

13. Proof

15. (a)

x	-4	-2	0	4
$f(f^{-1}(x))$	-4	-2	0	4

(b)

x	-3	-2	0	1
$(f + f^{-1})(x)$	5	1	-3	-5

(c)

x	-3	-2	0	1
$(f \circ f^{-1})(x)$	4	0	2	6

(d)

x	-4	-3	0	4
$ f^{-1}(x) $	2	1	1	3

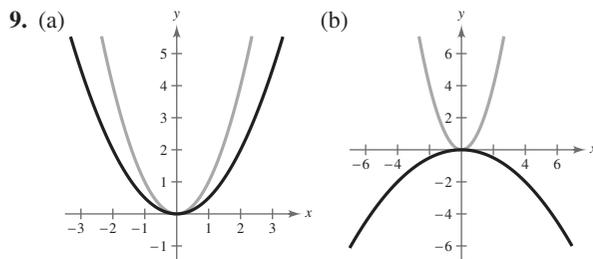
Chapter 2

Section 2.1 (page 134)

Vocabulary Check (page 134)

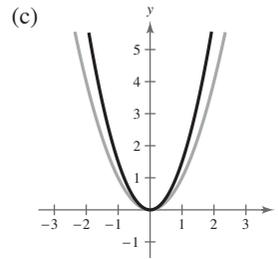
- 1. nonnegative integer; real
- 2. quadratic; parabola
- 3. axis
- 4. positive; minimum
- 5. negative; maximum

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

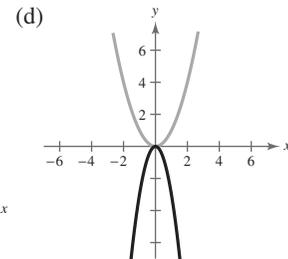


Vertical shrink

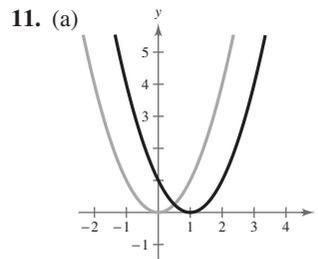
Vertical shrink and reflection in the x -axis



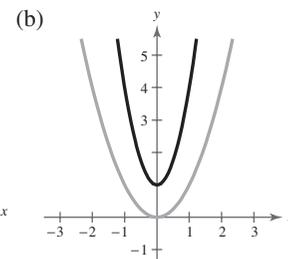
Vertical stretch



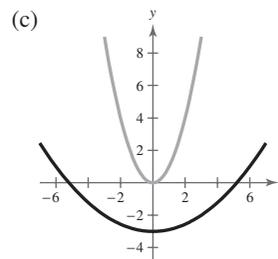
Vertical stretch and reflection in the x -axis



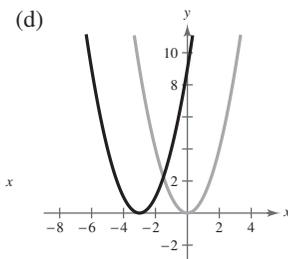
Horizontal shift



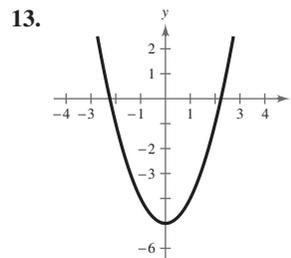
Horizontal shrink and vertical shift



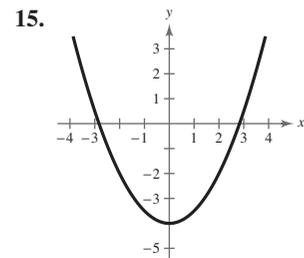
Horizontal stretch and vertical shift



Horizontal shift

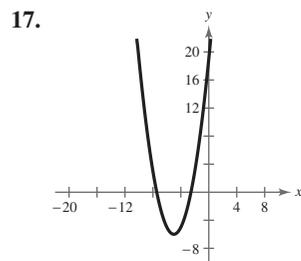


Vertex: $(0, -5)$
Axis of symmetry: y -axis
 x -intercepts: $(\pm\sqrt{5}, 0)$

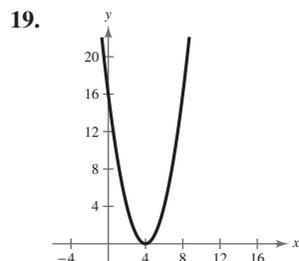


Vertex: $(0, -4)$
Axis of symmetry: y -axis
 x -intercepts: $(\pm 2\sqrt{2}, 0)$

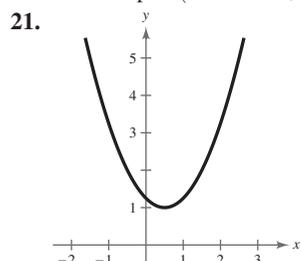
A104 Answers to Odd-Numbered Exercises and Tests



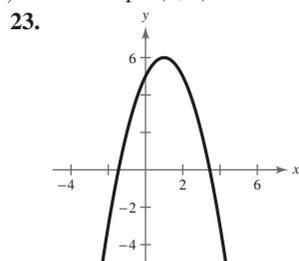
Vertex: $(-5, -6)$
 Axis of symmetry: $x = -5$
 x-intercepts: $(-5 \pm \sqrt{6}, 0)$



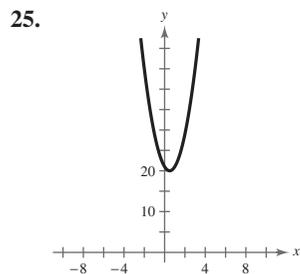
Vertex: $(4, 0)$
 Axis of symmetry: $x = 4$
 x-intercept: $(4, 0)$



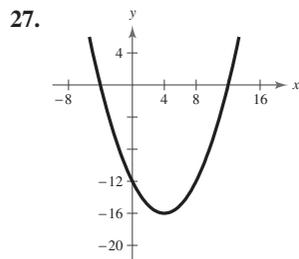
Vertex: $(\frac{1}{2}, 1)$
 Axis of symmetry: $x = \frac{1}{2}$
 No x-intercept



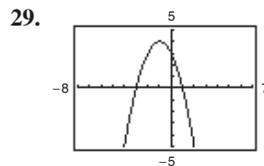
Vertex: $(1, 6)$
 Axis of symmetry: $x = 1$
 x-intercepts: $(1 \pm \sqrt{6}, 0)$



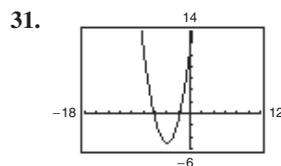
Vertex: $(\frac{1}{2}, 20)$
 Axis of symmetry: $x = \frac{1}{2}$
 No x-intercept



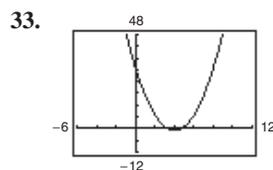
Vertex: $(4, -16)$
 Axis of symmetry: $x = 4$
 x-intercepts: $(-4, 0), (12, 0)$



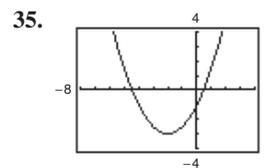
Vertex: $(-1, 4)$
 Axis of symmetry: $x = -1$
 x-intercepts: $(1, 0), (-3, 0)$



Vertex: $(-4, -5)$
 Axis of symmetry: $x = -4$
 x-intercepts: $(-4 \pm \sqrt{5}, 0)$



Vertex: $(4, -1)$
 Axis of symmetry: $x = 4$
 x-intercepts: $(4 \pm \frac{1}{2}\sqrt{2}, 0)$



Vertex: $(-2, -3)$
 Axis of symmetry: $x = -2$
 x-intercepts: $(-2 \pm \sqrt{6}, 0)$

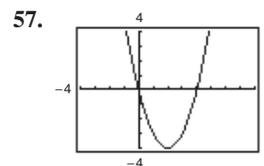
37. $y = (x - 1)^2$ **39.** $y = -(x + 1)^2 + 4$

41. $y = -2(x + 2)^2 + 2$ **43.** $f(x) = (x + 2)^2 + 5$

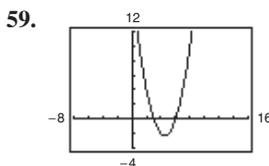
45. $f(x) = -\frac{1}{2}(x - 3)^2 + 4$ **47.** $f(x) = \frac{3}{4}(x - 5)^2 + 12$

49. $f(x) = -\frac{24}{49}(x + \frac{1}{4})^2 + \frac{3}{2}$ **51.** $f(x) = -\frac{16}{3}(x + \frac{5}{2})^2$

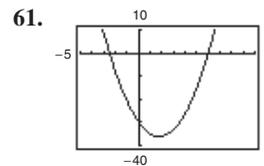
53. $(\pm 4, 0)$ **55.** $(5, 0), (-1, 0)$



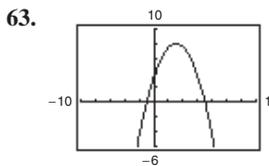
$(0, 0), (4, 0)$



$(3, 0), (6, 0)$



$(-\frac{5}{2}, 0), (6, 0)$



$(7, 0), (-1, 0)$

65. $f(x) = x^2 - 2x - 3$
 $g(x) = -x^2 + 2x + 3$

67. $f(x) = x^2 - 10x$
 $g(x) = -x^2 + 10x$

69. $f(x) = 2x^2 + 7x + 3$
 $g(x) = -2x^2 - 7x - 3$

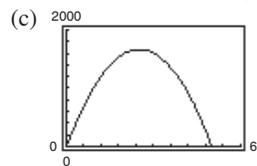
71. 55, 55 **73.** 12, 6

75. (a) $A = \frac{8x(50 - x)}{3}$

(b)

x	5	10	15	20	25	30
A	600	1067	1400	1600	1667	1600

$x = 25$ feet, $y = 33\frac{1}{3}$ feet



$x = 25$ feet, $y = 33\frac{1}{3}$ feet

(d) $A = -\frac{8}{3}(x - 25)^2 + \frac{5000}{3}$ (e) They are identical.

77. 16 feet **79.** 20 fixtures **81.** 350,000 units

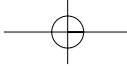
83. (a) \$14,000,000; \$14,375,000; \$13,500,000

(b) 24; \$14,400

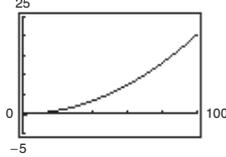
85. (a)

(b) 4299; answers will vary.

(c) 8879; 24



87. (a) (b) 69.6 miles per hour



89. True. The equation has no real solutions, so the graph has no x -intercepts.

91. $f(x) = a\left(x + \frac{b}{2a}\right)^2 + \frac{4ac - b^2}{4a}$

93. Yes. A graph of a quadratic equation whose vertex is on the x -axis has only one x -intercept.

95. $y = -\frac{1}{3}x + \frac{5}{3}$ 97. $y = \frac{5}{4}x + 3$ 99. 27

101. $-\frac{1408}{49}$ 103. 109 105. Answers will vary.

Section 2.2 (page 148)

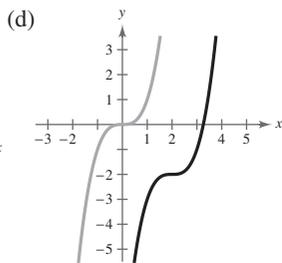
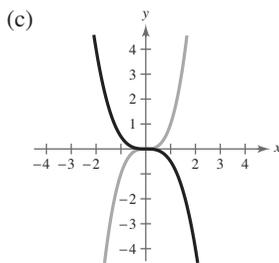
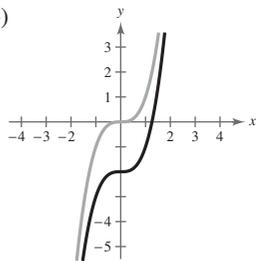
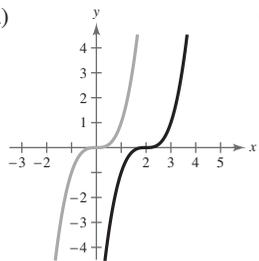
Vocabulary Check (page 148)

1. continuous 2. Leading Coefficient Test
 3. $n; n - 1$ 4. (a) solution; (b) $(x - a)$; (c) x -intercept
 5. touches; crosses 6. standard
 7. Intermediate Value

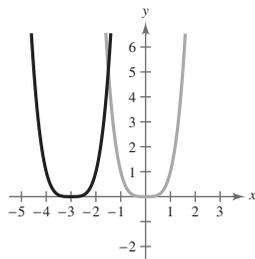
1. c 2. g 3. h 4. f

5. a 6. e 7. d 8. b

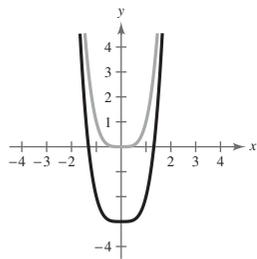
9. (a) (b)



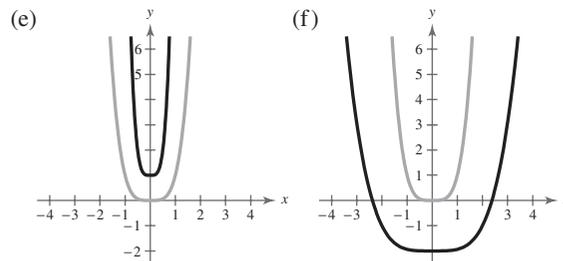
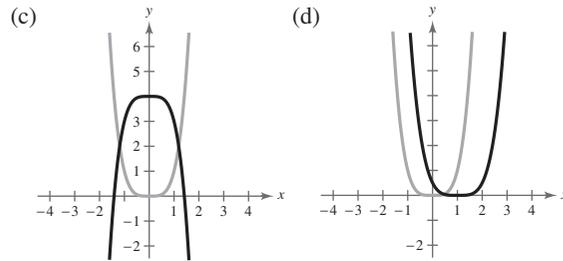
11. (a)



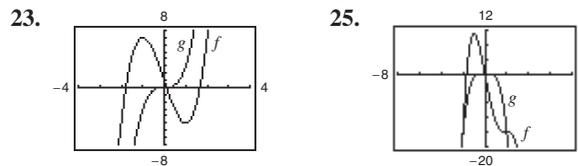
- (b)



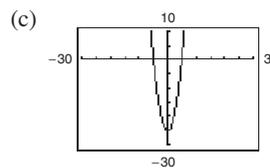
Answers to Odd-Numbered Exercises and Tests



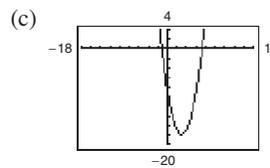
13. Falls to the left, rises to the right
 15. Falls to the left, falls to the right
 17. Rises to the left, falls to the right
 19. Rises to the left, falls to the right
 21. Falls to the left, falls to the right



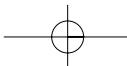
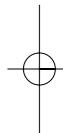
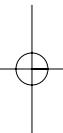
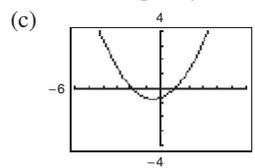
27. (a) ± 5
 (b) odd multiplicity; number of turning points: 1



29. (a) 3
 (b) even multiplicity; number of turning points: 1

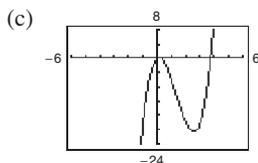


31. (a) $-2, 1$
 (b) odd multiplicity; number of turning points: 1

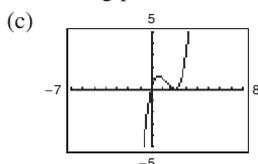


A106 Answers to Odd-Numbered Exercises and Tests

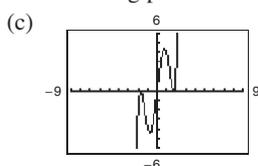
33. (a) $0, 2 \pm \sqrt{3}$
 (b) odd multiplicity; number of turning points: 2



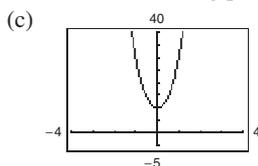
35. (a) 0, 2
 (b) 0, odd multiplicity; 2, even multiplicity; number of turning points: 2



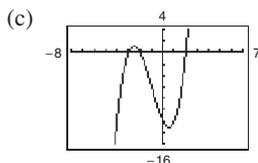
37. (a) $0, \pm\sqrt{3}$
 (b) 0, odd multiplicity; $\pm\sqrt{3}$, even multiplicity; number of turning points: 4



39. (a) No real zeros
 (b) number of turning points: 1



41. (a) $\pm 2, -3$
 (b) odd multiplicity; number of turning points: 2



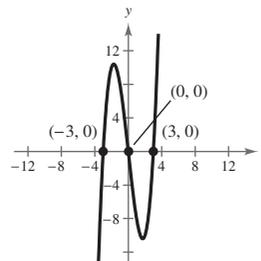
43. (a)
-
- (b) x -intercepts: $(0, 0), (\frac{5}{2}, 0)$ (c) $x = 0, \frac{5}{2}$
 (d) The answers in part (c) match the x -intercepts.

45. (a)
-

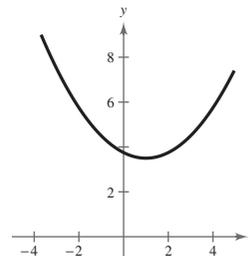
- (b) x -intercepts: $(0, 0), (\pm 1, 0), (\pm 2, 0)$
 (c) $x = 0, 1, -1, 2, -2$
 (d) The answers in part (c) match the x -intercepts.

47. $f(x) = x^2 - 10x$ 49. $f(x) = x^2 + 4x - 12$
 51. $f(x) = x^3 + 5x^2 + 6x$
 53. $f(x) = x^4 - 4x^3 - 9x^2 + 36x$
 55. $f(x) = x^2 - 2x - 2$ 57. $f(x) = x^2 + 4x + 4$
 59. $f(x) = x^3 + 2x^2 - 3x$ 61. $f(x) = x^3 - 3x$
 63. $f(x) = x^4 + x^3 - 15x^2 + 23x - 10$
 65. $f(x) = x^5 + 16x^4 + 96x^3 + 256x^2 + 256x$

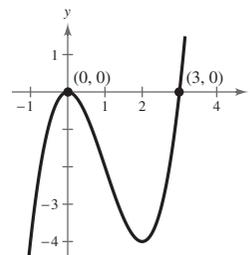
67. (a) Falls to the left, rises to the right
 (b) $0, \pm 3$ (c) Answers will vary.
 (d)



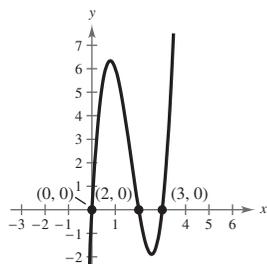
69. (a) Rises to the left, rises to the right
 (b) No zeros (c) Answers will vary.
 (d)



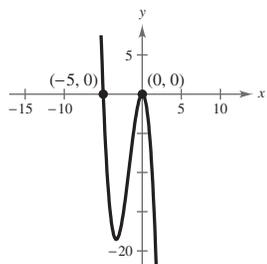
71. (a) Falls to the left, rises to the right
 (b) 0, 3 (c) Answers will vary.
 (d)



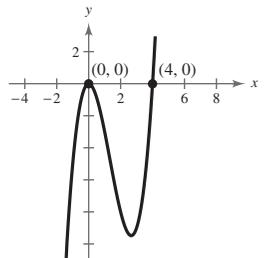
73. (a) Falls to the left, rises to the right
 (b) 0, 2, 3 (c) Answers will vary.
 (d)



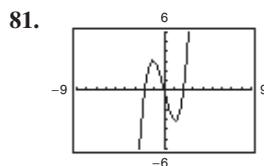
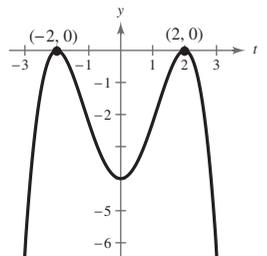
75. (a) Rises to the left, falls to the right
 (b) -5, 0 (c) Answers will vary.
 (d)



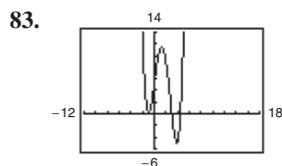
77. (a) Falls to the left, rises to the right
 (b) 0, 4 (c) Answers will vary.
 (d)



79. (a) Falls to the left, falls to the right
 (b) ± 2 (c) Answers will vary.
 (d)



Zeros: 0, ± 2 ,
 odd multiplicity



Zeros: -1,
 even multiplicity;
 $3, \frac{9}{2}$, odd multiplicity

85. $[-1, 0], [1, 2], [2, 3]; \approx -0.879, 1.347, 2.532$

Answers to Odd-Numbered Exercises and Tests

87. $[-2, -1], [0, 1]; \approx -1.585, 0.779$

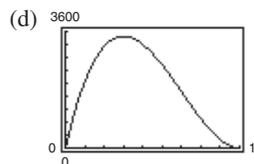
89. (a) $V = l \times w \times h$
 $= (36 - 2x)(36 - 2x)x$
 $= x(36 - 2x)^2$

- (b) Domain: $0 < x < 18$

(c)

x	1	2	3	4	5	6	7
V	1156	2048	2700	3136	3380	3456	3388

6 inches \times 24 inches \times 24 inches



$x = 6$

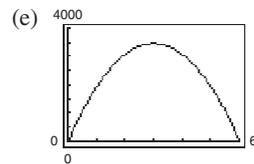
91. (a) $A = -2x^2 + 12x$ (b) $V = -384x^2 + 2304x$

- (c) 0 inches $< x <$ 6 inches

(d)

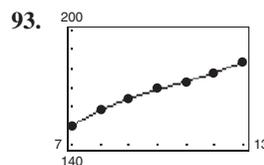
X	V1
0	0
1	1920
2	3840
3	5760
4	7680
5	9600
6	11520
7	13440
8	15360
9	17280
10	19200
11	21120
12	23040
13	24960
14	26880
15	28800
16	30720
17	32640
18	34560

When $x = 3$, the volume is maximum at $V = 3456$;
 dimensions of gutter are 3 inches \times 6 inches \times
 3 inches.



The maximum value is the same.

- (f) No. Answers will vary.

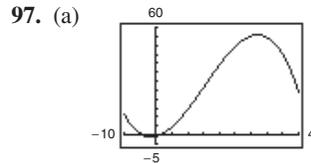


The model is a good fit.

95. Region 1: 259,370

Region 2: 223,470

Answers will vary.



- (b) $t \approx 15$ (c) Vertex: (15.22, 2.54)

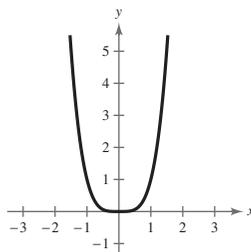
(d) The results are approximately equal.

A108 Answers to Odd-Numbered Exercises and Tests

99. False. A fifth-degree polynomial can have at most four turning points.

101. True. The degree of the function is odd and its leading coefficient is negative, so the graph rises to the left and falls to the right.

103.



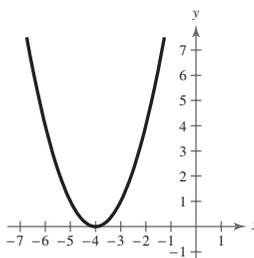
- (a) Vertical shift of two units; Even
 (b) Horizontal shift of two units; Neither even nor odd
 (c) Reflection in the y -axis; Even
 (d) Reflection in the x -axis; Even
 (e) Horizontal stretch; Even
 (f) Vertical shrink; Even
 (g) $g(x) = x^3$; Neither odd nor even
 (h) $g(x) = x^{16}$; Even

105. $(5x - 8)(x + 3)$ 107. $x^2(4x + 5)(x - 3)$

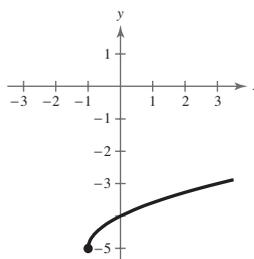
109. $-\frac{7}{2}, 4$ 111. $-\frac{5}{4}, \frac{1}{3}$ 113. $1 \pm \sqrt{22}$

115. $\frac{-5 \pm \sqrt{185}}{4}$

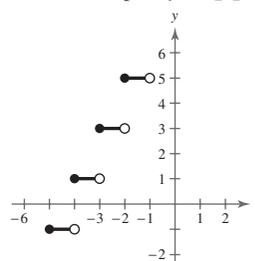
117. Horizontal translation four units to the left of $y = x^2$



119. Horizontal translation one unit left and vertical translation five units down of $y = \sqrt{x}$



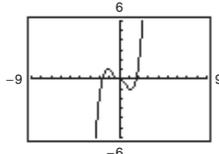
121. Vertical stretch by a factor of 2 and vertical translation nine units up of $y = \llbracket x \rrbracket$


Section 2.3 (page 159)

Vocabulary Check (page 159)

1. dividend; divisor; quotient; remainder
 2. improper; proper 3. synthetic division
 4. factor 5. remainder

1. Answers will vary.

3.  5. $2x + 4$

7. $x^2 - 3x + 1$ 9. $x^3 + 3x^2 - 1$ 11. $7 - \frac{11}{x + 2}$

13. $3x + 5 - \frac{2x - 3}{2x^2 + 1}$ 15. $x^2 + 2x + 4 + \frac{2x - 11}{x^2 - 2x + 3}$

17. $x + 3 + \frac{6x^2 - 8x + 3}{(x - 1)^3}$ 19. $3x^2 - 2x + 5$

21. $4x^2 - 9$ 23. $-x^2 + 10x - 25$

25. $5x^2 + 14x + 56 + \frac{232}{x - 4}$

27. $10x^3 + 10x^2 + 60x + 360 + \frac{1360}{x - 6}$

29. $x^2 - 8x + 64$

31. $-3x^3 - 6x^2 - 12x - 24 - \frac{48}{x - 2}$

33. $-x^3 - 6x^2 - 36x - 36 - \frac{216}{x - 6}$

35. $4x^2 + 14x - 30$

37. $f(x) = (x - 4)(x^2 + 3x - 2) + 3$, $f(4) = 3$

39. $f(x) = (x + \frac{2}{3})(15x^3 - 6x + 4) + \frac{34}{3}$, $f(-\frac{2}{3}) = \frac{34}{3}$

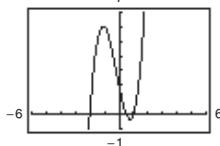
41. $f(x) = (x - \sqrt{2})[x^2 + (3 + \sqrt{2})x + 3\sqrt{2}] - 8$,
 $f(\sqrt{2}) = -8$

43. $f(x) = (x - 1 + \sqrt{3})[-4x^2 + (2 + 4\sqrt{3})x + (2 + 2\sqrt{3})]$,
 $f(1 - \sqrt{3}) = 0$

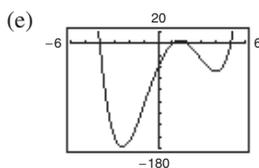
45. (a) 1 (b) 4 (c) 4 (d) 1954

47. (a) 97 (b) $-\frac{5}{3}$ (c) 17 (d) -199

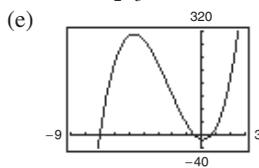
49. $(x - 2)(x + 3)(x - 1)$; Zeros: 2, -3, 1
 51. $(2x - 1)(x - 5)(x - 2)$; Zeros: $\frac{1}{2}$, 5, 2
 53. $(x + \sqrt{3})(x - \sqrt{3})(x + 2)$; Zeros: $-\sqrt{3}$, $\sqrt{3}$, -2
 55. $(x - 1)(x - 1 - \sqrt{3})(x - 1 + \sqrt{3})$;
 Zeros: 1, $1 + \sqrt{3}$, $1 - \sqrt{3}$
 57. (a) Answers will vary. (b) $2x - 1$
 (c) $f(x) = (2x - 1)(x + 2)(x - 1)$ (d) $\frac{1}{2}$, -2, 1
 (e)



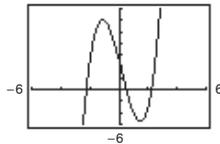
59. (a) Answers will vary. (b) $(x - 1), (x - 2)$
 (c) $f(x) = (x - 1)(x - 2)(x - 5)(x + 4)$
 (d) 1, 2, 5, -4



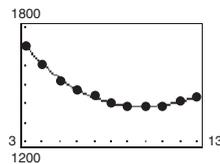
61. (a) Answers will vary. (b) $x + 7$
 (c) $f(x) = (x + 7)(2x + 1)(3x - 2)$
 (d) $-7, -\frac{1}{2}, \frac{2}{3}$



63. (a) Answers will vary. (b) $(x - \sqrt{5})$
 (c) $f(x) = (x - \sqrt{5})(x + \sqrt{5})(2x - 1)$ (d) $\pm\sqrt{5}, \frac{1}{2}$
 (e)



65. (a) Zeros are 2 and $\approx \pm 2.236$.
 (b) $x = 2$ (c) $f(x) = (x - 2)(x - \sqrt{5})(x + \sqrt{5})$
 67. (a) Zeros are -2, ≈ 0.268 , and ≈ 3.732 .
 (b) $x = -2$
 (c) $h(t) = (t + 2)[t - (2 + \sqrt{3})][t - (2 - \sqrt{3})]$
 69. $2x^2 - x - 1$, $x \neq \frac{3}{2}$ 71. $x^2 + 3x$, $x \neq -2, -1$
 73. (a) and (b)



$$M = -0.242x^3 + 12.43x^2 - 173.4x + 2118$$

(c)

t	3	4	5	6	7	8
$M(t)$	1703	1608	1531	1473	1430	1402

t	9	10	11	12	13
$M(t)$	1388	1385	1392	1409	1433

Answers will vary.

(d) 1614 thousand. No, because the model will approach negative infinity quickly.

75. False. $-\frac{4}{7}$ is a zero of f .
 77. True. The degree of the numerator is greater than the degree of the denominator.
 79. $x^{2n} + 6x^n + 9$ 81. The remainder is 0.
 83. $c = -210$ 85. 0; $x + 3$ is a factor of f .
 87. $\pm\frac{5}{3}$ 89. $-\frac{7}{5}, 2$ 91. $\frac{-3 \pm \sqrt{3}}{2}$
 93. $f(x) = x^3 - 7x^2 + 12x$
 95. $f(x) = x^3 + x^2 - 7x - 3$

Section 2.4 (page 167)

Vocabulary Check (page 167)

1. (a) iii (b) i (c) ii 2. $\sqrt{-1}; -1$
 3. complex numbers; $a + bi$ 4. principal square
 5. complex conjugates

1. $a = -10, b = 6$ 3. $a = 6, b = 5$ 5. $4 + 3i$
 7. $2 - 3\sqrt{3}i$ 9. $5\sqrt{3}i$ 11. 8
 13. $-1 - 6i$ 15. $0.3i$ 17. $11 - i$ 19. 4
 21. $3 - 3\sqrt{2}i$ 23. $-14 + 20i$ 25. $\frac{1}{6} + \frac{7}{6}i$
 27. $5 + i$ 29. $12 + 30i$ 31. 24 33. $-9 + 40i$
 35. -10 37. $6 - 3i, 45$ 39. $-1 + \sqrt{5}i, 6$
 41. $-2\sqrt{5}i, 20$ 43. $\sqrt{8}, 8$ 45. $-5i$
 47. $\frac{8}{41} + \frac{10}{41}i$ 49. $\frac{4}{5} + \frac{3}{5}i$ 51. $-5 - 6i$
 53. $-\frac{120}{1681} - \frac{27}{1681}i$ 55. $-\frac{1}{2} - \frac{5}{2}i$ 57. $\frac{62}{949} + \frac{297}{949}i$
 59. $-2\sqrt{3}$ 61. -10
 63. $(21 + 5\sqrt{2}) + (7\sqrt{5} - 3\sqrt{10})i$ 65. $1 \pm i$
 67. $-2 \pm \frac{1}{2}i$ 69. $-\frac{5}{2}, -\frac{3}{2}$ 71. $2 \pm \sqrt{2}i$
 73. $\frac{5}{7} \pm \frac{5\sqrt{15}}{7}$ 75. $-1 + 6i$
 77. $-5i$ 79. $-375\sqrt{3}i$ 81. i
 83. (a) $z_1 = 9 + 16i, z_2 = 20 - 10i$
 (b) $z = \frac{11,240}{877} + \frac{4630}{877}i$
 85. (a) 16 (b) 16 (c) 16 (d) 16
 87. False. If the complex number is real, the number equals its conjugate.

A110 Answers to Odd-Numbered Exercises and Tests

89. False.

$$i^{44} + i^{150} - i^{74} - i^{109} + i^{61} = 1 - 1 + 1 - i + i = 1$$

91. Proof 93. $-x^2 - 3x + 12$ 95. $3x^2 + \frac{23}{2}x - 2$ 97. -31 99. $\frac{27}{2}$ 101. $a = \frac{\sqrt{3V\pi b}}{2\pi b}$ 103. 1 liter

Section 2.5 (page 179)

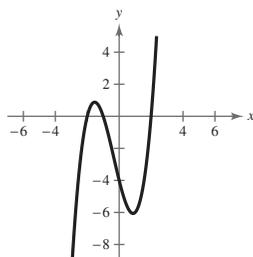
Vocabulary Check (page 179)

- Fundamental Theorem of Algebra
- Linear Factorization Theorem
- Rational Zero
- conjugate
- irreducible over the reals
- Descartes' Rule of Signs
- lower; upper

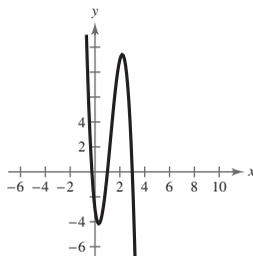
1. 0, 6 3. 2, -4 5. $-6, \pm i$ 7. $\pm 1, \pm 3$
 9. $\pm 1, \pm 3, \pm 5, \pm 9, \pm 15, \pm 45, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}, \pm \frac{9}{2}, \pm \frac{15}{2}, \pm \frac{45}{2}$
 11. 1, 2, 3 13. 1, -1, 4 15. -1, -10 17. $\frac{1}{2}, -1$
 19. $-2, 3, \pm \frac{2}{3}$ 21. -1, 2 23. $-6, \frac{1}{2}, 1$

25. (a) $\pm 1, \pm 2, \pm 4$

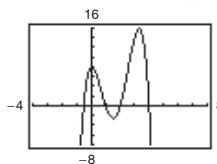
(b)

(c) $-2, -1, 2$ 27. (a) $\pm 1, \pm 3, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{1}{4}, \pm \frac{3}{4}$

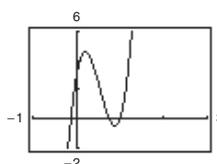
(b)

(c) $-\frac{1}{4}, 1, 3$ 29. (a) $\pm 1, \pm 2, \pm 4, \pm 8, \pm \frac{1}{2}$

(b)

(c) $-\frac{1}{2}, 1, 2, 4$ 31. (a) $\pm 1, \pm 3, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{1}{4}, \pm \frac{3}{4}, \pm \frac{1}{8}, \pm \frac{3}{8}, \pm \frac{1}{16}, \pm \frac{3}{16}, \pm \frac{1}{32}, \pm \frac{3}{32}$

(b)

(c) $1, \frac{3}{4}, -\frac{1}{8}$ 33. (a) $\pm 1, \approx \pm 1.414$

(b) $f(x) = (x+1)(x-1)(x+\sqrt{2})(x-\sqrt{2})$

35. (a) 0, 3, 4, $\approx \pm 1.414$

(b) $h(x) = x(x-3)(x-4)(x+\sqrt{2})(x-\sqrt{2})$

37. $x^3 - x^2 + 25x - 25$ 39. $x^3 + 4x^2 - 31x - 174$ 41. $3x^4 - 17x^3 + 25x^2 + 23x - 22$ 43. (a) $(x^2 + 9)(x^2 - 3)$

(b) $(x^2 + 9)(x + \sqrt{3})(x - \sqrt{3})$

(c) $(x + 3i)(x - 3i)(x + \sqrt{3})(x - \sqrt{3})$

45. (a) $(x^2 - 2x - 2)(x^2 - 2x + 3)$

(b) $(x - 1 + \sqrt{3})(x - 1 - \sqrt{3})(x^2 - 2x + 3)$

(c) $(x - 1 + \sqrt{3})(x - 1 - \sqrt{3})(x - 1 + \sqrt{2}i)(x - 1 - \sqrt{2}i)$

47. $-\frac{3}{2}, \pm 5i$ 49. $\pm 2i, 1, -\frac{1}{2}$ 51. $-3 \pm i, \frac{1}{4}$ 53. $2, -3 \pm \sqrt{2}i, 1$ 55. $\pm 5i; (x+5i)(x-5i)$ 57. $2 \pm \sqrt{3}; (x-2-\sqrt{3})(x-2+\sqrt{3})$ 59. $\pm 3, \pm 3i; (x+3)(x-3)(x+3i)(x-3i)$ 61. $1 \pm i; (z-1+i)(z-1-i)$ 63. $2, 2 \pm i; (x-2)(x-2+i)(x-2-i)$ 65. $-2, 1 \pm \sqrt{2}i; (x+2)(x-1+\sqrt{2}i)(x-1-\sqrt{2}i)$ 67. $-\frac{1}{5}, 1 \pm \sqrt{5}i; (5x+1)(x-1+\sqrt{5}i)(x-1-\sqrt{5}i)$ 69. $2, \pm 2i; (x-2)^2(x+2i)(x-2i)$ 71. $\pm i, \pm 3i; (x+i)(x-i)(x+3i)(x-3i)$ 73. $-10, -7 \pm 5i$ 75. $-\frac{3}{4}, 1 \pm \frac{1}{2}i$ 77. $-2, -\frac{1}{2}, \pm i$ 79. No real zeros

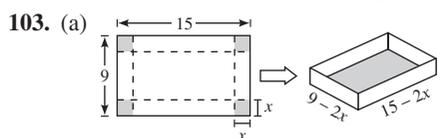
81. No real zeros 83. One positive zero

85. One or three positive zeros

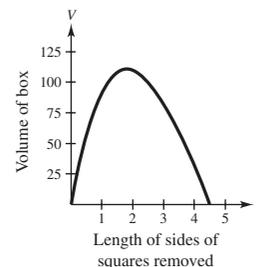
87. Answers will vary. 89. Answers will vary.

91. $1, -\frac{1}{2}$ 93. $-\frac{3}{4}$ 95. $\pm 2, \pm \frac{3}{2}$ 97. $\pm 1, \frac{1}{4}$

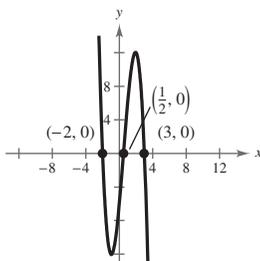
99. d 100. a 101. b 102. c

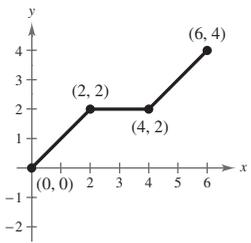
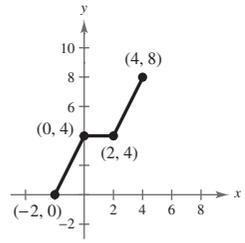
(b) $V = x(9 - 2x)(15 - 2x)$ Domain: $0 < x < \frac{9}{2}$

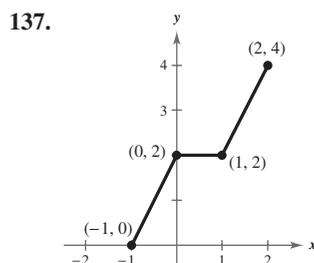
(c)

1.82 centimeters \times 5.36 centimeters \times 11.36 centimeters(d) $\frac{1}{2}, \frac{7}{2}, 8$; 8 is not in the domain of V .105. $x \approx 38.4$, or \$384,000

107. (a) $V = x^3 + 9x^2 + 26x + 24 = 120$
 (b) 4 feet by 5 feet by 6 feet
109. $x \approx 40$, or 4000 units
111. No. Setting $p = 9,000,000$ and solving the resulting equation yields imaginary roots.
113. False. The most complex zeros it can have is two, and the Linear Factorization Theorem guarantees that there are three linear factors, so one zero must be real.
115. r_1, r_2, r_3 117. $5 + r_1, 5 + r_2, 5 + r_3$
119. The zeros cannot be determined.
121. (a) $0 < k < 4$ (b) $k = 4$ (c) $k < 0$ (d) $k > 4$
123. Answers will vary. There are infinitely many possible functions for f . Sample equation and graph:
 $f(x) = -2x^3 + 3x^2 + 11x - 6$



125. Answers will vary.
127. (a) $x^2 + b$ (b) $x^2 - 2ax + a^2 + b^2$
129. $-11 + 9i$ 131. $20 + 40i$
133.  135. 



Section 2.6 (page 193)

Vocabulary Check (page 193)

1. rational functions 2. vertical asymptote
 3. horizontal asymptote 4. slant asymptote

Answers to Odd-Numbered Exercises and Tests

A111

1. (a)

x	$f(x)$	x	$f(x)$	x	$f(x)$
0.5	-2	1.5	2	5	0.25
0.9	-10	1.1	10	10	$0.\overline{1}$
0.99	-100	1.01	100	100	$0.0\overline{1}$
0.999	-1000	1.001	1000	1000	$0.00\overline{1}$

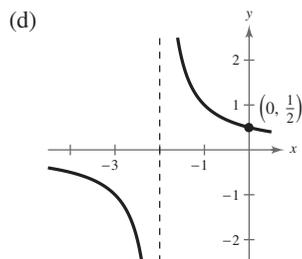
- (b) Vertical asymptote: $x = 1$
 Horizontal asymptote: $y = 0$
- (c) Domain: all real numbers x except $x = 1$

3. (a)

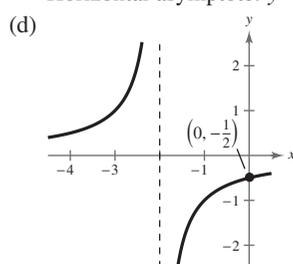
x	$f(x)$	x	$f(x)$	x	$f(x)$
0.5	-1	1.5	5.4	5	3.125
0.9	-12.79	1.1	17.29	10	$3.\overline{03}$
0.99	-147.8	1.01	152.3	100	$3.000\overline{3}$
0.999	-1498	1.001	1502	1000	3

- (b) Vertical asymptotes: $x = \pm 1$
 Horizontal asymptote: $y = 3$
- (c) Domain: all real numbers x except $x = \pm 1$

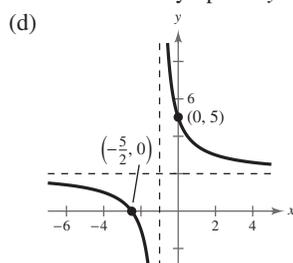
5. Domain: all real numbers x except $x = 0$
 Vertical asymptote: $x = 0$
 Horizontal asymptote: $y = 0$
7. Domain: all real numbers x except $x = 2$
 Vertical asymptote: $x = 2$
 Horizontal asymptote: $y = -1$
9. Domain: all real numbers x except $x = \pm 1$
 Vertical asymptotes: $x = \pm 1$
11. Domain: all real numbers x
 Horizontal asymptote: $y = 3$
13. d 14. a 15. c 16. b
17. 1 19. 6
21. Domain: all real numbers x except $x = \pm 4$;
 Vertical asymptote: $x = -4$; horizontal asymptote: $y = 0$
23. Domain: all real numbers x except $x = -1, 3$;
 Vertical asymptote: $x = 3$; horizontal asymptote: $y = 1$
25. Domain: all real numbers x except $x = -1, \frac{1}{2}$;
 Vertical asymptote: $x = \frac{1}{2}$; horizontal asymptote: $y = \frac{1}{2}$
27. (a) Domain: all real numbers x except $x = -2$
 (b) y-intercept: $(0, \frac{1}{2})$
 (c) Vertical asymptote: $x = -2$
 Horizontal asymptote: $y = 0$

A112 Answers to Odd-Numbered Exercises and Tests


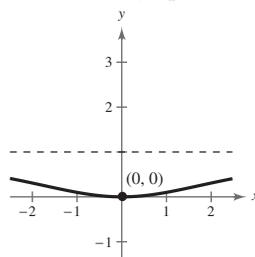
29. (a) Domain: all real numbers x except $x = -2$
 (b) y -intercept: $(0, -\frac{1}{2})$
 (c) Vertical asymptote: $x = -2$
 Horizontal asymptote: $y = 0$



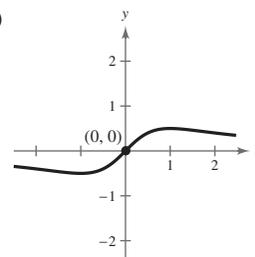
31. (a) Domain: all real numbers x except $x = -1$
 (b) x -intercept: $(-\frac{5}{2}, 0)$
 y -intercept: $(0, 5)$
 (c) Vertical asymptote: $x = -1$
 Horizontal asymptote: $y = 2$



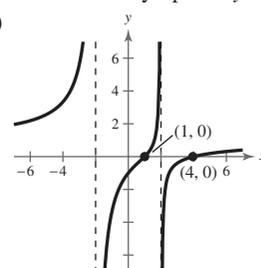
33. (a) Domain: all real numbers x
 (b) Intercept: $(0, 0)$
 (c) Horizontal asymptote: $y = 1$
 (d)



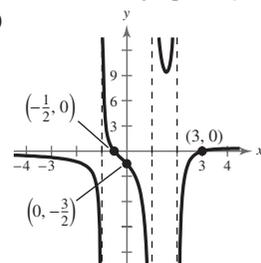
35. (a) Domain: all real numbers s
 (b) Intercept: $(0, 0)$ (c) Horizontal asymptote: $y = 0$
 (d)



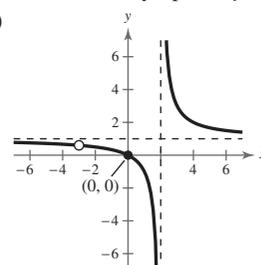
37. (a) Domain: all real numbers x except $x = \pm 2$
 (b) x -intercepts: $(1, 0)$ and $(4, 0)$
 y -intercept: $(0, -1)$
 (c) Vertical asymptotes: $x = \pm 2$
 Horizontal asymptote: $y = 1$
 (d)

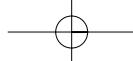


39. (a) Domain: all real numbers x except $x = \pm 1, 2$
 (b) x -intercept: $(3, 0), (-\frac{1}{2}, 0)$
 y -intercept: $(0, -\frac{3}{2})$
 (c) Vertical asymptotes: $x = 2, x = \pm 1$
 Horizontal asymptote: $y = 0$
 (d)

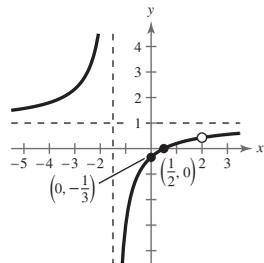


41. (a) Domain: all real numbers x except $x = 2, -3$
 (b) Intercept: $(0, 0)$
 (c) Vertical asymptote: $x = 2$
 Horizontal asymptote: $y = 1$
 (d)

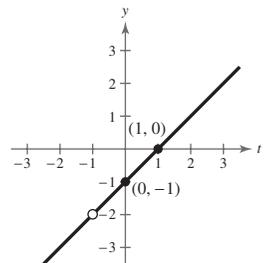




43. (a) Domain: all real numbers x except $x = -\frac{3}{2}, 2$
 (b) x -intercept: $(\frac{1}{2}, 0)$
 y -intercept: $(0, \frac{1}{3})$
 (c) Vertical asymptote: $x = -\frac{3}{2}$
 Horizontal asymptote: $y = 1$
 (d)

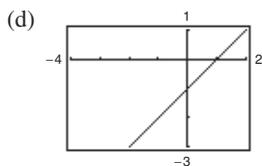


45. (a) Domain: all real numbers t except $t = -1$
 (b) t -intercept: $(1, 0)$
 y -intercept: $(0, -1)$
 (c) Vertical asymptote: None
 Horizontal asymptote: None
 (d)



47. (a) Domain of f : all real numbers x except $x = -1$
 Domain of g : all real numbers x
 (b) $x - 1$; Vertical asymptotes: none
 (c)

x	-3	-2	-1.5	-1	-0.5	0	1
$f(x)$	-4	-3	-2.5	Undef.	-1.5	-1	0
$g(x)$	-4	-3	-2.5	-2	-1.5	-1	0

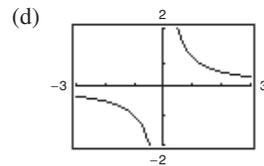


- (e) Because there are only a finite number of pixels, the graphing utility may not attempt to evaluate the function where it does not exist.
 49. (a) Domain of f : all real numbers x except $x = 0, 2$
 Domain of g : all real numbers x except $x = 0$

Answers to Odd-Numbered Exercises and Tests

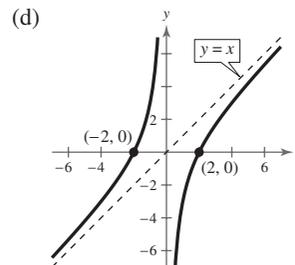
- (b) $\frac{1}{x}$; Vertical asymptote: $x = 0$
 (c)

x	-0.5	0	0.5	1	1.5	2	3
$f(x)$	-2	Undef.	2	1	$\frac{2}{3}$	Undef.	$\frac{1}{3}$
$g(x)$	-2	Undef.	2	1	$\frac{2}{3}$	$\frac{1}{2}$	$\frac{1}{3}$

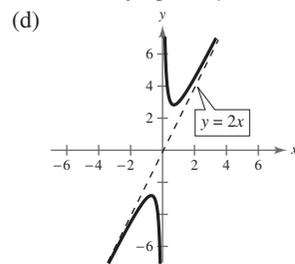


- (e) Because there are only a finite number of pixels, the graphing utility may not attempt to evaluate the function where it does not exist.

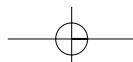
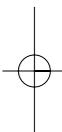
51. (a) Domain: all real numbers x except $x = 0$
 (b) x -intercepts: $(2, 0), (-2, 0)$
 (c) Vertical asymptote: $x = 0$
 Slant asymptote: $y = x$



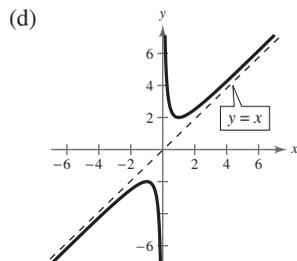
53. (a) Domain: all real numbers x except $x = 0$
 (b) No intercepts
 (c) Vertical asymptote: $x = 0$
 Slant asymptote: $y = 2x$



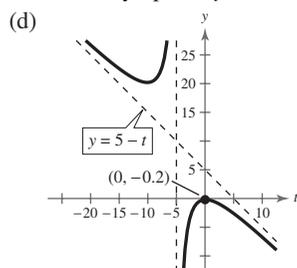
55. (a) Domain: all real numbers x except $x = 0$
 (b) No intercepts
 (c) Vertical asymptote: $x = 0$
 Slant asymptote: $y = x$



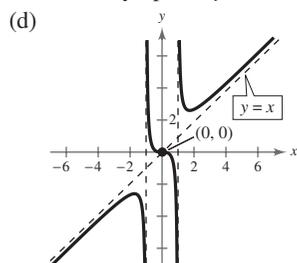
A114 Answers to Odd-Numbered Exercises and Tests



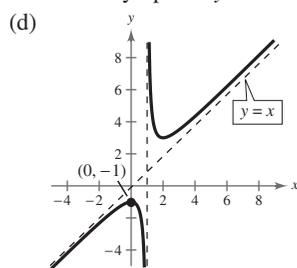
57. (a) Domain: all real numbers t except $t = -5$
 (b) y -intercept: $(0, -0.2)$
 (c) Vertical asymptote: $t = -5$
 Slant asymptote: $y = -t + 5$



59. (a) Domain: all real numbers x except $x = \pm 1$
 (b) Intercept: $(0, 0)$
 (c) Vertical asymptotes: $x = \pm 1$
 Slant asymptote: $y = x$

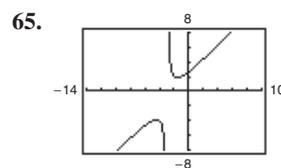
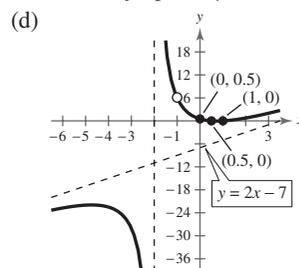


61. (a) Domain: all real numbers x except $x = 1$
 (b) y -intercept: $(0, -1)$
 (c) Vertical asymptote: $x = 1$
 Slant asymptote: $y = x$

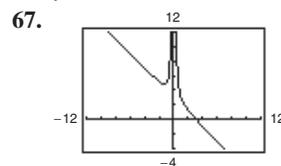


63. (a) Domain: all real numbers x except $x = -1, -2$
 (b) y -intercept: $(0, 0.5)$
 x -intercepts: $(0.5, 0), (1, 0)$

- (c) Vertical asymptote: $x = -2$
 Slant asymptote: $y = 2x - 7$

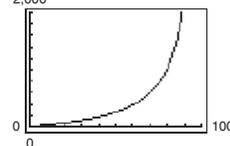


- Domain: all real numbers x except $x = -3$
 Vertical asymptote: $x = -3$
 Slant asymptote: $y = x + 2$
 $y = x + 2$

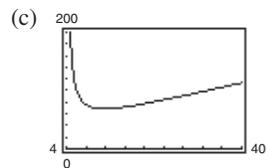


- Domain: all real numbers x except $x = 0$
 Vertical asymptote: $x = 0$
 Slant asymptote: $y = -x + 3$
 $y = -x + 3$

69. (a) $(-1, 0)$ (b) -1
 71. (a) $(1, 0), (-1, 0)$ (b) ± 1
 73. (a) $2,000$

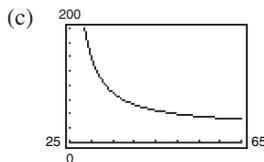


- (b) \$28.33 million; \$170 million; \$765 million
 (c) No. The function is undefined at $p = 100$.
 75. (a) 333 deer, 500 deer, 800 deer (b) 1500 deer
 77. (a) Answers will vary. (b) $(4, \infty)$



11.75 inches \times 5.87 inches

79. (a) Answers will vary.
 (b) Vertical asymptote: $x = 25$
 Horizontal asymptote: $y = 25$



(d)

x	30	35	40	45	50	55	60
y	150	87.5	66.7	56.3	50	45.8	42.9

- (e) Yes. You would expect the average speed for the round trip to be the average of the average speeds for the two parts of the trip.
 (f) No. At 20 miles per hour you would use more time in one direction than is required for the round trip at an average speed of 50 miles per hour.

81. False. Polynomials do not have vertical asymptotes.

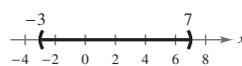
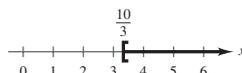
83. Answers will vary. Sample answer: $f(x) = \frac{2x^2}{x^2 + 1}$

85. $(x - 7)(x - 8)$

87. $(x - 5)(x + 2i)(x - 2i)$

89. $x \geq \frac{10}{3}$

91. $-3 < x < 7$



93. Answers will vary.

Section 2.7 (page 204)

Vocabulary Check (page 204)

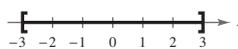
1. critical; test intervals 2. zeros; undefined values
 3. $P = R - C$

1. (a) No (b) Yes (c) Yes (d) No

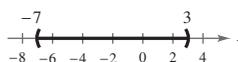
3. (a) Yes (b) No (c) No (d) Yes

5. $2, -\frac{3}{2}$ 7. $\frac{7}{2}, 5$

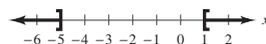
9. $[-3, 3]$



11. $(-7, 3)$



13. $(-\infty, -5] \cup [1, \infty)$



15. $(-3, 2)$

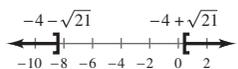


Answers to Odd-Numbered Exercises and Tests

17. $(-3, 1)$



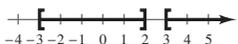
19. $(-\infty, -4 - \sqrt{21}] \cup [-4 + \sqrt{21}, \infty)$



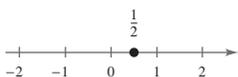
21. $(-1, 1) \cup (3, \infty)$



23. $[-3, 2] \cup [3, \infty)$

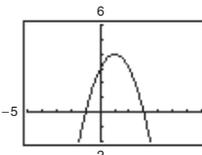


25. $x = \frac{1}{2}$



27. $(-\infty, 0) \cup (0, \frac{3}{2})$

29. $[-2, 0] \cup [2, \infty)$

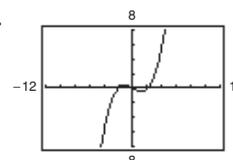


(a) $x \leq -1, x \geq 3$

(b) $0 \leq x \leq 2$

31. $[-2, \infty)$

35.

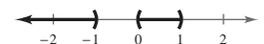


(a) $-2 \leq x \leq 0,$

$2 \leq x < \infty$

(b) $x \leq 4$

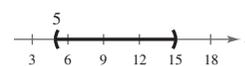
37. $(-\infty, -1) \cup (0, 1)$



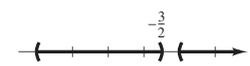
39. $(-\infty, -1) \cup (4, \infty)$



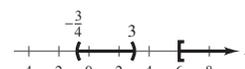
41. $(5, 15)$



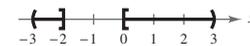
43. $(-5, -\frac{3}{2}) \cup (-1, \infty)$



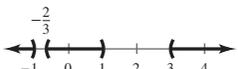
45. $(-\frac{3}{4}, 3) \cup [6, \infty)$



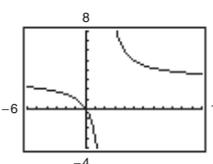
47. $(-3, -2] \cup [0, 3)$



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



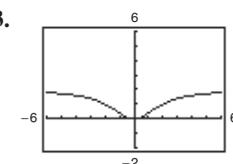
51.



(a) $0 \leq x < 2$

(b) $2 < x \leq 4$

53.

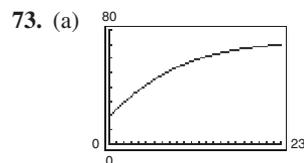


(a) $|x| \geq 2$

(b) $-\infty < x < \infty$

A116 Answers to Odd-Numbered Exercises and Tests

55. $[-2, 2]$ 57. $(-\infty, 3] \cup [4, \infty)$
 59. $(-5, 0] \cup (7, \infty)$ 61. $(-3.51, 3.51)$
 63. $(-0.13, 25.13)$ 65. $(2.26, 2.39)$
 67. (a) $t = 10$ seconds (b) 4 seconds $< t < 6$ seconds
 69. 13.8 meters $\leq L \leq 36.2$ meters
 71. $40,000 \leq x \leq 50,000$; $50.00 \leq p \leq 55.00$



(b)

t	24	26	28	30	32	34
C	70.5	71.6	72.9	74.6	76.8	79.6

2011

(c) $t \approx 31$

(d)

t	36	37	38	39
C	83.2	85.4	87.8	90.5

t	40	41	42	43
C	93.5	96.8	100.4	104.4

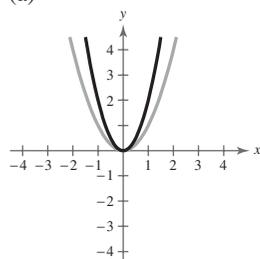
2016 to 2021

(e) $37 \leq t \leq 41$ (f) Answers will vary.

75. $R_1 \geq 2$ ohms
 77. True. The test intervals are $(-\infty, -3)$, $(-3, 1)$, $(1, 4)$, and $(4, \infty)$.
 79. $(-\infty, -4] \cup [4, \infty)$ 81. $(-\infty, -2\sqrt{30}] \cup [2\sqrt{30}, \infty)$
 83. (a) If $a > 0$ and $c \leq 0$, b can be any real number. If $a > 0$ and $c > 0$, $b < -2\sqrt{ac}$ or $b > 2\sqrt{ac}$.
 (b) 0
 85. $(2x + 5)^2$ 87. $(x + 3)(x + 2)(x - 2)$ 89. $2x^2 + x$

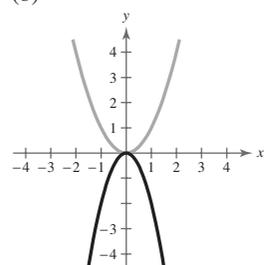
Review Exercises (page 208)

1. (a)



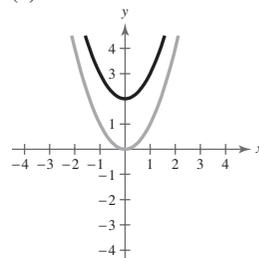
Vertical stretch

(b)



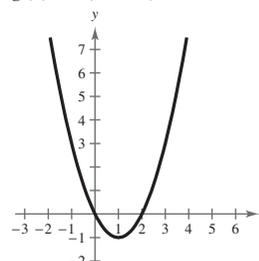
Vertical stretch and reflection in the x -axis

(c)



Vertical shift

3. $g(x) = (x - 1)^2 - 1$

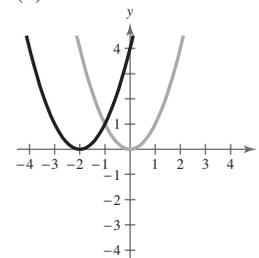


Vertex: $(1, -1)$

Axis of symmetry: $x = 1$

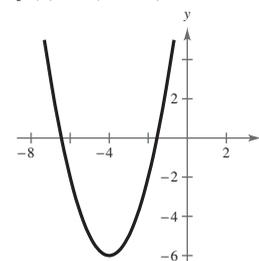
x -intercepts: $(0, 0)$, $(2, 0)$

(d)



Horizontal shift

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

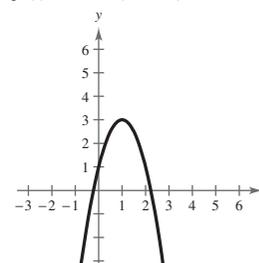


Vertex: $(-4, -6)$

Axis of symmetry: $x = -4$

x -intercepts: $(-4 \pm \sqrt{6}, 0)$

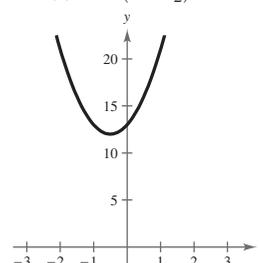
7. $f(t) = -2(t - 1)^2 + 3$ 9. $h(x) = 4(x + \frac{1}{2})^2 + 12$



Vertex: $(1, 3)$

Axis of symmetry: $t = 1$

t -intercepts: $(1 \pm \frac{\sqrt{6}}{2}, 0)$

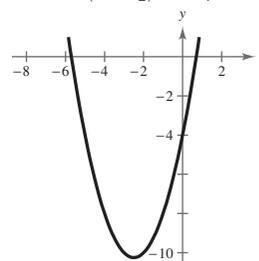


Vertex: $(-\frac{1}{2}, 12)$

Axis of symmetry: $x = -\frac{1}{2}$

No x -intercept

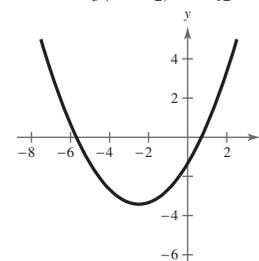
11. $h(x) = (x + \frac{5}{2})^2 - \frac{41}{4}$ 13. $f(x) = \frac{1}{3}(x + \frac{5}{2})^2 - \frac{41}{12}$



Vertex: $(-\frac{5}{2}, -\frac{41}{4})$

Axis of symmetry: $x = -\frac{5}{2}$

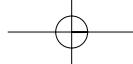
x -intercepts: $(\frac{\pm\sqrt{41} - 5}{2}, 0)$



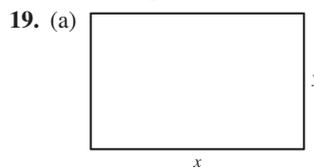
Vertex: $(-\frac{5}{2}, -\frac{41}{12})$

Axis of symmetry: $x = -\frac{5}{2}$

x -intercepts: $(\frac{\pm\sqrt{41} - 5}{2}, 0)$

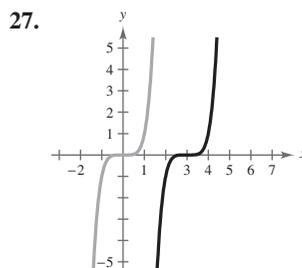
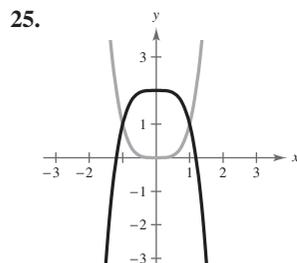
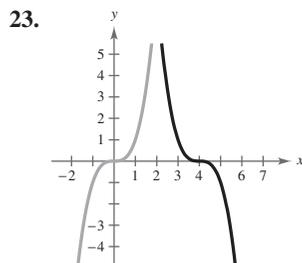


15. $f(x) = -\frac{1}{2}(x - 4)^2 + 1$ 17. $f(x) = (x - 1)^2 - 4$



(b) $y = 100 - x$
 $A = 100x - x^2$
 (c) $x = 50, y = 50$

21. 1091 units



29. Falls to the left, falls to the right

31. Rises to the left, rises to the right

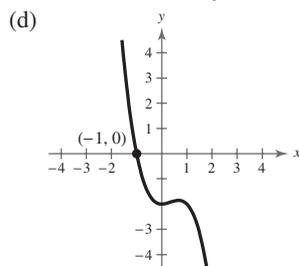
33. $-7, \frac{3}{2}$, odd multiplicity; turning point: 1

35. $0, \pm\sqrt{3}$, odd multiplicity; turning points: 2

37. 0, even multiplicity; $\frac{5}{3}$, odd multiplicity; turning points: 2

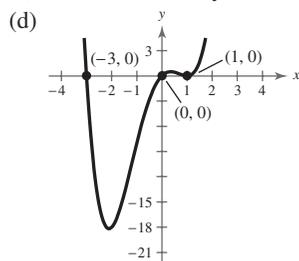
39. (a) Rises to the left, falls to the right (b) -1

(c) Answers will vary.



41. (a) Rises to the right, rises to the left (b) $-3, 0, 1$

(c) Answers will vary.



Answers to Odd-Numbered Exercises and Tests

A117

43. (a) $[-1, 0]$ (b) ≈ -0.900

45. (a) $[-1, 0], [1, 2]$ (b) $\approx -0.200, \approx 1.772$

47. $8x + 5 + \frac{2}{3x - 2}$ 49. $5x + 2$

51. $x^2 - 3x + 2 - \frac{1}{x^2 + 2}$

53. $6x^3 + 8x^2 - 11x - 4 - \frac{8}{x - 2}$

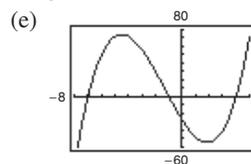
55. $2x^2 - 11x - 6$

57. (a) Yes (b) Yes (c) Yes (d) No

59. (a) -421 (b) -9

61. (a) Answers will vary. (b) $(x + 7), (x + 1)$

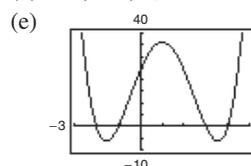
(c) $f(x) = (x + 7)(x + 1)(x - 4)$ (d) $-7, -1, 4$



63. (a) Answers will vary. (b) $(x + 1), (x - 4)$

(c) $f(x) = (x + 1)(x - 4)(x + 2)(x - 3)$

(d) $-2, -1, 3, 4$



65. $6 + 2i$ 67. $-1 + 3i$ 69. $3 + 7i$

71. $40 + 65i$ 73. $-4 - 46i$ 75. $\frac{23}{17} + \frac{10}{17}i$

77. $\frac{21}{13} - \frac{1}{13}i$ 79. $\pm\frac{\sqrt{3}}{3}i$ 81. $1 \pm 3i$

83. 0, 2 85. 8, 1 87. $-4, 6, \pm 2i$

89. $\pm 1, \pm 3, \pm 5, \pm 15, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{5}{2}, \pm \frac{15}{2}, \pm \frac{1}{4}, \pm \frac{3}{4}, \pm \frac{5}{4}, \pm \frac{15}{4}$

91. $-1, -3, 6$ 93. 1, 8 95. $-4, 3$

97. $3x^4 - 14x^3 + 17x^2 - 42x + 24$

99. $4, \pm i$ 101. $-3, \frac{1}{2}, 2 \pm i$

103. 0, 1, -5 ; $f(x) = x(x - 1)(x + 5)$

105. $-4, 2 \pm 3i$; $g(x) = (x + 4)^2(x - 2 - 3i)(x - 2 + 3i)$

107. Two or no positive zeros, one negative zero

109. Answers will vary.

111. Domain: all real numbers x except $x = -12$

113. Domain: all real numbers x except $x = 6, 4$

115. Vertical asymptote: $x = -3$

Horizontal asymptote: $y = 0$

117. Vertical asymptote: $x = -3$

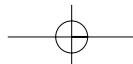
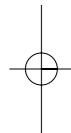
Horizontal asymptote: $y = 0$

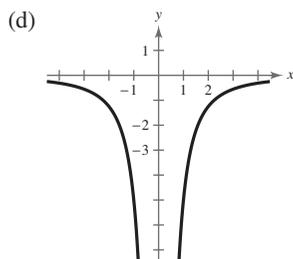
119. (a) Domain: all real numbers x except $x = 0$

(b) No intercepts

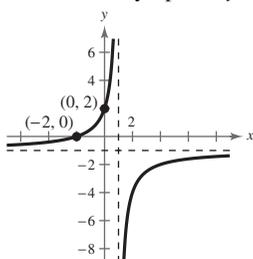
(c) Vertical asymptote: $x = 0$

Horizontal asymptote: $y = 0$

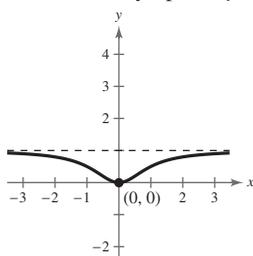


A118 Answers to Odd-Numbered Exercises and Tests


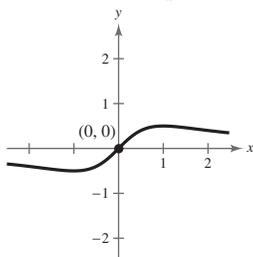
- 121.** (a) Domain: all real numbers x except $x = 1$
 (b) x -intercept: $(-2, 0)$
 y -intercept: $(0, 2)$
 (c) Vertical asymptote: $x = 1$
 Horizontal asymptote: $y = -1$
 (d)



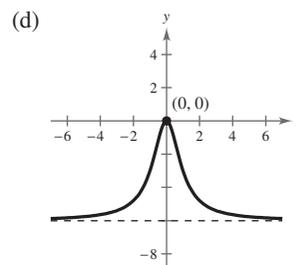
- 123.** (a) Domain: all real numbers x (b) Intercept: $(0, 0)$
 (c) Horizontal asymptote: $y = 1$
 (d)



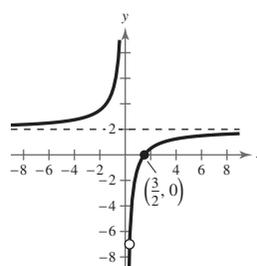
- 125.** (a) Domain: all real numbers x (b) Intercept: $(0, 0)$
 (c) Horizontal asymptote: $y = 0$
 (d)



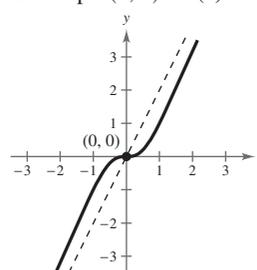
- 127.** (a) Domain: all real numbers x (b) Intercept: $(0, 0)$
 (c) Horizontal asymptote: $y = -6$



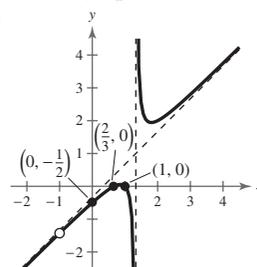
- 129.** (a) Domain: all real numbers x except $x = 0, \frac{1}{3}$
 (b) x -intercept: $(1.5, 0)$
 (c) Vertical asymptote: $x = 0$
 Horizontal asymptote: $y = 2$
 (d)



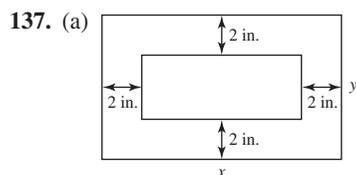
- 131.** (a) Domain: all real numbers x
 (b) Intercept: $(0, 0)$ (c) Slant asymptote: $y = 2x$
 (d)



- 133.** (a) Domain: all real numbers x except $x = \frac{4}{3}$
 (b) y -intercept: $(0, -0.5)$
 x -intercepts: $(\frac{2}{3}, 0), (1, 0)$
 (c) Vertical asymptote: $x = \frac{4}{3}$
 Slant asymptote: $y = x - \frac{1}{3}$
 (d)



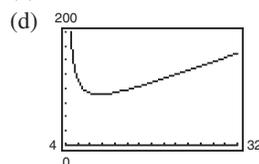
- 135.** \$0.50 is the horizontal asymptote of the function.



(b) $(x - 4)(y - 4) = 30$
 $y = \frac{4x + 14}{x - 4}$

Area = $x \left(\frac{4x + 14}{x - 4} \right)$
 $= \frac{2x(2x + 7)}{x - 4}$

(c) $4 < x < \infty$



9.48 inches \times 9.48 inches

139. $(-\frac{4}{3}, \frac{1}{2})$ 141. $[-4, 0] \cup [4, \infty)$

143. $[-5, -1) \cup (1, \infty)$ 145. $[-4, -3] \cup (0, \infty)$

147. 4.9%

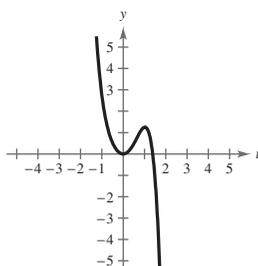
149. False. A fourth-degree polynomial can have at most four zeros, and complex zeros occur in conjugate pairs.

151. Find the vertex of the quadratic function and write the function in standard form. If the leading coefficient is positive, the vertex is a minimum. If the leading coefficient is negative, the vertex is a maximum.

153. An asymptote of a graph is a line to which the graph becomes arbitrarily close as x increases or decreases without bound.

Chapter Test (page 212)

- (a) Reflection in the x -axis followed by a vertical translation
 (b) Horizontal translation
- $y = (x - 3)^2 - 6$
- (a) 50 feet
 (b) 5. Yes, changing the constant term results in a vertical translation of the graph and therefore changes the maximum height.
- Rises to the left, falls to the right



Answers to Odd-Numbered Exercises and Tests

5. $3x + \frac{x - 1}{x^2 + 1}$ 6. $2x^3 + 4x^2 + 3x + 6 + \frac{9}{x - 2}$

7. $(4x - 1)(x - \sqrt{3})(x + \sqrt{3})$;
 Solutions: $\frac{1}{4}, \pm\sqrt{3}$

8. (a) $-3 + 5i$ (b) 7 9. $2 - i$

10. $f(x) = x^4 - 9x^3 + 28x^2 - 30x$

11. $f(x) = x^4 - 6x^3 + 16x^2 - 24x + 16$

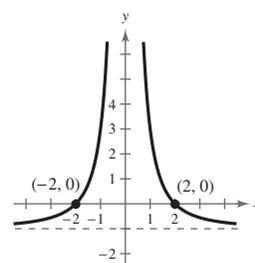
12. $-2, \pm\sqrt{5}i$ 13. $-2, 4, -1 \pm \sqrt{2}i$

14. x -intercepts: $(-2, 0), (2, 0)$

No y -intercept

Vertical asymptote: $x = 0$

Horizontal asymptote: $y = -1$

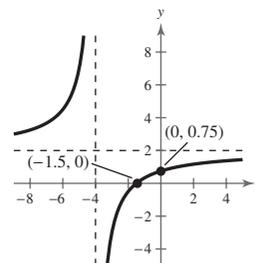


15. x -intercept: $(-1.5, 0)$

y -intercept: $(0, 0.75)$

Vertical asymptote: $x = -4$

Horizontal asymptote: $y = 2$

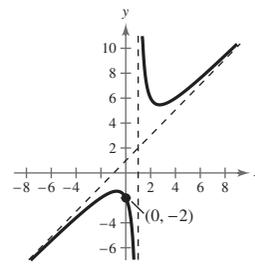


16. No x -intercept

y -intercept: $(0, -2)$

Vertical asymptote: $x = 1$

Slant asymptote: $y = x + 1$



17. $x < -4$ or $x > \frac{3}{2}$



18. $x < -6$ or $0 < x < 4$

