

Answer Key

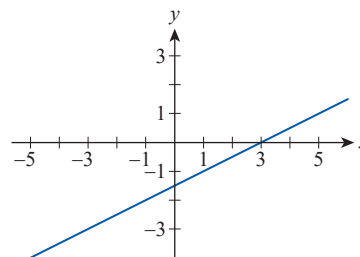
Chapter 1

Section 1.1

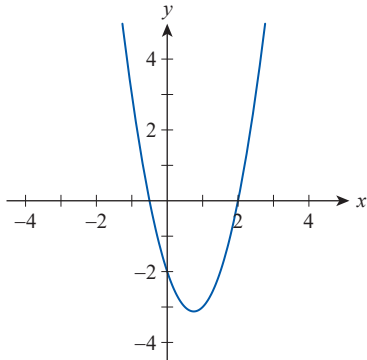
1. Dom = $\{-3, 0, 1\}$, Ran = $\{-1, 0, 1, 2, 5\}$
3. Dom = $\{-2, 3, 4\}$, Ran = $\{-8, 0, \cos 3, 5.98\}$
5. Dom = $\{\text{Tanisha, Don, Peter, David}\}$,
Ran = $\{\text{swimming, biking, skating, skateboarding}\}$
7. Dom = $\mathbb{Z}$, Ran = $\{\dots, -1, 1, 3, 5, \dots\}$
9. Dom = $\mathbb{R}$, Ran = $\{\dots, 3, 5, 7, 9, \dots\}$
11. Dom = $\mathbb{R}$, Ran = $\mathbb{R}$ 13. Dom = $\{5\}$, Ran = $\mathbb{R}$
15. Dom = $[-1, \infty)$, Ran = $\mathbb{R}$
17. Dom = $[-2, 4]$, Ran = $[-3, 3]$
19. Dom = $\mathbb{R}$, Ran = $[0, 1]$
21. Dom = $\mathbb{R}$, Ran = $\mathbb{R}$
23. Dom = $\{\text{Registered students}\}$,
Ran = $\{\text{Courses offered}\}$
25. Dom = $\{\text{People in a certain group}\}$,
Ran = $\{\text{Fathers of the people in the group}\}$
27. $\{(1, 1), (2, 2), (3, 3), (4, 4), (5, 5)\}$
29. $\left\{ \begin{array}{l} (1, 1), (1, 2), (1, 3), (1, 4), (1, 5), \\ (2, 2), (2, 4), (3, 3), (4, 4), (5, 5) \end{array} \right\}$
31. Function
33. Not a function; -1 appears twice as first coordinate.
35. Not a function; it doesn't pass the vertical line test.
37. Function 39. Function 41. Function
43. Not a function; it doesn't pass the vertical line test.
45. Function 47. Function
49. Not a function; it doesn't pass the vertical line test.
(However, x is a function of y .)
51. Function (F is a function of r .)
53. $y = -\frac{1}{3}x + \frac{10}{3}$ 55. $y = x^2 + \frac{1}{3}x - \frac{5}{3}$
57. $y = \frac{3x+1}{x^2-1}$
59. a. $\frac{4}{3}$ b. $\frac{1}{3}x + \frac{7}{3}$ c. $\frac{1}{3}(x+h)+2$ d. $\frac{1}{3}$
61. a. 1 b. $x^2 + 2x - 2$ c. $(x+h)^2 - 3$ d. $2x + h$
63. a. Undefined b. $\sqrt{x+1}$
c. $\sqrt{x+h}$ d. $\frac{\sqrt{x+h}-\sqrt{x}}{h}$
65. a. -1 b. $\frac{1}{x+2}$
c. $\frac{1}{x+h+1}$ d. $-\frac{1}{(x+1)(x+h+1)}$
67. Dom = $\mathbb{N}$, Cod = $\mathbb{N}$, Ran = $\{2, 3, 4, 5, \dots\}$
69. Dom = $\mathbb{Z}$, Cod = $\mathbb{Z}$, Ran = $\{0, 1, 4, 9, 16, \dots\}$
71. Dom = $[0, \infty)$, Cod = $\mathbb{R}$, Ran = $[0, \infty)$
73. $(-\infty, -2) \cup (-2, 3) \cup (3, \infty)$
75. $(-\infty, 1) \cup (3, \infty)$ 77. $[0, 2]$
79. $(-\infty, -3/2) \cup (-3/2, \infty)$ 81. $\{\theta \in \mathbb{R} \mid \theta \neq 2k\pi, k \in \mathbb{Z}\}$
83. $C(r) = 2\pi r$ 85. $C(F) = \frac{5}{9}(F - 32)$
87. $V(b, h) = \frac{1}{3}b^2h$; a function of two variables
89. Function 91. Not a function 93. Not a function
95. Decreasing on $(-\infty, 1)$; increasing on $(1, \infty)$
97. Increasing on $(-\infty, -2), (2, \infty)$; decreasing on $(-2, 2)$
99. Decreasing on $(-\infty, 1)$; increasing on $(1, \infty)$
101. Decreasing on $(-\infty, -1)$; constant on $(-1, 2)$;
increasing on $(2, \infty)$
103. Symmetric with respect to the x -axis
105. Symmetric with respect to both axes and the origin
107. Symmetric with respect to the origin
109. Symmetric with respect to the x -axis
111. $P(A) = 4\sqrt{A}$ 113. $V(x) = x(30 - 2x)(20 - 2x)$
115. $V(r) = \frac{2\pi r^3}{3}$ 117. $C(F) = \frac{5}{9}(F - 32)$

Section 1.2

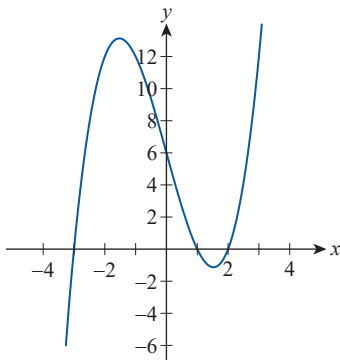
1. Deg.: 1; lead. coeff.: $1/2$;
 x -int.: 3; y -int.: $-3/2$; Ran = $\mathbb{R}$



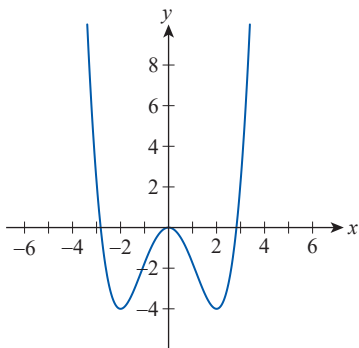
3. Deg.: 2; lead. coeff.: 2;
x-int.: 2, $-1/2$; y-int.: -2 ; $\text{Ran} = [-25/8, \infty)$



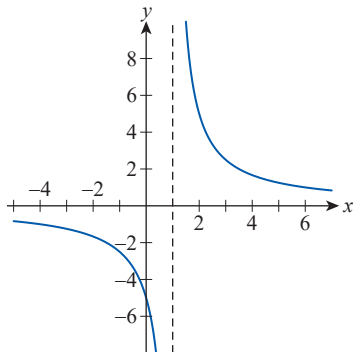
5. Deg.: 3; lead. coeff.: 1;
x-int.: $-3, 1, 2$; y-int.: 6; $\text{Ran} = \mathbb{R}$



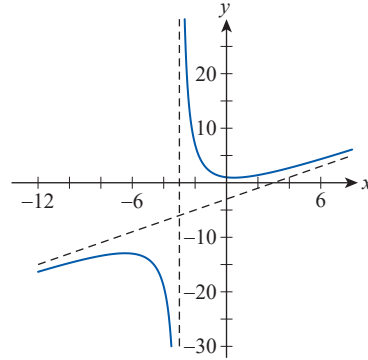
7. Deg.: 4; lead. coeff.: $1/4$;
x-int.: $\pm 2\sqrt{2}, 0$; y-int.: 0; $\text{Ran} = [-4, \infty)$



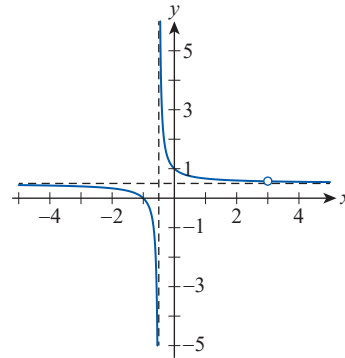
9. Vert. asym.: $x = 1$; horiz. asym.: $y = 0$;
x-int.: none; y-int.: -5



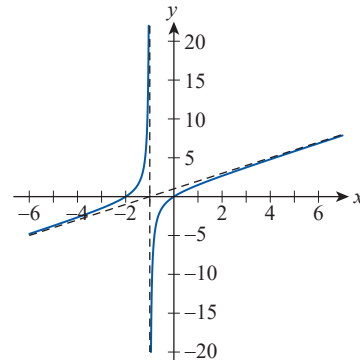
11. Vert. asym.: $x = -3$; slant asym.: $y = x - 3$;
x-int.: none; y-int.: 1



13. Vert. asym.: $x = -1/2$; horiz. asym.: $y = 1/2$;
x-int.: -1 ; y-int.: 1



15. Vert. asym.: $x = -1$; slant asym.: $y = x + 1$;
x-int.: 0, -2 ; y-int.: 0



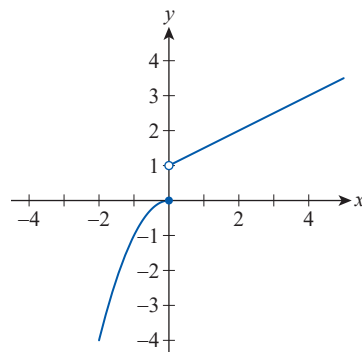
17. Answers will vary. 19. Answers will vary.

21. Answers will vary. 23. Answers will vary.

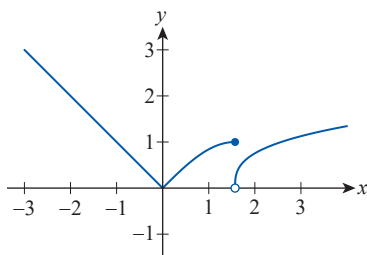
25. $\cos x$ 27. $\cos^2 \alpha$

29. $\cos^2 \theta$ 31. $\csc \beta$ 33. $\tan^2 x$

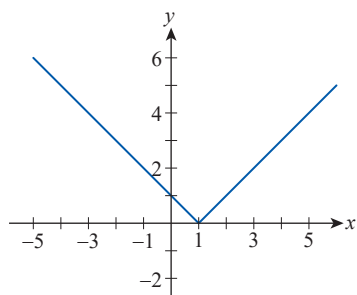
- 35.



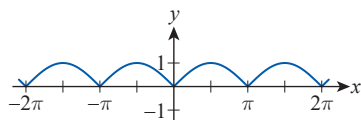
37.



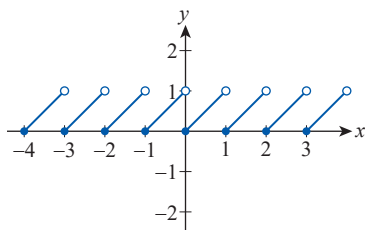
39.
$$f(x) = \begin{cases} -x+1 & \text{if } x < 1 \\ x-1 & \text{if } x \geq 1 \end{cases}$$



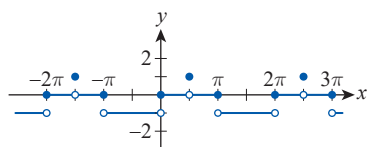
41.
$$h(x) = \begin{cases} -\sin x & \text{if } 2\pi n - \pi < x < 2\pi n \\ \sin x & \text{if } 2\pi n \leq x \leq 2\pi n + \pi \end{cases}, \quad n \in \mathbb{Z}$$



43.



45.



47. 3.5 hours

49. Width = 50 yd; length = 100 yd

51. 50 ft by 100 ft 53. (2,1) 55. 12 and 24

57. 25 sets 59. No; yes

 61. $y = -4 \sin(6\pi t)$; it takes a mere $1/3$ s to complete a period.

 63. a. 3 years b. 9 years 65. $V \approx 178$ people

67. a. 0.999567 b. 0.958 g c. 0.648 g

69. Approx. \$201,587

71. a. 0.965936 b. 0.707 kg c. 7.628 mg

73. True

 75. False; the line perpendicular to $y = Ax + B$ has a slope of $-1/A$.

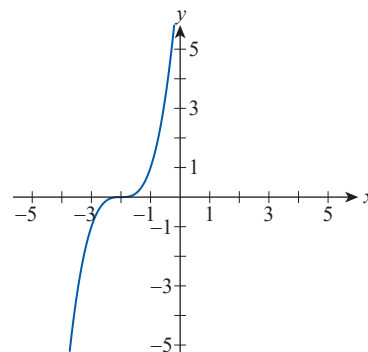
77. True

 79. False; consider $\frac{x^4}{1+x^2}$, which has no asymptotes.

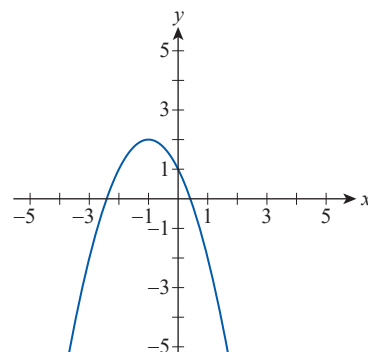
81. True

Section 1.3

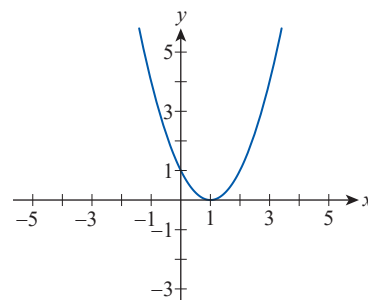
1.


 Dom = Ran = $\mathbb{R}$

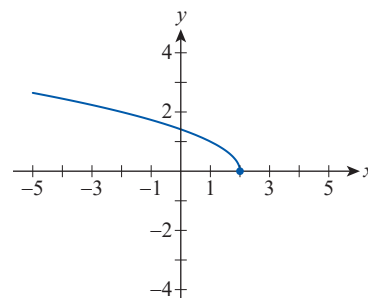
3.


 Dom = $\mathbb{R}$, Ran = $(-\infty, 2]$

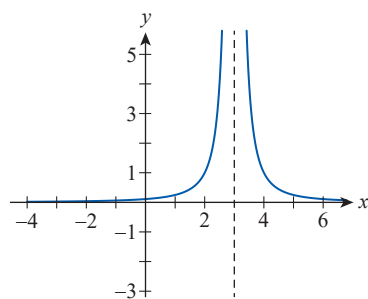
5.


 Dom = $\mathbb{R}$, Ran = $[0, \infty)$

7.

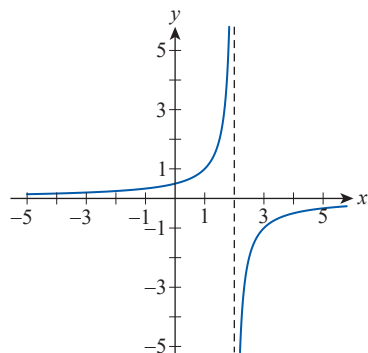

 Dom = $(-\infty, 2]$, Ran = $[0, \infty)$

9.



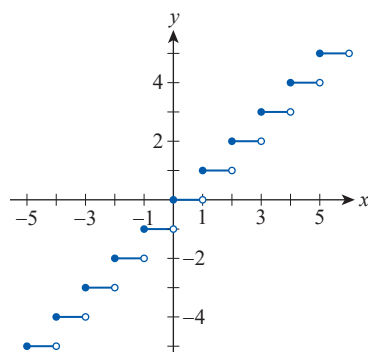
$$\text{Dom} = (-\infty, 3) \cup (3, \infty), \text{Ran} = (0, \infty)$$

11.



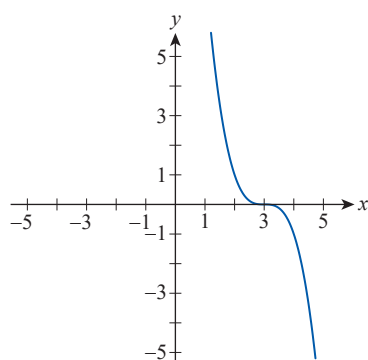
$$\text{Dom} = (-\infty, 2) \cup (2, \infty), \text{Ran} = (-\infty, 0) \cup (0, \infty)$$

13.



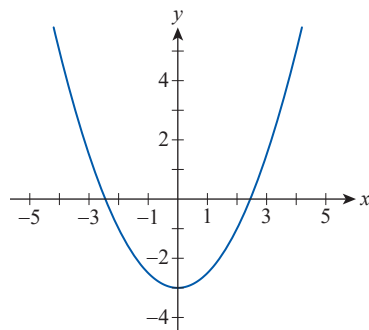
$$\text{Dom} = \mathbb{R}, \text{Ran} = \mathbb{Z}$$

15.



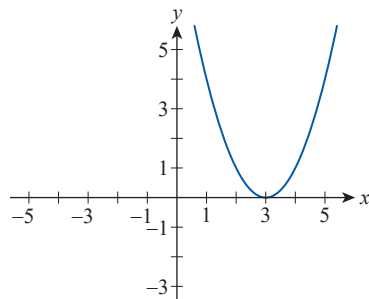
$$\text{Dom} = \text{Ran} = \mathbb{R}$$

17.



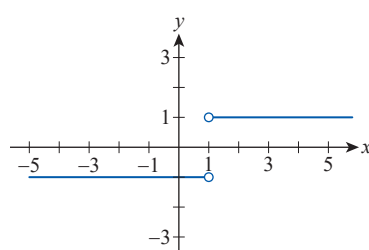
$$\text{Dom} = \mathbb{R}, \text{Ran} = [-3, \infty)$$

19.



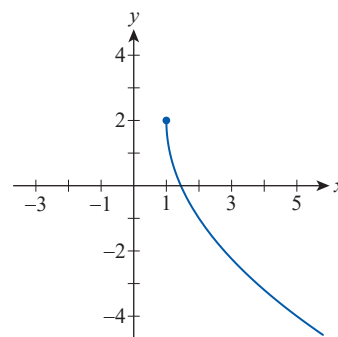
$$\text{Dom} = \mathbb{R}, \text{Ran} = [0, \infty)$$

21.



$$\text{Dom} = (-\infty, 1) \cup (1, \infty), \text{Ran} = \{-1, 1\}$$

23.



$$\text{Dom} = [1, \infty), \text{Ran} = (-\infty, 2]$$

25. $y = -x^2 + 6$ 27. $y = -\sqrt{x+5}$

29. $y = -|-x+7|$ 31. $f(x) = -\sqrt{x+4}$

33. $f(x) = 1 - (x-3)^3$

35. a. -1 b. 1 c. 0 d. 0

37. a. -3 b. 1 c. 2 d. 1/2

39. a. -4 b. 8 c. -12 d. -1/3

41. a. 4 b. 3 c. 7/4 d. 7

43. a. -1 b. 3 c. -2 d. -1/2

45. a. -1 b. -3 c. -2 d. -2

47. a. $x^2 + \sqrt[3]{x} - 1$; Dom = $\mathbb{R}$

b. $\frac{x^2 - 1}{\sqrt[3]{x}}$; Dom = $(-\infty, 0) \cup (0, \infty)$

49. a. $x^{3/2} + x - 3$; Dom = $[0, \infty)$

b. $\frac{x^{3/2}}{x - 3}$; Dom = $[0, 3) \cup (3, \infty)$

51. a. $x^3 + \sqrt{x - 2} + 4$; Dom = $[2, \infty)$

b. $\frac{x^3 + 4}{\sqrt{x - 2}}$; Dom = $(2, \infty)$

53. a. $x^{2/3} + 6x - 1$; Dom = $\mathbb{R}$

b. $\frac{6x - 1}{x^{2/3}}$; Dom = $(-\infty, 0) \cup (0, \infty)$

55. -1699/100 57. Undefined 59. -1/3

61. Undefined 63. -324

65. π^2 67. 4 69. 5 71. 3 73. 2

75. a. $\frac{1}{x - 1}$; Dom = $(-\infty, 1) \cup (1, \infty)$

b. $\frac{1}{x} - 1$; Dom = $(-\infty, 0) \cup (0, \infty)$

77. a. $1 - \sqrt{x}$; Dom = $[0, \infty)$

b. $\sqrt{1 - x}$; Dom = $(-\infty, 1]$

79. a. $9x^4 + 36x^2 + 35$; Dom = $\mathbb{R}$

b. $3x^4 + 12x^3 + 12x^2 + 5$; Dom = $\mathbb{R}$

81. a. $\sqrt{2x}$; Dom = $[0, \infty)$

b. $2\sqrt{x}$; Dom = $[0, \infty)$

83. a. x ; Dom = $(-\infty, 0) \cup (0, \infty)$

b. x ; Dom = $(-\infty, 0) \cup (0, \infty)$

85. a. x ; Dom = $\mathbb{R}$ b. x ; Dom = $\mathbb{R}$

87. a. $\frac{3}{1 - 3x^2}$;

Dom = $(-\infty, -\sqrt{3}/3) \cup (-\sqrt{3}/3, \sqrt{3}/3) \cup (\sqrt{3}/3, \infty)$

b. $\frac{27}{x^2 - 2x + 1}$; Dom = $(-\infty, 1) \cup (1, \infty)$

89. $g(x) = \frac{2}{x}$, $h(x) = 5x - 1$, $f(x) = g(h(x))$

91. $g(x) = x + \sqrt{x} - 7$, $h(x) = x + 2$, $f(x) = g(h(x))$

93. $g(x) = \frac{\sqrt{x}}{x^2}$, $h(x) = x - 3$, $f(x) = g(h(x))$

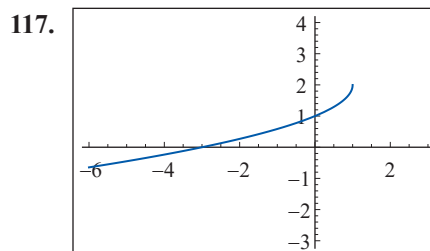
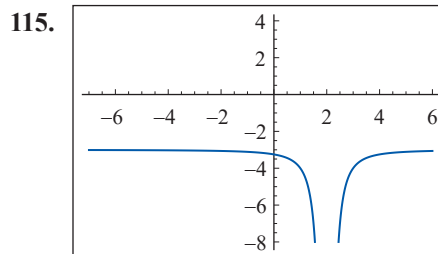
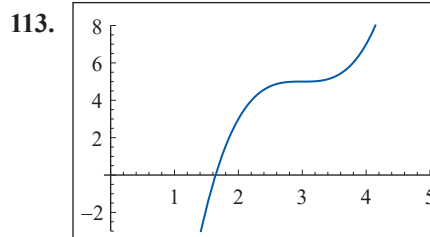
95. $S(t) = \pi r \sqrt{r^2 + \frac{t^4}{16}}$

97. $c(t) = 2040 + 17,400t - 43.5t^2$

99. $(f \circ g)(x) = \frac{-x}{\sqrt[3]{3x^2 - 9}} = -(f \circ g)(-x)$

101. Yes 103. Yes 105. No 107. No

109. True 111. True



119. $y = -(x + 3)^2 + 5$ 121. $y = -x^3 + 7$

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

125. $(f + g)(x) = 4 + 12x + 9x^2 + \sqrt{x^2 + 5}$;

$(fg)(x) = 4\sqrt{x^2 + 5} + 12x\sqrt{x^2 + 5} + 9x^2\sqrt{x^2 + 5}$;

$(f \circ g)(x) = 49 + 9x^2 + 12\sqrt{x^2 + 5}$;

$(g \circ f)(x) = \sqrt{(3x + 2)^4 + 5}$

127. $(f + g)(x) = \frac{2x^2 - x + 1}{x(x - 1)}$;

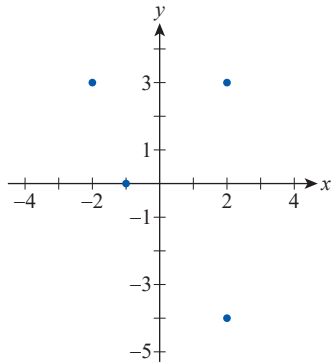
$(fg)(x) = \frac{x + 1}{x}$;

$(f \circ g)(x) = 1 - 2x$;

$(g \circ f)(x) = \frac{2}{x + 1}$

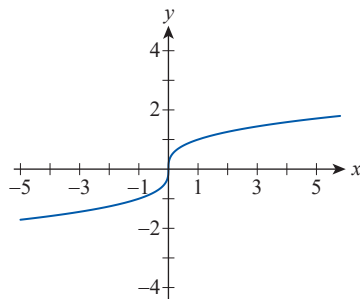
Section 1.4

1.



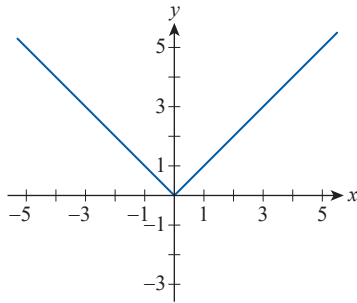
$$\text{Dom} = \{-2, -1, 2\}, \text{Ran} = \{-4, 0, 3\}$$

3.



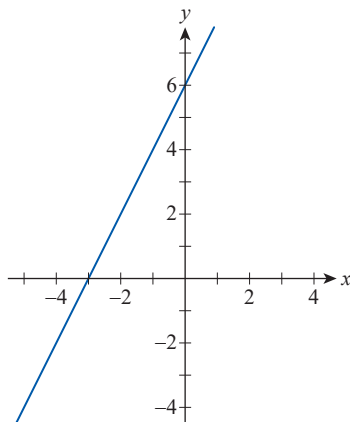
$$\text{Dom} = \text{Ran} = \mathbb{R}$$

5.



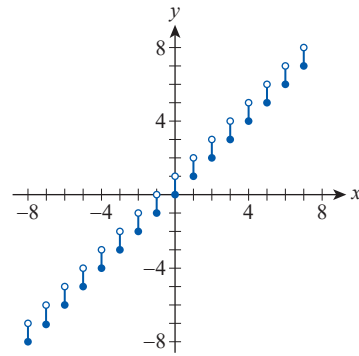
$$\text{Dom} = \mathbb{R}, \text{Ran} = [0, \infty)$$

7.



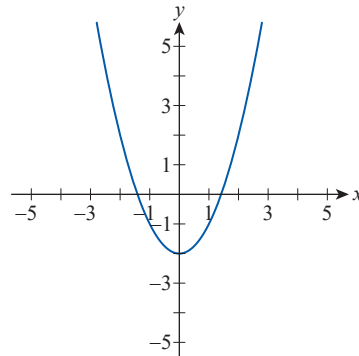
$$\text{Dom} = \text{Ran} = \mathbb{R}$$

9.



$$\text{Dom} = \mathbb{Z}, \text{Ran} = \mathbb{R}$$

11.



$$\text{Dom} = \mathbb{R}, \text{Ran} = [-2, \infty)$$

13. Restrict to $[0, \infty)$ 15. Inverse exists

17. Inverse exists 19. Inverse exists

21. Inverse exists 23. $f^{-1}(x) = (x+2)^3$

$$25. r^{-1}(x) = \frac{-2x-1}{3x-1} \quad 27. F^{-1}(x) = (x-2)^{1/3} + 5$$

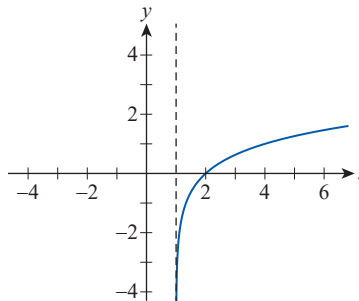
$$29. V^{-1}(x) = 2x-5 \quad 31. h^{-1}(x) = (x+2)^{5/3}$$

$$33. J^{-1}(x) = \frac{x-2}{3x} \quad 35. h^{-1}(x) = (x-6)^{1/7}$$

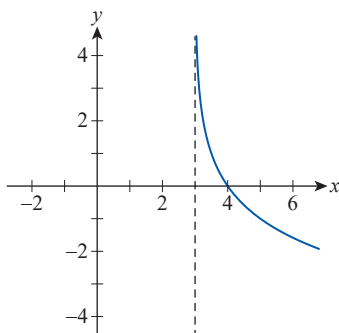
$$37. r^{-1}(x) = x^5/2 \quad 47. \text{F}$$

49. C 51. D 53. G 55. F 57. C 59. A

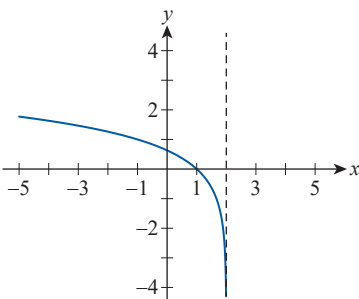
61.



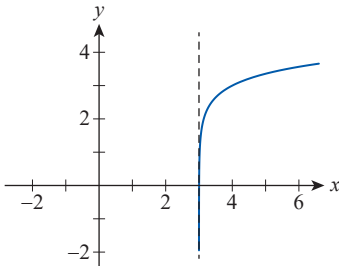
63.



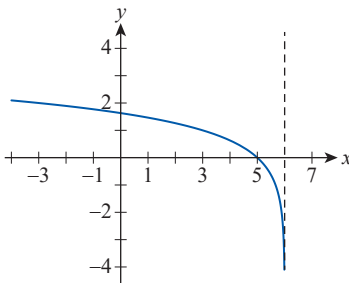
65.



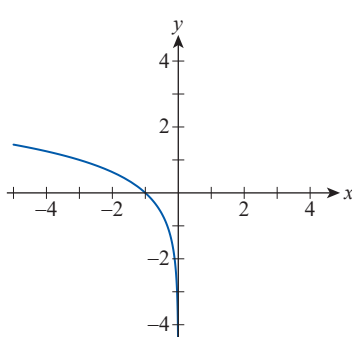
67.



69.



71.



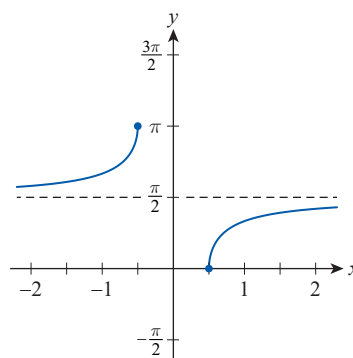
73. 2 75. 7 77. 1

79. 2.45 81. 3.30 83. 0.74 85. x^2 87. $e^2 p/x$ 89. x^3/y^4 91. $\frac{3}{2} \ln x + \ln p + 5 \ln q - 7$ 93. $\log(2 + 3 \log x)$ 95. $1 - \frac{1}{2} \log(x + y)$ 97. $\log_2(y^2 + z) - 4 - 4 \log_2 x$ 99. $2 \log_b x + \frac{1}{2} \log_b y - \log_b z$ 101. $\ln \frac{3p}{q^2}$ 103. $\log \frac{x-10}{x}$ 105. $\ln \frac{e^2}{x^3 y^3}$ 107. $-\pi/2$ 109. $-\pi/6$ 111. $\pi/4$

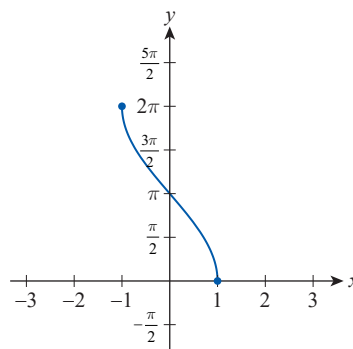
113. Does not exist 115. -1.3734 117. 1.0472

119. -1/2 121. 2 123. 2 125. $\frac{\sqrt{x^2 - 4}}{2}$ 127. $\frac{\sqrt{3}x}{3}$ 129. $\frac{4}{\sqrt{x^2 + 16}}$

131.



133.



135. 521 73 136 136 73 392 316 -7 73 188 392 217 8 -7 617

137. REMEMBER YOUR SUNBLOCK

139. 6.3 141. 13.4 decibels

143. a. 0.2898 rad b. 0.4429 rad c. 0.7956 rad

145. True 147. True

149. False; the domain of $\arcsin x$ is $[-1, 1]$.

151. True

Section 1.5

13. a. $y = 3.559x + 22.038$ b. 36,274 units15. a. $y = 10.743x - 25.829$ b. \$81,60117. a. $y = -1.345x + 79.771$ b. 69.011 cents per pound

19. $x = 0$

21. $x = \frac{(2k+1)\pi}{6} + \frac{2}{3}, k \in \mathbb{Z}$

23. $x = -1$ 25. $x = \pm\sqrt[4]{1/2}$ 27. $x \leq 0$

29. Answers will vary. 31. Answers will vary.

33. Answers will vary. 35. Answers will vary.

37. Answers will vary. 39. Answers will vary.

41. 20 43. -21.9787 45. -90.8519 47. 49.9990

49. 130,783 51. 1 53. Answers will vary.

55. Answers will vary. 57. Answers will vary.

59. -4.4213, -0.1001, 4.5213

61. 1.1974, 5.6240, 6.8003 63. 0.1586, 3.1462

65. $f(x)$ 67. $g(x)$ 69. $g(x)$

71. Answers will vary. 73. Answers will vary.

Chapter 1 Review

1. Dom = $\{-2, -3\}$, Ran = $\{-9, -3, 2, 9\}$;
not a function

3. Dom = $[-6, \infty)$, Ran = $\mathbb{R}$; not a function

5. Dom = $\mathbb{N}$, Cod = $\mathbb{R}$, Ran = $\left\{\frac{3x}{4} \mid x \in \mathbb{N}\right\}$

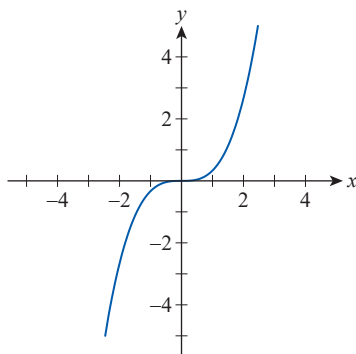
7. Dom = $\mathbb{R}$, Cod = $\mathbb{R}$, Ran = $(0, 1]$

9. a. $2x^2 + 6x - 8$ b. $2x^4 + 10x^2$ c. $4x + 2h + 10$

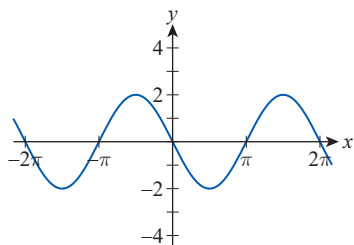
11. a. $\frac{3}{x+1}$ b. $\frac{3}{x^2+2}$ c. $\frac{-3}{(x+h+2)(x+2)}$

13. Decreasing on $(-\infty, 2)$; increasing on $(2, \infty)$

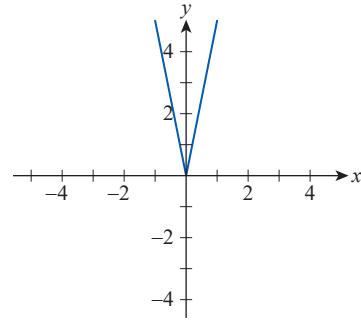
15. Odd



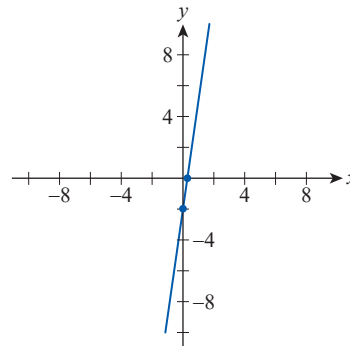
17. Odd



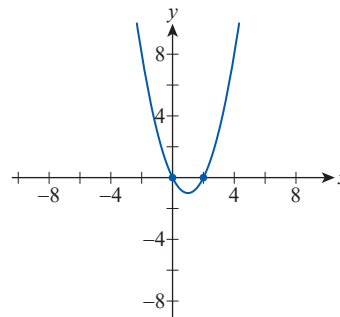
19. Symmetric with respect to the y-axis



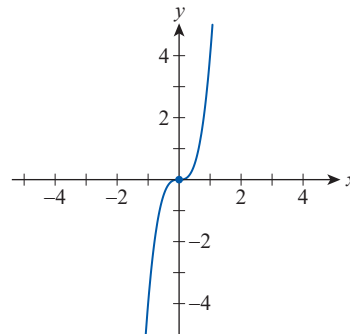
21.



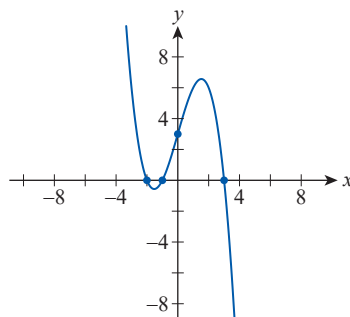
23.



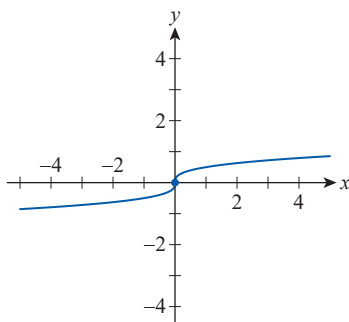
25.



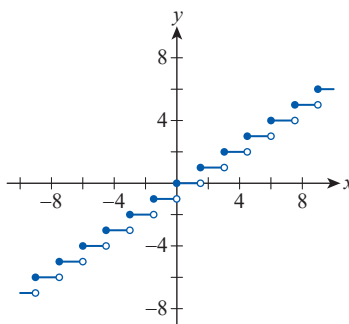
27.



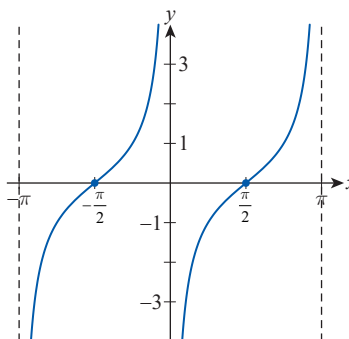
29.



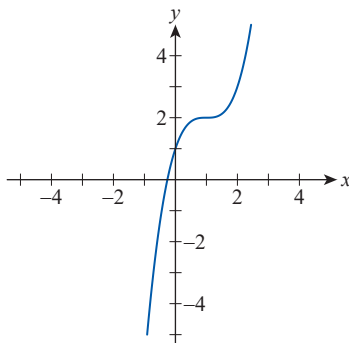
31.



33.



35.

Dom = $\mathbb{R}$, Ran = $\mathbb{R}$

37. $y = \frac{1}{x-2} + 3$

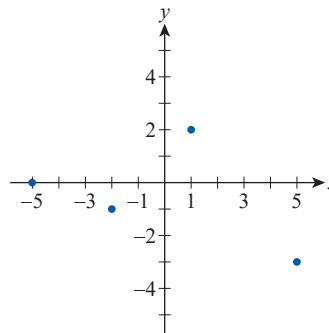
39. a. $x^2 + \sqrt{x}$; Dom = $[0, \infty)$

b. $x^{3/2}$; Dom = $(0, \infty)$

41. a. $x+2$ b. $x-2$ c. 5

43. $g(x) = \frac{\sqrt{x}+2}{x^2}$, $h(x) = x+3$; $f(x) = g(h(x))$

45.



Dom = $\{-5, -2, 1, 5\}$, Ran = $\{-3, -1, 0, 2\}$

47. $f^{-1}(x) = \frac{x+2}{7x}$ 49. $f^{-1}(x) = (x+6)^5$

53. $\frac{\sqrt{x^2-4}}{2}$ 55. $\frac{1}{3}(\log y + 2 \log z - 4 \log x)$

57. $A(t) = A_0 e^{-\frac{\ln 2}{10}t} = A_0 (1/2)^{t/10}$; approx. 17.7%

59. 15/2 and 15/2 61. Yes

63. False; a function may not be defined on (any subset of) $\mathbb{R}$ and thus may not have a graphical representation in the xy -system. Even graphs of numerical functions are not always curves.65. False; consider $f(x) = x^2$ with $a = 1$ and $b = -1$.67. False; consider $f(x) = (x-1)^2$.

69. False

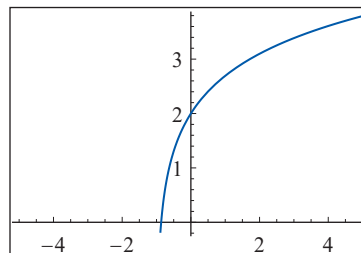
71. False; consider $c = 2$ and $f(x) = x^2$:

$$f(cx) = (2x)^2 = 4x^2, \text{ while } cf(x) = 2x^2.$$

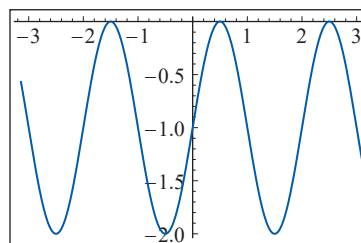
73. False; consider $y = x^2$. (The statement is only true for invertible functions.)

75. True

77.



79.



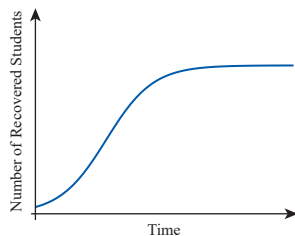
81. 1.4262 83. Answers will vary.

Chapter 1 Conceptual Project

- $r(t) = 2.6t$
- Doubling time is approximately 24 minutes and 51 seconds; the time to triple is approximately an additional 19 minutes and 4 seconds. (The exact values are $\sqrt{2} - 1$ hours and $\sqrt{3} - \sqrt{2}$ hours, respectively.)
- After 3 hours: radius 7.8 km and area approx. 191.13 km^2
After 5.5 hours: radius 14.3 km and area approx. 642.42 km^2
- Approx. $286.70 \text{ km}^2/\text{h}$
- Answers will vary, but a major flaw is that the model predicts a hole whose area will grow indefinitely, and is not a periodic function of time. A better approach is to use a periodic function.

Chapter 1 Application Project

- The independent variable is time t , and the dependent variable is the number of people infected.
 - Initially, the number of infected rises sharply, because there are few recovered and the susceptible population is large.
 - $P_i(t) + P_r(t) + P_s(t) = 25,000$
- The number is expected to increase at a growing, then at a steadily slowing rate.



- We can partition the infected population into ten subsets according to whether they got infected one day ago, two days ago, etc. Thus, we can assume that one-tenth of them will recover daily. Limitations: The aforementioned subsets may not all be of the same size, especially at the early stages of the epidemic, or later when the rate of infections slows down.
- $P_s = 4000$ students

Chapter 2

Section 2.1

- 3 3. 0 5. $-1/4$
- The exact answer is -2 .

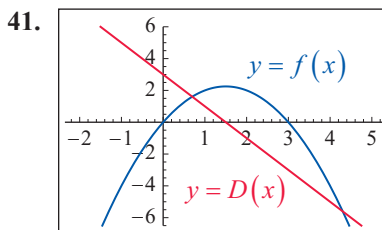
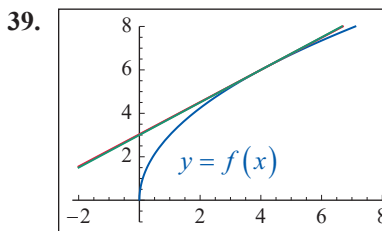
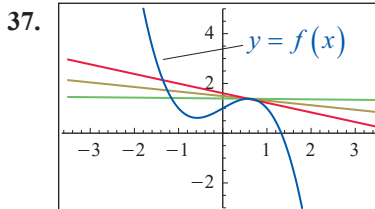
- The exact answer is 2.
- The exact answer is 2.
- The exact answer is $1/e$ or approx. 0.3679.
- The exact answer is $1/(5 \ln 10)$ or approx. 0.0869.
- The exact answer is -4 .
- a. 96 ft b. 16 ft/s c. 16 d. 2.5 s
- a. 176 ft b. 176 ft/s c. 192 ft/s
d. 64 ft/s e. 6 s
- a. 3 m/s b. 15 m/s c. $6t_0 + 3$
- a. 5 s; 45 m/s b. 10 s c. $-1.83g$
- a. 87.35 ft b. 34.94 ft/s
c. -28 ft/s d. -77.47 ft/s

- a. 60 b. 61.44

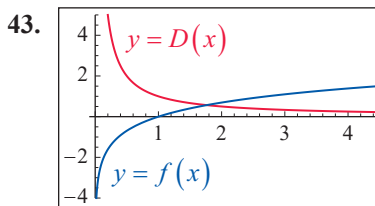
- a. 12.7234 b. 12.3129

- a. 1.0536 b. 1.0563

- a. 1.2217 b. 1.2218



The function value $D(x_0)$ at any given x_0 is approximately equal to the slope of the graph of f at x_0 .



The function value $D(x_0)$ at any given x_0 is approximately equal to the slope of the graph of f at x_0 , for any $x_0 > 0$.

45. $x = \pm 2$ 47. $x = 1$

49. a. 63.9936 b. 63.9999

51. a. 11.0508 b. 11.0050

53. a. 1.0612 b. 1.0612

55. a. 1.222 b. 1.222

Section 2.2

1. 4 3. 0

5.

x	y
1	2.414
1.4	2.814
1.41	2.824
1.414	2.828

The table points to a limit of $2\sqrt{2} \approx 2.828$.

7.

x	y
1.5	113.33
1.1	15.94
1.01	10.46
1.001	10.045

The table points to a limit of 10.

9.

x	y
3	-3.4696
3.14	-3.0048
3.141	-3.0018
3.1415	-3.0003

The table points to a limit of -3.

11.

x	y
7.5	210.5
7.1	994.1
7.01	9814.0
7.001	98014.0

The table points to an undefined limit.

13. $\lim_{x \rightarrow 1^-} f(x) = -\infty$; $\lim_{x \rightarrow 1^+} f(x) = \infty$

15. $\lim_{x \rightarrow 3^-} h(x) = \infty$; $\lim_{x \rightarrow 3^+} h(x) = \infty$

17. $\lim_{x \rightarrow -1^-} q(x) = \infty$; $\lim_{x \rightarrow -1^+} q(x) = -\infty$

19. $\lim_{x \rightarrow 1.5^-} v(x) = -\infty$; $\lim_{x \rightarrow 1.5^+} v(x) = \infty$

21. $\lim_{x \rightarrow \left(\frac{\pi}{2} + k\pi\right)^-} \tan x = \infty$; $\lim_{x \rightarrow \left(\frac{\pi}{2} + k\pi\right)^+} \tan x = -\infty$ ($k \in \mathbb{Z}$)

23. $\lim_{x \rightarrow 6^-} s(x) = -\infty$; $\lim_{x \rightarrow 6^+} s(x) = \infty$

25. $\lim_{x \rightarrow \infty} f(x) = 0$; $\lim_{x \rightarrow -\infty} f(x) = 0$

27. $\lim_{x \rightarrow \infty} h(x) = 0$; $\lim_{x \rightarrow -\infty} h(x) = 0$

29. $\lim_{x \rightarrow \infty} q(x) = -1$; $\lim_{x \rightarrow -\infty} q(x) = -1$

31. $\lim_{x \rightarrow \infty} v(x) = \infty$; $\lim_{x \rightarrow -\infty} v(x) = -\infty$

33. $\lim_{x \rightarrow \infty} \tan x$ does not exist; $\lim_{x \rightarrow -\infty} \tan x$ does not exist

35. $\lim_{x \rightarrow \infty} s(x) = 1$; $\lim_{x \rightarrow -\infty} s(x) = -1$

37. a. -2 b. 1 39. a. 1 b. 4

41. a. 1 b. $-\infty$ 43. a. 1 b. 1

45. a. Does not exist b. 0

47. $\lim_{x \rightarrow \infty} f(x) = \infty$; $\lim_{x \rightarrow -\infty} f(x) = -\infty$

49. $\lim_{x \rightarrow \infty} h(x) = -\infty$; $\lim_{x \rightarrow -\infty} h(x) = -\infty$

51. $\lim_{x \rightarrow \infty} F(x) = \infty$

53. $\lim_{x \rightarrow \infty} H(x) = \infty$; $\lim_{x \rightarrow -\infty} H(x) = \infty$

55. $\lim_{x \rightarrow \infty} u(x) = \infty$; $\lim_{x \rightarrow -\infty} u(x) = \infty$

57. $\lim_{x \rightarrow -\infty} s(x) = -\infty$

59. False; see $h(x)$ of Example 5 at $x = 2$.

61. True 63. True 65. Does not exist

67. 2 69. $3/2$ 71. 0

75. See the answer given for Exercise 65.

77. See the answer given for Exercise 67.

79. See the answer given for Exercise 69.

81. See the answer given for Exercise 71.

Section 2.3

1. $\delta \approx 0.23$ or smaller 3. $\delta \approx 0.2$ or smaller

5. L is incorrectly quantified and switched with c .

7. ε is incorrectly quantified.

9. The inequality $0 \leq |x - c|$ is incorrect.

11. $\delta = 0.02$ or smaller 13. $\delta = 0.1$ or smaller

15. $\delta = \sqrt{0.1}$ or smaller 17. $\delta = 0.09$ or smaller

19. $\delta = 1 - e^{-0.1} \approx 0.0952$ or smaller

21. $N = 10$ or larger 23. $N = -10$ or smaller

25. $N = \ln 0.1$ or smaller 27. $\delta = 0.1$ or smaller

29. $\delta = 0.1$ or smaller

31. $\delta = \frac{\pi}{2} - \arctan 100 \approx 0.0099997$ or smaller

63. The limit does not exist.

65. The limit does not exist.

67. The limit is 0. 69. 0.02256 mm

71. False; the function value and limit at c need not be equal. (See Example 2.)
 73. False; consider $f(x) = -x^2$ and $g(x) = x^2$ at $c = 0$.
 75. Answers will vary. 77. Answers will vary.
 79. Answers will vary. 81. Answers will vary.
 83. Answers will vary.
 85. Vert. asym.: $x \approx -1.3340, x \approx 1.1759$
 87. Vert. asym.: $x = (2n+1)\pi - 6, n \in \mathbb{Z}$
 89. Vert. asym.: $x = (2n-1)\pi/2, n \in \mathbb{Z}, n \neq 0$

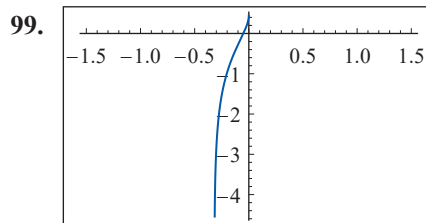
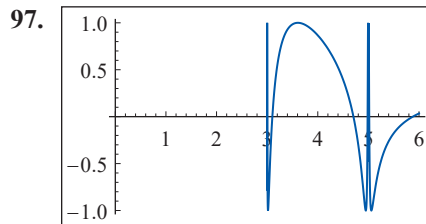
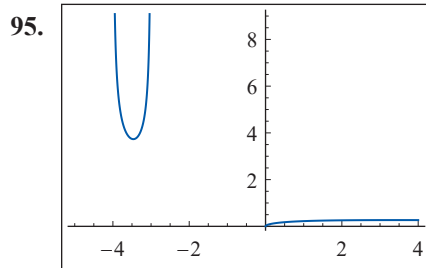
Section 2.4

1. a. -4 b. 21
 3. 5 5. 7 7. 9 9. 22 11. -4 13. -2 15. $\sqrt[3]{2}$
 17. $\sqrt[3]{100}$ 19. 16 21. 12 23. 11 25. $33/5$
 27. $1/6$ 29. $1/(2\sqrt{5})$ 31. $1/9$ 33. 6 35. 4
 37. $1/(2\sqrt{x})$ 39. $32/7$ 41. $-1/6$ 43. -1
 45. 8 47. 11 49. $9-2(c-2)$ 51. 1 53. 0
 55. 0 57. $2e^2$ 71. The limit is 0. 79. $r/2$

Section 2.5

1. Points of continuity: $(-\infty, 0) \cup (0, 3) \cup (3, \infty)$
 Points of discontinuity: $c = 0, \lim_{x \rightarrow 0} f(x)$ does not exist;
 $c = 3, \lim_{x \rightarrow 3} f(x) \neq f(3)$
 3. Answers will vary. 5. $c = 0$, nonremovable
 7. $c = 3$, removable 9. $c = 2$, nonremovable
 11. None
 13. $c = -(2n+1)\pi/2$ for $n \in \{-1, 0, 1, 2, \dots\}$, nonremovable
 15. $c = 4$, removable
 17. None 19. None 21. $c = \pm 1$, nonremovable
 23. None 25. All integers, nonremovable
 27. $c = \pm\sqrt{n}$, n a positive integer, nonremovable
 29. $c = 1/n$, n a nonzero integer, nonremovable
 35. Continuous on $[-3, -1] \cup (0, 2] \cup [3, \infty)$
 37. Continuous on $(-\sqrt{3}, \sqrt{3})$
 39. Continuous except on
 $\{n - 1/\pi | n \in \mathbb{Z}\} \cup \{\ln k - 2 | k \in \mathbb{N}\}$
 45. $f(3) = 7$ will make f continuous.
 47. $h(1) = 2$ will make h continuous.
 49. $G(0) = 0$ will make G continuous.
 51. Continuous on $[-4, 4]$

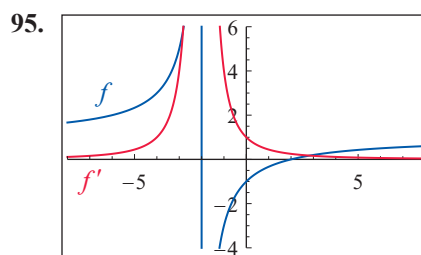
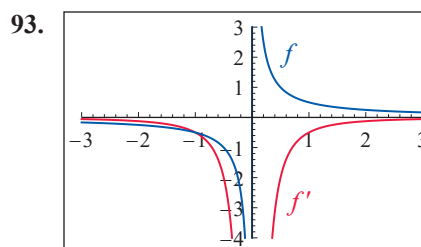
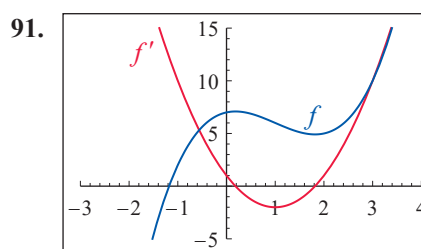
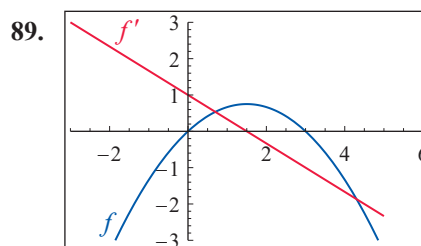
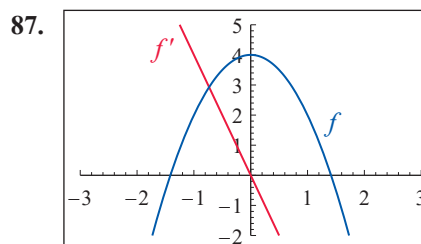
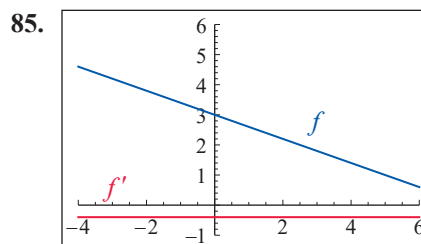
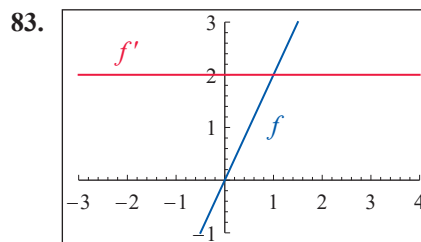
53. Not continuous at the endpoints 55. $a = 5$
 57. $a = 3/2, b = -5/2$
 63. Yes; $c = 2$ 65. Yes; $c = 2$
 67. No; G is not continuous on $[-2, 2]$
 83. a. Because speeds of everyday objects are smaller than c by orders of magnitude, the denominator of ΔT is approximately 1.
 b. No moving object can reach the speed of light.
 85. False; consider the Dirichlet function.
 87. True
 89. -0.2895 91. 0.8241 93. -1.7321

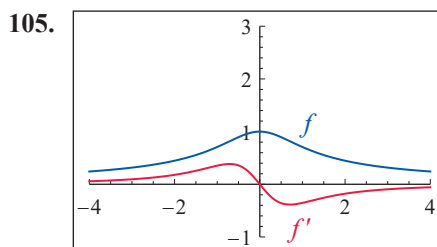
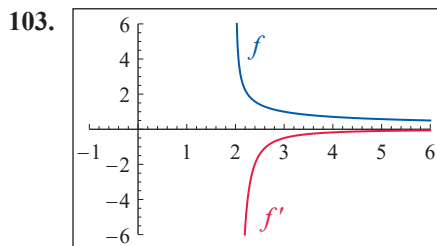
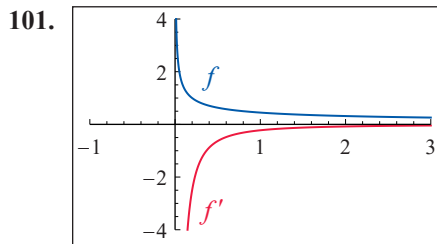
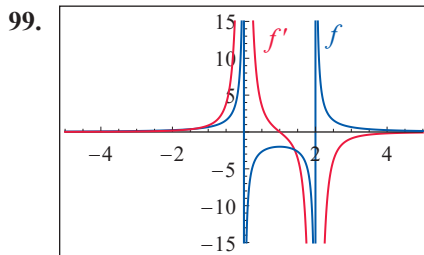
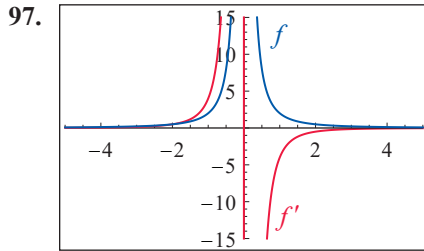


Section 2.6

1. a. $f'(-1) = 2$ b. $f'(1) = -2$
 3. $y = 4x - 6$ 5. $y = \frac{1}{2}x + 4$
 7. $y = 12x - 16$ 9. $y = \frac{1}{2}x + 1$
 11. $y = -4x + 4$ 13. $y = -\frac{1}{16}x + \frac{3}{4}$
 15. $f'(x) = 0$; tangent is horizontal for all x
 17. $f'(x) = 4$; tangent is never horizontal
 19. $f'(x) = 6x$; tangent is horizontal at $x = 0$
 21. $f'(x) = x + 5$; tangent is horizontal at $x = -5$
 23. $f'(x) = 3x^2 + 1$; tangent is never horizontal
 25. $f'(x) = 4x^3$; tangent is horizontal at $x = 0$

27. $f'(x) = -\frac{10}{(2x-4)^2}$; tangent is never horizontal
29. $f'(x) = -\frac{7}{(x-3)^2}$; tangent is never horizontal
31. $f'(x) = -\frac{2x}{(x^2+1)^2}$; tangent is horizontal at $x = 0$
33. $f'(x) = \frac{5}{2\sqrt{5x}}$; tangent is never horizontal
35. $f'(x) = \frac{1}{\sqrt{2x+1}}$; tangent is never horizontal
37. $f'(x) = \frac{x}{\sqrt{x^2+1}}$; tangent is horizontal at $x = 0$
39. $y = 6x - 6$
41. $y = -\frac{1}{2}x + 1$ or $y = -\frac{1}{2}x - 1$
43. $54y + x = 27$ 45. $f'(3.6) = -1/4$
47. $h'(3) = 10$ 49. $G'(7) = 1/2$
51. $u'(-3) = -1/2$ 53. $w'(5) = -1/54$
55. $G'(-2) = -32$
57. C 59. D
61. Answers will vary. 63. Answers will vary.
65. Answers will vary.
73. $t = 1, t = 5$; the particle stops at 2 s and at 4 s.
75. a. The respective velocities are 16 ft/s and -16 ft/s; the speed is 16 ft/s in both cases.
 b. It rises 36 ft above the cliff and reaches the bottom at approx. 4.91 s.
 c. Approx. -109.12 ft/s
77. She seems to have stopped for an extended time period (probably a red light); soon after, she turned around and sped back home (perhaps forgot something at home). Then she sped back to class, this time managing to do so without a red light, and also driving faster.
79. a. $P(x) = 0.1x^2 + 40x - 190$
 b. Approx. 5 suitcases
 c. $P(25) = 872.50, P(30) = 1100, P(40) = 1570$
 d. $P'(x) = 0.2x + 40$
 e. $P'(25) = 45, P'(30) = 46, P'(40) = 48$
81. $C(x) = 20 + 3x; C'(x) = 3$





Chapter 2 Review

- The limit is 3; the function is continuous.
- The limit is 2; there is a nonremovable (jump) discontinuity at 1.
- The exact answer is 3.
- The exact answer is $1/2$.
- a. 598 ft b. 576 ft/s c. 608 ft/s
d. 544 ft/s e. At 19 seconds
- 1.5568 13. 21.7102

15.

x	y
0.5	0.7071
0.1	0.7943
0.01	0.9550
0.001	0.9931

The table points to a limit of 1.

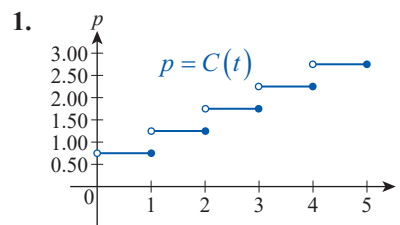
17.

x	y
0.5	0.47943
0.1	0.11969
0.01	-0.00264
0.001	-0.00194

The table points to a limit of 0.

- $\delta = 0.005$ or smaller
- 14 27. 7 29. 8 31. $-1/10$ 33. ∞
- $1/4$ 37. -2 39. 5 41. $2x$
- Answers will vary. 47. $c = 4$, nonremovable
- All integers, nonremovable
- No discontinuities 57. $y = 3x - 1$
- $f'(x) = 2 - 2x$; tangent is horizontal at $x = 1$
- Answers will vary.
- a. $P(x) = 0.1x^2 + 15x - 247.5$
b. 15 toys c. $P'(x) = 0.2x + 15$
- False; there could be, for example, a jump or oscillating discontinuity at $x = c$.
- False; the condition $B \neq 0$ is needed.
- True
- False; while $\lim_{x \rightarrow c} f(x) = L$ does follow, $f(c)$ doesn't even have to be defined.
- 5.3586 and 21.7491, respectively
- 0.6891 and 0.7729, respectively
- 1 81. 3

Chapter 2 Conceptual Project

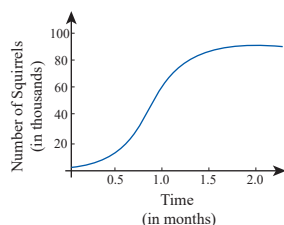


- No, the left- and right-hand limits are unequal.
- A call lasting for about two and a half minutes costs \$1.75.

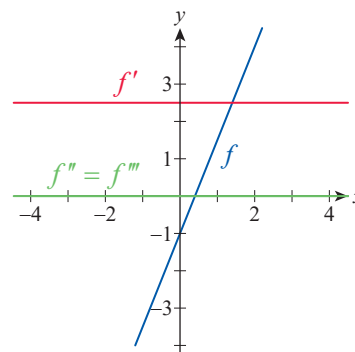
7. A call lasting just over three minutes costs \$2.25.
 9. Does not exist

Chapter 2 Application Project

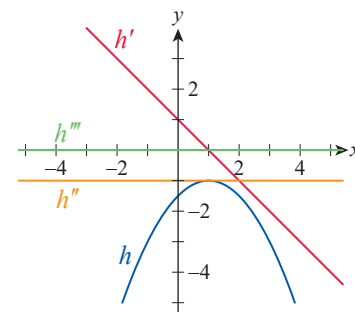
3. No population can grow toward infinity. Sooner or later, external (and/or internal) factors will slow down growth. A graph of a function whose (positive) derivative eventually decreases towards zero is a better choice.
5. a. $\lim_{t \rightarrow \infty} P(t) = 90$
 It means that according to the model, the population won't be able to grow beyond 90,000 squirrels (most likely due to limitations in food supply or the appearance of predators).
- b. The derivative increases first, then approaches zero as $t \rightarrow \infty$.



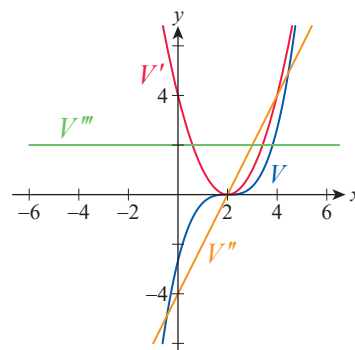
25. $f'(x) = 5/2$; $f''(x) = 0$; $f'''(x) = 0$



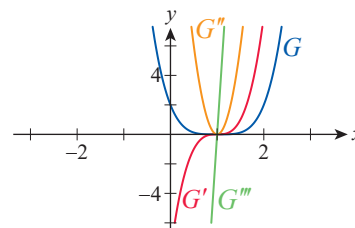
27. $h'(x) = -x + 1$; $h''(x) = -1$; $h'''(x) = 0$



29. $V'(x) = (x-2)^2$; $V''(x) = 2x-4$; $V'''(x) = 2$



31. $G'(x) = 8(x-1)^3$; $G''(x) = 24(x-1)^2$;
 $G'''(x) = 48x - 48$

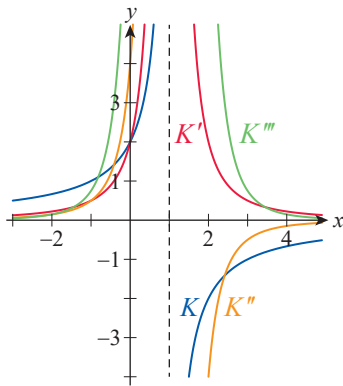


Chapter 3

Section 3.1

1. $\frac{df}{dx} = 0$; $\frac{df}{dx}\bigg|_{x=1} = 0$ 3. $\frac{dh}{dx} = x$; $\frac{dh}{dx}\bigg|_{x=0} = 0$
5. $\frac{dG}{ds} = s^2 - 1$; $\frac{dG}{ds}\bigg|_{s=-3} = 8$
7. $\frac{dK}{dz} = \frac{-15}{(3z+1)^2}$; $\frac{dK}{dz}\bigg|_{z=0} = -15$
9. $\frac{dw}{dz} = \frac{-2z}{(z^2+2)^2}$; $\frac{dw}{dz}\bigg|_{z=\sqrt{2}} = \frac{-\sqrt{2}}{8}$
11. $\frac{dQ}{dy} = \frac{-1}{2y\sqrt{3y}}$; $\frac{dQ}{dy}\bigg|_{y=1} = \frac{-\sqrt{3}}{6}$
13. $D_x f(x) = 0$ 15. $D_t h(t) = 3t + 10$
17. $D_y G(y) = -1/(3y^2)$ 19. $D_z S(z) = 6/z^3$
21. $D_v R(v) = 1/\sqrt{2v-3}$ 23. $D_y X(y) = 8y^3$

$$33. \quad K'(s) = 2/(s-1)^2; \quad K''(s) = -4/(s-1)^3; \\ K'''(s) = 12/(s-1)^4$$



35. Position: k ; velocity: g ; acceleration: h ; jerk: f

37. Position: k ; velocity: h ; acceleration: g ; jerk: f

39. Differentiable on $(-\infty, 3) \cup (3, \infty)$

41. Differentiable on $(-\infty, -1) \cup (-1, 3) \cup (3, \infty)$

43. Differentiable on $(-\infty, 1) \cup (1, \infty)$

45. Not differentiable at -2 and 4

Left-hand derivative at -2 : 0

Right-hand derivative at -2 : 2

Left-hand derivative at 4 : 2

Right-hand derivative at 4 : 0

47. Not differentiable at 1.5

One-sided derivatives do not exist at 1.5

49. Undefined and therefore not differentiable on $(-\infty, -\sqrt{3}) \cup (\sqrt{3}, \infty)$

One-sided derivatives do not exist at $\pm\sqrt{3}$

51. Not differentiable at 1 and 5

Left-hand derivative at 1 : -4

Right-hand derivative at 1 : 4

Left-hand derivative at 5 : -4

Right-hand derivative at 5 : 4

53. Not differentiable at $k \in \mathbb{Z}$

Left-hand derivative at each point of nondifferentiability: 1

Right-hand derivative at each point of nondifferentiability: 1

55. Undefined and therefore not differentiable for $z < 0$, not differentiable at 0

Right-hand derivative does not exist at 0

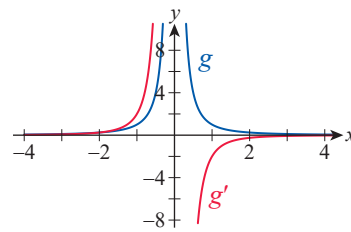
57. Differentiable on the entire real line

61. a. $a(t) = 2.2 \text{ m/s}^2$ b. $t = 15 \text{ s}$

c. The runway must be at least 247.5 m long.

63. b. $g(x) = |x|$; $c = 0$

65.



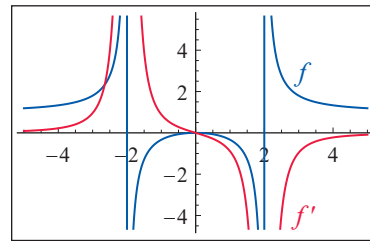
$g' > 0$ and g is increasing for $x < 0$;

$g' < 0$ and g is decreasing for $x > 0$

67. True

69. False; consider $f(x) = |x|$ at $c = 0$.

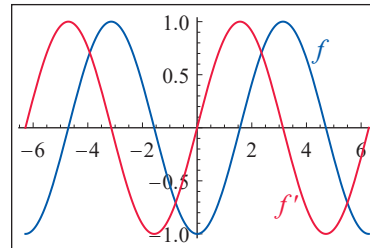
71.



$f' > 0$ and f is increasing for $x < -2$ and $-2 < x < 0$;

$f' < 0$ and f is decreasing for $0 < x < 2$ and $x > 2$

73.



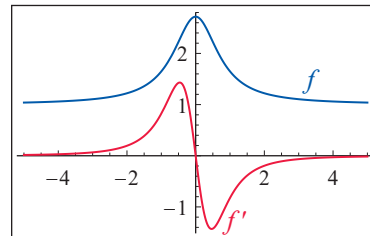
$f' > 0$ and f is increasing for

$2k\pi < x < (2k+1)\pi, k \in \mathbb{Z}$;

$f' < 0$ and f is decreasing for

$(2k-1)\pi < x < 2k\pi, k \in \mathbb{Z}$

75.

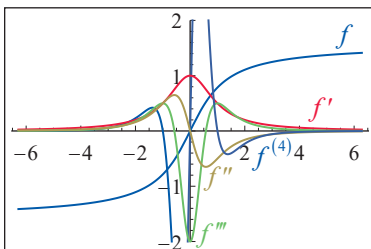


$f' > 0$ and f is increasing for $x < 0$;

$f' < 0$ and f is decreasing for $x > 0$

$$77. f'(x) = \frac{1}{1+x^2}; f''(x) = -\frac{2x}{(1+x^2)^2};$$

$$f'''(x) = \frac{-2+6x^2}{(1+x^2)^3}; f^{(4)}(x) = -\frac{24x(-1+x^2)}{(1+x^2)^4}$$

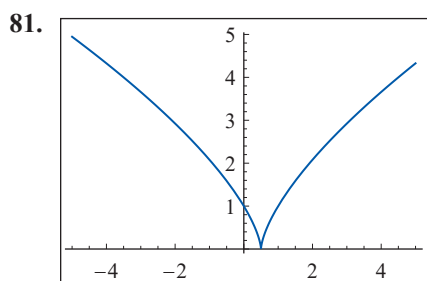
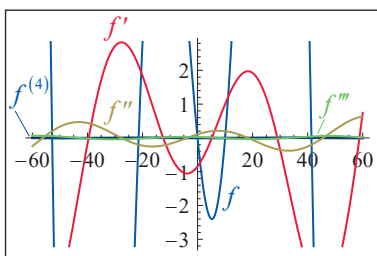


$$79. f'(x) = \frac{1}{10}x \cos\left(1 - \frac{x}{10}\right) - \sin\left(1 - \frac{x}{10}\right);$$

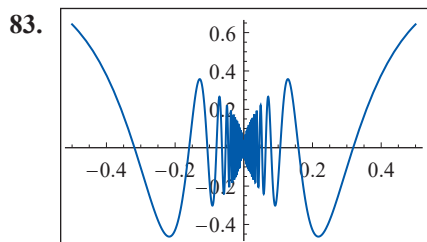
$$f''(x) = \frac{1}{5} \cos\left(1 - \frac{x}{10}\right) + \frac{1}{100}x \sin\left(1 - \frac{x}{10}\right);$$

$$f'''(x) = -\frac{1}{1000}x \cos\left(1 - \frac{x}{10}\right) + \frac{3}{100} \sin\left(1 - \frac{x}{10}\right);$$

$$f^{(4)}(x) = -\frac{1}{250} \cos\left(1 - \frac{x}{10}\right) - \frac{1}{10000}x \sin\left(1 - \frac{x}{10}\right)$$



Not differentiable at $t = 1/2$ (cusp)



Not differentiable at $t = 0$ (oscillating discontinuity)

Section 3.2

$$1. f'(x) = -2 \quad 3. h'(x) = -6x + 2$$

$$5. G'(x) = 2x^3 + 6x^2 - 2x + 3.2$$

$$7. H'(x) = 8x^7 + 5\sqrt{2}x^4 - 8x^3$$

$$9. S'(z) = 12z^2 - \frac{3}{2\sqrt{z}} \quad 11. T'(r) = 2\pi r + 2e^r$$

$$13. 6x + 11 \quad 15. 8x^3 + 15x^2 - 24x - 30$$

$$17. -\frac{196}{5}x^6 - \frac{20}{3}x^4 + \frac{56}{5}x^3 + \frac{4}{3}x \quad 19. \frac{1}{\sqrt{t}} + 8$$

$$21. f'(x) = \frac{2}{(1-2x)^2} \quad 23. h'(x) = \frac{-12x^2 + 20x - 6}{(2x^3 - 5x^2 + 3x + 1)^2}$$

$$25. G'(x) = \frac{-11}{(x-5)^2} \quad 27. H'(x) = \frac{11x^4 + 3x^2 - 6x}{(2x^3 + 5x^2 + 1)^2}$$

$$29. B'(u) = \frac{3u^{3/2} + 4u}{2(\sqrt{u} + 1)^2} \quad 31. g'(t) = \frac{5t - 8\sqrt{t} + 15}{2\sqrt{t}(4 - 5\sqrt{t})^2}$$

$$33. f'(x) = 6 - 10x^4 \quad 35. h'(x) = -27x^2 + 14x - 5$$

$$37. G'(x) = 1 \quad 39. f'(t) = \frac{3}{2} \left(\frac{4t+1}{\sqrt{t}} \right)$$

$$41. h'(s) = -\frac{1}{5s^2} + 10s + 1$$

$$43. G'(x) = -15x^{-6} - 6x^{-4} \quad 45. H'(t) = \frac{9}{2\sqrt{t}} - \frac{5}{2}t\sqrt{t}$$

$$47. w'(z) = 2 + \frac{4}{4 - \sqrt{z}} + \frac{2\sqrt{z}}{(4 - \sqrt{z})^2}$$

$$49. r'(x) = \frac{2a^2}{(x+a^2)^2}$$

$$51. F'(x) = e^x \left(2 + \sqrt{x} + \frac{1}{2\sqrt{x}} \right)$$

$$53. C'(x) = \frac{1}{(x+1)^2}$$

$$55. G'(s) = \frac{6s}{2e^s + s} - \frac{3s^2(1+2e^s)}{(2e^s + s)^2}$$

$$57. L'(y) = -18y^8 + 48y^7 + 6y^5 - 15y^4$$

$$59. H'(s) = -\frac{ace^s}{(b+ce^s)^2}$$

$$61. L'(t) = \frac{1}{2\sqrt{t}} - \frac{3\sqrt{t}}{2} - 2te'$$

$$63. g'(x) = \frac{1}{(x+1)^2}; g''(x) = \frac{-2}{(x+1)^3}; g'''(x) = \frac{6}{(x+1)^4}$$

65. $F'(x) = -3\pi x^2 + 10x - 1$; $F''(x) = -6\pi x + 10$;

$F'''(x) = -6\pi$

67. $W'(t) = 6t + 3e^t$; $W''(t) = 6 + 3e^t$; $W'''(t) = 3e^t$

69. $f(x) = \frac{1}{3}x^3 - 4x$ (Answers will vary.)

71. $f(x) = x^3 + 2x^2 + x + 1$ (Answers will vary.)

73. $g^{(k)}(x) = \frac{(-1)^k k!}{x^{k+1}}$

75. $q^{(k)}(x) = e^x \left[\sum_{i=0}^k \binom{k}{i} D^i x^n \right]$

77. a. 0 b. 18 c. 1

79. $y = -\frac{1}{2}x + 2$ 81. $y = -2ex + 4e$

83. $y = -x$ 85. $x = 1$

87. No horizontal tangent

89. No horizontal tangent

91. $x = 0$ 93. $x = 0$ 95. No horizontal tangent

97. $a = 2$, $b = -8$

99. The slopes are $1/2$ and -2 , respectively.

101. $y = ex$ 103. $y = -4x - 4$

105. $\frac{f(x) + xf'(x)}{g(x)} - \frac{xf'(x)g'(x)}{[g(x)]^2}$

107. $e^x \left[\frac{f(x) + f'(x)}{g(x) + 2} - \frac{f'(x)g'(x)}{(g(x) + 2)^2} \right]$

111. $2f(x)f'(x)$; $3[f'(x)]^2 f'(x)$

115. At the point $(12, 4)$

117. a. $a(2) = 125/36 \text{ ft/s}^2$ b. $a(10) = 5/4 \text{ ft/s}^2$

119. $a = -1.62 \text{ m/s}^2$; $t \approx 1.361 \text{ s}$; $v_{\text{imp}} \approx 2.205 \text{ m/s}$

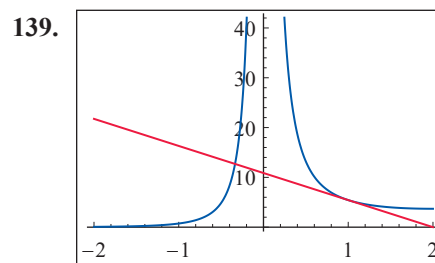
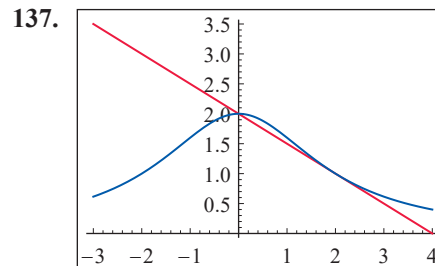
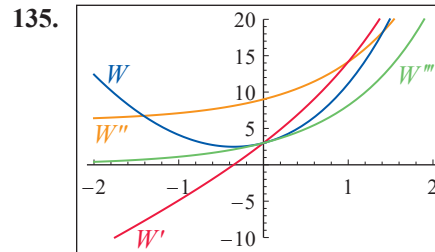
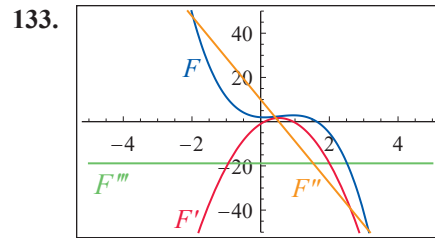
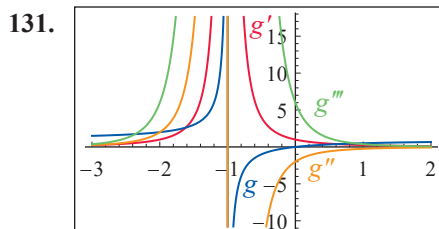
121. True

123. False; y' is found by applying the Reciprocal Rule or the Quotient Rule.

125. True

127. False; $\frac{d}{dx} F(x)$ is found by applying the Quotient Rule.

129. True



Section 3.3

1. $3/2$ 3. π 5. 0 7. 2 9. 1 11. 5

13. $f'(x) = 2 \cos x + 5 \sin x$

15. $h'(x) = \cos x - x \sin x$

17. $G'(x) = \sec x \left(\frac{1}{\sqrt{x}} + 2\sqrt{x} \tan x \right)$

19. $L'(x) = 3e^x (\csc x - 1)(\csc x + \cot x)$

21. $g'(x) = -2 \cot x \csc^2 x$

23. $F'(t) = \frac{t \sin t + 2 \cos t - 2}{t^3}$

25. $R'(z) = \frac{e^z (z-1) + z \cos z - \sin z}{z^2}$

27. $B'(x) = -\csc^2 x$

29. $T'(s) = se^s (2 \cot s + s \cot s - s \csc^2 s)$

31. $x = \frac{2\pi}{3} + 2k\pi$, $x = \frac{4\pi}{3} + 2k\pi$, $k \in \mathbb{Z}$

33. $x = k\pi$, $k \in \mathbb{Z}$ 35. $u = (2k+1)\frac{\pi}{4}$, $k \in \mathbb{Z}$

37. $x = 2k\pi, k \in \mathbb{Z}$ 39. $x = \pm \frac{\pi}{6} + k\pi, k \in \mathbb{Z}$

41. $y = 2x$ 43. $y = 1$

45. $F'(0) = 1, G'(0) = 2, H'(0) = 1$

49. $f^{(4k)}(x) = \sin x, f^{(4k+1)}(x) = \cos x,$
 $f^{(4k+2)}(x) = -\sin x, f^{(4k+3)}(x) = -\cos x$

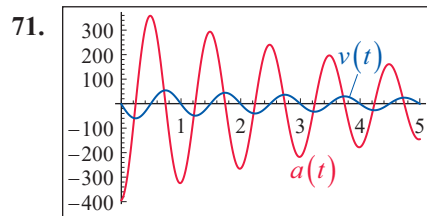
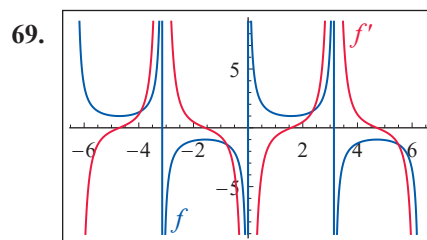
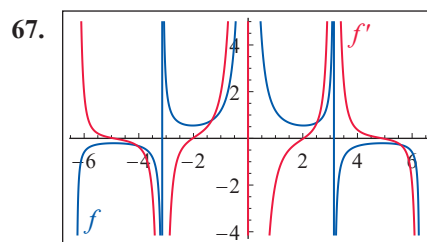
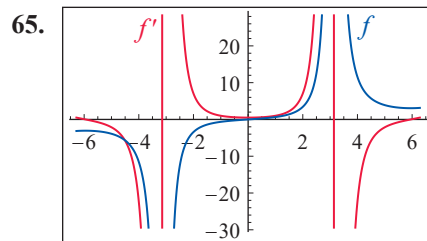
51. $f^{(4k)}(x) = (-4)^k e^x \sin x,$
 $f^{(4k+1)}(x) = (-4)^k e^x (\sin x + \cos x),$
 $f^{(4k+2)}(x) = (-4)^k 2e^x \cos x,$
 $f^{(4k+3)}(x) = (-4)^k 2e^x (\cos x - \sin x)$

61. a. $F'(x) = mg(\cos x + \mu \sin x)$

b. $x = \operatorname{arccot}(-\mu)$

63. $\left. \frac{dx}{d\beta} \right|_{\beta=\pi/6} = -15 \sin \frac{\pi}{6} = -7.5$. This rate is negative

since β is decreasing while x is increasing.



Max. velocity ≈ 54.19 cm/s;

max. acceleration ≈ 358.49 cm/s²

Section 3.4

1. $f(x) = x^6, g(x) = u = 3x - 2.5$

3. $f(x) = 2\sqrt[3]{x}, g(x) = u = x^2 - 9$

5. $f(x) = \sin x, g(x) = u = \frac{1}{x^2 + 1}$

7. $f(x) = \csc x, g(x) = u = 3e^x$

9. $f(x) = \frac{3}{\sqrt{x}}, g(x) = u = \ln x, h(x) = x^2 + 1$

11. $g'(x) = 33(x^5 - \pi x^2 + 7.5)^{10} (5x^4 - 2\pi x)$

13. $F'(x) = \frac{15}{\sqrt{x}(5 + 2\sqrt{x})^6}$

15. $k'(x) = \frac{2(5x^4 - 6x^2 + 10.5)}{(x^5 - 2x^3 + 10.5x)^{7/5}}$

17. $g'(x) = \frac{2x - 5}{2\sqrt{x^2 - 5x + 2}}$

19. $q'(x) = \frac{4}{3}(x^3 - 5x)^{-1/3} (3x^2 - 5)(x + 3)^{5/4}$
 $+ \frac{5}{2}(x^3 - 5x)^{2/3} (x + 3)^{1/4}$

21. $k'(z) = \frac{4z - 5}{(1 + 5z - 2z^2)^2}$

23. $S'(v) = \frac{(v^2 - 5)^2 (6v^2 + 6v + 30)}{(2v + 1)^4}$

25. $T'(s) = \frac{-8s}{3(s^2 + 1)^{1/3} (s^2 - 1)^{5/3}}$

27. $H'(x) = \frac{10x - 3x^3}{(x^2 + 2)^3 \sqrt{x^2 - 2}}$

29. $B'(t) = \frac{1 - 2t^2}{3t^{2/3} (1 + 2t^2)^{4/3}}$

31. $t'(x) = -\sin x \cos(\cos x)$

33. $P'(x) = \tan^2 x + 2x \tan x \sec^2 x$

35. $U'(z) = 10 \sec^2 z \tan z$

37. $C'(x) = \sec^2 x \sin(2 \tan x)$

39. $V'(x) = (-\sin x)e^{\cos x}$

41. $w'(x) = \frac{1}{\sqrt{2x+1}} \left(\cos \sqrt{2x+1} + e^{\tan \sqrt{2x+1}} \sec^2 \sqrt{2x+1} \right)$

43. $f'(x) = \pi^2 (\ln 2) \cos(\pi x) 2^{\sin \pi x}$

45. $t'(s) = (\ln 2) 2^s \sec^2(2^s)$

47. $E'(x) = (\ln 5)^2 5^x 5^{5^x}$

49. $N'(x) = 2x \sin(x^2) \sin\left(2e^{\cos(x^2)}\right) e^{\cos(x^2)}$

51. $C'(x) = -2x \sin(2x^2)$

53. $t'(s) = -\frac{(\ln 10)10^s \sin(10^s)}{2\sqrt{\cos(10^s)}}$

55. $H'(s) = 2^s \ln 2 \left(\cos(2^s) \tan(2^s) + \sin(2^s) \sec^2(2^s) \right)$

57. $T'(z) = e^z \cos(e^z) + e^{\sin z} \cos z$

59. $U'(\theta) = (1 + \sec^2(\theta + \tan(\theta + \tan \theta))) (1 + \sec^2(\theta + \tan \theta)) (1 + \sec^2 \theta)$

61. $y = \frac{4}{3}x + \frac{1}{3}$ 63. $y = 1$

65. $y = -\frac{1}{e\pi^2}x + \frac{2}{e\pi}$ 67. $y = x + 1$

69. $x = 3, x = 4, x = 5$ 71. $x = 0$

73. $x = 0, x = \pm\sqrt{k\pi - 2}, k \in \mathbb{Z}$ 75. $x = \pm 1$

77. $p''(x) = 1520x^2(x^2 + 5)^{18} + 40(x^2 + 5)^{19}$

79. $g''(x) = 10(\sin^2 x - \cos^2 x)$

81. $F''(t) = 6t \cos(t^2) - 4t^3 \sin(t^2)$

83. $G''(x) = 0$

85. $F'(1) + G'(1) = -20$

87. If $n = 4m$, $f^{(n)}(x) = k^n \cos(kx)$;

if $n = 4m + 1$, $f^{(n)}(x) = -k^n \sin(kx)$;

if $n = 4m + 2$, $f^{(n)}(x) = -k^n \cos(kx)$;

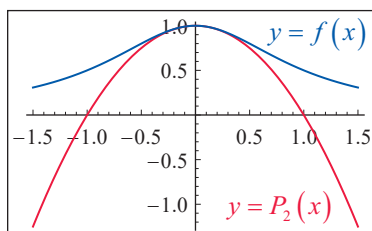
if $n = 4m + 3$, $f^{(n)}(x) = k^n \sin(kx)$.

93. $\frac{dV}{dt} = 6.4\pi \text{ in.}^3/\text{s}$

95. a. $v_{\max} = 1.5 \text{ m/s}$ b. $a_{\max} = 2250 \text{ m/s}^2$

97. $\frac{dP}{dt} \approx 243.63 \text{ Pa/s}$

99. $P_2(x) = 1 - x^2$



Section 3.5

1. $\frac{dy}{dx} = -\frac{1}{2y}$ 3. $\frac{dy}{dx} = \frac{x}{y}$

5. $\frac{dy}{dx} = \frac{1-3y^2}{6xy}$ 7. $\frac{dy}{dx} = \frac{y(2\sqrt{x+2}-1)}{2x-2x\sqrt{x+2}+4}$

9. $\frac{dy}{dx} = \frac{1+y(2\sin x+1)}{2\cos x-x}$ 11. $\frac{dy}{dx} = \frac{2y^2}{3x^2}$

13. $\frac{dx}{dy} = 2y$ 15. $\frac{dx}{dy} = -\frac{y^2}{x^2}$

17. $\frac{dx}{dy} = \frac{e^y - 3\cos y - x}{y}$ 19. $\frac{dx}{dy} = \frac{5y^3}{6x^2}$

21. Tangent line: $y = x - 1$; normal line: $y = -x + 1$

23. Tangent line: $y = -\frac{1}{2}x + 2$; normal line: $y = 2x - 3$

25. Tangent line: $y = -\frac{3}{2}x + \frac{9}{2}$; normal line: $y = \frac{2}{3}x - 2$

27. Tangent line: $y = \frac{7}{4}x - \frac{3}{2}$;
normal line: $y = -\frac{4}{7}x + \frac{22}{7}$

29. $\frac{dy}{dx} = -\frac{x^3}{y^3}$ 31. $\frac{dy}{dx} = \frac{4xy-3y^2}{4xy-3x^2}$ 33. $\frac{dy}{dx} = -1$

35. $\frac{dy}{dx} = \frac{\sin 2x - 2x \sec^2(x^2 + y^2)}{\sin 2y + 2y \sec^2(x^2 + y^2)}$

37. $\frac{dy}{dx} = \frac{2x^4 - 4x^2y - 6xy^2 - x^2 + 2y^2 - y}{3y^2 - 6x^2y - x}$

39. $\frac{dy}{dx} = \frac{5\sqrt{2xy} + y}{3\sqrt{2xy} - x}$ 41. $\frac{dy}{dx} = \frac{\sec^2 x + 2y}{\cos y - 2x}$

43. $\frac{dy}{dx} = \frac{\cos x - \sin x}{2\sqrt{\sin x + \cos x} \sec(x+y) \tan(x+y)} - 1$

45. $\frac{ds}{dt} = \frac{4s-6s^3t^2}{4s^2t^3-\sqrt{s}}$ 47. $\frac{d^2y}{dx^2} = \frac{4y^2-x^2}{16y^3}$

49. $\frac{d^2y}{dx^2} = \frac{(y^2-1)(3y^2+1)}{4x^2y^3}$ 51. $\frac{d^2y}{dx^2} = \frac{-2x(x^3+y^3)}{y^5}$

55. Horizontal tangent: $(1/2, 1)$;

vertical tangent: $(-1, -1/2)$

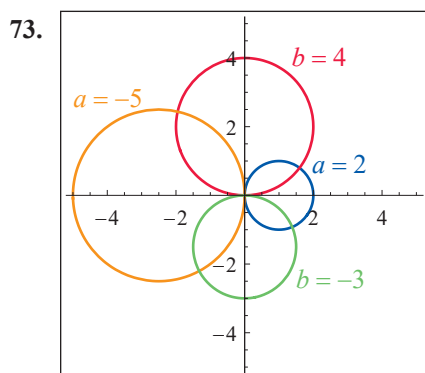
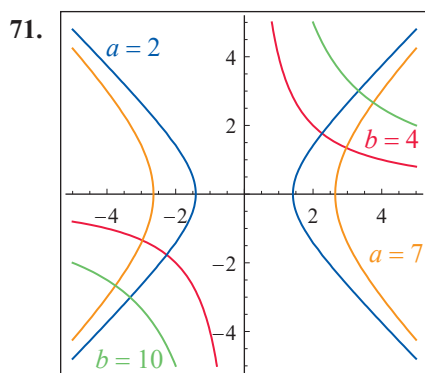
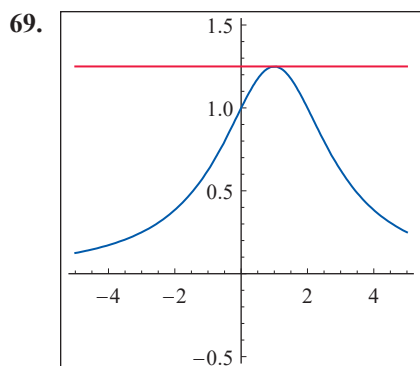
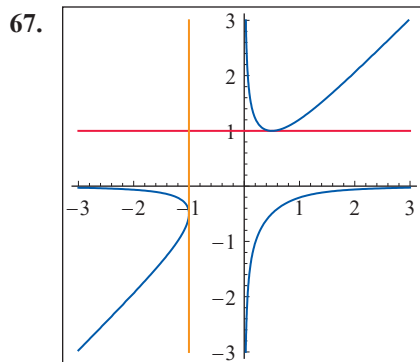
57. Horizontal tangent: $(1, 5/4)$;

vertical tangent: none

59. $y' = x/y$ and $y' = -y/x$, respectively

61. $y' = -1/b$ and $y' = b$, respectively

65. $y = \sqrt{2}x + 2$, $y = -\sqrt{2}x + 2$



Section 3.6

1. $1/12$ 3. 6 5. $1/4$ 7. $-1/2$ 9. $-3/2$
 11. $1/(10 \ln 10)$ 13. 2 15. $5/\cos 0.01$ 17. $1/39$
 19. $-\sqrt{5}/9$ 21. $-5/33$ 23. $1/37$ 25. $-16/7$
 27. 1 29. $2/\sec^2 1$ 31. $f'(x) = 3/x$

33. $h'(x) = \frac{2x}{x^2 + 3}$

35. $G'(x) = \ln \sqrt{x^2 + 4} + \frac{x^2}{x^2 + 4}$

37. $L'(x) = \frac{x^2 + 1 - 2x^2 \ln 2x}{x(x^2 + 1)^2}$

39. $g'(x) = \frac{2}{9 - x^2}$

41. $F'(t) = \frac{t + 2\sqrt{t^2 + 4}}{t^2 + 4 + 2t\sqrt{t^2 + 4}}$

43. $T'(x) = -\tan x$

45. $v'(x) = -2 \sin 2x (\ln(\cos 2x) + 1)$

47. $w'(x) = \log x + \frac{1}{\ln 10}$

49. $y' = (x+2)(x+3)(x+4) + (x+1)(x+3)(x+4) + (x+1)(x+2)(x+4) + (x+1)(x+2)(x+3)$

51. $y' = \sqrt[3]{(2x-1)(x-5)(3x+1)} \left(\frac{2}{6x-3} + \frac{1}{3x-15} + \frac{1}{3x+1} \right)$

53. $y' = \frac{\sqrt[3]{x^3 - 5x^2 + 7}(x+2)}{x^{2/3} \sqrt{3x^2 + 4}} \left(\frac{3x^2 - 10x}{3x^3 - 15x^2 + 21} + \frac{1}{x+2} - \frac{2}{3x} - \frac{3x}{3x^2 + 4} \right)$

55. $y' = \frac{x^2 \sqrt[5]{x^3 + 3}}{\sqrt[4]{x^4 + 4}} \left(\frac{2}{x} + \frac{3x^2}{5(x^3 + 3)} - \frac{x^3}{x^4 + 4} \right)$

57. $y' = (\sin x)^{1/x} \left(\frac{x \cot x - \ln(\sin x)}{x^2} \right)$

59. $y' = (\cos x)^{\sqrt{x}} \left(\frac{\ln(\cos x)}{2\sqrt{x}} - \sqrt{x} \tan x \right)$

61. $y' = (\ln x)^x \left(\ln(\ln x) + \frac{1}{\ln x} \right)$

63. $y' = x^{x^x} (x^x (\ln x + 1) \ln x + x^{x-1})$

65. $y' = (\ln x)^{\sin x} \left(\cos x \ln(\ln x) + \frac{\sin x}{x \ln x} \right)$

67. $y' = -\frac{1}{\sqrt{1-x^2}}$ 69. $y' = -\frac{1}{1+x^2}$

71. $\frac{dy}{dx} = \frac{1}{2x^2 + 2x + 1}$

73. $\frac{dy}{dx} = \frac{1}{(1+x^2) \arctan x}$ 75. $\frac{dy}{dx} = \frac{-1}{2\sqrt{x-x^2}}$

77. $\frac{dy}{dx} = -2\sqrt{1-x^2}$ 79. $\frac{dy}{dx} = \frac{e^x}{1+e^{2x}}$
81. $\frac{dy}{dx} = \frac{-2}{(1+x^2)(1+\arctan x)^2}$
83. $\frac{dy}{dx} = \frac{6x^2 \arcsin(x^3)}{\sqrt{1-x^6}}$ 85. $\frac{dy}{dx} = \frac{2}{(x^2+1)\sqrt{x^2+2}}$
87. $\frac{dy}{dx} = \frac{1}{x^2+1}$
89. $\frac{dy}{dx} = (\arctan x)^x \left[\ln(\arctan x) + \frac{x}{(1+x^2)\arctan x} \right]$
91. $\frac{dy}{dx} = \frac{2}{(x^2+1)^2 \sqrt{x^2+2}}$ 93. $\frac{dy}{dx} = \frac{1}{x^2}$
95. $y = -2.178x + 3.282$ 97. $y = 1.270x + 1.164$
99. $y = \ln(\pi/4)x + 1 - \ln(\pi/4)$
101. $f'(x) = 0$; as remarked in the text,
 $\arcsin(1/x) = \operatorname{arccsc} x$ for $|x| \geq 1$.
103. $\theta = \tan^{-1}(28/s) - \tan^{-1}(8/s)$;
 $\frac{d\theta}{ds} = \frac{8}{s^2+64} - \frac{28}{s^2+784}$
105. Restrict the domain of $\cot x$ to $(0, \pi)$.
107. False; $y = \log \pi$ is a constant function and therefore $y' = 0$.
109. True

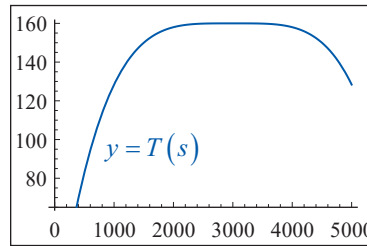
Section 3.7

3. 197,959 people 5. Approx. 367.88 g
7. a. $a = \sqrt[20]{1/2} \approx 0.9659$ b. Approx. 0.707 kg
 c. Approx. 7.629 mg
9. Approx. 8.75 more minutes (i.e., 13.75 total minutes)
11. 300 N 13. Approx. 58.86x N 15. 350 N
19. 0.073 atm/s
21. 0.75 mol/(L·s); 27 mL of water
23. a. \$152.80 b. \$152.50
25. a. \$792.29 b. \$2331 c. \$861.71; \$2311.50
27. \$1077.22 29. Approx. 36π in.³
31. The cost increases by \$465.
33. a. Cost decreases by approx. \$1250.
 b. Profit decreases by approx. \$1050.
 c. The actual decreases are \$1250.01 and \$1052.49, respectively.

35. Approx. 0.8042 cm³ 37. 1.5 percent increase
39. 0.3 percent decrease

Section 3.8

1. -3 ft/s 3. 1/6 5. 8 7. -5.2 9. 0
11. Increasing at 35 in.²/s
13. Approx. 0.8436 units/s
17. -10 cm/min 19. 2.641 cm/min
21. 15.524 mph 23. 0.0808 in./s 25. 12 ft/s
27. 1187.5 mph 29. 25 cm/s; 0.02 rad/s
31. -20 mm²/s 33. 1.52 in./min
35. 1 cm/min 37. $\sqrt{2}/4$ ft/s 39. 15 ft/s
41. 429.29 km/h 43. Approx. 0.494 in./min
45. a.



- b. Approx. 30.465 hp/s

Section 3.9

1. $L(x) = 2x - 2$ 3. $L(x) = 1$
5. $L(\theta) = 1$ 7. $L(t) = -\frac{3}{16}t + \frac{7}{8}$
9. $L(u) = -15u - 62$ 11. $L(z) = z + 1$
13. $dy = 1.4$ 15. $dy = -1.3$
17. $dy = 189/1024$ 19. $dy = -\frac{\pi+2}{8}$
21. $dy = -1/(2e^3)$ 23. $dy \approx -0.1083$
25. $dy = 0.5$; $\Delta y = 0.625$
27. $dy = (\ln 2)/2 \approx 0.3466$; $\Delta y = 2\sqrt[4]{2} - 2 \approx 0.3784$
29. $\Delta y = 1.52$ 31. $\Delta y = -1.4$
33. $\Delta y \approx 0.1854$ 35. $\Delta y = -0.4678$
37. $\Delta y \approx -0.02587$ 39. $\Delta y \approx -0.0934$
41. Approx. 3.0167; calculator value: 3.0166
43. Approx. 3.9667; calculator value: 3.9666
45. Approx. 1.9875; calculator value: 1.9873
47. Approx. 0.9933; calculator value: 0.9933
53. Approx. 0.1266 in. 55. 8.1566 mm²
57. 0.1% 59. Approx. 1 in.³

61. Approx. $\pm 1.24^\circ$

63. a. $F = 0.1875 \text{ N}$ b. $dF \approx 0.017 \text{ N}$

c. $dF \approx 0.0167 \text{ N}$

65. $dE_{kin} \approx 129.63 \text{ kJ}$; about a 24% increase

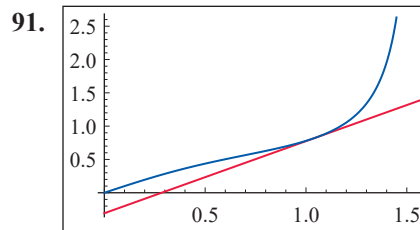
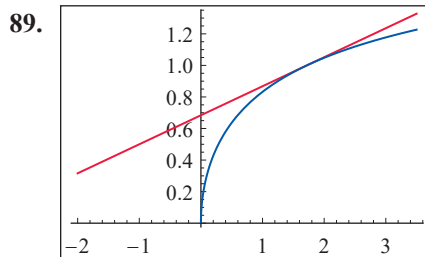
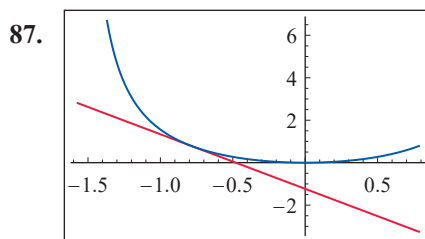
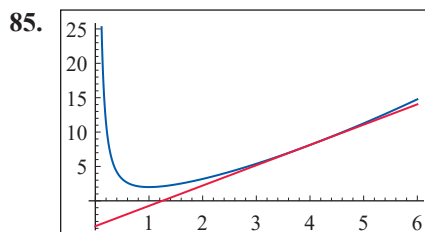
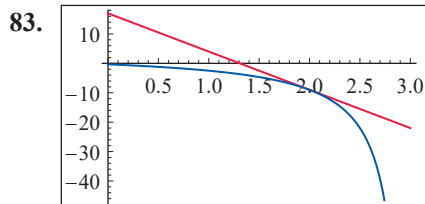
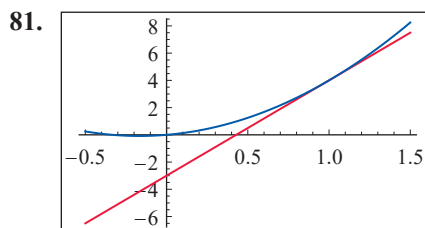
67. 3%; the generalization is $\frac{dA}{A} = \frac{2}{3} \cdot \frac{dV}{V}$

69. Up to 113.615 units

71. $x \approx 5.1$ 73. Yes, we can prove $\frac{dA}{A} = 2 \cdot \frac{dr}{r}$.

75. True 77. True

79. False; consider $f(x) = \sqrt{x}$, $x = 1$, $dx = 0.1$.



Chapter 3 Review

1. $\frac{df}{dx} = 3x^2 + 1$; $\left. \frac{df}{dx} \right|_{x=1} = 4$

3. $D_x s(x) = \frac{1}{2\sqrt{x-2}}$

5. $f'(x) = 2x$; $f''(x) = 2$; $f'''(x) = 0$

7. Not differentiable at 0
One-sided derivatives do not exist at 09. Not differentiable at $k \in \mathbb{Z}$
Left-hand derivative at each point of nondifferentiability: 1
Right-hand derivative at each point of nondifferentiability: 1

11. $f'(x) = x^4 - 8x^3 + 3x^2 + x$

13. $h'(x) = 6x^2 - 2x + 8$

15. $F'(t) = \frac{7}{2}t^{5/2} + 4t^3 + \frac{1}{2}t^{-1/2} - \frac{5}{2}t^{3/2} - 3t^2 + \frac{1}{2}t^{-3/2} + 1$

17. $u'(x) = \frac{7e^x}{(3e^x + 5)^2}$ 19. $v'(x) = \frac{2x}{x^2 + 2}$

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

$$f'''(x) = \frac{6}{(x+1)^4}$$

23. $f'(x) = \sec^2 x$; $f''(x) = 2\sec^2 x \tan x$;

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

25. $f(x) = x^3 - 4x^2 + 6x$ (Answers will vary.)

27. $y = -\frac{3}{8}x + \frac{7}{8}$

29. $y = x$, $y = 13x - 24$ 31. $-1/2$

33. $v(1) = 12.5 \text{ ft/s}$; $a(1) = -12.5 \text{ ft/s}^2$

35. $V'(1) = 784\pi/3 \text{ cm}^3/\text{s}$; $A'(1) = 224\pi/3 \text{ cm}^2/\text{s}$

37. $\frac{dy}{dx} = \frac{4x-5y}{5x-4y}$ 39. $\frac{dx}{dy} = \frac{y(3-y^2)}{3x}$

41. $y = x + 1$ 43. $y = -\frac{20}{9}x + \frac{56}{9}$

45. $\frac{d^2y}{dx^2} = \frac{x^{2/3} + y^{2/3}}{3x^{4/3}y^{1/3}}$ 47. 32 49. $1/2$

51. $f'(x) = \frac{1}{2\sqrt{x}(x+1)}$

53. $f'(x) = \frac{1}{x|\ln x|\sqrt{\ln^2 x - 1}}$ 55. $y' = \frac{(\sqrt{x})^{\ln x} \ln x}{x}$

57. Approx. 8 minutes (8 minutes 3 seconds)

59. Approx. 0.1 in/s 61. 2000 km/h

63. 5 ft 4 in. 65. $L(x) = \frac{\sqrt{2}}{2}x + \frac{\sqrt{2}(4-\pi)}{8}$

67. Approx. 0.7354 69. Approx. 10%

71. If $a > 1$, the slope of y increases as we scan the graph from left to right, while in the other case it decreases.

73. True

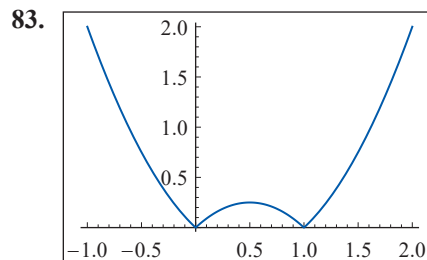
75. False; the Reciprocal Rule along with the Chain Rule (or Quotient Rule) should be used, which yields

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

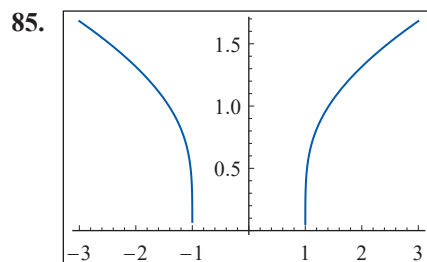
77. False; logarithmic differentiation should be used, which yields $y' = x^x(\ln x + 1)$.

79. True

81. False; $\Delta x = dx$ and even though $\Delta y \rightarrow dy$ might be true under certain circumstances, $x \rightarrow 0$ is not a necessary condition.

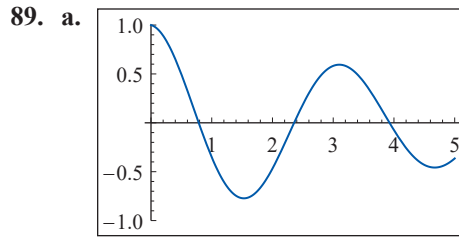


Not differentiable at $x = 0, 1$ (cusps)

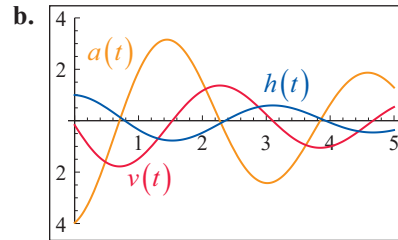


Not differentiable at $x = \pm 1$ (vertical tangents, undefined on $(-1, 1)$)

87. The algorithm employed by the graphing utility may not simplify before differentiating. Yes, we can simplify with an appropriate command. The simplified answer is $f'(x) = \cos x$.



It is an oscillating motion with the amplitude “dying down” as a result of retarding forces.



The object is near its equilibrium position when velocity is maximum and near its extreme positions when velocity is zero. Acceleration, on the other hand, is maximum near the extreme positions and zero near equilibrium.

Chapter 3 Conceptual Project

1. -0.0265 mm Hg/ft 3. -0.0225 mm Hg/ft
5. The symmetric difference quotient is the average of the difference quotients $\frac{f(c+h)-f(c)}{h}$ and $\frac{f(c-h)-f(c)}{-h}$.
7. -0.02302 mm Hg/ft

Chapter 3 Application Project

1. 3.953 s; 126.5 ft/s
3. When an object is dropped, its initial velocity is the same as in Question 2, and it is under the influence of gravity only, so the answer is the same as in Question 2.
5. 6.124 seconds; 196.0 ft/s
This is approximately 133.6 miles per hour, which is not realistic. In Gronk's case, a ball with such speed would most likely have caused significant injury. In reality, air resistance would slow down the ball to a lower speed.

7. $v_t = \sqrt{\frac{2mg}{\rho AC_d}}$

Chapter 4

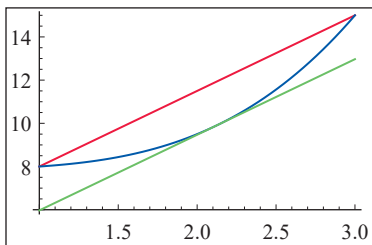
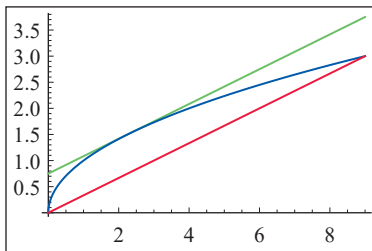
Section 4.1

1. Abs. min.: $f(-1) = f(1) = 0$; no maximum
3. Abs. min.: $f(3\pi/2) = -2$; abs. max.: $f(\pi/2) = 2$
5. Critical points at $x = 0, 1, 3$; rel. min. at $x = 0, 3$; abs. min. at $x = 3$; rel. max. at $x = -1, 1, 4.2$; abs. max. at $x = 4.2$
7. Critical points at $x = 0, 2$; rel. min. at $x = -2, 2$; abs. min. at $x = -2$; rel. max. at $x = 0$; abs. max. at $x = 0$
9. Abs. min.: $f(0) = 1$; abs. max.: $f(3) = 7$
11. No extrema
13. Abs. min.: $v(1) = -4$; abs. max.: $v(-2) = 5$ and $v(4) = 5$
15. No extrema
17. Abs. min.: $n(1) = -1$; no maximum
19. No minimum; abs. max.: $G(0) = 1$
21. Answers will vary. 23. Answers will vary.
25. Answers will vary. 27. Answers will vary.
29. Answers will vary. 31. Answers will vary.
33. Answers will vary. 35. Answers will vary.
37. Answers will vary. 39. $x = 1, -2$ 41. None
43. $x = 1.5$ 45. $x = 0, 4$
47. $t = 0$ 49. $s = 0, 0.5$
51. $\alpha = k\pi, \pm \frac{2\pi}{3} + 2k\pi, k \in \mathbb{Z}$
53. $x = e^{-2}$ 55. $t = 0$
57. Abs. min.: $g(5) = -68$; abs. max.: $g(0) = 7$
59. Abs. min.: $u(2) = -49$; abs. max.: $u(3) = 0$
61. Abs. min.: $k(-3) = k(1) = -4$; abs. max.: $k(-1) = 4$
63. Abs. min.: $m(x) = 6, x \in [-3, 3]$; abs. max.: $m(-4) = m(4) = 8$
65. Abs. min.: $g(1) = 2$; abs. max.: $g(-1.5) = 14.5$
67. Abs. min.: $G(1) = 2$; abs. max.: $G(1/4) = G(4) = 5/2$
69. Abs. min.: $r(-1) = r(1) = 0$; abs. max.: $r(0) = 1$
71. Abs. min.: $w(-2) = -4$; abs. max.: $w(2) = 4$
73. Abs. min.: $r(5\pi/4) = (-\sqrt{2}/2)e^{5\pi/4}$; abs. max.: $r(\pi/4) = (\sqrt{2}/2)e^{\pi/4}$
75. Abs. min.: $t(0) = t(1) = 0$; abs. max.: $t(0.5) = 1$
77. Abs. min.: $V(-25/12) = 5 + (35/12)(-25/12)^{5/7}$; abs. max.: $V(1) = 11$
79. Abs. min.: $g(0) = -4$; no maximum
81. No minimum; abs. max.: $K(0) = 2$
83. No extrema
85. Abs. min.: $L(0) = 0$; no maximum
87. Abs. min.: $t(2n+1) = 0, n \in \mathbb{Z}$; abs. max.: $t(2n) = 4, n \in \mathbb{Z}$
89. No extrema
91. The wire needs to be cut at $21.995 \approx 22$ inches, and this first piece is to be bent into a circle.
93. Approx. 11,500 calculators
95. False; consider $f(x) = \lfloor x \rfloor$ on $[0, 1]$.
97. True
99. False; the critical points shift by k units to the left.
101. True
103. False; f can only have one largest value (however, it can be attained at multiple x -values).
105. True

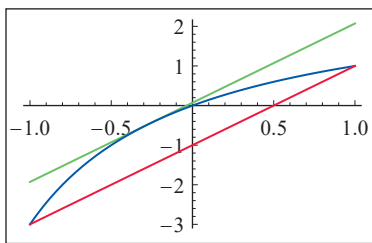
Section 4.2

1. $c = 5/2$ 3. $c = 3$ 9. $c = 2$
11. Rolle's Theorem does not apply; $h(1) \neq h(3)$.
13. $c = 0$
15. Rolle's Theorem does not apply; $H(x)$ is not differentiable at $x = 0$.
17. Rolle's Theorem does not apply; $T(z)$ is not continuous on $[0, 5\pi]$.
19. Rolle's Theorem does not apply; $w(t)$ is not continuous on $[-\pi/4, \pi/4]$.
21. The MVT does not apply; $f(x)$ is not differentiable at $x = 1$.
23. $c = 3/2$
25. The MVT does not apply; $G(x)$ is not continuous on $[-2, 3]$.
27. $c = 0$ 29. $c = -\sqrt{2}/2$
31. The MVT does not apply; $u(z)$ is not continuous on $[0, \pi]$.
33. 10
35. If $f(-5) = -1$ and $f'(x) \leq 0.1$, then $f(5) \leq 0$.
37. $f(x) = x^3 - x^2 + x - 20$
39. $p(t) = -t^2 + 5t - 12$

43. The average velocity is 460 mph, and thus, by the Mean Value Theorem, there must be a time t_0 when the velocity is $v(t_0) = 460$ mph. Use the Intermediate Value Theorem to argue that the equation $v(t) = 450$ has solutions on both intervals $[0, t_0]$ and $[t_0, 10.5]$.
51. No; consider for example $f(x) = \sin x$ on $[0, 2\pi/3]$ with $c = \pi/2$.
53. The average growth rate is 50 rabbits per month, and thus, by the Mean Value Theorem, there must exist a time when the instantaneous growth rate equals 50.
65. False; Rolle's Theorem is a special case of the Mean Value Theorem.
67. True
69. Tangent line: $y = \frac{1}{3}x + \frac{3}{4}$



71. Tangent line: $y = 2x + 7 - 4\sqrt{3}$



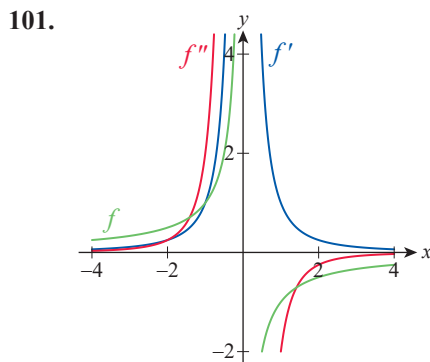
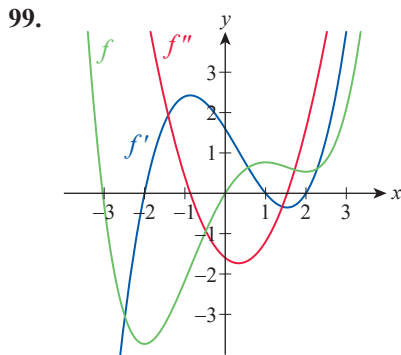
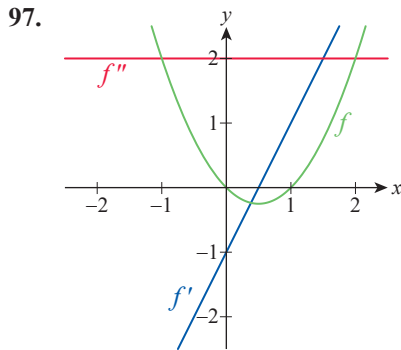
Section 4.3

1. Decreasing on $(-\infty, 2)$; increasing on $(2, \infty)$
3. Increasing on $(-\infty, -5)$, $(1, \infty)$; decreasing on $(-5, 1)$
5. Increasing on $(-\infty, -3)$, $(1/2, 1)$;
decreasing on $(-3, 1/2)$, $(1, \infty)$
7. Increasing on $(-\infty, 1)$; decreasing on $(1, \infty)$
9. Increasing on $(-\infty, -3 - 2\sqrt{3})$, $(-3 + 2\sqrt{3}, \infty)$;
decreasing on $(-3 - 2\sqrt{3}, -3)$, $(-3, -3 + 2\sqrt{3})$
11. Increasing on $(-\infty, 2 - \frac{\sqrt{39}}{3})$, $(2 + \frac{\sqrt{39}}{3}, \infty)$;
decreasing on $(2 - \frac{\sqrt{39}}{3}, 2)$, $(2, 2 + \frac{\sqrt{39}}{3})$
13. Increasing on $(-\infty, 3.125)$; decreasing on $(3.125, \infty)$
15. Decreasing on $(0, 1/3)$; increasing on $(1/3, \infty)$
17. Increasing on $(k\pi, k\pi + \frac{\pi}{2})$, $k \in \mathbb{Z}$;
decreasing on $(k\pi + \frac{\pi}{2}, (k+1)\pi)$, $k \in \mathbb{Z}$
19. Decreasing on $(0, 1/4)$; increasing on $(1/4, \infty)$
21. Increasing on $(-\infty, -2/\sqrt{11})$, $(2/\sqrt{11}, \infty)$;
decreasing on $(-2/\sqrt{11}, 2/\sqrt{11})$
23. Rel. max. at $x = -5$; rel. min. at $x = 1$
25. Rel. max. at $x = -3, 1$; rel. min. at $x = 0.5$
27. Rel. max. at $x = 1$
29. Rel. max. at $x = -3 - 2\sqrt{3}$; rel. min. at $x = -3 + 2\sqrt{3}$
31. Rel. max. at $x = 2 - \frac{\sqrt{39}}{3}$; rel. min. at $x = 2 + \frac{\sqrt{39}}{3}$
33. Rel. max. at $t = 3.125$ 35. Rel. min. at $s = 1/3$
37. Rel. min. at $x = k\pi$, $k \in \mathbb{Z}$;
rel. max. at $x = (2k+1)\frac{\pi}{2}$, $k \in \mathbb{Z}$
39. Rel. min. at $t = 1/4$
41. Rel. max. at $x = -2/\sqrt{11}$; rel. min. at $x = 2/\sqrt{11}$
43. Decreasing on $(-\infty, -1)$; increasing on $(-1, \infty)$;
local min. at $x = -1$; concave up on $(-\infty, \infty)$
45. Decreasing on $(-\infty, -2)$, $(2, \infty)$;
increasing on $(-2, 2)$;
local min. at $x = -2$; local max. at $x = 2$;
concave down on $(-\infty, -2\sqrt{3})$, $(0, 2\sqrt{3})$;
concave up on $(-2\sqrt{3}, 0)$, $(2\sqrt{3}, \infty)$;
inflection points at $x = \pm 2\sqrt{3}, 0$
47. Increasing on $(-\infty, -1)$, $(1, \infty)$;
decreasing on $(-1, 1)$;
local max. at $x = -1$; local min. at $x = 1$;
concave down on $(-\infty, -\sqrt{2}/2)$, $(0, \sqrt{2}/2)$;
concave up on $(-\sqrt{2}/2, 0)$, $(\sqrt{2}/2, \infty)$;
inflection points at $x = \pm \sqrt{2}/2, 0$

49. Decreasing on $(-\pi/2, -\pi/4)$, $(\pi/4, \pi/2)$;
 increasing on $(-\pi/4, \pi/4)$;
 local min. at $x = -\pi/4$; local max. at $x = \pi/4$;
 concave up on $(-\pi/2, 0)$; concave down on $(0, \pi/2)$;
 inflection point at $x = 0$
51. Concave down on $(-\infty, \infty)$
53. Concave down on $(-\infty, 1/4)$; concave up on $(1/4, \infty)$
55. Concave up on $(-\infty, -2)$, $(0, \infty)$;
 concave down on $(-2, 0)$
57. Concave down on $(-\infty, -3)$, $(0, 1)$;
 concave up on $(-3, 0)$, $(1, \infty)$
59. Concave down on $(-\infty, 5)$; concave up on $(5, \infty)$
61. Concave up on $(-\infty, \infty)$
63. Increasing on $(-\infty, \infty)$; no extrema;
 no inflection points
65. Increasing on $(-\infty, 5)$; decreasing on $(5, \infty)$;
 rel. max. (abs. max.) at $x = 5$;
 concave down on $(-\infty, \infty)$; no inflection points
67. Decreasing on $(-\infty, -3/2)$, $(1, \infty)$;
 increasing on $(-3/2, 1)$;
 rel. min. at $x = -3/2$; rel. max. at $x = 1$;
 concave up on $(-\infty, -1/4)$;
 concave down on $(-1/4, \infty)$;
 inflection point at $x = -1/4$
69. Increasing on $\left(-\infty, \frac{-1-\sqrt{21}}{2}\right)$, $\left(1, \frac{-1+\sqrt{21}}{2}\right)$;
 decreasing on $\left(\frac{-1-\sqrt{21}}{2}, 1\right)$, $\left(\frac{-1+\sqrt{21}}{2}, \infty\right)$;
 rel. max. (abs. max.) at $x = \frac{-1-\sqrt{21}}{2}$;
 rel. max. at $x = \frac{-1+\sqrt{21}}{2}$; rel. min. at $x = 1$;
 concave down on $(-\infty, -\sqrt{2})$, $(\sqrt{2}, \infty)$;
 concave up on $(-\sqrt{2}, \sqrt{2})$;
 inflection points at $x = \pm\sqrt{2}$
71. Decreasing on $(-\infty, 2)$, $(2, \infty)$; no extrema;
 concave down on $(-\infty, 2)$; concave up on $(2, \infty)$;
 no inflection points
73. Increasing on $\left(-\infty, 4 - \frac{\sqrt{66}}{2}\right)$, $\left(4 + \frac{\sqrt{66}}{2}, \infty\right)$;
 decreasing on $\left(4 - \frac{\sqrt{66}}{2}, 4\right)$, $\left(4, 4 + \frac{\sqrt{66}}{2}\right)$;
 rel. max. at $x = 4 - \frac{\sqrt{66}}{2}$; rel. min. at $x = 4 + \frac{\sqrt{66}}{2}$;
 concave down on $(-\infty, 4)$; concave up on $(4, \infty)$;
 no inflection points
75. Increasing on $(-\infty, -1)$, $(-1, 1)$, $(1, \infty)$;
 no extrema; concave up on $(-\infty, -1)$;
 concave down on $(-1, 1)$, $(1, \infty)$;
 no inflection points
77. Decreasing on $(-\infty, 0)$, $(4/15, \infty)$;
 increasing on $(0, 4/15)$;
 rel. min. at $x = 0$; rel. max. at $x = 4/15$;
 concave up on $(-\infty, -2/15)$;
 concave down on $(-2/15, \infty)$;
 inflection point at $x = -2/15$
79. Increasing on $(0, 1/2)$; decreasing on $(1/2, \infty)$;
 rel. min. (abs. min.) at $x = 0$;
 rel. max. (abs. max.) at $x = 1/2$;
 concave down on $\left(0, \frac{1+\sqrt{2}}{2}\right)$;
 concave up on $\left(\frac{1+\sqrt{2}}{2}, \infty\right)$;
 inflection point at $x = \frac{1+\sqrt{2}}{2}$
81. For $k \in \mathbb{Z}$: increasing on $\left(\frac{3\pi}{4} + 2k\pi, \frac{7\pi}{4} + 2k\pi\right)$;
 decreasing on $\left(-\frac{\pi}{4} + 2k\pi, \frac{3\pi}{4} + 2k\pi\right)$;
 rel. max. (abs. max.) at $x = -\frac{\pi}{4} + 2k\pi$;
 rel. min. (abs. min.) at $x = \frac{3\pi}{4} + 2k\pi$;
 concave down on $\left(-\frac{3\pi}{4} + 2k\pi, \frac{\pi}{4} + 2k\pi\right)$;
 concave up on $\left(\frac{\pi}{4} + 2k\pi, \frac{5\pi}{4} + 2k\pi\right)$;
 inflection points at $x = \frac{\pi}{4} + k\pi$
83. Answers will vary. 85. Answers will vary.
87. Answers will vary. 89. Answers will vary.
91. Direction is negative on $(0, 3/4)$, positive on $(3/4, \infty)$; changes direction at $t = 3/4$; acceleration is constant $a = 4$, never zero

93. Direction is positive on $(0,1)$, $(4,\infty)$, negative on $(1,4)$; changes direction at $t=1$ and $t=4$; acceleration is negative on $(0,2.5)$, positive on $(2.5,\infty)$, zero at $t=2.5$

95. Direction is negative on $\left(\frac{\pi}{4} + 2k\pi, \frac{5\pi}{4} + 2k\pi\right)$, $k \in \mathbb{Z}$, positive elsewhere; changes direction at $t = \frac{\pi}{4} + k\pi$; acceleration is positive on $\left(\frac{\pi}{2} + 2k\pi, \frac{3\pi}{2} + 2k\pi\right)$, $k \in \mathbb{N} \cup \{0\}$, negative elsewhere, zero at $t = \frac{\pi}{2} + k\pi$



103. a. Midday (temp. is rising, rate of increase is slowing)
 b. Morning (temp. is rising, rate of increase is accelerating)
 c. Early morning (temp. has local minimum)
 d. Evening or nighttime (temp. is falling, rate of decrease is accelerating)
 e. Early morning, just before minimum temperature (temp. is falling, rate of increase is slowing)
 f. Early afternoon (temp. has reached maximum)

105. a. $P(n) = -\frac{n^2}{10} + 50n - 5000$

- b. P is increasing on $(200, 250)$, decreasing on $(250, 350)$; P is maximal when producing 250 liners

107. Local max. at $x = -4$; local min. at $x = 3$

113. $a < 0$, $3ac > b^2$

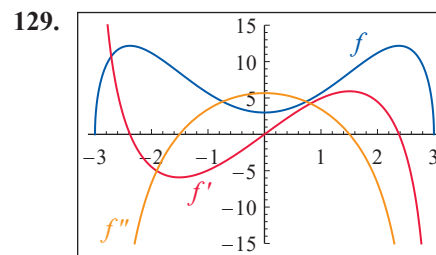
115. $a > 0$, $b = -6a$, $c = 0$, d is arbitrary

121. True

123. False; consider $f(x) = -1/x^2$ with $c = 0$.

125. False; consider $f(x) = g(x) = -x$.

127. False; consider $f(x) = x^3$ with $c = 0$.



131. Answers will vary. 133. Answers will vary.

135. Answers will vary.

Section 4.4

1. 12 3. $1/2$

5. Limit does not exist; L'Hôpital's Rule does not apply.

7. 0

9. Limit does not exist; L'Hôpital's Rule does not apply.

11. $1/2$ 13. ∞/∞ ; $0.2x^2 + 1$ dominates

15. $0 \cdot \infty$; e^{-x} dominates 17. 0 19. $-\infty$

21. L'Hôpital's Rule does not apply; the limit is 0.

23. L'Hôpital's Rule does not apply; the limit is 0.

25. 0 27. 0 29. $-\infty$ 31. $1/2$

33. $2/\ln 3$ 35. 0 37. 1

39. L'Hôpital's Rule does not apply; the limit does not exist.

41. -2 43. ∞ 45. $\frac{\ln 3}{\ln 2}$

47. L'Hôpital's Rule does not apply; the limit is 0.

49. $0 \cdot \infty$; the limit is 0.

51. Not indeterminate form; the limit is 0.

53. ∞^0 ; the limit is 1. 55. $\infty - \infty$; the limit is $-\infty$.

57. $\infty - \infty$; the limit is $-3/2$. 59. 1^∞ ; the limit is $2/e$.

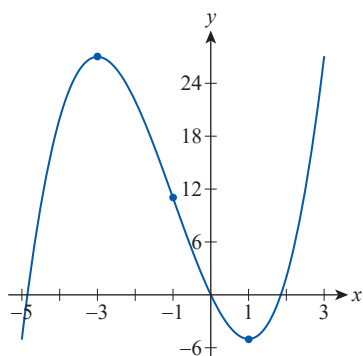
61. Not indeterminate form; the limit is ∞ .

63. ∞^0 ; the limit is 1. 65. 1^∞ ; the limit is 1.

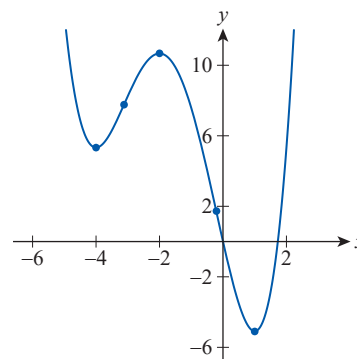
67. Not indeterminate form; the limit is 0.
 69. ∞/∞ ; the limit is $1/100$.
 71. 1^∞ ; the limit is e^2 . 73. $0/0$; the limit is $2/3$.
 75. 0 77. 1
 79. L'Hôpital's Rule does not apply; the limit is 0.
 81. 1 83. $1/2$ 85. $-1/2$
 87. $2/0$ is not indeterminate; L'Hôpital's Rule does not apply.
 89. L'Hôpital's Rule is applied incorrectly; the factors of a product are differentiated.
 91. The third use of L'Hôpital's Rule is unjustified; the limit is $-\infty$.
 93. The limit is 0. 95. The limit is 0.
 97. The limit is ∞ . 99. The limit is 1.
 101. The limit is -5 . 103. The limit is 1.
 105. The limit is 1. 107. The limit is 0.
 109. The limit is 1. 115. $c = 1/2$
 117. The theorem does not apply since $g(a) = g(b)$.
 119. $c = 1$ 121. $c = -\pi/4$ 123. $c = 1/3$
 127. The limit is $16a/9$. 129. $0 \cdot \infty$; the limit is 0.
 131. $\infty - \infty$; the limit is $1/3$.
 133. The limit of the limits is 0.

Section 4.5

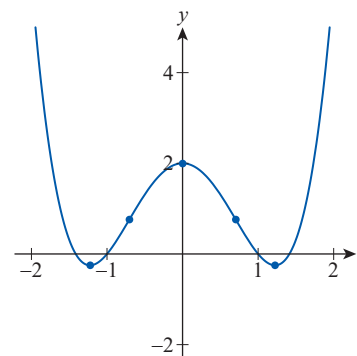
1. First derivative: a ; second derivative: b
 3. First derivative: b ; second derivative: a
 5. Dom = $\mathbb{R}$; x -int.: $0, \frac{-3 \pm 3\sqrt{5}}{2}$; y -int.: 0;
 no asymptotes;
 increasing on $(-\infty, -3), (1, \infty)$;
 decreasing on $(-3, 1)$;
 rel. max. at $x = -3$; rel. min. at $x = 1$;
 concave down on $(-\infty, -1)$;
 concave up on $(-1, \infty)$;
 inflection point at $x = -1$



7. Dom = $\mathbb{R}$; y -int.: 0; no asymptotes;
 decreasing on $(-\infty, -4), (-2, 1)$;
 increasing on $(-4, -2), (1, \infty)$;
 rel. min. at $x = -4$; rel. max. at $x = -2$;
 abs. min. at $x = 1$;
 concave up on $(-\infty, \frac{-5 - \sqrt{19}}{3}), (\frac{-5 + \sqrt{19}}{3}, \infty)$;
 concave down on $(\frac{-5 - \sqrt{19}}{3}, \frac{-5 + \sqrt{19}}{3})$;
 inflection points at $x = \frac{-5 \pm \sqrt{19}}{3}$



9. Dom = $\mathbb{R}$; x -int.: $\pm 1, \pm \sqrt{2}$; y -int.: 2;
 no asymptotes; even function;
 decreasing on $(-\infty, -\sqrt{3}/2), (0, \sqrt{3}/2)$;
 increasing on $(-\sqrt{3}/2, 0), (\sqrt{3}/2, \infty)$;
 rel. max. at $x = 0$;
 abs. min. at $x = \pm \sqrt{3}/2$;
 concave up on $(-\infty, -\sqrt{2}/2), (\sqrt{2}/2, \infty)$;
 concave down on $(-\sqrt{2}/2, \sqrt{2}/2)$;
 inflection points at $x = \pm \sqrt{2}/2$



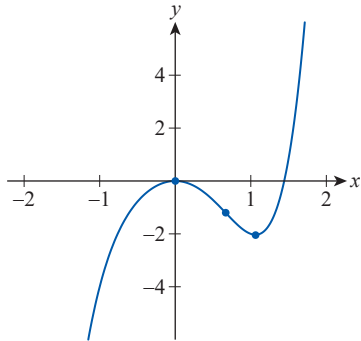
11. Dom = $\mathbb{R}$; x -int.: $0, \sqrt[3]{3}$; y -int.: 0;
 no asymptotes;
 increasing on $(-\infty, 0), (\sqrt[3]{6/5}, \infty)$;
 decreasing on $(0, \sqrt[3]{6/5})$;

rel. max. at $x = 0$; rel. min. at $x = \sqrt[3]{6/5}$;

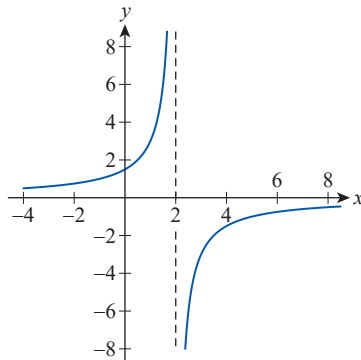
concave down on $(-\infty, \sqrt[3]{3/10})$;

concave up on $(\sqrt[3]{3/10}, \infty)$;

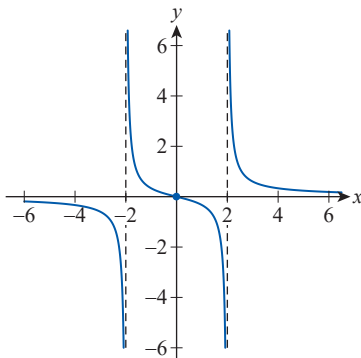
inflection point at $x = \sqrt[3]{3/10}$



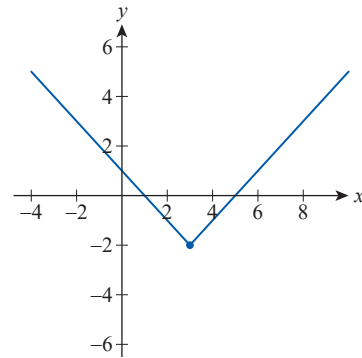
13. Dom = $(-\infty, 2) \cup (2, \infty)$; y-int.: $3/2$;
vert. asym.: $x = 2$; horiz. asym.: $y = 0$;
increasing on $(-\infty, 2)$, $(2, \infty)$; no extrema;
concave up on $(-\infty, 2)$; concave down on $(2, \infty)$;
no inflection points



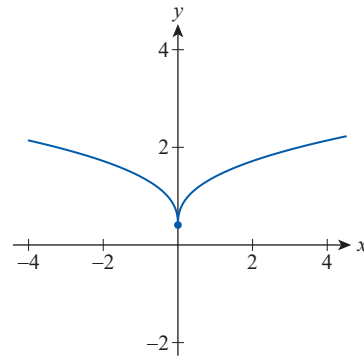
15. Dom = $(-\infty, -2) \cup (-2, 2) \cup (2, \infty)$;
odd function; x-int.: 0; y-int.: 0;
vert. asym.: $x = \pm 2$; horiz. asym.: $y = 0$;
decreasing on $(-\infty, -2)$, $(-2, 2)$, $(2, \infty)$;
no extrema; concave down on $(-\infty, -2)$, $(0, 2)$;
concave up on $(-2, 0)$, $(2, \infty)$; inflection point at $x = 0$



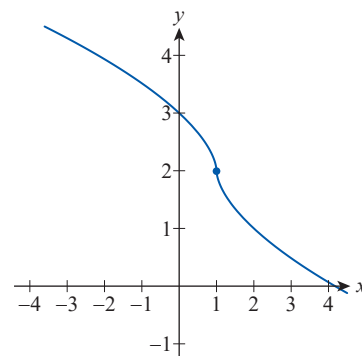
17. Dom = $\mathbb{R}$; x-int.: 1, 5; y-int.: 1; no asymptotes;
decreasing on $(-\infty, 3)$; increasing on $(3, \infty)$;
abs. min. at $x = 3$



19. Dom = $\mathbb{R}$; even function; y-int.: $2/5$;
no asymptotes; decreasing on $(-\infty, 0)$;
increasing on $(0, \infty)$; abs. min. at $x = 0$;
concave down everywhere on $\mathbb{R}$;
no inflection points



21. Dom = $\mathbb{R}$; x-int.: $1 + 2\sqrt[3]{4}$; y-int.: 3;
no asymptotes; decreasing everywhere on $\mathbb{R}$;
no extrema; concave down on $(-\infty, 1)$;
concave up on $(1, \infty)$; inflection point at $x = 1$

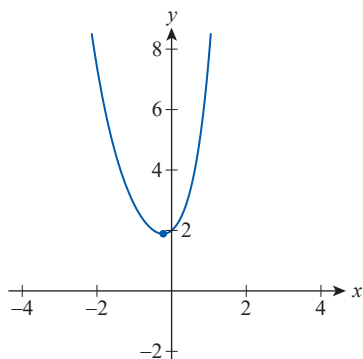


23. Dom = $\mathbb{R}$; y-int.: 2; no asymptotes;

decreasing on $\left(-\infty, -\frac{\ln 2}{3}\right)$;

increasing on $\left(-\frac{\ln 2}{3}, \infty\right)$; abs. min. at $x = -\frac{\ln 2}{3}$;

concave up everywhere on $\mathbb{R}$; no inflection points

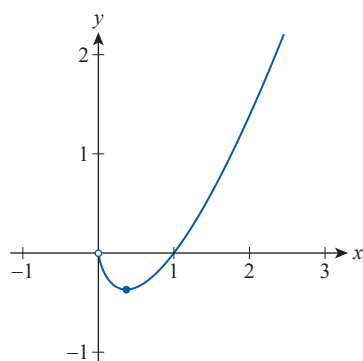


25. Dom = $(0, \infty)$; x-int.: 1; no asymptotes;

decreasing on $(0, 1/e)$; increasing on $(1/e, \infty)$;

abs. min. at $x = 1/e$; concave up on $(0, \infty)$;

no inflection points



27. Dom = $[-2, 2]$; odd function;

x-int.: 0, ± 2 ; y-int.: 0; no asymptotes;

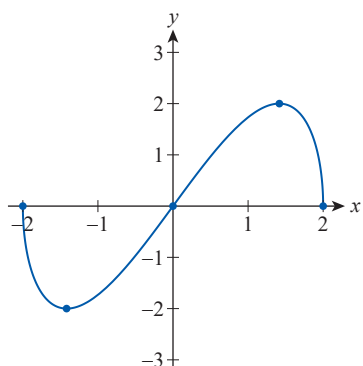
decreasing on $(-2, -\sqrt{2})$, $(\sqrt{2}, 2)$;

increasing on $(-\sqrt{2}, \sqrt{2})$;

abs. min. at $x = -\sqrt{2}$; abs. max. at $x = \sqrt{2}$;

concave up on $(-2, 0)$; concave down on $(0, 2)$;

inflection point at $x = 0$



29. Dom = $(-\infty, 7) \cup (7, \infty)$; y-int.: -1;

vert. asym.: $x = 7$; slant asym.: $y = x + 7$;

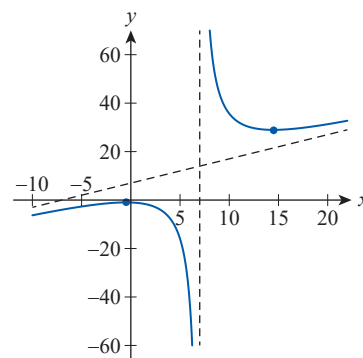
increasing on $(-\infty, 7 - 2\sqrt{14})$, $(7 + 2\sqrt{14}, \infty)$;

decreasing on $(7 - 2\sqrt{14}, 7)$, $(7, 7 + 2\sqrt{14})$;

rel. max. at $x = 7 - 2\sqrt{14}$; rel. min. at $x = 7 + 2\sqrt{14}$;

concave down on $(-\infty, 7)$; concave up on $(7, \infty)$;

no inflection points

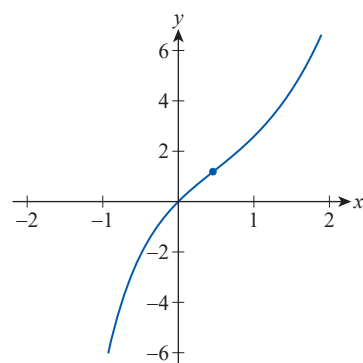


31. Dom = $\mathbb{R}$; x-int.: 0; y-int.: 0; no asymptotes;

increasing everywhere on $\mathbb{R}$; no extrema;

concave down on $\left(-\infty, \frac{\ln 4}{3}\right)$;

concave up on $\left(\frac{\ln 4}{3}, \infty\right)$; inflection point at $x = \frac{\ln 4}{3}$



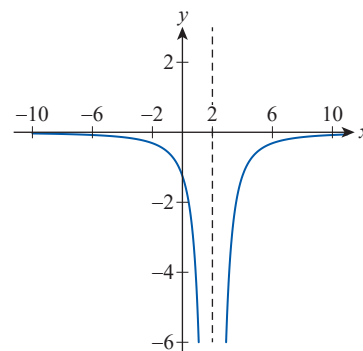
33. Dom = $(-\infty, 2) \cup (2, \infty)$; y-int.: $-5/4$;

vert. asym.: $x = 2$; horiz. asym.: $y = 0$;

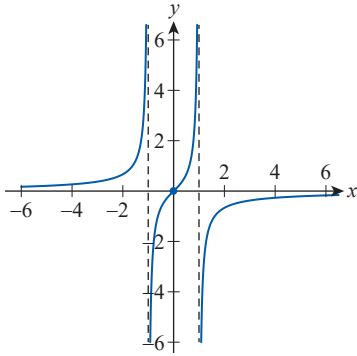
decreasing on $(-\infty, 2)$; increasing on $(2, \infty)$;

no extrema;

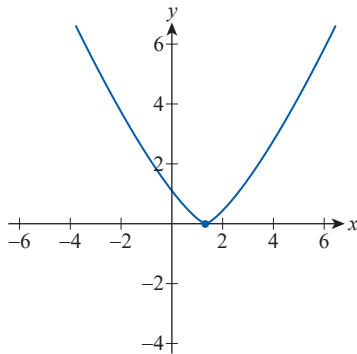
concave down on $(-\infty, 2)$, $(2, \infty)$; no inflection points



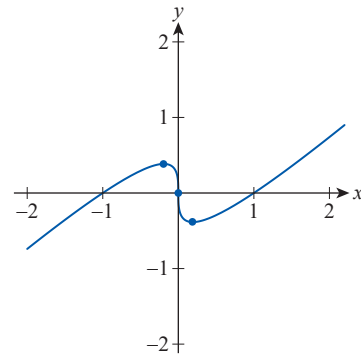
35. Dom = $(-\infty, -1) \cup (-1, 1) \cup (1, \infty)$;
 odd function; x-int.: 0, y-int.: 0;
 vert. asym.: $x = \pm 1$; horiz. asym.: $y = 0$;
 increasing on $(-\infty, -1), (-1, 1), (1, \infty)$; no extrema;
 concave up on $(-\infty, -1), (0, 1)$;
 concave down on $(-1, 0), (1, \infty)$;
 inflection point at $x = 0$



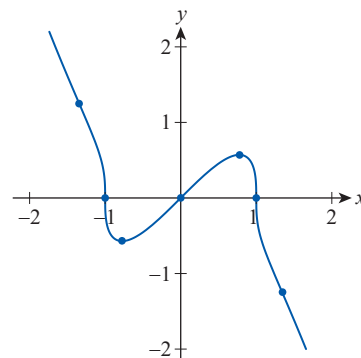
37. Dom = $\mathbb{R}$; x-int.: $4/3$; y-int.: $(4/3)^{1/3}$;
 no asymptotes;
 decreasing on $(-\infty, 4/3)$; increasing on $(4/3, \infty)$;
 abs. min. at $x = 4/3$;
 concave up everywhere on $\mathbb{R}$; no inflection points



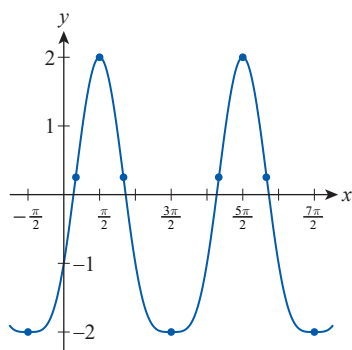
39. Dom = $\mathbb{R}$; odd function; x-int.: 0, ± 1 ; y-int.: 0;
 no asymptotes;
 increasing on $(-\infty, -\frac{1}{3\sqrt{3}}), (\frac{1}{3\sqrt{3}}, \infty)$;
 decreasing on $(-\frac{1}{3\sqrt{3}}, \frac{1}{3\sqrt{3}})$;
 rel. max. at $x = -\frac{1}{3\sqrt{3}}$; rel. min. at $x = \frac{1}{3\sqrt{3}}$;
 concave down on $(-\infty, 0)$;
 concave up on $(0, \infty)$; inflection point at $x = 0$



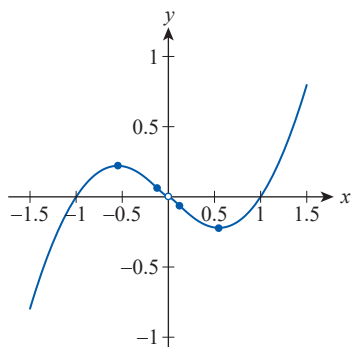
41. Dom = $\mathbb{R}$; odd function;
 x-int.: 0, ± 1 ; y-int.: 0; no asymptotes;
 decreasing on $(-\infty, -\sqrt{3/5}), (\sqrt{3/5}, \infty)$;
 increasing on $(-\sqrt{3/5}, \sqrt{3/5})$;
 rel. min. at $x = -\sqrt{3/5}$; rel. max. at $x = \sqrt{3/5}$;
 concave up on $(-\infty, -3/\sqrt{5}), (-1, 0), (1, 3/\sqrt{5})$;
 concave down on $(-3/\sqrt{5}, -1), (0, 1), (3/\sqrt{5}, \infty)$;
 inflection points at $x = 0, \pm \frac{3}{\sqrt{5}}, \pm 1$



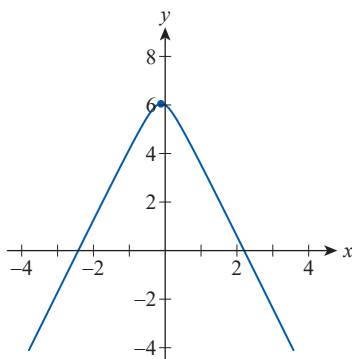
43. Dom = $\mathbb{R}$; 2π -periodic; for the period $-\pi/2 \leq x \leq 3\pi/2$ we have the following: y-int.: -1;
 no asymptotes;
 increasing on $(-\pi/2, \pi/2)$;
 decreasing on $(\pi/2, 3\pi/2)$;
 abs. min. at $x = -\pi/2, 3\pi/2$;
 abs. max. at $x = \pi/2$;
 concave up on $(-\pi/2, \pi/6), (5\pi/6, 3\pi/2)$;
 concave down on $(\pi/6, 5\pi/6)$;
 inflection points at $x = \pi/6, 5\pi/6$



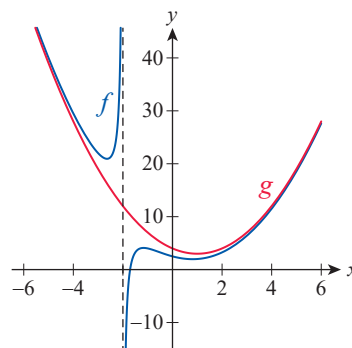
45. Dom = $(-\infty, 0) \cup (0, \infty)$; odd function;
 x-int.: ± 1 ; no asymptotes;
 decreasing on $(-e^{-3/5}, 0), (0, e^{-3/5})$;
 increasing on $(-\infty, -e^{-3/5}), (e^{-3/5}, \infty)$;
 rel. max. at $x = -e^{-3/5}$; rel. min. at $x = e^{-3/5}$;
 concave down on $(-\infty, -e^{-21/10}), (0, e^{-21/10})$;
 concave up on $(-e^{-21/10}, 0), (e^{-21/10}, \infty)$;
 inflection points at $x = \pm e^{-21/10}$



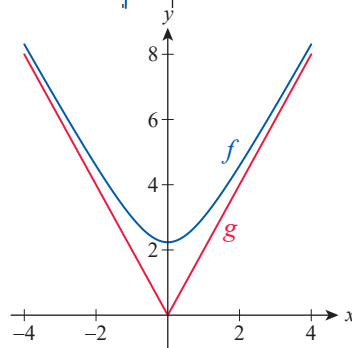
47. Dom = $\mathbb{R}$; x-int.: $\frac{-1 \pm \sqrt{433}}{9}$; y-int.: 6;
 no asymptotes;
 increasing on $(-\infty, -1/9)$;
 decreasing on $(-1/9, \infty)$;
 abs. max. at $x = -1/9$;
 concave down everywhere on $\mathbb{R}$;
 no inflection points



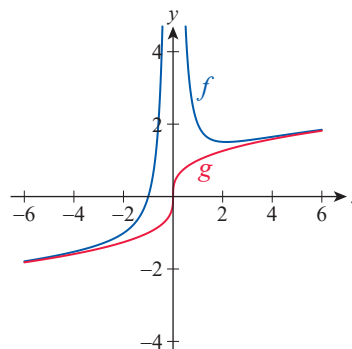
49.



51.



53.



55. No; depending on the starting point, the method may converge to a different root, or not converge at all.

57. 2.65914 59. 1.60943 61. -1.52138

63. 0.48046, 5.61953 65. -0.75487 67. 0.44171

69. 0.69005 71. 0.876726 73. 0.930407

75. 2.475353 77. 0.5671 79. 1.0768, 3.6435

 81. ± 1.15932 83. $f'(x_1) = 0$

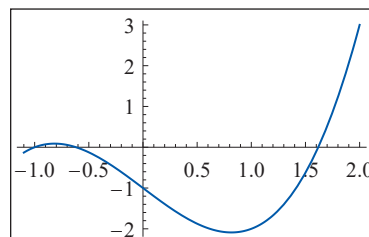
 85. $x_{n+1} = -x_n$ for all n .

 87. x_n alternates between the values of 3 and 1.

 89. $x_{n+1} = \frac{k-1}{k}x_n + \frac{a}{k(x_n)^{k-1}}$

91. 1.41421 93. 2.15443 95. 0.14285

99.



Section 4.6

1. 60 and 60 3. -18 and 18 5. n and n
7. 1 and 1 9. 120 and 80 11. 4 and 4
13. 1 and 0 15. $w = 2\sqrt{k/3}$; $h = 2k/3$
17. $w = 2$, $h = 24$ 19. $y = -\frac{1}{\sqrt[3]{3}}x + \sqrt[3]{9} + 1$
21. $(1/2, \sqrt{2}/2)$
23. Width: $2\sqrt{3}$, height: 2 25. 60 ft by 30 ft
27. Each pen is to be $30\sqrt{2} \times 20\sqrt{2}$ ft, joining along the $20\sqrt{2}$ ft side.
29. Width of cross-section: $w = 2r/\sqrt{3}$ in.,
depth of cross-section: $h = 2\sqrt{2}r/\sqrt{3}$ in.
31. Cut at $\frac{30\pi}{4+\pi}$ in., and use the first piece to form the circle.
33. In the first case, form a circle without cutting. In the second case, form a square.
37. A square of side length $\sqrt{A}$ units
39. $r = h = \sqrt{\frac{S}{3\pi}}$ in.
41. A $2 \times 2 \times 8$ in. box is cheapest, costing \$2.88.
43. $\alpha = 2\pi - 2\pi\sqrt{2/3}$ 45. 14×21 in.
47. $\alpha = 2$ rad, $r = 13$ ft 49. $s = 4\sqrt{14}$ ft
51. The wire needs to be staked 18 ft from the taller antenna.
53. The wire needs to be staked approx. 15.865 ft from the taller antenna.
55. We need to fold $(1/4)(8.5) = 2.125$ in. from the right lower corner.
57. Radius of base: $r = 2\sqrt{2}R/3$, height: $h = 4R/3$
59. Radius of base: $r = \frac{HR}{2(H-R)}$,
height: $h = \frac{H(H-2R)}{2(H-R)}$
61. $\frac{65}{3} \times \frac{65}{3} \times \frac{130}{3}$ in. 63. $b = P/4$
65. He should land approx. 9 miles from the store.
67. Approx. 10 minutes and 21.2 seconds later
69. $t = \pi/4$ s; $v(\pi/4) = -3\sqrt{2}$ ft/s
71. $\theta = \pi/4$
73. \$420; maximum revenue: \$588,000
75. \$1900; apartments rented: 95

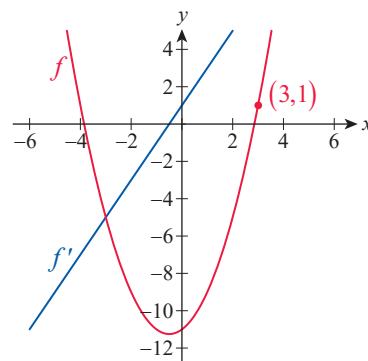
77. 2600 cars; \$29.75 each

81. $x = 7.5$ units

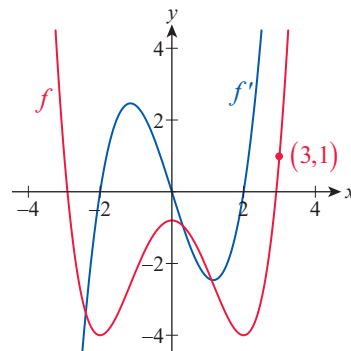
83. The total volume is maximum when we paint a sphere of radius $\frac{1}{2\sqrt{\pi}}$ ft (approx. 3.39 in.) and no tetrahedron. The total volume is a minimum when we paint a sphere of radius approx. 1.63 in., and a tetrahedron of side length approx. 7.99 in.

Section 4.7

9. $F(x) = x$ 11. $H(x) = x^4 - \frac{1}{2}x^2$
13. $V(x) = \tan x + \frac{3}{2}x^2$ 15. $F(x) = 5e^x$
17. $U(t) = 2/t^2$ 19. $W(z) = \arcsin z$
21. $F(x) = x^2 - 3x + C$, $C = 3$
23. $F(x) = 2\sqrt{x} + C$, $C = -1$
25. $F(x) = C$, $C = 1$
27. $F(x) = \frac{x^4}{4} + \frac{1}{x} + C$, $C = -1/4$
29. $F(x) = 10^x + C$, $C = -9$
31. $F(x) = \tan\left(\frac{\pi}{4}x\right) + x + C$, $C = -1$
33. Answers will vary. Sample graph:



35. Answers will vary. Sample graph:

37. $F(x) = 2x^3 - 2x^2 + 1.5x + C$ 39. $H(x) = \frac{x^6}{2} - 2x^5 + \frac{x^3}{3} + 7x + C$

41. $V(x) = 2x^3 + \frac{39}{2}x^2 + 18x + C$

43. $H(x) = \frac{2x^{9/2}}{9} + C$

45. $N(x) = \frac{x^2}{2} + 7\ln|x| + C$

47. $A(y) = \frac{3}{11}y^{11/3} - \frac{6}{7}y^{7/3} + y + C$

49. $G(t) = \frac{e^{3t}}{3} - 3\sec t + C$

51. $T(\theta) = \frac{\theta^2}{2} + \sin \theta + C$

53. $V(x) = \csc x - \cot x + C = \tan(x/2) + C$

55. $W(x) = \csc x + C$

57. $A(x) = \frac{5}{3}\arctan 3x + C$

59. $C(x) = \frac{4}{5}\operatorname{arcsec} 5x + C$

61. $f(x) = \frac{\pi}{2}x^2 - \pi x + \frac{\pi}{2}$

63. $f(x) = x^2 - 2x + 2$

65. $f(x) = \frac{9}{28}x^{7/3} - \frac{3}{4}x + \frac{4}{7}$

67. $f(x) = \frac{8}{105}x^{7/2} + \frac{x^3}{6} + \frac{x^2}{2} - x + 7$

69. $f(x) = 2\arctan 2x + \frac{\pi}{2}$

71. $f(x) = \frac{\sin 2x}{8} + \frac{x^2}{2} + \frac{3x}{4} - 1$

73. $f(x) = \frac{2^{5x}}{(\ln 32)^2} + Cx + D$

75. $f(x) = -\cos x - \frac{e^{2x}}{4} - \frac{3}{2}x + \frac{9}{4}$

77. 39 ft

79. It falls for approx. 7.49 s, and the speed of impact is approx. 83.47 m/s.

81. $16\sqrt{15} \approx 61.97$ ft/s 83. Approx. 22.12 m

87. Approx. 54.77 m 89. 5275

91. The position function (assuming the initial position is 0) is $p(t) = 5.5t^2$. It covers 12.5 m in the first 1.5 s. Its acceleration time from 0 to 60 mph is 2.4 s.

93. 8.25 ft/s^2

95. $p(t) = -\frac{4}{105}t^{5/2}(3t-14)+3$; in 5 seconds it will be at $x = 3 - \frac{20\sqrt{5}}{21} \approx 0.87$. Its instantaneous velocity will be zero at $t = 0$ and $t = 10/3$.

97. True

99. False; if $F(x)$ is an antiderivative, then $F(x) + C$ is also an antiderivative for any $C \in \mathbb{R}$.

101. True

103. False; consider $f(x) = g(x) = 1$ with $F(x) = G(x) = x$. Note that $x \cdot x = x^2$ is not an antiderivative of $1 \cdot 1 = 1$.

Chapter 4 Review

1. Answers will vary. 3. Answers will vary.

5. Abs. min.: $f(1) = -1/3$; abs. max.: $f(-1) = 7/3$

7. Abs. min.: $f(-2) = f(4) = 0$; abs. max.: $f(1) = 9$

9. Abs. min.: $f(2) = -\sqrt{2}$; abs. max.: $f(1/3) = 2/(3\sqrt{3})$

11. No extrema

13. Abs. min.: $f(\pi) = 1$; no maximum

17. $c = 4/3$ 19. $c = \sqrt[3]{65/4}$

23. $f(x) = \sin x + e^x + 2$

27. Increasing on $(-\infty, 3)$; decreasing on $(3, \infty)$

29. Decreasing on $(-\infty, -3)$, $(2, 4)$;
increasing on $(-3, 2)$, $(4, \infty)$

31. Concave down on $(-\infty, 0)$; concave up on $(0, \infty)$

33. Concave up on $(-\infty, -1)$, $(1, \infty)$;
concave down on $(-1, 1)$

35. Decreasing on $(-\infty, 0)$; increasing on $(0, \infty)$;
rel. min. (abs. min.) at $x = 0$;
concave down on $(-\infty, -1/\sqrt[4]{3})$, $(1/\sqrt[4]{3}, \infty)$;
concave up on $(-1/\sqrt[4]{3}, 1/\sqrt[4]{3})$;
inflection points at $x = \pm 1/\sqrt[4]{3}$

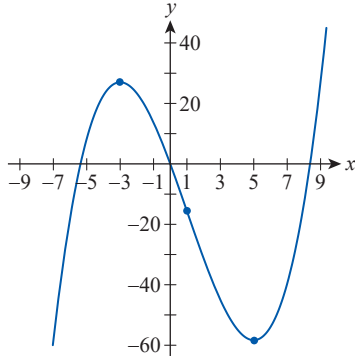
37. Direction is positive on $(0, \sqrt{3})$,
negative on $(\sqrt{3}, 3)$;
changes direction at $t = \sqrt{3}$;
acceleration is positive on $(0, 1)$,
negative on $(1, 3)$, zero at $t = 1$

39. 0

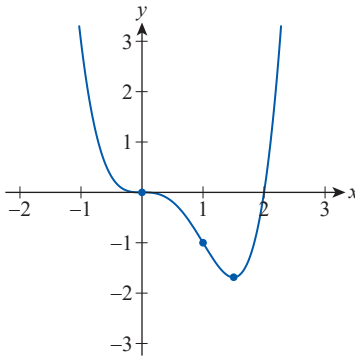
41. L'Hôpital's Rule does not apply; the limit is ∞ .

43. $-\infty$ 45. ∞ 47. $1/2$ 49. 0

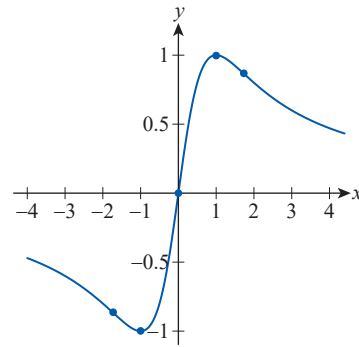
51. Dom = $\mathbb{R}$; x-int.: $0, \frac{3 \pm 3\sqrt{21}}{2}$; y-int.: 0;
 no asymptotes; increasing on $(-\infty, -3), (5, \infty)$;
 decreasing on $(-3, 5)$;
 rel. max. at $x = -3$; rel. min. at $x = 5$;
 concave down on $(-\infty, 1)$; concave up on $(1, \infty)$;
 inflection point at $x = 1$



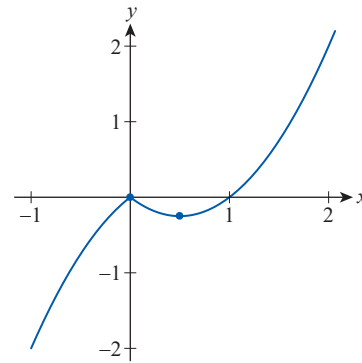
53. Dom = $\mathbb{R}$; x-int.: 0, 2; y-int.: 0;
 no asymptotes;
 decreasing on $(-\infty, 3/2)$;
 increasing on $(3/2, \infty)$;
 abs. min. at $x = 3/2$;
 concave up on $(-\infty, 0), (1, \infty)$;
 concave down on $(0, 1)$;
 inflection points at $x = 0, 1$



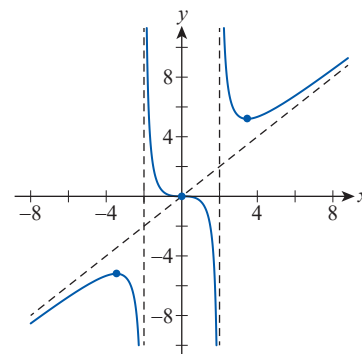
55. Dom = $\mathbb{R}$; odd function; x-int.: 0; y-int.: 0;
 horiz. asym.: $y = 0$;
 decreasing on $(-\infty, -1), (1, \infty)$;
 increasing on $(-1, 1)$;
 abs. min. at $x = -1$; abs. max. at $x = 1$;
 concave down on $(-\infty, -\sqrt{3}), (0, \sqrt{3})$;
 concave up on $(-\sqrt{3}, 0), (\sqrt{3}, \infty)$;
 inflection points at $x = 0, \pm\sqrt{3}$



57. Dom = $\mathbb{R}$; x-int.: 0, 1; y-int.: 0; no asymptotes;
 increasing on $(-\infty, 0), (1/2, \infty)$;
 decreasing on $(0, 1/2)$;
 rel. max. at $x = 0$; rel. min. at $x = 1/2$;
 concave down on $(-\infty, 0)$;
 concave up on $(0, \infty)$;
 inflection point at $x = 0$



59. Dom = $(-\infty, -2) \cup (-2, 2) \cup (2, \infty)$;
 odd function; x-int.: 0; y-int.: 0;
 vert. asym.: $x = \pm 2$; slant asym.: $y = x$;
 increasing on $(-\infty, -2\sqrt{3}), (2\sqrt{3}, \infty)$;
 decreasing on $(-2\sqrt{3}, -2), (-2, 2), (2, 2\sqrt{3})$;
 rel. max. at $x = -2\sqrt{3}$; rel. min. at $x = 2\sqrt{3}$;
 concave down on $(-\infty, -2), (0, 2)$;
 concave up on $(-2, 0), (2, \infty)$;
 inflection point at $x = 0$



61. 1.97435 63. 0.741912 65. 0.4797

67. $\frac{1}{n-1\sqrt{n}}$ 69. $a = (a_1 + \cdots + a_n)/n$

71. $l = 2\sqrt{2/3}$; $w = 2/\sqrt{3}$

73. $5\sqrt{10} \times 10\sqrt{10}$ 75. $4 - 2\sqrt{3}$

77. The equilateral triangle

79. The task is impossible, since $A(r)$ has no maximum. (The surface area approaches infinity as $r \rightarrow 0$ or $r \rightarrow \infty$.)

81. Nate needs to reach the other side approximately 500 ft downstream from the restaurant.

83. $F(x) = x^5 - 1.2x^4 + e^2x + C$

85. $F(x) = 0.16x^{5/2} - 4x^{1/2} + C$

87. $F(x) = x^2 + \tan 2x + C$

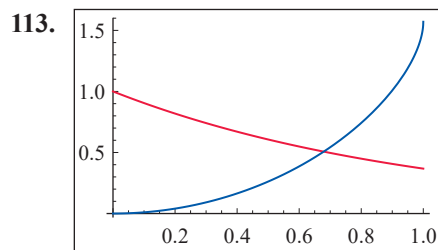
89. $F(x) = \frac{3}{2} \arctan 2x + C$

91. $f(x) = \frac{x^3}{3} - \frac{5x^2}{2} + 8x - \frac{17}{3}$

93. 80 ft/s

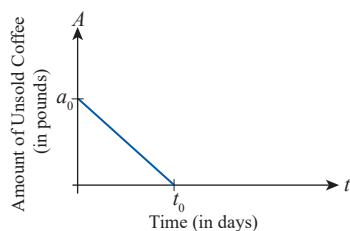
95. False; consider $y = 1/x$ on $(0, 1)$.

97. True 99. True

101. False; consider $y = x^5$ at $x = 0$.

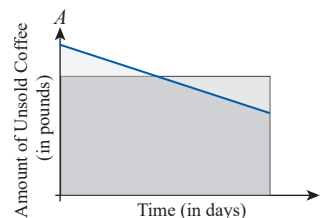
Chapter 4 Application Project

1. It is a linear function with a slope of
- $-c$
- .



3. Since the holding cost is proportional to time and the amount of unsold coffee at hand, it will also be proportional to their product. As a consequence, the holding cost is well represented by the area enclosed by the graph of $A(t)$ and the t -axis. (This is easiest to see when the amount stored is constant.) Since in Question 1 we saw that $A(t)$ was a decreasing linear

function, the area under the curve over a particular time period is the same as the area under the constant function equal to the average value over that time interval. A graphical interpretation of this is below.



5. a. $H_{t_0} = \frac{a_0}{2} h t_0$ b. $C_{t_0} = \frac{a_0}{2} h t_0 + f$

7. $x = \sqrt{\frac{2f}{ch}}$

Chapter 5

Section 5.1

1. $(O_4 + U_4)/2 = 17$ 3. $(O_8 + U_8)/2 = 16.25$

5. Approx. 126 ft; an overestimate

7. a. $O_{12} = 112$ m; $U_{12} = 97.45$ m b. $M_6 = 104.8$ m

c. $(O_{12} + U_{12})/2 = 104.725$ m;
 M_6 is greater, because the curve is likely concave down, as indicated by the data.

9. Left-endpoint est. ≈ 4.146 (underestimate);
 right-endpoint est. ≈ 6.146 (overestimate); midpoint
 est. ≈ 5.384 (overestimate)

11. Left-endpoint est. $= 25/12$ (overestimate);
 right-endpoint est. $= 77/60$ (underestimate); midpoint
 est. $= 496/315$ (underestimate)

13. Left-endpoint est. ≈ 2.367 (overestimate);
 right-endpoint est. ≈ 1.582 (underestimate); midpoint
 est. ≈ 2.013 (overestimate)

15. $\sum_{i=1}^{33} 3i$ 17. $\sum_{i=1}^{100} \frac{1}{i^2}$ 19. $\sum_{i=-2}^{38} a_{2i+1}$

21. $\sum_{i=1}^n f\left(\frac{3i}{n}\right)$ 23. $\sum_{i=0}^n f(x_i^*) \Delta x$ 25. 64 27. $501 + n$

29. $25 + 2n$ 31. $11/6$ 33. 255

35. $\frac{7n^2 + 2n}{2}$ 37. 17,080 39. $\frac{6n^3 + 15n^2 + 11n}{2}$

41. $\frac{n(n+1)(3n^2 - 5n - 4)}{6}$

43. $\frac{1}{1} - \frac{1}{2} + \frac{1}{2} - \cdots + \frac{1}{10} - \frac{1}{11} = \frac{10}{11}$

45. $\sqrt{1} - \sqrt{2} + \sqrt{2} - \cdots + \sqrt{n} - \sqrt{n+1} = 1 - \sqrt{n+1}$

47. $e^2 - e^3 + e^3 - \cdots + e^{n+3} - e^{n+4} = e^2 - e^{n+4}$

49. 88,573

51. $\frac{3(1-(2/3)^{100})}{5}$

55. $\sum_{j=1}^{n-2} \frac{1}{j}$ 57. $\sum_{l=5}^{21} \cos(2l\pi)$

59. 6 61. 1/4 63. 11/12

 65. The region between the graph of $x^3 + 2x$ and the x -axis from 0 to 3

 67. The region between the graph of $\sin x$ and the x -axis from 0 to $\pi/2$

71. Approx. 44.44 m 73. 22.5 m 85. 110

87. $\frac{mn(m+1)(n+1)}{4}$

89. $\lim_{n \rightarrow \infty} \frac{-\pi \csc \frac{\pi}{2n} \sin \frac{\pi - n\pi}{2n} + \pi \csc \frac{\pi}{2n} \sin \frac{\pi + n\pi}{2n}}{2n} = 2$

91. $\lim_{n \rightarrow \infty} \frac{3n + \csc \frac{\pi}{2n} \sin \frac{(2n+1)\pi}{2n}}{8n} = \frac{3}{8}$

Section 5.2

 1. a. 10 b. $(60+9\pi)/8 \approx 11.0343$

 c. 9 d. $(9\pi/8) - 18 \approx -14.4657$

3. 64 ft; -96 ft; -800 ft 5. 16

 7. $7564/11,025 \approx 0.686$ 9. $1899/16,000 \approx 0.119$

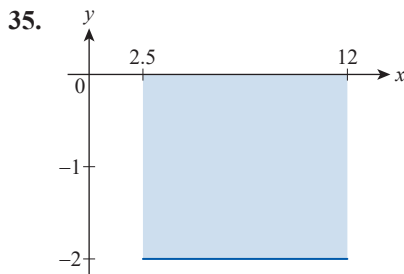
11. $1 + \frac{\ln 3}{2} \approx 1.549$

13. 19/25 15. 17/2 17. 26/3 19. 13

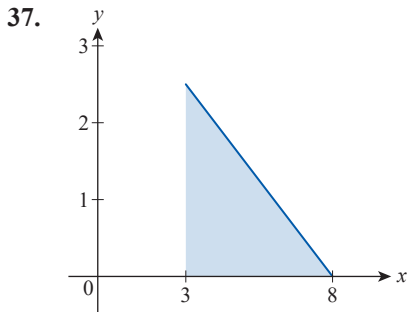
 21. 4 23. 1/4 25. 201/4 27. 44/3 29. $3/\sqrt[3]{4}$

31. $\lim_{n \rightarrow \infty} \sum_{i=1}^n \frac{4}{n} \cdot \left[\left(\frac{4i}{n} \right)^2 - \log_2 \frac{4i}{n} \right]$

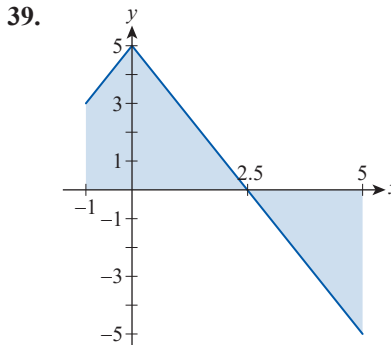
33. $\lim_{n \rightarrow \infty} \sum_{i=1}^n \frac{b-2}{n} \sqrt[4]{2 + \frac{(b-2)i}{n}}$



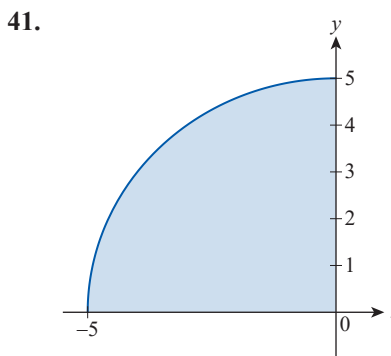
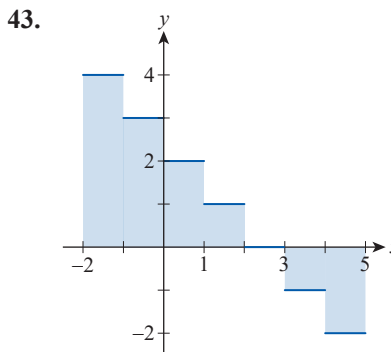
Value: -19



Value: -25/4

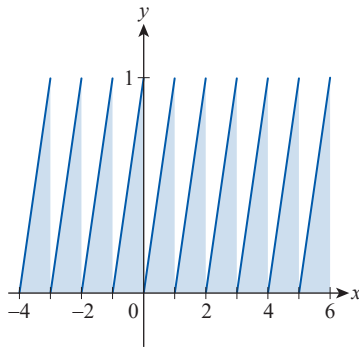


Value: 4


 Value: $25\pi/4$


Value: 7

45.



Value: 5

53. No; see Exercise 51.

55. Yes 57. Yes 59. No; see Exercise 49. 61. E

 63. A 65. C 67. $8 + (c - a)$ 69. 0

 71. $5\sqrt{2}/2$ 73. Not possible 75. $1 + 5\pi/4$

 77. $-1 - \frac{3\sqrt{2}}{4}$ 79. $69/2$ 81. $11/6$ 83. 0 85. 2

87. 0 89. Not possible

 93. $0 \leq \int_2^3 \sqrt{3-x} \, dx \leq 1$ 95. $6 \leq \int_0^6 \left(\frac{x^2}{32} - \frac{x}{4} + \frac{3}{2} \right) dx \leq 9$

 105. -1 107. $17/2$ 109. $-5/3$ 111. $13/5$

 113. $6/5$ 115. $-9/4$ 117. $\int_0^3 \left(\frac{2}{9}x + 4 \right) dx = 13$

 119. $\int_0^2 \sqrt{4-x^2} \, dx = \pi$ 123. $\frac{\pi^3}{3} - \frac{3\pi^2}{2} + \pi$

 125. False; consider $f(x) = g(x) = x$ on $[0, 1]$.

 Note: $\int_0^1 x^2 \, dx \neq \int_0^1 x \, dx \cdot \int_0^1 x \, dx$.

127. True 129. True

Section 5.3

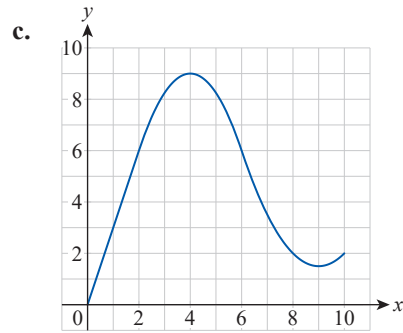
1. $c = \sqrt[3]{2}$ 3. $c = \pm 2/\sqrt[4]{5}$

5. $c = \sin^{-1}(2/\pi), \pi - \sin^{-1}(2/\pi)$

7. $c = \sin^{-1}(\sqrt{\pi}/2), \pi - \sin^{-1}(\sqrt{\pi}/2)$

9. a. $F(2) = 6, F(4) = 9, F(6) = 6, F(8) = 2,$
 $F(10) = 2$

b.
$$F(x) = \begin{cases} 3x & \text{if } 0 \leq x \leq 2 \\ -\frac{3}{4}x^2 + 6x - 3 & \text{if } 2 < x \leq 6 \\ \frac{x^2}{2} - 9x + 42 & \text{if } 6 < x \leq 10 \end{cases}$$



11. $14/3$ 13. $\sqrt{2}$ 15. $160/7$

17. $F'(x) = \frac{1}{3}(x^2 + \sqrt{x})$

19. $G'(x) = \frac{x^4}{x^4 + 4}$ 21. $y' = -\sin \sqrt{x+1}$

23. $y' = (27x^2 + 9)e^{3x-2}$ 25. $y' = (\sin^2 x + e^{\sin x}) \cos x$

27. $y' = \pi \sin(\pi x) - \sin x$

29. $F'(x) = \frac{-\sqrt{1 + \sqrt{1 + (1/x^2)}}}{\sqrt{1-x^2}}$

31. $H'(x) = \ln x - \frac{\ln(\ln x)}{x}$ 33. $F(x) = 2x - 2$

35. $F(x) = -\frac{x^3}{3} - \frac{x^2}{2} + \frac{5}{6}$ 37. $F(x) = 1 - \frac{1}{\sqrt{x}}$

39. -30 41. 175 43. 48 45. 990 47. $1 - \ln 4$

49. $\frac{14}{3} + 4 \ln 2$ 51. $\frac{8-2\sqrt{2}}{5}$ 53. $\frac{45-36\sqrt{2}}{32}$

55. $\frac{1}{2} - \frac{\sqrt{2}}{6}\pi^{3/2}$ 57. $3\pi/4$ 59. $e^{\pi/3}$

61. $44/3$ 63. $\pi/2$ 65. $e - \frac{1}{3}$ 67. $\int_0^2 x^4 \, dx = 32/5$

69. $\int_1^e (1/x) \, dx = 1$ 71. 8 73. 3 75. $63/2$

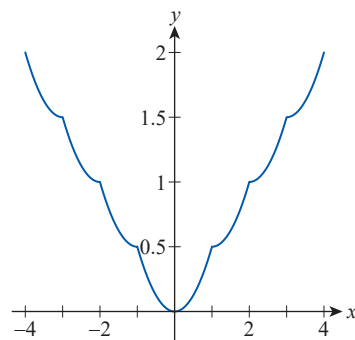
77. $2 \ln 2 - \ln 3$ 79. $1 + 2 \ln 2$ 81. $2e - 9$

83. $3 + \frac{\pi}{4}$ 85. $6 + \ln(33/13)$

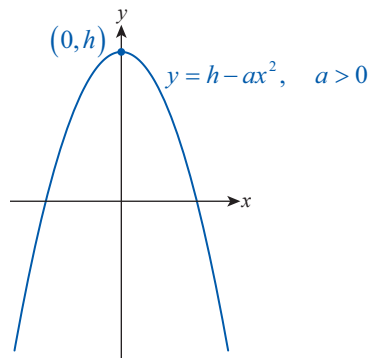
87. $2 + \ln 2$ 89. a. $\frac{3}{2} - \ln 4$ b. $1/2$

91. $f(x) = 2 \cos 2x + 1$

93.



101.



103. True 105. True

107. False; see part a. of Example 3.

109. a. \$3375; \$3250 b. 5.377 years

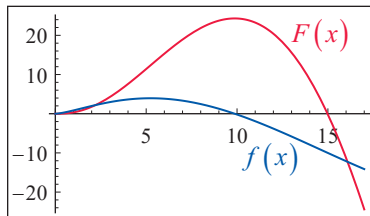
111. The following answers are based on a sine regression.

a. $N(t) = 1.637 \sin(0.023t - 0.936) + 2.583$

b. Approx. 1972 cars

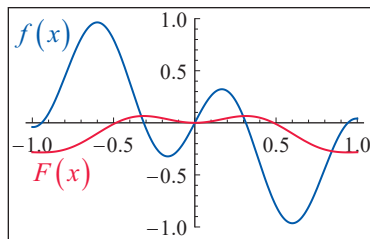
c. Approx. 3 cars per minute

113. $F(x) = (12 - 2x)\sqrt{x} \cos \sqrt{x} + 6(x - 2)\sin \sqrt{x}$



F is increasing where f is positive and decreasing where f is negative. F is concave up where f is increasing and concave down where f is decreasing. The zeros of f are critical points of F , and the critical points of f are potential inflection points for F .

115. $F(x) = \frac{\cos^2 x}{2} - \frac{\cos 8x + 7}{16}$



F is increasing where f is positive and decreasing where f is negative. F is concave up where f is increasing and concave down where f is decreasing. The zeros of f are critical points of F , and the critical points of f are potential inflection points for F .

Section 5.4

1. $2x^6 + 1.5x^5 - 0.25x^4 + 2x + C$

3. $\frac{10}{3}x^3 + 3x^2 - 4x + C$

5. $3/7$ 7. $\frac{2x^{5/2}}{5} - \frac{x^2}{\sqrt{2}} + C$

9. $\pi \tan x - \sec x + C$

11. $\frac{-\csc 2x}{2} + C$ 13. $\pi/2$ 15. $-\frac{7}{5}\sin^{-1}(5x) + C$

17. $\frac{(x^4 + 2)^{3/2}}{6} + C$ 19. $\tan^{-1}(2x) + C$

21. $2e^{2t+3} + C$ 23. $\frac{5^{\arctan x}}{\ln 5} + C$

25. $2 \tan(1 + \sqrt{s}) + C$ 27. $-\tan(1/x) + C$

29. $\frac{-\csc^3 x}{3} + C$ 31. $\frac{2z - 1 + \ln|2z - 1|}{4} + C$

33. $\frac{(6x + 20)(x - 5)^{3/2}}{15} + C$

35. $\frac{x\sqrt{1-x^2} + \sin^{-1} x}{2} + C$ 37. $\frac{(3x - 2)^8}{8} + C$

39. $\frac{(2x^2 + 3x)^{21}}{21} + C$ 41. $\ln|\sin z| + C$

43. $\frac{(x^3 - 5)^{20}}{60} + C$ 45. $e^{\sin x} + C$

47. $\frac{-(5-s)^{38}}{38} + C$ 49. $\frac{3(x^4 + 11)^{4/3}}{16} + C$

51. $\frac{-1}{x^2 + x - 7} + C$ 53. $\frac{-\sqrt{2+x^4}}{2} + C$

55. $-\frac{1}{4}\left(1 + \frac{1}{t}\right)^4 + C$ 57. $2 \ln(|\ln 2t|) + C$

59. $\frac{e^{x^2-3}}{2} + C$ 61. $\frac{\sin \pi x}{\pi} + C$

63. $\frac{\sin^4 2t}{8} + C$ 65. $e^{1-\cot v} + C$

67. $\frac{2}{3(30 - x^{3/2})} + C$ 69. $\ln(\sin^2 x + 2) + C$

71. $\sin(\sin x) + C$ 73. $\frac{\ln|1 - \cos 2x|}{2} + C$

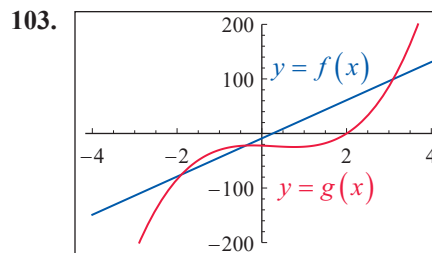
75. $\frac{\sec^3 2x - 3 \sec 2x}{6} + C$ 77. $\frac{4(1 + \sqrt{w})^{3/2}}{3} + C$

79. $\frac{(x+1)^{13}}{13} - \frac{(x+1)^{12}}{2} + C$ 81. $\frac{1 + 4x + 7 \ln|1 + 4x|}{16} + C$

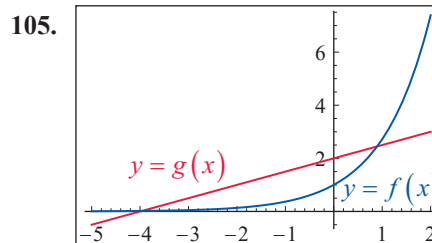
83. $\frac{(1-\ln x)^5}{5} - \frac{7(1-\ln x)^4}{8} + C$
85. $f(x) = \frac{8}{3}(1+x^2)^{3/2} - \frac{5}{3}$ 87. $y(t) = \ln(\sin^2 t + e) - 1$
89. $y(x) = \frac{16x+1-\cos 4x}{16}$ 91. $x = 5$
93. False; the indefinite integral is the set of all antiderivatives.
95. True
97. False; the integral doesn't fit the Substitution Rule with $F(g(x)) = \frac{(\cos x + 1)^3}{3}$. (You can check the falsity of the answer by differentiation.)

Section 5.5

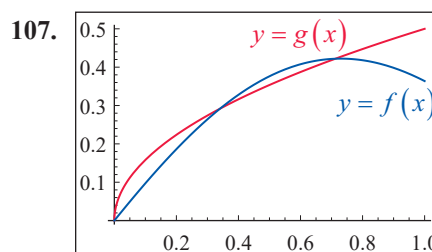
1. $364/3$ 3. $512/27$ 5. $\frac{12^{100}-5^{100}}{300}$ 7. $2/7$
9. $\frac{3(2^{4/3}-1)}{16}$ 11. $2/7$ 13. 1 15. $129/128$
17. $\frac{\ln 2}{3}$ 19. $1/2$ 21. $2/\pi$ 23. $1/6$
25. 0 27. $1 + \ln 2$ 29. 0 31. 2
33. $\frac{4(\sqrt{2}-1)}{3}$ 35. $e^{\pi/3} - 1$ 37. $\ln 2$
39. $\frac{20\sqrt{5}-32}{3}$ 41. $6 - 7\ln 3$
43. $53/72$ 45. 0 47. $33\ln 5 - 32$ 49. $\frac{608-56\sqrt{2}}{15}$
51. $\frac{2\sqrt{2}-1}{3}$ 53. $64/3$ 55. 10.5845
57. $4/3$ 59. $9/2$ 61. $35/4$ 63. $37/12$
65. $5/12$ 67. $\ln 2$ 69. $\frac{11+5\sqrt{5}}{6}$ 71. $1/e$
73. $324/5$ 75. $9/2$ 77. $37/32$ 79. 81
81. $7/2$ 83. $937/12$ 85. $144\sqrt{2} - \frac{2656}{15}$ 87. 1
89. $\frac{4-\pi}{\sqrt{2}}$ 91. $9\pi/4$ 93. $\frac{8}{5} + \frac{4}{\pi}$ 95. 2
101. a. Bike #1
b. Bike #2 starts gaining ground on #1.
c. Yes, it happens when $\int_0^T v_1(t) dt = \int_0^T v_2(t) dt$, at about $T = 2.5$ seconds.



The area is approx. 151.932.



The area is approx. 3.562.



The area is approx. 0.019.

Chapter 5 Review

1. $(O_4 + U_4)/2 = 1.375$
3. $\sum_{i=1}^{100} \frac{(-1)^{i+1}}{i^3 + 1}$ 5. $\sum_{i=1}^{50} f\left(\frac{2i}{n^2}\right)$
7. $212 + 2n$ 9. 9065 11. $\frac{n^2 + 2n}{(n+1)^2}$
13. 0.769399 15. $\frac{mn(m+1)(n+1)(2n+1)}{12}$
17. $1/4$
19. The region between the graph of $2x - x^2$ and the x -axis from 0 to 2; the limit is $4/3$.
23. 0 25. 1.5 27. $1/4$; $x = 3/4, 13/4$
29. $F'(x) = \sqrt{1+x^2}$ 31. $87/5$ 33. $\frac{3}{2} + \ln 4$
35. π 37. $1 + 3\ln 2$ 39. $9/20$ 41. $f(x) = \cos x$
43. $-2\sin^{-1} x + C$ 45. $\sec x + \tan x + C$
47. $\frac{(2x^3 - 7)^{10}}{10} + C$ 49. $\frac{-2}{x^2 + 1} + C$
51. $2\tan\sqrt{x} + C$ 53. $e^x - \ln(e^x + 1) + C$

55. $y(x) = \frac{2}{1-\sqrt{x}} + 2$ 57. $x = 1 + \frac{\ln 17}{2}$

59. $16\sqrt{6}$ 61. $\frac{\pi}{4\ln 2}$ 63. $1/3$ 65. $4/21$

67. $\frac{3-e}{2}$ 69. 2

73. If f is concave up, the integral is expected to be less than the average of L_n and R_n , while if f is concave down, the integral is expected to be greater than the average of L_n and R_n .

75. True

77. False; $\int \frac{1}{e^x} dx = \int e^{-x} dx = -e^{-x} + C$.

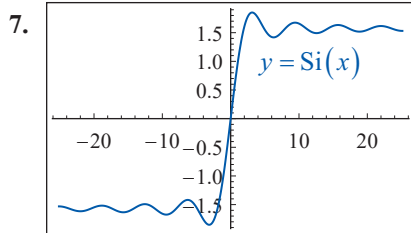
79. False; consider $f(x) = x - 1$ on $[0, 3]$.

81. False; $1/x^3$ is not continuous on $[-1, 1]$.

Chapter 5 Conceptual Project

3. $\frac{d}{dx} \text{Si}(x) = f(x)$

5. Rel. max. at $x = (2k-1)\pi$; rel. min. at $x = 2k\pi$, $k \in \mathbb{N}$



Chapter 5 Application Project

1. a. $a = 16.18 \text{ ft/s}^2$ b. $v(t) = at = 16.18t \text{ ft/s}$

c. $v(t) = \int_0^t 16.18 du$ d. 1496 ft

3. a. 45.47 ft b. 1975.6 ft; a Riemann sum.

5. a. $d = \int_{t_0}^{t_1} v(t) dt$

b. $d(t) = \int_{t_0}^t v(u) du$, $t_0 \leq t \leq t_1$

c. $v(t) = \int_{t_0}^t a(u) du$, $t_0 \leq t \leq t_1$

Chapter 6

Section 6.1

1. 3.2 m^3 3. $8/(15\sqrt{3})$ 5. 8 7. $1/\sqrt{3}$

9. $32/3$ 11. $4/315$ 13. $(2\pi + 6)/3$

15. $138,240\sqrt{5} \text{ cm}^3 \approx 0.309 \text{ m}^3$

17. $4\sqrt{3}\pi \text{ cm}^3$ 19. $384\pi/7$

21. 19π 23. $287\pi/30$ 25. $15\pi/2$ 27. 18π

29. $4\pi/3$ 31. $117\pi/2$ 33. $128\pi/7$ 35. $16\pi/3$

37. a. $2\pi/3$ b. $8\pi/3$ 39. a. $\pi/7$ b. $9\pi/14$

41. a. $128\pi/45$ b. $224\pi/45$

43. a. $3\pi/13$ b. $51\pi/52$

45. a. $93\pi/5$ b. $411\pi/10$

47. a. $4\pi/3$ b. $\frac{3\pi^2 + 4\pi}{3}$

49. a. $2\pi/5$ b. $7\pi/5$

51. a. $8\pi/3$ b. $104\pi/15$

53. a. $6\pi/11$ b. $45\pi/22$

55. a. $762\pi/7$ b. $1077\pi/7$

57. a. π^2 b. $3\pi^2$

59. 261π 61. $1250\pi/3$ 63. $11\pi/30$

65. $56\pi/15$ 67. $488\pi/15$

69. $\pi/2$ 71. $\pi^2/4$

73. The solid (paraboloid) generated by rotating the region bounded by $y = 0$ and $y = \sqrt{x}$, $0 \leq x \leq 4$ about the x -axis

75. The solid generated by rotating the region bounded by $y = e$, $y = e^x$, and $x = 0$ about the x -axis

77. The solid generated by rotating the region bounded by $y = \sqrt[4]{x}$ and $y = x^4$, $0 \leq x \leq 1$ about the x -axis

79. The solid generated by rotating the region bounded by $y = \log_2 x$ and $y = x - 1$, $1 \leq x \leq 2$ about the x -axis

81. Approx. 81.5 mL

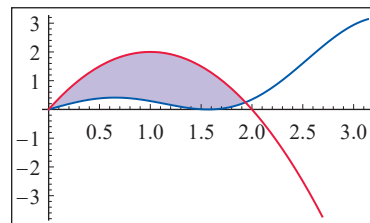
The rate from part b. should be used as a “water clock,” because the water level is falling at a constant rate.

85. For min. volume: $c = \sqrt{2}$; for max. volume: $c = 0, 2$

87. Approx. 45.6 mL 89. $\frac{\pi(\pi^2 - 8)}{4}$

91. Approx. 109.745

93. $V \approx 13.021$



Section 6.2

1. 4π 3. $24\pi/5$ 5. $\pi/3$ 7. $9\pi/4$

9. 18π 11. $931\pi/75$ 13. $81\pi/2$ 15. $33\pi/2$

17. $10\pi/13$ 19. $336\pi/5$ 21. $\pi/2$ 23. $\pi(2\ln 2 - 1)$

25. $2e(e-1)$ 27. $112\pi/3$ 29. $16\pi/3$ 31. $19\pi/15$
 33. $8\pi/3$ 35. $\pi \ln 17$ 37. π/e

39. a. $425\pi/12$ b. $100\pi/3$ c. $125\pi/6$ d. $200\pi/3$

41. a. $544\pi/15$ b. $40\pi/3$ c. $192\pi/5$ d. $40\pi/3$

43. a. 64π b. $512\pi/15$ c. 8π d. $832\pi/15$

45. $V = 2\pi \int_0^{\ln 2} (2xe^{-x} - x) dx$

47. $V = 2\pi \int_0^1 x \arcsin x dx$

49. $V = 2\pi \int_0^{\pi/3} x(\sqrt{3} - \tan x) dx$

51. The solid (circular cone) generated by rotating the region bounded by the y -axis, $y = 2x$, and $y = 4$ about the y -axis

53. The solid (sphere) generated by rotating the region bounded by the x -axis and the semicircle $y = \sqrt{2x - x^2}$ about the x -axis

55. The solid generated by rotating the region bounded by the x -axis and $y = 1 - x^4$, $0 \leq x \leq 1$ about $x = -1$

57. The solid generated by rotating the region bounded by $y = \sin x$, $\pi/2 \leq x \leq \pi$, and the x -axis about $x = \pi/2$

59. The solid generated by rotating the region bounded by $y = \csc x$, $x = \pi/4$, $x = 3\pi/4$, and the x -axis about $x = -1$

61. $\pi/2$ 63. $1024\pi/105$ 65. $144\pi/5$

69. $4\sqrt{3}\pi \text{ cm}^3$ 71. $V = 2\pi^2 R r^2$

73. False; the volume is k^2V .

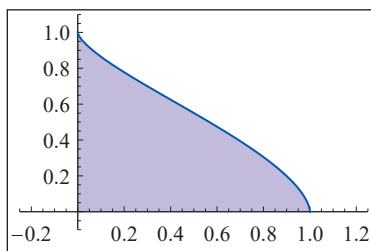
75. True

77. False; compare the formulas

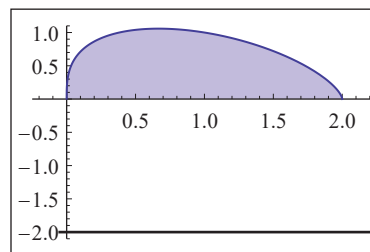
$$\int_a^b \pi \left([f(x)]^2 - [g(x)]^2 \right) dx \text{ and}$$

$$\int_a^b \pi \left([f(x)+1]^2 - [g(x)+1]^2 \right) dx.$$

79. $125\pi/312$



81. $\frac{416\pi^2}{81\sqrt{3}}$



Section 6.3

1. $6\sqrt{10}$ 3. $3\sqrt{5}$ 5. $18 - \frac{4\sqrt{2}}{3}$ 7. $\frac{e^2 + 7}{8}$

9. $521/480$ 11. $\pi/2$ 13. $\frac{e}{4} - \frac{1}{e} + \frac{3}{4}$ 15. 1

17. $\int_0^2 \sqrt{1+4x^2} dx$; $s(x) = \int_0^x \sqrt{1+4t^2} dt$

19. $\int_0^1 \sqrt{4y^2 - 4y + 2} dy$; $s(y) = \int_0^y \sqrt{4t^2 - 4t + 2} dt$

21. $\int_1^2 \sqrt{\frac{4}{x^6} + 1} dx$; $s(x) = \int_1^x \sqrt{\frac{4}{t^6} + 1} dt$

23. $\int_0^2 \sqrt{e^{4-2x} + 1} dx$; $s(x) = \int_0^x \sqrt{e^{4-2t} + 1} dt$

25. $\int_{-1/2}^{1/2} \sqrt{\frac{2-x^2}{1-x^2}} dx$; $s(x) = \int_{-1/2}^x \sqrt{\frac{2-t^2}{1-t^2}} dt$

27. $12\sqrt{2}\pi$ 29. $(40\sqrt{5} - 8)\pi/3$

31. $241\pi/192$ 33. $(16e - e^{-1} - 7)\pi/16$ 35. 2π

37. $(8\sqrt{3} - \frac{8}{3})\pi$ 39. $(16 - 4\sqrt{2})\pi/3$ 41. $515\pi/64$

43. $12\sqrt{5}\pi$ 45. $\pi \cdot \frac{[e(e+2)]^2 - 4e - 1}{4e^2}$

47. $2\pi \int_0^{\sqrt{3}/2} \sin^{-1} x \sqrt{\frac{2-x^2}{1-x^2}} dx$

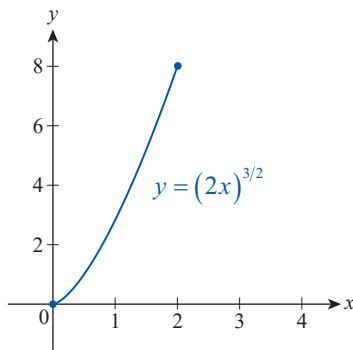
49. $2\pi \int_2^4 \sqrt{\frac{1}{x^4} + \frac{4}{x^{10}}} dx$

51. $2\pi \int_1^8 (3 + \sqrt[3]{x}) \sqrt{\frac{1}{9x^{4/3}} + 1} dx$

53. $2\pi \int_0^1 (2 + \sqrt[4]{y+1}) \sqrt{1 + \frac{1}{16(y+1)^{3/2}}} dy$

55. The surface area is 1200π square units. Yes, because of symmetry, we do obtain the same answer when rotating about the y -axis.

57. a.



b. $\frac{37\sqrt{37}-1}{27}$

61. $\frac{(61\sqrt{61}+185\sqrt{37}-130)\pi}{30}$ 63. $A = 4\pi^2 Rr$

65. $2\pi \left(b^2 + \frac{a^2 b}{\sqrt{a^2 - b^2}} \sin^{-1} \frac{\sqrt{a^2 - b^2}}{a} \right)$

67. Approx. 6.7573 69. Approx. 1.1321

71. Approx. 2.6625 73. Approx. 3.8202

75. Approx. 14.4236 77. Approx. 22.9430

79. Approx. 57.7233 81. Approx. 7.6031

83. Approx. 3.0444 yd

Section 6.4

1. $M_0 = -5$; $\bar{x} = -5/11$ 3. $M_0 = -6.5$; $\bar{x} = -0.5$

5. $M_x = 24$, $M_y = 30$; $(\bar{x}, \bar{y}) = (10/7, 8/7)$

7. She should sit on Christina's side, 1 ft ahead of her.

9. The nosepiece will land approx. 400 yd northeast from the target.

11. $\bar{x} = 63.7681$ 13. $(23/18, 4/9)$

15. $(0.7157, 2.7917)$

17. $(-2, -8/5)$ 19. $(-9/10, 18/5)$

21. $(8/5, 3/2)$ 23. $(1, 1)$ 25. $(2/\ln 3, 1/\ln 27)$

27. $(0, -18/5)$ 29. $(16/15, 64/21)$

31. $(\pi/2, 3/8)$ 33. $(\ln 4, 0)$ 35. $(0, 6/5)$

37. $\left(\frac{5-6\ln 2}{3+6\ln 2}, \frac{5}{6+12\ln 2} \right)$

39. $\left(\frac{14}{3\pi}, \frac{28}{9\pi} \right)$ 41. $(3, 1/2)$

43. $(1/2, 8/15)$ 45. $(2/3, 46/21)$

47. $(2/9, 11/21)$ 49. $(137/76, 25/76)$

51. $(0, 3r/4)$ 53. $\left(\frac{4r}{3\pi}, \frac{4r}{3\pi} \right)$ 55. $(0, r/2)$

59. $\left(\frac{n+1}{2n+1}, \frac{n+1}{2n+4} \right)$;

If $n \rightarrow \infty$ the centroid converges to $(1/2, 1/2)$.

61. $(h/3, R/3)$ 63. $\frac{\pi r^3 (3\pi - 4)}{3}$

65. $828\pi/5$ 67. $240\sqrt{2}\pi$ 69. $2\pi r^2 (\pi - 2)$

73. False; consider Example 4.

75. False; he or she has to sit at two-thirds of the distance (when compared to the other child) from the pivot point (i.e., approximately 33% closer).

Section 6.5

1. 3433.5 J 3. 27 ft·lb

5. a. 200 ft·lb b. 800 ft·lb

7. a. 4 ft·lb b. 3.0625 ft·lb

9. 7600 J 11. 0.84 J

15. $5/4$ ft·lb 17. 10,950 ft·lb 19. 3977.2 kJ

21. 42.2321 kJ

23. $27,500\pi$ ft·lb $\approx 86,393.80$ ft·lb. The work is 3 times that in Example 4a.

25. a. 100,000 ft·lb b. 75,000 ft·lb

c. No. The lower half of the water needs to be pumped higher than the top half.

d. Approx. 6 minutes and 4 seconds;
approx. 4 minutes 33 seconds

27. 2995.2 ft·lb 29. 11,980.8 ft·lb

31. $\delta\pi R^4/4$ 33. 31.2 ft·lb

35. a. 2620.8 lb b. 2433.6 lb

37. Approx. 98.17 N 39. Yes

41. 499.2 lb 43. Approx. 6.27 lb

45. $450 \ln 3$ J ≈ 494.38 J 47. Approx. 620.83 J

51. 4.02286×10^9 ft·lb 53. 4.09308×10^6 kJ

55. Rw 57. 6.75 J 71. Approx. 2.89 ft

Section 6.6

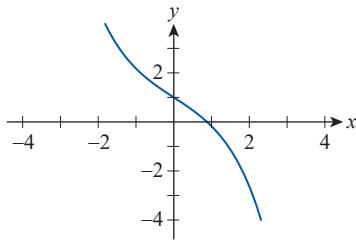
1. a. 1 b. $\frac{e^{-2} - e^2}{2} \approx -3.6269$

c. $\frac{e^{\pi/2} - e^{-\pi/2}}{2} \approx 2.3013$

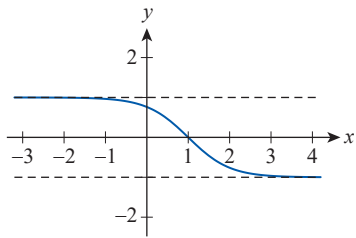
3. a. 0 b. 0 c. $\ln(2 + \sqrt{5}) \approx 1.4436$

5. Odd 7. Odd 9. Even

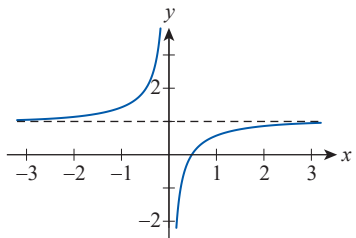
11.



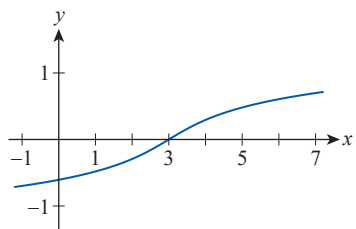
13.



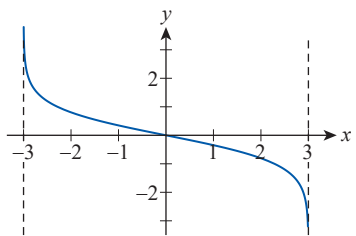
15.



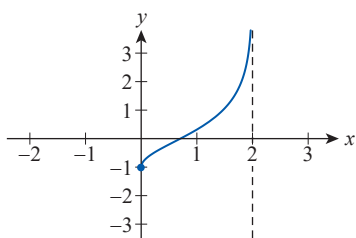
17.



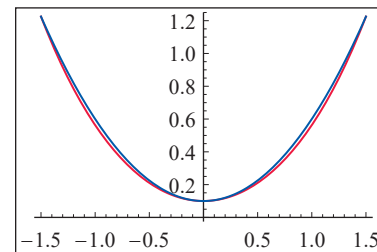
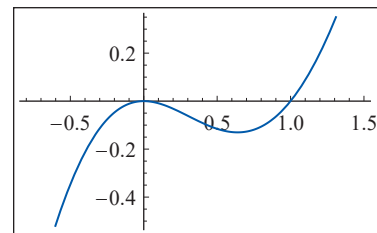
19.



21.

51. $\sinh 2x$ 53. $2 \operatorname{sech}^2 x \tanh x$ 55. $\frac{2 \cosh 2x - \sinh 2x}{e^x}$ 57. $\frac{\operatorname{sech}^2 2x}{\sqrt{1 + \tanh 2x}}$ 59. $3t^2 [\cosh(1+t^3) + (1+t^3) \sinh(1+t^3)]$ 61. $\frac{4y(1+y)}{(1+2y)^2}$ 63. $\sinh x + C$ 65. $\operatorname{sech}(1/z) + C$ 67. $-\ln(\cosh(2-w)) + C$ 69. $\frac{2e^2}{e^4 - 1}$ 71. $\csc^{-1}\left(\frac{4e^2}{e^4 + 1}\right) - \frac{\pi}{6}$ 83. $\frac{7}{\sqrt{49x^2 - 4}}$ 85. $-2 \csc 2x$ 87. $\frac{2}{1-4x^2}$ 89. $\frac{1}{4} \sinh^{-1}\left(\frac{4x}{3}\right) + C$ 91. $\tanh^{-1}(x-3) + C$ 93. $\operatorname{csch}^{-1}(\sin x) + C$ 95. $2 \sinh^{-1} 25$ 97. $\ln(2 - \sqrt{3})$ 99. $-\frac{2}{3} \tanh^{-1} \sqrt{1+x^3} + C$ 101. $\ln \frac{4+\sqrt{15}}{2+\sqrt{3}}$ 103. ∞ 105. 1 107. $1/2$ 109. 0113. a. At the left endpoint: approx. -0.30452 ; at the right endpoint: approx. 0.30452 ; The parabola predicts ± 0.3 .b. Approx. 3.0452 ; Yes, the answer is very close to that given by the parabolic model.115. True 117. False; $\operatorname{csch} 0$ is undefined.

119. a. Approx. 625.093 ft b. Approx. 598.45 ft

c. Approx. ± 0.641 121. $f'(x) = (x^2 - x) \operatorname{sech}^2 x + (2x - 1) \tanh x$;rel. max. at $x = 0$;rel. min. at $x \approx 0.63923$ 

Chapter 6 Review

1. $2/3$ 3. $\pi/2$ 5. $\frac{\pi(\pi-2)}{2}$ 7. $8\pi/3$ 9. $512\pi/21$

11. The solid (circular cone) generated by rotating the region bounded by the x -axis, $y = x$, $0 \leq x \leq 3$ about the x -axis
13. The solid (paraboloid) generated by rotating the first-quadrant region bounded by the graph of $y = 4 - x^2$ and the coordinate axes about the y -axis

15. 2π 17. $8\pi/15$

21. $\int_1^5 \sqrt{16y^2 + 8y + 2} \, dy$ 23. $\int_0^{\pi/3} \sec y \, dy$

25. $14/3$ 27. $\frac{3+e^4}{4}$ 29. $e - \frac{1}{e}$

31. $\pi \int_1^e \sqrt{\ln(x^4) + \frac{1}{x^2}} \, dx$

33. $2\pi \int_0^4 (\sqrt{y} + 1) \sqrt{1 + \frac{1}{4y}} \, dy$

35. $61\pi/432$ 37. $35\pi/16$ 39. $111\pi/16$

41. $(2/5, 1)$ 43. $\left(\frac{24\ln 2 - 14}{9}, \frac{13}{9}\right)$

45. $(8/7, 6/7)$ 47. $(11/2, 0)$

49. $\left(0, \frac{4b}{3\pi}\right)$ 53. $4200 \text{ ft} \cdot \text{lb}$ 55. 29.332 kJ

57. Approx. $123,686 \text{ ft} \cdot \text{lb}$

59. $0.524 \text{ ft} \cdot \text{lb}$ 63. $39,240 \text{ kN}$

65. Approx. $3.30313 \times 10^9 \text{ ft} \cdot \text{lb}$

67. a. Undefined b. 1

73. $e^{2x} (\operatorname{sech}^2 x + 2 \tanh x)$

75. $5 \coth(5x - 2)$ 77. $-\operatorname{sech} x + C$

79. $\sinh^{-1}(x - 2) + C$ 81. $\cosh^{-1}(e^x) + C$

85. $8c/9$

87. False; consider Example 3 and Exercise 60 of Section 6.2.

89. False; consider the region bounded by $y = 1$ and the x -axis over the interval $[0, 1]$.

91. True 93. Approx. 2.104

95. Approx. 26 97. Approx 2.259

99. Approx. 14.424

Chapter 6 Conceptual Project

5. $h_{\max} = \frac{Rv_0^2}{2gR - v_0^2}$ 7. Approx. 2.36 km/s

Chapter 6 Application Project

1. $F_t = (2500 \text{ m/s})(150 \text{ kg/s}) = 375 \text{ kN} = 3.75 \times 10^5 \text{ N}$

3. From Equation 1, $dv = \frac{v_f}{m} dm - gdt$. Thus,

$$v(t) = \int_0^t dv = v_f \int_0^t \frac{dm}{m} - g \int_0^t du = v_f \ln \frac{m(t)}{m(0)} - gt.$$

Chapter 7

Section 7.1

1. $e^x(x-1) + C$ 3. $x^4 \left(\ln x - \frac{1}{4} \right) + C$

5. $\frac{e^{5t}(4+5t)}{25} + C$ 7. $2(\sin x - x \cos x) + C$

9. $\frac{x^2 [\ln(x^2) - 1]}{2} + C$ 11. $\frac{x^3}{3} \left(\ln x - \frac{1}{3} \right) + C$

13. $(s-4)e^{s-3} + C$ 15. $\frac{19+6x}{9}e^{3x-1} + C$

17. $\frac{6x+8}{15}(x-2)^{3/2} + C$ 19. $\frac{(3x)^{4/3}}{16}(4 \ln x - 3) + C$

21. $2\sqrt{x}(\ln \sqrt{x} - 1) + C$

23. $x \sec x - \ln |\sec x + \tan x| + C$

25. $\ln |\sin x| - x \cot x + C$ 27. $-(3x+2)e^{-x} + C$

29. $(t+2)\sinh t - \cosh t + C$

31. $\frac{2(3x-2)(x+1)^{3/2}}{15} + C$

33. $-3 \ln(\cosh x) + \tanh x(3x+2) + C$

35. $\frac{(3x+5)(2x-5)^{3/2}}{15} + C$

37. $2\theta \cos \theta + (\theta^2 - 2)\sin \theta + C$

39. $\frac{1}{2}e^x(\cos x + \sin x) + C$

41. $2t \sin 3t - \frac{1}{3} \cos 3t(9t^2 - 2) + C$

43. $\frac{e^{3x}(3 \sin 2x - 2 \cos 2x)}{13} + C$

45. $(2+x^2)\cosh x - 2x \sinh x + C$

47. $\frac{x[\cos(\ln x) + \sin(\ln x)]}{2} + C$

49. $2(\sqrt{x}-1)e^{\sqrt{x}} + C$

51. $\sqrt{x} \arctan(1/\sqrt{x}) + \frac{1}{2} \ln(x+1) + C$
53. $2\sqrt{x} \cos^{-1} \sqrt{x} - 2\sqrt{1-x} + C$
55. $3x^3 (\ln x)^2 - 2x^3 \ln x + \frac{2}{3} x^3 + C$
57. $\frac{\sqrt{3}}{2} - \frac{\pi}{6}$ 59. $\frac{e^{2\pi} + 1}{5}$
61. $\frac{\sqrt{3}\pi + 9\ln 3}{18}$ 63. $\frac{\pi}{2} + \ln 2 - 2$
65. $x \sin^{-1} x + \sqrt{1-x^2} + C$
67. $x \tan^{-1} x - \frac{1}{2} \ln(1+x^2) + C$
69. $x \sinh^{-1} x - \sqrt{1+x^2} + C$
71. $\sqrt{3}\pi - 3\ln 2$
73. a. $\left(\frac{e-2}{e-1}, \frac{e+1}{4e}\right)$ b. $2\pi(e-2)/e$
75. a. $(\pi/8, 1)$ b. 2π 77. $\left(\frac{e^2+1}{4}, \frac{e-2}{2}\right)$
89. $\frac{x^3 \sin 2x}{2} + \frac{3x^2 \cos 2x}{4} - \frac{3x \sin 2x}{4} - \frac{3 \cos 2x}{8} + C$
91. $e^{\sin x} (\sin^3 x - 3 \sin^2 x + 6 \sin x - 6) + C$
93. $x(\ln x)^3 - 3x(\ln x)^2 + 6x \ln x - 6x + C$
95. $9e - 24$
99. $e^{2x} (4x^3 - 6x^2 + 6x - 3) + C$
101. $e^{3x} (3 \sin 2x - 2 \cos 2x) + C$
17. $\frac{3}{z+1} + 2 \ln|z| - 2 \ln|z+1| + C$
19. $\ln|x+1| - \ln|x+2| + C$
21. $2 \ln|x| - \ln|x+1| - \ln|x-1| + C$
23. $\frac{\ln(t^2+1)}{2} - \ln|t+1| + C$
25. $\frac{3}{2x^2} - \frac{1}{x} + C$
27. $\ln|x-2| + 2 \ln|x| - 3 \ln|x+3| + C$
29. $\ln|x+1| - \ln|x-3| - \frac{2}{x+1} - \frac{2}{x-3} + C$
31. $\ln|v-2| + \ln|v+2| - \ln(v^2+4) + C$
33. $\sqrt{3} \tan^{-1}\left(\frac{2x+1}{\sqrt{3}}\right) + \ln|x-1| - \ln\sqrt{x^2+x+1} + C$
35. $\frac{a}{b} \ln|x| - \frac{a}{2b} \ln|x^2+b| + C$
37. $\ln|x+1| - 4 \ln|x-1| + 3 \ln|x-7| + C$
39. $\ln(243/4096)$ 41. $\ln(3/4)$
47. $\frac{2}{3} \ln|x+1| + \frac{1}{6} \ln(x^2-x+1) + \frac{\sqrt{3}}{3} \arctan \frac{2x-1}{\sqrt{3}} + C$
49. $\frac{\ln 3}{8}$ 51. $\ln \sqrt{3/2}$
53. $3x - \sqrt{3} \tan^{-1}\left(\frac{2x+1}{\sqrt{3}}\right) + \ln|x-1| - \frac{\ln(x^2+x+1)}{2} + C$
55. $-2 \arctan(1-x) + \ln(x^2-2x+2) + \ln|x-3| + C$
57. $\ln(8/5) - 3/8$
59. $\frac{a}{(b-c)} \ln|x-b| - \frac{a}{(b-c)} \ln|x-c| + C$
61. $\frac{4x^2 + 2 \ln|x| - 17 \ln(x^2+4)}{8} + C$
63. $-\frac{2}{3} \ln|\cos x + 2| - \frac{1}{3} \ln|\cos x - 1| + C$
65. $2 \ln \left| \frac{\ln x - 3}{\ln x} \right| + C$
67. $2\sqrt{x} - \frac{2}{1+\sqrt{x}} - 4 \ln(1+\sqrt{x}) + C$
69. $2 \ln \left| \frac{1-\sqrt{1+\sqrt{x}}}{1+\sqrt{1+\sqrt{x}}} \right| + C$
71. $\ln|1 + \sec(\ln x)| + C$
73. $\left[(\ln w)^2 + 1\right] \arctan(\ln w) - \ln w + C$

Section 7.2

1. $\frac{A_1}{x} + \frac{A_2}{x-1}$
3. $\frac{A_1}{x+1} + \frac{A_2}{x-3} + \frac{A_3}{(x-3)^2} + \frac{A_4}{(x-3)^3}$
5. $\frac{B_1x+C_1}{x^2+x+2} + \frac{B_2x+C_2}{(x^2+x+2)^2} + \frac{B_3x+C_3}{(x^2+x+2)^3}$
7. $\frac{A_1}{2x+1} + \frac{A_2}{x-3}$
9. $\frac{A_1}{x+1} + \frac{B_1x+C_1}{x^2+1} + \frac{B_2x+C_2}{(x^2+1)^2}$
11. $4 \ln|3x-1| - 4 \ln|x| + C$
13. $2 \ln|2x+5| - 2 \ln|x+3| + C$
15. $\frac{2}{9} (\ln|x-2| - \ln|x+1|) - \frac{4}{3(x-2)} + C$

75. $\frac{2\pi}{3} \ln 4$

77. $\frac{1}{4c} \ln \left| \frac{c+y}{c-y} \right| - \frac{1}{2c} \tan^{-1} \left(\frac{y}{c} \right) = mt + C$

79. $I(t) = \frac{Ne^{Nkt}}{N-1+e^{Nkt}}$

81. $3x^2 - x + 5 + \frac{x}{x^2+2x+3} + \frac{3x-1}{x^2+1} + \frac{1}{x+2} - \frac{4}{(x+2)^2}$

Section 7.3

1. $\frac{\sin^3 x}{3} + C$

3. $\sin x - \frac{2\sin^3 x}{3} + \frac{\sin^5 x}{5} + C$

5. $\frac{3x}{8} - \frac{1}{4} \sin 2x + \frac{1}{32} \sin 4x + C$

7. 1 9. $5\pi/8$

11. $\frac{\cos^{15} x}{15} - \frac{3\cos^{13} x}{13} + \frac{3\cos^{11} x}{11} - \frac{\cos^9 x}{9} + C$

13. $\frac{3\theta}{128} - \frac{\sin \theta}{32} + \frac{\sin 2\theta}{256} + C$ 15. $\pi/2$

17. $\frac{2\cos^{7/2} x}{7} - \frac{2\cos^{3/2} x}{3} + C$

19. $-\frac{\cos^6 x}{6} + \frac{\cos^8 x}{8} + C$ 21. π

23. $x - \frac{\sin 4x}{4} + \frac{\sin^3 2x}{3} + C$

25. $\frac{\sin^8 x}{8} - \frac{\sin^{10} x}{10} + C$

27. $3/5$ 29. $\frac{-\sin x}{2} + \frac{\sin 15x}{30} + C$

31. $2(2\sqrt{2}-1)/5$ 33. $-2\sqrt{1-\sin x} + C$

35. $2\sqrt{2} \left[\frac{2}{3} \cos^3 \left(\frac{\pi-2x}{4} \right) - \cos \left(\frac{\pi-2x}{4} \right) \right] + C$

37. $\frac{\tan^4 x}{4} - \frac{\tan^2 x}{2} - \ln |\cos x| + C$

39. $\frac{\tan^3 x}{3} + \tan x + C$

41. $\frac{-2}{\sqrt{\sec \theta}} + C$ 43. $\frac{\sec^6 x}{6} + C$

45. $\frac{-2\cot^{9/2} t}{9} - \frac{2\cot^{5/2} t}{5} + C$

47. $\frac{1}{2} \sec x \tan x - \frac{1}{2} \ln |\sec x + \tan x| + C$

49. $848/105$ 51. $2\sqrt{3}$

53. $\frac{\tan^6 2\alpha}{12} + \frac{\tan^4 2\alpha}{8} + C$

55. $-\frac{1}{16} \csc^4 4x + C$ 57. $1/2$

59. $x \tan x - \ln |\sec x| + C$

61. $\frac{1}{4} [2z \tan 2z - 2z^2 - \ln |\sec 2z|] + C$

63. $\frac{-\cos 2x}{4} - \frac{\cos 4x}{8} + C$

65. a. $\frac{-\sin x \cos^6 x}{7} + \frac{\sin x}{7} - \frac{2\sin^3 x}{21} + \frac{\sin^5 x}{35} + C$

b. $\frac{-\sin x \cos^7 x}{8} +$

$\frac{1}{128} \left(5x + 4 \sin 2x + 3 \sin 4x - \frac{\sin^3 2x}{3} \right) + C$

67. $4\pi/\sqrt{3}$ 69. $\left(\frac{6\pi+2\pi^3}{3\pi^2+12}, \frac{15\pi+2\pi^3}{6\pi^2+24} \right)$

75. True 77. True

Section 7.4

1. d 3. c and d 5. b 7. c 9. b 11. c

13. $3 \ln |\sqrt{x^2+9}+x| + C$ 15. $-\sqrt{4-x^2} + C$

17. $\frac{1}{2} \left(25 \arcsin \frac{t}{5} - t \sqrt{25-t^2} \right) + C$

19. $\frac{\sqrt{x^2-36}}{36x} + C$ 21. $\sqrt{1-x^2} + C$

23. $2 \ln |\sqrt{x^2+4}+x| - \sqrt{x^2+4} + C$

25. $\frac{5\sqrt{5}-9}{120}$ 27. $25\pi/16$ 29. $-\frac{\sqrt{t^2+9}}{9t} + C$

31. $-2 \ln \left| \frac{2+\sqrt{4-9x^2}}{x} \right| + \sqrt{4-9x^2} + C$

33. $\frac{-(4-w^2)^{5/2}}{20w^5} + C$ 35. $\frac{3\sqrt{7}-\sqrt{3}}{16}$

37. $\frac{1}{2} x \sqrt{9x^2+16} + \frac{8}{3} \ln |\sqrt{9x^2+16}+3x| + C$

39. $-\frac{\sqrt{4-x^2}}{x} - \arcsin \frac{x}{2} + C$ 41. $\frac{\sqrt{3x^2+1}}{3} + C$

43. $-\frac{1}{\sqrt{1-x^2}} + C$ 45. $-\frac{\sqrt{25-9x^2}}{25x} + C$

47. $4/15$ 49. $\ln |2x+1+\sqrt{4x^2+4x+12}| + C$

$$51. \frac{27}{2} \arcsin \frac{x-3}{3} - \frac{(x+9)\sqrt{6x-x^2}}{2} + C$$

$$53. \frac{\pi}{4\sqrt{2}} \quad 55. \frac{1}{\sqrt{3}} - \frac{2}{\sqrt{15}}$$

$$57. \frac{x-3}{2} \sqrt{7+6x-x^2} - 8 \arcsin \frac{3-x}{4} + C$$

$$59. \frac{x-5}{4(x^2-10x+29)} + \frac{1}{8} \arctan \frac{x-5}{2} + C$$

$$61. \frac{1}{2} \left[e^x \sqrt{1-e^{2x}} + \arcsin(e^x) \right] + C$$

$$63. -\frac{\sqrt{\sin^2 x + 1}}{\sin x} + C$$

$$65. \frac{x}{2} \sqrt{x^2-a^2} - \frac{a^2}{2} \ln |x + \sqrt{x^2-a^2}| + C$$

$$67. \frac{1}{a} \sec^{-1} \left(\frac{x}{a} \right) + C \quad 69. \ln |x + \sqrt{x^2+a^2}| + C$$

$$71. \frac{1}{a} \ln \left| \frac{\sqrt{x^2+a^2}+a}{x} \right| + C \quad 73. \frac{1}{a} \operatorname{sech}^{-1} \left(\frac{x}{a} \right) + C$$

$$75. \sinh^{-1} \left(\frac{x}{4} \right) - \frac{x}{\sqrt{x^2+16}} + C;$$

$$\ln |\sqrt{x^2+a^2}+x| - \frac{x}{\sqrt{x^2+a^2}} + C;$$

$$\sinh^{-1} \left(\frac{x}{a} \right) - \frac{x}{\sqrt{x^2+a^2}} + C$$

$$77. \frac{1}{4} \left[-t\sqrt{1-t^2} + (2t^2-1) \operatorname{arccost} t \right] + C$$

$$79. \frac{\sqrt{6}}{9} - \frac{1}{6} \quad 81. 2\pi \left(\ln 3 - \frac{4}{5} \right)$$

$$83. \pi\sqrt{3}/2 \quad 85. 1 + \frac{1}{2} \ln \frac{3}{2} \approx 1.203$$

89. False; $x = \sec \theta$ is a recommended substitution.

91. False; the definite integral is not multiplicative.

$$93. \frac{x}{2} \sqrt{x^2+25} - \frac{25}{2} \sinh^{-1} \left(\frac{x}{5} \right) + C$$

$$95. -\sinh^{-1}(3-x) + C$$

$$13. \frac{x+1}{2} \sqrt{x^2+2x+5} + 2 \ln |x+1+\sqrt{x^2+2x+5}| + C$$

$$15. \frac{\sqrt{3}\pi+9\ln 3}{18} \quad 17. 2 \cot \frac{\pi}{8} - \frac{\pi}{4} - 2$$

$$19. \frac{2}{3} \left[(z+2)^{3/2} - z^{3/2} \right] + C$$

$$21. \sqrt{x^2-4} + 2 \ln |x + \sqrt{x^2-4}| + C$$

$$23. \frac{1}{3} \left(\ln |x| - \ln |3 + \sqrt{2x^2+9}| \right) + C$$

$$25. -\frac{1}{x^3} + 2 \ln \left| \frac{2x^3+1}{x^3} \right| + C$$

$$27. \frac{1}{3} (\tan u - 5) \sqrt{5+2 \tan u} + C$$

$$29. \frac{x \ln x - x}{2} + C \quad 31. \frac{\sin x - 2}{\sqrt{2 \sin x - \sin^2 x}} + C$$

$$33. 2\sqrt{3x-2} - 2\sqrt{2} \arctan \sqrt{\frac{3x-2}{2}} + C$$

$$35. \frac{1-x}{6} \sqrt{1+6x-3x^2} + \frac{2}{3\sqrt{3}} \arcsin \frac{\sqrt{3}(x-1)}{2} + C$$

$$37. \frac{17}{18} + \frac{3 \ln 3}{8} \quad 39. \pi/4$$

$$43. \sqrt{2} \arctan \frac{\tan(x/2)-1}{\sqrt{2}} + C$$

$$45. \frac{2}{\sqrt{5}} \arctan \frac{\tan(u/2)}{\sqrt{5}} + C$$

$$57. \frac{1}{2} (1+x) \sqrt{5+2x+x^2} + 2 \sinh^{-1} \left(\frac{1+x}{2} \right) + C$$

$$59. 2\sqrt{1+2x} + \ln(1-\sqrt{1+2x}) - \ln(1+\sqrt{1+2x}) + C$$

$$61. 2\sqrt{e^2+e^x} - 2e \tanh^{-1} \left(\frac{\sqrt{e^2+e^x}}{e} \right) + C$$

$$63. \frac{1}{3} \arctan \left(\frac{1}{3} \sqrt{-9+e^{2x}} \right) + C$$

$$65. \frac{1}{6} \left[\sqrt{5+2x+x^2} (7+x+2x^2) - 12 \sinh^{-1} \left(\frac{1+x}{2} \right) \right] + C$$

$$67. F(x) = \sqrt{x^2-4x+5} (x^2-x-1) - 3 \sinh^{-1}(2-x) + \sqrt{2} + 3 \sinh^{-1}(1)$$

$$69. x \approx 5.1292 \quad 71. x \approx 0.095142$$

Section 7.5

$$1. \frac{1}{25} \ln \left| \frac{x}{x+5} \right| + C \quad 3. -\ln \left| \frac{2+\sqrt{x^2+4}}{x} \right| + C$$

$$5. \frac{1}{2} \tan(2x) - x + C \quad 7. \frac{1}{2} \arctan \frac{x+2}{2} + C$$

$$9. \frac{x^2}{2} + \frac{4x^{3/2}}{3} + C \quad 11. \frac{1}{2} \arcsin \frac{x^2}{2} + C$$

Section 7.6

$$1. \mathbf{a. 40} \quad \mathbf{b. 42}$$

$$3. T_8 = 6724; S_8 \approx 6554.6667; \text{exact value: } 6553.6$$

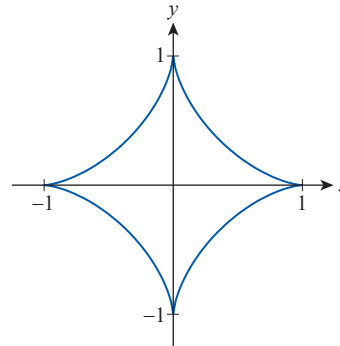
$$5. T_8 \approx 0.83954; S_8 \approx 0.8048; \text{exact value: } 0.8$$

7. $T_8 = 65$; $S_8 = 64$; exact value: 64
 9. $T_8 = 11.7296$; $S_8 = 11.8632$; exact value: 12
 11. $T_8 = 4.03068$; $S_8 = 4.0467$;
 exact value: $5 \ln 5 - 4 = 4.047189\dots$
 13. $T_8 = 84$; $S_8 \approx 85.33333$; exact value: $256/3 = 85.\bar{3}$
 15. $T_8 \approx 24.6507$; $S_8 = 24.5122$;
 exact value: $52\sqrt{2}/3 = 24.513035\dots$
 17. $T_8 \approx 6.9734$; $S_8 \approx 7.0665$;
 exact value: $\sqrt{65} - 1 = 7.062257\dots$
 19. a. 1.9541 b. 2.0009
 21. 6468.5 23. 0.7809 25. $\pi^3/300 \approx 0.1034$
 27. $1/100 = 0.01$ 29. $5/3 = 1.\bar{6}$
 31. $\pi^5/112,500 \approx 0.0027$ 33. $1/75,000 \approx 0.00001$
 35. $4/3 = 1.\bar{3}$ 37. $n > 71$ 39. $n > 36$
 41. $n > 25$ 43. $n > 10$ 45. $n > 5$ 47. $n > 3$
 49. 3.1415918; 0.00003% 51. 19.2407
 53. Approx. 1430.49 ft 55. 3750 cubic feet
 57. 3.36047; exact value: 3.361267...
 59. 1.20794; exact value: 1.207949...
 61. 3.36094 63. 1.208
 65. $S_{50} \approx 1.46265179$; error bound: 1.83635×10^{-7}
 67. $S_{50} \approx 0.56568724$; error bound: 4.35225×10^{-4}
 69. $S_{50} \approx 0.11714154$; error bound: 1.6636×10^{-7}
 71. $x \approx 1.3391165$ 73. $x \approx 2.080915$

Section 7.7

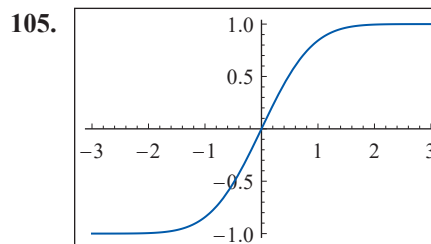
1. Yes, type I 3. Yes, type II 5. Not improper
 7. Yes, type I (doubly improper)
 9. $\lim_{b \rightarrow \infty} \int_2^b \frac{1}{x^2 - 1} dx$ 11. $\lim_{a \rightarrow -\infty} \int_a^{-1} \frac{-3}{x} dx$
 13. $\lim_{a \rightarrow -\infty} \int_a^0 e^x dx$ 15. $\lim_{c \rightarrow 0^+} \int_c^1 \frac{2}{x} dx + \lim_{b \rightarrow \infty} \int_1^b \frac{2}{x} dx$
 17. Divergent 19. Convergent; $6\sqrt{2}$
 21. Type I; convergent; 2 23. Type II; convergent; 2
 25. Type I; convergent; 1 27. Type II; divergent
 29. Type I; convergent; π 31. Type II; divergent
 33. Type I; convergent; π
 35. Both type I and type II; convergent; π
 37. Type II; convergent; π
 39. Both type I and type II; divergent
 41. Type II; divergent 43. Type I; convergent; $2/e^2$

45. Type I; convergent; 1 47. Type II; divergent
 49. Both type I and type II; convergent; $\pi/2$
 51. Type I; convergent; 0 53. Type II; convergent; $4\sqrt{2}$
 55. Type II; convergent; $\pi/3$
 57. Type II; divergent 59. Type II; divergent
 61. Type II; convergent; -4 63. Type I; convergent; $\ln 3$
 65. Diverges for $p \leq 1$; converges for $p > 1$
 67. Converges 69. Converges 71. Diverges
 73. Diverges 75. $4\pi/3$ 79. 1
 81.



The perimeter is 6.

85. $\pi/2$ (Substitute $u = \sqrt{x}$.)
 87. $\pi/4$ 89. $1/s^2$ 91. $\frac{1}{s-a}$ 93. $\frac{s}{s^2 + k^2}$
 95. \$200,000 97. \$603,448
 99. $v_0 = \sqrt{2Rg} \approx 11,180 \text{ m/s}$
 101. False; consider $\int_1^\infty \frac{dx}{x}$.
 103. True



Chapter 7 Review

1. $\frac{2x^{3/2}(3 \ln x - 2)}{9} + C$ 3. $\frac{2}{3}(x+2)\sqrt{x-1} + C$
 5. $2t \cos t + (t^2 - 2)\sin t + C$ 7. $\pi(\pi^2 - 6)$
 9. $\frac{[2 \ln(\sin t) - 1]\sin^2 t}{4} + C$ 11. $\frac{e^{\pi/2} + e^{-\pi/2}}{2}$
 13. a. $\left(\frac{27e^4 + 9}{32e^3 + 16}, \frac{459e^5 - 54}{500e^3 + 250} \right)$ b. $\frac{3\pi}{8}(3e^4 + 1)$

17. $2 \ln|x+1| - \ln|x-3| + C$
19. $\ln|x| - \ln|x-1| - \frac{1}{x} - \frac{2}{x^2} + C$
21. $\frac{1}{2} \ln(x^2 + 2) - \frac{4x^2 + 7}{4(x^2 + 2)^2} + C$
23. $2 \ln|x-1| + 2 \ln|x+5| - \ln|x+3| + C$
25. $-\frac{5 \ln 2}{2}$ 27. $\frac{2}{5} (\ln|\sqrt{x}-2| - \ln|\sqrt{x}+3|) + C$
29. $\pi \ln(256/9)$ 31. $16/3$
33. $\frac{\cos^5 x}{5} - \frac{\cos^3 x}{3} + C$ 35. $3/4$ 37. $-2 \cot 2x + C$
39. $\frac{1}{4} \sin 2x - \frac{1}{8} \sin 4x + C$
41. $5/12$ 43. $-\frac{\csc^2 x}{2} - \ln|\sin x| + C$
45. $\frac{\tan^5 x}{5} + C$ 47. $\frac{\sin^3 v}{3} + C$
49. 2 51. $\frac{5\pi(\pi+2)}{4}$
55. $4 \sin^{-1}(x/2) - x\sqrt{4-x^2} + C$
57. $\frac{t}{2\sqrt{t^2+4}} + C$ 59. $9(\sqrt{2} - \sinh^{-1} 1)$
61. $(x-2)\sqrt{5+4x-x^2} - 9 \sin^{-1}\left(\frac{2-x}{3}\right) + C$
63. $\sin^{-1}\left(\frac{e^x-1}{2}\right) + C$
65. $2\sqrt{3} - \sinh^{-1} \sqrt{3}$ 67. $\pi\left(\pi - \frac{7\sqrt{3}}{4}\right)$
69. $2\pi(\sqrt{2} + \sinh^{-1} 1) \approx 14.4236$
71. 6.3589
73. $\sqrt{2 \cos x - \cos^2 x} - \sin^{-1}(\cos x - 1) + C$
75. $T_6 \approx 0.50403; |E_T| \approx 0.00403$
77. $T_6 \approx 0.70067; |E_T| \approx 0.00752$
79. $|E_T| \leq 1/72 \approx 0.01389$
81. $|E_T| \leq \frac{\pi^3}{486\sqrt{3}} \approx 0.03683$
83. $S_6 \approx 0.50009; |E_S| \approx 0.00009$
85. $S_6 \approx 0.69347; |E_S| \approx 0.00033$
87. $|E_S| \leq 1/1944 \approx 0.00051$

$$89. |E_S| \leq \frac{11\pi^5}{590,490\sqrt{3}} \approx 0.00329$$

91. Type II; divergent 93. Type II; convergent; 4

95. Type I; convergent; $\pi/2$ 97. Converges

$$99. \int_0^{\pi^2/4} \frac{\cos \sqrt{x}}{\sqrt{x}} dx = \int_0^{\pi/2} 2 \cos u du = 2$$

101. Yes, the volume is $\pi/2$; the surface area is $\pi(\sqrt{2} + \sinh^{-1} 1) \approx 7.2118$.

$$103. \frac{1}{(s-a)^2} \quad 105. \frac{2ks}{(s^2+k^2)^2}$$

107. True 109. False; consider Gabriel's horn.

111. False; consider $f(x) = 1/\sqrt{|x|}$.

113. False; see Exercises 72–74 in Section 7.4.

115. $n = 35$ 117. $n = 4; n = 12$

119. $T_{50} \approx 1.08948$; $S_{50} \approx 1.08943$; Simpson's Rule is more accurate. (In fact, S_{50} agrees with the numerical integration command's value to 11 decimal digits!)

Chapter 7 Conceptual Project

1. $I_0 = \pi/2$; $I_1 = 1$; $I_2 = \pi/4$; $I_3 = 2/3$

3. $I_4 = 3\pi/16$; $I_5 = 8/15$; $I_6 = 5\pi/32$; $I_7 = 16/35$

Chapter 7 Application Project

3. a. No; the formula obtained in Question 2c implies that torque and power are numerically equal at 5252 rpm. (Torque must be measured in lb-ft and power in hp.)
- b. From about 40 hp to 83 hp
- c. From about 60 hp to 107 hp
- d. The 2021 car
- e. A "flat" torque curve means more torque at lower rpm's, hence more performance off the line. Since city driving rarely involves high rpm's, a flat torque curve means more power and better acceleration in stop-and-go traffic.
5. a. Approx. 175 kJ b. Approx. 250 kJ
- c. As illustrated by the problems in this project, more area under the torque curve generally translates into more horsepower early on and greater values of definite integrals of the power curve over various intervals (especially in lower rpm ranges). Therefore, the engine is capable of doing more work, and earlier on the rpm range, than engines that have low torque over lower rpm ranges, and thus have less area under the curve.

Chapter 8

Section 8.1

1. $\frac{dy}{dx} = \sqrt{\frac{y}{x}}$ 3. $\frac{dy}{dx} = x\sqrt{1-y^2}$
5. $\frac{dy}{dx} = \frac{y}{x^2} - \frac{y}{x}$ 13. $y = \frac{x^3}{3} + \sin x + 5$
15. $y = \ln|x| + x - 1$ 17. $y = -\frac{1}{x} + \frac{7}{2}$
19. $y = \arcsin x + 2$
21. Yes 23. Yes 25. Yes 27. No
29. $y = \tan(x^2 + C)$ 31. $y = Ce^{3x^2/2} - 2$
33. $y = Ce^{x^3}$ 35. $y = Ce^{\arcsin(x/2)}$
37. $x = \frac{1}{\ln(t^2 + C)}$ 39. $y = Cx - 6$
41. $x = C(y+1)$ 43. $x = \pm\sqrt{\frac{y^2}{2} + 2y + C}$
45. $y = \sqrt[3]{x^3 - 3x + 8}$
47. $y = \frac{1}{5}\ln\left(\frac{5}{2}e^{2x} - \frac{3}{2}\right)$ for $e^{2x} > \frac{3}{5}$
49. $y = \frac{1}{4 - \sin x}$ 51. $y = \frac{2e^{x^2/2}}{1 - 2e^{x^2/2}}$
53. $y = \ln((1 + \sin t)^2)$ 55. Approx. 2 min 21 s
57. Approx. 31.85 g 61. Approx. 73.84 cm
63. a. $\frac{dv}{dt} + \frac{k}{m}v = g$ b. $v = \frac{mg}{k}$
65. $x^2 + 2y^2 = C$ 67. $x^3 + 3x^2 + 3y^2 = C$
69. $x^3 + y^3 = C$ 71. $y^2 + x^2 - \ln(x^2) = C$
73. $2y^2 - x^2 - \ln(x^2) = C$ 75. True
77. False; for example, when solving motion problems, finding the velocity function from the acceleration and initial velocity is an initial value problem.

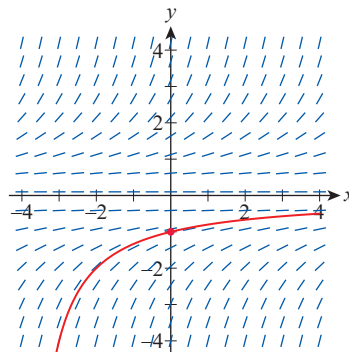
Section 8.2

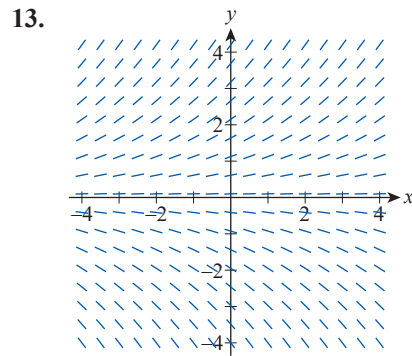
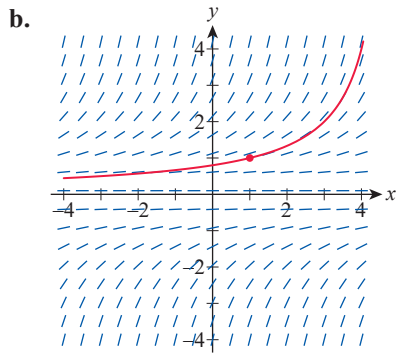
1. Linear 3. Linear 5. Linear 7. Linear in y
9. Linear in x
11. $y = \frac{C}{x^3}$ 13. $y = \frac{C}{x^4} + \frac{1}{4}$
15. $y = (2x - 3\ln x + C)x - 5$
17. $x = \frac{y^2}{10} + \frac{C}{y^8}$ 19. $y = \sin x + Ce^{-x}$
21. $y = \frac{(x^5/5) + x + C}{x^4 + 1}$ 23. $y = \frac{\ln x}{2} + \frac{C}{\ln x}$

25. $x = t + \sin t + C \cos t$ 27. $y = \frac{1 + 5e^{-x^3}}{3}$
29. $y = (x^2 + 1)(\arctan x + 10)$ 31. $y = \frac{e^x \ln(x+1)}{x+1}$
33. $x = \frac{5}{y^2} - 1 + 2\ln y$ 35. $y' + \frac{1}{x}y = \frac{\sin x}{x} + \cos x$
37. $y' + \frac{1}{x \ln x}y = \frac{1+x}{x \ln x}$ 39. $y = \frac{1}{x(C - \ln x)}$
41. $y = \frac{1}{x(-2\sqrt{x} + C)^2}$ 43. Approx. 7 min 47.4 s
45. Approx. 15.315 lb
47. $\frac{dy}{dt} + \frac{r_2 y}{V_0 + (r_1 - r_2)t} = a_1 r_1$; $y(0) = a_0$
49. $I(t) = \frac{1}{2} - \frac{1}{2}e^{-50t}$
51. $q(t) = 1.5 \times 10^5 - 1.5 \times 10^5 e^{-t/50,000}$; As $t \rightarrow \infty$, the charge stabilizes at 1.5×10^5 coulombs.
53. a. $\frac{dA}{dt} = d - kA$
b. $A = \frac{d}{k} - \frac{d}{k}e^{-kt}$; $A \rightarrow \frac{d}{k}$ as $t \rightarrow \infty$
55. False; the equation $xy' = y$ is both separable and linear.
57. False; for example, equations that are, say, both linear and separable can readily be solved by different methods.

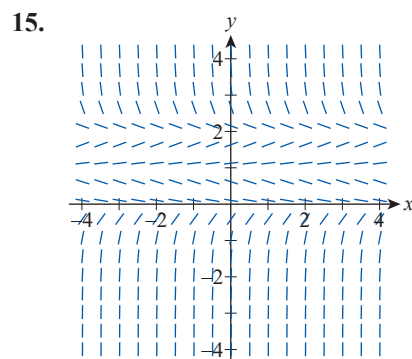
Section 8.3

1. C 3. A 5. D
7. $y = 0$: unstable; $y = 2$: stable
9. $y = -\pi/2$: unstable; $y = \pi/2$: stable
11. a.

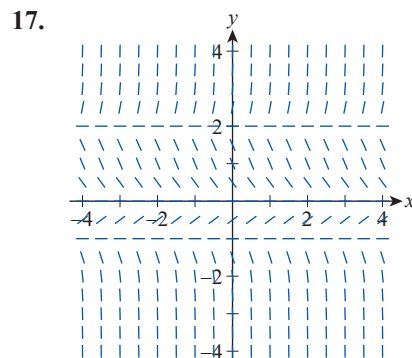




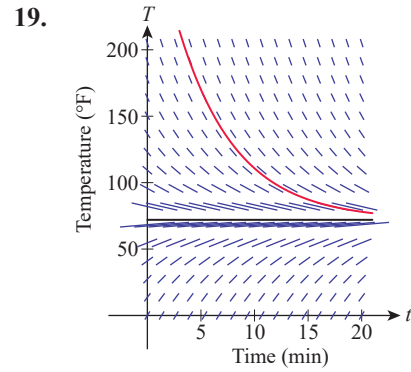
$y = 0$: unstable



$y = 0, y = 2$: stable; $y = 1$: unstable



$y = 2, y = -1$: unstable; $y = 0$: stable



21. a. $P(t) = \frac{500}{1 + 4e^{-0.3t}}$ b. Just under 6 years

23. $v = (mg/k)^2$

27. a. (i) 5.578 (ii) 6.990

b. Exact value: $\frac{5e^2 - 3}{4} \approx 8.486$

29. a. (i) 1.168 (ii) 1.326

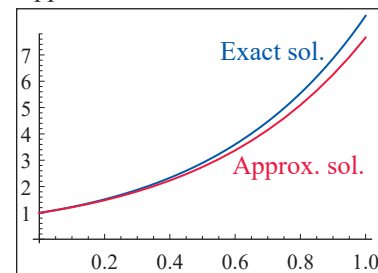
b. Exact value: $\frac{5}{4} + e^{-3/2} \approx 1.473$

31. a. (i) 1.345 (ii) 1.482

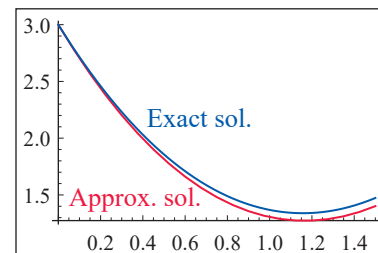
b. Exact value: $\sqrt{3} \approx 1.732$

33. 7.966

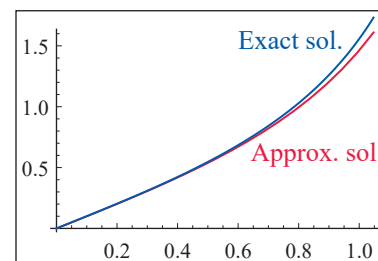
39. Approx. 7.659



41. Approx. 1.401



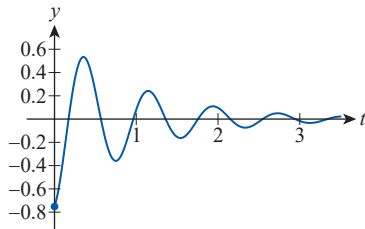
43. Approx. 1.610



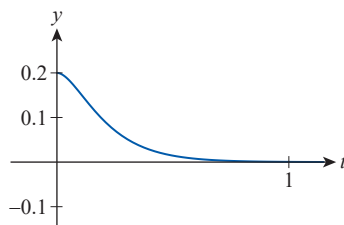
Section 8.4

1. $y = c_1 e^x + c_2 e^{-2x}$ 3. $y = c_1 e^{-x/3} + c_2 e^{2x}$
5. $y = c_1 e^{-x} + c_2 x e^{-x}$ 7. $y = c_1 e^{-x/2} + c_2 x e^{-x/2}$
9. $y = e^{2x} (c_1 \cos 3x + c_2 \sin 3x)$
11. $y = e^{x/5} (c_1 + x c_2)$
13. $y = c_1 e^{(\sqrt{13}+1)x/6} + c_2 e^{(\sqrt{13}-1)x/6}$
15. $w = e^{-t/2} [c_1 \cos(t/2) + c_2 \sin(t/2)]$
17. $y = c_1 e^{kx} + c_2 e^{-kx}$ 19. $y = \frac{5}{2} (e^{\sqrt{3}x} + e^{-\sqrt{3}x})$
21. $y = e^{-x} + 3e^{2x}$ 23. $y = e^x (\cos 2x - 2 \sin 2x)$
25. $y = 2x e^{3x/2} - e^{3x/2}$ 27. $y = 5(e^{5x} - e^{-5x})$
29. $y = e^x$ 31. No solution
33. $y = e^x (2 \cos 4x + e^{-\pi/8} \sin 4x)$
35. $y = c_1 e^{-x} + c_2 e^{3x} + c_3$
37. $y = c_1 e^x + c_2 \cos \sqrt{2}x + c_3 \sin \sqrt{2}x$
39. $y = c_1 e^x + c_2 e^{-2x} - \frac{x}{2} - \frac{1}{4}$
41. $y = c_1 e^x + c_2 e^{-5x} - \frac{1}{13} \cos x - \frac{3}{26} \sin x$
43. $y = \cos x + \sin x + x^2 - 2$
47. a. Underdamped: $c < 2\sqrt{10}$; oscillating motion, amplitude goes to 0 (Example 5)
b. Critically damped: $c = 2\sqrt{10}$; damped motion with no oscillation, but the smallest change in c will cause it to be underdamped or overdamped
c. Overdamped: $c > 2\sqrt{10}$; solution is a linear combination of exponential functions, no oscillation, displacement goes to 0
49. $c = 2\sqrt{g/5} \approx 2.8$

$$51. y(t) = \frac{-e^{-t}}{84} [63 \cos(3\sqrt{7}t) - 5\sqrt{7} \sin(3\sqrt{7}t)]$$



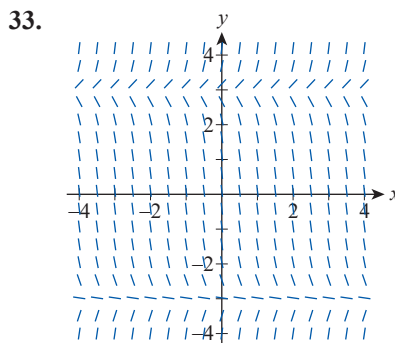
$$53. y(t) \approx -0.278e^{-11.85t} + 0.478e^{-6.9t}$$



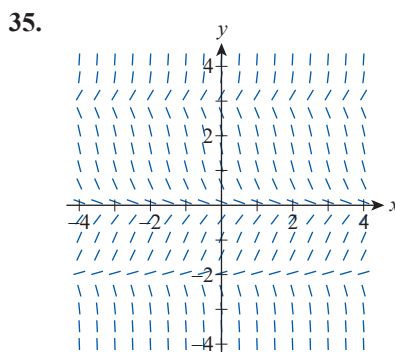
57. Approx. 8.2 s; approx. 16.66 m

Chapter 8 Review

1. Autonomous, separable, first-order
3. First-order, linear
5. $y = \ln \sqrt{x^2 + 1} + 1$ 7. $y = Cx^2$
9. $y = \left(\ln x - \frac{1}{x} + C \right)^2$ or $y = 0$
11. $u = \frac{1 - Cx^2}{1 + Cx^2}$ or $u = -1$
13. $y = \sqrt[3]{3x^3 + x^2 + 8}$
15. $y = (t^2 + 1)^2 + 2$ or $y = t^4 - 6t^2 + 11$
17. $y = Cx$
19. $y = \frac{C}{x^6} + \frac{1}{3}$ 21. $x = \frac{2y^2 + C}{y^2 + 1}$
23. $y' - 3x^2 y = x^2$ 25. $y = x(e^{1-x} + x - 1)$
27. $y = \frac{x}{x^2 + 1} - \frac{3}{\sqrt{x^2 + 1}}$
29. B; $y = 0$: unstable; $y = -2$: stable
31. A; $y = 2$: unstable; $y = -1$: stable



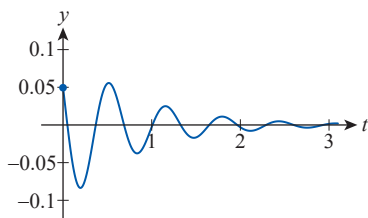
$y = 3$: unstable; $y = -3$: stable



$y = 3, y = -2$: unstable; $y = 0$: stable

37. a. (i) 8.063 (ii) 8.960
b. Exact value: $3 + e^2 \approx 10.389$

39. $y = c_1 e^{4x} + c_2 e^{-4x}$ 41. $y = c_1 e^{5x} + c_2$
 43. $y = c_1 e^{x/2} + c_2 x e^{x/2}$ 45. $y = 2e^{-2x} + e^{3x}$
 47. $y = 2e^{(3x-6)/2} - 7$ 49. No solution
 51. $y = c_1 e^{x/2} + c_2 e^{3x} + \frac{1}{50}(\cos x - 7 \sin x)$
 53. $x^4 + 2x^2 + 2y^2 = C$ 55. Approx. 13.446 kg
 57. a. $V' = kV^{2/3}$
 b. It melts away in just under 5.5 hours.
 59. $q(t) = 250,000e^{-t/2500} + 100t - 250,000$
 61. Approx. 68.43 °C
 63. $y(t) \approx e^{-1.25t} [0.05 \cos(9.83t) - 0.095 \sin(9.83t)]$



65. False; it is linear as well as separable.
 67. False; see the slope field in Figure 1 of Section 8.3.
 69. True

Chapter 8 Conceptual Project

1. $A_0 - \frac{X(t)}{1+b}$; $B_0 - \frac{bX(t)}{1+b}$
 3. $\frac{dX}{dt} = k \left(60 - \frac{X}{4} \right) \left(40 - \frac{3X}{4} \right)$; $X(0) = 0$
 5. $\lim_{t \rightarrow \infty} X(t) = 53\frac{1}{3}$; this means that ultimately $53\frac{1}{3}$ grams of C is formed, using up all of reactant B, while leaving $46\frac{2}{3}$ grams of reactant A.

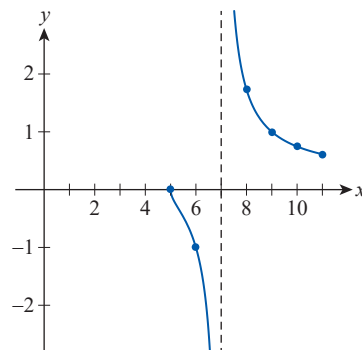
Chapter 8 Application Project

1. a. The equation here is nonhomogeneous; the nonzero term on the right-hand side indicates the presence of an additional, periodic force acting on the oscillating mass.
 b. Because of the presence of a periodic external force acting on the system, the motion is expected to exhibit some sort of periodicity, but a lot more “irregular” than that of a simple harmonic motion, such as in Example 4 of Section 8.4. No, the IVP doesn’t indicate the presence of damping forces.
 c. Period: $\frac{2\pi}{\theta}$; Frequency: $\frac{\theta}{2\pi}$
 3. $\lim_{\theta \rightarrow \omega} y(t) = Y(t) = \frac{f}{2\omega} \left(\frac{\sin(\omega t)}{\omega} - t \cos(\omega t) \right)$

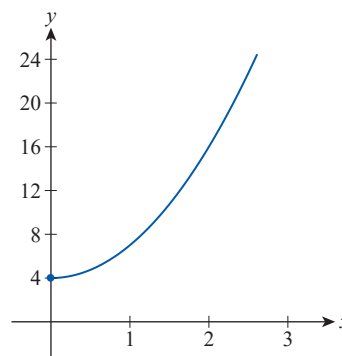
Chapter 9

Section 9.1

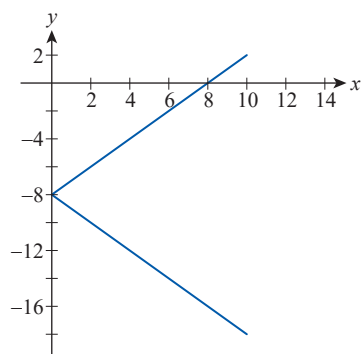
1.	t	x	y
	0	5	0
	1	6	-1
	2	7	undefined
	3	8	$\sqrt{3}$
	4	9	1
	5	10	$\sqrt{5}/3$
	6	11	$\sqrt{6}/4$



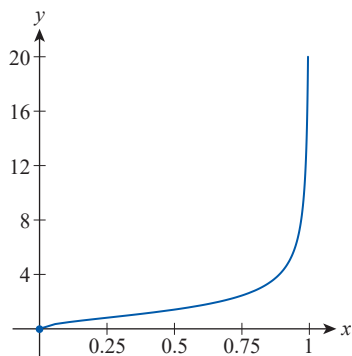
3. $x = t$, $y = -t^2 - 5$ 5. $x = t$, $y = \pm\sqrt{t-4}$
 7. $x = t$, $y = |t-1|$ 9. $x = t$, $y = \pm\sqrt{1-t^2}$
 11. $y = 3x^2 + 4$ ($t \geq 2$)



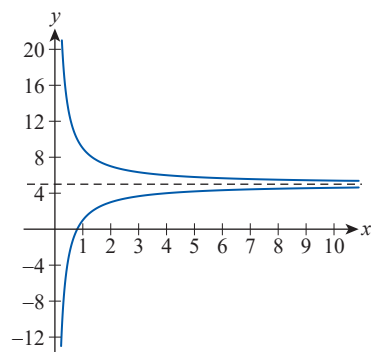
13. $x = |y + 8|$



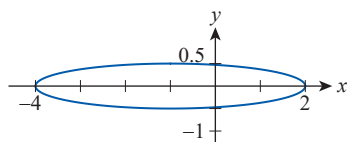
15. $y = \sqrt{\frac{2x}{1-x}} \quad (t \geq 0)$



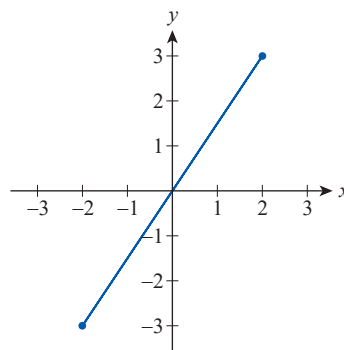
17. $x = \frac{4}{|y-5|} \quad (t \neq 3)$



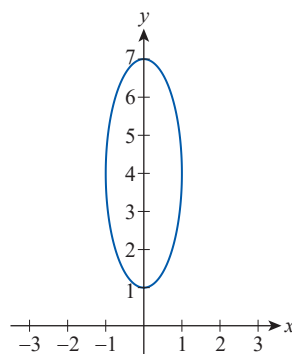
19. $y = \pm \frac{\sqrt{8-2x-x^2}}{6}$



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

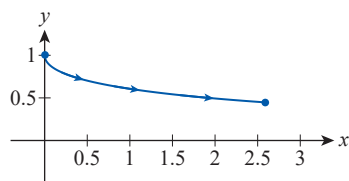


23. $y = 4 \pm 3\sqrt{1-x^2}$

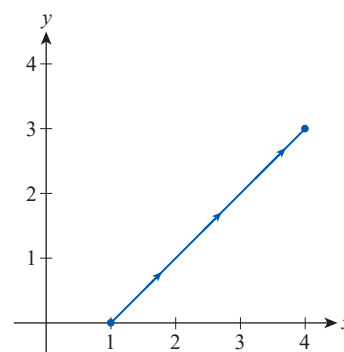


25. F 27. C 29. A

31.



33.



37. $x = h + a \cos t, y = k + b \sin t$

39. Sample answer: $x = t, y = -\frac{3}{2}t + 6$

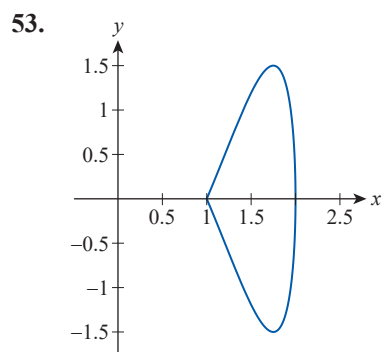
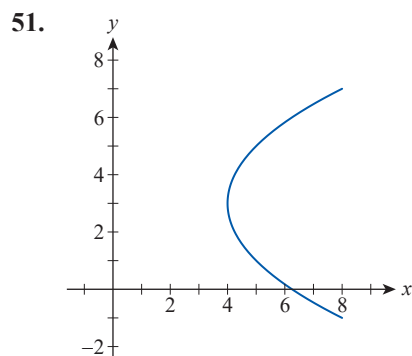
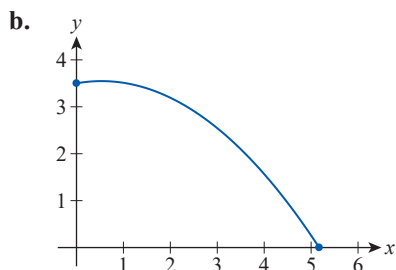
41. Sample answer: $x = t - 3, y = -\frac{3}{4}t + 1 \quad (0 \leq t \leq 8)$

43. Sample answer: $x = 6 \cos t, y = -2 + 6 \sin t$

45. Sample answer: $x = 6 \cos t, y = 1 + \sqrt{11} \sin t$

47. Yes

49. a. $x \approx 9.85t, y \approx -16t^2 + 1.74t + 3.5$



57. $(0, 0)$ and $(1, 3)$

59. $x = 3(\theta - \sin \theta), y = 3(1 - \cos \theta)$

65. $x = (R + r)\cos t - r\cos\left(\frac{R+r}{r}t\right),$

$$y = (R + r)\sin t - r\sin\left(\frac{R+r}{r}t\right)$$

67. $y = \frac{8r^3}{x^2 + 4r^2}$

69. True

71. False; consider the graph of a circle centered at the origin for which neither statement is true.

Section 9.2

1. Neither differentiable nor smooth
3. Differentiable but not smooth
7. Horizontal: $y = 1$; vertical: $x = -1/4$
9. Horizontal: none; vertical: $x = 1$
11. Horizontal: none; vertical: none
13. Horizontal: $y = \pm 5$; vertical: $x = \pm 2$

15. $\frac{dy}{dx}\bigg|_{t=1/2} = 1; \frac{d^2y}{dx^2}\bigg|_{t=1/2} = 1$

17. $\frac{dy}{dx}\bigg|_{t=0} = 0; \frac{d^2y}{dx^2}\bigg|_{t=0} = 2$

19. $\frac{dy}{dx}\bigg|_{t=0} = -1; \frac{d^2y}{dx^2}\bigg|_{t=0} = 3$

21. $\frac{dy}{dx}\bigg|_{t=\pi/4} = 0; \frac{d^2y}{dx^2}\bigg|_{t=\pi/4} = -8$

23. $\frac{dy}{dx}\bigg|_{t=1} = 1; \frac{d^2y}{dx^2}\bigg|_{t=1} = \frac{1}{2}$

25. $t = 10/3$ 27. $t = -1/2, 1/\sqrt[3]{4}$

29. $4/3$ 31. $\pi^3/6$ 33. $\frac{2}{5}(1 + e^{-\pi/2})$

39. π 41. $92/9$ 43. $59/24$ 45. $2e^{\pi/2} - 2$

47. $\frac{2e^2 + 3e - 2}{4e}$

49. a. $16\sqrt{2}\pi$ b. $24\sqrt{2}\pi$

51. a. $\frac{12,289\pi}{192}$ b. $\frac{(135 + \ln 2)\pi}{6}$

53. a. $\frac{(16e^4 + e^2 - 1)\pi}{16e^2}$ b. $\frac{\pi}{2}\left(5 - \frac{2}{e}\right)$

55. $48\pi/5$

57. a. $\frac{\pi}{2}(4 + \sinh 4)$ b. $2\pi(3 \sinh 2 - \cosh 2 + 1)$

59. Yes 61. $2\sqrt{5}$ m/s 63. 9 m/s

65. $t > 0$ 67. $32\pi/15$ 69. $(18/5, 9/8)$

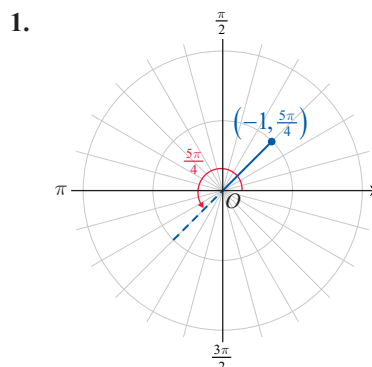
75. False; consider Example 1.

77. True

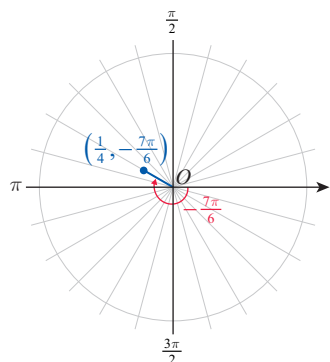
79. 28.362 81. 3.820

83. a. 81.870 b. 258.882

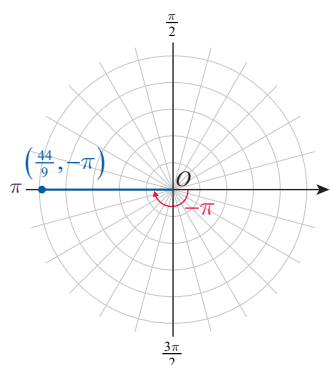
Section 9.3



3.



5.



7. $\left(\frac{5}{\sqrt{2}}, -\frac{5}{\sqrt{2}}\right)$ 9. $\left(-\frac{25}{4\sqrt{2}}, -\frac{25}{4\sqrt{2}}\right)$

11. $\left(-\frac{3\sqrt{3}}{2}, -\frac{3}{2}\right)$ 13. $(-3, 0)$ and $(3, \pi)$

15. $(\sqrt{145}, -0.08)$ and $(-\sqrt{145}, 3.06)$

17. $(2\sqrt{21}, 1.76)$ and $(-2\sqrt{21}, -1.38)$

19. $r^2 = 25$ 21. $r \cos \theta = 12$ 23. $\sin \theta = \cos \theta$

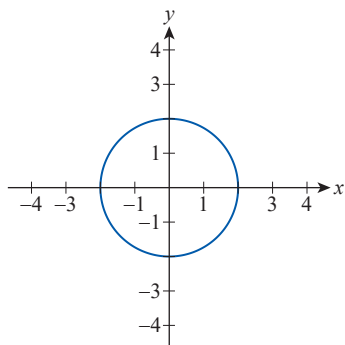
25. $r \cos \theta = 16a$ 27. $r^2 - 4a r \cos \theta = 0$

29. $r^2 \sin^2 \theta - 4r \cos \theta - 4 = 0$

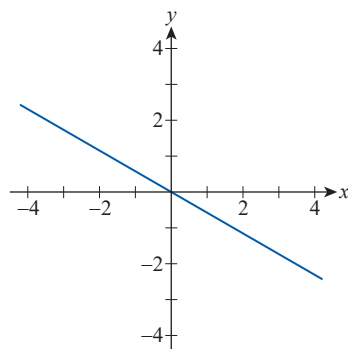
31. $x^2 + y^2 = 5x$ 33. $x^2 + y^2 = 49$ 35. $y = 1/2$

37. $x^4 + y^4 + 2x^2y^2 = 2xy$ 39. $4y + 7x = 12$

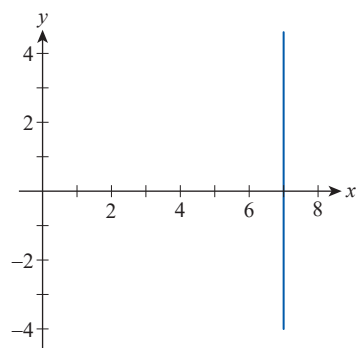
41. $x^2 + y^2 = 4$



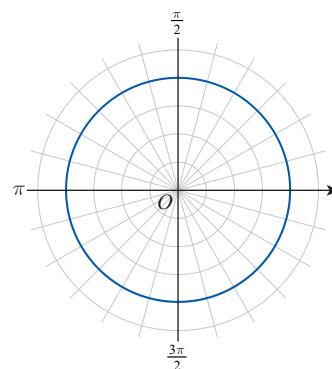
43. $y = -x/\sqrt{3}$



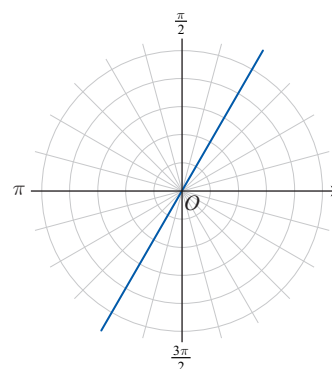
45. $x = 7$



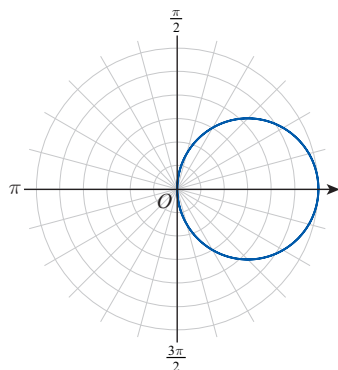
47.



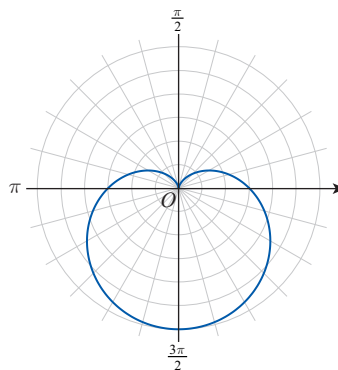
49.



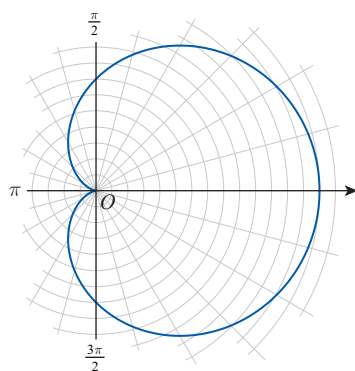
51.



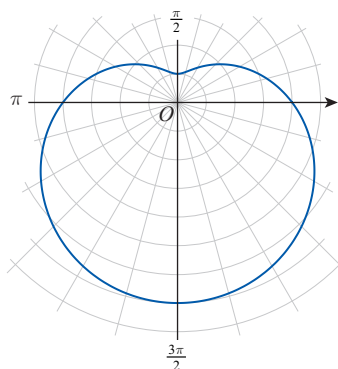
53.



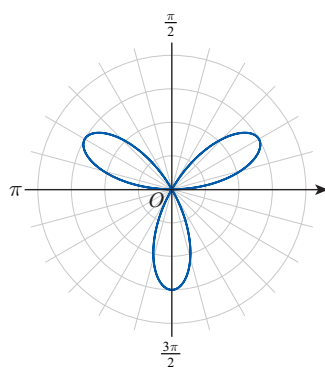
55.



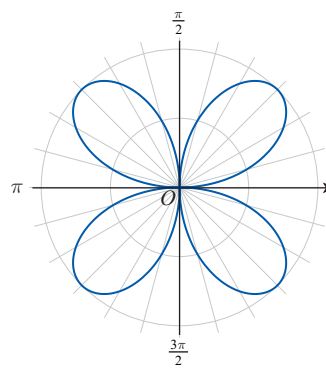
57.



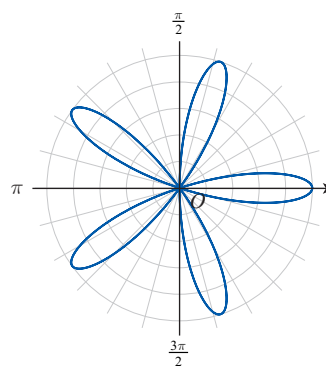
59.



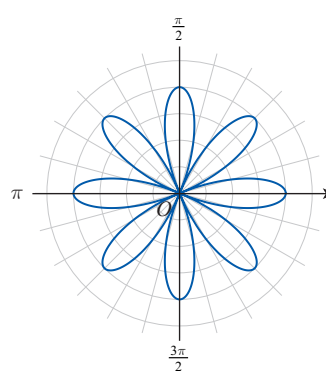
61.



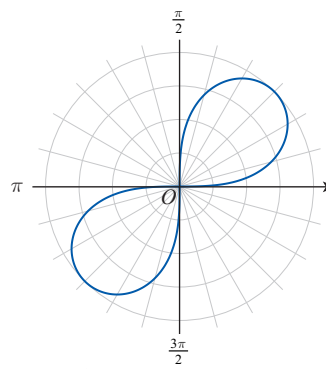
63.



65.



67.



69. $(0,0), (\sqrt{2}/2, \pi/4)$

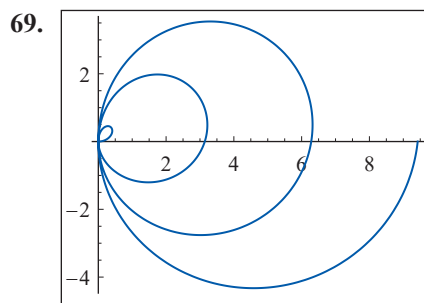
71. $(0,0), (1 + \sqrt{2}/2, 3\pi/4), (1 - \sqrt{2}/2, -\pi/4)$

73. The graph of $f(\theta - a)$ is that of $f(\theta)$ rotated about the origin by a radians.

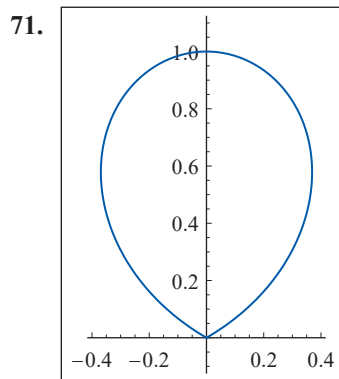
Section 9.4

1. $-\sqrt{3}/3$ 3. $-2/\pi$ 5. 3 7. $-\sqrt{3}/5$

9. $\frac{2\pi+3\sqrt{3}}{2\sqrt{3}\pi-3}$ 11. $\tan 1$ 13. 4
15. Horizontal: $(2, \pi/2)$, $(1/2, 7\pi/6)$, $(1/2, 11\pi/6)$;
vertical: the pole, $(3/2, \pi/6)$, $(3/2, 5\pi/6)$
17. Horizontal: the pole, $(3a/2, \pm\pi/3)$;
vertical: $(2a, 0)$, $(a/2, \pm 2\pi/3)$
21. $\theta = 0$ 23. $\theta = \pm\pi/4$ 25. $\theta = 0$ 27. $9\pi/4$
29. $3\pi/2$ 31. $11\pi/4$ 33. $19\pi/2$ 35. 5π
37. $\pi/2$ 39. 8π 41. 4 43. $\frac{6\sqrt{3}-2\pi}{3}$
45. $\frac{\sqrt{3}}{2} - \frac{\pi}{6}$ 47. $\pi - \frac{3\sqrt{3}}{2}$ 49. $\frac{11\sqrt{3}}{2} + \frac{14\pi}{3}$
51. $6\pi\sqrt{16\pi^2+1} + \frac{3\sinh^{-1} 4\pi}{2}$
53. $2/\sqrt{3}$ 55. $\frac{8(\pi^2+1)^{3/2}-8}{3}$
57. $4\sqrt{2}$ 59. π^2 61. $\frac{18\sqrt{2}\pi(e^{2\pi}+1)}{5}$



$L \approx 45.3582$



$L \approx 2.6825$

73. $A \approx 8580.85$ 75. $A \approx 37.1940$

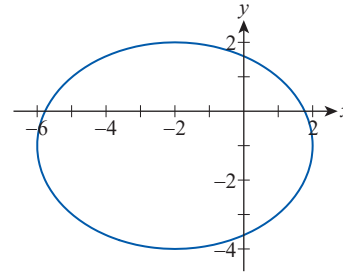
Section 9.5

1. Parabola 3. Ellipse 5. Parabola
7. Ellipse; H 9. Hyperbola; M 11. Hyperbola; J
13. Hyperbola; O 15. Ellipse; G 17. Parabola; N
19. Parabola; E 21. Hyperbola; I

23. $e = \frac{\sqrt{6}}{4}$; major = $4\sqrt{2}$; minor = $2\sqrt{5}$

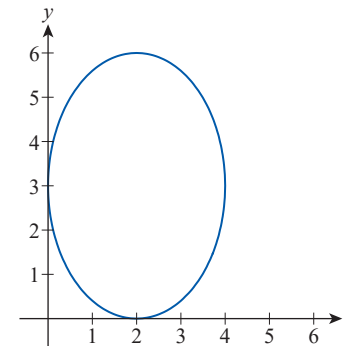
25. $e = \frac{\sqrt{6}}{3}$; major = $2\sqrt{6}$; minor = $2\sqrt{2}$

27.



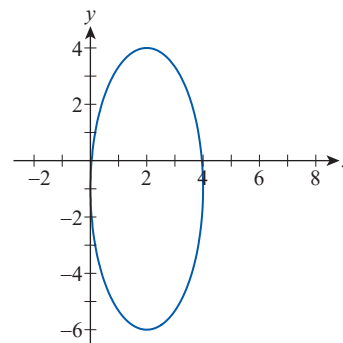
Foci: $(-2 \pm \sqrt{7}, -1)$

29.



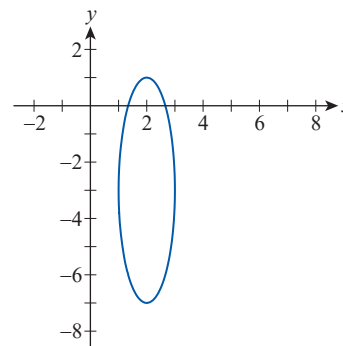
Foci: $(2, 3 \pm \sqrt{5})$

31.



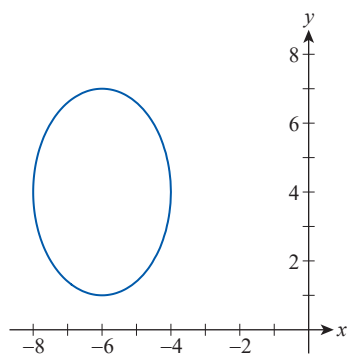
Foci: $(2, -1 \pm \sqrt{21})$

33.

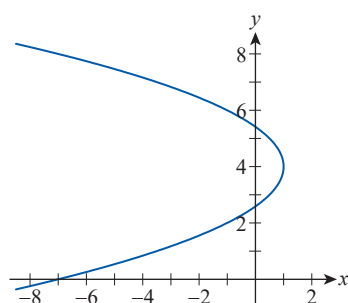


Foci: $(2, -3 \pm \sqrt{15})$

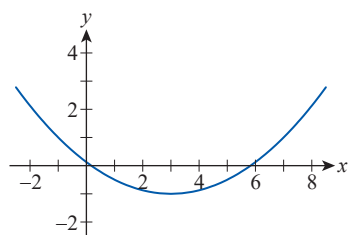
35.

Foci: $(-6, 4 \pm \sqrt{5})$

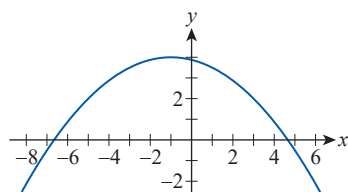
37.

Focus: $(1/2, 4)$; Directrix: $x = 3/2$

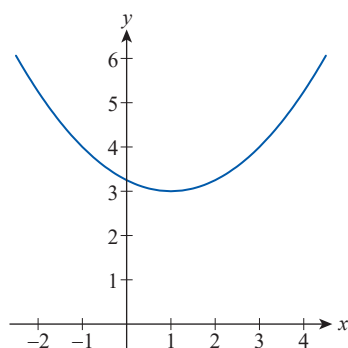
39.

Focus: $(3, 1)$; Directrix: $y = -3$

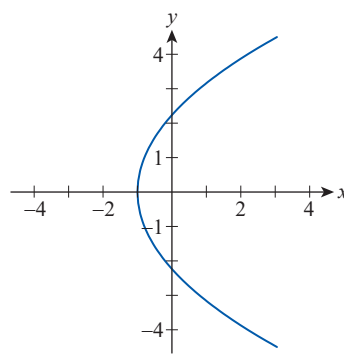
41.

Focus: $(-1, 2)$; Directrix: $y = 6$

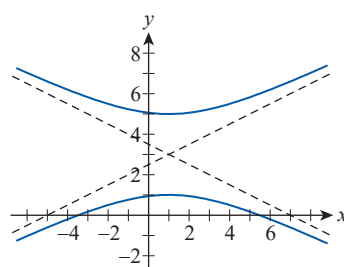
43.

Focus: $(1, 4)$; Directrix: $y = 2$

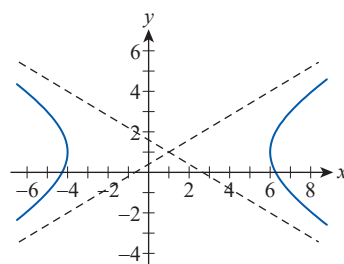
45.

Focus: $(1/4, 0)$; Directrix: $x = -9/4$

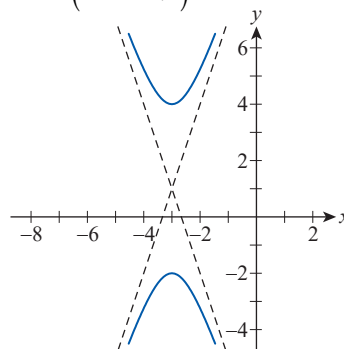
47.

Foci: $(1, 3 \pm 2\sqrt{5})$

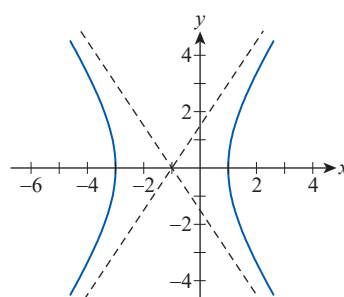
49.

Foci: $(1 \pm \sqrt{34}, 1)$

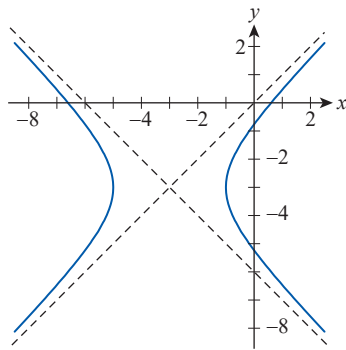
51.

Foci: $(-3, 1 \pm \sqrt{10})$

53.

Foci: $(-1 \pm \sqrt{13}, 0)$

55.

Foci: $(-3 \pm 2\sqrt{2}, -3)$

57. $(x+2)^2 = 2\left(y - \frac{1}{2}\right)$ 59. $(y-2)^2 - \frac{(x-1)^2}{8} = 1$

61. $\frac{(y-1)^2}{2} - \frac{(x+1)^2}{2} = 1$ 63. $\frac{(x-3)^2}{36} + \frac{y^2}{27} = 1$

65. $\frac{(x+9)^2}{25} + \frac{(y-6)^2}{21} = 1$ 67. $(y-1)^2 = -12(x+1)$

69. $\frac{(y+4)^2}{16} - \frac{(x-3)^2}{25} = 1$ 71. $\frac{(x+1)^2}{16} + \frac{(y+1)^2}{4} = 1$

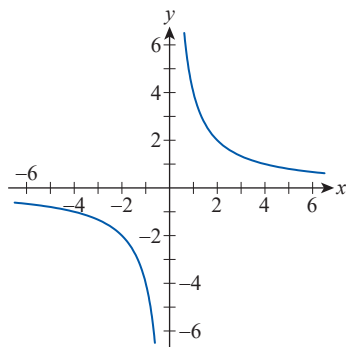
73. $(x-2)^2 = 2(y-1)$ 75. $e \approx 0.249$

77. 185.93 million miles 79. 2 ft 81. 1.5 in.

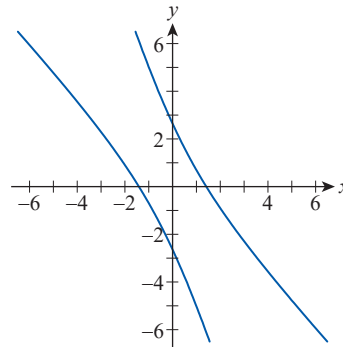
85. $\frac{y^2}{144} - \frac{x^2}{25} = 1$

87. $(4\sqrt{3}+3, -4+3\sqrt{3})$ 89. $\left(\frac{-5\sqrt{2}}{16}, \frac{3\sqrt{2}}{16}\right)$

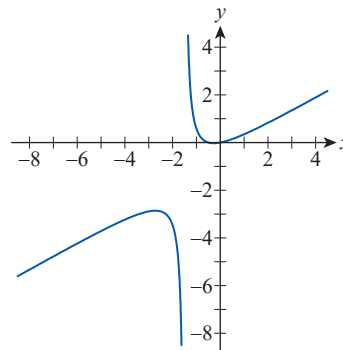
91. Hyperbola, $\theta = \pi/4$; $x'^2 - y'^2 = 8$



93. Hyperbola, $\theta = \pi/6$; $19x'^2 - y'^2 = 28$



95. Hyperbola, $\theta = \frac{\pi}{3}$; $\frac{(x'+2)^2}{3} - \left(y' - \frac{1}{\sqrt{3}}\right)^2 = 1$



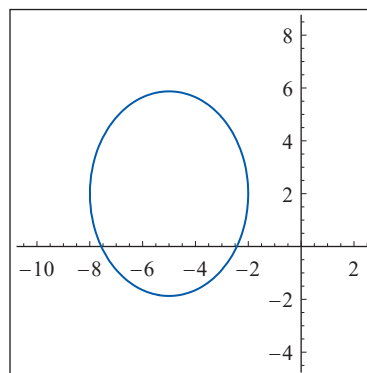
97. C 99. D

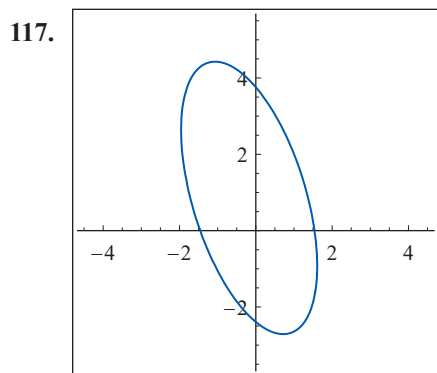
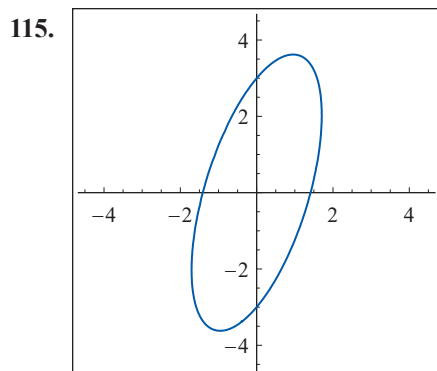
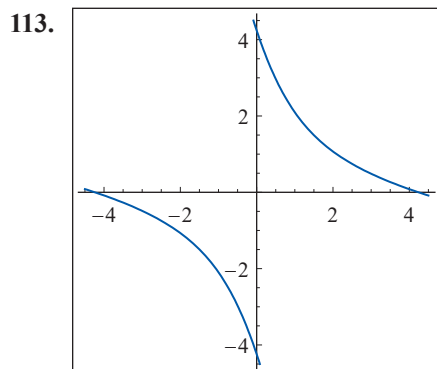
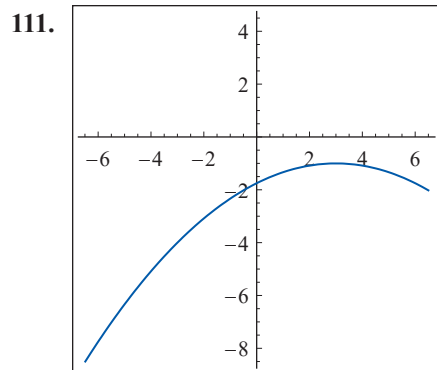
101. The objective of the rotation of axes is to eliminate the $x'y'$ -term. If your final equation contains an $x'y'$ -term, you know that a mistake has occurred.

105. False; every point on the parabola has to be the same distance from the directrix and the focus (which is at a positive distance from the directrix.) This would not be true of the point of tangency.

107. True

109.



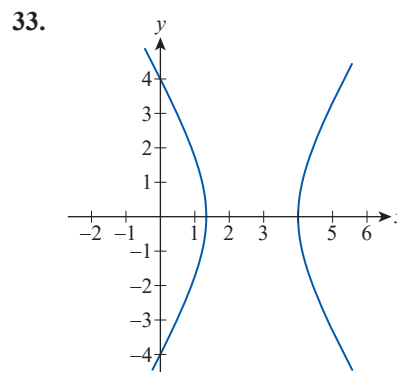
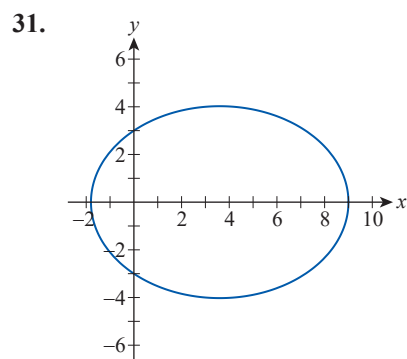
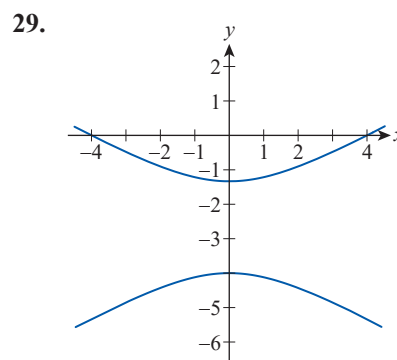
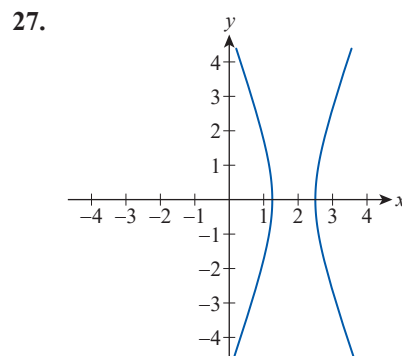


Section 9.6

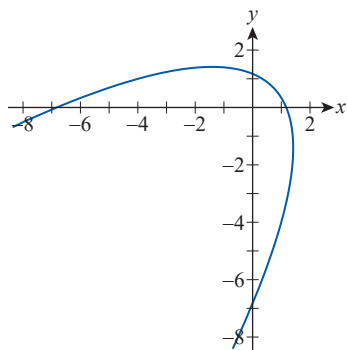
1. C 3. F 5. B 7. Hyperbola; $y = 7/6$
 9. Ellipse; $x = -3$ 11. Hyperbola; $x = 1/3$
 13. Ellipse; $x = 5$ 15. Hyperbola; $x = -6/5$
 17. Parabola; $y = 3/2$ 19. Hyperbola; $x = -4/7$

21. $r = \frac{2}{1 - \cos \theta}$ 23. $r = \frac{3}{1 - 4 \sin \theta}$

25. $r = \frac{3}{1 + \frac{1}{4} \cos \theta}$



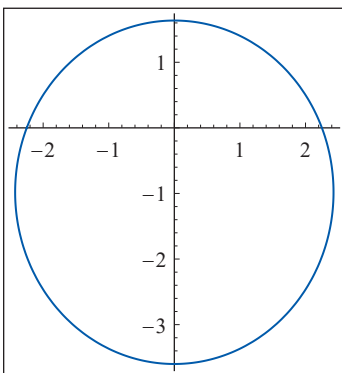
35.



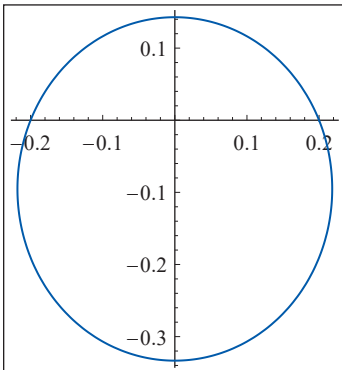
41. $2ed$ 43. $\left(\frac{ed}{e+1}, 0\right)$ and $\left(\frac{ed}{e-1}, 0\right)$

45. $\frac{(x-3.5)^2}{6.25} - \frac{y^2}{6} = 1$

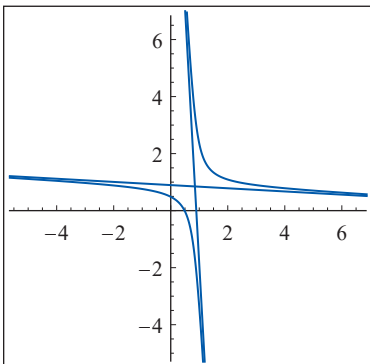
47.



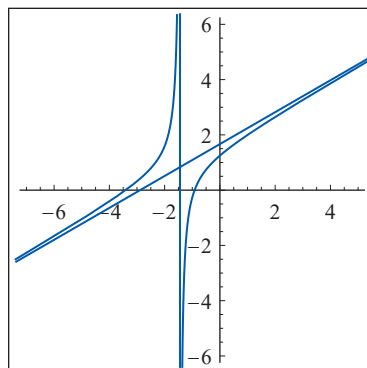
49.



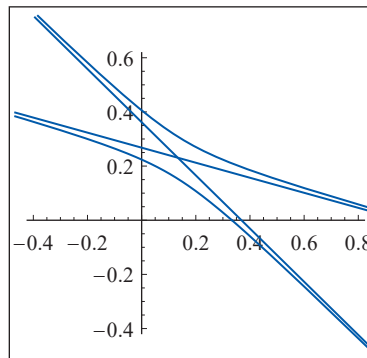
51.



53.

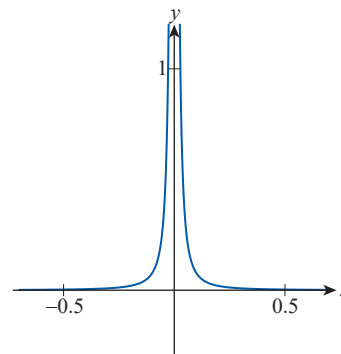


55.

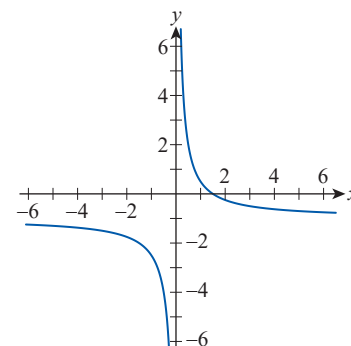


Chapter 9 Review

1. $y = \frac{1}{1296x^2}$



3. $y = \frac{3}{2x} - 1$



5. $x = t, y^2 = t^2 + 4$

7. Sample answer: $x = t, y = \frac{12}{17}t - \frac{100}{17}$

9. Horizontal: $y = -4$; vertical: none

11. $\left. \frac{dy}{dx} \right|_{t=2} = \frac{1}{16}; \left. \frac{d^2y}{dx^2} \right|_{t=2} = -\frac{1}{128}$

13. $\left. \frac{dy}{dx} \right|_{t=1} = -3; \left. \frac{d^2y}{dx^2} \right|_{t=1} = 8$ 15. $t = 0, t = \pm 1/\sqrt{3}$

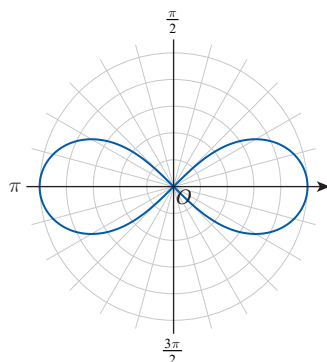
17. $6\sqrt{3}/5$ 19. $76/3$ 21. $61\pi/108$ 23. 81π

25. $(-6.06, -3.5)$

27. $(2\sqrt{61}, 0.88)$ and $(-2\sqrt{61}, 4.02)$

29. $r^2 - 9a r \cos \theta = 0$ 31. $x + y = 4$

33.

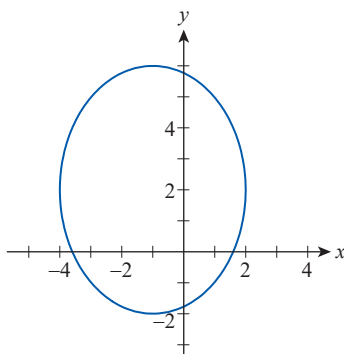


35. $\frac{4\pi}{4 + \pi^2}$

37. Horizontal: $(4/3, \cos^{-1} \sqrt{2/3}), (4/3, \cos^{-1} (-\sqrt{2/3}))$;
vertical: $(2, 0), (0, \pi/2), (2, \pi)$

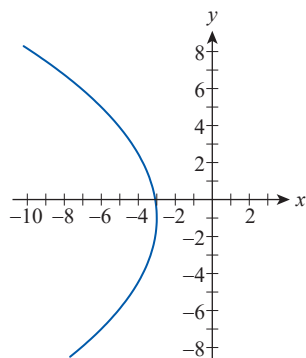
39. $\frac{33\sqrt{3} + 28\pi}{6}$ 41. $4\sqrt{3} + \frac{8\pi}{3}$ 43. 2 45. 16

47.



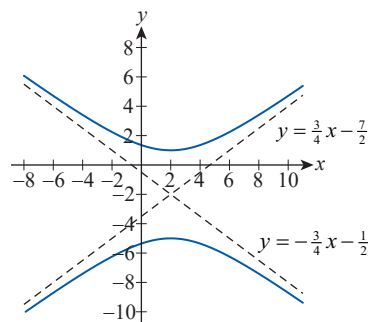
Foci: $(-1, 2 \pm \sqrt{7})$

49.



Focus: $(-6, -1)$; Directrix: $x = 0$

51.



Foci: $(2, 3), (2, -7)$

53. $\frac{(x+1)^2}{9} + \frac{(y-4)^2}{16} = 1$ 55. $\frac{(x-2)^2}{9/4} + \frac{(y+1)^2}{9/4} = 1$

57. $(x+2)^2 = 4(y-3)$ 59. $(y+1)^2 = 2\left(x - \frac{5}{2}\right)$

61. $\frac{(x+1)^2}{4} - \frac{(y+2)^2}{25} = 1$ 63. $\frac{(y-2)^2}{9} - (x-2)^2 = 1$

65. Hyperbola; $y = -5/8$ 67. Parabola; $x = -2/3$

69. Ellipse; $x = -4/3$

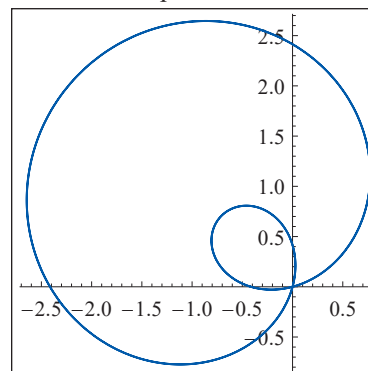
71. $r = \frac{3}{1 - \cos \theta}$ 73. $r = \frac{3}{1 - \frac{1}{5} \sin \theta}$

75. $r = \frac{7}{1 - \sin \theta}$ 77. $1\frac{1}{4}$ inches 81. True

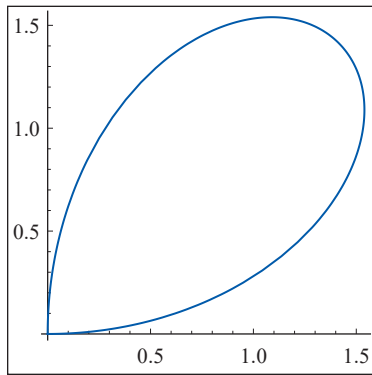
83. False; see Example 1 in Section 9.2.

85. True 87. True 89. True

91. $r = 1 - 2 \cos\left(\theta + \frac{\pi}{4}\right)$; the curve is a rotated limaçon with inner loop.

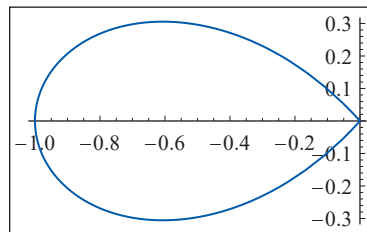


95.


 Horizontal: $\theta = 0$, $\theta = \cos^{-1}(1/\sqrt{3})$;

 vertical: $\theta = \tan^{-1}(\sqrt{2}/2)$, $\theta = \pi/2$

97.



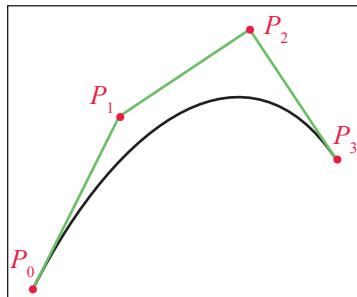
$$A = \frac{17 \cos^{-1}(2/3) - 6\sqrt{5}}{2} \approx 0.441$$

 99. $L \approx 6.8694$ 101. $A \approx 34.3518$

Chapter 9 Conceptual Project

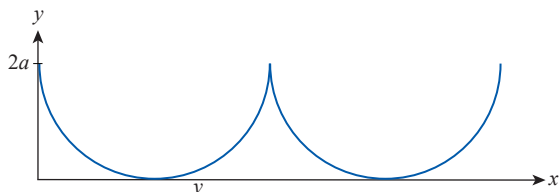
1. $x(t) = (a_1 - a_0)t + a_0$, $y(t) = (b_1 - b_0)t + b_0$, $t \in [0, 1]$

7.

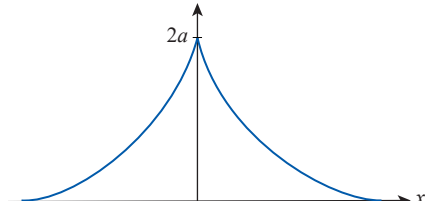


Chapter 9 Application Project

1. a.



b.



c. Period: $\frac{2\pi}{\theta}$; Frequency: $\frac{\theta}{2\pi}$

3. a. At the lowest points of the cycloid (these points are called vertices of the cycloid).

b. $s = 4a \left(1 - \cos \frac{\theta_0}{2} \right)$

Chapter 10

Section 10.1

1. $\frac{1}{2}, \frac{2}{5}, \frac{3}{10}, \frac{4}{17}, \frac{5}{26}, \frac{6}{37}$

3. $3, 3, \frac{3}{2}, \frac{1}{2}, \frac{1}{8}, \frac{1}{40}$ 5. 1, 3, 7, 15, 31, 63

7. 4, 8, 24, 96, 480, 2880 9. $a_n = n^2 + n$

11. $a_n = 10 - n^2$ 15. B 17. E 19. D

25. Converges to $1/2$ 27. Converges to 0

29. Converges to 0 31. Converges to 0

33. Diverges 35. Converges to 0

37. Converges to 0.5 39. Converges to 0

41. Converges to 0 43. Converges to $\ln 3$

45. Converges to 1 47. Converges to $\pi/6$

49. Diverges 51. Converges to 1

53. Diverges 55. Converges to 1

57. Converges to 1 59. Converges to 0

61. Converges to 1 63. Converges to 0

65. Converges to e^2 67. Converges to e^3

69. Converges to 2 75. The limit is 1.

77. The limit is 2. 83. $T_n = 2T_{n-1} + 1$, $T_1 = 1$

99. No; consider $a_n = -1/n$ and $b_n = 1/n$.

101. $a_n = \frac{5}{3} + \frac{1}{3} \left(-\frac{1}{2} \right)^{n-2}$; the limit is $5/3$.

103. True 105. True 107. True

109. False; consider the constant sequence $(-2)^2, (-2)^2, (-2)^2, \dots$ that converges to 4, but $-2, -2, -2, \dots$ does not converge to 2.

111. True 113. True

Section 10.2

1. No. The convergence of a_n to 0 does not imply the convergence of the series (see Example 6).

3. 1, 0, 1, 0, 1 5. $\frac{\sqrt{3}}{2}, \sqrt{3}, \sqrt{3}, \frac{\sqrt{3}}{2}, 0$

9. $25/6$ 11. Diverges 13. $10/17$

15. $40/27$ 17. $25/36$ 19. $x < 2$ or $x > 3$
 21. $41/333$ 23. $169/50$ 25. 2 27. 1
 29. $1/3$ 31. Diverges
 33. Diverges 35. $14/3$ 37. Diverges
 39. $1/6$ 41. Diverges 43. $33/2$
 45. Diverges 47. Diverges 49. Diverges
 55. Answers will vary. $\sum_{n=1}^{\infty} \frac{1}{n}$ and $\sum_{n=1}^{\infty} \frac{1}{n^2}$ are an example.
 77. 150 km
 79. $\sum_{n=1}^{\infty} \frac{1}{4^n} = \frac{1}{3}$ 81. $\sum_{n=3}^{\infty} \frac{1}{2^n} = \frac{1}{4}$

Section 10.3

1. Diverges 3. Diverges 5. Converges
 7. Converges 9. Diverges 11. Converges
 13. Converges 15. Converges 17. Diverges
 19. Converges 21. Converges 23. Converges
 25. Converges 27. Diverges 29. Converges
 31. Diverges
 33. The terms of the series are not monotonically decreasing.
 35. The terms of the series are not positive nor monotonically decreasing.
 39. $1.19955 \leq s \leq 1.20566$ 41. $1.06621 \leq s \leq 1.08946$
 43. $2.08997 \leq s \leq 2.13419$ 45. $n = 5; s \approx 1.2026$
 47. $n = 4; s \approx 0.404881426$ 49. $n = 5; s \approx 3.2357$
 51. $n = 40; s \approx 1.0369277553$
 53. $n = 20; s \approx 1.0020083928262$

Section 10.4

1. Converges 3. Diverges 5. Converges
 7. Diverges 9. Converges 11. Converges
 13. Converges 15. Diverges 17. Converges
 19. Converges 21. Converges 23. Converges
 25. Converges 27. Diverges 29. Converges
 31. Converges 33. Diverges 35. Diverges
 37. Converges 39. Converges 41. Converges
 43. Diverges 45. Converges 47. Diverges
 49. Diverges 51. Converges 53. Converges
 55. Converges 57. Diverges 59. Converges
 61. Diverges 63. Diverges 65. Converges

67. Converges 69. Converges 83. True
 85. False; consider $a_n = 1/n$ and $b_n = 1/n^2$.
 87. False; consider $b_n = c_n = 1/n$.
 89. True 91. True

Section 10.5

1. Converges 3. Converges 5. Converges
 7. Converges 9. Converges 11. Converges
 13. Diverges 15. Converges 17. Diverges
 19. Converges 21. Diverges 23. Converges
 25. Converges 27. Diverges 29. Converges
 31. Diverges 33. Diverges 35. Diverges
 37. Diverges 39. Converges 41. Converges
 43. Converges 45. Converges 47. Converges
 49. Diverges 51. Converges 53. Converges
 55. Converges 57. Diverges 59. Converges
 61. Converges 63. Diverges 65. Diverges
 67. Diverges 69. Converges 73. $0 < p < 1$
 75. True 77. False
 79. False; consider Example 3.

Section 10.6

1. Converges by the Alternating Series Test
 3. Diverges by the n^{th} -Term Divergence Test
 5. Converges by the Alternating Series Test
 7. Diverges by the n^{th} -Term Divergence Test
 9. Diverges by the n^{th} -Term Divergence Test
 11. Converges by the Alternating Series Test
 13. Diverges by the n^{th} -Term Divergence Test
 15. Diverges by the n^{th} -Term Divergence Test
 17. Converges by the Alternating Series Test
 19. Diverges by the n^{th} -Term Divergence Test
 21. Converges by the theorem "Absolute Convergence Implies Convergence"
 23. Diverges by the n^{th} -Term Divergence Test
 25. 0.90 27. 0.36788 29. 0.057
 31. Converges conditionally
 33. Diverges 35. Converges conditionally
 37. Converges absolutely
 39. Converges conditionally
 41. Converges absolutely 43. Diverges

45. Converges conditionally
 47. Converges absolutely
 49. Converges conditionally
 51. Converges absolutely
 53. Diverges 55. Diverges 57. Diverges
 59. No; a_n is not monotonic, so the test doesn't apply. The series is actually divergent.
 65. An example is $\sum \frac{(-1)^n}{\sqrt{n}}$.
 67. At least 1000 terms are needed.

Section 10.7

1. $(-1/3, 1/3)$; $R = 1/3$ 3. $[-1/4, 1/4]$; $R = 1/4$
 5. $[-1, 1]$; $R = 1$ 7. $\{0\}$; $R = 0$
 9. $(-\infty, \infty)$; $R = \infty$ 11. $(-5, -1)$; $R = 2$
 13. $\{0\}$; $R = 0$ 15. $[3, 5]$; $R = 1$
 17. $\{5\}$; $R = 0$ 19. $[-4, 0]$; $R = 2$
 21. $[0, 2]$; $R = 1$ 23. $(-\infty, \infty)$; $R = \infty$
 25. $(2/3, 4/3)$; $R = 1/3$ 27. $(-1, 1)$; $R = 1$
 29. $[-7/3, -5/3]$; $R = 1/3$
 31. $(2, 4)$; $R = 1$ 33. $(0, 2/3)$; $f(x) = \frac{1}{2-3x}$
 35. $(-3, 3)$; $f(x) = \frac{3}{3+x}$ 37. $(1, 5)$; $f(x) = \frac{2}{5-x}$
 39. $(3/5, 9/5)$; $f(x) = \frac{9}{9-(5x-6)^2}$
 41. $\sum_{n=0}^{\infty} 2^n x^n$; $R = 1/2$ 43. $\sum_{n=0}^{\infty} (-1)^n x^{2n}$; $R = 1$
 45. $\sum_{n=0}^{\infty} \frac{4^n x^n}{3^n}$; $R = 3/4$ 47. $\sum_{n=0}^{\infty} [(-1)^n + 2] x^n$; $R = 1$
 49. $\sum_{n=0}^{\infty} (-1)^n (x-1)^n$; $R = 1$
 51. $\sum_{n=1}^{\infty} (-1)^n n(x-1)^{n-1}$; $R = 1$ 53. 10 terms
 55. $\sum_{n=2}^{\infty} n(n-1)x^{n-2} = \frac{2}{(1-x)^3}$;
 $\sum_{n=3}^{\infty} n(n-1)(n-2)x^{n-3} = \frac{6}{(1-x)^4}$
 57. $\frac{18}{(2-3x)^3}$ on $(0, 2/3)$
 59. $\sum_{n=1}^{\infty} (-1)^{n+1} (2n)x^{2n-1}$; $R = 1$

65. $\sum_{n=0}^{\infty} \frac{(-1)^n 2^{2n} x^{2n}}{(2n)!}$; this is the series expansion of $\cos 2x$ about 0.
 67. False; consider Exercise 16.
 69. False; consider Exercise 62.

Section 10.8

1. $4 + 2x - \frac{x^2}{2} + \frac{x^3}{2} + \frac{x^4}{24}$
 3. $f(x) = -7 + 3x + 5x^2 - x^3 + 2x^4$; $R = \infty$
 5. $\sum_{n=0}^{\infty} \frac{e(x-1)^n}{n!}$; $R = \infty$ 7. $\sum_{n=0}^{\infty} (-1)^n \frac{(x-1)^n}{5^{n+1}}$; $R = 5$
 9. $\sum_{n=1}^{\infty} (-1)^{n+1} \frac{n(x-2)^{n-1}}{2^{n+1}}$; $R = 2$
 11. $\sum_{n=0}^{\infty} \frac{(-1)^n x^{4n}}{(2n)!}$; $R = \infty$
 13. $\sum_{n=0}^{\infty} \frac{(-1)^n 2^{2n} x^{2n+1}}{(2n+1)!}$; $R = \infty$
 15. $\sum_{n=0}^{\infty} \frac{x^{2n}}{(2n)!}$; $R = \infty$ 17. $\sum_{n=0}^{\infty} \frac{(-1)^n x^n}{(2n)!}$; $R = \infty$
 19. $-x - x^2 + \sum_{n=0}^{\infty} \frac{(2n^2 + 6n + 3)x^{n+3}}{(n+2)!}$; $R = \infty$
 21. $\sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+2}}{n+1}$; $R = 1$
 23. $\sum_{n=1}^{\infty} (-1)^{n+1} \frac{n(x-3)^{n-1}}{3^{n+1}}$; $R = 3$
 25. $\sum_{n=0}^{\infty} \frac{(-1)^n 2^{n+1} - 3^{n+1}}{6^{n+1}} x^n$; $R = 2$
 27. $\sum_{n=0}^{\infty} x^{2n+2}$; $R = 1$ 29. $\sum_{n=0}^{\infty} (-1)^n \frac{x^{3n+1}}{(2n)!}$; $R = \infty$
 31. $\frac{\pi}{4} + \frac{x-1}{2} - \frac{1}{4}(x-1)^2 + \frac{1}{12}(x-1)^3 - \frac{1}{40}(x-1)^5 + \dots$
 33. $e - \frac{ex^2}{2} + \frac{ex^4}{6} - \frac{31ex^6}{720} + \frac{379ex^8}{40,320} - \dots$
 35. $2 + (\ln 2)(x-1) + (\ln 2)^2(x-1)^2 + \frac{(\ln 2)^3(x-1)^3}{3} + \frac{(\ln 2)^4(x-1)^4}{12} + \dots$
 37. $1 + 2x + \frac{5x^2}{2} + \frac{8x^3}{3} + \frac{65x^4}{24} + \dots$
 39. $x - 2x^2 + \frac{11x^3}{6} - x^4 + \frac{41x^5}{120} - \dots$

$$41. x - \frac{x^3}{3} + \frac{2x^5}{15} - \frac{17x^7}{315} + \frac{62x^9}{2835} - \dots$$

$$43. x^2 - \frac{x^3}{2} + \frac{x^4}{6} - \frac{x^5}{6} + \frac{11x^6}{72} - \dots$$

$$45. -x - \frac{x^2}{2} + \frac{x^3}{6} - \frac{3x^5}{40} - \frac{x^6}{16} - \dots$$

$$47. 1 - 2x + \left(1 - \frac{\pi^2}{2}\right)x^2 + \pi^2 x^3 + \frac{\pi^4 - 12\pi^2}{24}x^4 - \dots$$

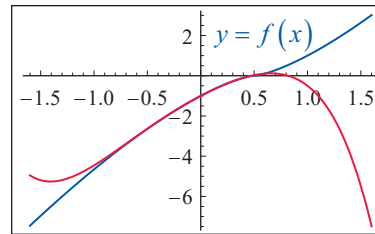
$$49. 0.36786; 8 \text{ terms} \quad 51. 0.8452; 5 \text{ terms}$$

$$53. 0.3102682; 4 \text{ terms} \quad 55. 0.304; 3 \text{ terms}$$

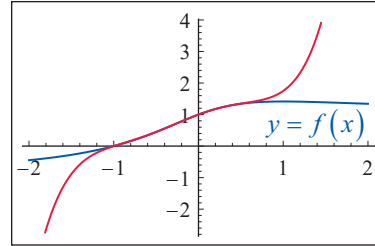
$$57. 0.922; 6 \text{ terms} \quad 61. 2 \quad 63. 1$$

$$67. 4 \quad 71. 0 \text{ and } -162!, \text{ respectively}$$

47.



49.



Section 10.9

$$1. i \quad 3. \frac{5e^2}{2} + i\frac{5\sqrt{3}e^2}{2}$$

$$5. \frac{2}{3}\sin 2 \quad 7. -4e^{i\pi/3} \quad 9. -4$$

$$13. 1 + 5x^2 + 10x^4 + 10x^6 + 5x^8 + x^{10}$$

$$15. 1 - \frac{x}{2} + \frac{x^2}{8} - \frac{x^3}{16} + \frac{5x^4}{128} - \frac{7x^5}{256} - \dots$$

$$17. 1 + \frac{x^2}{3} - \frac{x^4}{9} + \frac{5x^6}{81} - \frac{10x^8}{243} + \frac{22x^{10}}{729} + \dots$$

$$19. 1 + \frac{4x^2}{3} + \frac{20x^4}{9} + \frac{320x^6}{81} + \frac{1760x^8}{243} + \frac{9856x^{10}}{729} + \dots$$

$$21. 5 - \frac{5x}{2} + \frac{25x^2}{8} - \frac{75x^3}{16} + \frac{975x^4}{128} - \frac{3315x^5}{256} + \dots$$

$$23. \sin^{-1} x = \sum_{n=0}^{\infty} \frac{(2n)!}{(n!)^2 4^n (2n+1)} x^{2n+1}; R=1$$

$$25. \sinh^{-1} x = \sum_{n=0}^{\infty} \frac{(-1)^n (2n)!}{(n!)^2 4^n (2n+1)} x^{2n+1}; R=1$$

$$31. \text{Approx. } 5.777 \text{ miles}$$

$$35. \text{Approx. } 4.211 \times 10^7 \text{ m/s}$$

$$39. y = a \sum_{n=0}^{\infty} \frac{(-1)^n (3x)^{2n}}{(2n)!} + \frac{1}{3} b \sum_{n=0}^{\infty} \frac{(-1)^n (3x)^{2n+1}}{(2n+1)!}$$

$$= a \cos 3x + \frac{1}{3} b \sin 3x$$

$$41. y = a \sum_{n=0}^{\infty} x^{2n} + b \sum_{n=0}^{\infty} x^{2n+1} = \frac{a}{1-x^2} + \frac{bx}{1-x^2}$$

$$45. a_0 = 1/2; a_k = 0; b_k = \frac{(-1)^k - 1}{k\pi} \quad (k \geq 1)$$

Chapter 10 Review

$$1. 1, 0, \frac{1}{25}, -\frac{1}{125}, \frac{81}{83,521} \quad 3. 0, 2, 8, 26, 80$$

$$7. \text{Diverges} \quad 9. \text{Converges to } e^6$$

$$13. 219/999 \quad 15. \text{The limit is } 3.$$

$$19. \text{a. } d_1 = d, d_n = \frac{1}{2}d_{n-1} + d, n \geq 2 \quad \text{b. } \lim_{n \rightarrow \infty} d_n = 2d$$

$$23. 3 \quad 25. 85/4 \quad 27. \text{Diverges}$$

$$29. \text{Converges} \quad 31. \text{Converges} \quad 33. n=5; s \approx 2.616$$

$$35. \text{Diverges} \quad 37. \text{Converges} \quad 39. \text{Converges}$$

$$41. \text{Diverges} \quad 43. \text{Converges} \quad 45. \text{Converges}$$

$$47. \text{Converges} \quad 49. \text{Converges}$$

$$51. \text{Converges by Alternating Series Test}$$

$$53. \text{Diverges by } n^{\text{th}}\text{-Term Divergence Test}$$

$$55. 0.9498; \text{three terms were needed. According to the } n^{\text{th}}\text{-remainder estimate, five terms are sufficient.}$$

$$57. \text{Converges absolutely} \quad 59. \text{Converges absolutely}$$

$$61. \text{Converges absolutely}$$

$$63. (-1/2, 1/2) \quad 65. (-\infty, \infty) \quad 67. [-4, 2)$$

$$69. (1, 2); f(x) = \frac{1}{4-2x} \quad 71. \sum_{n=0}^{\infty} (-1)^n (3x)^n; R=1/3$$

$$73. \frac{1}{x} = \sum_{n=0}^{\infty} (-1)^n \frac{(x-2)^n}{2^{n+1}},$$

$$\frac{1}{x^3} = \sum_{n=0}^{\infty} (-1)^n \frac{(n+1)(n+2)(x-2)^n}{2^{n+4}}; R=2$$

$$75. \sum_{n=0}^{\infty} \frac{(-1)^n 4^n x^{6n}}{(2n)!}; R=\infty$$

$$77. \ln 3 + \sum_{n=1}^{\infty} \frac{(-1)^{n-1} (x-3)^n}{n3^n}; R=3$$

79. $\sum_{n=1}^{\infty} \frac{(-1)^{n+1} 2^{2n-1} x^{2n}}{(2n)!}; R = \infty$

81. $\frac{1}{3} + \sum_{n=1}^{\infty} \frac{(-1)^{n+1} 2(x-1)^n}{3^{n+1}}; R = 3$

83. $\sqrt{2} - \sqrt{2} \left(x - \frac{\pi}{4} \right) + \frac{3}{\sqrt{2}} \left(x - \frac{\pi}{4} \right)^2 - \frac{11}{3\sqrt{2}} \left(x - \frac{\pi}{4} \right)^3 + \dots$

85. $1 - x + \frac{x^2}{2} - \frac{x^3}{2} + \frac{13x^4}{24} - \dots$

87. 0.540302; 5 terms

89. $\sqrt[4]{1.2} \approx 1.04663$; 5 terms 91. -1

93. The sum is 2.

95. $1 - \frac{x^2}{2} + \frac{3x^4}{8} - \frac{5x^6}{16} + \frac{35x^8}{128} - \frac{63x^{10}}{256} + \dots$

97. $1 + x^3 - \frac{x^6}{2} + \frac{x^9}{2} - \frac{5x^{12}}{8} + \frac{7x^{15}}{8} - \dots$

99. $y = a \sum_{n=0}^{\infty} \frac{(-1)^n 2^{2n} x^{2n}}{(2n)!} + \frac{1}{2} b \sum_{n=0}^{\infty} \frac{(-1)^n 2^{2n+1} x^{2n+1}}{(2n+1)!}$
 $= a \cos 2x + \frac{1}{2} b \sin 2x$

101. $\sum_{n=0}^{\infty} \frac{(-1)^n 2x^n}{n!} = 2e^{-x}$, this is the Maclaurin series of $2e^{-x}$.

113. False; consider $a_n = 1/n$.

115. False; consider $a_n = 1$ (for all n).

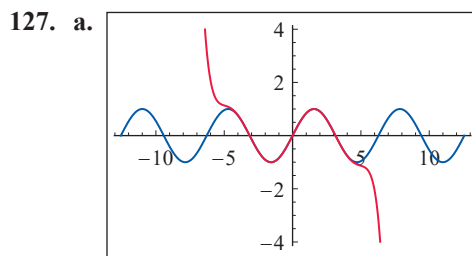
117. False; consider $a_n = 1/n$.

119. False; consider $\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n}$.

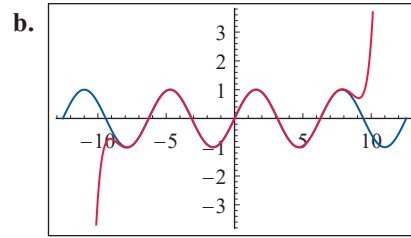
121. False; consider $a_n = \frac{(-1)^n}{\sqrt{n}}$.

123. False; the series $\sum_{n=0}^{\infty} (n!)x^n$ converges only at $x = 0$.

125. a. 91,380 terms b. Approx. 15.0859



The approximation seems acceptable on the interval $(-3\pi/2, 3\pi/2)$.



The approximation seems acceptable on the interval $(-5\pi/2, 5\pi/2)$.

Chapter 10 Conceptual Project

5. $\gamma \approx 0.5772156649$

Chapter 10 Application Project

1. a. $C'(t) = -kC(t); C(0) = D$

b. $C(t) = De^{-kt}$

3. $C_n = D(e^{-kp} + e^{-2kp} + \dots + e^{-nkp}) = De^{-kp} \cdot \frac{1 - e^{-nkp}}{1 - e^{-kp}}$

5. $p = \frac{1}{k} \ln \frac{m_t}{m_e}$