $A = 135°, B \approx 23.2°, C \approx 21.8°$
47. $A \approx 20.6°, B \approx 15.3°, C \approx 144.1°$ **49.** 58.78 cm
51. $a = 13$ $A \approx 133.2°$ **53.** 33.7°; 150 ft²
$b = 5$ $B \approx 16.3°$
$c = \sqrt{82}$ $C \approx 30.5°$
55. a. 0.65 = 65% **b.** $1,950,000 **57.** about 483,529 km²
59. 387 + 502 = 889 < 902 **61.** (1) $a^2 = b^2 + c^2 - 2bc \cos A$ (2) $b^2 = a^2 + c^2 - 2ac \cos B$, use substitution for a^2 and (2) becomes $b^2 = (b^2 + c^2 - 2bc \cos A) + c^2 - 2ac \cos B$. Then $0 = 2c^2 - 2bc \cos A - 2ac \cos B$, $2bc \cos A + 2ac \cos B = 2c^2$, $b \cos A + a \cos B = c$ **63.** 2
65. $\sin x = \frac{-5}{13}, \csc x = \frac{-13}{5}, \cos x = \frac{12}{13}, \sec x = \frac{13}{12}$, $\tan x = \frac{-5}{12}, \cot x = \frac{-12}{5}$

Exercises 7.3, pp. 747–751

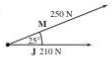
1. scalar **3.** directed; line **5.** Answers will vary.
7.



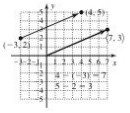
9.



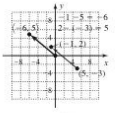
11.



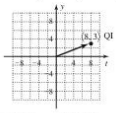
13.



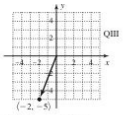
15.



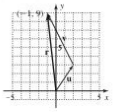
17. Terminal point: $(5, -1)$, magnitude: $\sqrt{53}$
19. Terminal point: $(-1, 1)$, magnitude: $\sqrt{34}$
21. a.

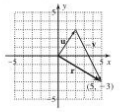


b. $\sqrt{73}$ **c.** 20.6°
23. a.

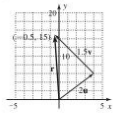


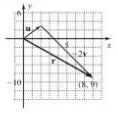
b. $\sqrt{29}$ **c.** 68.2°
25. $\langle -10.9, 5.1 \rangle$ **27.** $\langle 106, -92.2 \rangle$ **29.** $\langle -9.7, -2.6 \rangle$
31. a. $\langle -1, 9 \rangle$ **b.** $\langle 5, -3 \rangle$



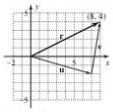


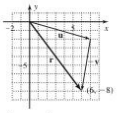
c. $\langle -0.5, 15 \rangle$ **d.** $\langle 8, -9 \rangle$



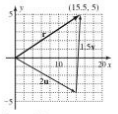


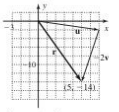
33. a. $\langle 8, 4 \rangle$ **b.** $\langle 6, -8 \rangle$



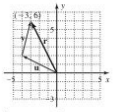


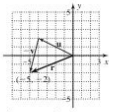
c. $\langle 15.5, 5 \rangle$ **d.** $\langle 5, -14 \rangle$



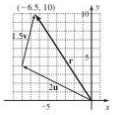


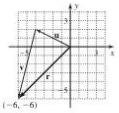
35. a. $\langle -3, 6 \rangle$ **b.** $\langle -5, -2 \rangle$



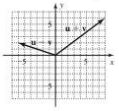


c. $\langle -6.5, 10 \rangle$ **d.** $\langle -6, -6 \rangle$

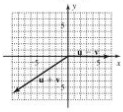




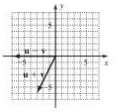
37. True **39.** False **41.** True
43. $\mathbf{u} + \mathbf{v} = \langle 8, 6 \rangle$
$\mathbf{u} - \mathbf{v} = \langle -6, 2 \rangle$



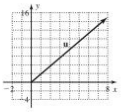
45. $\mathbf{u} + \mathbf{v} = \langle -9, -6 \rangle$
$\mathbf{u} - \mathbf{v} = \langle 7, 0 \rangle$



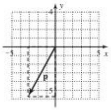
47. $\mathbf{u} + \mathbf{v} = \langle -3, -6 \rangle$
$\mathbf{u} - \mathbf{v} = \langle -7, 0 \rangle$



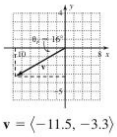
49. $\mathbf{u} = 8\mathbf{i} + 15\mathbf{j}$
$|\mathbf{u}| = 17$



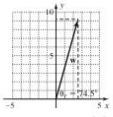
51. $\mathbf{p} = -3.2\mathbf{i} - 5.7\mathbf{j}$
$|\mathbf{p}| \approx 6.54$



53. a.



b. $\mathbf{v} = \langle -11.5, -3.3 \rangle$
c. $\mathbf{v} = -11.5\mathbf{i}, -3.3\mathbf{j}$

55. a. 

b. $\mathbf{w} = \langle 2.5, 9.2 \rangle$ **c.** $\mathbf{w} = 2.5\mathbf{i} + 9.2\mathbf{j}$

57. a. $\mathbf{p} = -2\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| = 2\sqrt{2}$, $\theta = 135°$
b. $\mathbf{q} = 6\mathbf{i} - 8\mathbf{j}$; $|\mathbf{q}| = 10$, $\theta = 306.9°$
c. $\mathbf{r} = -2\mathbf{i} + 1.5\mathbf{j}$; $|\mathbf{r}| = 2.5$, $\theta = 143.1°$
d. $\mathbf{s} = 10\mathbf{i} - 13\mathbf{j}$; $|\mathbf{s}| \approx 16.4$, $\theta = 307.6°$

59. a. $\mathbf{p} = 2\sqrt{2}\mathbf{i} + 2\mathbf{j}$; $|\mathbf{p}| \approx 3.5$, $\theta = 35.3°$
b. $\mathbf{q} = 8\sqrt{2}\mathbf{i} + 12\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 46.7°$
c. $\mathbf{r} = 5.5\sqrt{2}\mathbf{i} + 6.5\mathbf{j}$; $|\mathbf{r}| \approx 10.1$, $\theta \approx 39.9°$
d. $\mathbf{s} = 11\sqrt{2}\mathbf{i} + 17\mathbf{j}$; $|\mathbf{s}| \approx 23.0$, $\theta \approx 47.5°$

61. a. $\mathbf{p} = 8\mathbf{i} + 4\mathbf{j}$; $|\mathbf{p}| \approx 8.9$, $\theta \approx 26.6°$
b. $\mathbf{q} = 16\mathbf{i} + 4\mathbf{j}$; $|\mathbf{q}| \approx 16.5$, $\theta \approx 14.0°$
c. $\mathbf{r} = 18\mathbf{i} + 8\mathbf{j}$; $|\mathbf{r}| \approx 19.7$, $\theta \approx 24.0°$
d. $\mathbf{s} = 20\mathbf{i} + 4\mathbf{j}$; $|\mathbf{s}| \approx 20.4$, $\theta \approx 11.3°$

63. $\left\langle \frac{7}{25}, \frac{24}{25} \right\rangle$, verified **65.** $\left\langle \frac{-20}{29}, \frac{21}{29} \right\rangle$, verified

67. $\frac{20}{29}\mathbf{i} - \frac{21}{29}\mathbf{j}$, verified **69.** $\frac{7}{25}\mathbf{i} + \frac{24}{25}\mathbf{j}$, verified

71. $\left\langle -\frac{13}{\sqrt{178}}, \frac{3}{\sqrt{178}} \right\rangle$, verified **73.** $\frac{6}{\sqrt{157}}\mathbf{i} + \frac{11}{\sqrt{157}}\mathbf{j}$, verified

75. $\approx 4.48\left\langle \frac{5}{\sqrt{29}}, \frac{2}{\sqrt{29}} \right\rangle \approx \langle 4.16, 1.66 \rangle$

77. $\approx 5.83\left\langle \frac{8}{\sqrt{73}}, \frac{-3}{\sqrt{73}} \right\rangle \approx \langle 5.46, -2.05 \rangle$ **79.** ≈ 14.4 **81.** $\approx 24.3°$

83. hor. comp. $\approx$ 79.9 ft/sec; vert. comp. $\approx$ 60.2 ft/sec

85. heading 68.2° at 266.7 mph **87.** $\approx$(82.10 cm, 22.00 cm)

89. $1\langle a, b \rangle = \langle 1a, 1b \rangle = \langle a, b \rangle$

91. $\langle a, b \rangle - \langle c, d \rangle = \langle a - c, b - d \rangle = \langle a + (-c), b + (-d) \rangle$
$= \langle a, b \rangle + \langle -c, -d \rangle = \langle a, b \rangle + -\mathbf{1}\langle c, d \rangle = \mathbf{u} + (-1\mathbf{v})$

93. $(ck)\mathbf{u} = \langle cka, ckb \rangle = c\langle ka, kb \rangle = c(k\mathbf{u})$
$c(k\mathbf{u}) = \langle cka, ckb \rangle = \langle kca, kcb \rangle = k\langle ca, cb \rangle = k(c\mathbf{u})$

95. $\mathbf{u} + (-\mathbf{u}) = \langle a, b \rangle + \langle -a, -b \rangle = \langle a - a, b - b \rangle = \langle 0, 0 \rangle$

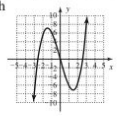
97. $(c + k)\mathbf{u} = (c + k)\langle a, b \rangle = \langle (c + k)a, (c + k)b \rangle =$
$\langle ca + ka, cb + kb \rangle = \langle ca, cb \rangle + \langle ka, kb \rangle = c\mathbf{u} + k\mathbf{u}$

99. $\langle 1, 3 \rangle + \langle 3, 3 \rangle + \langle 4, -1 \rangle + \langle 2, -4 \rangle + \langle -4, -3 \rangle + \langle -6, 2 \rangle = \langle 0, 0 \rangle$

101. Answers will vary, one possibility: 0°, 81.4°, −34°

103. a. not a real number **b.** not possible **c.** not a real number

105. $x = 0, \pm\sqrt{7}$; see graph



Mid-Chapter Check, p. 751

1. $\sin B = \frac{b \sin A}{a}$ **2.** $\cos B = \frac{a^2 + c^2 - b^2}{2ac}$

3. $a \approx 129$ m, $B \approx 86.5°$, $C \approx 62.5°$

4. $A \approx 42.3°$, $B \approx 81.5°$, $C \approx 56.2°$

5.
$A = 44°$	$a = 2.1$ km		
$B \approx 68.1°$	$b \approx 2.8$ km		
$C \approx 67.9°$	$c = 2.8$ km		
or			
$A = 44°$	$a = 2.1$ km		
$B \approx 23.9°$	$b \approx 1.2$ km		
$C \approx 112.1°$	$c = 2.8$ km		

6.
$A \approx 18.5°$	$a = 70$ yd
$B \approx 134.5°$	$b \approx 157.1$ yd
$C = 27°$	$c = 100$ yd

7. about 60.7 ft **8.** 169 m **9.** $\alpha \approx 49.6°$; $\beta \approx 92.2°$; $\gamma \approx 38.2°$

10. 9.4 mi

Reinforcing Basic Concepts, p. 751

1.
Angles	Sides
$A = 35°$	$a = 11.6$ cm
$B \approx 81.5°$	$a = 20$ cm
$C \approx 63.5°$	$c = 18$ cm

Very close.

2. For $\angle A = 35°$, $a \approx 10.3$
For $\angle A = 50°$, $a \approx 14.2$
For $\angle A = 70°$, $a \approx 19.1$;
yes, very close

Exercises 7.4, pp. 761–765

1. equilibrium; zero **3.** orthogonal **5.** Answers will vary.

7. $\langle 6, 8 \rangle$ **9.** $\langle -5, 10 \rangle$ **11.** $-6\mathbf{i} - 8\mathbf{j}$ **13.** $-2.2\mathbf{i} + 0.4\mathbf{j}$

15. $\langle -11.48, -9.16 \rangle$ **17.** $\langle -24, -27 \rangle$ **19.** $|\mathbf{F}_3| \approx 3336.8$; $\theta \approx 268.5°$

21. 37.16 kg **23.** 644.49 lb **25.** 2606.74 kg **27.** approx. 286.79 lb

29. approx. 43.8° **31.** 1125 N-m **33.** approx. 957.0 ft **35.** approx. 64,951.90 ft-lb **37.** approx. 451.72 lb **39.** approx. 2819.08 N-m

41. 800 ft-lb **43.** 118 ft-lb **45.** verified **47.** verified **49. a.** 29 **b.** 45°

51. a. 0 **b.** 90° **53. a.** 1 **b.** 89.4° **55.** yes **57.** no **59.** yes

61. 3.68 **63.** −4 **65.** 3.17

67. a. $\langle 3.73, 1.40 \rangle$ **b.** $\mathbf{u}_1 = \langle 3.73, 1.40 \rangle$, $\mathbf{u}_2 = \langle -1.73, 4.60 \rangle$

69. a. $\langle -0.65, 0.11 \rangle$ **b.** $\mathbf{u}_1 = \langle -0.65, 0.11 \rangle$, $\mathbf{u}_2 = \langle -1.35, -8.11 \rangle$

71. a. $10.54\mathbf{i} + 1.76\mathbf{j}$ **b.** $\mathbf{u}_1 = 10.54\mathbf{i} + 1.76\mathbf{j}$, $\mathbf{u}_2 = -0.54\mathbf{i} + 3.24\mathbf{j}$

73. a. projectile is about 375 ft away, and 505.52 ft high **b.** approx. 1.27 sec and 12.26 sec **75. a.** projectile is about 424.26 ft away, and 280.26 ft high **b.** approx. 2.44 sec and 6.40 sec

77. about 74.84 ft; $t \approx 3.9 - 1.2 = 2.7$ sec

79. $\mathbf{w} \cdot (\mathbf{u} + \mathbf{v}) = \langle e, f \rangle \cdot \langle a + c, b + d \rangle$
$= e(a + c) + f(b + d) = ea + ec + fb + fd$
$= (ea + fb) + (ec + fd)$
$= \langle e, f \rangle \cdot \langle a, b \rangle + \langle e, f \rangle \cdot \langle c, d \rangle$
$= \mathbf{w} \cdot \mathbf{u} + \mathbf{w} \cdot \mathbf{v}$

81. $\mathbf{0} \cdot \mathbf{u} = \langle 0, 0 \rangle \cdot \langle a, b \rangle = 0(a) + 0(b) = 0$
$\mathbf{u} \cdot \mathbf{0} = \langle a, b \rangle \cdot \langle 0, 0 \rangle = a(0) + b(0) = 0$

83. $\theta \approx 56.9°$; answers will vary. **85.** $x \approx -20$

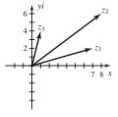
87. $a \approx 138.4$,
$B \approx 106.8°$
$C \approx 41.2°$;
$P \approx 560.4$ m,
$A \approx 11{,}394.3$ m^2

Exercises 7.5, pp. 773–776

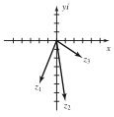
1. modulus; argument **3.** multiply; add

5. $2(\cos 240° + i \sin 240°)$, z is in QIII

7. $z_2 = z_1 + z_3$



9. $z_2 = z_1 + z_3$



11. $2\sqrt{2}(\cos 225° + i \sin 225°)$ **13.** $10(\cos 210° + i \sin 210°)$

15. $6\left[\cos\left(\frac{3\pi}{4}\right) + i\sin\left(\frac{3\pi}{4}\right)\right]$ **17.** $8\left[\cos\left(\frac{11\pi}{6}\right) + i\sin\left(\frac{11\pi}{6}\right)\right]$

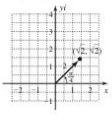
19. $10 \operatorname{cis}\left[\tan^{-1}\left(\frac{6}{8}\right)\right]$; $10 \operatorname{cis} 36.9°$

21. $13 \operatorname{cis}\left[180° + \tan^{-1}\left(\frac{12}{5}\right)\right]$; $13 \operatorname{cis} 247.4°$

23. $18.5 \operatorname{cis}\left[\tan^{-1}\left(\frac{17.5}{6}\right)\right]$; $18.5 \operatorname{cis} 1.2405$

25. $2\sqrt{34} \operatorname{cis}\left[\pi + \tan^{-1}\left(\frac{-5}{3}\right)\right]$; $2\sqrt{34} \operatorname{cis} 2.1112$

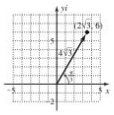
27. $r = 2$, $\theta = \frac{\pi}{4}$
$z = 2 \operatorname{cis}\left(\frac{\pi}{4}\right)$
$= \sqrt{2} + \sqrt{2}i$



29. $r = 4\sqrt{3}, \theta = \frac{\pi}{3}$

$z = 4\sqrt{3}\operatorname{cis}\left(\frac{\pi}{3}\right)$

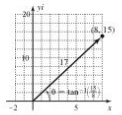
$= 2\sqrt{3} + 6i$



31. $r = 17, \theta = \tan^{-1}\left(\frac{15}{8}\right)$

$z = 17\operatorname{cis}\left[\tan^{-1}\left(\frac{15}{8}\right)\right]$

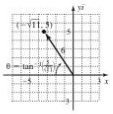
$= 17\left(\frac{8}{17} + \frac{15}{17}i\right) = 8 + 15i$



33. $r = 6, \theta = \pi - \tan^{-1}\left(\frac{5}{\sqrt{11}}\right)$

$z = 6\operatorname{cis}\left[\pi - \tan^{-1}\frac{5}{\sqrt{11}}\right]$

$= 6\left(-\frac{\sqrt{11}}{6} + \frac{5}{6}i\right) = -\sqrt{11} + 5i$



35. $r_1 = 2\sqrt{2}, \quad r_2 = 3\sqrt{2}, \quad \theta_1 = 135°, \quad \theta_2 = 45°;$
$z = z_1 z_2 = -12 + 0i \Rightarrow r = 12, \quad \theta = 180°;$
$r_1 r_2 = 2\sqrt{2}(3\sqrt{2}) = 12$✓
$\theta_1 + \theta_2 = 135° + 45° = 180°$✓

37. $r_1 = 2, r_2 = 2, \theta_1 = 30°, \theta_2 = 60°;$
$z = \frac{z_1}{z_2} = \frac{\sqrt{3}}{2} - \frac{1}{2}i \Rightarrow r = 1, \theta = -30°; \frac{r_1}{r_2} = \frac{2}{2} = 1$✓
$\theta_1 - \theta_2 = 30° - 60° = -30°$✓

39. $z_1 z_2 = -24 + 0i, \frac{z_1}{z_2} = -\frac{4}{3} + \frac{4\sqrt{3}}{3}i$

41. $z_1 z_2 = 21\sqrt{3} - 21i, \frac{z_1}{z_2} = \frac{\sqrt{3}}{7} + \frac{1}{7}i$

43. $z_1 z_2 = -10.84 + 12.04i, \frac{z_1}{z_2} = -1.55 - 4.76i$

45. $z_1 z_2 = 0 + 40i, \frac{z_1}{z_2} = \frac{5\sqrt{3}}{4} + \frac{5}{4}i$

47. $z_1 z_2 = -10 - 10\sqrt{3}i, \frac{z_1}{z_2} = \frac{-5}{2} + 0i$

49. $z_1 z_2 = -2.93 + 8.5i, \frac{z_1}{z_2} = 2.29 + 3.28i$

51. verified; verified, $u^2 + v^2 + w^2 = uv + uw + vw$
$(1 + 4\sqrt{3}i) + (97 + 20\sqrt{3}i) + (-39 + 60\sqrt{3}i)$
$= (17 + 12\sqrt{3}i) + (-3 + 16\sqrt{3}i) + (45 + 56\sqrt{3}i),$
$59 + 84\sqrt{3}i = 59 + 84\sqrt{3}i$

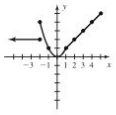
53. a. $V(t) = 170\sin(120\pi t)$

b.

t	$V(t)$
0	0
0.001	62.6
0.002	116.4
0.003	153.8
0.004	169.7
0.005	161.7
0.006	131.0
0.007	81.9
0.008	21.3

c. $t \approx 0.00257$ sec

55. a. 17 cis 28.1° **b.** 51 V **57. a.** 8.60 cis 324.5° **b.** 15.48 V
59. a. 13 cis 22.6° **b.** 22.1 V
61. $I = 2$ cis 30°; $Z = 5\sqrt{2}$ cis 45°; $V = 10\sqrt{2}$ cis 75°
63. $I = \sqrt{13}$ cis 326.3°; $Z = \frac{17}{4}$ cis 61.9°; $V = \frac{17\sqrt{13}}{4}$ cis 28.2°
65. $V = 4$ cis 60°; $Z = 4\sqrt{2}$ cis 315°; $I = \frac{\sqrt{2}}{2}$ cis 105°
67. $V = 5$ cis 306.9°; $Z = 8.5$ cis 61.9°; $I = \frac{10}{17}$ cis 245°
69. $\frac{\sqrt{65}\text{ cis } 29.7°}{4}$ **71.** verified
73. $z_2 = \frac{24}{5} - \frac{7}{5}i, z_3 = -\frac{24}{5} + \frac{7}{5}i$ **75.** $\frac{5\pi}{24}, \frac{13\pi}{24}, \frac{29\pi}{24}, \frac{37\pi}{24}$
77.



Exercises 7.6, pp. 781–783

1. $r^5[\cos(5\theta) + i\sin(5\theta)]$; De Moivre's **3.** complex
5. $z_5 = 2$ cis 366° $= 2$ cis 6°, $z_6 = 2$ cis 438° $= 2$ cis 78°,
$z_7 = 2$ cis 510° $= 2$ cis 150°; Answers will vary.
7. $r = 3\sqrt{2}; n = 4; \theta = 45°; -324$ **9.** $r = 2; n = 3; \theta = 120°; 8$
11. $r = 1; n = 5; \theta = -60°; \frac{1}{2} + \frac{\sqrt{3}}{2}i$ **13.** $r = 1; n = 6; \theta = -45°; i$
15. $r = 4; n = 3; \theta = 330°; -64i$
17. $r = \frac{\sqrt{2}}{2}; n = 5; \theta = 135°; \frac{1}{8} - \frac{1}{8}i$
19. verified **21.** verified **23.** verified **25.** verified
27. $r = 1; n = 5; \theta = 0°$; roots: $1, 0.3090 \pm 0.9511i, -0.8090 \pm 0.5878i$
29. $r = 243; n = 5; \theta = 0°$; roots: $3, 0.9271 \pm 2.8532i, -2.4271 \pm 1.7634i$
31. $r = 27; n = 3; \theta = 270°$; roots: $3i, \frac{-3\sqrt{3}}{2} - \frac{3}{2}i, \frac{3\sqrt{3}}{2} - \frac{3}{2}i$
33. $2, 0.6180 \pm 1.9021i, -1.6180 \pm 1.1756i$
35. $\frac{3\sqrt{3}}{2} + \frac{3}{2}i, -\frac{3\sqrt{3}}{2} + \frac{3}{2}i, -3i$
37. $1.1346 + 0.1797i, 0.1797 + 1.1346i, -1.0235 + 0.5215i,$
$-0.8123 - 0.8123i, 0.5215 - 1.0235i$
39. $x = 1, -\frac{1}{2} \pm \frac{\sqrt{3}}{2}i$. These are the same results as in Example 3.
41. $r = 16; n = 4; \theta = 120°$; roots: $\sqrt{3} + i, -1 + \sqrt{3}i, -\sqrt{3} - i, 1 - \sqrt{3}i$
43. $r = 7\sqrt{2}; n = 4; \theta = 225°$; roots: $0.9855 + 1.4749i, -1.4749 + 0.9855i, -0.9855 - 1.4749i, 1.4749i - 0.9855i$
45. $D = -4, z_0 = 8^{\frac{1}{3}}\text{cis } 45°, z_1 = 8^{\frac{1}{3}}\text{cis } 165°, z_2 = 8^{\frac{1}{3}}\text{cis } 285°,$
$z_0 = 8^{\frac{1}{3}}\text{cis } 75°, z_1 = 8^{\frac{1}{3}}\text{cis } 195°, z_2 = 8^{\frac{1}{3}}\text{cis } 315°$ **47.** verified
49. a. numerator: $-117 + 44j$, denominator: $-21 + 72j$ **b.** $1 + \frac{4}{3}j$
c. verified **51.** Answers will vary. **53.** $-7 - 24i$
55. $z \approx -2.7320, z \approx 0.7320, z = 2.$
Note: Using sum and difference identities, all three solutions can actually be given in exact form: $-1 - \sqrt{3}, -1 + \sqrt{3}, 2$.

57. $\frac{\tan^2 x}{\sec x + 1} = \frac{\sec^2 x - 1}{\sec x + 1}$

$= \frac{(\sec x + 1)(\sec x - 1)}{\sec x + 1}$

$= \sec x - 1$

$= \frac{1}{\cos x} - \frac{\cos x}{\cos x}$

$= \frac{1 - \cos x}{\cos x}$

59. $y = -\frac{4}{5}x + \frac{12}{5}$

Summary and Concept Review pp. 783–787

1.

Angles	Sides
$A = 36°$	$a \approx 205.35$ cm
$B = 21°$	$b \approx 125.20$ cm
$C = 123°$	$c = 293$ cm

2.

Angles	Sides
$A = 28°$	$a \approx 140.59$ yd
$B = 10°$	$b = 52$ yd
$C = 142°$	$c \approx 184.36$ yd

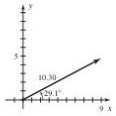
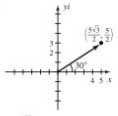
3. approx. 41.84 ft

4. approx. 20.2° and 159.8°

5.

Angles	Sides
$A = 35°$	$a = 67$ cm
$B_1 \approx 64.0°$	$b = 105$ cm
$C_1 \approx 81.0°$	$c_1 \approx 115.37$ cm

Angles	Sides
$A = 35°$	$a = 67$ cm
$B_2 \approx 116.0°$	$b = 105$ cm
$C_2 \approx 29.0°$	$c_2 \approx 56.63$ cm

6. no; 36° **7.** approx. 36.9° **8.** approx. 385.5 m
9. 133.2°, 30.1°, and 16.7° **10.** 85,570.7 m^2
11.  **12.** $-8\mathbf{i} + 3\mathbf{j}$; $|\mathbf{u}| \approx 8.54$; $\theta \approx 159.4°$
13. horiz. comp. ≈ 11.08, vertical comp. ≈ 14.18
14. $\langle -4, -2\rangle$; $|2\mathbf{u} + \mathbf{v}| \approx 4.47$, $\theta \approx 206.6°$ **15.** $\frac{7}{\sqrt{193}}\mathbf{i} + \frac{12}{\sqrt{193}}\mathbf{j}$
16. QII; since the x-component is negative and the y-component is positive.
17. $\frac{1}{6}$ mi **18.** approx. 19.7° **19.** $\langle -25, -123\rangle$ **20.** approx. −0.87
21. 4 **22.** $\mathbf{p} \cdot \mathbf{q} = -6$; $\theta \approx 97.9°$ **23.** 4340 ft-lb **24.** approx. 417.81 lb
25. approx. 8156.77 ft-lb **26. a.** $x \approx 269.97$ ft; $y \approx 285.74$ ft
b. approx. 0.74 sec **27.** $2(\cos 240° + i \sin 240°)$ **28.** $3 + 3i$
29.  **30.** $z_1 z_2 = 16 \operatorname{cis}\left(\frac{5\pi}{12}\right)$; $\frac{z_1}{z_2} = 4 \operatorname{cis}\left(\frac{\pi}{12}\right)$
31. $2\sqrt{3} + 2j$ **32.** $|Z| \approx 10.44$; $\theta \approx 16.7°$, 10.44 cis 16.7°
33. $-16 - 16\sqrt{3}i$ **34.** verified **35.** $\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -5i$
36. $6, -3 \pm 3i\sqrt{3}$ **37.** $2 - 2i, -2 \pm 2i$ **38.** $1 \pm 2i, -1 \pm 2i$
39. verified

Mixed Review pp. 787–788

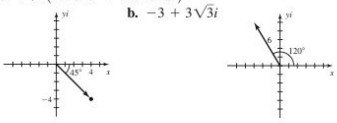
1.

Angles	Sides
$A = 41°$	$a \approx 13.44$ in.
$B = 27°$	$b \approx 9.30$ in.
$C = 112°$	$c = 19$ in.

Area ≈ 57.9 in^2

3. $x \approx 16.09$, $y \approx 13.50$ **5.** approx. 176.15 ft **7.** approx. 793.70 mph; heading 28.2°
9. One solution possible since side $a >$ side b

Angles	Sides
$A = 31°$	$a = 36$ m
$B \approx 20.1°$	$b = 24$ m
$C \approx 128.9°$	$c \approx 54.4$ m

11. No; barely touches ("tangent") at 30°
13. a. $4\sqrt{2}(\cos 315° + i \sin 315°)$ **b.** $-3 + 3\sqrt{3}i$

15. ≈13.1° **17.** $\operatorname{comp}_{\mathbf{v}}\mathbf{u} \approx -0.87$, $\operatorname{proj}_{\mathbf{v}}\mathbf{u} \approx \frac{-38}{53} + \frac{26}{53}\mathbf{i}$
19. $z_0 = \frac{\sqrt{6}}{2} + \frac{\sqrt{2}}{2}i$, $z_1 = \frac{-\sqrt{2}}{2} + \frac{\sqrt{6}}{2}i$,
$z_2 = \frac{-\sqrt{6}}{2} - \frac{\sqrt{2}}{2}i$, $z_3 = \frac{\sqrt{2}}{2} - \frac{\sqrt{6}}{2}i$

Practice Test pp. 788–790

1. 6.58 mi **2.** 137.18 ft
3.

Angles	Sides (in.)
$A_1 \approx 58.8°$	$a = 15$
$B = 20°$	$b = 6$
$C_1 \approx 101.2°$	$c_1 \approx 17.21$

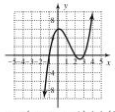
Angles	Sides (in.)
$A_2 \approx 121.2°$	$a = 15$
$B = 20°$	$b = 6$
$C_2 \approx 38.8°$	$c_2 \approx 11.0$

4. a. No **b.** 2.66 mi **5. a.** No **b.** 1 **c.** 8.43 sec
6. a. 2.30 mi **b.** 7516.5 ft
7. $A \approx 438{,}795$ mi^2, $P \approx 61.7°$, $B \approx 61.2°$, $M \approx 57.1°$
8. speed ≈ 73.36 mph, bearing ≈ 47.8° **9.** $\theta \approx 36.5°$ **10.** 63.48 cm to the right and 130.05 cm down from the initial point on the ceiling
11. $|\mathbf{F}_3| \approx 212.94$ N, $\theta \approx 251.2°$
12. a. $\theta \approx 42.5°$ **b.** $\operatorname{proj}_{\mathbf{v}}\mathbf{u} = \langle -2.4, 7.2\rangle$
c. $\mathbf{u}_1 = \langle -2.4, 7.2\rangle$, $\mathbf{u}_2 = \langle -6.6, -2.2\rangle$
13. 104.53 ft; 3.27 sec **14.** $2 \operatorname{cis}\left(\frac{\pi}{24}\right)$ **15.** $48\sqrt{2}$ cis 75°; verified
16. $-8 - 8\sqrt{3}i$ **17.** verified **18.** $\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -\frac{5\sqrt{3}}{2} + \frac{5}{2}i, -5i$
19. $2.3039 \pm 1.5192i, -2.3039 \pm 1.5192i$ **20.** ≈ 2,414,300 mi^2

Strengthening Core Skills p. 791

Exercise 1: 664.46 lb, 640.86 lb
Exercise 2: 106.07 lb, 106.07 lb
Exercise 3: yes

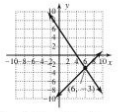
Cumulative Review Chapters 1–7 pp. 791–792

1. $20\sqrt{3}$; 40; 60°; 90° **3.** $R = \frac{1}{\pi}\sqrt{A + (\pi r)^2}$
5. QIV $\sin\theta = \frac{-3}{5}$; $\cos\theta = \frac{4}{5}$; $\tan\theta = \frac{-3}{4}$; $\csc\theta = -\frac{5}{3}$; $\sec\theta = \frac{5}{4}$; $\cot\theta = \frac{-4}{3}$ **7.** $x = \frac{-4}{5} \pm \frac{\sqrt{6}}{5}$
9. $\cos = 19° \approx 0.94$, $\cos 125° \approx -0.58$ **11. a.** about $66,825
b. 13, 13, $7\sqrt{2}$; $A = 59.5$ mi^2 **13. a.** $m = \frac{y_2 - y_1}{x_2 - x_1}$
b. $\left(\frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}\right)$ **c.** $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
d. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ **e.** $A = Pe^{rt}$
15. $\angle A = 37°$, $a \approx 33$ cm,
$\angle B = 34.4°$, $b = 31$ cm,
$\angle C = 108.6°$, $c = 52$ cm
17. about 422.5 lb
19. 
$x \in (-\infty, -1) \cup (2, 3)$
21. $-128 - 128i\sqrt{3}$ **23.** about 3.6 yr **25.** $A = 2$, $B = 1$, $C = \frac{\pi}{4}$

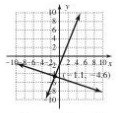
CHAPTER 8

Exercises 8.1, pp. 801–805

1. inconsistent **3.** consistent; independent
5. Multiply the first equation by 6 and the second equation by 10.
7. $y = \frac{7}{4}x - 6,\ y = \frac{-4}{3}x + 5$ **9.** $y = x + 2$ **11.** $x + 3y = -3$
13. $y = x + 2,\ x + 3y = -3$ **15.** yes **17.** yes
19.



21.



23. $(-4, 1)$ **25.** $(3, -5)$ **27.** second equation, y, $(4, -3)$
29. second equation, x, $(10, -1)$ **31.** second equation, x, $(\frac{5}{2}, \frac{7}{4})$
33. $(3, -1)$ **35.** $(-2, -3)$ **37.** $(\frac{11}{2}, 2)$ **39.** $(-2, 3)$ **41.** $(-3, 4)$
43. $(-6, 12)$ **45.** $(2, 8)$; consistent/independent **47.** $\varnothing$; inconsistent
49. $\{(x, y) | 6x + y = 22\}$; consistent/dependent
51. $(4, 1)$; consistent/independent **53.** $(-3, -4)$; consistent/independent
55. $(\frac{-1}{2}, \frac{4}{3})$; consistent/independent **57.** $(-2, \frac{5}{2})$ **59.** $(2, -1)$
61. 1 mph 4 mph **63.** 2318 adult tickets; 1482 child tickets
65. premium: \$3.97, regular: \$3.87 **67.** nursing student \$6500; science major \$3500 **69.** 150 quarters, 75 dimes
71. **a.** 100 lawns/mo, **b.** \$11,500/mo
73. **a.** 1.6 billion bu, 3 billion bu, yes; **b.** 2.7 billion bu, 2.25 billion bu, yes; **c.** \$6.65, 2.43 billion bu **75.** **a.** 3 mph, **b.** 5 mph
77. **a.** 3.6 ft/sec, **b.** 4.4 ft/sec **79.** 1776; 1865
81. Tahiti: 402 mi^2, Tonga: 290 mi^2
83. $m_1 \neq m_2$; consistent/independent
85. \$6552 at 8.5%; \$11,551 at 6% **87.** 472°, 832°, −248°, −608°
89. verified

Exercises 8.2, pp. 814–818

1. triple **3.** equivalent; systems **5.** $z = 5$ **7.** Answers will vary.
9. Answers will vary. **11.** yes, no **13.** $(5, 7, 4)$ **15.** $(-2, 4, 3)$
17. $(1, 1, -2)$ **19.** $(4, 0, -3)$ **21.** $(3, 4, 5)$ **23.** $(1, 6, 9)$
25. no solution, inconsistent **27.** $(p, 2 - p, 2 - p)$
29. $\left(-\frac{5}{3}p - \frac{2}{3}, -p - 2, p\right)$, other solutions possible
31. $(p, 2p, p + 1)$ **33.** $(p + 9, p - 4, p)$
35. $\{(x, y, z) | x - 6y + 12z = 5\}$
37. $(1, 1, 2)$ **39.** $\left\{(x, y, z) | x - \frac{5}{2}y - 2z = 3\right\}$ **41.** $\left(2, 1, \frac{-1}{3}\right)$
43. $(p + 5, p - 2, p)$ **45.** $(18, -6, 10)$ **47.** $\left(\frac{11}{3}, \frac{10}{3}, \frac{7}{3}\right)$
49. $(1, -2, 3)$ **51.** $\left(\frac{1}{2}, \frac{1}{3}, 3\right)$ **53.** ≈3.464 units
55. Monet \$1,900,000; Picasso \$1,100,000; van Gogh \$4,000,000
57. elephant, 650 days; rhino, 464 days; camel, 406 days
59. Albatross: 3.6 m, Condor: 3.0 m, Quetzalcoatlus: 12.0 m
61. 175 \$5 gold pieces; 50 \$10 gold pieces; 25 \$20 gold pieces
63. $A = -1, B = 1, C = -2$; verified **65.** $x^2 + y^2 - 4x + 6y + 9 = 0$
67. $\langle -11, -5 \rangle$; $\langle 6, -\frac{43}{2} \rangle$ **69.** $x = 1$

Mid-Chapter Check, pp. 817–818

1. (1, 1) consistent **2.** (5, 3) consistent **3.** 20 oz **4.** No
5. 2R1 = R2 **6.** (1, 2, 3) **7.** (1, 2, 3) **8.** $(p, p - 5, -p - 4)$
9. Morphy: 13, Mozart: 8, Pascal: 16 **10.** prelude: 2.75 min, storm: 2.5 min, sunrise: 2.5 min, finale: 3.25 min

Reinforcing Basic Concepts, p. 818

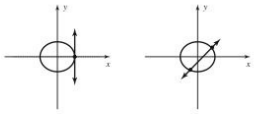
Exercise 1. Premium: \$4.17/gal, Regular: \$4.07/gal

$$\begin{cases} 15.3R + 35.7P = 211.14 \\ P = R + 0.10 \end{cases}$$

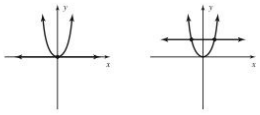
Exercise 2. Verified

Exercises 8.3, pp. 823–826

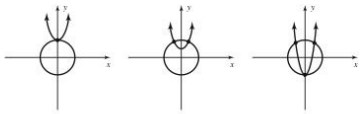
1. a. 3 or 4 not possible

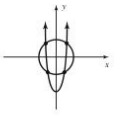


b. 3 or 4 not possible

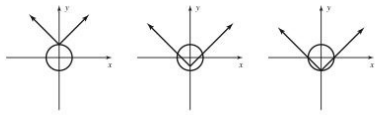


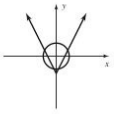
c.



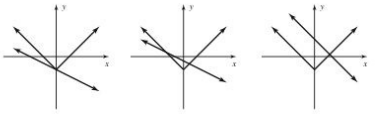


d.

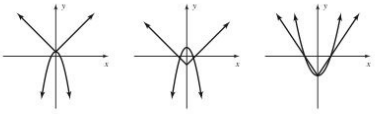


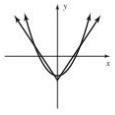


e. 3 or 4 solutions not possible

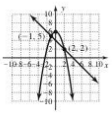


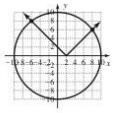
f.

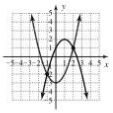




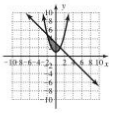
3. region; solutions **5.** Answers will vary.

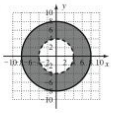
7.  line, parabola; $(-1, 5), (2, 2)$

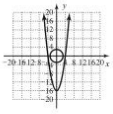
9.  circle, absolute value; $(-6, 8), (8, 6)$

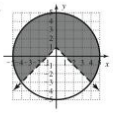
11.  parabola, parabola; $(-1, -2), (2, 1)$

13. $(-4, -3), (3, 4)$ **15.** $(2, 5), (-4, -7)$ **17.** $(-3, 4), (-4, -3), (3, 4), (4, -3)$ **19.** $(4, -3), (-4, -3)$ **21.** no solution
23. $(-8, 1), (-7, 4)$ **25.** $(5, \log 5 + 5)$
27. $(-3, \ln 9 + 1), (4, \ln 16 + 1)$ **29.** $(0, 10), (\ln 6, 45)$
31. $(-3, 1), (2, 1024)$ **33.** $(-3, -21), (1, -1), (2, 4)$
35. $(2, -4), (6, 4)$ **37.** $(3, 5), (3, -5)$
39. $(-2.43, -2.81), (2, 1)$ **41.** $(0.72, 2.19), (2, 3), (4, 3), (5.28, 2.19)$

43. 

45. 

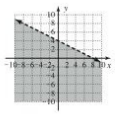
47. no solution 

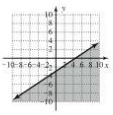
49. 

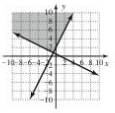
51. $h \approx 45.8$ ft; $h = 40$ ft; $h = 30$ ft
53. The company breaks even if either 18,400 or 48,200 cars are sold.
55. \$1.83; \$90,000 gal $\begin{cases} 10P^2 + 6D = 144 \\ 8P^2 - 8P - 4D = 12 \end{cases}$
57. 8.5 m × 10 m **59.** 5 km, 9 km **61.** 8 × 8 × 25 ft
63. Answers will vary. **65.** 18 in. by 18 in. by 77 in. **67.** $\frac{\sqrt{6} - \sqrt{2}}{4}$
69. $W \approx 191.7$ ft-lb

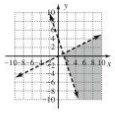
Exercises 8.4 pp. 835–838

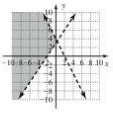
1. half, planes **3.** solution
5. The feasible region may be bordered by three or more oblique lines, with two of them intersecting outside and away from the feasible region.
7. No, No, No, No **9.** No, Yes, Yes, No

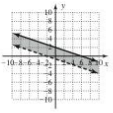
11. 

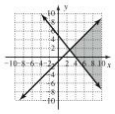
13. 

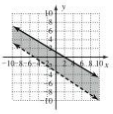
15. No, No, No, Yes **17.** 

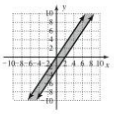
19. 

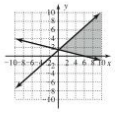
21. 

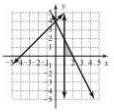
23. 

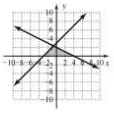
25. 

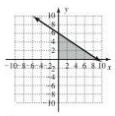
27. 

29. 

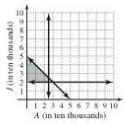
31. 

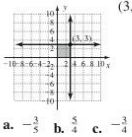
33. 

35. 

37. 

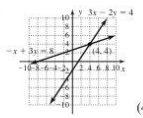
39. $\begin{cases} y - x \leq 1 \\ x + y > 3 \end{cases}$

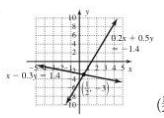
41. $\begin{cases} y - x \leq 1 \\ x + y < 3 \\ y \geq 0 \end{cases}$ **43.** $(5, 3)$ **45.** $(12, 11)$ **47.** $(2, 2)$
49. $(4, 3)$ **51.** $5 < H < 10$
53. 

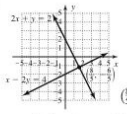
55. 300 acres of corn; 200 acres of soybeans
$J + A \leq 50{,}000$
$J \geq 20{,}000$
$A \leq 25{,}000$
57. 240 sheet metal screws; 480 wood screws
59. 65 traditionals, 30 Double-T's
61. 220,000 gallons from Tulsa to Colorado; 100,000 gal from Tulsa to Mississippi; 0 thousand gal from Houston to Colorado; 150,000 gal from Houston to Mississippi
63. (3, 3); optimal solutions occur at vertices 

65. **a.** $-\frac{3}{5}$ **b.** $\frac{5}{4}$ **c.** $-\frac{3}{4}$ **67.** 324 Ω

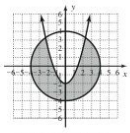
Summary and Concept Review, pp. 839–841

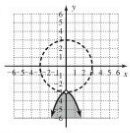
1. 
(4, 4)

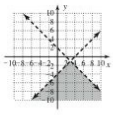
2. 
$\left(\frac{1}{2}, -3\right)$

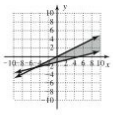
3. 
$\left(\frac{8}{5}, \frac{-6}{5}\right)$

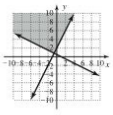
4. no solution; inconsistent **5.** $(5, -1)$; consistent **6.** $(7, 2)$; consistent
7. $(3, -1)$; consistent **8.** $(2, 2)$; consistent **9.** $\left(\frac{11}{4}, \frac{-1}{6}\right)$; consistent
10. Sears Tower is 1450 ft; Hancock Building is 1127 ft. **11.** $(0, 3, 2)$
12. $(1, 1, 1)$ **13.** no solution, inconsistent **14.** 3 aces, 4 face cards, 5 numbered cards **15.** 1530 quarters, 1180 dimes, 710 nickels
16. circle, line, $(4, 3)$, $(-3, -4)$ **17.** parabola, line, $(3, -2)$
18. parabola, circle, $(\sqrt{3}, 2)$,$(-\sqrt{3}, 2)$
19. circle, parabola, $(1, 3)$, $(-1, 3)$

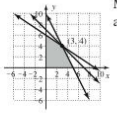
20. 
parabola, circle

21. 
note the open circle showing noninclusion at $(0, -3)$; circle, parabola

22. 

23. 

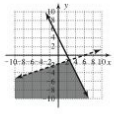
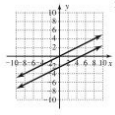
24. 

25. 
Maximum of 270 occurs at both (0, 6) and (3, 4).

26. 50 cows, 425 chickens

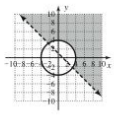
Mixed Review, pp. 841–842

1. a. $\begin{cases} y = \frac{3}{5}x + 2 \\ y = \frac{3}{5}x + 2 \end{cases}$; consistent/dependent **b.** $\begin{cases} y = \frac{4}{5}x - 3 \\ y = \frac{2}{5}x - 2 \end{cases}$; consistent/independent **c.** $\begin{cases} y = \frac{1}{3}x - 3 \\ y = \frac{1}{3}x - \frac{5}{3} \end{cases}$; inconsistent

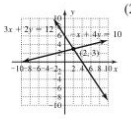
3. $(-2\ 3)$ **5.** 21 veggie, 33 beef **7.** $(9, 1, 1)$
9. $\{(x, y, z) | x \in \mathbb{R}, y = -7x + 7, z = -5x + 6\}$
11. 
13. no solution 

15.

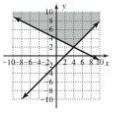
(x, y)	$P(x, y) = 2.5x + 3.75y$
(0, 0)	0
(0, 7)	26.25
(7.5, 0)	18.75
(2, 6)	27.5
(6, 2)	22.5

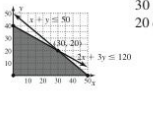
max value 27.5 at (2, 6)
17. $(2, 5)$, $(2, -5)$ $(-2, 5)$, $(-2, -5)$
19. 

Practice Test, pp. 842–843

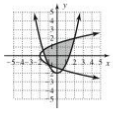
1. 
$(2, 3)$ **2.** $\left(\frac{2}{5}, \frac{-4}{5}\right)$ **3.** $(-3, 2)$ **4.** $(2, -1, 4)$

5. $\{(x, y, z) | x = 2z - 1, y = 5z - 6, z \in \mathbb{R}\}$
6. $a = 5$, $b = 2$ **7.** 21.59 cm by 35.56 cm **8.** Tahiti 402 mi^2; Tonga 290 mi^2 **9.** Corn 25¢, Beans 20¢, Peas 29¢ **10.** $15,000 at 7%, $8000 at 5%, $7000 at 9%

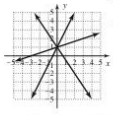
11. 

12. $(5, 0)$ **13.** 
30 plain; 20 deluxe

14. $(-1 - \sqrt{7}, 1 - \sqrt{7}), (-1 + \sqrt{7}, 1 + \sqrt{7})$
15. $(\sqrt{3}, 1), (-\sqrt{3}, 1)$
16. 15 ft, 20 ft

17. 

18. $\begin{cases} y > 0 \\ x^2 + y^2 < 9 \end{cases}$

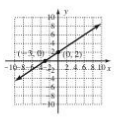
19. 
the solution is (0, 1)

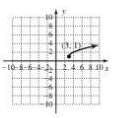
20. Answers may vary. Possible solution:
$\begin{cases} x^2 + y^2 > 1 \\ x^2 + y^2 < 4 \\ x > 0, y < 0 \end{cases}$

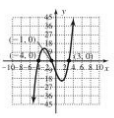
Strengthening Core Skills, pp. 844–845

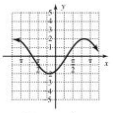
Exercise 1. $(-1, 4)$, elimination

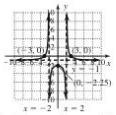
Cumulative Review Chapters 1–8, pp. 845–846

1. 

3. 

5. 

7. 

9. 

11. a. $D: x \in (-\infty, \infty)$ **b.** $R: y \in (-\infty, 4]$ **c.** $f(x)\uparrow: x \in (-\infty, -1)$ $f(x)\downarrow: x \in (-1, \infty)$ **d.** n/a **e.** max: $(-1, 4)$
f. $f(x) > 0: x \in (-4, 2)$ $f(x) < 0: x \in (-\infty, -4) \cup (2, \infty)$
g. $\dfrac{\Delta y}{\Delta x} = \dfrac{7}{4}$

13. a. no solution **b.** no solution **c.** $n = 1, n = -9$ **d.** $x = 3 \pm 2i$
e. $x = \frac{1}{8}, x = \frac{-1}{5}$ **f.** $x = -6$ **g.** $x = \dfrac{\ln 7}{\ln 3} + 2$ **h.** $x = 4$ **i.** $x = 3$

15. $a = 20, b = 20\sqrt{3}, c = 40, A = 30°, B = 60°, C = 90°$
17. $\sin^2 x + \cos^2 x = 1$
$\tan^2 x + 1 = \sec^2 x$
$1 + \cot^2 x = \csc^2 x$

19. $\cot \alpha = -\dfrac{4}{3}, \sin \alpha = -\dfrac{3}{5}, \cos \alpha = \dfrac{4}{5}$
$\csc \alpha = -\dfrac{5}{3}, \sec \alpha = \dfrac{5}{4}$

21. $\dfrac{\Delta y}{\Delta x} = -\dfrac{7}{10}$ **23.** $x \in (-2, 5)$
25. $a \approx 13.4, b = 19, c \approx 9.3, A = 41°, B = 112°, C = 27°$
27. $(1, 3)$
29. $900 \cos 69° \approx 322.5$ lb

CHAPTER 9

Exercises 9.1, pp. 855–858

1. square **3.** 2; 3; 1 **5.** Multiply R1 by -2 and add that result to R2. This sum will be the new R2. **7.** 3×2, 5.8 **9.** 4×3, -1

11. $\begin{bmatrix} 1 & 2 & -1 & 1 \\ 1 & 0 & 1 & 3 \\ 2 & -1 & 1 & 3 \end{bmatrix}$; diagonal entries 1, 0, 1

13. $\begin{cases} x + 4y = 5 \\ y = \frac{1}{2} \end{cases} \rightarrow (3, \frac{1}{2})$ **15.** $\begin{cases} x + 2y - z = 0 \\ y + 2z = 2 \\ z = 3 \end{cases} \rightarrow (11, -4, 3)$

17. $\begin{cases} x + 3y - 4z = 29 \\ y - \frac{3}{2}z = \frac{21}{2} \\ z = 3 \end{cases} \rightarrow (-4, 15, 3)$

19. $\begin{bmatrix} 1 & -6 & -2 \\ 0 & -28 & -6 \end{bmatrix}$ **21.** $\begin{bmatrix} 1 & -3 & 3 & 2 \\ 0 & 23 & -12 & -15 \\ -2 & 1 & 0 & 4 \end{bmatrix}$

23. $\begin{bmatrix} 3 & 1 & 1 & 8 \\ 0 & -3 & -3 & -6 \\ 0 & -10 & -13 & 34 \end{bmatrix}$

25. $2R_1 + R_2 \rightarrow R_2$, $-3R_1 + R_3 \rightarrow R_3$ **27.** $-5R_1 + R_2 \rightarrow R_2$, $4R_1 + R_3 \rightarrow R_3$

29. (20, 10) **31.** (1, 6, 9) **33.** (1, 1, 2) **35.** (1, 1, 1) **37.** $(-1, \frac{-3}{2}, 2)$

39. linear dependence $(p - 4, -2p + 8, p)$ **41.** coincident dependence $\{(x, y, z) | 3x - 4y + 2z = -2\}$ **43.** no solution **45.** linear dependence, $(-\frac{5}{4}p - 3, \frac{1}{8}p - \frac{1}{2}, p)$ **47.** 28.5 units^2 **49.** Heat: 95, Mavericks: 92

51. Poe, $12,500; Baum, $62,500; Wouk, $25,000

53. $A = 35°$, $B = 45°$, $C = 100°$ **55.** $.4 million at 4%; $.6 million at 7%; $1.5 million at 8% **57.** $x = 84°$; $y = 25°$

59. a. $z_1 = \sqrt{10}\,\text{cis}[\pi + \tan^{-1}(3)]$ **b.** $z_2 = -\frac{5}{2} + \frac{5\sqrt{3}}{2}i$

61. $C > 30{,}000$ in the year 2011 ($t \approx 6.39$)

Exercises 9.2, pp. 866–870

1. a_{ij}; b_{ij} **3.** scalar **5.** Answers will vary.

7. 2×2, $a_{12} = -3$, $a_{21} = 5$ **9.** 2×3, $a_{12} = -3$, $a_{23} = 6$, $a_{22} = 5$

11. 3×3, $a_{12} = 1$, $a_{23} = 1$, $a_{31} = 5$ **13.** true **15.** conditional, $c = -2$, $a = -4$, $b = 3$

17. $\begin{bmatrix} 10 & 0 \\ 0 & 10 \end{bmatrix}$ **19.** different orders, sum not possible

21. $\begin{bmatrix} 20 & -15 \\ -25 & -10 \end{bmatrix}$ **23.** $\begin{bmatrix} \frac{5}{2} & -1 & 0 \\ 0 & \frac{-7}{2} & 1 \\ 2 & \frac{3}{2} & -6 \end{bmatrix}$ **25.** $\begin{bmatrix} 1 & 2 & 0 \\ 0 & -1 & 2 \\ 4 & 3 & -6 \end{bmatrix}$

27. $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ **29.** $\begin{bmatrix} 6 & -3 & 9 \\ 12 & 0 & -6 \end{bmatrix}$ **31.** $\begin{bmatrix} 12 & -24 & 90 \\ -6 & 15 & -57 \end{bmatrix}$

33. $\begin{bmatrix} 79 & -30 \\ -50 & 19 \end{bmatrix}$ **35.** $\begin{bmatrix} 42 & 18 & -60 \\ -12 & -42 & 36 \end{bmatrix}$

37. $\begin{bmatrix} 0.71 & 0.65 \\ 1.78 & 3.55 \end{bmatrix}$ **39.** $\begin{bmatrix} 1 & -1.25 & 0.25 \\ -0.5 & -0.63 & 2.13 \\ 3.75 & 3.69 & -5.94 \end{bmatrix}$

41. $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ **43.** $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ **45.** $\begin{bmatrix} \frac{-3}{19} & \frac{4}{57} \\ \frac{1}{19} & \frac{5}{57} \end{bmatrix}$ **47.** $\begin{bmatrix} 0 & \frac{3}{4} & \frac{1}{4} \\ \frac{-1}{2} & \frac{3}{8} & \frac{1}{8} \\ \frac{-1}{4} & \frac{11}{16} & \frac{1}{16} \end{bmatrix}$

49. $\begin{bmatrix} 1.75 & 2.5 \\ 7.5 & 13 \end{bmatrix}$ **51.** $\begin{bmatrix} -0.26 & 0.32 & -0.07 \\ 0.63 & 0.30 & 0.10 \end{bmatrix}$ **53.** verified

55. verified **57.** $P = 21.448$ cm; $A = 27.7269$ cm^2

59. a.
$$V = \begin{matrix} \\ S \\ D \\ P \end{matrix}\begin{matrix} \begin{matrix} T & S \end{matrix} \\ \begin{bmatrix} 3820 & 1960 \\ 2460 & 1240 \\ 1540 & 920 \end{bmatrix} \end{matrix} \qquad M = \begin{matrix} \\ S \\ D \\ P \end{matrix}\begin{matrix} \begin{matrix} T & S \end{matrix} \\ \begin{bmatrix} 4220 & 2960 \\ 2960 & 3240 \\ 1640 & 820 \end{bmatrix} \end{matrix}$$

b. 3900 more by Minsk

c. $V = \begin{bmatrix} 3972.8 & 2038.4 \\ 2558.4 & 1289.6 \\ 1601.6 & 956.8 \end{bmatrix}$ **d.** $\begin{bmatrix} 8361.6 & 5116.8 \\ 5636.8 & 4659.2 \\ 3307.2 & 1809.6 \end{bmatrix}$

$M = \begin{bmatrix} 4388.8 & 3078.4 \\ 3078.4 & 3369.6 \\ 1705.6 & 852.8 \end{bmatrix}$

61. [22,000 19,000 23,500 14,000];
total profit
North: $22,000
South: $19,000
East: $23,500
West: $14,000

63. a. $108.20 **b.** $101

c.
$$\begin{matrix} \\ \text{Science} \\ \text{Math} \end{matrix}\begin{matrix} \begin{matrix} \quad & \quad & \quad \end{matrix} \\ \begin{bmatrix} 100 & 101 & 119 \\ 108.2 & 107 & 129.5 \end{bmatrix} \end{matrix}$$

First row, total cost for science from each restaurant; Second row, total cost for math from each restaurant.

65. a. 10 **b.** 20

c.
$$\begin{matrix} \\ \text{Female} \\ \text{Male} \end{matrix}\begin{matrix} \begin{matrix} \text{Spanish} & \text{Chess} & \text{Writing} \end{matrix} \\ \begin{bmatrix} 32.4 & 10.3 & 21.3 \\ 29.9 & 9.6 & 19.5 \end{bmatrix} \end{matrix},$$

the approximate number of females expected to join the writing club

67. $\begin{bmatrix} 2^{n-1} & 0 & 2^{n-1} \\ 2^n - 1 & 1 & 2^n - 1 \\ 2^{n-1} & 0 & 2^{n-1} \end{bmatrix}$

69. $a = 2$, $b = 1$, $c = -3$, $d = -2$ **71.** 0.3211 **73.** $x^2 + 2x - 5$

Mid-Chapter Check pp. 870–871

1. 3×3, -0.9 **2.** 2×4, 0 **3.** $(2, -3)$ **4.** $(2, 0, -5)$

5. $(p - 3, 2p - 8, p)$

6. a. $\begin{bmatrix} -13 & -17 \\ 35 & 9 \end{bmatrix}$ **b.** $\begin{bmatrix} 4 & 6 \\ -12 & -2 \end{bmatrix}$ **c.** $\begin{bmatrix} -5 & 5 \\ -5 & 15 \end{bmatrix}$

7. a. $\begin{bmatrix} 0.8 & 0.5 & 2.2 \\ -0.1 & 0.8 & -1 \\ 2.1 & 0.3 & 1.9 \end{bmatrix}$ **b.** $\begin{bmatrix} -3 & -1.5 & -6 \\ 1.5 & 0 & 3 \\ -6 & -1.5 & -6 \end{bmatrix}$ **c.** $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

8. a. $\begin{bmatrix} 17 & -32 & -13 \\ 5 & 0 & -5 \end{bmatrix}$ **b.** $\begin{bmatrix} -26 & -18 & 24 \\ 2 & -10 & -4 \end{bmatrix}$ **c.** $\begin{bmatrix} 24 & 4 \\ 0 & -5 \\ 16 & -39 \end{bmatrix}$

d. $\begin{bmatrix} -4 & -33 \\ -2 & 29 \end{bmatrix}$ **9.** used: \$80, new: \$125

10. $\begin{bmatrix} 4375 & 110 \\ 2400 & 59 \end{bmatrix}$,

P_{11}: total rebates paid by individuals, P_{21}: total rebates paid by business, P_{12}: free AAA years given to individuals, P_{22}: free AAA years given to business

Reinforcing Basic Concepts, p. 871

Exercise 1: P_{32}

Exercise 2: **1st row of A with 3rd column of B**
2nd row of A with 2nd column of B

Exercise 3: $[A] \to 3 \times 1; [B] \to 1 \times 3$
$[A] \to 3 \times 2; [B] \to 2 \times 3$
$[A] \to 3 \times 3; [B] \to 3 \times 3$
$[A] \to 3 \times n; [B] \to n \times 3; n \in \mathbb{N}$

Exercises 9.3, pp. 881–885

1. diagonal; zeroes **3.** identity **5.** Answers will vary.
7. verified **9.** verified **11.** verified **13.** verified

15. $\begin{bmatrix} \frac{1}{9} & \frac{2}{9} \\ \frac{-1}{9} & \frac{5}{18} \end{bmatrix}$ **17.** $\begin{bmatrix} -5 & 1.5 \\ -2 & 0.5 \end{bmatrix}$ **19.** verified **21.** verified

23. $\begin{bmatrix} \frac{-2}{39} & \frac{1}{13} & \frac{10}{39} \\ \frac{1}{3} & 0 & \frac{1}{3} \\ \frac{-4}{39} & \frac{2}{13} & \frac{-19}{39} \end{bmatrix}$ **25.** $\begin{bmatrix} \frac{-9}{80} & \frac{31}{400} & \frac{27}{400} \\ \frac{1}{80} & \frac{41}{400} & \frac{-3}{400} \\ \frac{-1}{20} & \frac{-1}{100} & \frac{-17}{100} \end{bmatrix}$ **27.** $\begin{bmatrix} 2 & -3 \\ -5 & 7 \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 9 \\ 8 \end{bmatrix}$

29. $\begin{bmatrix} 1 & 2 & -1 \\ 1 & 0 & 1 \\ 2 & -1 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 1 \\ 3 \\ 3 \end{bmatrix}$

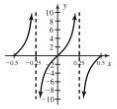
31. $\begin{bmatrix} -2 & 1 & -4 & 5 \\ 2 & -5 & 1 & -3 \\ -3 & 1 & 6 & 1 \\ 1 & 4 & -5 & 1 \end{bmatrix}\begin{bmatrix} w \\ x \\ y \\ z \end{bmatrix} = \begin{bmatrix} -3 \\ 4 \\ 1 \\ -9 \end{bmatrix}$

33. (4, 5) **35.** (12, 12) **37.** no solution **39.** (1.5, −0.5, −1.5)
41. no solution **43.** (−1, −0.5, 1.5, 0.5) **45.** 1, yes **47.** 0, no **49.** 1
51. singular matrix **53.** singular matrix **55.** −34 **57.** 7
59. $\det(A) = -5$; (1, 6, 9) **61.** $\det(A) = 0$ **63.** $A^{-1} = \begin{bmatrix} \frac{1}{13} & \frac{5}{13} \\ \frac{-2}{13} & \frac{3}{13} \end{bmatrix}$
65. singular **67.** 31 behemoth, 52 gargantuan, 78 mammoth, 30 jumbo
69. Jumpin' Jack Flash: 3.75 min
Tumbling Dice: 3.75 min
You Can't Always Get: 7.5 min
Wild Horses: 5.75 min
71. 30 of clock A; 20 of clock B; 40 of clock C; 12 of clock D
73. $p_1 = 72.25°, p_2 = 74.75°, p_3 = 80.25°, p_4 = 82.75°$
75. $y = x^3 + 2x^2 - 9x - 10$
77. 2 oz food I, 1 oz Food II, 4 oz Food III
79. Answers will vary. **81. a.** −45 **b.** 52 **c.** −19 **d.** −4
83. $A = 125$, period $= \frac{2\pi}{3}$ **85.** $x \in \left(-\infty, -\frac{9}{2}\right] \cup \left[-\frac{1}{2}, \infty\right)$

Exercises 9.4 pp. 896–899

1. $a_{11}a_{22} - a_{21}a_{12}$ **3.** constant **5.** Answers will vary.
7. $D = \begin{vmatrix} 2 & 5 \\ -3 & 4 \end{vmatrix}$; $D_x = \begin{vmatrix} 7 & 5 \\ 1 & 4 \end{vmatrix}$; $D_y = \begin{vmatrix} 2 & 7 \\ -3 & 1 \end{vmatrix}$
9. (−5, 9) **11.** $\left(\frac{-26}{3}, \frac{25}{3}\right)$ **13.** no solution

15. a. $D = \begin{vmatrix} 4 & -1 & 2 \\ -3 & 2 & -1 \\ 1 & -5 & 3 \end{vmatrix}$ $D_x = \begin{vmatrix} -5 & -1 & 2 \\ 8 & 2 & -1 \\ -3 & -5 & 3 \end{vmatrix}$
$D_y = \begin{vmatrix} 4 & -5 & 2 \\ -3 & 8 & -1 \\ 1 & -3 & 3 \end{vmatrix}$ $D_z = \begin{vmatrix} 4 & -1 & -5 \\ -3 & 2 & 8 \\ 1 & -5 & -3 \end{vmatrix}$
$D = 22$, solutions possible
b. $D = 0$, Cramer's rule cannot be used
17. (1, 2, 1) **19.** $\left(\frac{3}{4}, \frac{5}{3}, \frac{-1}{3}\right)$ **21.** (0, −1, 2, −3) **23.** $\frac{A}{x+3} + \frac{B}{x-2}$
25. $\frac{A}{x-1} + \frac{B}{x+2} + \frac{C}{x-3}$ **27.** $\frac{A}{x} + \frac{B}{x-3} + \frac{C}{x+1}$
29. $\frac{A}{x} + \frac{B}{x^2} + \frac{C}{x+2}$ **31.** $\frac{A}{x+1} + \frac{Bx+C}{x^2+2} + \frac{Dx+E}{(x^2+2)^2}$
33. $\frac{4}{x} - \frac{5}{x+1}$ **35.** $\frac{-4}{2x-5} + \frac{3}{x+3}$ **37.** $\frac{7}{x} + \frac{2}{x+1} - \frac{1}{x-1}$
39. $\frac{-1}{x} + \frac{4}{x+1} + \frac{5}{(x+1)^2}$ **41.** $\frac{3}{2-x} - \frac{4}{4+2x+x^2}$
43. $\frac{5}{x+2} + \frac{x-1}{x^2+3}$ **45.** $\frac{1}{x} + \frac{3x-2}{(x^2+1)^2}$
47. $\frac{3}{x+1} - \frac{2}{x-3} + \frac{1}{(x-3)^3}$ **49.** $320 + 32\pi \approx 420.5$ in^2
51. 8 cm^2 **53.** 27 ft^2 **55.** 19 m^3 **57.** yes **59.** no **61.** yes, yes, yes
63. $\begin{cases} 15{,}000x + 25{,}000y = 2900 \\ 25{,}000x + 15{,}000y = 2700 \end{cases}$; 6%, 8%
65. (−1, −1, 2); answers will vary. **67.** $x^2 + y^2 - 4x - 6y - 12 = 0$
69. $\angle B \approx 76.3°, \angle C \approx 54.7°$, side $c = 9.4$ in.
71. ; $p = \frac{1}{2}, A = 3, x = \pm\frac{1}{4}$



Summary and Concept Review, pp. 899–901

1. Answers will vary. **2.** (−2, −4) **3.** (1, 6, 9) **4.** (−2, 7, 1, 8)
5. $\left\{(x, y, z) | x = 3y + 2, y \in \mathbb{R}, z = -\frac{5}{2}y - \frac{5}{2}\right\}$
6. $\begin{bmatrix} -7.25 & 5.25 \\ 0.875 & -2.875 \end{bmatrix}$ **7.** $\begin{bmatrix} -6.75 & 6.75 \\ 1.125 & -1.125 \end{bmatrix}$ **8.** not possible
9. $\begin{bmatrix} -2 & -6 \\ -1 & -7 \end{bmatrix}$ **10.** $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ **11.** $\begin{bmatrix} 1 & 0 & 4 \\ 5.5 & -1 & -1 \\ 10 & -2.9 & 7 \end{bmatrix}$
12. $\begin{bmatrix} 3 & -6 & -4 \\ -4.5 & 3 & -1 \\ -2 & 3.1 & 3 \end{bmatrix}$ **13.** not possible
14. $\begin{bmatrix} -8 & 12 & 0 \\ -2 & -4 & 4 \\ -16 & -0.4 & -20 \end{bmatrix}$ **15.** $\begin{bmatrix} 15.5 & 6.4 & 17 \\ 9 & -17 & 2 \\ 18.5 & -20.8 & 13 \end{bmatrix}$ **16.** D
17. It's an identity. **18.** It's the inverse of B. **19.** E **20.** It is the inverse of F. **21.** Matrix multiplication is not generally commutative.
22. (−8, −6) **23.** (2, 0, −3) **24.** $\left(\frac{-19}{35}, \frac{25}{14}\right)$ **25.** $\left(\frac{-37}{19}, \frac{36}{19}, \frac{31}{19}\right)$
26. (1, −1, 2) **27.** $\frac{91}{2}$ units^2 **28.** $\frac{5}{x-2} + \frac{2x-1}{x^2+3}$

Mixed Review, pp. 901–902

1. (−10, 12) **3.** $\{(x, y, z) | x = z - 1, y = 2z - 2, z \in \mathbb{R}\}$
5. a. $\begin{bmatrix} -8 & 16 & -10 \\ 12 & 0 & 6 \end{bmatrix}$ **b.** $\begin{bmatrix} 9 & -6 & -7 \\ -7 & -1 & 2 \end{bmatrix}$

7. a. 3 **b.** 3 **c.** -4 **d.** 1 **9.** $(-9, -3, 2)$ **11.** $A^{-1} = \begin{bmatrix} 8 & -3 \\ -5 & 2 \end{bmatrix}$

13. $\begin{cases} x + 2y - z = 1 \\ x + z = 3 \\ 2x - y + z = 3 \end{cases}$ **15.** $\left(\frac{33}{31}, \frac{-10}{31}, \frac{-57}{31}\right)$ **17.** $A = 4.5$ units^2

19. 137 m by 82 m

Practice Test, pp. 902–903

1. $\left(-3, \frac{1}{2}\right)$ **2.** $\left\{(x, y, z) \middle| x = -3y + \frac{16}{3}, y \in \mathbb{R}, z = 2y - 3\right\}$

3. $\left(2, 1, \frac{-1}{3}\right)$ **4. a.** $\begin{bmatrix} -6 & -5 \\ 8 & 9 \end{bmatrix}$ **b.** $\begin{bmatrix} 1.2 & 1.2 \\ -1.2 & -2 \end{bmatrix}$ **c.** $\begin{bmatrix} -3 & 1 \\ 3 & -5 \end{bmatrix}$

d. $\begin{bmatrix} -2 & -1 \\ 2.5 & 1.5 \end{bmatrix}$ **e.** -2

5. a. $\begin{bmatrix} 0 & -0.1 & 0 \\ 0.5 & -0.6 & 0 \\ -0.2 & -0.8 & -0.9 \end{bmatrix}$ **b.** $\begin{bmatrix} -0.3 & -0.06 & -0.12 \\ 0.06 & -0.06 & 0 \\ -0.18 & -0.24 & -0.48 \end{bmatrix}$

c. $\begin{bmatrix} 0.31 & -0.13 & 0.08 \\ -0.01 & -0.05 & -0.02 \\ 0.39 & -0.52 & -0.02 \end{bmatrix}$ **d.** $\begin{bmatrix} \frac{40}{17} & 0 & \frac{-10}{17} \\ \frac{40}{17} & 10 & \frac{-10}{17} \\ \frac{-35}{17} & -5 & \frac{30}{17} \end{bmatrix}$ **e.** $\frac{17}{500}$

6. $(-1, -6, 0)$, $(1, -1, 1)$, $(3, 4, 2)$, answers vary as $(2p - 1, 5p - 6, p)$

7. $\left(2, \frac{2}{3}\right)$ **8.** $(3, -2, 3)$ **9.** $\left(\frac{97}{34}, \frac{-18}{17}\right)$ **10.** $(1, 6, 9)$

11. $(1, -1, 2)$ **12.** $B = \begin{bmatrix} 6 \\ 13 \\ -11 \end{bmatrix}$ **13.** $(-1, 4)$, $(2, 1)$, $(4, -1)$

14. 5 mi^2 **15.** $r = -2$, $s = 1$ **16.** Dr. Brown owes \$31,000; Dr. Stamper owes \$124,000 **17.** 7.5 hr, 15.5 hr **18.** 11 one day, 6 two day, 3 five day **19.** federal program: \$200,000; municipal bonds: \$1,300,000; bank loan: \$300,000 **20.** $\frac{1}{x - 3} + \frac{3x + 2}{x^2 + 3x + 9}$

Strengthening Core Skills p. 905

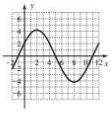
Exercise 1: $(1, -4, 1)$

Cumulative Review Chapters 1–9, pp. 905–906

1. a. $x = \frac{2}{3}$ **b.** $x = 0, 7$ **c.** $x = 5, \pm i\sqrt{2}$ **d.** $x = -1, 0, 4$

3. $R = \pm\frac{1}{\pi}\sqrt{A + (\pi r)^2}$

5.



7. a. $(a + bi) + (a - bi) = 2a$ **b.** $(a + bi)(a - bi) = a^2 - (bi)^2 = a^2 + b^2$ **9.** $x - 12 \pm \frac{\sqrt{15}}{3}$

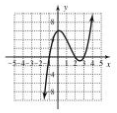
11. $\sin\theta = \frac{\sqrt{13}}{4}$, $\cos\theta = \frac{\sqrt{3}}{4}$, $\tan\theta = \frac{\sqrt{39}}{3}$

13. a. $m = \frac{y_2 - y_1}{x_2 - x_1}$ **b.** $\left(\frac{x_2 + x_1}{2}, \frac{y_2 + y_1}{2}\right)$

c. $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ **d.** $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

e. $A = Pe^{rt}$ **15.** $\langle -3, -18 \rangle$ **17. a.** $\frac{\sqrt{121 + x^2}}{11}$ **b.** $\frac{x}{\sqrt{9 + x^2}}$

19.



$x \in (-\infty, -1) \cup (2, 3)$

21. $-128 - 128i\sqrt{3}$ **23.** about 3.6 yr **25.** $A = 2$, $B = 1$, $C = \frac{\pi}{4}$

Modeling With Technology Exercises, pp. 914–917

1. 225 boards at \$400 a piece **3.** 90,000,000 gal at \$3.07 per gallon

5. (~410.07. ~226.58)or about 227 boards at approximately \$410 a piece

7. (~3.0442, ~8.9964), or about 90,000,000 gal at approximately \$3.04 per gallon **9.** 214.5 ft^2 of skin, 231.0 ft^2 of wood veneer, 516 tension rods, and 498 ft of hoop **11.** 955 ft^2 of skin, 1021.5 ft^2 of wood veneer, 2180 tension rods, and 2129.5 ft of hoop

13. 92,250 gal gasoline, 595,000 lb corn, 227,500 oz yeast, and 134,750 gal water **15.** 5 Silver, 9 Gold, and 2 Platinum

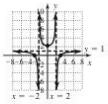
17. one bundle of first class = 9.25 measures of grain;
one bundle of second class = 4.25 measures of grain;
one bundle of third class = 2.75 measures of grain

19. Answers will vary. **21.** Answers will vary. **23.** Answers will vary. **25.** Answers will vary. **27.** Answers will vary. **29.** Answers will vary. **31.** Answers will vary. **33.** Answers will vary. **35.** Answers will vary.

CHAPTER 10

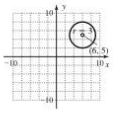
Exercises 10.1, pp. 925–927

1. geometry, algebra **3.** perpendicular **5.** point, intersecting
7. $(-2, -2)$; verified **9.** $(2, -2)$; verified **11.** $(\frac{13}{2}, -9)$; verified
13. $(x + 2)^2 + (y + 2)^2 = 5^2$ **15.** $(x - 2)^2 + (y + 2)^2 = 5^2$
17. $\left(x - \frac{13}{2}\right)^2 + (y + 9)^2 = \left(\frac{25}{2}\right)^2$
19. a. $d = 13$; B, C, E, G; **b.** $(13, 3 + 4\sqrt{3})$, $(14, 8)$; Many others
21. Verified, $d = \frac{8\sqrt{5}}{5}$ **23. a.** B, C, E; **b.** Answers will vary.
25. Verified **27.** $y = -\frac{1}{16}x^2$ **29.** $4x^2 + 3y^2 = 48$
31. Verified, verified **33.** $3x^2 - y^2 = 3$
35. a. $\left(-\frac{12}{7}, -\frac{30}{7}\right)$, **b.** $\left(-2, -\frac{4}{3}\right)$ **37.** Verified (both add to 8)
39. $x = \frac{4\pi}{3}$ **41.** $h(x) = \frac{(x + 3)(x - 3)}{(x + 2)(x - 2)}$

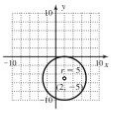


Exercises 10.2, pp. 935–940

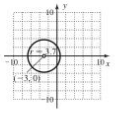
1. $c^2 = |a^2 - b^2|$ **3.** $2a$; $2b$ **5.** answers will vary. **7.** $x^2 + y^2 = 49$
9. $(x - 5)^2 + y^2 = 3$ **11.** $(x - 1)^2 + (y - 5)^2 = 25$
13. $(x - 6)^2 + (y - 5)^2 = 9$
center: $(6, 5)$, $r = 3$



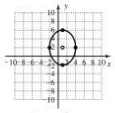
15. $(x - 2)^2 + (y + 5)^2 = 25$
center: $(2, -5)$, $r = 5$



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



19.



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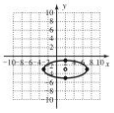

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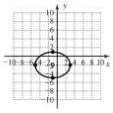
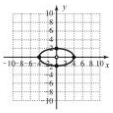
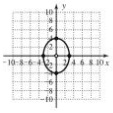


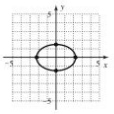
25. a. $\frac{x^2}{16} + \frac{y^2}{4} = 1$, $(0, 0)$, $a = 4$, $b = 2$
b. $(-4, 0)$, $(4, 0)$, $(0, -2)$, $(0, 2)$ c.



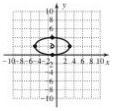
27. a. $\frac{x^2}{9} + \frac{y^2}{16} = 1$, $(0, 0)$, $a = 3$, $b = 4$
b. $(0, -4)$, $(0, 4)$, $(-3, 0)$, $(3, 0)$ c.



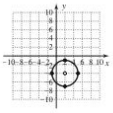
29. a. $\frac{x^2}{5} + \frac{y^2}{2} = 1$, $(0, 0)$, $a = \sqrt{5}$, $b = \sqrt{2}$
b. $(-\sqrt{5}, 0)$, $(\sqrt{5}, 0)$, $(0, -\sqrt{2})$, $(0, \sqrt{2})$ c.



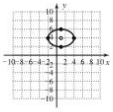
31. ellipse



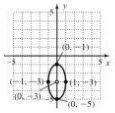
33. circle



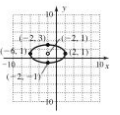
35. ellipse



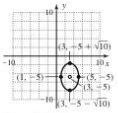
37. $x^2 + \frac{(y + 3)^2}{4} = 1$



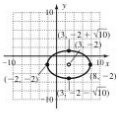
39. $\frac{(x + 2)^2}{16} + \frac{(y - 1)^2}{4} = 1$



41. $\frac{(x - 3)^2}{4} + \frac{(y + 5)^2}{10} = 1$

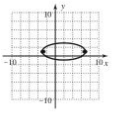


43. $\frac{(x - 3)^2}{25} + \frac{(y + 2)^2}{10} = 1$

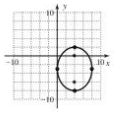


45. 20 **47.** 20

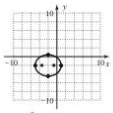
49. a. (2, 1) **b.** $(-3, 1)$ and $(7, 1)$ **c.** $(2 - \sqrt{21}, 1)$ and $(2 + \sqrt{21}, 1)$
d. $(2, 3)$ and $(2, -1)$ **e.**



51. a. $(4, -3)$ **b.** $(4, 2)$ and $(4, -8)$ **c.** $(4, 0)$ and $(4, -6)$
d. $(0, -3)$ and $(8, -3)$ **e.**



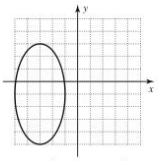
53. a. $(-2, -2)$ **b.** $(-5, -2)$ and $(1, -2)$ **c.** $(-2 + \sqrt{3}, -2)$ and $(-2 - \sqrt{3}, -2)$ **d.** $(-2, -2 + \sqrt{6})$ and $(-2, -2 - \sqrt{6})$
e.



55. $\frac{x^2}{36} + \frac{y^2}{20} = 1$ **57.** $\frac{(x - 3)^2}{9} + \frac{(y + 2)^2}{25} = 1$

59. $\frac{x^2}{16} + \frac{y^2}{9} = 1$, $(\pm\sqrt{7}, 0)$

61.



$\frac{(x + 3)^2}{4} + \frac{(y + 1)^2}{16} = 1$,
$(-3, -1 \pm 2\sqrt{3})$

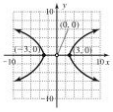
63. $A = 12\pi$ units^2 **65.** $\sqrt{7} \approx 2.65$ ft, 2.25 ft **67.** 8.9 ft, 17.9 ft

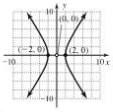
69. $\frac{x^2}{15^2} + \frac{y^2}{8^2} = 1$; 6.4 ft **71.** $\frac{x^2}{36^2} + \frac{y^2}{(35.25)^2} = 1$

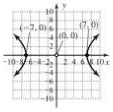
73. $a \approx 142$ million miles, $b \approx 141$ million miles, orbit time ≈ 686 days
75. $90{,}000\pi$ yd^2
77. $L = 8$ units; $(3\sqrt{5}, 4)$, $(3\sqrt{5}, -4)$, $(-3\sqrt{5}, 4)$, $(-3\sqrt{5}, -4)$; verified
79. Verified **81.** $R = \frac{kL}{d^2}$ $k = 0.003$ 250 Ω
83. 261.8 mph, heading 26.2°

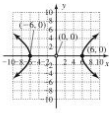
Exercises 10.3, pp. 950–953

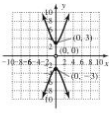
1. transverse **3.** midway **5.** Answers will vary.

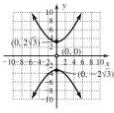
7. 

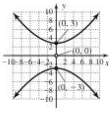
9. 

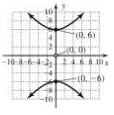
11. 

13. 

15. 

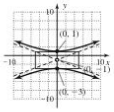
17. 

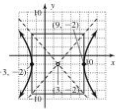
19. 

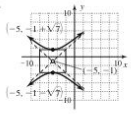
21. 

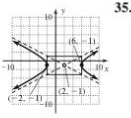
23. $(-4, -2), (2, -2), y = -2, (-1, -2), x = -1$

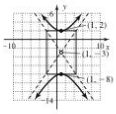
25. $(4, 1), (4, -3), x = 4, (4, -1), y = -1$

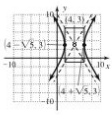
27. 

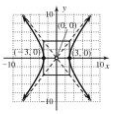
29. 

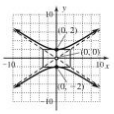
31. 

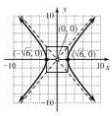
33. 

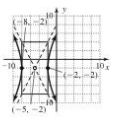
35. 

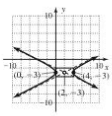
37. 

39. 

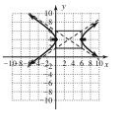
41. 

43. 

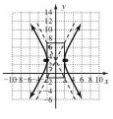
45. 

47. 

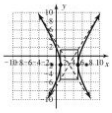
49. circle **51.** circle **53.** hyperbola **55.** hyperbola
57. circle **59.** ellipse **61.** $8, 2a = 8, 2b = 6$
63. $12, 2a = 16, 2b = 12$
65. a. $(3, 4)$ **b.** $(0, 4)$ and $(6, 4)$ **c.** $(3 - \sqrt{13}, 4)$ and $(3 + \sqrt{13}, 4)$
d. $2a = 6, 2b = 4$ **e.**



67. a. $(0, 3)$ **b.** $(-2, 3)$ and $(2, 3)$ **c.** $(-2\sqrt{5}, 3$ and $(2\sqrt{5}, 3)$
d. $2a = 4, 2b = 8$ **e.**



69. a. $(3, -2)$ **b.** $(1, -2)$ and $(5, -2)$ **c.** $(-1, -2)$ and $(7, -2)$
d. $2a = 4, 2b = 4\sqrt{3}$ **e.**



71. $\frac{x^2}{36} - \frac{y^2}{28} = 1$ **73.** $\frac{y^2}{9} - \frac{(x+2)^2}{9} = 1$

75. $\frac{x^2}{4} - \frac{y^2}{9} = 1, (\pm\sqrt{13}, 0)$ **77.** $\frac{(y-1)^2}{4} - \frac{(x-2)^2}{5} = 1$, 4 by $2\sqrt{5}$

79. a. $y = \frac{2}{3}\sqrt{x^2 - 9}$ **b.** $x \in (-\infty, -3] \cup [3, \infty)$ **c.** $y = \frac{-2}{3}\sqrt{x^2 - 9}$

81. 40 yd **83.** 40 ft

85. $\frac{x^2}{225} - \frac{y^2}{2275} = 1$, about $(24.1, 60)$ or $(-24.1, 60)$

87. a. $\frac{(x-4)^2}{\frac{1}{4}} - (y-2)^2 = 0$ **b.** $(x-2)^2 + \frac{(x-4)^2}{\frac{1}{5}} = 0$

89. a **91.** $\frac{(x-2)^2}{43} + \frac{(y-3)^2}{9} = 1$ **93.** $700 \cos 65° \approx 295.8$, yes

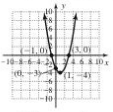
95. b and c

Exercises 10.4, pp. 960–963

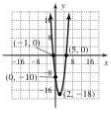
1. horizontal; right; $a < 0$ **3.** $(p, 0)$; $x = -p$

5. Answers will vary.

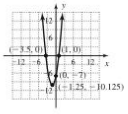
7. $x \in (-\infty, \infty), y \in [-4, \infty)$



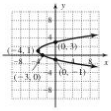
9. $x \in (-\infty, \infty), y \in [-18, \infty)$



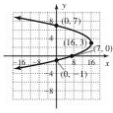
11. $x \in (-\infty, \infty)$, $y \in [-10.125, \infty)$



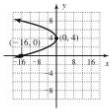
13. $x \in [-4, \infty), y \in (-\infty, \infty)$



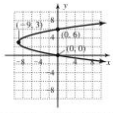
15. $x \in (-\infty, 16], y \in (-\infty, \infty)$



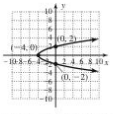
17. $x \in (-\infty, 0], y \in (-\infty, \infty)$



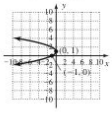
19. $x \in [-9, \infty), y \in (-\infty, \infty)$



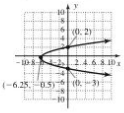
21. $x \in [-4, \infty), y \in (-\infty, \infty)$



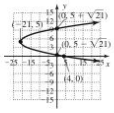
23. $x \in (-\infty, 0], y \in (-\infty, \infty)$



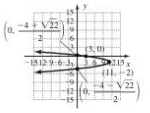
25. $x \in [-6.25, \infty), y \in (-\infty, \infty)$



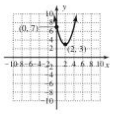
27. $x \in [-21, \infty), y \in (-\infty, \infty)$



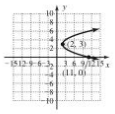
29. $x \in (-\infty, 11], y \in (-\infty, \infty)$



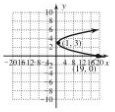
31. $x \in (-\infty, \infty), y \in [3, \infty)$



33. $x \in [2, \infty), y \in (-\infty, \infty)$



35. $x \in [1, \infty), y \in (-\infty, \infty)$



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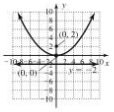

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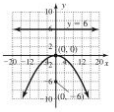

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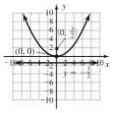

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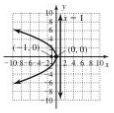

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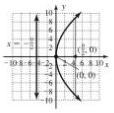

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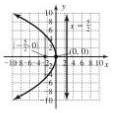

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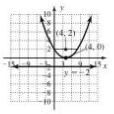

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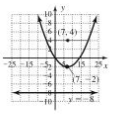

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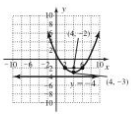

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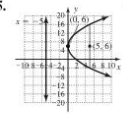

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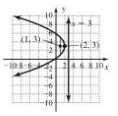

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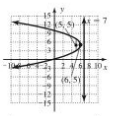


61. $x^2 = 8y$ **63.** $y^2 = 16x$ **65.** $x^2 = -20y$

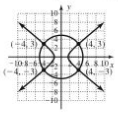
67. $(y + 2)^2 = -12(x - 2)$ **69.** $(x - 4)^2 = 12(y + 7)$

71. $(x - 3)^2 = 8(y - 2)$

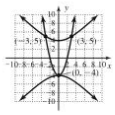
73. $y^2 = 8(x + 1)$
vertex $(-1, 0)$
focus $(1, 0)$

75. $(y - 2)^2 = -8(x + 2)$
directrix: $x = 0$
endpoints $(-4, 6)$ and $(-4, -2)$

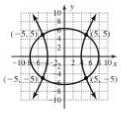
77. 7.3/19 $\left(\frac{\sqrt{555}}{3}, -\frac{16}{3}\right)$



79. 7.3/21

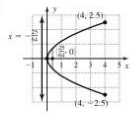


81. 7.3/23



83. 16 units^2

85.



87. 6 in.; (13.5, 0) **89.** 14.97 ft, (0, 41.75)

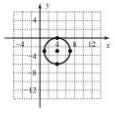
91. $y^2 = 5x$ or $x^2 = 5y$, 1.25 cm

93. $(x - 2)^2 = \frac{1}{2}(y + 8)$; $p = \frac{1}{8}$; $(2, -8)$ **95.** 18 units^2

97. Answers will vary. **99.** about 120 days

Mid-Chapter Check, p. 964

1.



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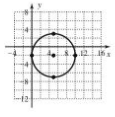

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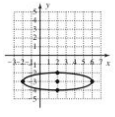

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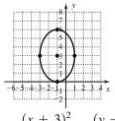

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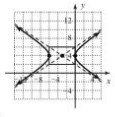

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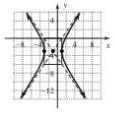
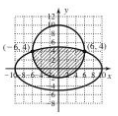


7. a. $\frac{(x + 3)^2}{4} + \frac{(y - 1)^2}{16} = 1$; D: $x \in [-5, -1]$; R: $y \in [-3, 5]$

b. $(x - 3)^2 + (y - 2)^2 = 16$; D: $x \in [-1, 7]$; R: $y \in [-2, 6]$

c. $y = (x - 3)^2 - 4$ D: $x \in (-\infty, \infty)$; R: $y \in [-4, \infty)$

8.



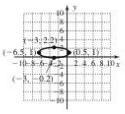
9. $\frac{x^2}{16} + \frac{y^2}{4} = 1$ **10.** yes, distance $d \approx 49$ mi

Reinforcing Basic Concepts, pp. 964–965

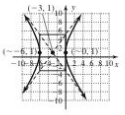
1. $\frac{(x - 2)^2}{\left(\frac{\sqrt{2}}{5}\right)^2} + \frac{(y + 3)^2}{\left(\frac{2}{3}\right)^2} = 1$ $a = \frac{\sqrt{2}}{5}, b = \frac{2}{3}$

2. $\frac{(x - 1)^2}{\left(\frac{5\sqrt{7}}{14}\right)^2} + \frac{(y + 2)^2}{\left(\frac{5\sqrt{3}}{12}\right)^2} = 1$ $a = \frac{5\sqrt{17}}{14}, b = \frac{5\sqrt{3}}{12}$

3. $\dfrac{(x+3)^2}{\left(\frac{7}{2}\right)^2}+\dfrac{(y-1)^2}{\left(\frac{6}{5}\right)^2}=1;\ a=\dfrac{7}{2}, b=\dfrac{6}{5}$



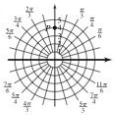
4. $\dfrac{(x+3)^2}{\left(\frac{4\sqrt{5}}{3}\right)^2}-\dfrac{(y-1)^2}{\left(\frac{9}{2}\right)^2}=1;\ a=\dfrac{4\sqrt{5}}{3}\approx 3, b=\dfrac{9}{2}$

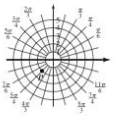


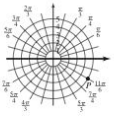
Exercises 10.5, pp. 975–978

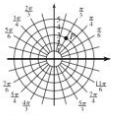
1. polar **3.** II; IV

5. To plot the point (r, θ) start at the origin or pole and move $|r|$ units out along the polar axis. Then move counterclockwise an angle measure of θ. You should be r units straight out from the pole in a direction of θ from the positive polar axis. If r is negative, final resting place for the point (r, θ) will be 180° from θ.

7. 

9. 

11. 

13. 

15. $\left(4, \dfrac{\pi}{2}\right)$ **17.** $\left(4\sqrt{2}, \dfrac{\pi}{4}\right)$ **19.** $\left(8, \dfrac{2\pi}{3}\right)$ **21.** $\left(4\sqrt{2}, \dfrac{3\pi}{4}\right)$

23. $\left(3\sqrt{2}, \dfrac{-5\pi}{4}\right), \left(-3\sqrt{2}, \dfrac{7\pi}{4}\right), \left(3\sqrt{2}, \dfrac{11\pi}{4}\right), \left(-3\sqrt{2}, \dfrac{-\pi}{4}\right)$

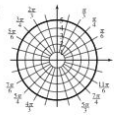
25. $\left(2, \dfrac{5\pi}{6}\right), \left(2, \dfrac{-7\pi}{6}\right), \left(2, \dfrac{17\pi}{6}\right), \left(-2, \dfrac{-\pi}{6}\right)$

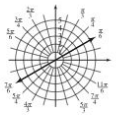
27. *C* **29.** *C* **31.** *D* **33.** *B* **35.** *D* **37.** (8, 180°) or (8, π)

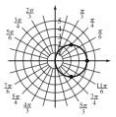
39. $(4\sqrt{2}, 45°)$ or $\left(4\sqrt{2}, \dfrac{\pi}{4}\right)$ **41.** (10, 45°) or $\left(10, \dfrac{\pi}{4}\right)$

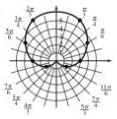
43. (13, 247.4°) or (13, 4.3176) **45.** $(4\sqrt{2}, 4\sqrt{2})$ **47.** $(-2\sqrt{2}, 2\sqrt{2})$

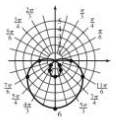
49. $(\sqrt{3}, 1)$ **51.** $\left(\dfrac{5\sqrt{2}}{2}, \dfrac{5\sqrt{2}}{2}\right)$

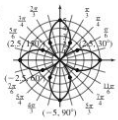
53. 

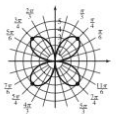
55. 

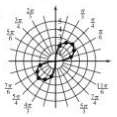
57. 

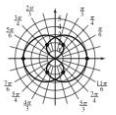
59. 

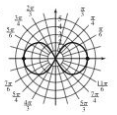
61. 

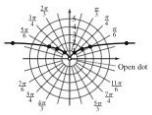
63. 

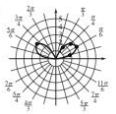
65. 

67. 

69. 

71. 

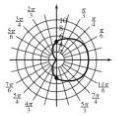
73. 

75. 

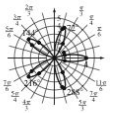
77. $\left(\dfrac{4\sqrt{3}+3\sqrt{2}}{2}, \dfrac{4+3\sqrt{2}}{2}\right)$; $(3\sqrt{2}, 3\sqrt{2})$; $(4\sqrt{3}, 4)$; yes

$M = \left(\dfrac{3\sqrt{2}+4\sqrt{3}}{2}, \dfrac{3\sqrt{2}+4}{2}\right)$

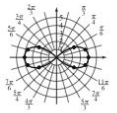
79. $r = 4 + 4\cos\theta$



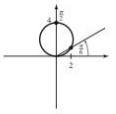
81. $r = 4\cos(5\theta)$



83. $r^2 = 16\cos(2\theta)$



85. $r = 4\sin\theta$



87. a; this is a circle through (6, 0°) symmetric about the polar axis

89. g; this is a circle through $\left(6, \dfrac{\pi}{2}\right)$ symmetric about $\theta = \dfrac{\pi}{2}$.

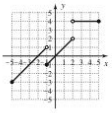
91. f; this is a limaçon symmetric about $\theta = \dfrac{\pi}{2}$ with an inner loop. Thus $a < b$.

93. b; this is a cardioid symmetric about $\theta = \dfrac{\pi}{2}$ through $\left(6, \dfrac{3\pi}{2}\right)$.

95. $r^2 = 7200^2\sin(2\theta)$ **97.** $r = 15\cos(5\theta)$ or $r = 15\sin(5\theta)$

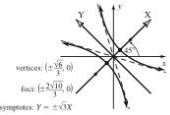
99. π; π; π; Answers will vary.

101. Consider $r = a\sqrt{\cos(2\theta)}$ and $r = -a\sqrt{\cos(2\theta)}$; both satisfy $r^2 = a^2\cos(2\theta)$. Thus, (r, θ) and $(-r, \theta)$ will both be on the curve. The same is true with $a\sqrt{\sin(2\theta)}$ and $-a\sqrt{\sin(2\theta)}$.
103. 9π units^2 **105.** $3y^2 - x^2 - 12y + 9 = 0$
107. $t = 0, \frac{2\pi}{3}, \pi, \frac{5\pi}{3}$
109. D: $x \in [-5, 2) \cup (2, 5]$
R: $y \in [-3, 2) \cup \{4\}$

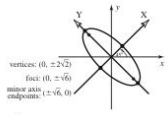


Exercises 10.6, pp. 989–994

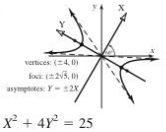
1. rotation of axes; $\frac{B}{A - C}$ **3.** invariants **5.** Answers will vary.
7. $\frac{Y^2}{8} - \frac{X^2}{8} = 1$ **9.** $6 + 3\sqrt{2} = X, -6 + 3\sqrt{2} = Y$
11. $\frac{5\sqrt{2}}{2} = X, \frac{5\sqrt{2}}{2} = Y$ **13.** $0 = x, 4 = y$
15. $\frac{3\sqrt{3}}{2} - 2 = x; \frac{3}{2} + 2\sqrt{3} = y$ **17.** $\frac{-x^2}{2} + xy\sqrt{3} + \frac{y^2}{2} = 9$
19. $4X^2 + 2Y^2 = 9$
21. a. $3X^2 - Y^2 = 2$
b.



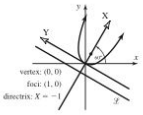
23. a. $4X^2 + Y^2 = 8$
b.



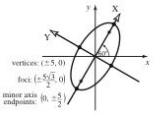
25. a. $Y^2 - 4X^2 = 16$
b.



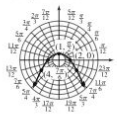
27. a. $Y^2 - 4X = 0$
b.



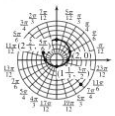
29. a. $X^2 + 4Y^2 = 25$
b.



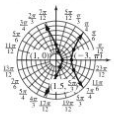
31. $336 > 0$; hyperbola; $\cos(2\beta) = \frac{7}{25}; \frac{4}{5} = \cos\beta; \frac{3}{5} = \sin\beta$
33. a. parabola **b.** $\beta = 45°; 2Y^2 = 5$ **c.** verified
35. a. circle or ellipse **b.** $\beta = 60°; \frac{9}{2}X^2 + \frac{5Y^2}{2} + 2X - 2\sqrt{3}Y = 1$ (ellipse) **c.** verified **37.** f **39.** g **41.** h
43. parabola



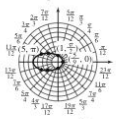
45. ellipse



47. hyperbola



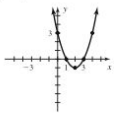
49. ellipse



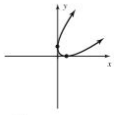
51. $r = \frac{3.2}{1 - 0.8\cos\theta}$
53. $r = \frac{4}{1 - \cos\theta}$ **55.** $r = \frac{7.5}{1 + 1.5\sin\theta}$
57. a. $r = \frac{12}{2\cos\theta + 3\sin\theta}$ **b.** $-\frac{r(\pi/2)}{r(0)} = \frac{-2}{3}$ and $\frac{-A}{B} = \frac{-2}{3}$
59. Jupiter: $e \approx 0.0486$, Saturn: $e \approx 0.0567$
61. about 2757.1 million miles **63.** Saturn: $e \approx 0.0567$
65. $r \approx \frac{482.36}{1 - 0.0486\cos\theta}$ **67.** $r \approx \frac{1780.77}{1 - 0.0457\cos\theta}$
69. In millions of miles (approx): $\overline{IS}$: 405.3, $\overline{JU}$: 1298.4, $\overline{JN}$: 2310.3, $\overline{SU}$: 893.1, $\overline{SN}$: 1905.0, $\overline{UN}$: 1011.9
71. $r = \frac{0.7638}{1 \pm 0.7862\cos\theta}$ **73.** $r = \frac{0.2864}{1 \pm 0.7862\cos\theta}$
75. \$582.45; \$445.94; \$881.32; \$97.92 **77.** $y = \frac{3}{1 - \cos\theta}$
79. verified **81.** Answers will vary
83. $r = 12\cos\left(\theta - \frac{\pi}{4}\right) = 6\sqrt{2}(\cos\theta + \sin\theta)$
85. $425X^2 - 416Y^2 - 400 = 0$ **87.** (0, 0), (4, 0), (4, 4), (0, 4)
89. $x \approx 29.0$ **91.** 9.2 mph at heading 347.7°

Exercise 10.7, pp. 1002–1006

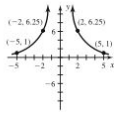
1. parameter **3.** direction **5.** Answers will vary.
7. a. parabola with vertex at $(2, -1)$
b. $y = x^2 - 4x + 3$



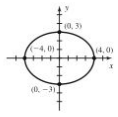
9. a. parabola
b. $y = x \pm 2\sqrt{x} + 1$



11. a. power function with $p = -2$
b. $y = \frac{25}{x^2}, x \neq 0$

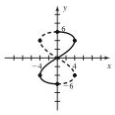


13. a. ellipse
b. $\frac{x^2}{16} + \frac{y^2}{9} = 1$

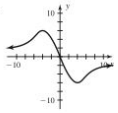


15. a. Lissajous figure

b. $y = 6\cos\left[\frac{1}{2}\sin^{-1}\left(\frac{x}{4}\right)\right]$



17.



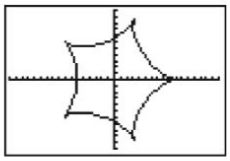
19. $x = t, y = 3t - 2; x = \frac{1}{3}t, y = t - 2; x = \cos t, y = 3\cos t - 2$

21. $x = t, y = (t + 3)^2 + 1; x = t - 3, y = t^2 + 1; x = \tan t - 3, y = \sec^2 t, t \neq \frac{(2k + 1)\pi}{2}, k \in \mathbb{Z}$

23. $x = t, y = \tan^2(t - 2) + 1, t \neq \pi k + \frac{\pi}{2} + 2, k \in \mathbb{Z}; x = t + 2, y = \sec^2 t, t \neq \left(k + \frac{1}{2}\right)\pi, k \in \mathbb{Z}; x = \tan^{-1} t + 2, y = t^2 + 1$

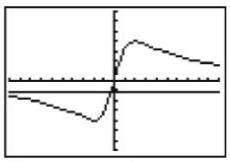
25. verified

27. a.



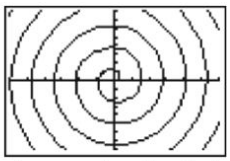
b. x-intercepts: $t = 0, x = 10, y = 0$ and $t = \pi, x = -6, y = 0$; y-intercepts: $t \approx 1.757, x = 0, y \approx 6.5$ and $t \approx 4.527, x = 0, y \approx -6.5$; minimum x-value is -8.1; maximum x-value is 10; minimum y-value is -9.5; the maximum y-value is 9.5

29. a.



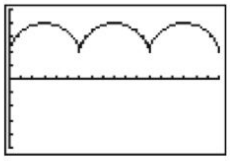
b. x-intercepts none, y-intercepts none; no minimum or maximum x-values; minimum y-value is -4 and maximum y-value is 4

31. a.



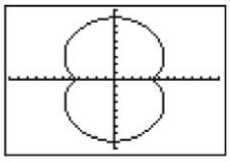
b. x-intercepts: $t = 0, x = 2, y = 0$ and $t \approx 4.493, x \approx -9.2, y = 0$; infinitely many others; y-intercepts: $t \approx 2.798, x = 0, y \approx 5.9$ and $t \approx 6.121, x = 0, y \approx -12.4$; infinitely many others; no minimum or maximum values for x or y

33. a.



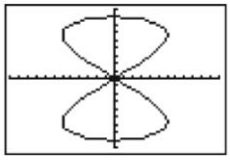
b. no x-intercepts; y-intercept is $t = 0, x = 0, y = 2$; no minimum or maximum x-values; minimum y-value is 2; maximum y-value is 4

35. a.



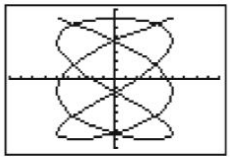
b. x-intercepts: $t = 0, x = 4, y = 0$ and $t = \pi, x = -4, y = 0$; y-intercepts: $t = \frac{\pi}{2}, x = 0, y = 8$ and $t = \frac{3\pi}{2}, x = 0, y = -8$; minimum and maximum x-values are approx. ± 5.657; minimum and maximum y-values are ± 8

37.



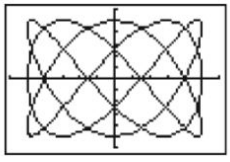
width 12 and length 16; including the endpoint $t = 2\pi$, the graph crosses itself two times from 0 to 2π.

39.



width 10 and length 14; including the endpoint $t = 2\pi$, the graph crosses itself nine times from 0 to 2π.

41.



width 20 and length 20; including the endpoint $t = 4\pi$, the graph crosses itself 23 times from 0 to 4π.

43. The maximum value (as the graph swells to a peak) is at $(x, y) = \left(a, \frac{b}{2}\right)$. The minimum value (as the graph dips to the valley) is at $(x, y) = \left(-a, \frac{-b}{2}\right)$.

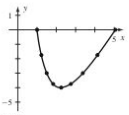
45. a. The curve is approaching $y = 2$ as t approaches $\frac{3\pi}{2}$, but $\cot\left(\frac{3\pi}{2}\right)$ is undefined, and the trig form seems to indicate a hole at $t = \frac{3\pi}{2}, x = 0, y = 2$. The algebraic form does not have this problem and shows a maximum defined at $t = 0, x = 0, y = 2$.
b. As $|t| \to \infty, y(t) \to 0$ **c.** The maximum value occurs at $(0, 2k)$.

47. a. Yes **b.** Yes **c.** ≈ 0.82 ft **49.** No, the kick is short.

51. The electron is moving left and downward.

53. $\left(t, \frac{6t}{17} - \frac{6}{17}, \frac{13t}{17} + \frac{21}{17}\right)$ **55.** Inconsistent, no solutions

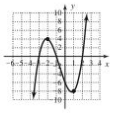
57. $x = 1.22475t$
$y = 0.25t^2 - 2t$



The parametric equations fit the data very well.

59. Answers will vary. **61.** by 25%

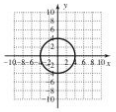
63.



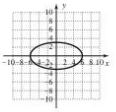
Summary and Concept Review, pp. 1006–1010

1. verified (segments are perpendicular and equal length)
2. $x^2 + (y - 1)^2 = 34$ **3.** verified **4.** verified

5.



6.



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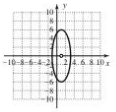

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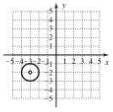

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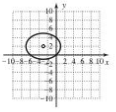
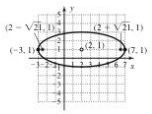
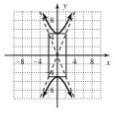


10. $\frac{x^2}{25} + \frac{y^2}{9} = 1$

11. a. $\frac{x^2}{169} + \frac{y^2}{25} = 1$ **b.** $\frac{x^2}{400} + \frac{y^2}{144} = 1$

12. $\frac{(x-2)^2}{25} + \frac{(y-1)^2}{4} = 1$ **13.**





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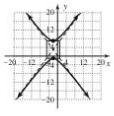

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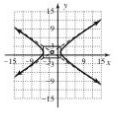
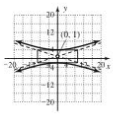


16.



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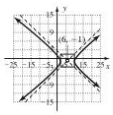

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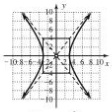
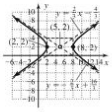
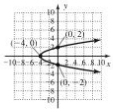


$\frac{x^2}{9} - \frac{y^2}{16} = 1$

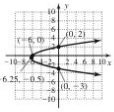
19. a. $\frac{x^2}{225} - \frac{y^2}{64} = 1$ **b.** $\frac{y^2}{16} - \frac{x^2}{9} = 1$

20. $\frac{(x-5)^2}{9} - \frac{(y-2)^2}{4} = 1$ **21.**

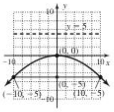




22.



23.



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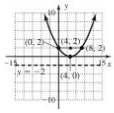
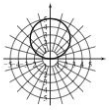
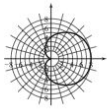


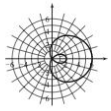
25.



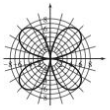
26.



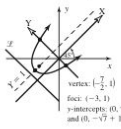
27.



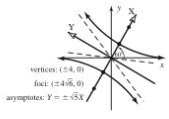
28.



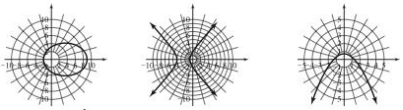
29. $Y^2 - 2Y - 2X - 6 = 0$
$(Y - 1)^2 = 2\left(X + \frac{7}{2}\right)$



30. $5X^2 - Y^2 - 80 = 0$
$\frac{X^2}{16} - \frac{Y^2}{80} = 1$

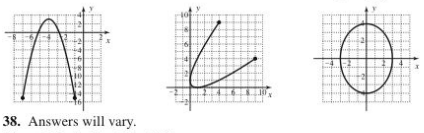


31. ellipse, $e = \frac{2}{3}$; **32.** hyperbola, $e = \frac{3}{2}$; **33.** parabola, $e = 1$;



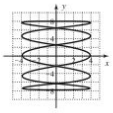
34. $r = \dfrac{de}{1 - e\cos\theta}$ with $e \approx 0.0935$ and $d \approx 1501.1$; focal cord: ≈280.82 million miles

35. $y = -2(x + 4)^2 + 3$ **36.** $y = (-1 \pm \sqrt{x})^2$ **37.** $\dfrac{x^2}{9} + \dfrac{y^2}{16} = 1$



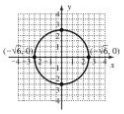
38. Answers will vary.

39. $x \in [-4, 4]$; $y \in [-8, 8]$

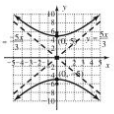


Mixed Review, pp. 1010–1011

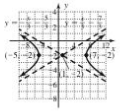
1. circle, center: (0, 0); $r = \sqrt{6}$



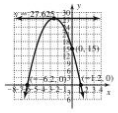
3. hyperbola; center (0, 0);
$a = 5$, $b = 3$, $c = \sqrt{34}$;
vertices (0, 5), (0, −5);
foci $(0, \sqrt{34})$, $(0, -\sqrt{34})$;
asymptotes $y = \frac{5}{3}x$, $y = -\frac{5}{3}x$



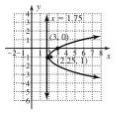
5. hyperbola; center (1, −2);
$a = 6$, $b = 2$, $c = 2\sqrt{10}$
vertices (−5, −2), (7, −2);
foci $(1 - 2\sqrt{10}, -2)$, $(1 + 2\sqrt{10}, -2)$;
asymptotes: $y = \frac{1}{3}x - \frac{7}{3}$,
$y = -\frac{1}{3}x - \frac{5}{3}$



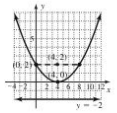
7. parabola; $p = 0.125$
vertex (−2.5, 27.5);
focus (−2.5, 27.375);
directrix $y = 27.625$;
y-intercepts: approx. (−6.2, 0), (1.2, 0)



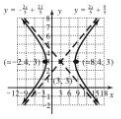
9. parabola; $p = 0.25$
vertex (2, −1);
focus (2.25, −1);
directrix $x = 1.75$;
y-intercepts: none



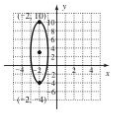
11. parabola; $p = 2$ vertex (4, 0);
focus (4, 2); directrix $y = -2$;
x-intercept (4, 0)



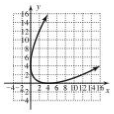
13. hyperbola; center (3, 3);
$a = 5$, $b = 2$, $c = \sqrt{29}$
vertices (8, 3), (−2, 3);
foci $(3 - \sqrt{29}, 3)$, $(3 + \sqrt{29}, 3)$,
≈ (−2.39, 3), (8.39, 3);
asymptotes $y = \frac{2}{5}x + \frac{9}{5}$,
$y = -\frac{2}{5}x + \frac{21}{5}$



15. ellipse; center (−2, 3);
$a = 1$, $b = 7$, $c = 4\sqrt{3}$
vertices (−2, −4), (−2, 10);
endpoints of minor axis (−3, 3), (−1, 3);
foci $(-2, 3 - 4\sqrt{3})$, $(-2, 3 + 4\sqrt{3})$,
≈ (−2, −3.93), ≈ (−2, 9.93)



17. parabola



19. a. (2, 5), (−2, 5), (−2, −5), (2, −5)

b. $(0, 2), \left(-2\sqrt{2}, -\frac{2}{3}\right), \left(2\sqrt{2}, -\frac{2}{3}\right)$

21. $x = 50\cos t$; $y = 30\sin t$

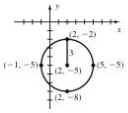
23. a. elliptic; 0.494 million miles **b.** parabolic; 3.1 million miles

25. $12x^2 + 26xy + 12y^2 = 160{,}000$

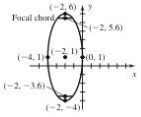
Practice Test, pp. 1011–1012

1. c **2.** d **3.** b **4.** a

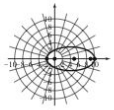
5. circle; center (2, −5); radius 3



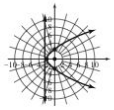
6. ellipse; center (−2, 1); vertices (−2, −4), (−2, 6); foci $(-2, 1 - \sqrt{21})$, $(-2, 1 + \sqrt{21})$



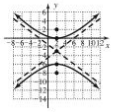
7. ellipse; center $(\frac{40}{9}, 0)$; vertices $(\frac{-10}{9}, 0)$, (10, 0); foci (0, 0), $(\frac{80}{9}, 0)$



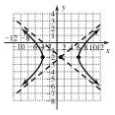
8. parabola; vertex (−1.2, 0);
focus (0, 0); directrix at $y = -2.4$



9. hyperbola; center: (2, −3);
vertices: (2, 0), (2, −6); foci:
(2, −8), (2, 2); asymptotes:
$y = \frac{3}{4}x - \frac{9}{2}$, $y = \frac{-3}{4}x - \frac{3}{2}$

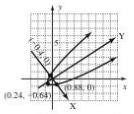


10. hyperbola; center $(1, -2)$;
vertices $(-4, -2), (6, -2)$;
foci $(1 - \sqrt{29}, -2), (1 + \sqrt{29}, -2)$,
$\approx (-4.39, -2), (6.39, -2)$;
asymptotes: $y = -\frac{2}{5}x - \frac{8}{5}$,
$y = \frac{2}{5}x - \frac{12}{5}$

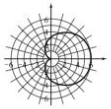


11. parabola; $\beta = 36.87°$; $\cos\beta = \frac{4}{5}$, $\sin\beta = \frac{3}{5}$

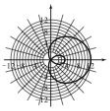
12. $Y = \frac{25}{16}X^2 - \frac{3}{4}X - \frac{11}{20}$



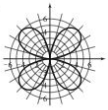
13.



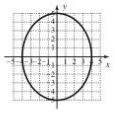
14.



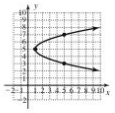
15.



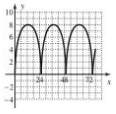
16. ellipse; $\frac{x^2}{16} + \frac{y^2}{25} = 1$



17. parabola; $x = (y - 5)^2 + 1$



18. max: $y = 8$; min: $y = 0$; $P = 8\pi$



19. a. $(3\frac{1}{3}, 5\frac{1}{3}), (-2, 0)$ **b.** $\left(\sqrt{\frac{12}{5}}, \sqrt{\frac{8}{5}}\right), \left(-\sqrt{\frac{12}{5}}, -\sqrt{\frac{8}{5}}\right)$
$\left(-\sqrt{\frac{12}{5}}, \sqrt{\frac{8}{5}}\right), \left(\sqrt{\frac{12}{5}}, -\sqrt{\frac{8}{5}}\right)$ **20.** $r \approx \frac{1654(1 - 0.967^2)}{1 - 0.967\cos\theta}$
e is very close to 1. This makes its orbit a very elongated ellipse, where the orbit of most planets is nearly circular. **21.** The ball is 0.43 ft above the ground at $x = 165$ ft, and will likely go into the goal. **22.** Perihelion: 128.41 million miles Aphelion: 154.89 million miles
23. $y = (x - 1)^2 - 4$; D: $x \in \mathbb{R}$; R: $y \in [-4, \infty)$; focus: $(1, -3.75)$
24. $(x - 1)^2 + (y - 1)^2 = 25$; D: $x \in [-4, 6]$; R: $y \in [-4, 6]$
25. $\frac{(x + 2)^2}{9} + \frac{(y - 1)^2}{25} = 1$; D: $x \in [-5, 1]$; R: $y \in [-4, 6]$

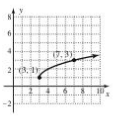
Strengthening Core Skills, pp. 1013–1015

Exercise 1: Yes, the calculations are much "cleaner" with the right triangle definitions.

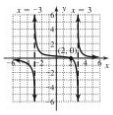
Cumulative Review Chapters 1–10, pp. 1015–1016

1. $x = 7, x = -1$ is extraneous **3.** $x = -6$ **5.** $x = 4$
7. $\frac{5\pi}{6} + k\pi, k \in \mathbb{Z}$ **9.** $x \approx 61.98° + 360°k; k \in \mathbb{Z}$;
$x \approx 118.02° + 360°k; k \in \mathbb{Z}$
11. about 24.7 pesos/kg **13.** The formation is 1152.4 yd wide

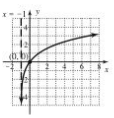
15.



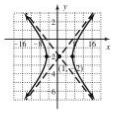
17. horizontal asymptote: $y = 0$
vertical asymptotes: $x = 3, x = -3$,
x-intercept: $(2, 0)$; y-intercept: $(0, \frac{2}{9})$



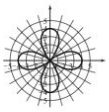
19.



21. center $(1, -2)$;
foci $(1 + 2\sqrt{10}, -2) \approx (7.32, -2)$,
$(1 - 2\sqrt{10}, -2) \approx (-5.32, -2)$; asymptotes
$y = \frac{1}{3}x - \frac{7}{3}, y = -\frac{1}{3}x - \frac{5}{3}$



23.



25. 61.9° **27.** $(-3, 4), (3, 4), (-3, -4), (3, -4)$
29. $\frac{1}{x} - \frac{3}{x^2} + \frac{2x + 1}{x^2 + 1}$

CHAPTER 11

Exercise 11.1, pp. 1024–1026

1. pattern; order **3.** increasing **5.** formula defining the sequence uses the preceding term(s); answers will vary.

7. 1, 3, 5, 7; $a_8 = 15$; $a_{12} = 23$ **9.** 0, 9, 24, 45; $a_8 = 189$; $a_{12} = 429$

11. $-1, 2, -3, 4$; $a_8 = 8$; $a_{12} = 12$ **13.** $\frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{4}{5}$; $a_8 = \frac{8}{9}$; $a_{12} = \frac{12}{13}$

15. $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$; $a_8 = \frac{1}{256}$; $a_{12} = \frac{1}{4096}$ **17.** $1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}$; $a_8 = \frac{1}{8}$; $a_{12} = \frac{1}{12}$

19. $\frac{-1}{2}, \frac{1}{6}, \frac{-1}{12}, \frac{1}{20}$; $a_8 = \frac{1}{72}$; $a_{12} = \frac{1}{156}$

21. $-2, 4, -8, 16$; $a_8 = 256$; $a_{12} = 4096$ **23.** 79 **25.** $\frac{1}{5}$ **27.** $\frac{1}{32}$

29. $\left(\frac{11}{10}\right)^{10}$ **31.** $\frac{1}{36}$ **33.** 2, 7, 32, 157, 782 **35.** $-1, 4, 19, 364, 132{,}499$

37. 64, 32, 16, 8, 4 **39.** 336 **41.** 36 **43.** 28 **45.** $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}$

47. $\frac{1}{3}, \frac{1}{120}, \frac{1}{15{,}120}, \frac{1}{3{,}991{,}680}$ **49.** $1, 2, \frac{9}{2}, \frac{32}{3}$ **51.** 15 **53.** 64 **55.** $\frac{137}{60}$

57. 10 **59.** 95 **61.** -4 **63.** 15 **65.** 50 **67.** $\frac{-27}{112}$ **69.** $\sum_{n=1}^{5}(4n)$

71. $\sum_{n=1}^{6}(-1)^n n^2$ **73.** $\sum_{n=1}^{5}(n+3)$ **75.** $\sum_{n=1}^{3}\frac{n^2}{3}$ **77.** $\sum_{n=3}^{7}\frac{n}{2^n}$

79. 35 **81.** 100

83. 35 **85.** $a_n = 6000(0.8)^{n-1}$; 6000, 4800, 3840, 3072, 2457.60, 1966.08 **87.** 5.20, 5.70, 6.20, 6.70, 7.20, $13,824 **89.** ≈2690

91. verified **93.** approaches $\frac{1}{2}$ **95.** $\frac{3\pi}{4}, \frac{7\pi}{4}$

97. $\angle A \approx 53.1°, \angle B = 90°, \angle C \approx 36.9°$

Exercise 11.2, pp. 1031–1033

1. common; difference **3.** $\frac{n(a_1 + a_n)}{2}$; *n*th **5.** Answers will vary.

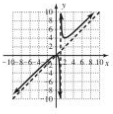
7. arithmetic; $d = 3$ **9.** arithmetic; $d = 2.5$
11. not arithmetic; all prime **13.** arithmetic; $d = \frac{1}{24}$
15. not arithmetic; $a_n = n^2$ **17.** arithmetic; $d = \frac{-\pi}{6}$ **19.** 2, 5, 8, 11
21. 7, 5, 3, 1 **23.** 0.3, 0.33, 0.36, 0.39 **25.** $\frac{3}{2}, 2, \frac{5}{2}, 3$ **27.** $\frac{3}{4}, \frac{5}{8}, \frac{1}{2}, \frac{3}{8}$
29. −2, −5, −8, −11 **31.** $a_1 = 2, d = 5, a_n = 5n - 3$, $a_6 = 27, a_{10} = 47, a_{12} = 57$ **33.** $a_1 = 5.10, d = 0.15$, $a_n = 0.15n + 4.95, a_6 = 5.85, a_{10} = 6.45, a_{12} = 6.75$
35. $a_1 = \frac{3}{2}, d = \frac{3}{4}, a_n = \frac{3}{4}n + \frac{3}{4}, a_6 = \frac{21}{4}, a_{10} = \frac{33}{4}, a_{12} = \frac{39}{4}$
37. 61 **39.** 1 **41.** 2.425 **43.** 9 **45.** 43 **47.** 21 **49.** 26
51. $d = 3, a_1 = 1$ **53.** $d = 0.375, a_1 = 0.65$ **55.** $d = \frac{115}{126}, a_1 = \frac{-472}{63}$
57. 1275 **59.** 601.25 **61.** −534 **63.** 82.5 **65.** 74.04
67. $210\sqrt{2}$ **69.** $S_6 = 21; S_{75} = 2850$ **71.** at 11 P.M.
73. 5.5 in.; 54.25 in. **75.** 220; 2520; yes

77. a. linear function **b.** quadratic **79.** $A = 7, P = 6$, HS: $\frac{1}{2}$ unit right, VS: 10 units up, PI: $\frac{1}{2} \le t < \frac{13}{2}$. **81.** $f(x) = 4ax + 972, 1364$

Exercises 11.3, pp. 1040–1043

1. multiplying **3.** $a_1 r^{n-1}$ **5.** Answers will vary. **7.** $r = 2$
9. $r = -2$ **11.** $a_n = n^2 + 1$ **13.** $r = 0.1$ **15.** not geometric; ratio of terms decreases by 1 **17.** $r = \frac{2}{5}$ **19.** $r = \frac{1}{2}$ **21.** $r = \frac{4}{x}$
23. not geometric; $a_n = \frac{240}{n!}$ **25.** 5, 10, 20, 40 **27.** $-6, 3, \frac{-3}{2}, \frac{3}{4}$
29. $4, 4\sqrt{3}, 12, 12\sqrt{3}$ **31.** 0.1, 0.01, 0.001, 0.0001 **33.** $-\frac{3}{8}$ **35.** $\frac{25}{4}$
37. 16 **39.** $a_1 = \frac{1}{27}, r = -3, a_n = \frac{1}{27}(-3)^{n-1}, a_6 = -9, a_{10} = -729$, $a_{12} = -6561$
41. $a_1 = 729, r = \frac{1}{3}, a_n = 729(\frac{1}{3})^{n-1}, a_6 = 3, a_{10} = \frac{1}{27}, a_{12} = \frac{1}{243}$
43. $a_1 = \frac{1}{2}, r = \sqrt{2}, a_n = \frac{1}{2}(\sqrt{2})^{n-1}, a_6 = 2\sqrt{2}, a_{10} = 8\sqrt{2}, a_{12} = 16\sqrt{2}$
45. $a_1 = 0.2, r = 0.4, a_n = 0.2(0.4)^{n-1}, a_6 = 0.002048$, $a_{10} = 0.0000524288, a_{12} = 0.000008388608$ **47.** 5 **49.** 11 **51.** 9
53. 8 **55.** 13 **57.** 9 **59.** $r = \frac{2}{3}, a_1 = 729$ **61.** $r = \frac{3}{2}, a_1 = \frac{32}{243}$
63. $r = \frac{3}{2}, a_1 = \frac{256}{81}$ **65.** −10,920 **67.** $\frac{3872}{27} \approx 143.41$
69. $\frac{2059}{8} = 257.375$ **71.** 728 **73.** $\frac{85}{8} = 10.625$ **75.** ≈1.60
77. 1364 **79.** $\frac{31,525}{2187} \approx 14.41$ **81.** $\frac{-387}{512} \approx -0.76$ **83.** $\frac{521}{25}$ **85.** $\frac{3367}{1296}$
87. $14 + 15\sqrt{2}$ **89.** no **91.** $\frac{27}{7}$ **93.** $\frac{125}{3}$ **95.** 12 **97.** 4 **99.** $\frac{1}{3}$
101. $\frac{3}{2}$ **103.** $-\frac{18}{5}$ **105.** 1296 **107.** about 6.3 ft; 120 ft
109. $18,841.60; 10 yr **111.** 125.4 gpm; 10 months
113. about 347.7 million **115.** 51,200 bacteria; 12 half-hours later (6 hr)
117. ≈ 0.42 m; 8 m **119.** 35.9 in^3; 7 strokes **121.** 6 yr

123. $S_n = \log n!$ **125.** $x = \frac{-5}{2} \pm \frac{\sqrt{11}}{2}i$ **127.**



Exercises 11.4, pp. 1049–1051

1. finite; universally **3.** induction; hypothesis **5.** Answers will vary.
7. $a_n = 10n - 6$
$a_4 = 10(4) - 6 = 40 - 6 = 34;$
$a_5 = 10(5) - 6 = 50 - 6 = 44;$
$a_k = 10k - 6;$
$a_{k+1} = 10(k + 1) - 6 = 10k + 10 - 6 = 10k + 4$

9. $a_n = n$
$a_4 = 4;$
$a_5 = 5;$
$a_k = k;$
$a_{k+1} = k + 1$
11. $a_n = 2^{n-1}$
$a_4 = 2^{4-1} = 2^3 = 8;$
$a_5 = 2^{5-1} = 2^4 = 16;$
$a_k = 2^{k-1};$
$a_{k+1} = 2^{k+1-1} = 2^k$
13. $S_n = n(5n - 1)$
$S_4 = 4(5(4) - 1) = 4(20 - 1) = 4(19) = 76;$
$S_5 = 5(5(5) - 1) = 5(25 - 1) = 5(24) = 120;$
$S_k = k(5k - 1);$
$S_{k+1} = (k + 1)(5(k + 1) - 1) = (k + 1)(5k + 5 - 1) = (k + 1)(5k + 4)$
15. $S_n = \frac{n(n + 1)}{2}$
$S_4 = \frac{4(4 + 1)}{2} = \frac{4(5)}{2} = 10;$
$S_5 = \frac{5(5 + 1)}{2} = \frac{5(6)}{2} = 15;$
$S_k = \frac{k(k + 1)}{2};$
$S_{k+1} = \frac{(k + 1)(k + 1 + 1)}{2} = \frac{(k + 1)(k + 2)}{2}$
17. $S_n = 2^n - 1$
$S_4 = 2^4 - 1 = 16 - 1 = 15;$
$S_5 = 2^5 - 1 = 32 - 1 = 31;$
$S_k = 2^k - 1;$
$S_{k+1} = 2^{k+1} - 1$
19. $a_n = 10n - 6; S_n = n(5n - 1)$
$S_4 = 4(5(4) - 1) = 4(20 - 1) = 4(19) = 76;$
$a_5 = 10(5) - 6 = 50 - 6 = 44;$
$S_5 = 5(5(5) - 1) = 5(25 - 1) = 5(24) = 120;$
$S_4 + a_5 = S_5$
$76 + 44 = 120$
$120 = 120$
Verified
21. $a_n = n; S_n = \frac{n(n + 1)}{2}$
$S_4 = \frac{4(4 + 1)}{2} = \frac{4(5)}{2} = 10;$
$a_5 = 5;$
$S_5 = \frac{5(5 + 1)}{2} = \frac{5(6)}{2} = 15;$
$S_4 + a_5 = S_5$
$10 + 5 = 15$
$15 = 15$
Verified

23. $a_n = 2^{n-1}; S_n = 2^n - 1$
$S_4 = 2^4 - 1 = 16 - 1 = 15;$
$a_5 = 2^{5-1} = 2^4 = 16;$
$S_5 = 2^5 - 1 = 32 - 1 = 31;$
$S_4 + a_5 = S_5$
$15 + 16 = 31$
$31 = 31$
Verified
25. $a_n = n^3; S_n = (1 + 2 + 3 + 4 + \cdots + n)^2$
$S_1 = 1^2 = 1^3$
$S_5 = (1 + 2 + 3 + 4 + 5)^2$
$= 15^2$
$= 225$
$1 + 8 + 27 + 64 + 125 = 225$

$S_9 = (1 + 2 + \cdots + 9)^2$
$= 45^2$
$= 2025$
$1 + 8 + \cdots + 729 = 2025$
$\left[\frac{n(n+1)}{2}\right]^2 = \frac{n^2(n+1)^2}{4}$

27. 1. Show S_n is true for $n = 1$.
$S_1 = 1(1 + 1) = 1(2) = 2$
Verified
2. Assume S_k is true: $2 + 4 + 6 + 8 + 10 + \cdots + 2k = k(k + 1)$
and use it to show the truth of S_{k+1} follows. That is:
$2 + 4 + 6 + \cdots + 2k + 2(k + 1) = (k + 1)(k + 2)$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$2 + 4 + 6 + \cdots + 2k + 2(k + 1)$
$= k(k + 1) + 2(k + 1)$
$= k^2 + k + 2k + 2$
$= k^2 + 3k + 2$
$= (k + 1)(k + 2)$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

29. 1. Show S_n is true for $n = 1$.
$S_1 = \frac{5(1)(1 + 1)}{2} = \frac{5(2)}{2} = 5$
Verified
2. Assume S_k is true:
$5 + 10 + 15 + \cdots + 5k = \frac{5k(k + 1)}{2}$
and use it to show the truth of S_{k+1} follows. That is:
$5 + 10 + 15 + \cdots + 5k + 5(k + 1) = \frac{5(k + 1)(k + 1 + 1)}{2}$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$5 + 10 + 15 + \cdots + 5k + 5(k + 1)$
$= \frac{5k(k + 1)}{2} + 5(k + 1)$
$= \frac{5k(k + 1) + 10(k + 1)}{2}$
$= \frac{(k + 1)(5k + 10)}{2}$
$= \frac{5(k + 1)(k + 2)}{2}$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

31. 1. Show S_n is true for $n = 1$.
$S_1 = 1(2(1) + 3) = 5$
Verified
2. Assume S_k is true:
$5 + 9 + 13 + 17 + \cdots + 4k + 1 = k(2k + 3)$
and use it to show the truth of S_{k+1} follows. That is:
$5 + 9 + 13 + 17 + \cdots + 4k + 1 + 4(k + 1) + 1$
$= (k + 1)(2(k + 1) + 3)$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$5 + 9 + 13 + 17 + \cdots + 4k + 1 + 4k + 5$
$= k(2k + 3) + 4k + 5$
$= 2k^2 + 3k + 4k + 5 = 2k^2 + 7k + 5$
$= (k + 1)(2k + 5) = S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

33. 1. Show S_n is true for $n = 1$.
$S_1 = \frac{3(3^1 - 1)}{2} = \frac{3(3 - 1)}{2} = \frac{3(2)}{2} = 3$
Verified
2. Assume S_k is true:
$3 + 9 + 27 + \cdots + 3^k = \frac{3(3^k - 1)}{2}$
and use it to show the truth of S_{k+1} follows. That is:
$3 + 9 + 27 + \cdots + 3^k + 3^{k+1}$
$= \frac{3(3^{k+1} - 1)}{2}$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$3 + 9 + 27 + \cdots + 3^k + 3^{k+1}$
$= \frac{3(3^k - 1)}{2} + 3^{k+1}$
$= \frac{3(3^k - 1) + 2(3^{k+1})}{2}$
$= \frac{3^{k+1} - 3 + 2(3^{k+1})}{2}$
$= \frac{3(3^{k+1}) - 3}{2}$
$= \frac{3(3^{k+1} - 1)}{2}$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

35. 1. Show S_n is true for $n = 1$.
$S_n = 2^{n+1} - 2$
$S_1 = 2^{1+1} - 2 = 2^2 - 2 = 4 - 2 = 2$
Verified
2. Assume S_k is true:
$2 + 4 + 8 + \cdots + 2^k = 2^{k+1} - 2$
and use it to show the truth of S_{k+1} follows. That is:
$2 + 4 + 8 + \cdots + 2^k + 2^{k+1} = 2^{k+1} - 2$
$S_k + a_{k+1} = S_{k+1}$
Working with the left hand side:
$2 + 4 + 8 + \cdots + 2^k + 2^{k+1}$
$= 2^{k+1} - 2 + 2^{k+1}$
$= 2(2^{k+1}) - 2$
$= 2^{k+2} - 2$
$= S_{k+1}$
Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

37. 1. Show S_n is true for $n = 1$.
$S_n = \frac{n}{2n + 1}$
$S_1 = \frac{1}{2(1) + 1} = \frac{1}{2 + 1} = \frac{1}{3}$
Verified
2. Assume S_k is true:
$\frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \cdots + \frac{1}{(2k - 1)(2k + 1)} = \frac{k}{2k + 1}$
and use it to show the truth of S_{k+1} follows. That is:
$\frac{1}{3} + \frac{1}{15} + \frac{1}{35} + \cdots + \frac{1}{(2k - 1)(2k + 1)}$
$+ \frac{1}{(2(k + 1) - 1)(2(k + 1) + 1)} = \frac{k + 1}{2(k + 1) + 1}$
$S_k + a_{k+1} = S_{k+1}$

Working with the left hand side:

$$\frac{1}{3}+\frac{1}{15}+\frac{1}{35}+\cdots+\frac{1}{(2k-1)(2k+1)}+\frac{1}{(2k+1)(2k+3)}$$
$$=\frac{k}{2k+1}+\frac{1}{(2k+1)(2k+3)}$$
$$=\frac{k(2k+3)+1}{(2k+1)(2k+3)}$$
$$=\frac{2k^2+3k+1}{(2k+1)(2k+3)}$$
$$=\frac{(2k+1)(k+1)}{(2k+1)(2k+3)}$$
$$=\frac{k+1}{2k+3}$$
$$=S_{k+1}$$

Since the truth of S_{k+1} follows from S_k, the formula is true for all n.

39. 1. Show S_n is true for $n=1$.
$S_1: 3^1 \geq 2(1)+1$
$3 \geq 2+1$
$3 \geq 3$
Verified

2. Assume $S_k: 3^k \geq 2k+1$ is true and use it to show the truth of S_{k+1} follows. That is: $3^{k+1} \geq 2k+3$.
Working with the left hand side:
$3^{k+1}=3(3^k)$
$\geq 3(2k+1)$
$\geq 6k+3$
Since k is a positive integer,
$6k+3 \geq 2k+3$
Showing $S_{k+1}: 3^{k+1} \geq 2k+3$
Verified

41. 1. Show S_n is true for $n=1$.
$S_1: 3\cdot 4^{1-1} \leq 4^1-1$
$3\cdot 4^0 \leq 4-1$
$3\cdot 1 \leq 3$
$3 \leq 3$
Verified

2. Assume $S_k: 3\cdot 4^{k-1} \leq 4^k-1$ is true and use it to show the truth of S_{k+1} follows. That is: $3\cdot 4^k \leq 4^{k+1}-1$.
Working with the left hand side:
$3\cdot 4^k = 3\cdot 4(4^{k-1})$
$= 4\cdot 3(4^{k-1})$
$\leq 4(4^k-1)$
$\leq 4^{k+1}-4$
Since k is a positive integer, $4^{k+1}-4 \leq 4^{k+1}-1$
Showing that $3\cdot 4^k \leq 4^{k+1}-1$

43. n^2-7n is divisible by 2
1. Show S_n is true for $n=1$.
$S_n: n^2-7n=2m$
$S_1: (1)^2-7(1)=2m$
$1-7=2m$
$-6=2m$ Verified

2. Assume $S_k: k^2-7k=2m$ for $m \in Z$ and use it to show the truth of S_{k+1} follows. That is: $(k+1)^2-7(k+1)=2p$ for $p \in Z$.
Working with the left hand side:
$=(k+1)^2-7(k+1)$
$=k^2+2k+1-7k-7$
$=k^2-7k+2k-6$
$=2m++2k-6$
$=2(m+k-3)$
is divisible by 2.

45. n^3+3n^2+2n is divisible by 3
1. Show S_n is true for $n=1$. $S_n: n^3+3n^2+2n=3m$
$S_1: (1)^3+3(1)^2+2(1)=3m$
$1+3+2=3m$
$6=3m$
$2=m$
Verified

2. Assume $S_k: k^3+3k^2+2k=3m$ for $m \in Z$ and use it to show the truth of S_{k+1} follows.
That is: $S_{k+1}: (k+1)^3+3(k+1)^2+2(k+1)=3p$ for $p \in Z$.
Working with the left hand side:
$(k+1)^3+3(k+1)^2+2(k+1)$ is true.
$=k^3+3k^2+3k+1+3(k^2+2k+1)+2k+2$
$=k^3+3k^2+2k+3(k^2+2k+1)+3k+3$
$=k^3+3k^2+2k+3(k^2+2k+1)+3(k+1)$
$=3m+3(k^2+2k+1)+3(k+1)$ is divisible by 3.

47. 6^n-1 is divisible by 5
1. Show S_n is true for $n=1$. $S_n: 6^n-1=5m$
$S_1: 6^1-1=5m$
$6-1=5m$
$5=5m$
$1=m$ Verified

2. Assume $S_k: 6^k-1=5m$ for $m \in Z$ and use it to show the truth of S_{k+1} follows.
That is: $S_{k+1}: 6^{k+1}-1=5p$ for $p \in Z$.
Working with the left hand side:
$=6^k-1$
$=6(6^k)-1$
$=6(5m+1)-1$
$=30m+6-1$
$=30m+5$
$=5(6m+1)$
is divisible by 5, Verified

49. verified **51.** verified **53.** $(x-4)^2+(y-3)^2=25$
$(x-3)^2+(x-4)^2=25$

Mid-Chapter Check, pp. 1051–1052

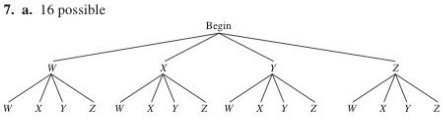
1. 3, 10, 17, $a_9=59$ **2.** 4, 7, 12, $a_9=84$ **3.** $-1, 3, -5, a_9=-17$
4. 360 **5.** $\sum_{k=1}^{6}(3k-2)$ **6.** d **7.** e **8.** a **9.** b **10.** c
11. a. $a_1=2, d=3, a_n=3n-1$ **b.** $a_1=\frac{3}{2}, d=\frac{3}{4}, a_n=\frac{3}{4}n+\frac{3}{4}$
12. $n=25, S_{25}=950$ **13.** $n=16, S_{16}=128$
14. $S_{10}=-5$ **15.** $S_{10}=\dfrac{-29{,}524}{27}$
16. a. $a_1=2, r=3, a_n=2(3)^{n-1}$ **b.** $a_1=\frac{1}{2}, r=\frac{1}{2}, a_n=(\frac{1}{2})^n$
17. $n=8, S_8=\frac{1640}{27}$ **18.** $\frac{-343}{6}$ **19.** 1785 **20.** ≈4.5 ft; ≈127.9 ft

Reinforcing Basic Concepts, p. 1052

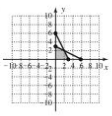
Exercise 1: $71,500

Exercises 11.5, pp. 1060–1064

1. experiment; well-defined **3.** distinguishable **5.** Answers will vary.
7. a. 16 possible



b. *WW, WX, WY, WZ, XW, XX, XY, XZ, YW, YX, YY, YZ, ZW, ZX, ZY, ZZ*
9. 32 **11.** 15,625 **13.** 2,704,000 **15. a.** 59,049 **b.** 15,120
17. 360 if double veggies are not allowed, 432 if double veggies are allowed. **19. a.** 120 **b.** 625 **c.** 12 **21.** 24 **23.** 4 **25.** 120 **27.** 6
29. 720 **31.** 3024 **33.** 40,320 **35.** 6; 3 **37.** 90 **39.** 336
41. a. 720 **b.** 120 **c.** 24 **43.** 360 **45.** 60 **47.** 60 **49.** 120
51. 30 **53.** 60, BANANA **55.** 126 **57.** 56 **59.** 1 **61.** verified
63. verified **65.** 495 **67.** 364 **69.** 252 **71.** 40,320 **73.** 336
75. 15,504 **77.** 70 **79. a.** ≈1.2% **b.** ≈0.83% **81.** 7776 **83.** 324
85. 800 **87.** 6,272,000,000 **89.** 518,400 **91.** 357,696 **93.** 6720
95. 8 **97.** 10,080 **99.** 5040 **101.** 2880 **103.** 5005 **105.** 720
107. 52,650, no **109. a.** $\dfrac{10!}{2!3!5!}$ **b.** $\dfrac{9!}{2!3!4!}$ **c.** $\dfrac{11!}{4!5!2!}$ **d.** $\dfrac{8!}{2!3!3!}$

111. 

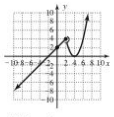
113. $\cos(5\alpha)$

Exercises 11.6, pp. 1071–1077

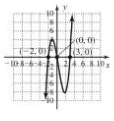
1. $n(E)$ **3.** 0; 1; 1; 0 **5.** Answers will vary.
7. $S = \{\text{HH, HT, TH, TT}\}$, $\frac{1}{4}$ **9.** $S = \{\text{coach of Patriots, Cougars, Angels, Sharks, Eagles, Stars}\}$, $\frac{1}{6}$ **11.** $P(E) = \frac{4}{9}$ **13. a.** $\frac{1}{13}$ **b.** $\frac{1}{4}$ **c.** $\frac{1}{2}$ **d.** $\frac{1}{26}$
15. $P(E_1) = \frac{1}{8}$, $P(E_2) = \frac{5}{8}$, $P(E_3) = \frac{3}{4}$ **17. a.** $\frac{3}{4}$ **b.** 1 **c.** $\frac{1}{4}$ **d.** $\frac{1}{2}$ **19.** $\frac{3}{4}$
21. $\frac{6}{7}$ **23.** 0.991 **25. a.** $\frac{1}{12}$ **b.** $\frac{11}{12}$ **c.** $\frac{8}{9}$ **d.** $\frac{5}{6}$ **27.** $\frac{10}{21}$ **29.** $\frac{60}{143}$
31. b, about 12% **33. a.** 0.3651 **b.** 0.3651 **c.** 0.3969 **35.** 0.9
37. $\frac{7}{24}$ **39.** 0.59 **41. a.** $\frac{1}{6}$ **b.** $\frac{7}{36}$ **c.** $\frac{1}{9}$ **d.** $\frac{4}{9}$ **43. a.** $\frac{2}{25}$ **b.** $\frac{9}{50}$ **c.** 0
d. $\frac{2}{25}$ **e.** 1 **45.** $\frac{3}{4}$ **47.** $\frac{11}{15}$ **49. a.** $\frac{1}{18}$ **b.** $\frac{2}{9}$ **c.** $\frac{8}{9}$ **d.** $\frac{3}{4}$ **e.** $\frac{1}{36}$ **f.** $\frac{5}{12}$
51. $\frac{1}{4}$; $\frac{1}{256}$; answers will vary. **53. a.** 0.33 **b.** 0.67 **c.** 1 **d.** 0
e. 0.67 **f.** 0.08 **55. a.** $\frac{1}{2}$ **b.** $\frac{1}{2}$ **c.** 0.2165 **57. a.** $\frac{9}{16}$ **b.** $\frac{1}{4}$
c. $\frac{1}{16}$ **d.** $\frac{5}{16}$ **59. a.** $\frac{3}{26}$ **b.** $\frac{3}{26}$ **c.** $\frac{1}{13}$ **d.** $\frac{9}{26}$ **e.** $\frac{2}{13}$ **f.** $\frac{11}{26}$
61. a. $\frac{1}{8}$ **b.** $\frac{1}{16}$ **c.** $\frac{3}{16}$ **63. a.** $\frac{47}{100}$ **b.** $\frac{2}{25}$ **c.** $\frac{3}{100}$ **d.** $\frac{9}{50}$ **e.** $\frac{11}{100}$
65. a. $\frac{5}{429}$ **b.** $\frac{8}{2145}$ **67.** $\frac{1}{3360}$ **69.** $\frac{1}{1{,}048{,}576}$; answers will vary; 20 heads in a row. **71.** $\sin\theta = \frac{1}{3}$, $\cos\theta = -\frac{2\sqrt{2}}{3}$, $\tan\theta = -\frac{1}{2\sqrt{2}}$, $\sec\theta = -\frac{3}{2\sqrt{2}}$, $\cot\theta = -2\sqrt{2}$
73. $\sin(2\theta) = -\frac{840}{841}$, $\cos(2\theta) = \frac{41}{841}$, $\tan(2\theta) = -\frac{840}{41}$

Exercises 11.7, pp. 1083–1084

1. one **3.** $(a + (-2b))^5$ **5.** Answers will vary.
7. $x^5 + 5x^4y + 10x^3y^2 + 10x^2y^3 + 5xy^4 + y^5$
9. $16x^4 + 96x^3 + 216x^2 + 216x + 81$
11. $41 + 38i$ **13.** 35 **15.** 10 **17.** 1140 **19.** 9880 **21.** 1 **23.** 1
25. $c^5 + 5c^4d + 10c^3d^2 + 10c^2d^3 + 5cd^4 + d^5$
27. $a^6 - 6a^5b + 15a^4b^2 - 20a^3b^3 + 15a^2b^4 - 6ab^5 + b^6$
29. $16x^4 - 96x^3 + 216x^2 - 216x + 81$
31. $-11 + 2i$ **33.** $x^9 + 18x^8y + 144x^7y^2 + \cdots$
35. $v^{24} - 6v^{22}w + \frac{33}{2}v^{20}w^2$ **37.** $35x^4y^3$ **39.** $1792p^2$ **41.** $264x^2y^{10}$
43. ≈0.25 **45. a.** ≈17.8% **b.** ≈23.0% **47. a.** ≈ 0.88% **b.** ≈ 6.9%
c. ≈ 99.0% **d.** ≈ 61.0% **49. a.** 99.33% **b.** 94.22%
51. $\binom{6}{6} = \binom{6}{0} = 1$; $\binom{6}{5} = \binom{6}{1} = 6$; $\binom{6}{4} = \binom{6}{2} = 15$; $\binom{6}{3} = 20$
53.



$f(3) = 1$
55. $g(x) > 0$: $x \in (-2, 0) \cup (3, \infty)$



Summary and Concept Review, pp. 1085–1089

1. 1, 6, 11, 16; $a_{10} = 46$ **2.** $1, \frac{3}{5}, \frac{2}{5}, \frac{5}{17}$; $a_{10} = \frac{11}{101}$
3. $a_n = n^4$; $a_6 = 1296$ **4.** $a_n = -17 + (n-1)(3)$; $a_6 = -2$
5. $\frac{255}{256}$ **6.** −112 **7.** 140 **8.** 35 **9.** not defined, 2, 6, 12, 20, 30
10. $\frac{1}{2}, \frac{3}{4}, \frac{5}{4}, \frac{9}{4}, \frac{17}{4}$ **11.** $\sum_{n=1}^{7}(n^2 + 3n - 2)$; 210 **12.** $a_n = 2 + 3(n-1)$; 119
13. $a_n = 3 + (-2)(n-1)$; −65 **14.** 740 **15.** 1335 **16.** 630
17. −11.25 **18.** 875 **19.** 3240 **20.** 3645 **21.** 32 **22.** 2401
23. 10.75 **24.** 6560 **25.** $\frac{819}{512}$ **26.** does not exist **27.** $\frac{50}{9}$ **28.** 4
29. $\frac{63{,}050}{6561}$ **30.** does not exist **31.** 5 **32.** $a_9 = \$36{,}980$; $S_9 = \$314{,}900$
33. ≈7111.1 ft^3 **34.** $a_9 \approx$ 2105 credit hrs; $S_9 \approx$ 14,673 credit hours
35. (1) Show S_n is true for $n = 1$: $S_1 = \frac{1(1+1)}{2} = 1$✓

(2) Assume S_k is true:

$$1 + 2 + 3 + \cdots + k = \frac{k(k+1)}{2}$$

Use it to show the truth of S_{k+1}:

$$1 + 2 + 3 + \cdots + k + (k+1) = \frac{(k+1)(k+2)}{2}$$

left-hand side: $1 + 2 + 3 + \cdots + k + (k+1)$

$$= \frac{\boldsymbol{k(k+1)}}{\boldsymbol{2}} + \frac{2(k+1)}{2} = \frac{k(k+1) + 2(k+1)}{2}$$

$$= \frac{(k+1)(k+2)}{2} \quad \text{verified}$$

36. (1) Show S_n is true for $n = 1$: $S_1 = \frac{1[2(1)+1](1+1)}{6} = 1$✓

(2) Assume S_k is true:

$$1 + 4 + 9 + \cdots + k^2 = \frac{k(2k+1)(k+1)}{6}$$

Use it to show the truth of S_{k+1}:

$$1 + 4 + 9 + \cdots + k^2 + (k+1)^2 = \frac{(k+1)(2k+3)(k+2)}{6}$$

left-hand side: $1 + 4 + 9 + \cdots + k^2 + (k+1)^2$

$$= \frac{\boldsymbol{k(k+1)(2k+1)}}{\boldsymbol{6}} + \frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2+k+6k+6]}{6}$$

$$= \frac{(k+1)(2k^2+7k+6)}{6} = \frac{(k+1)(2k+3)(k+2)}{6}$$

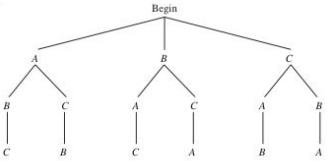
verified

37. (1) Show S_n is true for $n = 1$: S_1: $4^1 \geq 3(1) + 1$✓
(2) Assume S_k is true: $4^k \geq 3k + 1$
Use it to show the truth of S_{k+1}:
$4^{k+1} \geq 3(k+1) + 1 = 3k + 4$
left-hand side: $4^{k+1} = 4(4^k)$
$\geq 4(\boldsymbol{3k + 1}) = 12k + 4$
Since k is a positive integer, $12k + 4 \geq 3k + 4$ showing
$4^{k+1} \geq 3k + 4$
verified

38. (1) Show S_n is true for $n = 1$: S_1: $6 \cdot 7^{1-1} \leq 7^1 - 1$✓
(2) Assume S_k is true: $6 \cdot 7^{k-1} \leq 7^k - 1$
Use it to show the truth of S_{k+1}:
$6 \cdot 7^k \leq 7^{k+1} - 1$
left-hand side: $6 \cdot 7^k = 7 \cdot 6 \cdot 7^{k-1}$
$\leq 7 \cdot \boldsymbol{7^k - 1}$
$\leq 7^{k+1} - 1$
verified

39. (1) Show S_n is true for $n = 1$: S_1: $3^1 - 1 = 2$ or $2(1)$✓
(2) Assume S_k is true: $3^k - 1 = 2p$ for $p \in Z$
Use it to show the truth of S_{k+1}:
$3^{k+1} - 1 = 2q$ for $q \in Z$
left-hand side: $3^{k+1} - 1 = 3 \cdot 3^k - 1$
$= 3 \cdot \boldsymbol{2p}$
$= 2(3p) = 2q$ is divisible by 2
verified

40. 6 ways



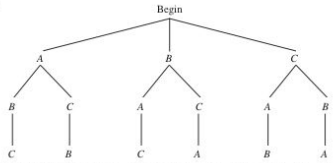
41. 720; 1000 **42.** 24 **43.** 220 **44.** 32
45. a. 5040 **b.** 840 **c.** 35 **46. a.** 720 **b.** 120 **c.** 24 **47.** 3360
48. a. 220 **b.** 1320 **49.** $\frac{4}{13}$ **50.** $\frac{3}{13}$ **51.** $\frac{5}{6}$ **52.** $\frac{7}{24}$ **53.** $\frac{175}{396}$
54. a. 0.608 **b.** 0.392 **c.** 1 **d.** 0 **e.** 0.928 **f.** 0.178
55. a. 21 **b.** 56 **56. a.** $x^4 - 4x^3y + 6x^2y^2 - 4xy^3 + y^4$ **b.** $41 - 38i$
57. a. $a^8 + 8\sqrt{3}a^7 + 84a^6 + 168\sqrt{3}a^5$
b. $78{,}125a^7 + 218{,}750a^6b + 262{,}500a^5b^2 + 175{,}000a^4b^3$
58. a. $280x^4y^3$ **b.** $-64{,}064a^3b^9$

Mixed Review, pp. 1089–1090

1. a. arithmetic **b.** $a_n = 4$ **c.** $a_n = n!$ **d.** arithmetic **e.** geometric
f. geometric **g.** arithmetic **h.** geometric **i.** $a_n = \frac{1}{2n}$ **3.** 27,600
5. 0.1, 0.5, 2.5, 12.5, 62.5; $a_{15} = 610{,}351{,}562.5$ **7.** $\frac{5}{6}$
9. a. 2 **b.** 200 **c.** 210 **11. a.** $a^{20} + 20a^{19}b + 190a^{18}b^2$
b. $190a^2b^{18} + 20ab^{19} + b^{20}$ **c.** $52{,}360a^{31}b^4$ **d.** 4.6×10^{-18}
13. verified **15.** 0.01659 **17.** $\frac{4}{11}$ **19.** $10, 2, \frac{2}{5}, \frac{2}{25}, \frac{2}{125}$

Practice Test, pp. 1091–1092

1. a. $\frac{1}{2}, \frac{4}{5}, 1, \frac{8}{7}$; $a_8 = \frac{16}{11}, a_{12} = \frac{8}{5}$ **b.** 6, 12, 20, 30; $a_8 = 90, a_{12} = 182$
c. $3, 2\sqrt{2}, \sqrt{7}, \sqrt{6}$; $a_8 = \sqrt{2}, a_{12} = i\sqrt{2}$ **2. a.** 165 **b.** $\frac{311}{420}$ **c.** $\frac{-2343}{512}$
d. 7 **3. a.** $a_1 = 7, d = -3, a_n = 10 - 3n$
b. $a_1 = -8, d = 2, a_n = 2n - 10$ **c.** $a_1 = 4, r = -2, a_n = 4(-2)^{n-1}$
d. $a_1 = 10, r = \frac{2}{5}, a_n = 10\left(\frac{2}{5}\right)^{n-1}$
4. a. 199 **b.** 9 **c.** $\frac{3}{4}$ **d.** 6 **5. a.** 1712 **b.** 2183 **c.** 2188 **d.** 12
6. a. ≈8.82 ft **b.** ≈72.4 ft **7.** $6756.57 **8.** $22,185.27 **9.** verified
10. verified
11. a.



b. ABC, ACB, BAC, BCA, CAB, CBA **12.** 302,400 **13.** 64
14. 720, 120, 20 **15.** 900,900 **16.** 302,400
17. a. $x^4 - 8x^3y + 24x^2y^2 - 32xy^3 + 16y^4$ **b.** -4
18. a. $x^{10} + 10\sqrt{2}x^9 + 90x^8$ **b.** $a^8 - 16a^7b^3 + 112a^6b^6$
19. 0.989 **20. a.** $\frac{1}{4}$ **b.** $\frac{5}{12}$ **c.** $\frac{1}{3}$ **d.** $\frac{1}{2}$ **e.** $\frac{7}{12}$ **f.** $\frac{1}{4}$ **g.** $\frac{5}{12}$ **h.** 0
21. a. 0.08 **b.** 0.92 **c.** 1 **d.** 0 **e.** 0.95 **f.** 0.03
22. a. 0.1875 **b.** 0.589 **c.** 0.4015 **d.** 0.2945 **e.** 0.4110 **f.** 0.2055
23. a. $\frac{59}{100}$ **b.** $\frac{53}{100}$ **c.** $\frac{13}{100}$ **d.** $\frac{47}{100}$
24. a. 0.8075 **b.** 0.0075 **c.** 0.9925 **25.** verified

Strengthening Core Skills, pp. 1093–1094

Exercise 1. $\frac{{}_4C_1 \cdot {}_{13}C_5 - 40}{{}_{52}C_5} \approx 0.001\,970$

Exercise 2. $\frac{4 \cdot {}_{13}C_3 \cdot {}_{39}C_2}{{}_{52}C_5} \approx 0.326\,170$

Exercise 3. $\frac{4 \cdot {}_{13}C_4 \cdot {}_{39}C_1}{{}_{52}C_5} \approx 0.042\,917$

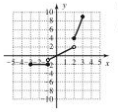
Exercise 4. $\frac{4 \cdot {}_{10}C_5}{{}_{52}C_5} \approx 0.000\,388$

Cumulative Review Chapters 1–11, pp. 1094–1096

1. a. 23 cards are assembled each hour. **b.** 184 cards
c. $y = 23x - 155$ **d.** ≈ 6:45 A.M.
3.

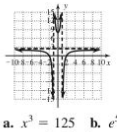
x	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	$\frac{2\pi}{3}$	$\frac{5\pi}{6}$	π
y	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0	$-\frac{1}{2}$	$-\frac{\sqrt{3}}{2}$	-1

5. $x = \frac{-5 \pm \sqrt{109}}{6}$; $x \approx 0.91$; $x \approx -2.57$
7. a. $x = 0$ **b.** $x \in (-1, 0)$ **c.** $x \in (-\infty, -1) \cup (0, \infty)$
d. $x \in (-\infty, -1) \cup (-1, 1)$ **e.** $x \in (1, \infty)$ **f.** $y = 3$ at $(1, 3)$
g. none **h.** $x \approx -2.3, 0.4, 2$ **i.** $g(4) \approx 0.25$ **j.** does not exist
k. $-\infty$ **l.** 0 **m.** $x \in (-\infty, 1) \cup (-1, \infty)$
9.



D: $x \in [-3, 3]$
R: $y \in [-2, -2] \cup (-1, 2) \cup [4, 9]$

11. a. $4x + 2h - 3$ **b.** $\frac{-1}{(x + h - 2)(x - 2)}$
13.



15. a. $x^3 = 125$ **b.** $e^5 = 2x - 1$
17. a. $x \approx 3.19$ **b.** $x = 334$ **19.** (5, 10, 15)
21. $(-3, 3); (-7, 3), (1, 3); (-3 - 2\sqrt{3}, 3), (-3 + 2\sqrt{3}, 3)$
23. a. verified **b.** $\frac{\sqrt{6} + \sqrt{2}}{4}$ **25.** 1333 **27. a.** ≈7.0% **b.** ≈91.9%
c. ≈98.9% **d.** $\binom{12}{0}(0.04)^{12}(0.96)^0$; virtually nil
29. $\cos(2\theta) = \cos^2\theta - \sin^2\theta$
$= 1 - 2\sin^2\theta$
$= 2\cos^2\theta - 1$;

$\frac{1}{2} = 1 - 2\sin^2\theta$

$\frac{1}{4} = \sin^2\theta$

$\pm\frac{1}{2} = \sin\theta$

$\theta = \frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{13\pi}{6}$

Index

S

T

Special Constants

$\pi \approx 3.1416$ $\quad \frac{\pi}{2} \approx 3.1416$ $\quad \frac{\pi}{3} \approx 1.0472$ $\quad \frac{\pi}{4} \approx 0.7854$ $\quad \frac{\pi}{6} \approx 0.5236$ $\quad \frac{\pi}{12} \approx 0.2618$

$e \approx 2.7183$ $\quad \sqrt{2} \approx 1.4142$ $\quad \sqrt{3} \approx 1.7321$ $\quad \frac{\sqrt{2}}{2} \approx 0.7071$ $\quad \frac{\sqrt{3}}{2} \approx 0.8660$ $\quad \frac{\sqrt{3}}{3} \approx 0.5774$

Special Products

$$(x + a)(x + b) = x^2 + (a + b)x + ab$$
$$(a + b)^2 = a^2 + 2ab + b^2$$
$$(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$
$$(a + b)(a - b) = a^2 - b^2$$
$$(a - b)^2 = a^2 - 2ab + b^2$$
$$(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$$

Special Factorizations

$$x^2 + (a + b)x + ab = (x + a)(x + b)$$
$$a^2 + 2ab + b^2 = (a + b)^2$$
$$a^3 - b^3 = (a - b)(a^2 + ab + b^2)$$
$$a^2 - b^2 = (a + b)(a - b)$$
$$a^2 - 2ab + b^2 = (a - b)^2$$
$$a^3 + b^3 = (a + b)(a^2 - ab + b^2)$$

Formulas from Plane Geometry: $P \rightarrow$ perimeter, $C \rightarrow$ circumference, $A \rightarrow$ area

Rectangle

$P = 2l + 2w$

$A = lw$

Square

$P = 4s$

$A = s^2$

Regular Polygon

$P = ns$

$A = \frac{a}{2}P$

Parallelogram

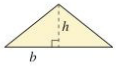
$A = bh$

Trapezoid

$A = \frac{h}{2}(a + b)$

Triangle

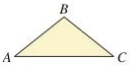
$A = \frac{1}{2}bh$



Triangle

Sum of angles

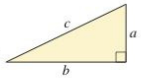
$A + B + C = 180°$



Right Triangle

Pythagorean Theorem

$a^2 + b^2 = c^2$



Circle

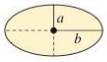
$A = \pi r^2$

$C = 2\pi r = \pi d$

Ellipse

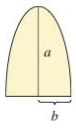
$A = \pi ab$

$C \approx \pi\sqrt{2(a^2 + b^2)}$



Right Parabolic Segment

$A = \frac{4}{3}ab$



Formulas from Solid Geometry: $S \rightarrow$ surface area, $V \rightarrow$ volume

Rectangular Solid

$V = lwh$

$S = lw + lh + wh$

Cube

$V = s^3$

$S = 6s^2$

Right Circular Cylinder

$V = \pi r^2 h$

$S = 2\pi r(r + h)$

Right Circular Cone

$V = \frac{1}{3}\pi r^2 h$

$S = \pi r(r + s)$

Right Square Pyramid

$V = \frac{1}{3}b^2 h$

$S = b^2 + b\sqrt{b^2 + 4h^2}$

Sphere

$V = \frac{4}{3}\pi r^3$

$S = 4\pi r^2$

Formulas from Analytical Geometry: $P_1 \to (x_1, y_1)$, $P_2 \to (x_2, y_2)$

Distance between P_1 and P_2

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Slope of Line Containing P_1 and P_2

$$m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

Equation of Line Containing P_1 and P_2

Point-Slope Form

$$y - y_1 = m(x - x_1)$$

Equation of Line Containing P_1 and P_2

Slope-Intercept Form (slope m, y-intercept b)

$$y = mx + b, \text{ where } b = y_1 - mx_1$$

Parallel Lines

Slopes Are Equal: $m_1 = m_2$

Perpendicular Lines

Slopes Have a Product of -1: $m_1 m_2 = -1$

Intersecting Lines

Slopes Are Unequal: $m_1 \neq m_2$

Dependent (Coincident) Lines

Slopes and y-Intercepts Are Equal: $m_1 = m_2$, $b_1 = b_2$

Logarithms and Logarithmic Properties

$$y = \log_b x \Leftrightarrow b^y = x \qquad \log_b b = 1 \qquad \log_b 1 = 0$$

$$\log_b b^x = x \qquad b^{\log_b x} = x \qquad \log_c x = \frac{\log_b x}{\log_b c}$$

$$\log_b MN = \log_b M + \log_b N \qquad \log_b \frac{M}{N} = \log_b M - \log_b N \qquad \log_b M^P = P \cdot \log_b M$$

Applications of Exponentials and Logarithms

$A \to$ amount accumulated $\quad P \to$ initial deposit, $p \to$ periodic payment $\quad n \to$ compounding periods/year

$r \to$ interest rate per year $\quad R \to$ interest rate per time period $\left(\frac{r}{n}\right)$ $\quad t \to$ time in years

Interest Compounded n Times per Year

$$A = P\left(1 + \frac{r}{n}\right)^{nt}$$

Interest Compounded Continuously

$$A = Pe^{rt}$$

Accumulated Value of an Annuity

$$A = \frac{p}{R}[(1 + R)^{nt} - 1]$$

Payments Required to Accumulate Amount A

$$p = \frac{AR}{(1 + R)^{nt} - 1}$$

Sequences and Series:

$a_1 \to$ 1st term, $a_n \to n$th term, $S_n \to$ sum of n terms, $d \to$ common difference, $r \to$ common ratio

Arithmetic Sequences

$$a_1, a_2 = a_1 + d, a_3 = a_1 + 2d, \ldots, a_n = a_1 + (n - 1)d$$

$$S_n = \frac{n}{2}(a_1 + a_n)$$

$$S_n = \frac{n}{2}[2a_1 + (n - 1)d]$$

Geometric Sequences

$$a_1, a_2 = a_1 r, a_3 = a_1 r^2, \ldots, a_n = a_1 r^{n-1}$$

$$S_n = \frac{a_1 - a_1 r^n}{1 - r}$$

$$S_\infty = \frac{a_1}{1 - r}; \; |r| < 1$$

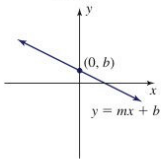
Binomial Theorem

$$(a + b)^n = \binom{n}{0}a^n b^0 + \binom{n}{1}a^{n-1}b^1 + \binom{n}{2}a^{n-2}b^2 + \cdots + \binom{n}{n-1}a^1 b^{n-1} + \binom{n}{n}a^0 b^n$$

$$n! = n(n - 1)(n - 2) \cdots (3)(2)(1) \qquad \binom{n}{k} = \frac{n!}{k!(n - k)!}; \qquad 0! = 1$$

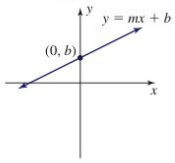
The Toolbox and Other Functions

linear



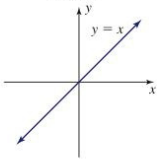
$m < 0, b > 0$

linear



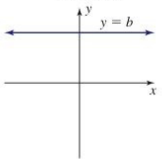
$m > 0, b > 0$

identity



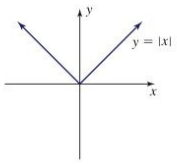
$m = 1, b = 0$

constant

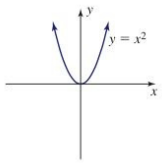


$m = 0, b > 0$

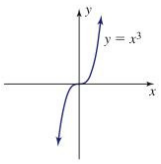
absolute value



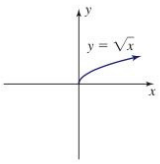
squaring



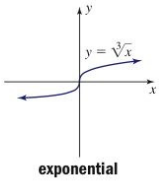
cubing



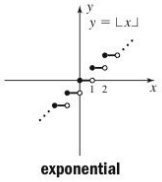
square root



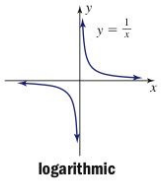
cube root



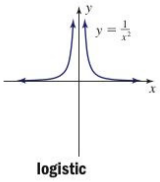
floor function



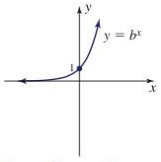
reciprocal



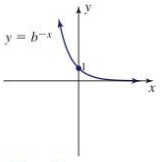
reciprocal quadratic



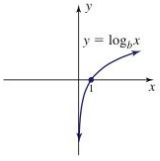
exponential



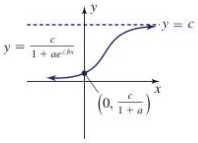
exponential



logarithmic



logistic



Transformations of Basic Graphs

Given Function	Transformation of Given Function
$y = f(x)$	$y = af(x \pm h) \pm k$
	vertical reflections vertical stretches/compressions
	horizontal shift h units, opposite direction of sign
	vertical shift k units, same direction as sign

Average Rate of Change of $f(x)$

For linear function models, the average rate of change on the interval $[x_1, x_2]$ is constant, and given by the slope formula: $\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$. The average rate of change for other function models is non-constant. By writing the slope formula in function form using $y_1 = f(x_1)$ and $y_2 = f(x_2)$, we can compute the average rate of change of other functions on this interval:

$$\frac{\Delta y}{\Delta x} = \frac{f(x_2) - f(x_1)}{x_2 - x_1}$$

Quick Counting and Probability

Fundamental Counting Principle: Given an experiment with two tasks completed in sequence, if the first can be completed in m ways and the second in n ways, the experiment can be completed in $\boldsymbol{m \times n}$ ways.

Permutations—Order Is a Consideration: (Al, Bo, Ray) and (Ray, Bo, Al) finish the race in a different order.

The permutations of r objects selected from a set of n (unique) objects is given by $\boldsymbol{{}_nP_r = \frac{n!}{(n-r)!}}$.

Combinations—Order Is Not a Consideration: (Al, Bo, Ray) and (Ray, Bo, Al) form the same committee.

The combinations of r objects selected from a set of n (unique) objects is given by $\boldsymbol{{}_nC_r = \frac{n!}{r!(n-r)!}}$.

Basic Probability: Given S is a sample space of equally likely events and E is an event defined relative to S.

The probability of E is $\boldsymbol{P(E) = \frac{n(E)}{n(S)}}$, where $n(E)$ and $n(S)$ represent the number of elements in each.

For any event E_1: $0 \le P(E_1) \le 1$ and $P(E_1) + P(\sim E_1) = 1$.

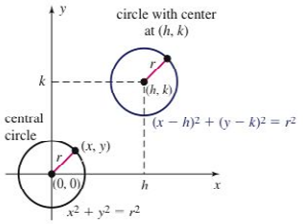
Probability of E_1 and E_2

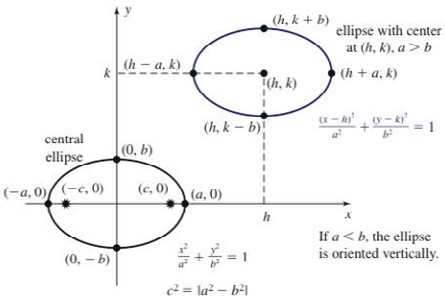
$$P(E_1 \cap E_2) = P(E_1)P(E_2)$$

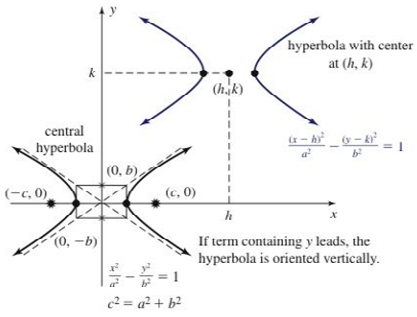
Probability of E_1 or E_2

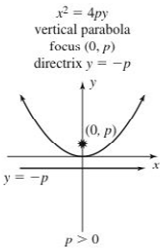
$$P(E_1 \cup E_2) = P(E_1) + P(E_2) - P(E_1 \cap E_2)$$

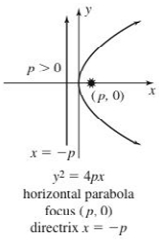
Conic Sections











Commonly used, small case Greek letters

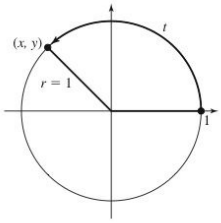
α	alpha	β	beta	γ	gamma	δ	delta	ϵ	epsilon
ζ	zeta	θ	theta	λ	lamda	μ	mu	π	pi
ρ	rho	σ	sigma	ϕ	phi	ψ	psi	ω	omega

Trigonometric Functions of a Real Number

For any real number t and point $P(x, y)$ on the unit circle associated with t:

$\cos t = x$ $\quad \sin t = y$ $\quad \tan t = \frac{y}{x}; x \neq 0$

$\sec t = \frac{1}{x}; x \neq 0$ $\quad \csc t = \frac{1}{y}; y \neq 0$ $\quad \cot t = \frac{x}{y}; y \neq 0$

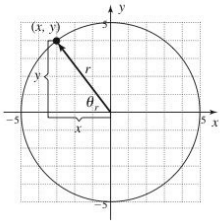


Trigonometry and the Coordinate Plane

For $P(x, y)$ a point on the terminal side of an angle θ in standard position:

$\cos\theta = \frac{x}{r}$ $\quad \sin\theta = \frac{y}{r}$ $\quad \tan\theta = \frac{y}{x}, x \neq 0$

$\sec\theta = \frac{r}{x}, x \neq 0$ $\quad \csc\theta = \frac{r}{y}, y \neq 0$ $\quad \cot\theta = \frac{x}{y}, y \neq 0$

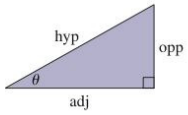


Right Triangle Trigonometry

For right ΔABC with indicated sides **adj**acent and **opp**osite to acute angle θ:

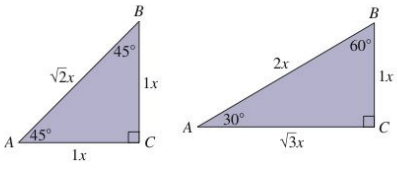
$\cos\theta = \frac{\text{adj}}{\text{hyp}}$ $\quad \sin\theta = \frac{\text{opp}}{\text{hyp}}$ $\quad \tan\theta = \frac{\text{opp}}{\text{adj}}$

$\sec\theta = \frac{\text{hyp}}{\text{adj}}$ $\quad \csc\theta = \frac{\text{hyp}}{\text{opp}}$ $\quad \cot\theta = \frac{\text{adj}}{\text{opp}}$

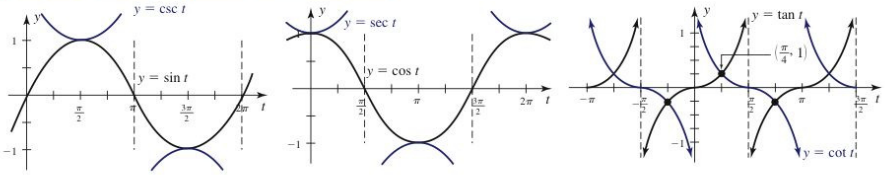


Special Triangles and Special Angles

θ	$\sin\theta$	$\cos\theta$	$\tan\theta$	$\csc\theta$	$\sec\theta$	$\cot\theta$
0°	0	1	0	—	1	—
30°	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{3}}$	2	$\frac{2}{\sqrt{3}}$	$\sqrt{3}$
45°	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{2}}{2}$	1	$\sqrt{2}$	$\sqrt{2}$	1
60°	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$	$\frac{2}{\sqrt{3}}$	2	$\frac{1}{\sqrt{3}}$
90°	1	0	—	1	—	0



Graphs of the Trigonometric Functions



Fundamental Identities

Reciprocal Identities

$$\sec\theta = \frac{1}{\cos\theta}$$

$$\csc\theta = \frac{1}{\sin\theta}$$

$$\cot\theta = \frac{1}{\tan\theta}$$

Ratio Identities

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

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

Pythagorean Identities

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

$$1 + \tan^2\theta = \sec^2\theta$$

$$1 + \cot^2\theta = \csc^2\theta$$

Identities due to Symmetry

$$\sin(-\theta) = -\sin\theta$$

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

$$\tan(-\theta) = -\tan\theta$$

Cofunction Identities

$$\sin\left(\frac{\pi}{2} - x\right) = \cos x \qquad \cos\left(\frac{\pi}{2} - x\right) = \sin x$$

$$\tan\left(\frac{\pi}{2} - x\right) = \cot x \qquad \cot\left(\frac{\pi}{2} - x\right) = \tan x$$

$$\sec\left(\frac{\pi}{2} - x\right) = \csc x \qquad \csc\left(\frac{\pi}{2} - x\right) = \sec x$$

Sum and Difference Identities

$$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$$

$$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$$

$$\tan(\alpha \pm \beta) = \frac{\tan\alpha \pm \tan\beta}{1 \mp \tan\alpha\tan\beta}$$

Double-Angle Identities

$$\sin(2\alpha) = 2\sin\alpha\cos\alpha$$

$$\cos(2\alpha) = \cos^2\alpha - \sin^2\alpha$$

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

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

$$\tan(2\alpha) = \frac{2\tan\alpha}{1 - \tan^2\alpha}$$

Half-Angle Identities

$$\sin\frac{\theta}{2} = \pm\sqrt{\frac{1 - \cos\theta}{2}}$$

$$\cos\frac{\theta}{2} = \pm\sqrt{\frac{1 + \cos\theta}{2}}$$

$$\tan\frac{\theta}{2} = \frac{1 - \cos\theta}{\sin\theta}$$

$$= \frac{\sin\theta}{1 + \cos\theta}$$

Power Reduction Identities

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

$$\cos^2\theta = \frac{1 + \cos(2\theta)}{2}$$

$$\tan^2\theta = \frac{1 - \cos(2\theta)}{1 + \cos(2\theta)}$$

Product-to-Sum Identities

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

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

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

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

Sum-to-Product Identities

$$\sin\alpha + \sin\beta = 2\sin\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

$$\sin\alpha - \sin\beta = 2\cos\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

$$\cos\alpha + \cos\beta = 2\cos\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

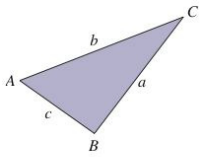
$$\cos\alpha - \cos\beta = -2\sin\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

Law of Sines

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

Area of a Triangle

$$A = \frac{1}{2}bc\sin A$$



Law of Cosines

$$a^2 = b^2 + c^2 - 2bc\cos A$$

$$b^2 = a^2 + c^2 - 2ac\cos B$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

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