

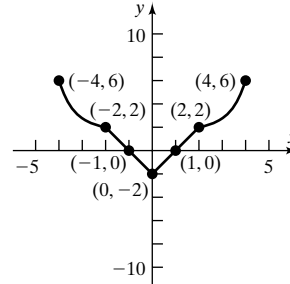
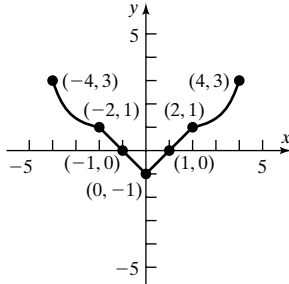
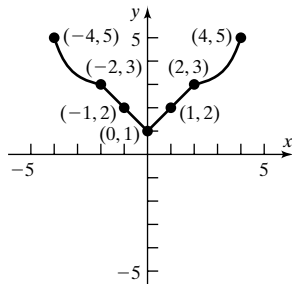
7. Yes, a function 8. (a) -3 (b) $x^2 - 4x - 2$ (c) $x^2 + 4x + 1$ (d) $-x^2 + 4x - 1$ (e) $x^2 - 3$ (f) $2x + h - 4$ 9. $\left\{z \mid z \neq \frac{7}{6}\right\}$
 10. Yes, a function 11. (a) No (b) -1 ; $(-2, -1)$ is on the graph. (c) -8 ; $(-8, 2)$ is on the graph. 12. Neither
 13. Local maximum is 5.30 and occurs at $x = -1.29$. 14. (a) -4 (b) $\{x \mid x > -4\}$ or $(-4, \infty)$

Local minimum is -3.30 and occurs at $x = 1.29$.

Increasing: $(-4, -1.29)$ or $(1.29, 4)$

Decreasing: $(-1.29, 1.29)$

15. (a) Domain: $\{x \mid -4 \leq x \leq 4\}$; Range: $\{y \mid -1 \leq y \leq 3\}$ (b) $(-1, 0)$, $(0, -1)$, $(1, 0)$ (c) y -axis (d) 1 (e) -4 and 4 (f) $\{x \mid -1 < x < 1\}$
 (g) (h) (i)



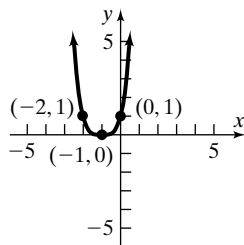
(j) Even (k) $(0, 4)$

CHAPTER 3 Polynomial and Rational Functions

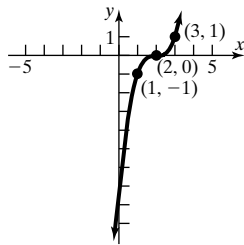
3.1 Assess Your Understanding (page 199)

5. smooth; continuous 6. zero or root 7. touches 8. True 9. False 10. False 11. Yes; degree 3 12. Yes; degree 4 13. Yes; degree 2
 14. Yes; degree 1 15. No; x is raised to the -1 power. 16. Yes; degree 2 17. No; x is raised to the $\frac{3}{2}$ power. 18. No; x is raised to the $\frac{1}{2}$ power.
 19. Yes; degree 4 20. No; it is the ratio of two polynomials, and the polynomial in the denominator is of positive degree. 21. Yes; degree 4
 22. Yes; degree 5

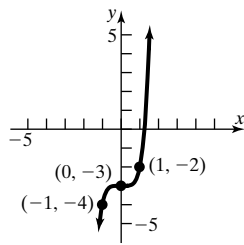
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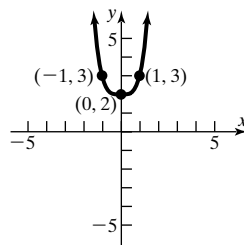
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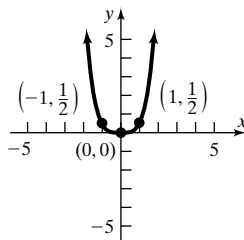
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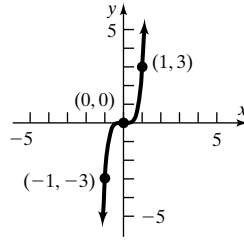
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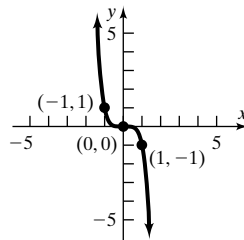
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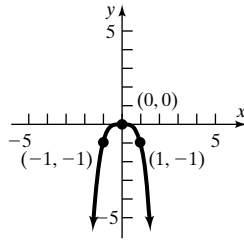
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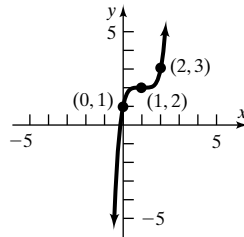
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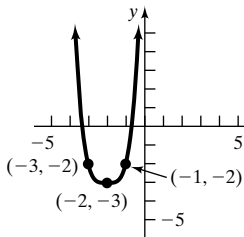
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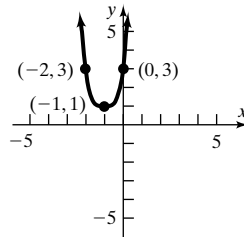
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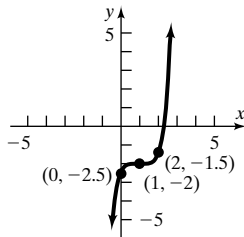
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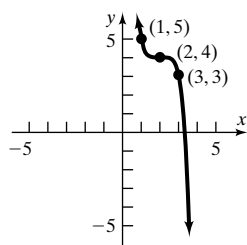
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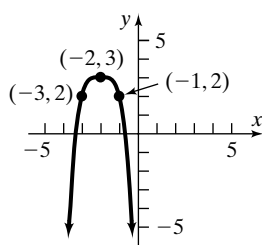
34.



35.



36.



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

38. $f(x) = x^3 - 3x^2 - 4x + 12$ for $a = 1$

39. $f(x) = x^3 - x^2 - 12x$ for $a = 1$

40. $f(x) = x^3 + 2x^2 - 8x$ for $a = 1$

41. $f(x) = x^4 - 15x^2 + 10x + 24$ for $a = 1$

42. $f(x) = x^4 - 3x^3 - 15x^2 + 19x + 30$ for $a = 1$

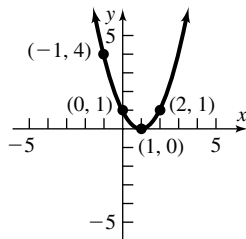
43. $f(x) = x^3 - 5x^2 + 3x + 9$ for $a = 1$

44. $f(x) = x^3 - 12x - 16$ for $a = 1$

45. (a) 7, multiplicity 1; -3, multiplicity 2 (b) Graph touches the x -axis at -3 and crosses it at 7. (c) Near -3: $f(x) \approx -30(x + 3)^2$; Near 7: $f(x) \approx 300(x - 7)$ (d) 2 (e) $y = 3x^3$ 46. (a) -4, multiplicity 1; -3, multiplicity 3 (b) Graph crosses the x -axis at -4 and -3. (c) Near -4: $f(x) \approx -4(x + 4)$; Near -3: $f(x) \approx 4(x + 3)^2$ (d) 3 (e) $y = 4x^4$ 47. (a) 2, multiplicity 3 (b) Graph crosses the x -axis at 2 (c) Near 2: $f(x) \approx 20(x - 2)^3$ (d) 4 (e) $y = 4x^5$ 48. (a) 3, multiplicity 1; -4, multiplicity 3 (b) Graph crosses the x -axis at -4 and 3. (c) Near -4: $f(x) \approx -14(x + 4)^3$; Near 3: $f(x) \approx 686(x - 3)$ (d) 3 (e) $y = 2x^4$ 49. (a) $-\frac{1}{2}$, multiplicity 2 (b) Graph touches the x -axis at $-\frac{1}{2}$. (c) Near $-\frac{1}{2}$: $f(x) \approx -36.125\left(x + \frac{1}{2}\right)^2$ (d) 5 (e) $y = -2x^6$ 50. (a) $\frac{1}{3}$, multiplicity 2; 1, multiplicity 3 (b) Graph touches the x -axis at $\frac{1}{3}$ and crosses it at 1. (c) Near $\frac{1}{3}$: $f(x) \approx -\frac{8}{27}\left(x - \frac{1}{3}\right)^2$; Near 1: $f(x) \approx \frac{4}{9}(x - 1)^3$ (d) 4 (e) $y = x^5$ 51. (a) 5, multiplicity 3; -4, multiplicity 2 (b) Graph touches the x -axis at -4 and crosses it at 5. (c) Near -4: $f(x) \approx -729(x + 4)^2$; Near 5: $f(x) \approx 81(x - 5)^3$ (d) 4 (e) $y = x^5$ 52. (a) $-\sqrt{3}$, multiplicity 2; 2, multiplicity 4 (b) Graph touches the x -axis at $-\sqrt{3}$ and 2. (c) Near $-\sqrt{3}$: $f(x) \approx 194(x + \sqrt{3})^2$; Near 2: $f(x) \approx 13.93(x - 2)^4$ (d) 5 (e) $y = x^6$ 53. (a) No real zeros (b) Graph neither crosses nor touches the x -axis. (c) No real zeros (d) 5 (e) $y = 3x^6$ 54. (a) No real zeros (b) Graph neither crosses nor touches the x -axis. (c) No real zeros (d) 5 (e) $y = -2x^6$ 55. (a) 0, multiplicity 2; $-\sqrt{2}$, $\sqrt{2}$, multiplicity 1 (b) Graph touches the x -axis at 0 and crosses at $-\sqrt{2}$ and $\sqrt{2}$. (c) Near $-\sqrt{2}$: $f(x) \approx 11.31(x + \sqrt{2})$; Near 0: $f(x) \approx 4x^2$; Near $\sqrt{2}$: $f(x) \approx -11.31(x - \sqrt{2})$ (d) 3 (e) $y = -2x^4$ 56. (a) 0, multiplicity 1; $-\sqrt{3}$, $\sqrt{3}$, multiplicity 1 (b) Graph crosses the x -axis at $-\sqrt{3}$, 0, and $\sqrt{3}$. (c) Near $-\sqrt{3}$: $f(x) \approx 24(x + \sqrt{3})$; Near 0: $f(x) \approx -12x$; Near $\sqrt{3}$: $f(x) \approx 24(x - \sqrt{3})$ (d) 2 (e) $y = 4x^3$ 57. Could be; zeros: -1, 1, 2; Least degree is 3 58. Could be; zeros: -1, 2; Least degree is 4 59. Cannot be the graph of a polynomial; gap at $x = -1$ 60. Can't be; cusp at $x = 0$ 61. c, e, f 62. c, e, f 63. c, e 64. d, f

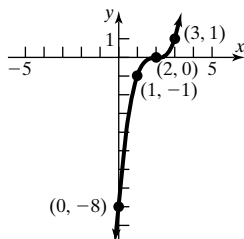
65. (a) x -intercept: 1; y -intercept: 1
(b) Touches at 1
(c) $y = x^2$
(d) 1
(e) Near 1: $f(x) = (x - 1)^2$

(f)



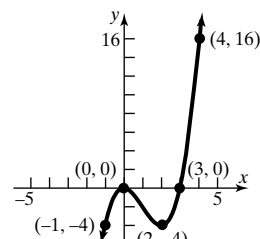
66. (a) x -intercept: 2; y -intercept: -8
(b) Crosses at 2
(c) $y = x^3$
(d) 2
(e) Near 2: $f(x) = (x - 2)^3$

(f)



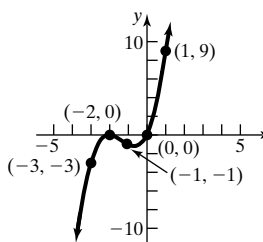
67. (a) x -intercepts: 0, 3; y -intercept: 0
(b) Touches at 0; crosses at 3
(c) $y = x^3$
(d) 2
(e) Near 0: $f(x) \approx -3x^2$; Near 3: $f(x) \approx 9(x - 3)$

(f)



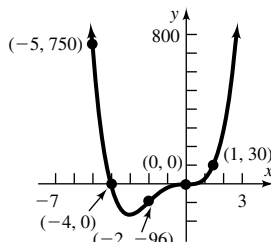
68. (a) x -intercepts: -2, 0; y -intercept: 0
(b) Touches at -2; crosses at 0
(c) $y = x^3$
(d) 2
(e) Near -2: $f(x) \approx -2(x + 2)^2$; Near 0: $f(x) \approx 4x$

(f)



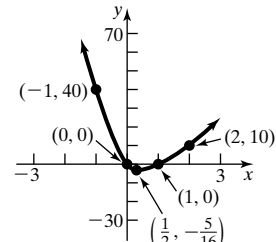
69. (a) x -intercepts: -4, 0; y -intercept: 0
(b) Crosses at -4, 0
(c) $y = 6x^4$
(d) 3
(e) Near -4: $f(x) \approx -384(x + 4)$; Near 0: $f(x) \approx 24x^3$

(f)

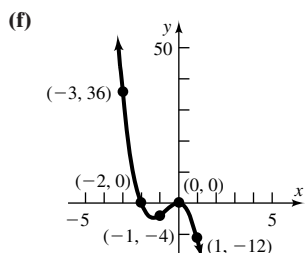


70. (a) x -intercepts: 0, 1; y -intercept: 0
(b) Crosses at 0 and 1
(c) $y = 5x^4$
(d) 3
(e) Near 0: $f(x) \approx -5x$; Near 1: $f(x) \approx 5(x - 1)^3$

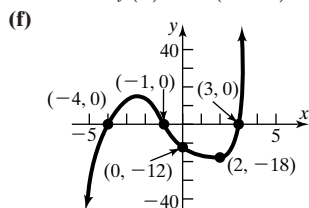
(f)



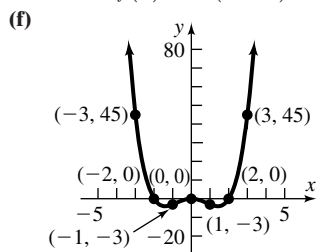
71. (a) x-intercepts: $-2, 0$; y-intercept: 0
 (b) Crosses at -2 ; touches at 0
 (c) $y = -4x^3$
 (d) 2
 (e) Near -2 : $f(x) \approx -16(x + 2)$;
 Near 0 : $f(x) \approx -8x^2$



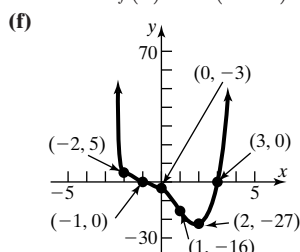
74. (a) x-intercepts: $-4, -1, 3$; y-intercept: -12
 (b) Crosses at $-4, -1$, and 3
 (c) $y = x^3$
 (d) 2
 (e) Near -4 : $f(x) \approx 21(x + 4)$;
 Near -1 : $f(x) \approx -12(x + 1)$;
 Near 3 : $f(x) \approx 28(x - 3)$



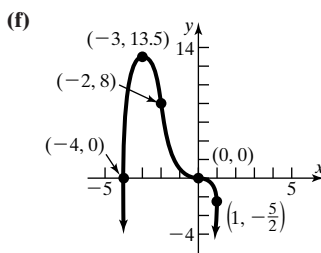
77. (a) x-intercepts: $-2, 0, 2$; y-intercept: 0
 (b) Crosses at $-2, 2$; touches at 0
 (c) $y = x^4$ (d) 3
 (e) Near -2 : $f(x) \approx -16(x + 2)$;
 Near 0 : $f(x) \approx -4x^2$;
 Near 2 : $f(x) \approx 16(x - 2)$



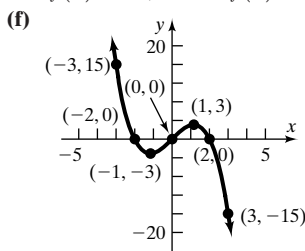
80. (a) x-intercepts: $-1, 3$; y-intercept: -3
 (b) Crosses at -1 and 3
 (c) $y = x^4$ (d) 3
 (e) Near -1 : $f(x) \approx -4(x + 1)^3$;
 Near 3 : $f(x) \approx 64(x - 3)$



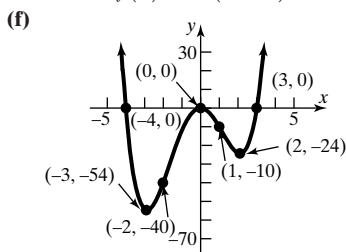
72. (a) x-intercepts: $-4, 0$; y-intercept: 0
 (b) Crosses at -4 and 0
 (c) $y = -\frac{1}{2}x^4$
 (d) 3
 (e) Near -4 : $f(x) \approx 32(x + 4)$;
 Near 0 : $f(x) \approx -2x^3$



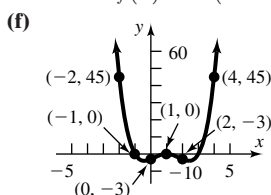
75. $f(x) = 4x - x^3 = -x(x^2 - 4) = -x(x + 2)(x - 2)$
 (a) x-intercepts: $-2, 0, 2$; y-intercept: 0
 (b) Crosses at $-2, 0$, and 2 (c) $y = -x^3$
 (d) 2
 (e) Near -2 : $f(x) \approx -8(x + 2)$; Near 0 :
 $f(x) \approx 4x$; Near 2 : $f(x) \approx -8(x - 2)$



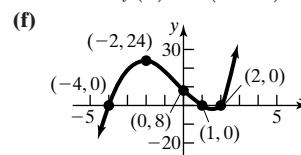
78. (a) x-intercepts: $-4, 0, 3$; y-intercept: 0
 (b) Crosses at -4 and 3 ; touches at 0
 (c) $y = x^4$ (d) 3
 (e) Near -4 : $f(x) \approx -112(x + 4)$;
 Near 0 : $f(x) \approx -12x^2$;
 Near 3 : $f(x) \approx 63(x - 3)$



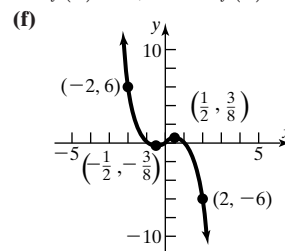
81. (a) x-intercepts: $-1, 1, 3$; y-intercept: -3
 (b) Crosses at $-1, 3$; touches at 1
 (c) $y = x^4$ (d) 3
 (e) Near -1 : $f(x) \approx -16(x + 1)$;
 Near 1 : $f(x) \approx -4(x - 1)^2$;
 Near 3 : $f(x) \approx 16(x - 3)$



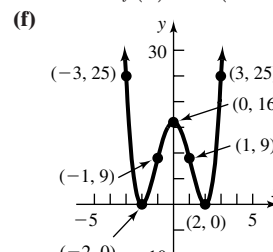
73. (a) x-intercepts: $-4, 1, 2$; y-intercept: 8
 (b) Crosses at $-4, 1, 2$
 (c) $y = x^3$
 (d) 2
 (e) Near -4 : $f(x) \approx 30(x + 4)$;
 Near 1 : $f(x) \approx -5(x - 1)$;
 Near 2 : $f(x) \approx 6(x - 2)$



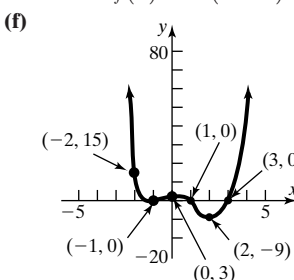
76. $f(x) = x - x^3 = -x(x^2 - 1) = -x(x - 1)(x + 1)$
 (a) x-intercepts: $-1, 0, 1$; y-intercept: 0
 (b) Crosses at $-1, 0$, and 1 (c) $y = -x^3$
 (d) 2
 (e) Near -1 : $f(x) \approx -2(x + 1)$; Near 0 :
 $f(x) \approx x$; Near 1 : $f(x) \approx -2(x - 1)$



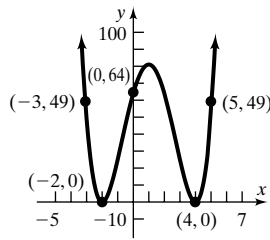
79. (a) x-intercepts: $-2, 2$; y-intercept: 16
 (b) Touches at $-2, 2$
 (c) $y = x^4$ (d) 3
 (e) Near -2 : $f(x) \approx 16(x + 2)^2$;
 Near 2 : $f(x) \approx 16(x - 2)^2$



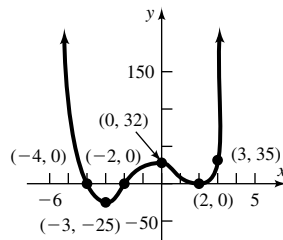
82. (a) x-intercepts: $-1, 1$, and 3 ; y-intercept: 3
 (b) Touches at -1 ; crosses at 1 and 3
 (c) $y = x^4$ (d) 3
 (e) Near -1 : $f(x) \approx 8(x + 1)^2$;
 Near 1 : $f(x) \approx -8(x - 1)$;
 Near 3 : $f(x) \approx 32(x - 3)$



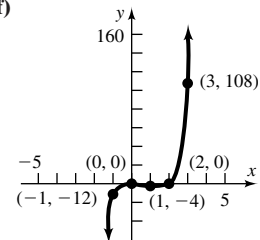
83. (a) x -intercepts: $-2, 4$; y -intercept: 64
 (b) Touches at -2 and 4
 (c) $y = x^4$
 (d) 3
 (e) Near -2 : $f(x) \approx 36(x + 2)^2$;
 Near 4 : $f(x) \approx 36(x - 4)^2$
 (f)



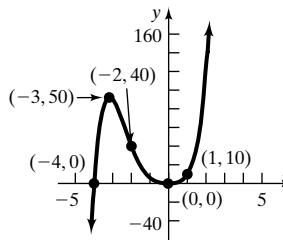
84. (a) x -intercepts: $-4, -2, 2$; y -intercept: 32
 (b) Crosses at $-4, -2$; touches at 2
 (c) $y = x^4$ (d) 3
 (e) Near -4 : $f(x) \approx -72(x + 4)$;
 Near -2 : $f(x) \approx 32(x + 2)$;
 Near 2 : $f(x) \approx 24(x + 2)^2$
 (f)



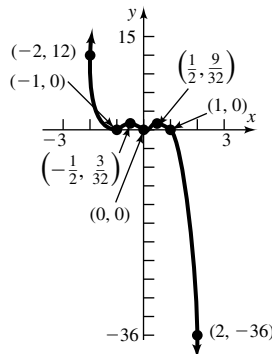
85. (a) x -intercepts: $0, 2$; y -intercept: 0
 (b) Touches at 0 ; crosses at 2
 (c) $y = x^5$
 (d) 4
 (e) Near 0 : $f(x) \approx -6x^2$;
 Near 2 : $f(x) \approx 28(x - 2)$
 (f)



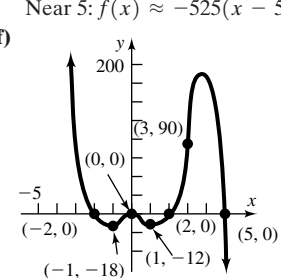
86. (a) x -intercepts: $-4, 0$; y -intercept: 0
 (b) Crosses at -4 ; touches at 0
 (c) $y = x^5$
 (d) 4
 (e) Near -4 : $f(x) \approx 272(x + 4)$;
 Near 0 : $f(x) \approx 4x^2$
 (f)

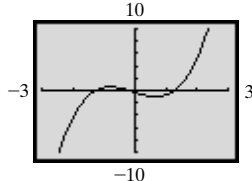


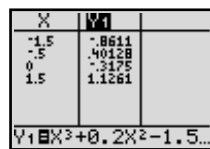
87. (a) x -intercepts: $-1, 0, 1$; y -intercept: 0
 (b) Crosses at 1 ; touches at -1 and 0
 (c) $y = -x^5$ (d) 4
 (e) Near -1 : $f(x) \approx 2(x + 1)^2$;
 Near 0 : $f(x) \approx x^2$;
 Near 1 : $f(x) \approx -4(x - 1)$
 (f)

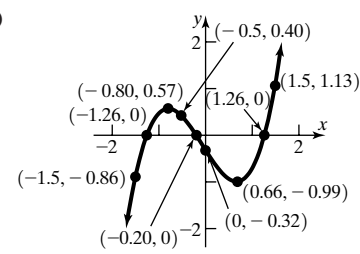


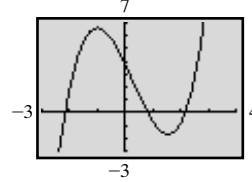
88. (a) x -intercepts: $-2, 0, 2, 5$; y -intercept: 0
 (b) Touches at 0 ; crosses at $-2, 2$, and 5
 (c) $y = -x^5$ (d) 4
 (e) Near -2 : $f(x) \approx -112(x + 2)$;
 Near 0 : $f(x) \approx -20x^2$;
 Near 2 : $f(x) \approx 48(x - 2)$;
 Near 5 : $f(x) \approx -525(x - 5)$
 (f)

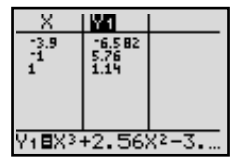


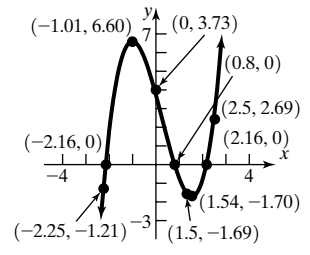
89. (a) Degree 3; $y = x^3$
 (b)
- 
- (c) x -intercepts: $-1.26, -0.20, 1.26$;
 y -intercept: -0.31752

- (d) Above on $(-1.26, -0.20)$ and $(1.26, \infty)$;
 below on $(-\infty, -1.26)$ and $(-0.20, 1.26)$
- 
- (e) Local maximum at $(-0.80, 0.57)$;
 local minimum at $(0.66, -0.99)$

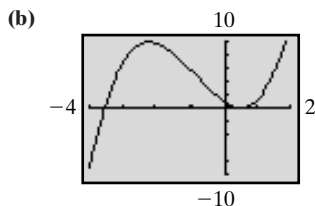
- (f)
- 
- (g) Increasing on $(-\infty, -0.80)$ and $(0.66, \infty)$; decreasing on $(-0.80, 0.66)$

90. (a) Degree 3; $y = x^3$
 (b)
- 
- (c) x -intercepts: $-2.16, 0.8, 2.16$;
 y -intercept: 3.73248

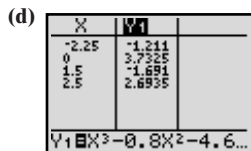
- (d)
- 
- Above on $(-2.16, 0.8)$ and $(2.16, \infty)$;
 below on $(-\infty, -2.16)$ and $(0.8, 2.16)$
- (e) Local maximum at $(-1.01, 6.60)$; local
 minimum at $(1.54, -1.70)$

- (f)
- 
- (g) Increasing on $(-\infty, -1.01)$ and $(1.54, \infty)$; decreasing on $(-1.01, 1.54)$

91. (a) Degree 3; $y = x^3$

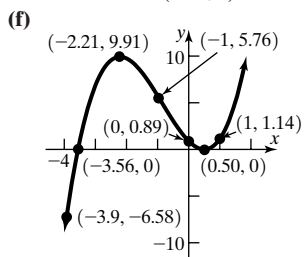


(c) x-intercepts: $-3.56, 0.50$; y-intercept: 0.89



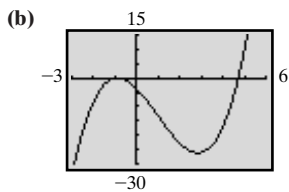
Above on $(-3.56, 0.5)$ and $(0.5, \infty)$;
below on $(-\infty, -3.56)$

(e) Local maximum at $(-2.21, 9.91)$; local minimum at $(0.50, 0)$

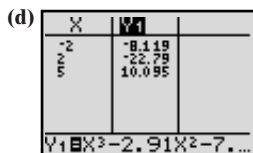


(g) Increasing on $(-\infty, -2.21)$ and $(0.50, \infty)$; decreasing on $(-2.21, 0.50)$

92. (a) Degree 3; $y = x^3$

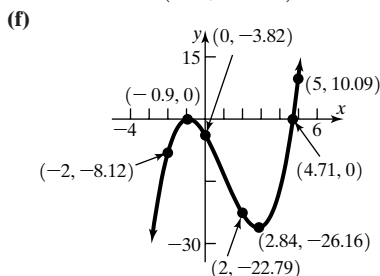


(c) x-intercepts: $-0.9, 4.71$; y-intercept: -3.8151



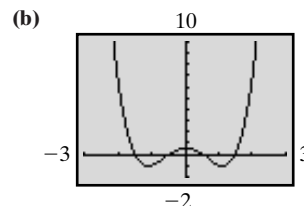
Above on $(4.71, \infty)$; below on $(-\infty, -0.9)$ and $(-0.9, 4.71)$

(e) Local maximum at $(-0.9, 0)$; local minimum at $(2.84, -26.16)$

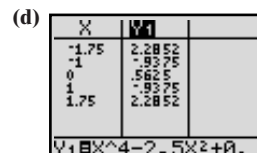


(g) Increasing on $(-\infty, -0.9)$ and $(2.84, \infty)$; decreasing on $(-0.9, 2.84)$

93. (a) Degree 4; $y = x^4$

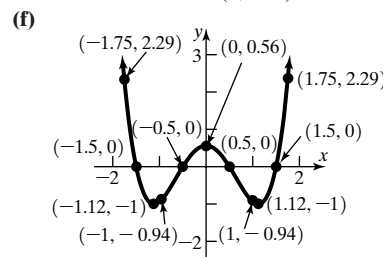


(c) x-intercepts: $-1.5, -0.5, 0.5, 1.5$; y-intercept: 0.5625



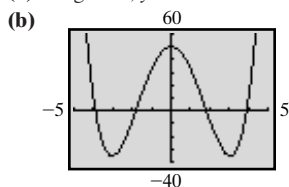
Above on $(-\infty, -1.5)$, $(-0.5, 0.5)$, and $(1.5, \infty)$; below on $(-1.5, -0.5)$ and $(0.5, 1.5)$

(e) Local minima at $(-1.12, -1)$, $(1.12, -1)$; local maximum at $(0, 0.56)$

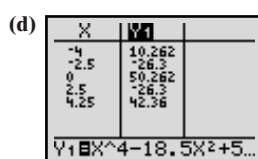


(g) Increasing on $(-1.12, 0)$ and $(1.12, \infty)$; decreasing on $(-\infty, -1.12)$ and $(0, 1.12)$

94. (a) Degree 4; $y = x^4$

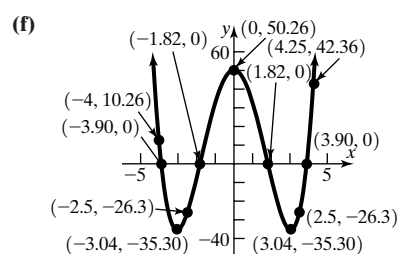


(c) x-intercepts: $-3.90, -1.82, 1.82, 3.90$; y-intercept: 50.2619



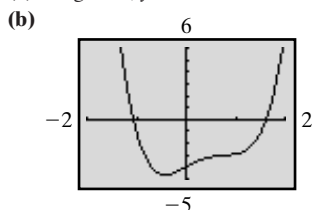
Above on $(-\infty, -3.90)$, $(-1.82, 1.82)$, and $(3.90, \infty)$; below on $(-3.90, -1.82)$ and $(1.82, 3.90)$

(e) Local minima at $(-3.04, -35.30)$, $(3.04, -35.30)$; local maximum at $(0, 50.26)$

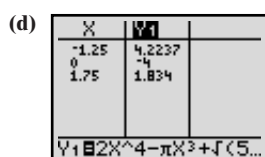


(g) Increasing on $(-3.04, 0)$ and $(3.04, \infty)$; decreasing on $(-\infty, -3.04)$ and $(0, 3.04)$

95. (a) Degree 4; $y = 2x^4$

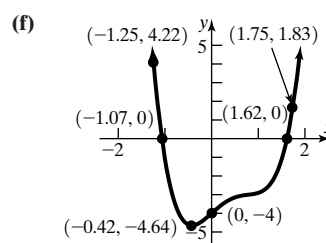


(c) x-intercepts: $-1.07, 1.62$; y-intercept: -4



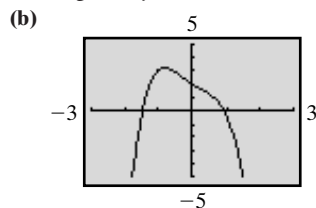
Above on $(-\infty, -1.07)$ and $(1.62, \infty)$; below on $(-1.07, 1.62)$

(e) Local minimum at $(-0.42, -4.64)$



(g) Increasing on $(-0.42, \infty)$; decreasing on $(-\infty, -0.42)$

96. (a) Degree 4;
- $y = -1.2x^4$



- (c) x-intercepts:
- $-1.47, 0.91$
- ; y-intercept: 2

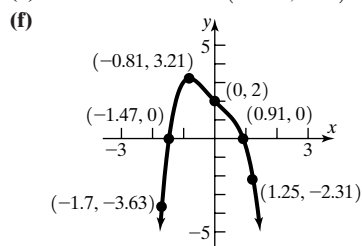
(d)

X	Y1	Y2
-1.7	-3.633	
-0.81	3.2145	
0	2	
0.91	0	
1.25	-2.314	

Y1 = $-1.2X^4 + 0.5X^2$

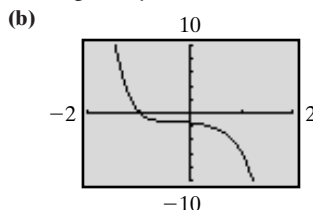
Above on $(-1.47, 0.91)$; below on $(-\infty, -1.47)$ and $(0.91, \infty)$

- (e) Local maximum at
- $(-0.81, 3.21)$



- (g) Increasing on
- $(-\infty, -0.81)$
- ; decreasing on
- $(-0.81, \infty)$

97. (a) Degree 5;
- $y = -2x^5$



- (c) x-intercept:
- -0.98
- ; y-intercept:
- $-\sqrt{2}$

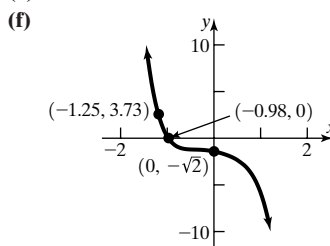
(d)

X	Y1	Y2
-1.25	3.7296	
0	-1.414	
1.25	-3.7296	

Y1 = $-2X^5 - \sqrt{2}$

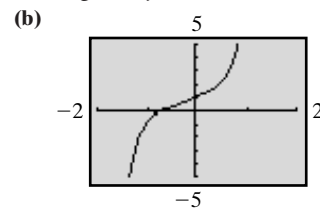
Above on $(-\infty, -0.98)$; below on $(-0.98, \infty)$

- (e) None



- (g) Decreasing on
- $(-\infty, \infty)$

98. (a) Degree 5;
- $y = \pi x^5$



- (c) x-intercept:
- -0.71
- ; y-intercept: 1

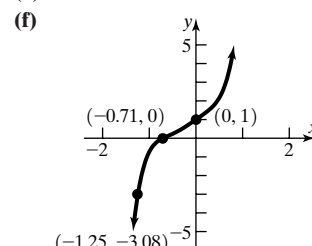
(d)

X	Y1	Y2
-1.25	-3.083	
0	1	
1.25	3.083	

Y1 = $\pi X^5 + 1$

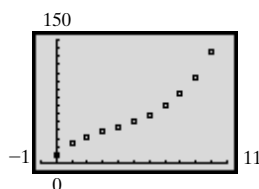
Above on $(-0.71, \infty)$; below on $(-\infty, -0.71)$

- (e) None



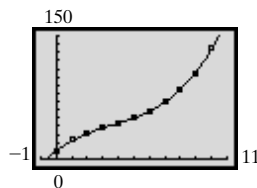
- (g) Increasing on
- $(-\infty, \infty)$

99. (a) Cubic,
- $a > 0$



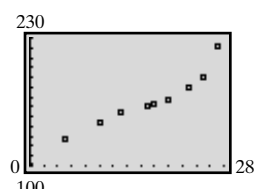
- (b) \$7000 per car (c) \$20,000 per car
-
- (d)
- $C(x) = 0.2156x^3 - 2.3473x^2 + 14.3275x + 10.2238$

- (e)



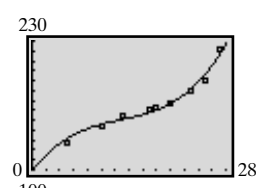
- (f) About \$171,000
-
- (g) Fixed costs of about \$10,200

100. (a) Cubic,
- $a > 0$



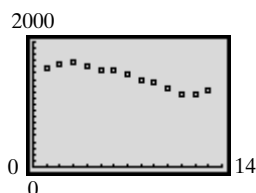
- (b) About \$3.17 per textbook
-
- (c) \$1.85 per textbook
-
- (d)
- $C(x) = 0.01546x^3 - 0.5951x^2 + 9.1502x + 98.4327$

- (e)

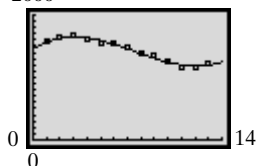


- (f) About \$176,000
-
- (g) Fixed costs of about \$98,400

101. (a) Cubic,
- $a > 0$

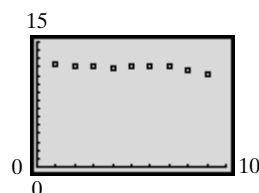


- (b)
- $T(x) = 1.2582x^3 - 28.6146x^2 + 139.5808x + 1453.2098$
-
- (c) 2000

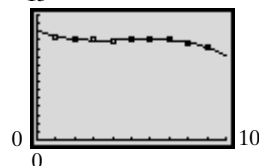


- (d) About 1,738,000 thefts

102. (a) Cubic,
- $a < 0$



- (b)
- $M(x) = -0.0154x^3 + 0.2130x^2 - 0.8978x + 13.1548$
-
- (c) 15

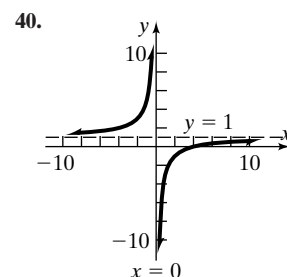
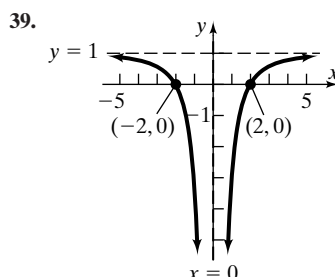
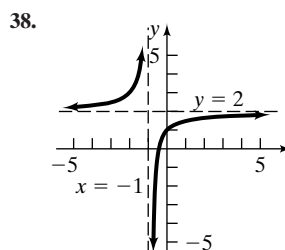
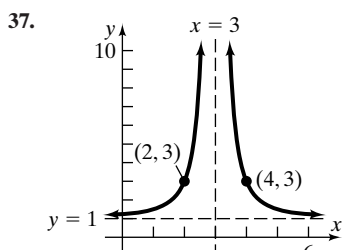
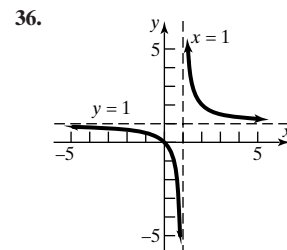
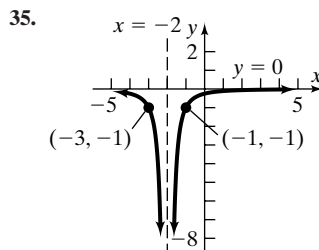
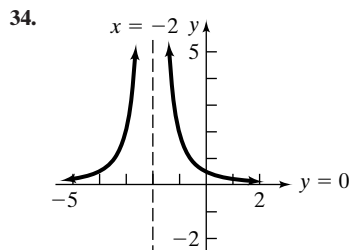
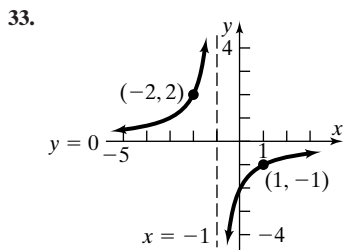
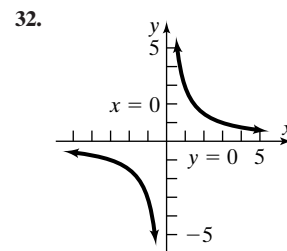
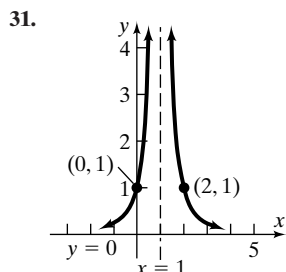
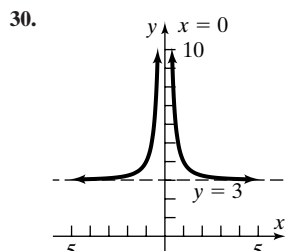
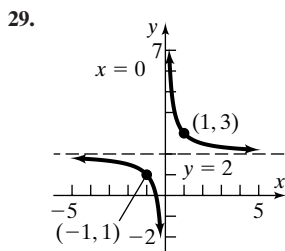


- (d) About 3600 miles

103. No; yes 107.
- $f(x) = \text{int}(x)$
- ;
- $g(x) = |x|$
108. (a)-(d)

3.2 Assess Your Understanding (page 211)

5. $y = 1$ 6. $x = -1$ 7. Proper 8. False 9. True 10. True 11. All real numbers except 3; $\{x|x \neq 3\}$ 12. All real numbers except -3 ; $\{x|x \neq -3\}$ 13. All real numbers except 2 and -4 ; $\{x|x \neq 2, x \neq -4\}$ 14. All real numbers except -3 and 4; $\{x|x \neq -3, x \neq 4\}$ 15. All real numbers except $-\frac{1}{2}$ and 3; $\{x|x \neq -\frac{1}{2}, x \neq 3\}$ 16. All real numbers except $\frac{1}{3}$ and -2 ; $\{x|x \neq \frac{1}{3}, x \neq -2\}$ 17. All real numbers except 2; $\{x|x \neq 2\}$ 18. All real numbers except -1 and 1; $\{x|x \neq -1, x \neq 1\}$ 19. All real numbers 20. All real numbers 21. All real numbers except -3 and 3; $\{x|x \neq -3, x \neq 3\}$ 22. All real numbers except -2 ; $\{x|x \neq -2\}$ 23. (a) Domain: $\{x|x \neq 2\}$; Range: $\{y|y \neq 1\}$ (b) $(0, 0)$ (c) $y = 1$ (d) $x = 2$ (e) None 24. (a) Domain: $\{x|x \neq -1\}$; Range: $\{y|y > 0\}$ (b) $(0, 2)$ (c) $y = 0$ (d) $x = -1$ (e) None 25. (a) Domain: $\{x|x \neq 0\}$; Range: all real numbers (b) $(-1, 0), (1, 0)$ (c) None (d) $x = 0$ (e) $y = 2x$ 26. (a) Domain: $\{x|x \neq 0\}$; Range: $\{y|y \leq -2, y \geq 2\}$ (b) None (c) None (d) $x = 0$ (e) $y = -x$ 27. (a) Domain: $\{x|x \neq -2, x \neq 2\}$; Range: $\{y|y \leq 0, y > 1\}$ (b) $(0, 0)$ (c) $y = 1$ (d) $x = -2, x = 2$ (e) None 28. (a) Domain: $\{x|x \neq -1, x \neq 1\}$; Range: all real numbers (b) $(0, 0)$ (c) $y = 0$ (d) $x = -1, x = 1$ (e) None

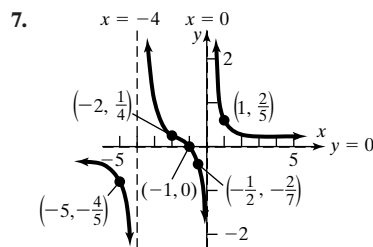


41. Vertical asymptote: $x = -4$ horizontal asymptote: $y = 3$; 42. Vertical asymptote: $x = 6$ horizontal asymptote: $y = 3$; 43. Vertical asymptote: $x = 3$; oblique asymptote: $y = x + 5$ 44. Vertical asymptotes: $x = 2, x = 3$; horizontal asymptote: $y = -1$ 45. Vertical asymptotes: $x = 1, x = -1$ horizontal asymptote: $y = 0$; 46. Vertical asymptote: $x = 1$ 47. Vertical asymptote: $x = 0$ horizontal asymptote: $y = 0$; 48. Vertical asymptotes: $x = 0, x = -2$ horizontal asymptote: $y = 0$; 49. Vertical asymptote: $x = 0$ oblique asymptote: $y = 3x$; 50. Vertical asymptotes: $x = -\frac{1}{3}, x = 2$ horizontal asymptote: $y = 2$; 51. Vertical asymptote: $x = 0$ oblique asymptote: $y = -(x + 1)$; 52. Vertical asymptotes $x = -1, x = 0$ horizontal asymptote: $y = 0$; 53. (a) 9.8208 m/sec^2 (b) 9.8195 m/sec^2 (c) 9.7936 m/sec^2 (d) h -axis 54. (a) 25 (b) Approximately 596 (c) $y = 2500$

3.3 Assess Your Understanding (page 227)

2. in lowest terms 3. False 4. False 5. False 6. True 7. 1. Domain: $\{x|x \neq 0, x \neq -4\}$; no y -intercept 2. R is in lowest terms; x -intercept: -1 3. R is in lowest terms; vertical asymptotes: $x = 0, x = -4$ 4. Horizontal asymptote: $y = 0$, intersected at $(-1, 0)$ 5.

Interval	$(-\infty, -4)$	$(-4, -1)$	$(-1, 0)$	$(0, \infty)$
Number Chosen	-5	-2	$-\frac{1}{2}$	1
Value of R	$R(-5) = -\frac{4}{5}$	$R(-2) = \frac{1}{4}$	$R(-\frac{1}{2}) = -\frac{2}{7}$	$R(1) = \frac{2}{5}$
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-5, -\frac{4}{5})$	$(-2, \frac{1}{4})$	$(-\frac{1}{2}, -\frac{2}{7})$	$(1, \frac{2}{5})$

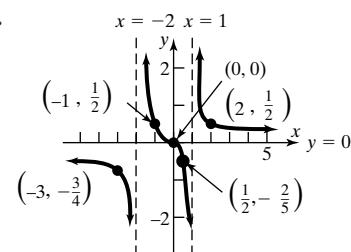


8. 1. Domain $\{x|x \neq -2, x \neq 1\}$; y-intercept: 0 2. R is in lowest terms; x-intercept: 0 3. R is in lowest terms; vertical asymptotes: $x = 1, x = -2$
 4. Horizontal asymptotes: $y = 0$, intersected at $(0, 0)$

5.

	$-\infty$	-2	0	1	∞
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, 1)$	$(1, \infty)$	
Number Chosen	-3	-1	$\frac{1}{2}$	2	
Value of R	$R(-3) = -\frac{3}{4}$	$R(-1) = \frac{1}{2}$	$R(\frac{1}{2}) = -\frac{2}{5}$	$R(2) = \frac{1}{2}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, -\frac{3}{4})$	$(-1, \frac{1}{2})$	$(\frac{1}{2}, -\frac{2}{5})$	$(2, \frac{1}{2})$	

7.

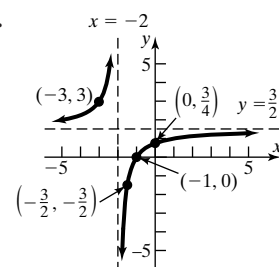


9. 1. $R(x) = \frac{3(x+1)}{2(x+2)}$; domain: $\{x|x \neq -2\}$; y-intercept: $\frac{3}{4}$ 2. R is in lowest terms; x-intercept: -1 3. R is in lowest terms; vertical asymptote: $x = -2$ 4. Horizontal asymptote: $y = \frac{3}{2}$, not intersected

5.

	$-\infty$	-2	-1	∞
Interval	$(-\infty, -2)$	$(-2, -1)$	$(-1, \infty)$	
Number Chosen	-3	$-\frac{3}{2}$	4	
Value of R	$R(-3) = 3$	$R(-\frac{3}{2}) = -\frac{3}{2}$	$R(4) = \frac{3}{4}$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, 3)$	$(-\frac{3}{2}, -\frac{3}{2})$	$(4, \frac{3}{4})$	

7.

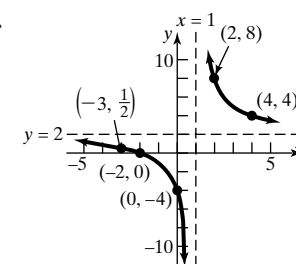


10. 1. $R(x) = \frac{2(x+2)}{x-1}$; domain: $\{x|x \neq 1\}$; y-intercept: -4 2. R is in lowest terms; x-intercept: -2 3. R is in lowest terms; vertical asymptotes: $x = 1$ 4. Horizontal asymptotes: $y = 2$, not intersected

5.

	$-\infty$	-2	1	∞
Interval	$(-\infty, -2)$	$(-2, 1)$	$(1, \infty)$	
Number Chosen	-3	0	2	
Value of R	$R(-3) = \frac{1}{2}$	$R(0) = -4$	$R(2) = 8$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, \frac{1}{2})$	$(0, -4)$	$(2, 8)$	

7.

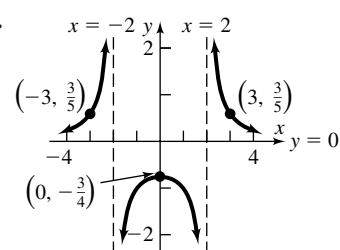


11. 1. $R(x) = \frac{3}{(x+2)(x-2)}$; domain: $\{x|x \neq -2, x \neq 2\}$; y-intercept: $-\frac{3}{4}$ 2. R is in lowest terms; no x -intercept 3. R is in lowest terms; vertical asymptotes: $x = 2, x = -2$ 4. Horizontal asymptote: $y = 0$, not intersected

5.

	$-\infty$	-2	2	∞
Interval	$(-\infty, -2)$	$(-2, 2)$	$(2, \infty)$	
Number Chosen	-3	0	3	
Value of R	$R(-3) = \frac{3}{5}$	$R(0) = -\frac{3}{4}$	$R(3) = \frac{3}{5}$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, \frac{3}{5})$	$(0, -\frac{3}{4})$	$(3, \frac{3}{5})$	

7.

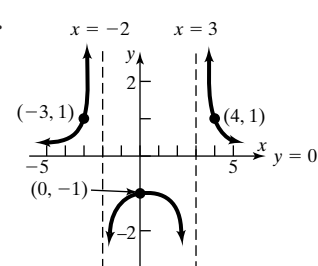


12. 1. $R(x) = \frac{6}{(x+2)(x-3)}$; domain: $\{x|x \neq -2, x \neq 3\}$; y-intercept: -1 2. R is in lowest terms; no x -intercept 3. R is in lowest terms; vertical asymptotes: $x = -2, x = 3$ 4. Horizontal asymptote: $y = 0$, not intersected

5.

	$-\infty$	-2	3	∞
Interval	$(-\infty, -2)$	$(-2, 3)$	$(3, \infty)$	
Number Chosen	-3	0	4	
Value of R	$R(-3) = 1$	$R(0) = -1$	$R(4) = 1$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, 1)$	$(0, -1)$	$(4, 1)$	

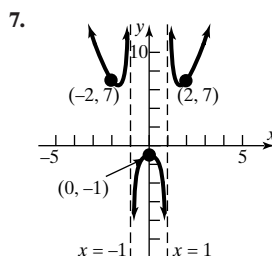
7.



13. 1. $P(x) = \frac{x^4 + x^2 + 1}{(x+1)(x-1)}$; domain: $\{x|x \neq -1, x \neq 1\}$; y-intercept: -1 2. P is in lowest terms; no x -intercept 3. P is in lowest terms; vertical asymptotes: $x = -1, x = 1$ 4. No horizontal or oblique asymptotes

5.

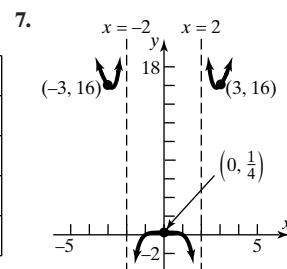
	$-\infty$	-1	1	∞
Interval	$(-\infty, -1)$	$(-1, 1)$	$(1, \infty)$	
Number Chosen	-2	0	2	
Value of P	$P(-2) = 7$	$P(0) = -1$	$P(2) = 7$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-2, 7)$	$(0, -1)$	$(2, 7)$	



14. 1. $Q(x) = \frac{(x^2 + 1)(x + 1)(x - 1)}{(x + 2)(x - 2)}$; domain: $\{x|x \neq -2, x \neq 2\}$; y-intercept: $\frac{1}{4}$ 2. Q is in lowest terms; x -intercepts: $-1, 1$ 3. Q is in lowest terms; Vertical asymptotes: $x = -2, x = 2$ 4. No horizontal or oblique asymptotes

5.

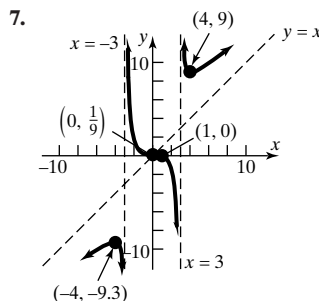
	$-\infty$	-2	-1	1	2	∞
Interval	$(-\infty, -2)$	$(-2, -1)$	$(-1, 1)$	$(1, 2)$	$(2, \infty)$	
Number Chosen	-3	$-\frac{3}{2}$	0	$\frac{3}{2}$	3	
Value of Q	$Q(-3) = 16$	$Q(-\frac{3}{2}) \approx -2.3$	$Q(0) = \frac{1}{4}$	$Q(\frac{3}{2}) \approx -2.3$	$Q(3) = 16$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, 16)$	$(-\frac{3}{2}, -2.3)$	$(0, \frac{1}{4})$	$(\frac{3}{2}, -2.3)$	$(3, 16)$	



15. 1. $H(x) = \frac{(x - 1)(x^2 + x + 1)}{(x + 3)(x - 3)}$; domain: $\{x|x \neq -3, x \neq 3\}$; y-intercept: $\frac{1}{9}$ 2. H is in lowest terms; x -intercept: 1 3. H is in lowest terms; vertical asymptotes: $x = 3, x = -3$ 4. Oblique asymptote: $y = x$, intersected at $(\frac{1}{9}, \frac{1}{9})$

5.

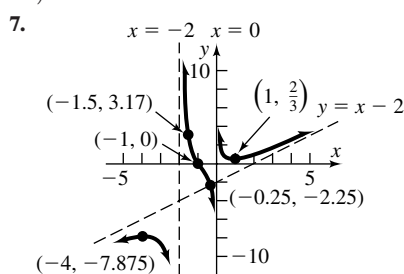
	$-\infty$	-3	1	3	∞
Interval	$(-\infty, -3)$	$(-3, 1)$	$(1, 3)$	$(3, \infty)$	
Number Chosen	-4	0	2	4	
Value of H	$H(-4) \approx -9.3$	$H(0) = \frac{1}{9}$	$H(2) = -1.4$	$H(4) = 9$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-4, -9.3)$	$(0, \frac{1}{9})$	$(2, -1.4)$	$(4, 9)$	



16. 1. $G(x) = \frac{(x + 1)(x^2 - x + 1)}{x(x + 2)}$; domain: $\{x|x \neq -2, x \neq 0\}$; no y -intercept 2. G is in lowest terms; x -intercept: -1 3. G is in lowest terms; vertical asymptotes: $x = 0, x = -2$ 4. Oblique asymptote: $y = x - 2$, intersected at $(-0.25, -2.25)$

5.

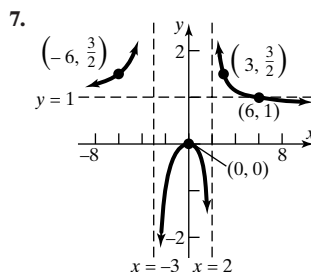
	$-\infty$	-2	-1	0	∞
Interval	$(-\infty, -2)$	$(-2, -1)$	$(-1, 0)$	$(0, \infty)$	
Number Chosen	-4	-1.5	-0.25	1	
Value of G	$G(-4) = -7.875$	$G(-1.5) \approx 3.2$	$G(-0.25) = -2.25$	$G(1) = \frac{2}{3}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-4, -7.875)$	$(-1.5, 3.17)$	$(-0.25, -2.25)$	$(1, \frac{2}{3})$	



17. 1. $R(x) = \frac{x^2}{(x + 3)(x - 2)}$; domain: $\{x \neq -3, x \neq 2\}$; y-intercept: 0 2. R is in lowest terms; x -intercept: 0 3. R is in lowest terms; vertical asymptotes: $x = 2, x = -3$ 4. Horizontal asymptote: $y = 1$, intersected at $(6, 1)$

5.

	$-\infty$	-3	0	2	∞
Interval	$(-\infty, -3)$	$(-3, 0)$	$(0, 2)$	$(2, \infty)$	
Number Chosen	-6	-1	1	3	
Value of R	$R(-6) = 1.5$	$R(-1) = -\frac{1}{6}$	$R(1) = -0.25$	$R(3) = 1.5$	
Location of Graph	Above x -axis	Below x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-6, 1.5)$	$(-1, -\frac{1}{6})$	$(1, -0.25)$	$(3, 1.5)$	

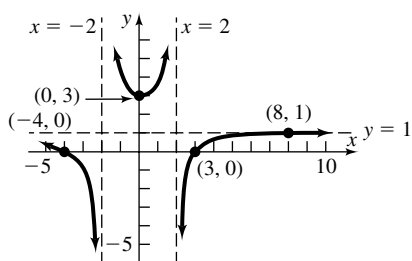


18. 1. $R(x) = \frac{(x+4)(x-3)}{(x+2)(x-2)}$; domain $\{x|x \neq -2, x \neq 2\}$; y-intercept: 3 2. R is in lowest terms; x-intercepts: 3, -4 3. R is in lowest terms; vertical asymptotes: $x = -2, x = 2$ 4. Horizontal asymptote: $y = 1$, intersected at (8, 1)

5.

	$\xleftarrow{\quad} \bullet_{-4} \quad \bullet_{-2} \quad \bullet_2 \quad \bullet_3 \xrightarrow{\quad}$				
Interval	$(-\infty, -4)$	$(-4, -2)$	$(-2, 2)$	$(2, 3)$	$(3, \infty)$
Number Chosen	-7	-3	0	2.5	8
Value of R	$R(-7) = \frac{2}{3}$	$R(-3) = -1.2$	$R(0) = 3$	$R(2.5) = -1.44$	$R(8) = 1$
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-7, \frac{2}{3})$	$(-3, -1.2)$	$(0, 3)$	$(2.5, -1.44)$	$(8, 1)$

7.

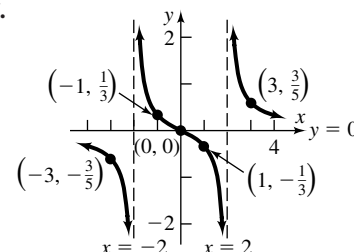


19. 1. $G(x) = \frac{x}{(x+2)(x-2)}$; domain $\{x|x \neq -2, x \neq 2\}$; y-intercept: 0 2. G is in lowest terms; x-intercept: 0 3. G is in lowest terms; vertical asymptotes: $x = -2, x = 2$ 4. Horizontal asymptote: $y = 0$, intersected at (0, 0)

5.

	$\xleftarrow{\quad} \bullet_{-2} \quad \bullet_0 \quad \bullet_2 \xrightarrow{\quad}$			
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, 2)$	$(2, \infty)$
Number Chosen	-3	-1	1	3
Value of G	$G(-3) = -\frac{3}{5}$	$G(-1) = \frac{1}{3}$	$G(1) = -\frac{1}{3}$	$G(3) = \frac{3}{5}$
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-3, -\frac{3}{5})$	$(-1, \frac{1}{3})$	$(1, -\frac{1}{3})$	$(3, \frac{3}{5})$

7.

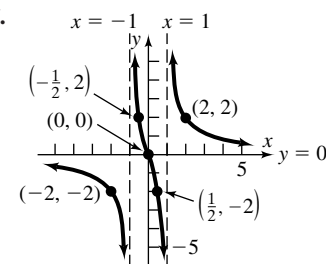


20. 1. $G(x) = \frac{3x}{(x+1)(x-1)}$; domain $\{x|x \neq -1, x \neq 1\}$; y-intercept: 0 2. G is in lowest terms; x-intercept: 0 3. G is in lowest terms; vertical asymptotes: $x = -1, x = 1$ 4. Horizontal asymptote: $y = 0$, intersected at (0, 0)

5.

	$\xleftarrow{\quad} \bullet_{-1} \quad \bullet_0 \quad \bullet_1 \xrightarrow{\quad}$			
Interval	$(-\infty, -1)$	$(-1, 0)$	$(0, 1)$	$(1, \infty)$
Number Chosen	-2	$-\frac{1}{2}$	$\frac{1}{2}$	2
Value of G	$G(-2) = -2$	$G(-\frac{1}{2}) = 2$	$G(\frac{1}{2}) = -2$	$G(2) = 2$
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-2, -2)$	$(-\frac{1}{2}, 2)$	$(\frac{1}{2}, -2)$	$(2, 2)$

7.

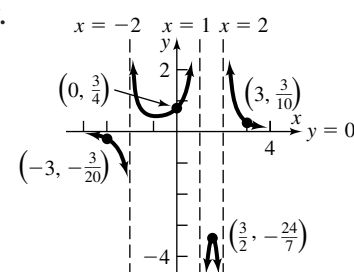


21. 1. $R(x) = \frac{3}{(x-1)(x+2)(x-2)}$; domain $\{x|x \neq 1, x \neq -2, x \neq 2\}$; y-intercept: $\frac{3}{4}$ 2. R is in lowest terms; no x -intercept 3. R is in lowest terms; vertical asymptotes: $x = -2, x = 1, x = 2$ 4. Horizontal asymptote: $y = 0$, not intersected

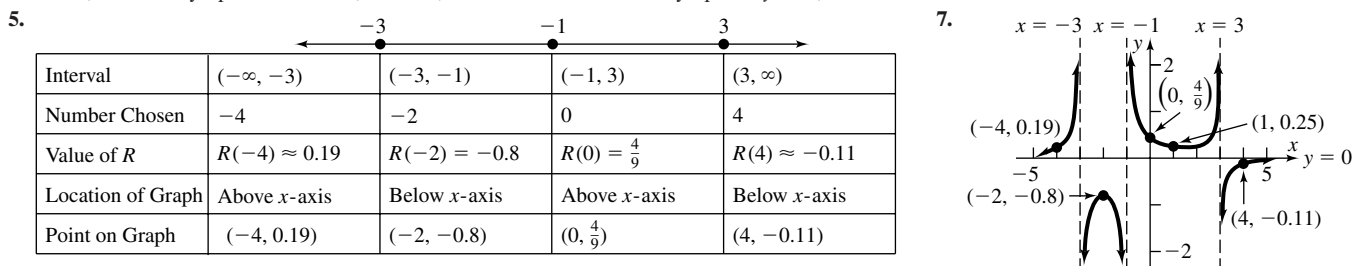
5.

	$\xleftarrow{\quad} \bullet_{-2} \quad \bullet_1 \quad \bullet_2 \xrightarrow{\quad}$			
Interval	$(-\infty, -2)$	$(-2, 1)$	$(1, 2)$	$(2, \infty)$
Number Chosen	-3	0	1.5	3
Value of R	$R(-3) = -\frac{3}{20}$	$R(0) = \frac{3}{4}$	$R(1.5) = -\frac{24}{7}$	$R(3) = \frac{3}{10}$
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-3, -\frac{3}{20})$	$(0, \frac{3}{4})$	$(1.5, -\frac{24}{7})$	$(3, \frac{3}{10})$

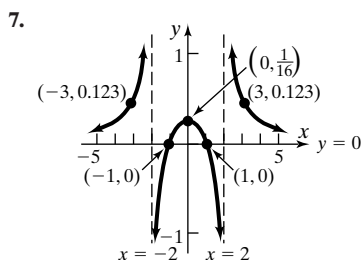
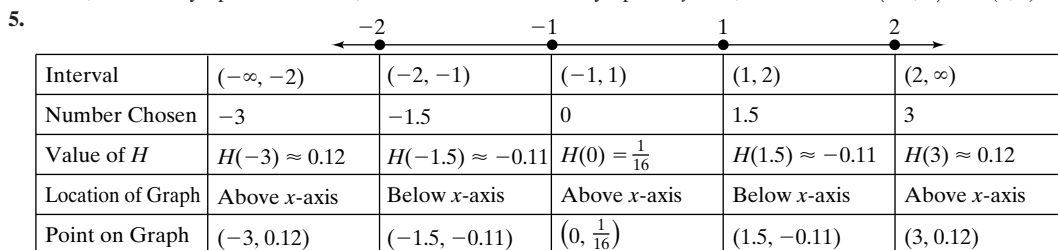
7.



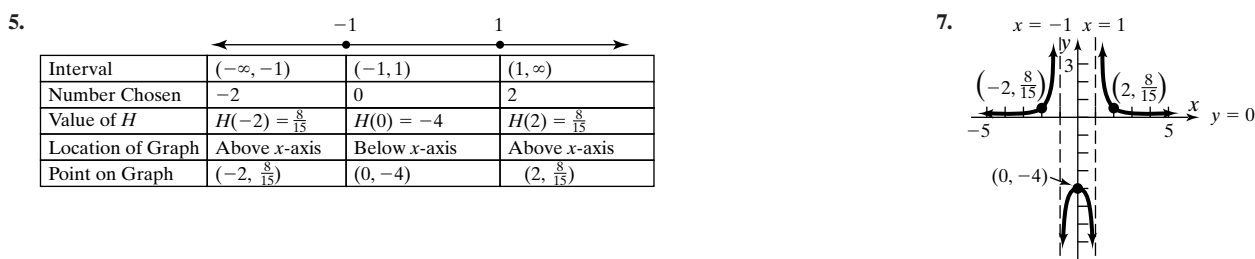
22. 1. $R(x) = \frac{-4}{(x+1)(x+3)(x-3)}$; domain $\{x|x \neq -1, x \neq -3, x \neq 3\}$; y-intercept: $\frac{4}{9}$ 2. R is in lowest terms; no x -intercept 3. R is in lowest terms; vertical asymptotes: $x = -3, x = -1, x = 3$ 4. Horizontal asymptote: $y = 0$, not intersected



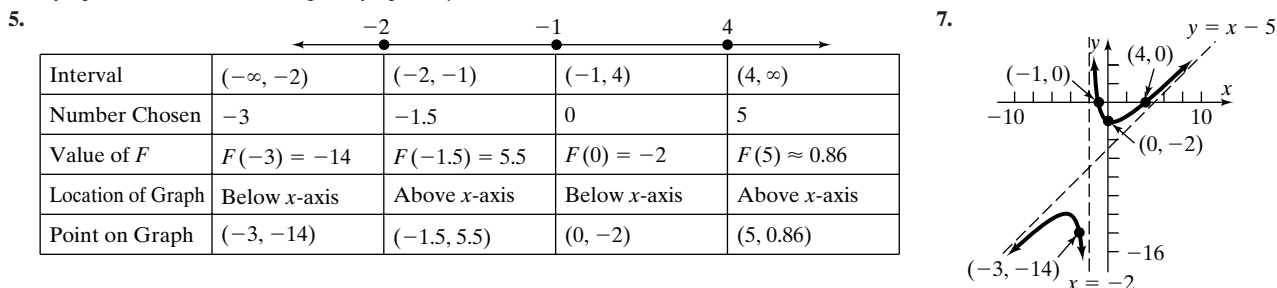
23. 1. $H(x) = \frac{(x+1)(x-1)}{(x^2+4)(x+2)(x-2)}$; domain $\{x|x \neq -2, x \neq 2\}$; y-intercept: $\frac{1}{16}$ 2. H is in lowest terms; x -intercepts: $-1, 1$ 3. H is in lowest terms; vertical asymptotes: $x = -2, x = 2$ 4. Horizontal asymptote: $y = 0$, intersected at $(-1, 0)$ and $(1, 0)$



24. 1. $H(x) = \frac{x^2+4}{(x^2+1)(x+1)(x+1)}$; domain $\{x|x \neq -1, x \neq 1\}$; y-intercept: -4 2. H is in lowest terms; no x -intercept 3. H is in lowest terms; vertical asymptotes: $x = -1, x = 1$ 4. Horizontal asymptote: $y = 0$, not intersected



25. 1. $F(x) = \frac{(x+1)(x-4)}{x+2}$; domain $\{x|x \neq -2\}$; y-intercept: -2 2. F is in lowest terms; x -intercepts: $-1, 4$ 3. F is in lowest terms; vertical asymptote: $x = -2$ 4. Oblique asymptote: $y = x - 5$, not intersected

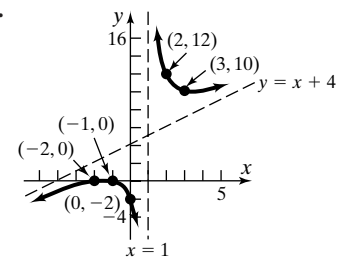


26. 1. $F(x) = \frac{(x+2)(x+1)}{x-1}$; domain $\{x|x \neq 1\}$; y-intercept: -2 2. F is in lowest terms; x -intercepts: $-1, -2$ 3. F is in lowest terms; vertical asymptote: $x = 1$ 4. Oblique asymptote: $y = x + 4$, not intersected

5.

	\leftarrow	\bullet	\bullet	\bullet	\rightarrow
		-2	-1	1	
Interval	$(-\infty, -2)$	$(-2, -1)$	$(-1, 1)$	$(1, \infty)$	
Number Chosen	-3	-1.5	0	2	
Value of F	$F(-3) = -0.5$	$F(-1.5) = 0.1$	$F(0) = -2$	$F(2) = 12$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, -0.5)$	$(-1.5, 0.1)$	$(0, -2)$	$(2, 12)$	

7.

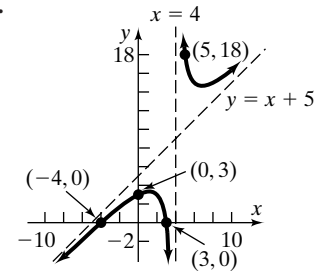


27. 1. $R(x) = \frac{(x+4)(x-3)}{x-4}$; domain: $\{x|x \neq 4\}$; y-intercept: 3 2. R is in lowest terms; x-intercepts: -4, 3 3. R is in lowest terms; vertical asymptote: $x = 4$ 4. Oblique asymptote: $y = x + 5$, not intersected

5.

	\leftarrow	\bullet	\bullet	\bullet	\rightarrow
		-4	3	4	
Interval	$(-\infty, -4)$	$(-4, 3)$	$(3, 4)$	$(4, \infty)$	
Number Chosen	-5	0	3.5	5	
Value of R	$R(-5) = -\frac{8}{9}$	$R(0) = 3$	$R(3.5) = -7.5$	$R(5) = 18$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-5, -\frac{8}{9})$	$(0, 3)$	$(3.5, -7.5)$	$(5, 18)$	

7.

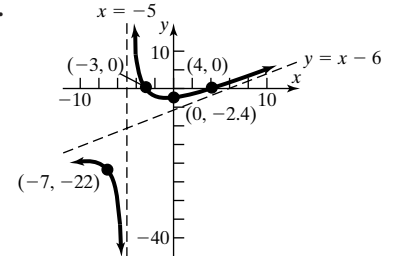


28. 1. $R(x) = \frac{(x+3)(x-4)}{x+5}$; domain: $\{x|x \neq -5\}$; y-intercept: $-\frac{12}{5}$ 2. R is in lowest terms; x-intercepts: -3, 4 3. R is in lowest terms; vertical asymptote: $x = -5$ 4. Oblique asymptote: $y = x - 6$, not intersected

5.

	\leftarrow	\bullet	\bullet	\bullet	\rightarrow
		-5	-3	4	
Interval	$(-\infty, -5)$	$(-5, -3)$	$(-3, 4)$	$(4, \infty)$	
Number Chosen	-7	-4	0	5	
Value of R	$R(-7) = -22$	$R(-4) = 8$	$R(0) = -2.4$	$R(5) = 0.8$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-7, -22)$	$(-4, 8)$	$(0, -2.4)$	$(5, -0.8)$	

7.

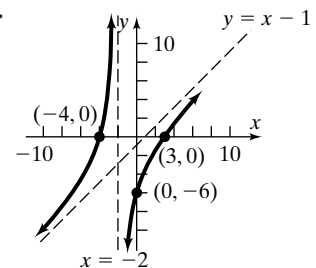


29. 1. $F(x) = \frac{(x+4)(x-3)}{x+2}$; domain: $\{x|x \neq -2\}$; y-intercept: -6 2. F is in lowest terms; x-intercepts: -4, 3 3. F is in lowest terms; vertical asymptote: $x = -2$ 4. Oblique asymptote: $y = x - 1$, not intersected

5.

	\leftarrow	\bullet	\bullet	\bullet	\rightarrow
		-4	-2	3	
Interval	$(-\infty, -4)$	$(-4, -2)$	$(-2, 3)$	$(3, \infty)$	
Number Chosen	-5	-3	0	4	
Value of F	$F(-5) = -\frac{8}{3}$	$F(-3) = 6$	$F(0) = -6$	$F(4) = \frac{4}{3}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-5, -\frac{8}{3})$	$(-3, 6)$	$(0, -6)$	$(4, \frac{4}{3})$	

7.

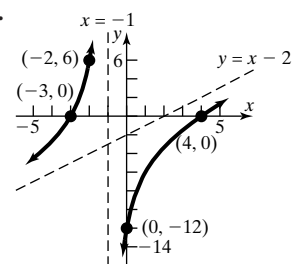


30. 1. $G(x) = \frac{(x+3)(x-4)}{x+1}$; domain: $\{x|x \neq -1\}$; y-intercept: -12 2. G is in lowest terms; x-intercepts: -3, 4 3. G is in lowest terms; vertical asymptote: $x = -1$ 4. Oblique asymptote: $y = x - 2$, not intersected

5.

	\leftarrow	\bullet	\bullet	\bullet	\rightarrow
		-3	-1	4	
Interval	$(-\infty, -3)$	$(-3, -1)$	$(-1, 4)$	$(4, \infty)$	
Number Chosen	-4	-2	0	5	
Value of G	$G(-4) = -\frac{8}{3}$	$G(-2) = 6$	$G(0) = -12$	$G(5) = \frac{4}{3}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-4, -\frac{8}{3})$	$(-2, 6)$	$(0, -12)$	$(5, \frac{4}{3})$	

7.

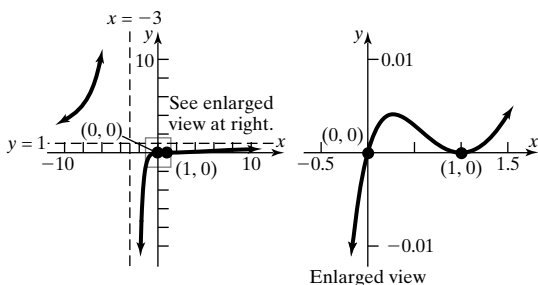


31. 1. Domain: $\{x|x \neq -3\}$; y-intercept: 0 2. x-intercepts: 0, 1 3. vertical asymptote: $x = -3$ 4. Horizontal asymptote: $y = 1$, not intersected

5.

	$-\infty$	-3	0	1	∞
Interval	$(-\infty, -3)$	$(-3, 0)$	$(0, 1)$	$(1, \infty)$	
Number Chosen	-4	-1	$\frac{1}{2}$	2	
Value of R	$R(-4) = 100$	$R(-1) = -0.5$	$R(\frac{1}{2}) \approx 0.003$	$R(2) = 0.016$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-4, 100)$	$(-1, -0.5)$	$(\frac{1}{2}, 0.003)$	$(2, 0.016)$	

7.



32. 1. Domain $\{x|x \neq 0, x \neq 4\}$; no y-intercept

2. x-intercepts: 1, -2, 3

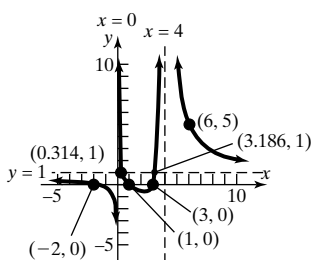
3. R is in lowest terms; vertical asymptotes: $x = 0, x = 4$

4. Horizontal asymptote: $y = 1$, intersected at $(3.186, 1), (0.314, 1)$

5.

	$-\infty$	-2	0	1	3	4	∞
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, 1)$	$(1, 3)$	$(3, 4)$	$(4, \infty)$	
Number Chosen	-3	-1	$\frac{1}{2}$	2	3.186	6	
Value of R	$R(-3) \approx 0.16$	$R(-1) = -0.32$	$R(\frac{1}{2}) \approx 0.51$	$R(2) = -0.5$	$R(3.186) \approx 1$	$R(6) = 5$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-3, 0.16)$	$(-1, -0.32)$	$(\frac{1}{2}, 0.51)$	$(2, -0.5)$	$(3.186, 1)$	$(6, 5)$	

7.



33. 1. $R(x) = \frac{(x+4)(x-3)}{(x+2)(x-3)}$; domain: $\{x|x \neq -2, x \neq 3\}$; y-intercept: 2

2. In lowest terms, $R(x) = \frac{x+4}{x+2}$; x-intercept: -4

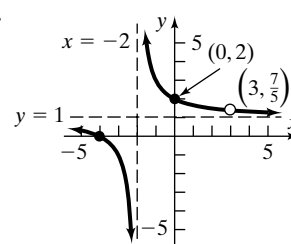
3. Vertical asymptote: $x = -2$; hole at $(3, \frac{7}{5})$

4. Horizontal asymptote: $y = 1$, not intersected

5.

	$-\infty$	-4	-2	3	∞
Interval	$(-\infty, -4)$	$(-4, -2)$	$(-2, 3)$	$(3, \infty)$	
Number Chosen	-5	-3	0	4	
Value of R	$R(-5) = \frac{1}{3}$	$R(-3) = -1$	$R(0) = 2$	$R(4) = \frac{4}{3}$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-5, \frac{1}{3})$	$(-3, -1)$	$(0, 2)$	$(4, \frac{4}{3})$	

7.

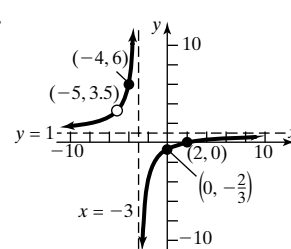


34. 1. $R(x) = \frac{(x+5)(x-2)}{(x+5)(x+3)}$; domain $\{x|x \neq -3, x \neq -5\}$; y-intercept: $-\frac{2}{3}$ 2. In lowest terms, $R(x) = \frac{x-2}{x+3}$; x-intercept: 2 3. Vertical asymptote: $x = -3$; hole at $(-5, 3.5)$ 4. Horizontal asymptote: $y = 1$, not intersected

5.

	$-\infty$	-5	-3	2	∞
Interval	$(-\infty, -5)$	$(-5, -3)$	$(-3, 2)$	$(2, \infty)$	
Number Chosen	-6	-4	0	3	
Value of R	$R(-6) = \frac{8}{3}$	$R(-4) = 6$	$R(0) = -\frac{2}{3}$	$R(3) = \frac{1}{6}$	
Location of Graph	Above x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-6, \frac{8}{3})$	$(-4, 6)$	$(0, -\frac{2}{3})$	$(3, \frac{1}{6})$	

7.



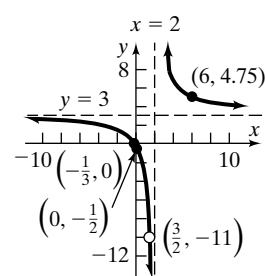
35. 1. $R(x) = \frac{(3x+1)(2x-3)}{(x-2)(2x-3)}$; domain: $\left\{x \mid x \neq \frac{3}{2}, x \neq 2\right\}$; y-intercept: $-\frac{1}{2}$ 2. In lowest terms, $R(x) = \frac{3x+1}{x-2}$; x-intercept: $-\frac{1}{3}$

3. Vertical asymptote: $x = 2$; hole at $\left(\frac{3}{2}, -11\right)$ 4. Horizontal asymptote: $y = 3$, not intersected

5.

	$-\frac{1}{3}$	$\frac{3}{2}$	2	
Interval	$(-\infty, -\frac{1}{3})$	$(-\frac{1}{3}, \frac{3}{2})$	$(\frac{3}{2}, 2)$	$(2, \infty)$
Number Chosen	-1	0	1.7	6
Value of R	$R(-1) = \frac{2}{3}$	$R(0) = -\frac{1}{2}$	$R(1.7) \approx -20.3$	$R(6) = 4.75$
Location of Graph	Above x -axis	Below x -axis	Below x -axis	Above x -axis
Point on Graph	$(-1, \frac{2}{3})$	$(0, -\frac{1}{2})$	$(1.7, -20.3)$	$(6, 4.75)$

7.



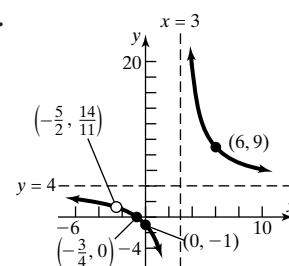
36. 1. $R(x) = \frac{(4x+3)(2x+5)}{(x-3)(2x+5)}$; domain: $\left\{x \mid x \neq -\frac{5}{2}, x \neq 3\right\}$; y-intercept: -1 2. In lowest terms, $R(x) = \frac{4x+3}{x-3}$; x-intercept: $-\frac{3}{4}$

3. Vertical asymptote: $x = 3$; hole at $(-\frac{5}{2}, \frac{14}{11})$ 4. Horizontal asymptote: $y = 4$

5.

	-2.5	$-\frac{3}{4}$	3	
Interval	$(-\infty, -2.5)$	$(-2.5, -\frac{3}{4})$	$(-\frac{3}{4}, 3)$	$(3, \infty)$
Number Chosen	-3	-1	0	6
Value of R	$R(-3) = \frac{3}{2}$	$R(-1) = \frac{1}{4}$	$R(0) = -1$	$R(6) = 9$
Location of Graph	Above x -axis	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-3, \frac{3}{2})$	$(-1, \frac{1}{4})$	$(0, -1)$	$(6, 9)$

7.

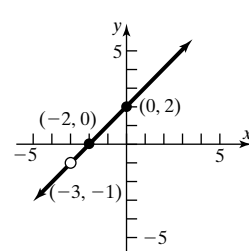


37. 1. $R(x) = \frac{(x+3)(x+2)}{x+3}$; domain: $\{x \mid x \neq -3\}$; y-intercept: 2 2. In lowest terms, $R(x) = x+2$; x-intercept: -2 3. Vertical asymptote: none; hole at $(-3, -1)$ 4. Oblique asymptote: $y = x+2$ intersected at all points except $x = -3$

5.

	-3	-2	
Interval	$(-\infty, -3)$	$(-3, -2)$	$(-2, \infty)$
Number Chosen	-4	-2.5	0
Value of R	$R(-4) = -2$	$R(-2.5) = -\frac{1}{2}$	$R(0) = 2$
Location of Graph	Below x -axis	Below x -axis	Above x -axis
Point on Graph	$(-4, -2)$	$(-2.5, -\frac{1}{2})$	$(0, 2)$

7.

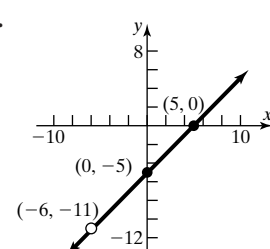


38. 1. $R(x) = \frac{(x+6)(x-5)}{x+6}$; domain: $\{x \mid x \neq -6\}$; y-intercept: -5 2. In lowest terms, $R(x) = x-5$; x-intercept: 5 3. Vertical asymptote: none; hole at $(-6, -11)$ 4. Oblique asymptote: $y = x-5$ intersected at all points except $x = -6$

5.

	-6	5	
Interval	$(-\infty, -6)$	$(-6, 5)$	$(5, \infty)$
Number Chosen	-7	0	6
Value of R	$R(-7) = -12$	$R(0) = -5$	$R(6) = 1$
Location of Graph	Below x -axis	Below x -axis	Above x -axis
Point on Graph	$(-7, -12)$	$(0, -5)$	$(6, 1)$

7.

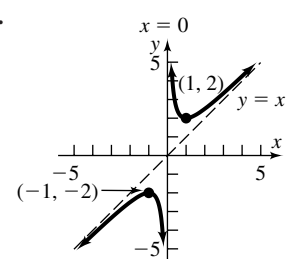


39. 1. $f(x) = \frac{x^2+1}{x}$; domain: $\{x \mid x \neq 0\}$; no y-intercepts 2. f is in lowest terms; no x-intercepts 3. f is in lowest terms; vertical asymptote: $x = 0$ 4. Oblique asymptotes: $y = x$, not intersected

5.

	0	
Interval	$(-\infty, 0)$	$(0, \infty)$
Number Chosen	-1	1
Value of f	$f(-1) = -2$	$f(1) = 2$
Location of Graph	Below x -axis	Above x -axis
Point on Graph	$(-1, -2)$	$(1, 2)$

7.

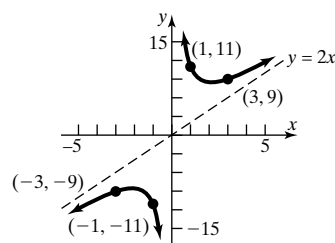


40. 1. $f(x) = \frac{2x^2 + 9}{x}$; domain $\{x|x \neq 0\}$; no y-intercept 2. f is in lowest terms; no x-intercepts 3. f is in lowest terms; vertical asymptote: $x = 0$
 4. Oblique asymptote: $y = 2x$, not intersected

5.

	$\xleftarrow{\hspace{1cm}} \bullet \hspace{0.5cm} \xrightarrow{\hspace{1cm}}$ 0	
Interval	$(-\infty, 0)$	$(0, \infty)$
Number Chosen	-1	1
Value of f	$f(-1) = -11$	$f(1) = 11$
Location of Graph	Below x-axis	Above x-axis
Point on Graph	$(-1, -11)$	$(1, 11)$

7.

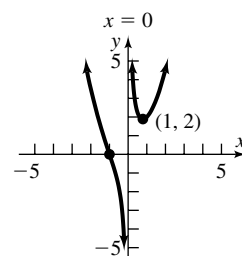


41. 1. $f(x) = \frac{x^3 + 1}{x} = \frac{(x+1)(x^2 - x + 1)}{x}$; domain: $\{x|x \neq 0\}$; no y-intercepts 2. f is in lowest terms; x-intercept: -1 3. f is in lowest terms
 vertical asymptote: $x = 0$ 4. No horizontal or oblique asymptotes

5.

	$\xleftarrow{\hspace{1cm}} \bullet \hspace{0.5cm} \bullet \hspace{0.5cm} \xrightarrow{\hspace{1cm}}$ $-1 \hspace{1cm} 0$		
Interval	$(-\infty, -1)$	$(-1, 0)$	$(0, \infty)$
Number Chosen	-2	$-\frac{1}{2}$	1
Value of f	$f(-2) = 3.5$	$f(-\frac{1}{2}) = -1.75$	$f(1) = 2$
Location of Graph	Above x-axis	Below x-axis	Above x-axis
Point on Graph	$(-2, 3.5)$	$(-\frac{1}{2}, -1.75)$	$(1, 2)$

7.

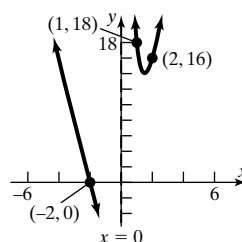


42. 1. $f(x) = \frac{2x^3 + 16}{x} = \frac{2(x+2)(x^2 - 2x + 4)}{x}$; domain $\{x|x \neq 0\}$; no y-intercept 2. f is in lowest terms; x-intercept: -2 3. f is in lowest terms
 vertical asymptote: $x = 0$ 4. No oblique or horizontal asymptotes

5.

	$\xleftarrow{\hspace{1cm}} \bullet \hspace{0.5cm} \bullet \hspace{0.5cm} \xrightarrow{\hspace{1cm}}$ $-2 \hspace{1cm} 0$		
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, \infty)$
Number Chosen	-4	-1	1
Value of f	$f(-4) = 28$	$f(-1) = -14$	$f(1) = 18$
Location of Graph	Above x-axis	Below x-axis	Above x-axis
Point on Graph	$(-3, 16)$	$(-1, -14)$	$(1, 18)$

7.

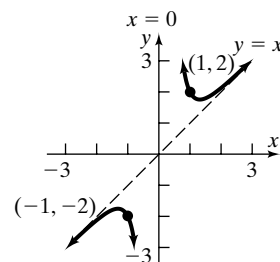


43. 1. $f(x) = \frac{x^4 + 1}{x^3}$; domain: $\{x|x \neq 0\}$; no y-intercepts 2. f is in lowest terms; no x-intercepts 3. f is in lowest terms; vertical asymptote: $x = 0$
 4. Oblique asymptote: $y = x$, not intersected

5.

	$\xleftarrow{\hspace{1cm}} \bullet \hspace{0.5cm} \xrightarrow{\hspace{1cm}}$ 0	
Interval	$(-\infty, 0)$	$(0, \infty)$
Number Chosen	-1	1
Value of f	$f(-1) = -2$	$f(1) = 2$
Location of Graph	Below x-axis	Above x-axis
Point on Graph	$(-1, -2)$	$(1, 2)$

7.

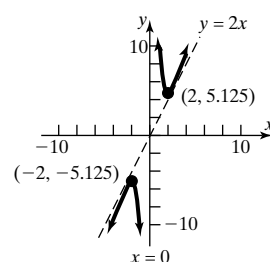


44. 1. $f(x) = \frac{2x^4 + 9}{x^3}$; domain $\{x|x \neq 0\}$; no y-intercept 2. f is in lowest terms; no x-intercepts 3. f is in lowest terms; vertical asymptote: $x = 0$
 4. Oblique asymptote: $y = 2x$, not intersected

5.

	$\xleftarrow{\hspace{1cm}} \bullet \hspace{0.5cm} \xrightarrow{\hspace{1cm}}$ 0	
Interval	$(-\infty, 0)$	$(0, \infty)$
Number Chosen	-2	2
Value of f	$f(-2) = -5.125$	$f(2) = 5.125$
Location of Graph	Below x-axis	Above x-axis
Point on Graph	$(-2, -5.125)$	$(2, 5.125)$

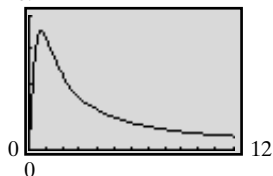
7.



45. One possibility: $R(x) = \frac{x^2}{x^2 - 4}$ 46. One possibility: $R(x) = -\frac{x}{x^2 - 1}$ 47. One possibility: $R(x) = \frac{(x-1)(x-3)(x^2 + \frac{4}{3})}{(x+1)^2(x-2)^2}$
48. One possibility: $R(x) = \frac{3(x+2)(x-1)^2}{(x+3)(x-4)^2}$

49. (a) t -axis; $C(t) \rightarrow 0$

(b) 0.4

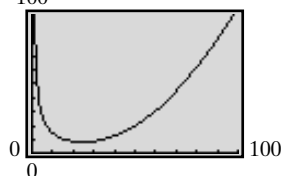


(c) 0.71 hr after injection

52. (a) $\bar{C}(x) = \frac{0.015x^3 - 0.595x^2 + 9.15x + 98.43}{x}$

(b) $\approx \$11.52$ (c) $\approx \$7.59$

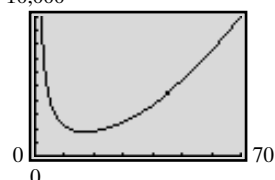
(d) 100



(e) $\approx 25,058$ books (f) $\approx \$7.59$

54. (a) $S(x) = 2x^2 + \frac{20,000}{x}$

(b) 10,000



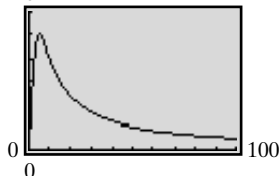
(c) 1754.41 sq in.

(d) 17.10 in. \times 17.10 in. \times 17.10 in.

(e) To minimize the cost of material needed for construction

50. (a) t -axis; $C(t) \rightarrow 0$

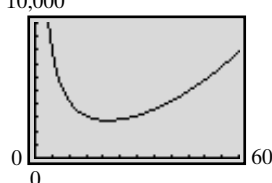
(b) 6



(c) 5 min after injection

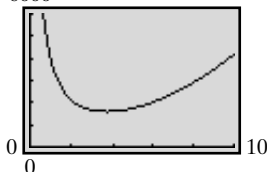
53. (a) $S(x) = 2x^2 + \frac{40,000}{x}$

(b) 10,000



55. (a) $C(r) = 12\pi r^2 + \frac{4000}{r}$

(b) 6000



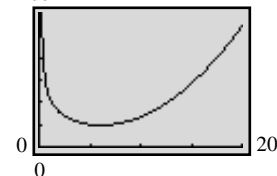
The cost is smallest when

$r = 3.76$ cm.

51. (a) $\bar{C}(x) = \frac{0.2x^3 - 2.3x^2 + 14.3x + 10.2}{x}$

(b) \$9400 (c) $\approx \$10,933$

(d) 60



(e) 6 (f) \$9400

(c) 2784.95 sq in.

(d) 21.54 in. \times 21.54 in. \times 21.54 in.

(e) To minimize the cost of material needed for construction

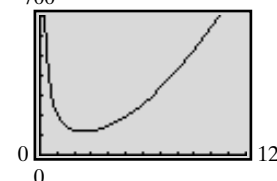
56. (a) $A(r) = 2\pi r^2 + \frac{200}{r}$

(b) Approximately 123.22 sq ft

(c) Approximately 150.53 sq ft

(d) Approximately 197.08 sq ft

(e) 700



A is smallest when $r = 2.52$ ft.

57. (a) $D(p) = \frac{429}{p}$ (b) 143 58. (a) $t(s) = \frac{1200}{s}$ (b) 30 minutes 59. 450 cm³ 60. 24 amperes 61. 124.76 pounds 62. 0.012 foot-candle

63. $V = \pi r^2 h$ 64. $V = \frac{\pi}{3} r^2 h$ 65. $\sqrt[3]{6} \approx 1.82$ in. 66. $V = \frac{kT}{P}$, $k = 5$; 19.375 atmospheres 67. 2812.5 Joules 68. 282.2 ft 69. 384 psi

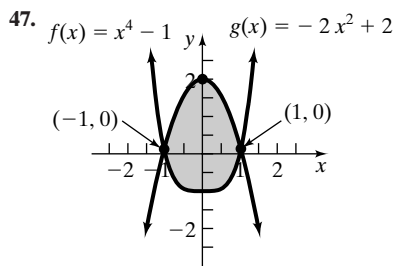
70. 900 lb 71. No. Each function is a quotient of polynomials, but it is not written in lowest terms. Each function is undefined for $x = 1$;

each graph has a hole at $x = 1$. 72. All four graphs have a vertical asymptote at $x = 1$; $y = \frac{x^2}{x-1}$ has an oblique asymptote at $y = x + 1$.

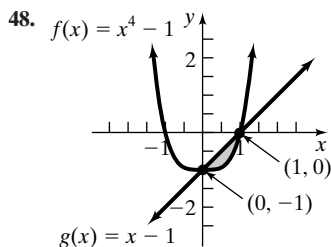
3.4 Assess Your Understanding (page 235)

2. False 3. $\{x|x < -2\}; (-\infty, -2)$ 4. $\{x|x > 5\}; (5, \infty)$ 5. $\{x|x > 4\}; (4, \infty)$ 6. $\{x|x < -8\}; (-\infty, -8)$ 7. $\{x|x \leq -3 \text{ or } 0 \leq x \leq 3\}; (-\infty, -3] \text{ or } [0, 3]$ 8. $\{x|-1 \leq x \leq 0 \text{ or } x \geq 1\}; [-1, 0] \text{ or } [1, \infty)$ 9. $\{x|-4 < x < 0 \text{ or } x > 0\}; (-4, 0) \text{ or } (0, \infty)$ 10. $\{x|x < -5\}; (-\infty, -5)$
11. $\{x|x \geq 1\}; [1, \infty)$ 12. $\{x|x \geq -2\}; [-2, \infty)$ 13. $\{x|x \leq 1 \text{ or } 2 \leq x \leq 3\}; (-\infty, 1] \text{ or } [2, 3]$ 14. $\{x|x \leq -3 \text{ or } -2 \leq x \leq -1\}; (-\infty, -3] \text{ or } [-2, -1]$ 15. $\{x|-1 < x < 0 \text{ or } x > 3\}; (-1, 0) \text{ or } (3, \infty)$ 16. $\{x|-3 < x < 0 \text{ or } x > 1\}; (-3, 0) \text{ or } (1, \infty)$ 17. $\{x|x < -1 \text{ or } x > 1\}; (-\infty, -1) \text{ or } (1, \infty)$ 18. $\{x|-3 < x < 0 \text{ or } 0 < x < 3\}; (-3, 0) \text{ or } (0, 3)$ 19. $\{x|x < -1 \text{ or } x > 1\}; (-\infty, -1) \text{ or } (1, \infty)$ 20. $\{x|x > 1\}; (1, \infty)$ 21. $\{x|x < -1 \text{ or } x > 1\}; (-\infty, -1) \text{ or } (1, \infty)$ 22. $\{x|x < -1 \text{ or } x > 3\}; (-\infty, -1) \text{ or } (3, \infty)$ 23. $\{x|x \leq -1 \text{ or } 0 < x \leq 1\}; (-\infty, -1] \text{ or } (0, 1]$ 24. $\{x|x \leq -2 \text{ or } 1 < x \leq 3\}; (-\infty, -2] \text{ or } (1, 3]$ 25. $\{x|x < -1 \text{ or } x > 1\}; (-\infty, -1) \text{ or } (1, \infty)$ 26. $\{x|x < -2 \text{ or } x > 2\}; (-\infty, -2) \text{ or } (2, \infty)$ 27. $\left\{x \left| x < -\frac{2}{3} \text{ or } 0 < x < \frac{3}{2} \right.\right\}; \left(-\infty, -\frac{2}{3}\right) \text{ or } \left(0, \frac{3}{2}\right)$ 28. $\{x|x < 0 \text{ or } 3 < x < 4\}; (-\infty, 0) \text{ or } (3, 4)$
29. $\{x|x < 2\}; (-\infty, 2)$ 30. $\{x|x > 4\}; (4, \infty)$ 31. $\{x|-2 < x \leq 9\}; (-2, 9]$ 32. $\{x|-8 \leq x < -2\}; [-8, -2)$ 33. $\{x|x < 2 \text{ or } 3 < x < 5\}; (-\infty, 2) \text{ or } (3, 5)$ 34. $\{x|-7 < x < -1 \text{ or } x > 3\}; (-7, -1) \text{ or } (3, \infty)$ 35. $\{x|x < -3 \text{ or } -1 < x < 1 \text{ or } x > 2\}; (-\infty, -3) \text{ or } (-1, 1) \text{ or } (2, \infty)$ 36. $\left\{x \left| x < -\frac{5}{2} \text{ or } -2 < x < -1 \right.\right\}; \left(-\infty, -\frac{5}{2}\right) \text{ or } (-2, -1)$ 37. $\{x|x < -5 \text{ or } -4 \leq x \leq -3 \text{ or } x = 0 \text{ or } x > 1\}; (-\infty, -5) \text{ or } [-4, -3] \text{ or } 0 \text{ or } (1, \infty)$ 38. $\{x|x < -1 \text{ or } 0 \leq x < 1 \text{ or } x \geq 2\}; (-\infty, -1) \text{ or } [0, 1) \text{ or } [2, \infty)$ 39. $\left\{x \left| -\frac{1}{2} < x < 1 \text{ or } x > 3 \right.\right\}$

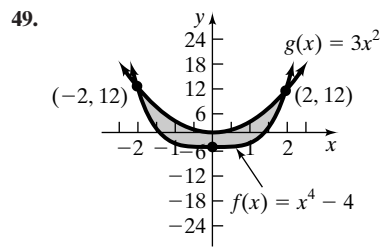
40. $\left\{x \mid -1 < x < \frac{2}{3} \text{ or } x > 2\right\}; \left(-1, \frac{2}{3}\right) \text{ or } (2, \infty)$ 41. $\{x \mid x > 4\}; (4, \infty)$ 42. $\{x \mid 0 < x < 1\}; (0, 1)$ 43. $\{x \mid x \leq -2 \text{ or } x \geq 2\}; (-\infty, -2] \text{ or } [2, \infty)$ 44. $\{x \mid x = 0 \text{ or } x \geq 3\}; 0 \text{ or } [3, \infty)$ 45. $\{x \mid x < -4 \text{ or } x \geq 2\}; (-\infty, -4) \text{ or } [2, \infty)$ 46. $\{x \mid x < -4 \text{ or } x \geq 1\}; (-\infty, -4) \text{ or } [1, \infty)$



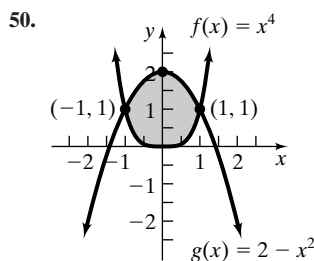
$$f(x) \leq g(x) \text{ if } -1 \leq x \leq 1$$



$$f(x) \leq g(x) \text{ if } 0 \leq x \leq 1$$



$$f(x) \leq g(x) \text{ if } -2 \leq x \leq 2$$



$$f(x) \leq g(x) \text{ if } -1 \leq x \leq 1$$

51. Produce at least 250 bicycles

52. Produce at least 300 bicycles

Historical Problems (page 247)

1. $\left(x - \frac{b}{3}\right)^3 + b\left(x - \frac{b}{3}\right)^2 + c\left(x - \frac{b}{3}\right) + d = 0$
 $x^3 - bx^2 + \frac{b^2x}{3} - \frac{b^3}{27} + bx^2 - \frac{2b^2x}{3} + \frac{b^3}{9} + cx - \frac{bc}{3} + d = 0$
 $x^3 + \left(c - \frac{b^2}{3}\right)x + \left(\frac{2b^3}{27} - \frac{bc}{3} + d\right) = 0$
 Let $p = c - \frac{b^2}{3}$ and $q = \frac{2b^3}{27} - \frac{bc}{3} + d$. Then $x^3 + px + q = 0$.

2. $(H + K)^3 + p(H + K) + q = 0$
 $H^3 + 3H^2K + 3HK^2 + K^3 + pH + pK + q = 0$
 Let $3HK = -p$.
 $H^3 - pH - pK + K^3 + pH + pK + q = 0 \quad H^3 + K^3 = -q$

3. $3HK = -p$
 $K = -\frac{p}{3H}$
 $H^3 + \left(-\frac{p}{3H}\right)^3 = -q$
 $H^3 - \frac{p^3}{27H^3} = -q$
 $27H^6 - p^3 = -27qH^3$
 $27H^6 + 27qH^3 - p^3 = 0$
 $H^3 = \frac{-27q \pm \sqrt{(27q)^2 - 4(27)(-p^3)}}{2 \cdot 27}$
 $H^3 = \frac{-q}{2} \pm \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}$
 $H^3 = \frac{-q}{2} \pm \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}$
 $H = \sqrt[3]{\frac{-q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}}$

Choose the positive root for now.

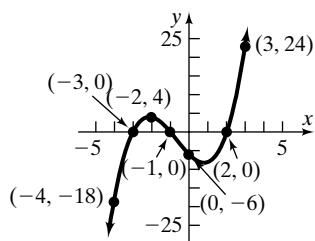
4. $H^3 + K^3 = -q$
 $K^3 = -q - H^3$
 $K^3 = -q - \left[\frac{-q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}\right]$
 $K^3 = \frac{-q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}$
 $K = \sqrt[3]{\frac{-q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}}$
 5. $x = H + K$
 $x = \sqrt[3]{\frac{-q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}} + \sqrt[3]{\frac{-q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}} \quad (\text{Note that had we used the negative root in 3 the result would be the same.})$
 6. $x = 3$ 7. $x = 2$ 8. $x = 2$

3.5 Assess your Understanding (page 248)

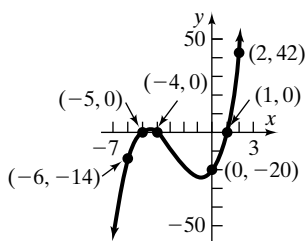
5. Remainder; dividend 6. $f(c)$ 7. -4 8. False 9. False 10. True 11. $R = f(2) = 8$; no 12. $R = f(-3) = 161$; no 13. $R = f(2) = 0$; yes 14. $R = f(2) = 0$; yes 15. $R = f(-3) = 0$; yes 16. $R = f(-3) = 0$; yes 17. $R = f(-4) = 1$; no 18. $R = f(-4) = 0$; yes

19. $R = f\left(\frac{1}{2}\right) = 0$; yes 20. $R = f\left(-\frac{1}{3}\right) = 2$; no 21. 7; 3 or 1 positive; 2 or 0 negative 22. 4; 1 positive; 1 negative
 23. 6; 2 or 0 positive; 2 or 0 negative 24. 5; 1 positive; 0 negative 25. 3; 2 or 0 positive; 1 negative 26. 3; 1 positive; 2 or 0 negative
 27. 4; 2 or 0 positive; 2 or 0 negative 28. 4; 1 positive; 1 negative 29. 5; 0 positive; 3 or 1 negative 30. 5; 5, 3 or 1 positive; 0 negative
 31. 6; 1 positive; 1 negative 32. 6; no positive; no negative 33. $\pm 1, \pm \frac{1}{3}$ 34. $\pm 1, \pm 3$ 35. $\pm 1, \pm 3$ 36. $\pm 1, \pm \frac{1}{2}$ 37. $\pm 1, \pm 2, \pm \frac{1}{4}, \pm \frac{1}{2}$
 38. $\pm 1, \pm 2, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{1}{6}, \pm \frac{2}{3}$ 39. $\pm 1, \pm 3, \pm 9, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{1}{6}, \pm \frac{3}{2}, \pm \frac{9}{2}$ 40. $\pm 1, \pm 2, \pm 3, \pm 6, \pm \frac{1}{4}, \pm \frac{1}{2}, \pm \frac{3}{4}, \pm \frac{3}{2}$ 41. $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12, \pm \frac{1}{2}, \pm \frac{3}{2}$
 42. $\pm 1, \pm 2, \pm 3, \pm 6, \pm 9, \pm 18, \pm \frac{1}{3}, \pm \frac{2}{3}$ 43. $\pm 1, \pm 2, \pm 4, \pm 5, \pm 10, \pm 20, \pm \frac{1}{2}, \pm \frac{5}{2}, \pm \frac{1}{3}, \pm \frac{2}{3}, \pm \frac{4}{3}, \pm \frac{5}{3}, \pm \frac{10}{3}, \pm \frac{20}{3}, \pm \frac{1}{6}, \pm \frac{5}{6}$
 44. $\pm 1, \pm 2, \pm 5, \pm 10, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{1}{6}, \pm \frac{2}{3}, \pm \frac{5}{3}, \pm \frac{5}{2}, \pm \frac{5}{6}, \pm \frac{10}{3}$ 45. $-3, -1, 2; f(x) = (x+3)(x+1)(x-2)$
 46. $-4, -5, 1; f(x) = (x-1)(x+5)(x+4)$ 47. $\frac{1}{2}; f(x) = 2\left(x - \frac{1}{2}\right)(x^2 + 1)$ 48. $-\frac{1}{2}; f(x) = 2\left(x + \frac{1}{2}\right)(x^2 + 1)$
 49. $-1, 1; f(x) = (x+1)(x-1)(x^2 + 2)$ 50. $2, -2; f(x) = (x-2)(x+2)(x^2 + 1)$
 51. $-\frac{1}{2}, \frac{1}{2}; f(x) = 4\left(x + \frac{1}{2}\right)\left(x - \frac{1}{2}\right)(x^2 + 2)$ 52. $\frac{1}{2}, -\frac{1}{2}; f(x) = 4\left(x - \frac{1}{2}\right)\left(x + \frac{1}{2}\right)(x^2 + 4)$
 53. 1, multiplicity 2; $-2, -1; f(x) = (x+2)(x+1)(x-1)^2$ 54. 2, multiplicity 2; $-1, -2; f(x) = (x+1)(x+2)(x-2)^2$
 55. $-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}, 2; f(x) = 4\left(x + \frac{\sqrt{2}}{2}\right)\left(x - \frac{\sqrt{2}}{2}\right)(x-2)\left(x^2 + \frac{1}{2}\right)$ 56. $-3, -\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}; f(x) = 4(x+3)\left(x + \frac{\sqrt{2}}{2}\right)\left(x - \frac{\sqrt{2}}{2}\right)\left(x^2 + \frac{1}{2}\right)$
 57. $\{-1, 2\}$ 58. $\left\{-\frac{3}{2}\right\}$ 59. $\left\{\frac{2}{3}, -1 + \sqrt{2}, -1 - \sqrt{2}\right\}$ 60. $\left\{\frac{5}{2}\right\}$ 61. $\left\{\frac{1}{3}, \sqrt{5}, -\sqrt{5}\right\}$ 62. $\left\{-\frac{1}{2}, 2, 4\right\}$ 63. $\{-3, -2\}$ 64. $\{1\}$
 65. $\left\{-\frac{1}{3}\right\}$ 66. $\left\{\frac{1}{2}\right\}$ 67. $\left\{\frac{1}{2}, 2, 5\right\}$ 68. $\left\{-4, -\frac{1}{2}, 2\right\}$

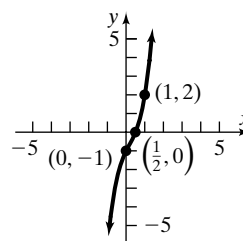
69. y-intercept: -6;
x-intercepts: -3, -1, 2



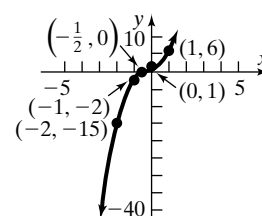
70. y-intercept: -20;
x-intercepts: -5, -4, 1



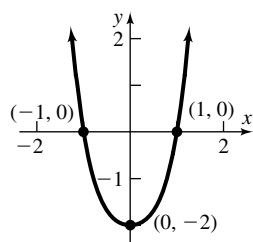
71. y-intercept: -1;
x-intercept: $\frac{1}{2}$



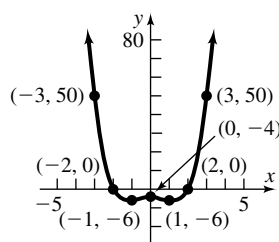
72. y-intercept: 1;
x-intercept: $-\frac{1}{2}$



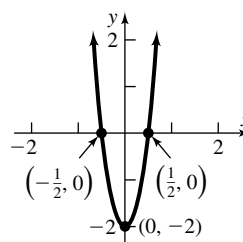
73. y-intercept: -2;
x-intercepts: -1, 1



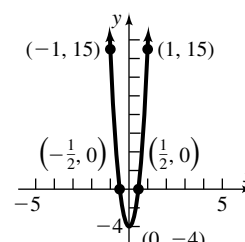
74. y-intercept: -4;
x-intercepts: -2, 2



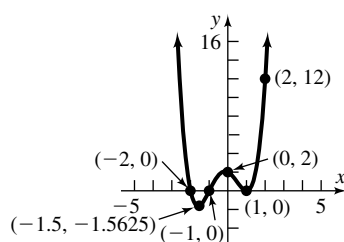
75. y-intercept: -2;
x-intercepts: $-\frac{1}{2}, \frac{1}{2}$



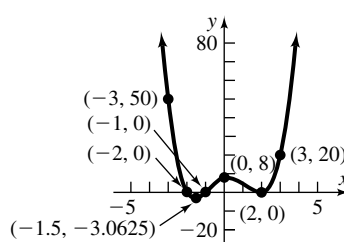
76. y-intercept: -4;
x-intercepts: $-\frac{1}{2}, \frac{1}{2}$



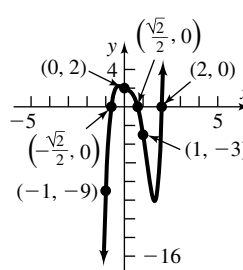
77. y-intercept: 2;
x-intercepts: -2, -1, 1



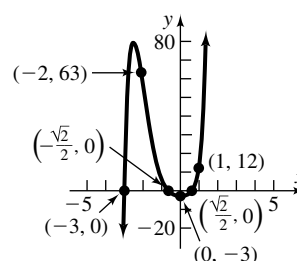
78. y-intercept: 8;
x-intercepts: -2, -1, 2



79. y-intercept: 2;
x-intercepts: $-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}, 2$



80. y-intercept: -3;
x-intercepts: $-3, -\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}$



81. 5 82. 37 83. 2 84. 2 85. 5 86. 13 87. $\frac{3}{2}$ 88. $\frac{3}{2}$ 89. $f(0) = -1; f(1) = 10$ 90. $f(-1) = -6; f(0) = 2$ 91. $f(-5) = -58$;
 $f(-4) = 2$ 92. $f(-3) = -42; f(-2) = 5$ 93. $f(1.4) = -0.17536; f(1.5) = 1.40625$ 94. $f(1.7) = 0.35627; f(1.8) = -1.02112$ 95. 0.21
 96. -0.60 97. -4.04 98. -2.17 99. 1.15 100. 0.70 101. 2.53 102. 2.13 103. $k = 5$ 104. $k = -\frac{17}{12}$ 105. -7 106. 1 107. If
 $f(x) = x^n - c^n$, then $f(c) = c^n - c^n = 0$, so $x - c$ is a factor of f . 108. If $n \geq 1$ is odd, $(-c)^n = -c^n$, so $f(-c) = (-c)^n + c^n = -c^n + c^n = 0$,
 so, $x + c$ is a factor of f when n is odd. 109. 5 110. -3 111. 7 in. 112. 6 cm or 12 cm 113. All the potential rational zeros are integers, so, r
 is either an integer or is not a rational zero (and is therefore irrational).

114. Let $\frac{p}{q}$, where p and q have no common factors except 1 and -1 , be a solution of the polynomial $f(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$
 whose coefficients are all integers. Then

$$f\left(\frac{p}{q}\right) = a_n \left(\frac{p}{q}\right)^n + a_{n-1} \left(\frac{p}{q}\right)^{n-1} + \cdots + a_1 \left(\frac{p}{q}\right) + a_0 = 0$$

$$a_n p^n + a_{n-1} p^{n-1} q + \cdots + a_1 p q^{n-1} + a_0 q^n = 0$$

Because p is a factor of the first n terms of this equation, p must also be a factor of $a_0 q^n$. Since p is not a factor of q (p and q have no common factors except 1 and -1), p must be a factor of a_0 . Similarly, q must be a factor of a_n .

116. No, by the Rational Zeros Theorem, $\frac{1}{3}$ is not a potential rational zero.

117. No, by the Rational Zeros Theorem, $\frac{1}{3}$ is not a potential rational zero.

118. No, by the Rational Zeros Theorem, $\frac{3}{5}$ is not a potential rational zero. 119. No, by the Rational Zeros Theorem, $\frac{2}{3}$ is not a potential rational zero.

3.6 Assess Your Understanding (page 255)

3. one 4. $3 - 4i$ 5. True 6. False 7. $4 + i$ 8. $3 - i$ 9. $-i, 1 - i$ 10. $2 - i$ 11. $-i, -2i$ 12. $-i$ 13. $-i$ 14. $2 + i, i$ 15. $2 - i, -3 + i$
 16. $-i, 3 + 2i, -2 - i$ 17. $f(x) = x^4 - 14x^3 + 77x^2 - 200x + 208; a = 1$ 18. $f(x) = x^4 - 2x^3 + 6x^2 - 2x + 5; a = 1$
 19. $f(x) = x^5 - 4x^4 + 7x^3 - 8x^2 + 6x - 4; a = 1$ 20. $f(x) = x^6 - 12x^5 + 55x^4 - 120x^3 + 139x^2 - 108x + 85; a = 1$
 21. $f(x) = x^4 - 6x^3 + 10x^2 - 6x + 9; a = 1$ 22. $f(x) = x^5 - 5x^4 + 11x^3 - 13x^2 + 8x - 2; a = 1$ 23. $-2i, 4$ 24. $5i, -3$ 25. $2i, -3, \frac{1}{2}$
 26. $-3i, -2, \frac{1}{3}$ 27. $3 + 2i, -2, 5$ 28. $1 - 3i, -1, 6$ 29. $4i, -\sqrt{11}, \sqrt{11}, -\frac{2}{3}$ 30. $-3i, -3, 4, \frac{1}{2}$ 31. $1, -\frac{1}{2} - \frac{\sqrt{3}}{2}i, -\frac{1}{2} + \frac{\sqrt{3}}{2}i$;

$$f(x) = (x - 1)\left(x + \frac{1}{2} + \frac{\sqrt{3}}{2}i\right)\left(x + \frac{1}{2} - \frac{\sqrt{3}}{2}i\right) \quad 32. -i, i, -1, 1; f(x) = (x + i)(x - i)(x + 1)(x - 1) \quad 33. 2, 3 - 2i, 3 + 2i;$$

$$f(x) = (x - 2)(x - 3 + 2i)(x - 3 - 2i) \quad 34. -5, -4 + i, -4 - i; f(x) = (x + 5)(x + 4 - i)(x + 4 + i) \quad 35. -i, i, -2i, 2i;$$

$$f(x) = (x + i)(x - i)(x + 2i)(x - 2i) \quad 36. -2i, 2i, -3i, 3i; f(x) = (x + 2i)(x - 2i)(x + 3i)(x - 3i) \quad 37. -5i, 5i, -3, 1;$$

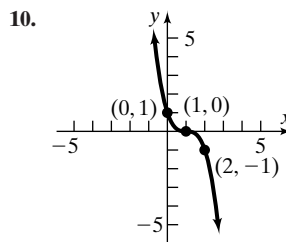
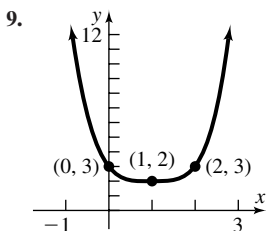
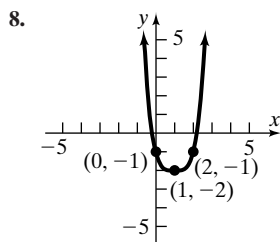
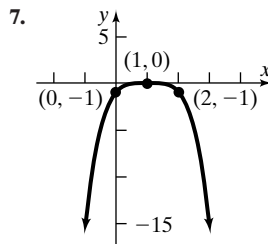
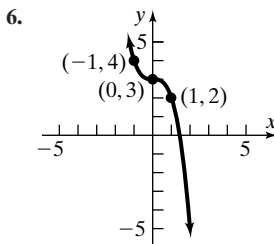
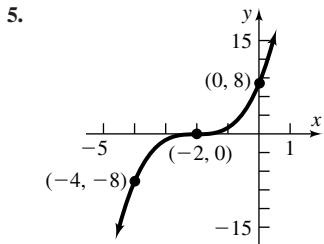
$$f(x) = (x + 5i)(x - 5i)(x + 3)(x - 1) \quad 38. -3i, 3i, -7, 4; f(x) = (x + 3i)(x - 3i)(x + 7)(x - 4) \quad 39. -4, \frac{1}{3}, 2 - 3i, 2 + 3i;$$

$$f(x) = 3(x + 4)\left(x - \frac{1}{3}\right)(x - 2 + 3i)(x - 2 - 3i) \quad 40. -3 - 2i, -3 + 2i, \frac{1}{2}, 5; f(x) = 2(x + 3 + 2i)(x + 3 - 2i)\left(x - \frac{1}{2}\right)(x - 5)$$

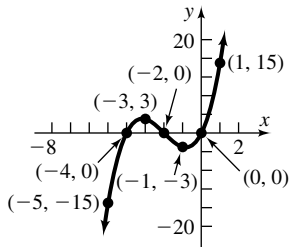
41. Zeros that are complex numbers must occur in conjugate pairs; or a polynomial with real coefficients of odd degree must have at least one real zero. 42. Zeros that are complex numbers must occur in conjugate pairs. 43. If the remaining zero were a complex number, its conjugate would also be a zero, creating a polynomial of degree 5. 44. A missing zero is $4 + i$. If the remaining zero were a complex number, its conjugate would also be a zero, creating a polynomial of degree 5.

Review Exercises (page 257)

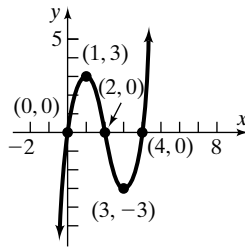
1. Polynomial of degree 5 2. Not a polynomial 3. Not a polynomial 4. Polynomial of degree 0



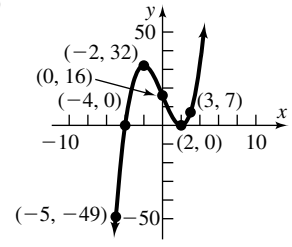
11. (a) x -intercepts: $-4, -2, 0$; y -intercept: 0
 (b) Crosses at $-4, -2, 0$
 (c) $y = x^3$ (d) 2
 (e) Near -4 : $f(x) \approx 8(x + 4)$;
 Near -2 : $f(x) \approx -4(x + 2)$;
 Near 0 : $f(x) \approx 8x$
 (f)



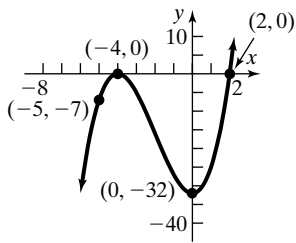
12. (a) x -intercepts: $0, 2, 4$; y -intercept: 0
 (b) Crosses at $0, 2$, and 4
 (c) $y = x^3$ (d) 2
 (e) Near 0 : $f(x) \approx 8x$;
 Near 2 : $f(x) \approx -4(x - 2)$;
 Near 4 : $f(x) \approx 8(x - 4)$
 (f)



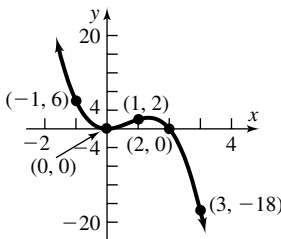
13. (a) x -intercepts: $-4, 2$; y -intercept: 16
 (b) Crosses at -4 ; touches at 2
 (c) $y = x^3$ (d) 2
 (e) Near -4 : $f(x) \approx 36(x + 4)$;
 Near 2 : $f(x) \approx 6(x - 2)^2$
 (f)



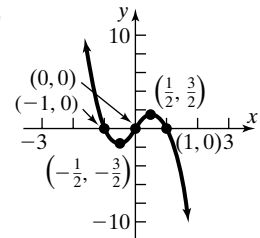
14. (a) x -intercepts: $-4, 2$; y -intercept: -32
 (b) Touches at -4 ; crosses at 2
 (c) $y = x^3$ (d) 2
 (e) Near -4 : $f(x) \approx -6(x + 4)^2$;
 Near 2 : $f(x) \approx 36(x - 2)$
 (f)



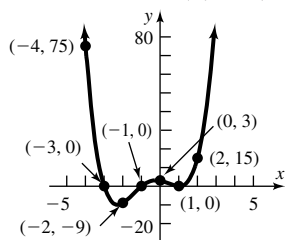
15. (a) $f(x) = -2x^2(x - 2)$;
 x -intercepts: $0, 2$; y -intercept: 0
 (b) Touches at 0 ; crosses at 2
 (c) $y = -2x^3$ (d) 2
 (e) Near 0 : $f(x) \approx 4x^2$;
 Near 2 : $f(x) \approx -8(x - 2)$
 (f)



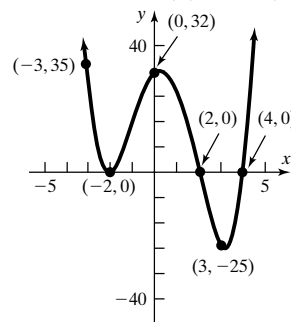
16. (a) $f(x) = -4x(x + 1)(x - 1)$;
 x -intercepts: $-1, 0, 1$; y -intercept: 0
 (b) Crosses at $-1, 0, 1$
 (c) $y = -4x^3$ (d) 2
 (e) Near -1 : $f(x) \approx -8(x + 1)$;
 Near 0 : $f(x) \approx 4x$;
 Near 1 : $f(x) \approx -8(x - 1)$
 (f)



17. (a) x -intercepts: $-3, -1, 1$; y -intercept: 3
 (b) Crosses at $-3, -1$; touches at 1 (c) $y = x^4$
 (d) 3 (e) Near -3 : $f(x) \approx -32(x + 3)$;
 Near -1 : $f(x) \approx 8(x + 1)$; Near 1 : $f(x) \approx 8(x - 1)^2$
 (f)



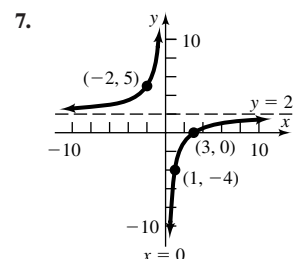
18. (a) x -intercepts: $-2, 2, 4$; y -intercept: 32
 (b) Crosses at 2 and 4 ; touches at -2 (c) $y = x^4$
 (d) 3 (e) Near -2 : $f(x) \approx 24(x + 2)^2$;
 Near 2 : $f(x) = -32(x - 2)$; Near 4 : $f(x) \approx 72(x - 4)$
 (f)



19. Domain: $\{x|x \neq -3, x \neq 3\}$; horizontal asymptote: $y = 0$; vertical asymptotes: $x = -3, x = 3$ 20. Domain: $\{x|x \neq 2\}$; oblique asymptote: $y = x + 2$; vertical asymptote: $x = 2$ 21. Domain: $\{x|x \neq -2\}$; horizontal asymptote: $y = 1$; vertical asymptote: $x = -2$ 22. Domain: $\{x|x \neq 1\}$; horizontal asymptote: $y = 1$; vertical asymptote: $x = 1$
 23. 1. $R(x) = \frac{2(x-3)}{x}$; domain: $\{x|x \neq 0\}$; no y -intercept 2. R is in lowest terms; x -intercept: 3 3. R is in lowest terms; vertical asymptote: $x = 0$ 4. Horizontal asymptote: $y = 2$; not intersected

5.

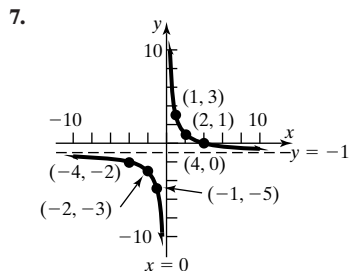
Interval	$(-\infty, 0)$	$(0, 3)$	$(3, \infty)$
Number Chosen	-2	1	4
Value of R	$R(-2) = 5$	$R(1) = -4$	$R(4) = \frac{1}{2}$
Location of Graph	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-2, 5)$	$(1, -4)$	$(4, \frac{1}{2})$



24. 1. Domain: $\{x|x \neq 0\}$; no y-intercept 2. R is in lowest terms; x-intercept: 4 3. R is in lowest terms; vertical asymptote: $x = 0$ 4. Horizontal asymptote: $y = -1$; not intersected

5.

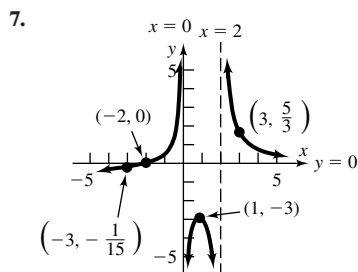
	$-\infty$	0	4	∞
Interval	$(-\infty, 0)$	$(0, 4)$	$(4, \infty)$	
Number Chosen	-1	1	5	
Value of R	$R(-1) = -5$	$R(1) = 3$	$R(5) = -0.2$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	
Point on Graph	$(-1, -5)$	$(1, 3)$	$(5, -0.2)$	



25. 1. Domain: $\{x|x \neq 0, x \neq 2\}$; no y-intercept 2. H is in lowest terms; x-intercept: -2 3. H is in lowest terms; vertical asymptotes: $x = 0, x = 2$ 4. Horizontal asymptote: $y = 0$; intersected at $(-2, 0)$

5.

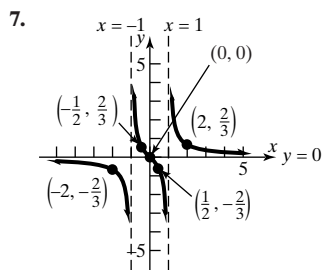
	$-\infty$	-2	0	2	∞
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, 2)$	$(2, \infty)$	
Number Chosen	-3	-1	1	3	
Value of H	$H(-3) = -\frac{1}{15}$	$H(-1) = \frac{1}{3}$	$H(1) = -3$	$H(3) = \frac{5}{3}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, -\frac{1}{15})$	$(-1, \frac{1}{3})$	$(1, -3)$	$(3, \frac{5}{3})$	



26. 1. $H(x) = \frac{x}{(x+1)(x-1)}$; domain: $\{x|x \neq -1, x \neq 1\}$; y-intercept: 0 2. H is in lowest terms; x-intercept: 0 3. H is in lowest terms; vertical asymptotes: $x = -1$ and $x = 1$ 4. Horizontal asymptote: $y = 0$; intersected at $(0, 0)$

5.

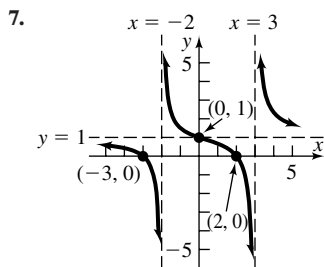
	$-\infty$	-1	0	1	∞
Interval	$(-\infty, -1)$	$(-1, 0)$	$(0, 1)$	$(1, \infty)$	
Number Chosen	-2	$-\frac{1}{2}$	$\frac{1}{2}$	2	
Value of H	$H(-2) = -\frac{2}{3}$	$H(-\frac{1}{2}) = \frac{2}{3}$	$H(\frac{1}{2}) = -\frac{2}{3}$	$H(2) = \frac{2}{3}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-2, -\frac{2}{3})$	$(-\frac{1}{2}, \frac{2}{3})$	$(\frac{1}{2}, -\frac{2}{3})$	$(2, \frac{2}{3})$	



27. 1. $R(x) = \frac{(x+3)(x-2)}{(x-3)(x+2)}$ domain: $\{x|x \neq -2, x \neq 3\}$; y-intercept: 1 2. R is in lowest terms; x-intercepts: -3, 2 3. R is in lowest terms; asymptote: $x = -2, x = 3$ 4. Horizontal asymptote: $y = 1$; intersected at $(0, 1)$

5.

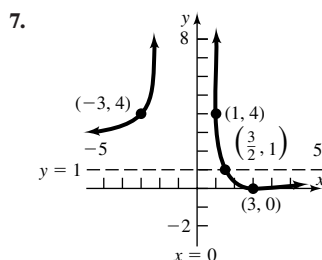
	$-\infty$	-3	-2	2	3	∞
Interval	$(-\infty, -3)$	$(-3, -2)$	$(-2, 2)$	$(2, 3)$	$(3, \infty)$	
Number Chosen	-4	-2.5	0	2.5	4	
Value of R	$R(-4) \approx 0.43$	$R(-2.5) \approx -0.82$	$R(0) = 1$	$R(2.5) \approx -1.22$	$R(4) = \frac{7}{3}$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-4, 0.43)$	$(-2.5, -0.82)$	$(0, 1)$	$(2.5, -1.22)$	$(4, \frac{7}{3})$	



28. 1. $R(x) = \frac{(x-3)^2}{x^2}$; domain: $\{x|x \neq 0\}$; no y-intercept
 2. R is in lowest terms; x-intercept: 3;
 3. R is in lowest terms; vertical asymptote: $x = 0$
 4. Horizontal asymptote: $y = 1$; intersected at $(\frac{3}{2}, 1)$

5.

	$-\infty$	0	3	∞
Interval	$(-\infty, 0)$	$(0, 3)$	$(3, \infty)$	
Number Chosen	-3	1	4	
Value of R	$R(-3) = 4$	$R(1) = 4$	$R(4) = \frac{1}{16}$	
Location of Graph	Above x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-3, 4)$	$(1, 4)$	$(4, \frac{1}{16})$	

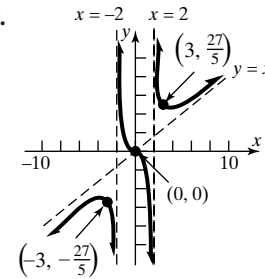


29. 1. $F(x) = \frac{x^3}{(x+2)(x-2)}$; domain: $\{x|x \neq -2, x \neq 2\}$; y-intercept: 0 2. F is in lowest terms; x-intercept: 0 3. F is in lowest terms; vertical asymptotes: $x = -2, x = 2$ 4. Oblique asymptote: $y = x$; intersected at $(0, 0)$

5.

	$-\infty$	-2	0	2	∞
Interval	$(-\infty, -2)$	$(-2, 0)$	$(0, 2)$	$(2, \infty)$	
Number Chosen	-3	-1	1	2	
Value of F	$F(-3) = -\frac{27}{5}$	$F(-1) = \frac{1}{3}$	$F(1) = -\frac{1}{3}$	$F(2) = \frac{27}{5}$	
Location of Graph	Below x -axis	Above x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-3, -\frac{27}{5})$	$(-1, \frac{1}{3})$	$(1, -\frac{1}{3})$	$(2, \frac{27}{5})$	

7.

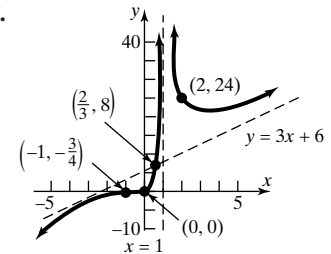


30. 1. Domain: $\{x|x \neq 1\}$; y-intercept: 0 2. F is in lowest terms; x-intercept: 0 3. F is in lowest terms; vertical asymptote: $x = 1$ 4. Oblique asymptote: $y = 3x + 6$; intersected at $(\frac{2}{3}, 8)$

5.

	$-\infty$	0	1	∞
Interval	$(-\infty, 0)$	$(0, 1)$	$(1, \infty)$	
Number Chosen	-1	$\frac{1}{2}$	2	
Value of F	$F(-1) = -\frac{3}{4}$	$F(\frac{1}{2}) = 1.5$	$F(2) = 24$	
Location of Graph	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-1, -\frac{3}{4})$	$(\frac{1}{2}, 1.5)$	$(2, 24)$	

7.

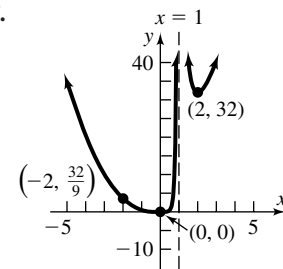


31. 1. Domain: $\{x|x \neq 1\}$; y-intercept: 0 2. R is in lowest terms; x-intercept: 0 3. R is in lowest terms; vertical asymptote: $x = 1$ 4. No oblique or horizontal asymptote

5.

	$-\infty$	0	1	∞
Interval	$(-\infty, 0)$	$(0, 1)$	$(1, \infty)$	
Number Chosen	-2	$\frac{1}{2}$	2	
Value of R	$R(-2) \approx \frac{32}{9}$	$R(\frac{1}{2}) = \frac{1}{2}$	$R(2) = 32$	
Location of Graph	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-2, \frac{32}{9})$	$(\frac{1}{2}, \frac{1}{2})$	$(2, 32)$	

7.

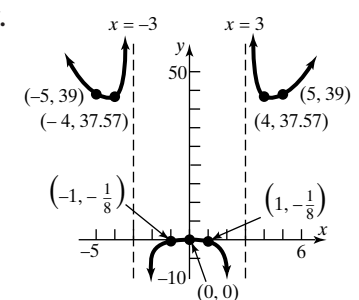


32. 1. $R(x) = \frac{x^4}{(x+3)(x-3)}$; domain: $\{x|x \neq -3, x \neq 3\}$; y-intercept: 0 2. R is in lowest terms; x-intercept: 0 3. R is in lowest terms; vertical asymptotes: $x = 3$ and $x = -3$ 4. No oblique or horizontal asymptote.

5.

	$-\infty$	-3	0	3	∞
Interval	$(-\infty, -3)$	$(-3, 0)$	$(0, 3)$	$(3, \infty)$	
Number Chosen	-4	-1	1	4	
Value of R	$R(-4) \approx 37.57$	$R(-1) = -\frac{1}{8}$	$R(1) = -\frac{1}{8}$	$R(4) = 37$	
Location of Graph	Above x -axis	Below x -axis	Below x -axis	Above x -axis	
Point on Graph	$(-4, 37.57)$	$(-1, -\frac{1}{8})$	$(1, -\frac{1}{8})$	$(4, 37.57)$	

7.



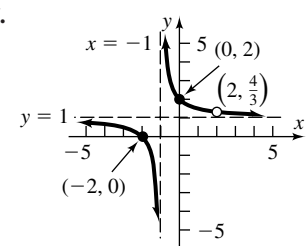
33. 1. $G(x) = \frac{(x+2)(x-2)}{(x+1)(x-2)}$; domain: $\{x|x \neq -1, x \neq 2\}$; y-intercept: 2 2. In lowest terms, $G(x) = \frac{x+2}{x+1}$; x-intercept: -2

3. Vertical asymptote: $x = -1$; hole at $(2, \frac{4}{3})$ 4. Horizontal asymptote: $y = 1$, not intersected

5.

	$-\infty$	-2	-1	2	∞
Interval	$(-\infty, -2)$	$(-2, -1)$	$(-1, 2)$	$(2, \infty)$	
Number Chosen	-3	-1.5	0	3	
Value of G	$G(-3) = \frac{1}{2}$	$G(-1.5) = -1$	$G(0) = 2$	$G(3) = 1.25$	
Location of Graph	Above x -axis	Below x -axis	Above x -axis	Above x -axis	
Point on Graph	$(-3, \frac{1}{2})$	$(-1.5, -1)$	$(0, 2)$	$(3, 1.25)$	


7.



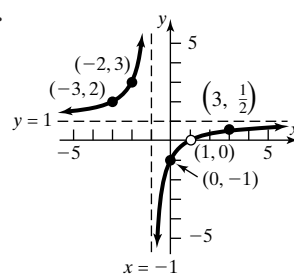
34. 1. $F(x) = \frac{(x-1)^2}{(x+1)(x-1)}$; domain: $\{x|x \neq -1, x \neq 1\}$; y-intercept: -1 2. In lowest terms, $F(x) = \frac{x-1}{x+1}$; no x -intercepts

3. Vertical asymptote: $x = -1$; hole at $(1, 0)$ 4. Horizontal asymptote: $y = 1$, not intersected

5.

			
Interval	$(-\infty, -1)$	$(-1, 1)$	$(1, \infty)$
Number Chosen	-2	0	3
Value of F	$F(-2) = 3$	$F(0) = -1$	$F(3) = \frac{1}{2}$
Location of Graph	Above x -axis	Below x -axis	Above x -axis
Point on Graph	$(-2, 3)$	$(0, -1)$	$(3, \frac{1}{2})$

7.



35. $\{x | -\infty < x < -2 \text{ or } -1 < x < 2\}; (-\infty, -2) \text{ or } (-1, 2)$

36. $\{x | -4 \leq x \leq -1 \text{ or } x \geq 1\}; [-4, -1] \text{ or } [1, \infty)$

37. $\{x | -3 < x \leq 3\}; (-3, 3]$

38. $\{x | x < \frac{1}{3} \text{ or } x > 1\}; (-\infty, \frac{1}{3}) \text{ or } (1, \infty)$

39. $\{x | x < 1 \text{ or } x > 2\}; (-\infty, 1) \text{ or } (2, \infty)$

40. $\{x | -\frac{5}{2} < x \leq -\frac{7}{6}\}; (-\frac{5}{2}, -\frac{7}{6}]$

41. $\{x | 1 \leq x \leq 2 \text{ or } x > 3\}; [1, 2] \text{ or } (3, \infty)$

42. $\{x | x \leq -1 \text{ or } 0 < x < 5\}; (-\infty, -1] \text{ or } (0, 5)$

43. $\{x | x < -4 \text{ or } 2 < x < 4 \text{ or } x > 6\};$

$(-\infty, -4) \text{ or } (2, 4) \text{ or } (6, \infty)$

44. $\{x | x < -5 \text{ or } -4 < x \leq -2 \text{ or } 0 \leq x \leq 1\}; (-\infty, -5) \text{ or } (-4, -2] \text{ or } [0, 1]$

45. $q(x) = 8x^2 + 5x + 6$;

$R = 10$; g is not a factor of f .

46. $q(x) = 2x^2 + 12x + 19$; $R = 43$; g is not a factor of f .

47. $q(x) = x^3 - 4x^2 + 8x - 1$; $R = 0$;

g is a factor of f .

48. $q(x) = x^3 - x^2 + 2$; $R = 0$; g is a factor of f .

49. $f(4) = 47,105$

50. $f(-2) = 204$

51. 4, 2, or 0 positive; 2 or 0 negative

52. 1 positive; 2 or 0 negative

53. $\pm 1, \pm 3, \pm \frac{1}{2}, \pm \frac{3}{2}, \pm \frac{1}{3}, \pm \frac{4}{3}, \pm \frac{1}{4}, \pm \frac{3}{4}, \pm \frac{1}{6}, \pm \frac{1}{12}$

54. $\pm 1, \pm \frac{1}{2}, \pm \frac{1}{3}, \pm \frac{1}{6}$

55. -2, 1, 4; $f(x) = (x + 2)(x - 1)(x - 4)$

56. -1, 4, -2; $f(x) = (x + 1)(x - 4)(x + 2)$

57. $\frac{1}{2}$, multiplicity 2; -2; $f(x) = 4(x - \frac{1}{2})^2(x + 2)$

58. $-\frac{1}{2}$, multiplicity 2; 2;

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

59. 2, multiplicity 2; $f(x) = (x - 2)^2(x^2 + 5)$

60. -3, multiplicity 2; $f(x) = (x + 3)^2(x^2 + 2)$

61. $\{-3, 2\}$

62. $\{-3, 2\}$

63. $\{-3, -1, -\frac{1}{2}, 1\}$

64. $\{-3, -2, -\frac{1}{2}, 2\}$

65. 5

66. 11

67. $\frac{37}{2}$

68. $\frac{17}{3}$

69. $f(0) = -1$; $f(1) = 1$

70. $f(1) = -2$; $f(2) = 9$

71. $f(0) = -1$; $f(1) = 1$

72. $f(1) = -3$; $f(2) = 62$

73. 1.52

74. 1.33

75. 0.93

76. 1.14

77. $4 - i$

78. $3 - 4i$

79. $-i, 1 - i$

80. $1 - i$

81. -2, 1, 4; $f(x) = (x + 2)(x - 1)(x - 4)$

82. -2, -1, 4; $f(x) = (x + 2)(x + 1)(x - 4)$

83. -2; $\frac{1}{2}$ (multiplicity 2); $f(x) = 4(x + 2)(x - \frac{1}{2})^2$

84. $-\frac{1}{2}$ (multiplicity 2); 2; $f(x) = 4(x + \frac{1}{2})^2(x - 2)$

85. 2 (multiplicity 2); $-\sqrt{5}i, \sqrt{5}i$; $f(x) = (x + \sqrt{5}i)(x - \sqrt{5}i)(x - 2)^2$

86. -3 (multiplicity 2); $-\sqrt{2}i, \sqrt{2}i$; $f(x) = (x + 3)^2(x + \sqrt{2}i)(x - \sqrt{2}i)$

87. -3, 2, $-\frac{\sqrt{2}}{2}i, \frac{\sqrt{2}}{2}i$; $f(x) = 2(x + 3)(x - 2)(x + \frac{\sqrt{2}}{2}i)(x - \frac{\sqrt{2}}{2}i)$

88. -3, 2, $-\frac{\sqrt{3}}{3}i, \frac{\sqrt{3}}{3}i$; $f(x) = 3(x + 3)(x - 2)(x + \frac{\sqrt{3}}{3}i)(x - \frac{\sqrt{3}}{3}i)$

89. 199.9 pounds

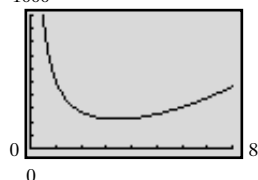
90. 14.7 ohms

91. (a) $A(r) = 2\pi r^2 + \frac{500}{r}$

(b) 223.22 cm^2

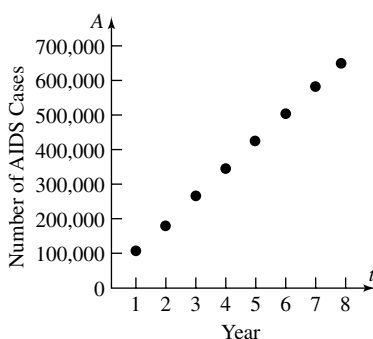
(c) 257.08 cm^2

(d) 1000



A is smallest when $r \approx 3.41$ cm.

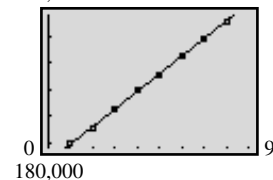
92. (a)



(b) $A(t) = -212.01t^3 + 2429.13t^2 + 59,568.85t + 130,003.14$

(c) 797,003

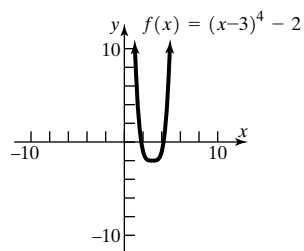
680,000



95. (a) Even (b) Positive (c) Even (d) The graph touches the x -axis at $x = 0$, but does not cross it there. (e) 8

Chapter Test (page 259)

1.



2. (a) 3 (b) Every zero of g lies between -15 and 15.

(c) $\frac{p}{q}: \pm \frac{1}{2}, \pm 1, \pm \frac{3}{2}, \pm \frac{5}{2}, \pm 3, \pm 5, \pm \frac{15}{2}, \pm 15$

(d) -5, $-\frac{1}{2}$; $g(x) = (x + 5)(2x + 1)(x - 3)$

(e) y -intercept: -15 x -intercepts: -5, $-\frac{1}{2}$, 3

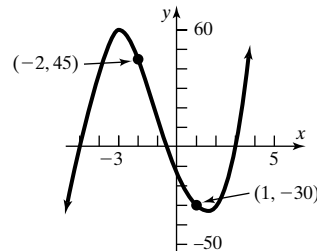
(f) Crosses at -5, $-\frac{1}{2}$, 3 (g) $y = 2x^3$

(h) Near -5: $g(x) \approx 72(x + 5)$

Near $-\frac{1}{2}$: $g(x) \approx -\frac{63}{4}(2x + 1)$

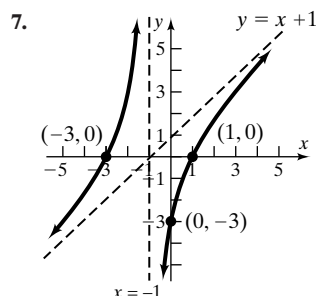
Near 3: $g(x) \approx 56(x - 3)$

(i)



3. $4, -5i, 5i$ 4. $\left\{1, \frac{5 - \sqrt{61}}{6}, \frac{5 + \sqrt{61}}{6}\right\}$ 5. Domain: $\{x|x \neq -10, x \neq 4\}$; asymptotes: $x = -10, y = 2$

6. Domain: $\{x|x \neq -1\}$; asymptotes: $x = -1, y = x + 1$



8. Answers may vary. One possibility is $f(x) = x^4 - 4x^3 - 2x^2 + 20x$.

9. Answers may vary. One possibility is $r(x) = \frac{2(x-9)(x-1)}{(x-4)(x-9)}$.

10. $f(0) = 8; f(4) = -36$

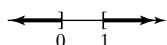
Since $f(0) = 8 > 0$ and $f(4) = -36 < 0$, the Intermediate Value Theorem guarantees that there is at least one real zero between 0 and 4.

11. $\{x|x < 3 \text{ or } x > 8\}; (-\infty, 3) \text{ or } (8, \infty)$

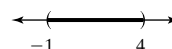
Cumulative Review (page 261)

1. $\sqrt{26}$

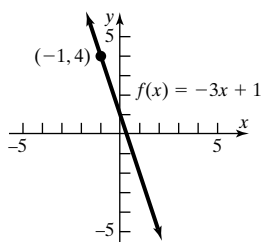
2. $\{x|x \leq 0 \text{ or } x \geq 1\};$
 $(-\infty, 0] \text{ or } [1, \infty)$



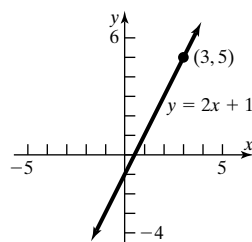
3. $\{x|-1 < x < 4\}; (-1, 4)$



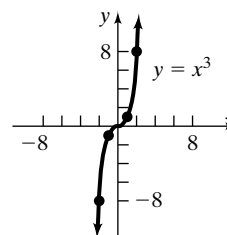
4. $f(x) = -3x + 1$



5. $y = 2x - 1$



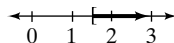
6.



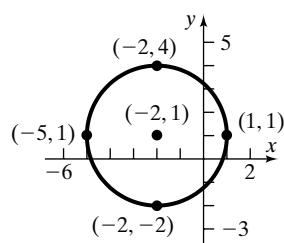
7. Not a function; 3 has two images

8. $\{0, 2, 4\}$

9. $\left\{x \mid x \geq \frac{3}{2}\right\}; \left[\frac{3}{2}, \infty\right)$



10. Center: $(-2, 1)$; radius: 3



11. x-intercepts: $-3, 0, 3$; y-intercept: 0; symmetric with respect to the origin

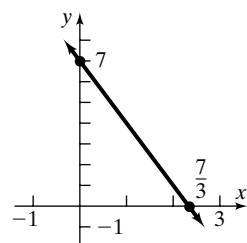
12. $y = -\frac{2}{3}x + \frac{17}{3}$

13. Not a function; it fails the Vertical Line Test.

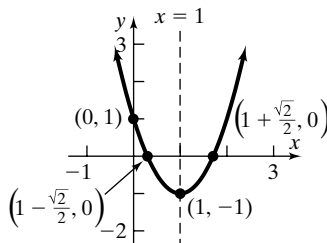
14. (a) 22 (b) $x^2 - 5x - 2$ (c) $-x^2 - 5x + 2$ (d) $9x^2 + 15x - 2$ (e) $2x + h + 5$

15. (a) $\{x|x \neq 1\}$ (b) No, $(2, 7)$ is on the graph. (c) 4; $(3, 4)$ is on the graph. (d) $\frac{7}{4}; \left(\frac{7}{4}, 9\right)$ is on the graph.

16.



17.



18. $x + 4; m_{\text{sec}} = 6$

19. (a) x-intercepts: $-5, -1, 5$; y-intercept: -3

(b) No symmetry

(c) Neither

(d) Increasing: $(-\infty, -3)$ and $(2, \infty)$;

decreasing: $(-3, 2)$

(e) Local maximum is 5 and occurs at $x = -3$.

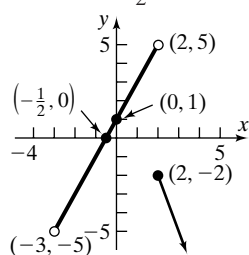
(f) Local minimum is -6 and occurs at $x = 2$.

20. Odd

21. (a) Domain: $\{x|-3 < x\} \text{ or } (-3, \infty)$

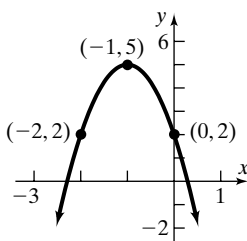
(b) x-intercept: $-\frac{1}{2}$; y-intercept: 1

(c)



(d) Range: $\{y|y < 5\} \text{ or } (-\infty, 5)$

22.



23. (a) $(f + g)(x) = x^2 - 9x - 6$; domain: all real numbers

(b) $\left(\frac{f}{g}\right)(x) = \frac{x^2 - 5x + 1}{-4x - 7}$; domain: $\left\{x \mid x \neq -\frac{7}{4}\right\}$

24. (a) $R(x) = -\frac{1}{10}x^2 + 150x$

(b) \$14,000 (c) 750; \$56,250 (d) \$75