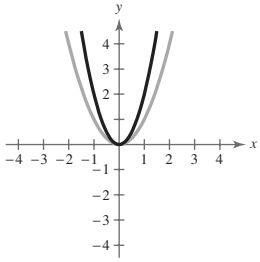
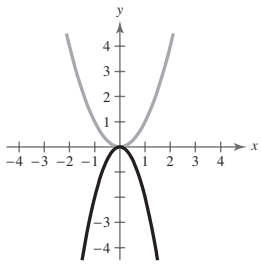
Review Exercises *(page 208)*

1. (a)



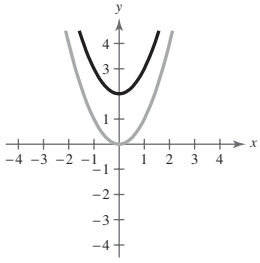
Vertical stretch

(b)



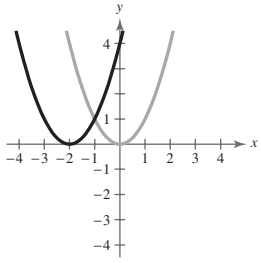
Vertical stretch and reflection in the x-axis

(c)



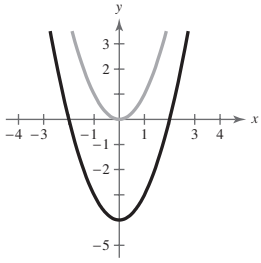
Vertical shift

(d)



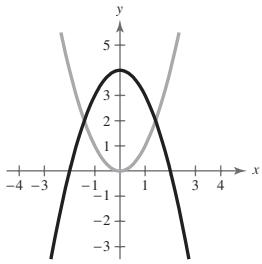
Horizontal shift

2. (a)



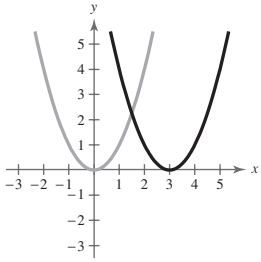
Vertical shift

(b)



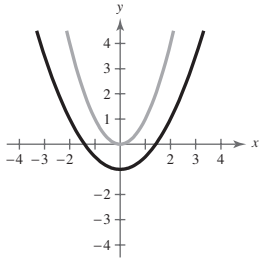
Reflection in the x-axis and vertical shift

(c)



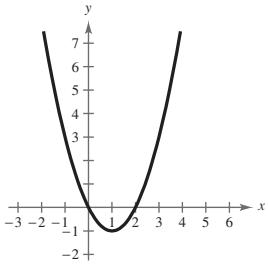
Horizontal shift

(d)



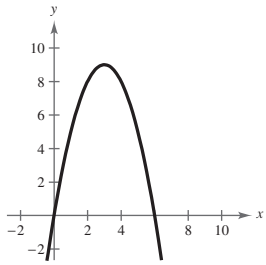
Vertical shrink and vertical shift

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



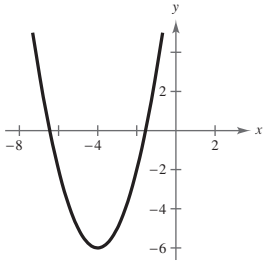
Vertex: $(1, -1)$
Axis of symmetry: $x = 1$
x-intercepts: $(0, 0), (2, 0)$

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



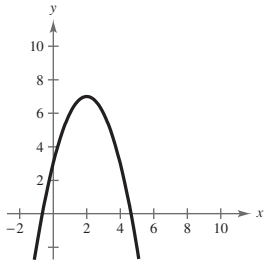
Vertex: $(3, 9)$
Axis of symmetry: $x = 3$
x-intercepts: $(0, 0), (6, 0)$

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



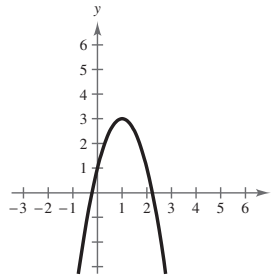
Vertex: $(-4, -6)$
Axis of symmetry: $x = -4$
x-intercepts: $\left(-4 \pm \sqrt{6}, 0\right)$

6. $h(x) = -(x - 2)^2 + 7$



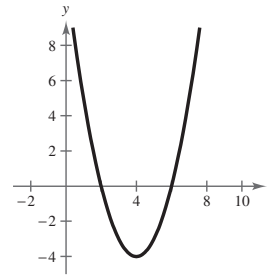
Vertex: $(2, 7)$
Axis of symmetry: $x = 2$
x-intercepts: $\left(2 \pm \sqrt{7}, 0\right)$

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



Vertex: $(1, 3)$
Axis of symmetry: $t = 1$
t-intercepts: $\left(1 \pm \frac{\sqrt{6}}{2}, 0\right)$

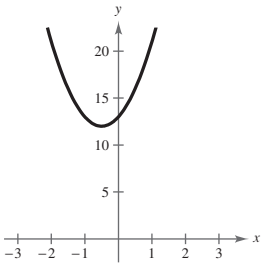
8. $f(x) = (x - 4)^2 - 4$



Vertex: $(4, -4)$
Axis of symmetry: $x = 4$
x-intercepts: $(2, 0), (6, 0)$

(Continued)

9. $h(x) = 4\left(x + \frac{1}{2}\right)^2 + 12$

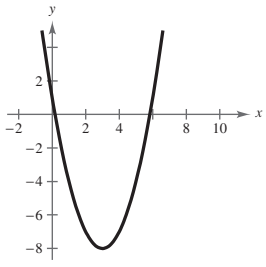


Vertex: $\left(-\frac{1}{2}, 12\right)$

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

No x-intercept

10. $f(x) = (x - 3)^2 - 8$

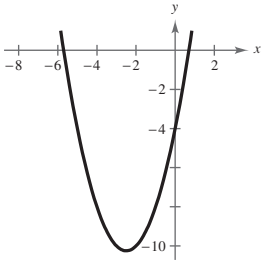


Vertex: $(3, -8)$

Axis of symmetry: $x = 3$

x-intercepts: $\left(3 \pm 2\sqrt{2},\ 0\right)$

11. $h(x) = \left(x + \frac{5}{2}\right)^2 - \frac{41}{4}$

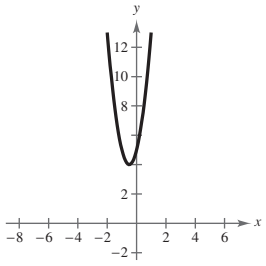


Vertex: $\left(-\frac{5}{2}, -\frac{41}{4}\right)$

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

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

12. $f(x) = 4\left(x + \frac{1}{2}\right)^2 + 4$

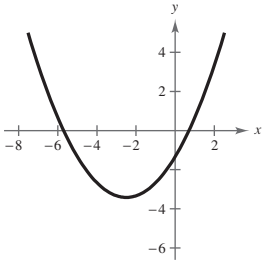


Vertex: $\left(-\frac{1}{2}, 4\right)$

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

No x-intercept

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

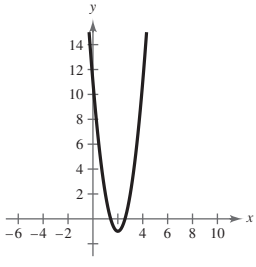


Vertex: $\left(-\frac{5}{2}, -\frac{41}{12}\right)$

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

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

14. $f(x) = 3(x - 2)^2 - 1$



Vertex: $(2, -1)$

Axis of symmetry: $x = 2$

x-intercepts: $\left(2 \pm \frac{\sqrt{3}}{3}, 0\right)$

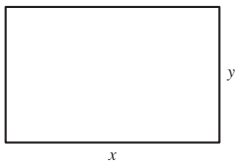
15. $f(x) = -\frac{1}{2}(x - 4)^2 + 1$

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

17. $f(x) = (x - 1)^2 - 4$

18. $f(x) = \frac{1}{3}(x - 2)^2 + 3$

19. (a)



(b) $y = 100 - x$

$A = 100x - x^2$

(c) $x = 50,\ y = 50$

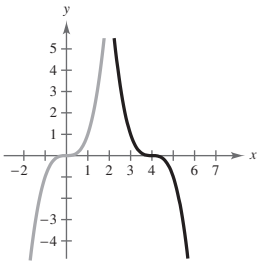
20. (a) \$12,000; \$13,750; \$15,000

(b) Maximum revenue at \$40; \$16,000. Any price greater or less than \$40 per unit will not yield as much revenue.

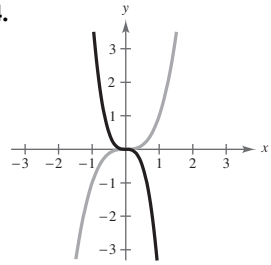
21. 1091 units

22. 24 years old

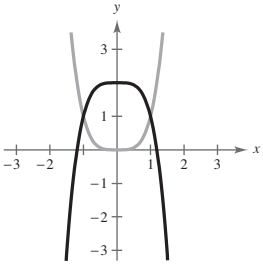
23.



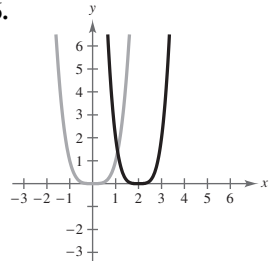
24.



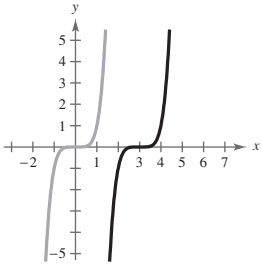
25.



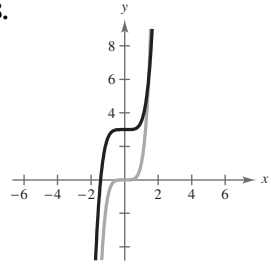
26.



27.



28.



29. Falls to the left, falls to the right

30. Falls to the left, rises to the right

31. Rises to the left, rises to the right

32. Rises to the left, falls to the right

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

34. 0, odd multiplicity; -3, even multiplicity; turning points: 2

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

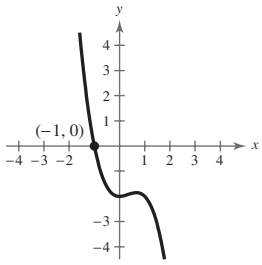
36. 8, odd multiplicity; 0, even multiplicity; turning points: 2

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

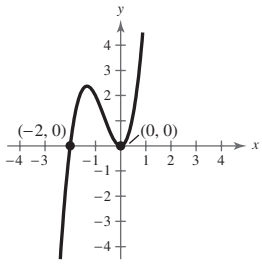
38. -1, 2, odd multiplicity; 0, even multiplicity; turning points: 3

(Continued)

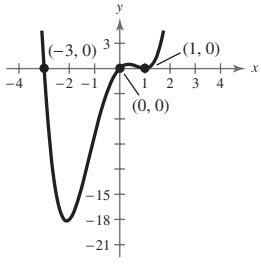
39. (a) Rises to the left, falls to the right (b) -1
(c) Answers will vary.
(d)



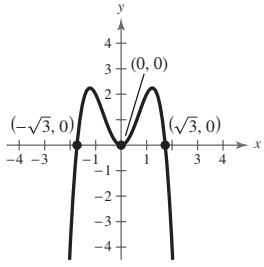
40. (a) Rises to the right, falls to the left
(b) $-2, 0$ (c) Answers will vary.
(d)



41. (a) Rises to the right, rises to the left (b) $-3, 0, 1$
(c) Answers will vary.
(d)



42. (a) Falls to the left, falls to the right
(b) $0, \pm\sqrt{3}$ (c) Answers will vary.
(d)



43. (a) $[-1, 0]$ (b) ≈ -0.900
44. (a) $[-5, -4]$ (b) ≈ -4.479
45. (a) $[-1, 0], [1, 2]$ (b) $\approx -0.200, \approx 1.772$
46. (a) $[-2, -1], [-1, 0]$ (b) $\approx -0.509, \approx -1.211$

47. $8x + 5 + \dfrac{2}{3x - 2}$ **48.** $\dfrac{4}{3} + \dfrac{29}{3(3x - 2)}$

49. $5x + 2$ **50.** $3x^2 + 3 + \dfrac{3}{x^2 - 1}$

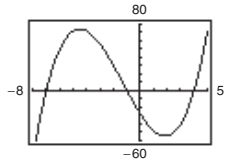
51. $x^2 - 3x + 2 - \dfrac{1}{x^2 + 2}$

52. $3x^2 + 5x + 8 + \dfrac{10}{2x^2 - 1}$

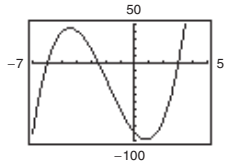
53. $6x^3 + 8x^2 - 11x - 4 - \dfrac{8}{x - 2}$

54. $0.1x^2 + 0.8x + 4 + \dfrac{19.5}{x - 5}$

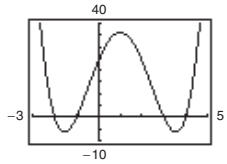
55. $2x^2 - 11x - 6$ **56.** $3x^2 + 11x - 4$
57. (a) Yes (b) Yes (c) Yes (d) No
58. (a) Yes (b) No (c) Yes (d) No
59. (a) -421 (b) -9 **60.** (a) -3276 (b) 0
61. (a) Answers will vary.
(b) $(x + 7), (x + 1)$
(c) $f(x) = (x + 7)(x + 1)(x - 4)$
(d) $-7, -1, 4$
(e)



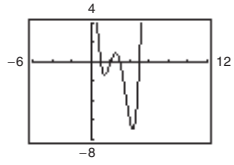
62. (a) Answers will vary. (b) $(2x + 5), (x - 3)$
(c) $f(x) = (2x + 5)(x - 3)(x + 6)$ (d) $-\frac{5}{2}, 3, -6$
(e)



63. (a) Answers will vary. (b) $(x + 1), (x - 4)$
(c) $f(x) = (x + 1)(x - 4)(x + 2)(x - 3)$
(d) $-2, -1, 3, 4$
(e)



64. (a) Answers will vary. (b) $(x - 1), (x - 3)$
(c) $f(x) = (x - 1)(x - 3)(x - 2)(x - 5)$ (d) $1, 2, 3, 5$
(e)



65. $6 + 2i$ **66.** $3 - 5i$ **67.** $-1 + 3i$
68. $-1 - 5i$ **69.** $3 + 7i$ **70.** $-\sqrt{2}\,i$
71. $40 + 65i$ **72.** $17 + 28i$ **73.** $-4 - 46i$

(Continued)

74. $9 + 20i$ **75.** $\frac{23}{17} + \frac{10}{17}i$ **76.** $\frac{17}{26} + \frac{7}{26}i$ **77.** $\frac{21}{13} - \frac{1}{13}i$

78. $\frac{9}{85} + \frac{83}{85}i$ **79.** $\pm\frac{\sqrt{3}}{3}i$ **80.** $\pm\frac{1}{2}i$ **81.** $1 \pm 3i$

82. $-\frac{1}{4} \pm \frac{\sqrt{71}}{4}i$ **83.** $0, 2$ **84.** $-9, 4$ **85.** $8, 1$

86. $0, \pm\sqrt{6}i$ **87.** $-4, 6, \pm 2i$ **88.** $5, 8, 3 \pm i$

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

90. $\pm 1, \pm 2, \pm 4, \pm 8, \pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{4}{3}, \pm\frac{8}{3}$

91. $-1, -3, 6$ **92.** $-1, \frac{5}{3}, 6$ **93.** $1, 8$

94. $-5, -2$ **95.** $-4, 3$ **96.** $-3, 2, \pm\frac{2}{5}$

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

98. $x^4 - x^3 - 3x^2 + 17x - 30$

99. $4, \pm i$ **100.** $2, \pm 4i$ **101.** $-3, \frac{1}{2}, 2 \pm i$

102. $0, \frac{3}{4}, 1 \pm i$

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

104. $-2, 3, 6; g(x) = (x + 2)(x - 3)(x - 6)$

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

106. $\pm 3, -4 \pm i$;
$f(x) = (x - 3)(x + 3)(x + 4 - i)(x + 4 + i)$

107. Two or no positive zeros, one negative zero

108. One or three positive real zeros, two or no negative real zeros

109–110. Answers will vary.

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

112. Domain: all real numbers x except $x = -\frac{1}{3}$

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

114. Domain: all real numbers x

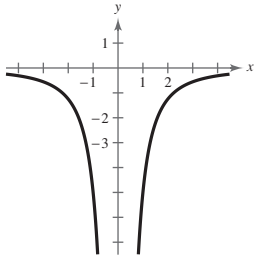
115. Vertical asymptote: $x = -3$
Horizontal asymptote: $y = 0$

116. Horizontal asymptote: $y = 2$

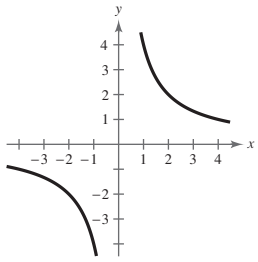
117. Vertical asymptote: $x = -3$
Horizontal asymptote: $y = 0$

118. Vertical asymptotes: $x = -2, -1$
Horizontal asymptotes: None

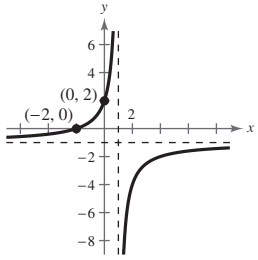
119. (a) Domain: all real numbers x except $x = 0$
(b) No intercepts
(c) Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 0$
(d)



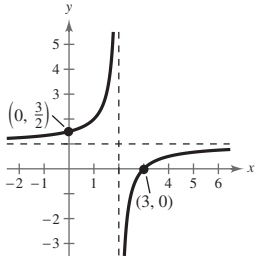
120. (a) Domain: all real numbers x except $x = 0$
(b) No intercepts
(c) Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 0$
(d)



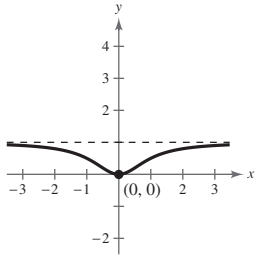
121. (a) Domain: all real numbers x except $x = 1$
(b) x-intercept: $(-2, 0)$
y-intercept: $(0, 2)$
(c) Vertical asymptote: $x = 1$
Horizontal asymptote: $y = -1$
(d)



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



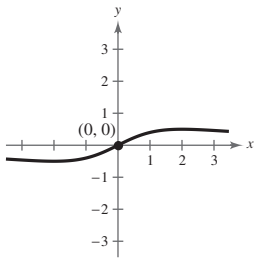
123. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = 1$
(d)



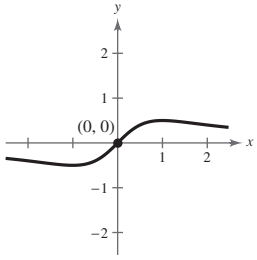
124. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = 0$

(Continued)

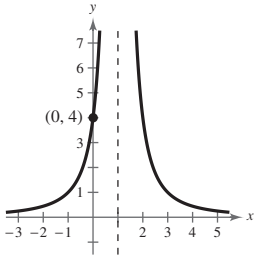
(d)



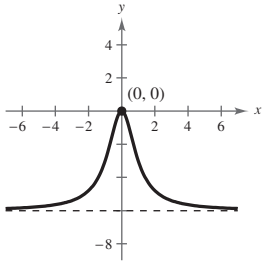
125. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = 0$
(d)



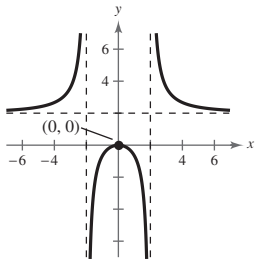
126. (a) Domain: all real numbers x except $x = 1$
(b) y-intercept: $(0, 4)$
(c) Vertical asymptote: $x = 1$
Horizontal asymptote: $y = 0$
(d)



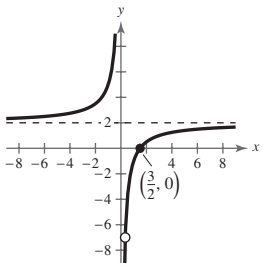
127. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = -6$
(d)



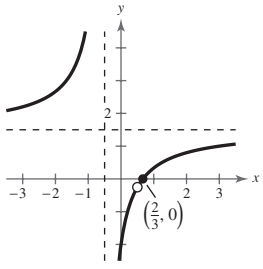
128. (a) Domain: all real numbers x except $x = \pm 2$
(b) Intercept: $(0, 0)$
(c) Vertical asymptotes: $x = \pm 2$
Horizontal asymptote: $y = 2$
(d)



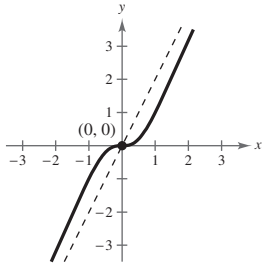
129. (a) Domain: all real numbers x except $x = 0, \frac{1}{3}$
(b) x-intercept: $(1.5, 0)$
(c) Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 2$
(d)



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



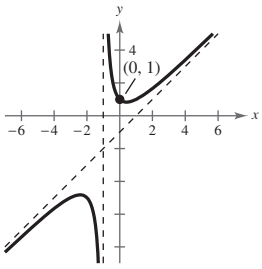
131. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$ (c) Slant asymptote: $y = 2x$
(d)



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

(Continued)

(d)



133. (a) Domain: all real numbers x except $x = \frac{4}{3}$

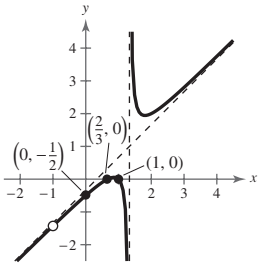
(b) y-intercept: $(0, -0.5)$

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

(c) Vertical asymptote: $x = \frac{4}{3}$

Slant asymptote: $y = x - \frac{1}{3}$

(d)



134. (a) Domain: all real numbers x except $x = \frac{1}{3}, -2$

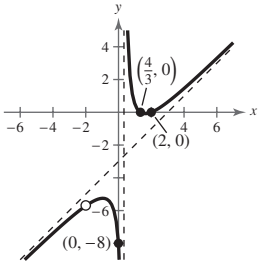
(b) x-intercepts: $(2, 0)$, $\left(\frac{4}{3}, 0\right)$

y-intercept: $(0, -8)$

(c) Vertical asymptote: $x = \frac{1}{3}$

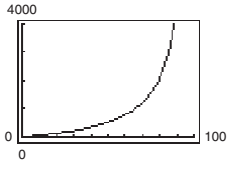
Slant asymptote: $y = x - 3$

(d)



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

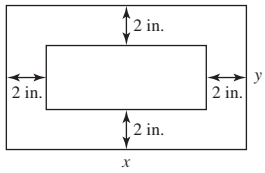
136. (a)



(b) \$176 million; \$528 million; \$1584 million (or \$1.584 billion)

(c) No

137. (a)



(b) $(x - 4)(y - 4) = 30$

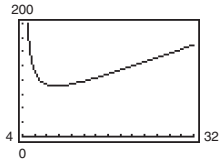
$$y = \frac{4x + 14}{x - 4}$$

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

$$= \frac{2x(2x + 7)}{x - 4}$$

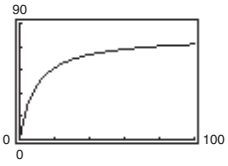
(c) $4 < x < \infty$

(d)



9.48 inches × 9.48 inches

138.



80.3 milligrams per square decimeter per hour

139. $\left(-\frac{4}{3}, \frac{1}{2}\right)$

140. $(-\infty, -3] \cup \left[\frac{5}{2}, \infty\right)$

141. $[-4, 0] \cup [4, \infty)$

142. $(-\infty, 0) \cup \left(0, \frac{5}{3}\right)$

143. $[-5, -1) \cup (1, \infty)$

144. $(-\infty, 3) \cup (5, \infty)$

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

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

147. 4.9%

148. 9 days

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

150. False. The domain of $f(x) = \dfrac{1}{x^2 + 1}$ is the set of all real numbers.

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

152. Answers will vary. Sample answer:

A polynomial of degree $n > 0$ with real coefficients can be written as the product of linear and quadratic factors with real coefficients, where the quadratic factors have no real zeros.

Setting the factors equal to zero and solving for the variable can find the zeros of a polynomial function.

To solve an equation is to find all the values of the variable for which the equation is true.

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

Chapter Test *(page 212)*

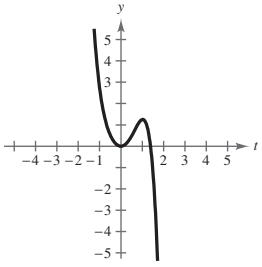
1. (a) Reflection in the x-axis followed by a vertical translation
(b) Horizontal translation

2. $y = (x - 3)^2 - 6$

3. (a) 50 feet

(b) 5. Yes, changing the constant term results in a vertical translation of the graph and therefore changes the maximum height.

4. Rises to the left, falls to the right



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

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

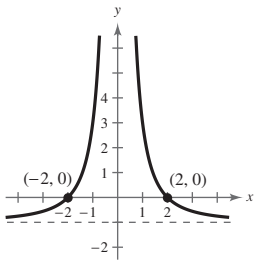
8. (a) $-3 + 5i$ (b) 7 **9.** $2 - i$

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

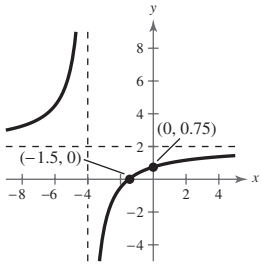
11. $f(x) = x^4 - 6x^3 + 16x^2 - 24x + 16$

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

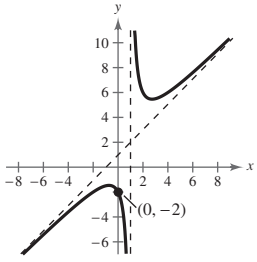
14. x-intercepts: $(-2, 0), (2, 0)$
No y-intercept
Vertical asymptote: $x = 0$
Horizontal asymptote: $y = -1$



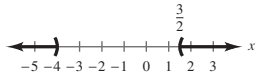
15. x-intercept: $(-1.5, 0)$
y-intercept: $(0, 0.75)$
Vertical asymptote: $x = -4$
Horizontal asymptote: $y = 2$



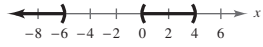
16. No x-intercept
y-intercept: $(0, -2)$
Vertical asymptote: $x = 1$
Slant asymptote: $y = x + 1$



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



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



Problem Solving *(page 215)*

1. Answers will vary.

2. (a)

y	1	2	3	4	5
$y^3 + y^2$	2	12	36	80	150

y	6	7	8	9	10
$y^3 + y^2$	252	392	576	810	1100

(b) $x = 6$ (c) $x = 6$ (d) $x = 3$ (e) $x = 10$
(f) $x = 6$ (g) $x = 3$

3. 2 inches $\times$ 2 inches $\times$ 5 inches

4. False, the statement would be true if the 2 were replaced by $f(-1)$.

5. (a) and (b) $y = -x^2 + 5x - 4$

6. (a) $m_1 = 5$; less than (b) $m_2 = 3$; greater than
(c) $m_3 = 4.1$; less than (d) $m_h = h + 4$
(e) $m_h = 3, 5, 4.1$; The values are the same.
(f) $m_{\tan} = 4$ since $h = 0$.

7. (a) $f(x) = (x - 2)x^2 + 5 = x^3 - 2x^2 + 5$
(b) $f(x) = -(x + 3)x^2 + 1 = -x^3 - 3x^2 + 1$

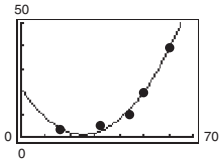
8. (a) $\frac{1}{2} - \frac{1}{2}i$ (b) $\frac{3}{10} + \frac{1}{10}i$ (c) $-\frac{1}{34} - \frac{2}{17}i$

9. $(a + bi)(a - bi) = a^2 + abi - abi - b^2i^2$
$= a^2 + b^2$

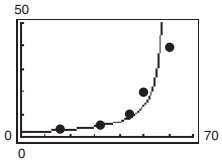
10. (i) d (ii) b (iii) a (iv) c

11. (a) As $|a|$ increases, the graph stretches vertically. For $a < 0$, the graph is reflected in the x-axis.
(b) As $|b|$ increases, the vertical asymptote is translated. For $b > 0$, the graph is translated to the right. For $b < 0$, the graph is reflected in the x-axis and is translated to the left.

12. (a) $y_1 = 0.031x^2 - 1.57x + 21.0$



(b) $y_2 = \dfrac{-134.82}{x - 59.93}$



(c) The models are a good fit for the original data.
(d) $y_1 = 1.125$; $y_2 = 3.861$
The rational model is the better fit for the original data.
(e) The reciprocal model should not be used to predict the near point for a person who is 70 years old because a negative value is obtained. The quadratic model is a better fit.