ANSWERS TO ODD-NUMBERED EXERCISES

Chapter 1

SECTION 1.1, pp. 11–13

1. $D: (-\infty, \infty)$, $R: [1, \infty)$ **3.** $D: [-2, \infty)$, $R: [0, \infty)$

5. $D: (-\infty, 3) \cup (3, \infty)$, $R: (-\infty, 0) \cup (0, \infty)$

7. (a) Not a function of x because some values of x have two values of y

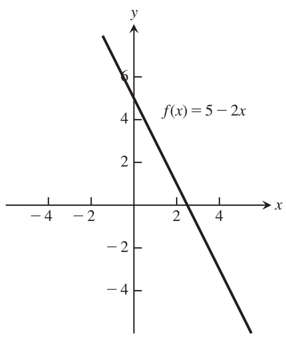
(b) A function of x because for every x there is only one possible y

9. $A = \dfrac{\sqrt{3}}{4}x^2$, $p = 3x$

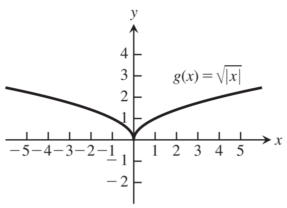
11. $x = \dfrac{d}{\sqrt{3}}$, $A = 2d^2$, $V = \dfrac{d^3}{3\sqrt{3}}$

13. $L = \dfrac{\sqrt{20x^2 - 20x + 25}}{4}$

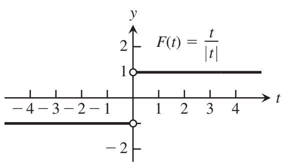
15. $(-\infty, \infty)$



17. $(-\infty, \infty)$

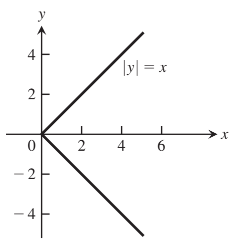


19. $(-\infty, 0) \cup (0, \infty)$

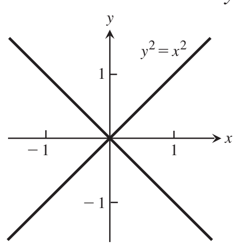


21. $(-\infty, -5) \cup (-5, -3] \cup [3, 5) \cup (5, \infty)$

23. (a) For each positive value of x, there are two values of y.



(b) For each value of $x \neq 0$, there are two values of y.



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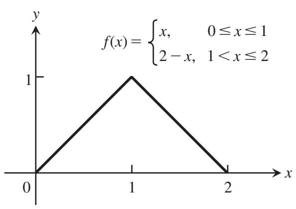

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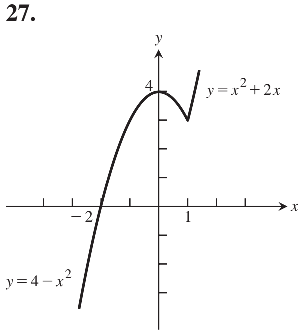


29. (a) $f(x) = \begin{cases} x, & 0 \le x \le 1 \\ -x + 2, & 1 < x \le 2 \end{cases}$

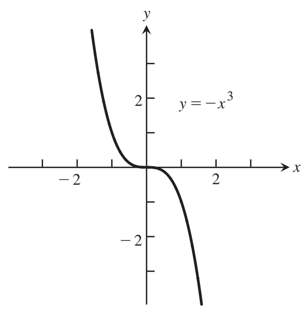
(b) $f(x) = \begin{cases} 2, & 0 \le x < 1 \\ 0, & 1 \le x < 2 \\ 2, & 2 \le x < 3 \\ 0, & 3 \le x \le 4 \end{cases}$

31. (a) $f(x) = \begin{cases} -x, & -1 \le x < 0 \\ 1, & 0 < x \le 1 \\ -\frac{1}{2}x + \frac{3}{2}, & 1 < x < 3 \end{cases}$

(b) $f(x) = \begin{cases} \frac{1}{2}x, & -2 \le x \le 0 \\ -2x + 2, & 0 < x \le 1 \\ -1, & 1 < x \le 3 \end{cases}$

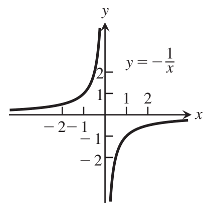
33. (a) $0 \le x < 1$ **(b)** $-1 < x \le 0$ **35.** Yes

37. Symmetric about the origin



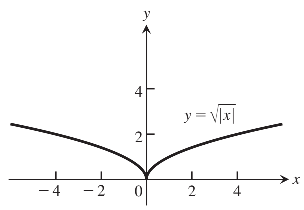
Dec. $-\infty < x < \infty$

39. Symmetric about the origin



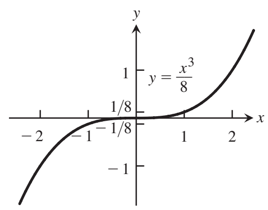
Inc. $-\infty < x < 0$ and $0 < x < \infty$

41. Symmetric about the y-axis



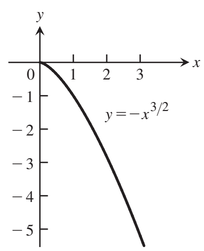
Dec. $-\infty < x \le 0$; Inc. $0 \le x < \infty$

43. Symmetric about the origin



Inc. $-\infty < x < \infty$

45. No symmetry



Dec. $0 \le x < \infty$

47. Even **49.** Even **51.** Odd **53.** Even

55. Neither **57.** Neither **59.** Odd **61.** Even

63. $t = 180$ **65.** $s = 2.4$ **67.** $V = x(14 - 2x)(22 - 2x)$

69. (a) h **(b)** f **(c)** g **71. (a)** $(-2, 0) \cup (4, \infty)$

75. $C = 5(2 + \sqrt{2})h$

SECTION 1.2, pp. 18–21

1. $D_f: -\infty < x < \infty$, $D_g: x \ge 1$, $R_f: -\infty < y < \infty$, $R_g: y \ge 0$, $D_{f+g} = D_{f\cdot g} = D_g$, $R_{f+g}: y \ge 1$, $R_{f\cdot g}: y \ge 0$

3. $D_f: -\infty < x < \infty$, $D_g: -\infty < x < \infty$, $R_f: y = 2$, $R_g: y \ge 1$, $D_{f/g}: -\infty < x < \infty$, $R_{f/g}: 0 < y \le 2$, $D_{g/f}: -\infty < x < \infty$, $R_{g/f}: y \ge 1/2$

5. **(a)** 2 **(b)** 22 **(c)** $x^2 + 2$ **(d)** $x^2 + 10x + 22$ **(e)** 5 **(f)** -2 **(g)** $x + 10$ **(h)** $x^4 - 6x^2 + 6$

7. $13 - 3x$ **9.** $\sqrt{\dfrac{5x+1}{4x+1}}$

11. **(a)** $f(g(x))$ **(b)** $j(g(x))$ **(c)** $g(g(x))$ **(d)** $j(j(x))$ **(e)** $g(h(f(x)))$ **(f)** $h(j(f(x)))$

13.

	$g(x)$	$f(x)$	$(f \circ g)(x)$
(a)	$x - 7$	$\sqrt{x}$	$\sqrt{x-7}$
(b)	$x + 2$	$3x$	$3x + 6$
(c)	x^2	$\sqrt{x-5}$	$\sqrt{x^2-5}$
(d)	$\dfrac{x}{x-1}$	$\dfrac{x}{x-1}$	x
(e)	$\dfrac{1}{x-1}$	$1 + \dfrac{1}{x}$	x
(f)	$\dfrac{1}{x}$	$\dfrac{1}{x}$	x

15. **(a)** 1 **(b)** 2 **(c)** -2 **(d)** 0 **(e)** -1 **(f)** 0

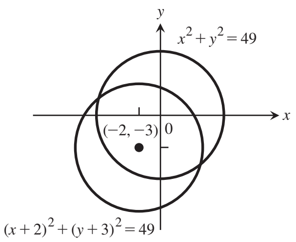
17. **(a)** $f(g(x)) = \sqrt{\dfrac{1}{x} + 1}$, $g(f(x)) = \dfrac{1}{\sqrt{x+1}}$
(b) $D_{f\circ g} = (-\infty, -1] \cup (0, \infty)$, $D_{g\circ f} = (-1, \infty)$
(c) $R_{f\circ g} = [0, 1) \cup (1, \infty)$, $R_{g\circ f} = (0, \infty)$

19. $g(x) = \dfrac{2x}{x-1}$ **21.** $V(t) = 4t^2 - 8t + 6$

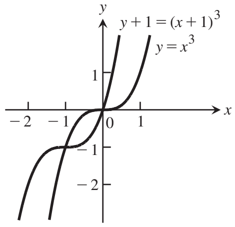
23. **(a)** $y = -(x+7)^2$ **(b)** $y = -(x-4)^2$

25. **(a)** Position 4 **(b)** Position 1 **(c)** Position 2 **(d)** Position 3

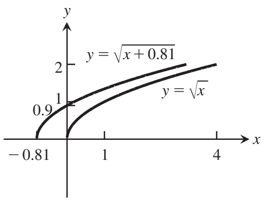
27. $(x+2)^2 + (y+3)^2 = 49$



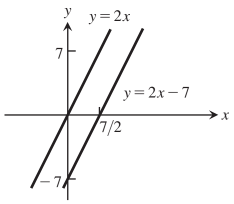
29. $y + 1 = (x+1)^3$



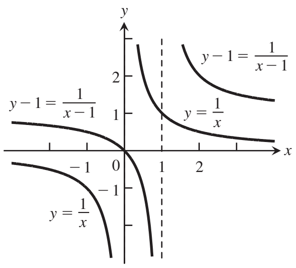
31. $y = \sqrt{x + 0.81}$



33. $y = 2x$



35. $y - 1 = \dfrac{1}{x-1}$



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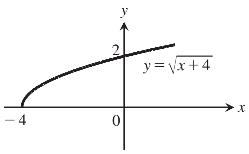

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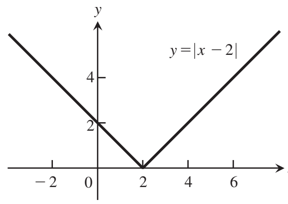

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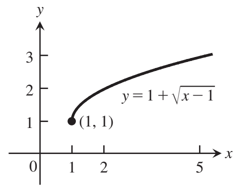

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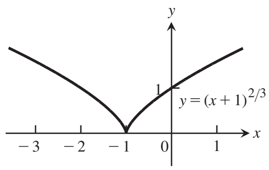

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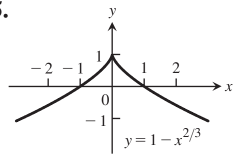

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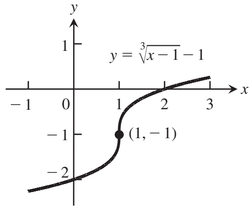

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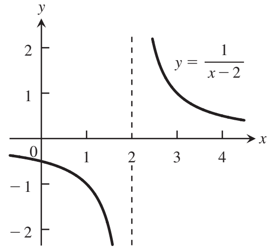

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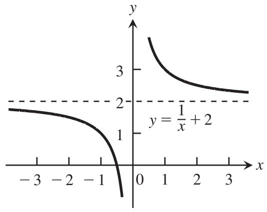

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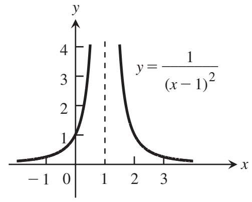

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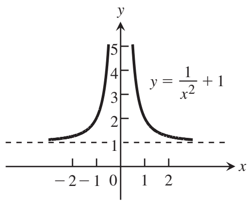
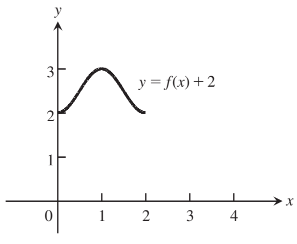
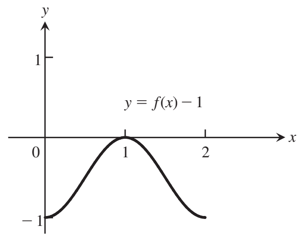


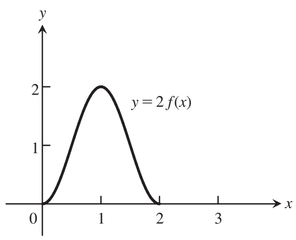
57. **(a)** $D: [0, 2]$, $R: [2, 3]$



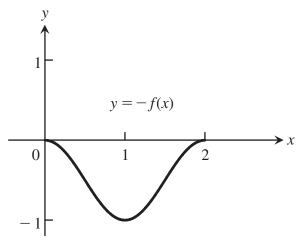
(b) $D: [0, 2]$, $R: [-1, 0]$



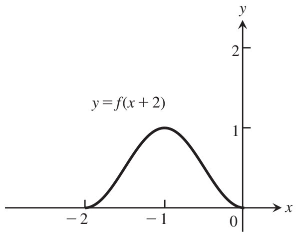
(c) $D: [0, 2]$, $R: [0, 2]$



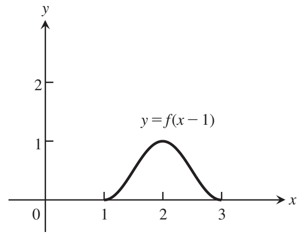
(d) $D: [0, 2]$, $R: [-1, 0]$



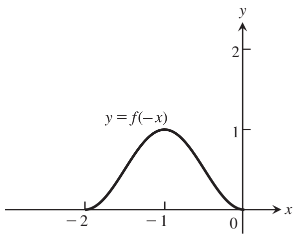
(e) $D: [-2, 0]$, $R: [0, 1]$



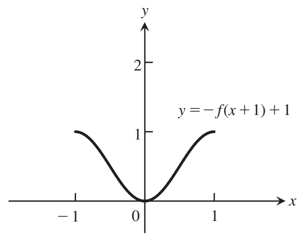
(f) $D: [1, 3], R: [0, 1]$



(g) $D: [-2, 0]$, $R: [0, 1]$



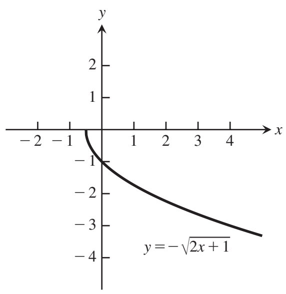
(h) $D: [-1, 1]$, $R: [0, 1]$



59. $y = 3x^2 - 3$ **61.** $y = \frac{1}{2} + \frac{1}{2x^2}$ **63.** $y = \sqrt{4x + 1}$

65. $y = \sqrt{4 - \frac{x^2}{4}}$ **67.** $y = 1 - 27x^3$

69.



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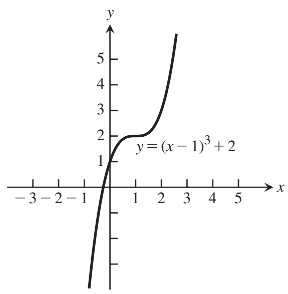

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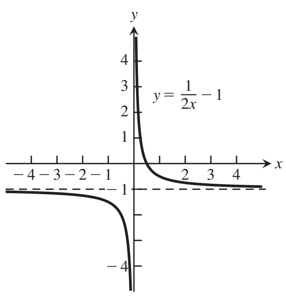

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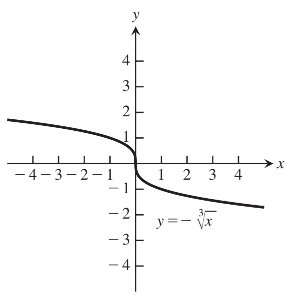

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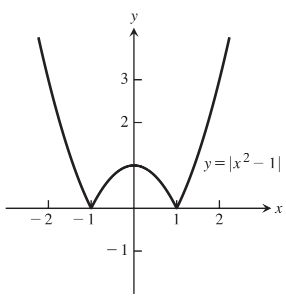


79. **(a)** Odd **(b)** Odd **(c)** Odd **(d)** Even **(e)** Even
(f) Even **(g)** Even **(h)** Even **(i)** Odd

SECTION 1.3, pp. 27–29

1. **(a)** 8π m **(b)** $\frac{55\pi}{9}$ m **3.** 8.4 in.

5.

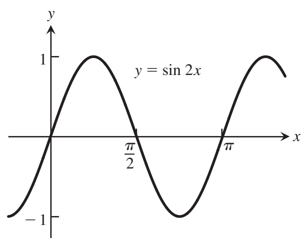
θ	$-\pi$	$-2\pi/3$	0	$\pi/2$	$3\pi/4$
$\sin\theta$	0	$-\frac{\sqrt{3}}{2}$	0	1	$\frac{1}{\sqrt{2}}$
$\cos\theta$	-1	$-\frac{1}{2}$	1	0	$-\frac{1}{\sqrt{2}}$
$\tan\theta$	0	$\sqrt{3}$	0	UND	-1
$\cot\theta$	UND	$\frac{1}{\sqrt{3}}$	UND	0	-1
$\sec\theta$	-1	-2	1	UND	$-\sqrt{2}$
$\csc\theta$	UND	$-\frac{2}{\sqrt{3}}$	UND	1	$\sqrt{2}$

7. $\cos x = -4/5, \tan x = -3/4$

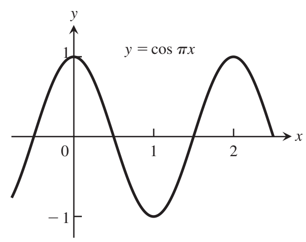
9. $\sin x = -\frac{\sqrt{8}}{3}, \tan x = -\sqrt{8}$

11. $\sin x = -\frac{1}{\sqrt{5}}, \cos x = -\frac{2}{\sqrt{5}}$

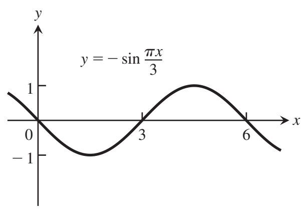
13. Period π



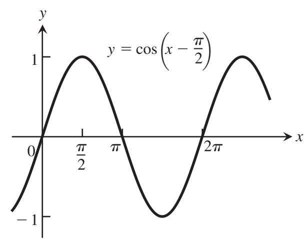
15. Period 2



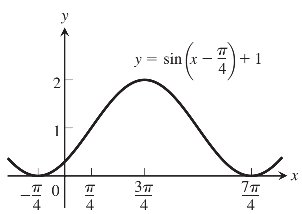
17. Period 6



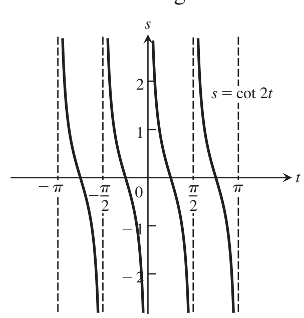
19. Period 2π



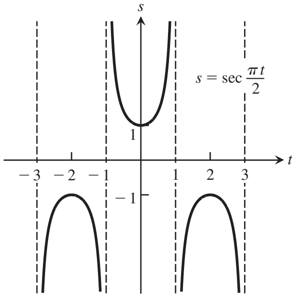
21. Period 2π



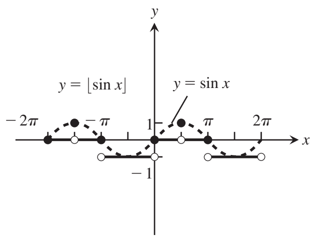
23. Period $\pi/2$, symmetric about the origin



25. Period 4, symmetric about the y-axis



29. $D: (-\infty, \infty)$, $R: y = -1, 0, 1$



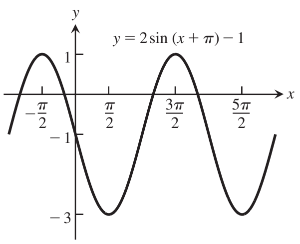
39. $-\cos x$ **41.** $-\cos x$ **43.** $\dfrac{\sqrt{6}+\sqrt{2}}{4}$ **45.** $\dfrac{\sqrt{2}+\sqrt{6}}{4}$

47. $\dfrac{2+\sqrt{2}}{4}$ **49.** $\dfrac{2-\sqrt{3}}{4}$ **51.** $\dfrac{\pi}{3}, \dfrac{2\pi}{3}, \dfrac{4\pi}{3}, \dfrac{5\pi}{3}$

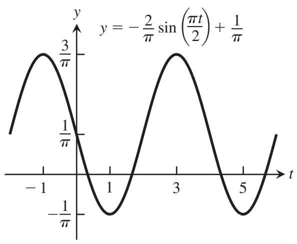
53. $\dfrac{\pi}{6}, \dfrac{\pi}{2}, \dfrac{5\pi}{6}, \dfrac{3\pi}{2}$ **59.** $\sqrt{7} \approx 2.65$ **63.** $a = 1.464$

65. $r = \dfrac{\alpha \sin\theta}{1 - \sin\theta}$

67. $A = 2, B = 2\pi$, $C = -\pi, D = -1$



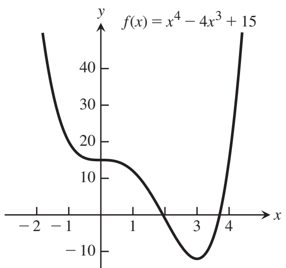
69. $A = -\dfrac{2}{\pi}, B = 4$, $C = 0, D = \dfrac{1}{\pi}$



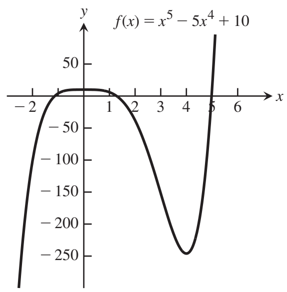
SECTION 1.4, p. 33

1. d **3.** d

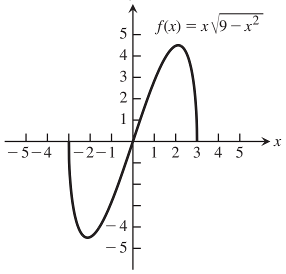
5. $[-3, 5]$ by $[-15, 40]$



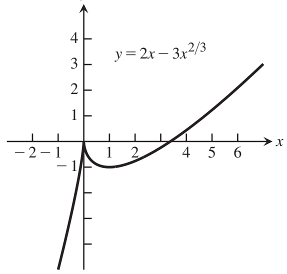
7. $[-3, 6]$ by $[-250, 50]$



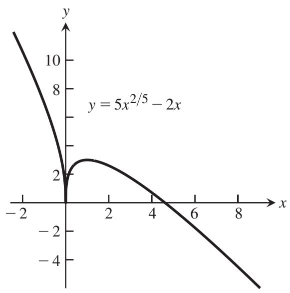
9. $[-5, 5]$ by $[-6, 6]$



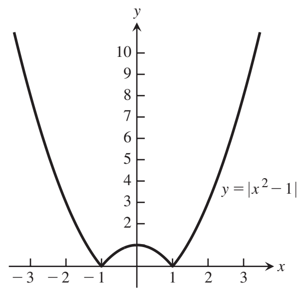
11. $[-2, 6]$ by $[-5, 4]$



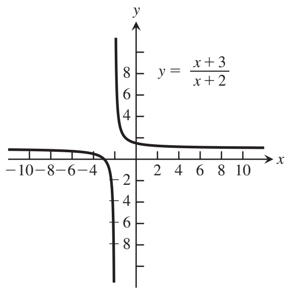
13. $[-2, 8]$ by $[-5, 10]$



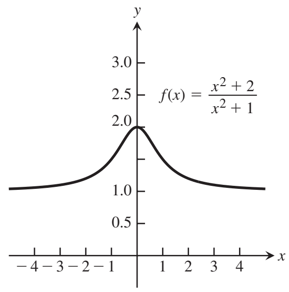
15. $[-3, 3]$ by $[0, 10]$



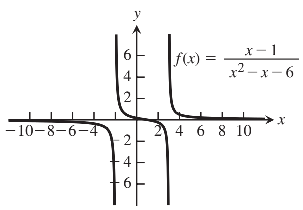
17. $[-10, 10]$ by $[-10, 10]$



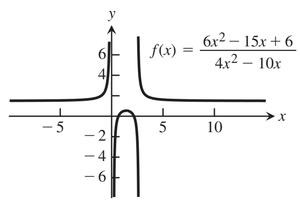
19. $[-4, 4]$ by $[0, 3]$



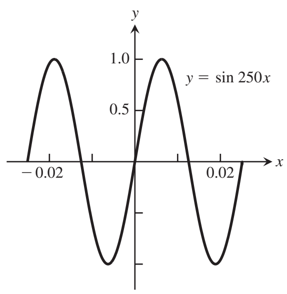
21. $[-10, 10]$ by $[-6, 6]$



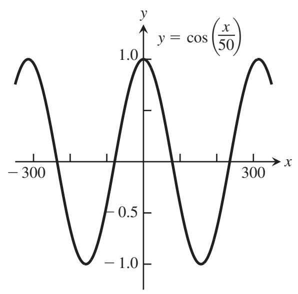
23. $[-6, 10]$ by $[-6, 6]$



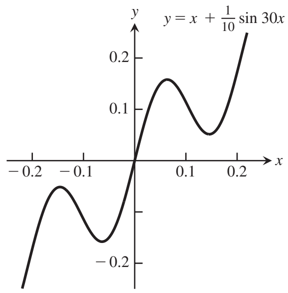
25. $\left[-\dfrac{\pi}{125}, \dfrac{\pi}{125}\right]$ by $[-1.25, 1.25]$



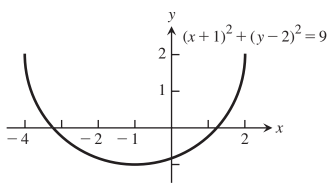
27. $[-100\pi, 100\pi]$ by $[-1.25, 1.25]$



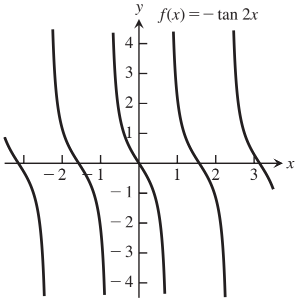
29. $\left[-\dfrac{\pi}{15}, \dfrac{\pi}{15}\right]$ by $[-0.25, 0.25]$



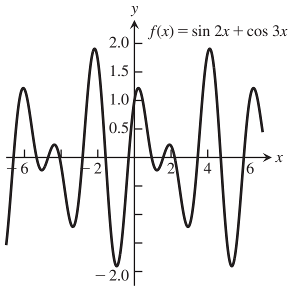
31.



33.



35.



PRACTICE EXERCISES, pp. 34–35

1. $A = \pi r^2, C = 2\pi r, A = \dfrac{C^2}{4\pi}$ **3.** $x = \tan\theta, y = \tan^2\theta$

5. Origin **7.** Neither **9.** Even **11.** Even
13. Odd **15.** Neither
17. **(a)** Even **(b)** Odd **(c)** Odd **(d)** Even **(e)** Even
19. **(a)** Domain: all reals **(b)** Range: $[-2, \infty)$
21. **(a)** Domain: $[-4, 4]$ **(b)** Range: $[0, 4]$
23. **(a)** Domain: all reals **(b)** Range: $(-3, \infty)$
25. **(a)** Domain: all reals **(b)** Range: $[-3, 1]$
27. **(a)** Domain: all reals **(b)** Range: $[0, 2]$
29. **(a)** Domain: $(-\infty, -1]$ and $[3, \infty)$ **(b)** Range: $(-\infty, 5]$
31. **(a)** Domain: $(-\infty, 0)$ and $(0, \infty)$ **(b)** Range: $[-4, 4]$
33. **(a)** Increasing **(b)** Neither **(c)** Decreasing **(d)** Increasing
35. **(a)** Domain: $[-4, 4]$ **(b)** Range: $[0, 2]$

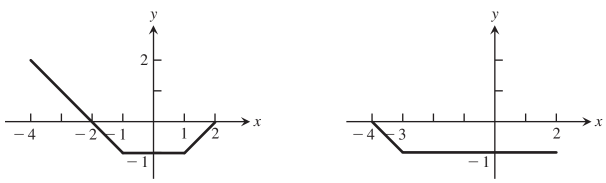
37. $f(x) = \begin{cases} 1 - x, & 0 \le x < 1 \\ 2 - x, & 1 \le x \le 2 \end{cases}$

39. **(a)** 1 **(b)** $\dfrac{1}{\sqrt{2.5}} = \sqrt{\dfrac{2}{5}}$ **(c)** $x, x \neq 0$

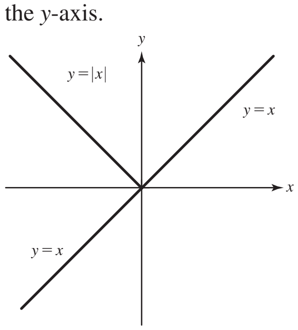
(d) $\dfrac{1}{\sqrt{1/\sqrt{x+2}+2}}$

41. **(a)** $(f \circ g)(x) = -x, x \ge -2, (g \circ f)(x) = \sqrt{4 - x^2}$
(b) Domain $(f \circ g)$: $[-2, \infty)$, domain $(g \circ f)$: $[-2, 2]$
(c) Range $(f \circ g)$: $(-\infty, 2]$, range $(g \circ f)$: $[0, 2]$

43.



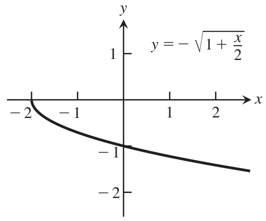
45. Replace the portion for $x < 0$ with the mirror image of the portion for $x > 0$ to make the new graph symmetric with respect to the y-axis.



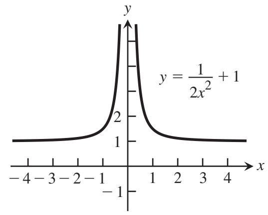
47. Reflects the portion for $y < 0$ across the x-axis
49. Reflects the portion for $y < 0$ across the x-axis
51. Adds the mirror image of the portion for $x > 0$ to make the new graph symmetric with respect to the y-axis

53. **(a)** $y = g(x - 3) + \dfrac{1}{2}$ **(b)** $y = g\left(x + \dfrac{2}{3}\right) - 2$
(c) $y = g(-x)$ **(d)** $y = -g(x)$ **(e)** $y = 5g(x)$
(f) $y = g(5x)$

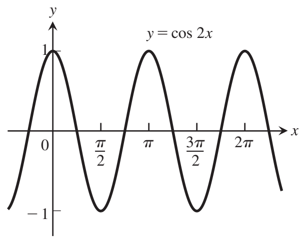
55.



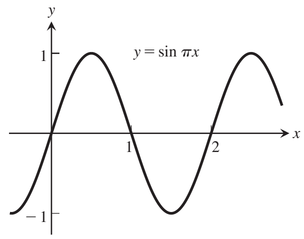
57.



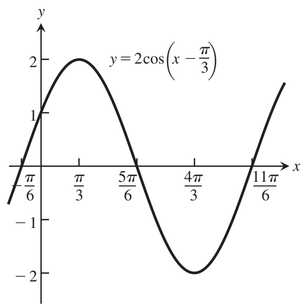
59. Period π



61. Period 2



63.



65. **(a)** $a = 1 \quad b = \sqrt{3}$ **(b)** $a = 2\sqrt{3}/3 \quad c = 4\sqrt{3}/3$

67. **(a)** $a = \dfrac{b}{\tan B}$ **(b)** $c = \dfrac{a}{\sin A}$

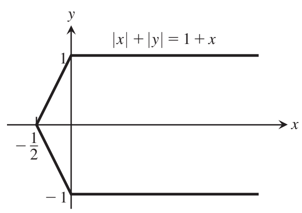
69. ≈ 16.98 m **71.** **(b)** 4π

ADDITIONAL AND ADVANCED EXERCISES, pp. 35–36

1. Yes. For instance: $f(x) = 1/x$ and $g(x) = 1/x$, or $f(x) = 2x$ and $g(x) = x/2$, or $f(x) = e^x$ and $g(x) = \ln x$.

3. If $f(x)$ is odd, then $g(x) = f(x) - 2$ is not odd. Nor is $g(x)$ even, unless $f(x) = 0$ for all x. If f is even, then $g(x) = f(x) - 2$ is also even.

5.



Chapter 2

SECTION 2.1, pp. 43–45

1. **(a)** 19 **(b)** 1

3. **(a)** $-\frac{4}{\pi}$ **(b)** $-\frac{3\sqrt{3}}{\pi}$ **5.** 1

7. **(a)** 4 **(b)** $y = 4x - 9$

9. **(a)** 2 **(b)** $y = 2x - 7$

11. **(a)** 12 **(b)** $y = 12x - 16$

13. **(a)** -9 **(b)** $y = -9x - 2$

15. **(a)** $-1/4$ **(b)** $y = -x/4 - 1$

17. **(a)** $1/4$ **(b)** $y = x/4 + 1$

19. Your estimates may not completely agree with these.

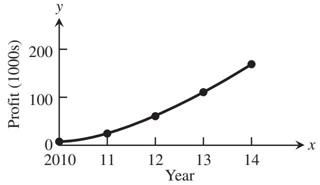
(a)

PQ_1	PQ_2	PQ_3	PQ_4
43	46	49	50

The appropriate units are m/sec.

(b) ≈50 m/sec or 180 km/h

21. **(a)**



(b) ≈$56,000/year

(c) ≈$42,000/year

23. **(a)** 0.414213, 0.449489, $(\sqrt{1+h} - 1)/h$ **(b)** $g(x) = \sqrt{x}$

$1 + h$	1.1	1.01	1.001	1.0001	1.00001	1.000001
$\sqrt{1+h}$	1.04880	1.004987	1.0004998	1.0000499	1.000005	1.0000005
$(\sqrt{1+h} - 1)/h$	0.4880	0.4987	0.4998	0.499	0.5	0.5

(c) 0.5 **(d)** 0.5

25. **(a)** 15 mph, 3.3 mph, 10 mph **(b)** 10 mph, 0 mph, 4 mph

(c) 20 mph when $t = 3.5$ hr

SECTION 2.2, pp. 53–56

1. **(a)** Does not exist. As x approaches 1 from the right, $g(x)$ approaches 0. As x approaches 1 from the left, $g(x)$ approaches 1. There is no single number L that all the values $g(x)$ get arbitrarily close to as $x \to 1$.

(b) 1 **(c)** 0 **(d)** 1/2

3. **(a)** True **(b)** True **(c)** False **(d)** False **(e)** False **(f)** True **(g)** True **(h)** False **(i)** True **(j)** True **(k)** False

5. As x approaches 0 from the left, $x/|x|$ approaches -1. As x approaches 0 from the right, $x/|x|$ approaches 1. There is no single number L that the function values all get arbitrarily close to as $x \to 0$.

7. Nothing can be said. **9.** No; no; no **11.** -4 **13.** -8

15. 3 **17.** $-25/2$ **19.** 16 **21.** $3/2$ **23.** $1/10$

25. -7 **27.** $3/2$ **29.** $-1/2$ **31.** -1 **33.** $4/3$

35. $1/6$ **37.** 4 **39.** $1/2$ **41.** $3/2$ **43.** -1

45. 1 **47.** $1/3$ **49.** $\sqrt{4 - \pi}$

51. **(a)** Quotient Rule **(b)** Difference and Power Rules **(c)** Sum and Constant Multiple Rules

53. **(a)** -10 **(b)** -20 **(c)** -1 **(d)** $5/7$

55. **(a)** 4 **(b)** -21 **(c)** -12 **(d)** $-7/3$

57. 2 **59.** 3 **61.** $1/(2\sqrt{7})$ **63.** $\sqrt{5}$

65. **(a)** The limit is 1.

67. **(a)** $f(x) = (x^2 - 9)/(x + 3)$

x	-3.1	-3.01	-3.001	-3.0001	-3.00001	-3.000001
$f(x)$	-6.1	-6.01	-6.001	-6.0001	-6.00001	-6.000001

x	-2.9	-2.99	-2.999	-2.9999	-2.99999	-2.999999
$f(x)$	-5.9	-5.99	-5.999	-5.9999	-5.99999	-5.999999

(c) $\lim_{x \to -3} f(x) = -6$

69. **(a)** $G(x) = (x + 6)/(x^2 + 4x - 12)$

x	-5.9	-5.99	-5.999	-5.9999	-5.99999	-5.999999
$G(x)$	$-.126582$	$-.1251564$	$-.1250156$	$-.1250015$	$-.1250001$	$-.1250000$

x	-6.1	-6.01	-6.001	-6.0001	-6.00001	-6.000001
$G(x)$	$-.123456$	$-.124843$	$-.124984$	$-.124998$	$-.124999$	$-.124999$

(c) $\lim_{x \to -6} G(x) = -1/8 = -0.125$

71. **(a)** $f(x) = (x^2 - 1)/(|x| - 1)$

x	-1.1	-1.01	-1.001	-1.0001	-1.00001	-1.000001
$f(x)$	2.1	2.01	2.001	2.0001	2.00001	2.000001

x	$-.9$	$-.99$	$-.999$	$-.9999$	$-.99999$	$-.999999$
$f(x)$	1.9	1.99	1.999	1.9999	1.99999	1.999999

(c) $\lim_{x \to -1} f(x) = 2$

73. **(a)** $g(\theta) = (\sin\theta)/\theta$

θ	.1	.01	.001	.0001	.00001	.000001
$g(\theta)$	.998334	.999983	.999999	.999999	.999999	.999999

θ	$-.1$	$-.01$	$-.001$	$-.0001$	$-.00001$	$-.000001$
$g(\theta)$	.998334	.999983	.999999	.999999	.999999	.999999

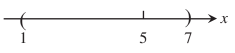
$\lim_{\theta \to 0} g(\theta) = 1$

75. $c = 0, 1, -1$; the limit is 0 at $c = 0$, and 1 at $c = 1, -1$.

77. 7 **79.** **(a)** 5 **(b)** 5 **81.** **(a)** 0 **(b)** 0

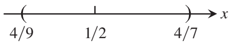
SECTION 2.3, pp. 61–64

1. $\delta = 2$



3. $\delta = 1/2$

5. $\delta = 1/18$



7. $\delta = 0.1$ **9.** $\delta = 7/16$ **11.** $\delta = \sqrt{5} - 2$

13. $\delta = 0.36$ **15.** $(3.99, 4.01)$, $\delta = 0.01$

17. $(-0.19, 0.21)$, $\delta = 0.19$ **19.** $(3, 15)$, $\delta = 5$

21. $(10/3, 5)$, $\delta = 2/3$

23. $(-\sqrt{4.5}, -\sqrt{3.5})$, $\delta = \sqrt{4.5} - 2 \approx 0.12$

25. $(\sqrt{15}, \sqrt{17})$, $\delta = \sqrt{17} - 4 \approx 0.12$

27. $\left(2 - \frac{0.03}{m}, 2 + \frac{0.03}{m}\right), \quad \delta = \frac{0.03}{m}$

29. $\left(\frac{1}{2} - \frac{c}{m}, \frac{c}{m} + \frac{1}{2}\right), \quad \delta = \frac{c}{m}$

31. $L = -3, \quad \delta = 0.01$ **33.** $L = 4, \quad \delta = 0.05$

35. $L = 4, \quad \delta = 0.75$

55. $[3.384, 3.387]$. To be safe, the left endpoint was rounded up and the right endpoint rounded down.

59. The limit does not exist as x approaches 3.

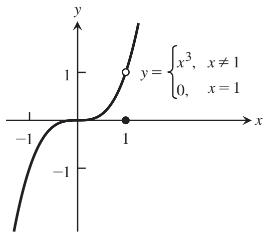
SECTION 2.4, pp. 70–72

1. **(a)** True **(b)** True **(c)** False **(d)** True **(e)** True **(f)** True **(g)** False **(h)** False **(i)** False **(j)** False **(k)** True **(l)** False

3. **(a)** 2, 1 **(b)** No, $\lim_{x\to 2^+} f(x) \neq \lim_{x\to 2^-} f(x)$ **(c)** 3, 3 **(d)** Yes, 3

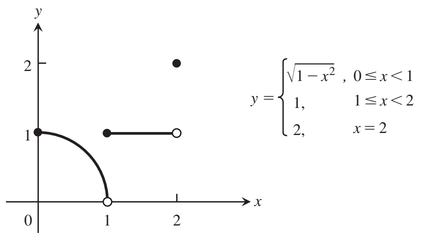
5. **(a)** No **(b)** Yes, 0 **(c)** No

7. **(a)**



(b) 1, 1 **(c)** Yes, 1

9. **(a)** $D: 0 \le x \le 2, R: 0 < y \le 1$ and $y = 2$ **(b)** $[0, 1) \cup (1, 2]$ **(c)** $x = 2$ **(d)** $x = 0$



11. $\sqrt{3}$ **13.** 1 **15.** $2/\sqrt{5}$ **17.** **(a)** 1 **(b)** -1

19. **(a)** 1 **(b)** -1 **21.** **(a)** 1 **(b)** $2/3$ **23.** 1 **25.** $3/4$

27. 2 **29.** $1/2$ **31.** 2 **33.** 0 **35.** 1 **37.** $1/2$

39. 0 **41.** $3/8$ **43.** 3 **45.** 0

51. $\delta = \varepsilon^2, \ \lim_{x\to 5^+} \sqrt{x-5} = 0$

55. **(a)** 400 **(b)** 399 **(c)** The limit does not exist.

SECTION 2.5, pp. 81–83

1. No; not defined at $x = 2$

3. Continuous **5.** **(a)** Yes **(b)** Yes **(c)** Yes **(d)** Yes

7. **(a)** No **(b)** No **9.** 0

11. 1, nonremovable; 0, removable **13.** All x except $x = 2$

15. All x except $x = 3, x = 1$ **17.** All x

19. All x except $x = 0$ **21.** All x except $n\pi/2$, n any integer

23. All x except $n\pi/2$, n an odd integer **25.** All $x \ge -3/2$

27. All x **29.** All x **31.** 0; continuous at $x = \pi$

33. 1; continuous at $y = 1$ **35.** $\sqrt{2}/2$; continuous at $t = 0$

37. $g(3) = 6$ **39.** $f(1) = 3/2$ **41.** $a = 4/3$

43. $a = -2, 3$ **45.** $a = 5/2, b = -1/2$

65. $x \approx 1.8794, -1.5321, -0.3473$ **67.** $x \approx 1.7549$

69. $x \approx 0.7391$

SECTION 2.6, pp. 93–96

1. **(a)** 0 **(b)** -2 **(c)** 2 **(d)** Does not exist **(e)** -1 **(f)** ∞ **(g)** Does not exist **(h)** 1 **(i)** 0

3. **(a)** -3 **(b)** -3 **5.** **(a)** $1/2$ **(b)** $1/2$ **7.** **(a)** $-5/3$ **(b)** $-5/3$ **9.** 0 **11.** -1 **13.** **(a)** $2/5$ **(b)** $2/5$

15. **(a)** 0 **(b)** 0 **17.** **(a)** 7 **(b)** 7 **19.** **(a)** 0 **(b)** 0

21. **(a)** ∞ **(b)** ∞ **23.** 2 **25.** ∞ **27.** 0 **29.** 1

31. ∞ **33.** 1 **35.** $1/2$ **37.** ∞ **39.** $-\infty$

41. $-\infty$ **43.** ∞ **45.** **(a)** ∞ **(b)** $-\infty$ **47.** ∞

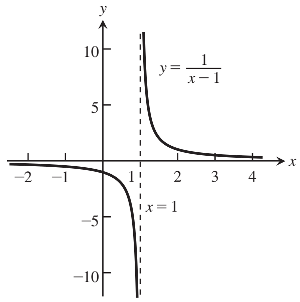
49. ∞ **51.** $-\infty$ **53.** **(a)** ∞ **(b)** $-\infty$ **(c)** $-\infty$ **(d)** ∞

55. **(a)** $-\infty$ **(b)** ∞ **(c)** 0 **(d)** $3/2$

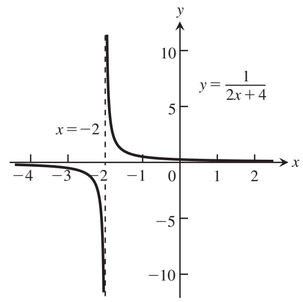
57. **(a)** $-\infty$ **(b)** $1/4$ **(c)** $1/4$ **(d)** $1/4$ **(e)** It will be $-\infty$.

59. **(a)** $-\infty$ **(b)** ∞ **61.** **(a)** ∞ **(b)** ∞ **(c)** ∞ **(d)** ∞

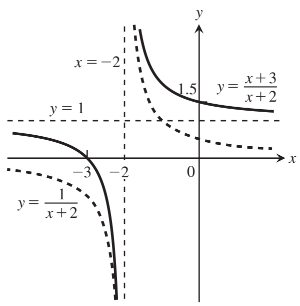
63.



65.



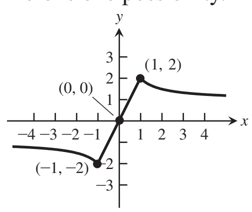
67.



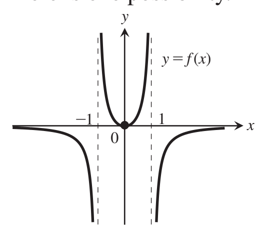
69. Domain: $(-\infty, \infty)$, Range: $[4, 7)$

71. Domain: $(-\infty, 0)$ and $(0, \infty)$, Range: $(-\infty, -1)$ and $(1, \infty)$

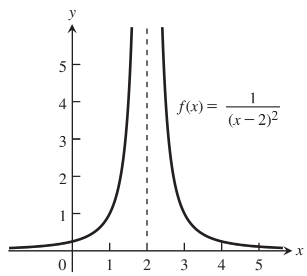
73. Here is one possibility.



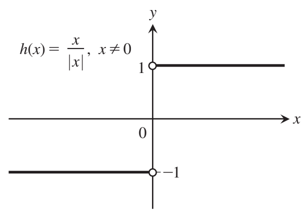
75. Here is one possibility.



77. Here is one possibility.



79. Here is one possibility.



83. At most one **85.** 0 **87.** $-3/4$ **89.** $5/2$

97. (a) For every positive real number B there exists a corresponding number $\delta > 0$ such that for all x

$$c - \delta < x < c \implies f(x) > B.$$

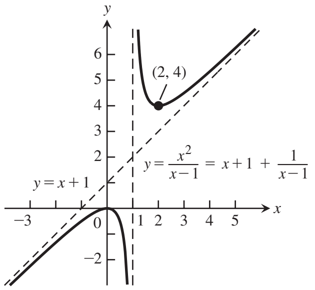
(b) For every negative real number $-B$ there exists a corresponding number $\delta > 0$ such that for all x

$$c < x < c + \delta \implies f(x) < -B.$$

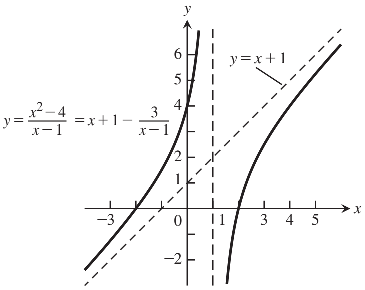
(c) For every negative real number $-B$ there exists a corresponding number $\delta > 0$ such that for all x

$$c - \delta < x < c \implies f(x) < -B.$$

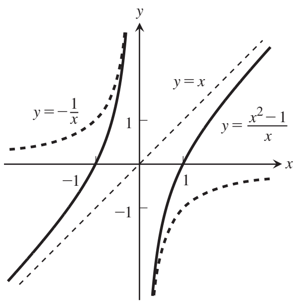
103.



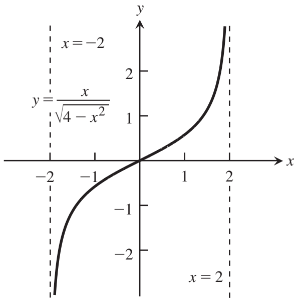
105.



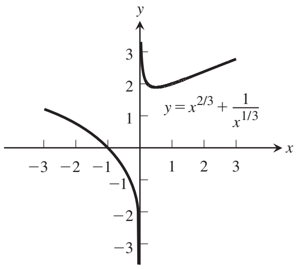
107.



109.



111.



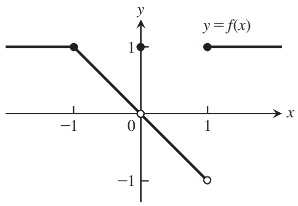
113. At ∞: ∞, at $-\infty$: 0

PRACTICE EXERCISES, pp. 97–98

1. At $x = -1$: $\lim_{x\to-1^-} f(x) = \lim_{x\to-1^+} f(x) = 1$, so $\lim_{x\to-1} f(x) = 1 = f(-1)$; continuous at $x = -1$

At $x = 0$: $\lim_{x\to0^-} f(x) = \lim_{x\to0^+} f(x) = 0$, so $\lim_{x\to0} f(x) = 0$. However, $f(0) \neq 0$, so f is discontinuous at $x = 0$. The discontinuity can be removed by redefining $f(0)$ to be 0.

At $x = 1$: $\lim_{x\to1^-} f(x) = -1$ and $\lim_{x\to1^+} f(x) = 1$, so $\lim_{x\to1} f(x)$ does not exist. The function is discontinuous at $x = 1$, and the discontinuity is not removable.



3. (a) -21 **(b)** 49 **(c)** 0 **(d)** 1 **(e)** 1 **(f)** 7 **(g)** -7 **(h)** $-\frac{1}{7}$ **5.** 4

7. (a) $(-\infty, +\infty)$ **(b)** $[0, \infty)$ **(c)** $(-\infty, 0)$ and $(0, \infty)$ **(d)** $(0, \infty)$

9. (a) Does not exist **(b)** 0 **11.** $\frac{1}{2}$ **13.** $2x$ **15.** $-\frac{1}{4}$

17. $2/3$ **19.** $2/\pi$ **21.** 1 **23.** 4 **25.** 2 **27.** 0

31. No in both cases, because $\lim_{x\to1} f(x)$ does not exist, and $\lim_{x\to-1} f(x)$ does not exist.

33. Yes, f does have a continuous extension, to $a = 1$ with $f(1) = 4/3$.

35. No **37.** $2/5$ **39.** 0 **41.** $-\infty$ **43.** 0 **45.** 1

47. (a) $x = 3$ **(b)** $x = 1$ **(c)** $x = -4$

49. Domain: $[-4, 2)$ and $(2, 4]$, Range: $(-\infty, \infty)$

ADDITIONAL AND ADVANCED EXERCISES, pp. 98–101

1. 0; the left-hand limit was taken because the function is undefined for $v > c$.

3. $65 < t < 75$; within 5°F **11. (a)** B **(b)** A **(c)** A **(d)** A

19. (a) $\lim_{a\to0} r_+(a) = 0.5$, $\lim_{a\to-1^+} r_+(a) = 1$

(b) $\lim_{a\to0} r_-(a)$ does not exist, $\lim_{a\to-1^+} r_-(a) = 1$

23. 0 **25.** 1 **27.** 4 **29.** $y = 2x$ **31.** $y = x, y = -x$

35. $-4/3$

37. (a) Domain: $\{1, 1/2, 1/3, 1/4 \ldots\}$
(b) The domain intersects (a, b) if $a < 0$ and $b > 0$.
(c) 0

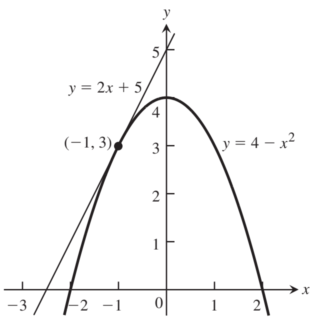
39. (a) Domain: $(-\infty, -1/\pi] \cup [-1/(2\pi), -1/(3\pi)] \cup [-1/(4\pi), -1/(5\pi)] \cup \cdots \cup [1/(5\pi), 1/(4\pi)] \cup [1/(3\pi), 1/(2\pi)] \cup [1/\pi, \infty)$
(b) The domain intersects any open interval (a, b) containing 0 because $1/(n\pi) < b$ for large enough n.
(c) 0

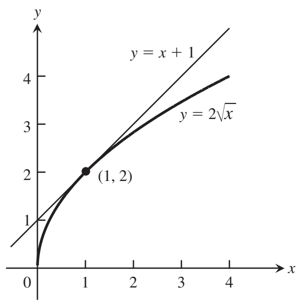
Chapter 3

SECTION 3.1, pp. 104–106

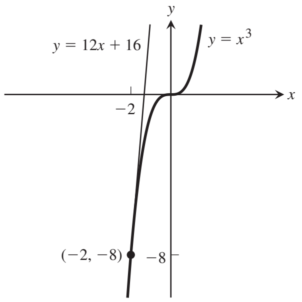
1. P_1: $m_1 = 1$, P_2: $m_2 = 5$ **3.** P_1: $m_1 = 5/2$, P_2: $m_2 = -1/2$

5. $y = 2x + 5$ **7.** $y = x + 1$





9. $y = 12x + 16$



11. $m = 4,\ y - 5 = 4(x - 2)$
13. $m = -2,\ y - 3 = -2(x - 3)$
15. $m = 12,\ y - 8 = 12(t - 2)$
17. $m = \frac{1}{4},\ y - 2 = \frac{1}{4}(x - 4)$
19. $m = -1$ **21.** $m = -1/4$
23. **(a)** It is the rate of change of the number of cells when $t = 5$. The units are the number of cells per hour.
(b) $P'(3)$ because the slope of the curve is greater there.
(c) $51.72 \approx 52$ cells/h
25. $(-2, -5)$ **27.** $y = -(x + 1),\ y = -(x - 3)$
29. 19.6 m/sec **31.** 6π **35.** Yes **37.** Yes
39. **(a)** Nowhere **41.** **(a)** At $x = 0$ **43.** **(a)** Nowhere
45. **(a)** At $x = 1$ **47.** **(a)** At $x = 0$

SECTION 3.2, pp. 111–115

1. $-2x, 6, 0, -2$ **3.** $-\frac{2}{t^3}, 2, -\frac{1}{4}, -\frac{2}{3\sqrt{3}}$

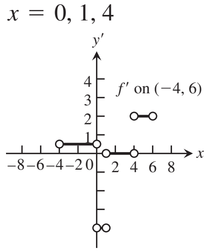
5. $\frac{3}{2\sqrt{3\theta}}, \frac{3}{2\sqrt{3}}, \frac{1}{2}, \frac{3}{2\sqrt{2}}$ **7.** $6x^2$ **9.** $\frac{1}{(2t + 1)^2}$

11. $\frac{3}{2}q^{1/2}$ **13.** $1 - \frac{9}{x^2}, 0$ **15.** $3t^2 - 2t, 5$

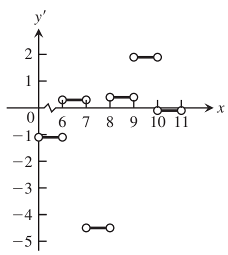
17. $\frac{-4}{(x - 2)\sqrt{x - 2}},\quad y - 4 = -\frac{1}{2}(x - 6)$ **19.** 6

21. 1/8 **23.** $\frac{-1}{(x + 2)^2}$ **25.** $\frac{-1}{(x - 1)^2}$ **27.** (b) **29.** (d)

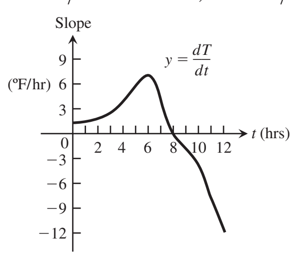
31. **(a)** $x = 0, 1, 4$
(b)



33.



35. **(a)** **i)** 1.5 °F/hr **ii)** 2.9 °F/hr
iii) 0 °F/hr **iv)** −3.7 °F/hr
(b) 7.3 °F/hr at 12 P.M., −11 °F/hr at 6 P.M.
(c)



37. Since $\lim_{h\to 0^+} \frac{f(0 + h) - f(0)}{h} = 1$ while $\lim_{h\to 0^-} \frac{f(0 + h) - f(0)}{h} = 0$, $f'(0) = \lim_{h\to 0} \frac{f(0 + h) - f(0)}{h}$ does not exist and $f(x)$ is not differentiable at $x = 0$.

39. Since $\lim_{h\to 0^+} \frac{f(1 + h) - f(1)}{h} = 2$ while $\lim_{h\to 0^-} \frac{f(1 + h) - f(1)}{h} = \frac{1}{2}$, $f'(1) = \lim_{h\to 0} \frac{f(1 + h) - f(1)}{h}$ does not exist and $f(x)$ is not differentiable at $x = 1$.

41. Since $f(x)$ is not continuous at $x = 0$, $f(x)$ is not differentiable at $x = 0$.

43. Since $\lim_{h\to 0^+} \frac{f(0 + h) - f(0)}{h} = 3$ while $\lim_{h\to 0^-} \frac{f(0 + h) - f(0)}{h} = 0$, f is not differentiable at $x = 0$.

45. **(a)** $-3 \le x \le 2$ **(b)** None **(c)** None
47. **(a)** $-3 \le x < 0, 0 < x \le 3$ **(b)** None **(c)** $x = 0$
49. **(a)** $-1 \le x < 0, 0 < x \le 2$ **(b)** $x = 0$ **(c)** None

SECTION 3.3, pp. 121–123

1. $\frac{dy}{dx} = -2x, \frac{d^2y}{dx^2} = -2$

3. $\frac{ds}{dt} = 15t^2 - 15t^4, \frac{d^2s}{dt^2} = 30t - 60t^3$

5. $\frac{dy}{dx} = 4x^2 - 1, \frac{d^2y}{dx^2} = 8x$

7. $\frac{dw}{dz} = -\frac{6}{z^3} + \frac{1}{z^2}, \frac{d^2w}{dz^2} = \frac{18}{z^4} - \frac{2}{z^3}$

9. $\frac{dy}{dx} = 12x - 10 + 10x^{-3}, \frac{d^2y}{dx^2} = 12 - 30x^{-4}$

11. $\frac{dr}{ds} = \frac{-2}{3s^3} + \frac{5}{2s^2}, \frac{d^2r}{ds^2} = \frac{2}{s^4} - \frac{5}{s^3}$

13. $y' = -5x^4 + 12x^2 - 2x - 3$

15. $y' = 3x^2 + 10x + 2 - \frac{1}{x^2}$ **17.** $y' = \frac{-19}{(3x - 2)^2}$

19. $g'(x) = \frac{x^2 + x + 4}{(x + 0.5)^2}$ **21.** $\frac{dv}{dt} = \frac{t^2 - 2t - 1}{(1 + t^2)^2}$

23. $f'(s) = \frac{1}{\sqrt{s}(\sqrt{s} + 1)^2}$ **25.** $v' = -\frac{1}{x^2} + 2x^{-3/2}$

27. $y' = \frac{-4x^3 - 3x^2 + 1}{(x^2 - 1)^2(x^2 + x + 1)^2}$

29. $y' = 2x^3 - 3x - 1,\ y'' = 6x^2 - 3,\ y''' = 12x,\ y^{(4)} = 12,\ y^{(n)} = 0$ for $n \ge 5$
31. $y' = 3x^2 + 8x + 1,\ y'' = 6x + 8,\ y''' = 6,\ y^{(n)} = 0$ for $n \ge 4$
33. $y' = 2x - 7x^{-2},\ y'' = 2 + 14x^{-3}$

35. $\frac{dr}{d\theta} = 3\theta^{-4}, \frac{d^2r}{d\theta^2} = -12\theta^{-5}$ **37.** $\frac{dw}{dz} = -z^{-2} - 1, \frac{d^2w}{dz^2} = 2z^{-3}$

39. **(a)** 13 **(b)** −7 **(c)** 7/25 **(d)** 20

41. **(a)** $y = -\frac{x}{8} + \frac{5}{4}$ **(b)** $m = -4$ at $(0, 1)$
(c) $y = 8x - 15,\ y = 8x + 17$
43. $y = 4x,\ y = 2$ **45.** $a = 1, b = 1, c = 0$
47. $(2, 4)$ **49.** $(0, 0), (4, 2)$ **51.** $y = -16x + 24$

53. **(a)** $y = 2x + 2$ **(c)** $(2, 6)$ **55.** 50 **57.** $a = -3$

59. $P'(x) = na_n x^{n-1} + (n-1)a_{n-1}x^{n-2} + \cdots + 2a_2x + a_1$

61. The Product Rule is then the Constant Multiple Rule, so the latter is a special case of the Product Rule.

63. **(a)** $\frac{d}{dx}(uvw) = uvw' + uv'w + u'vw$

(b) $\frac{d}{dx}(u_1u_2u_3u_4) = u_1u_2u_3u_4' + u_1u_2u_3'u_4 + u_1u_2'u_3u_4 + u_1'u_2u_3u_4$

(c) $\frac{d}{dx}(u_1 \cdots u_n) = u_1u_2 \cdots u_{n-1}u_n' + u_1u_2 \cdots u_{n-2}u_{n-1}'u_n + \cdots + u_1'u_2 \cdots u_n$

65. $\frac{dP}{dV} = -\frac{nRT}{(V-nb)^2} + \frac{2an^2}{V^3}$

SECTION 3.4, pp. 130–134

1. **(a)** -2 m, -1 m/sec
(b) 3 m/sec, 1 m/sec; 2 m/sec^2, 2 m/sec^2
(c) Changes direction at $t = 3/2$ sec

3. **(a)** -9 m, -3 m/sec
(b) 3 m/sec, 12 m/sec; 6 m/sec^2, -12 m/sec^2
(c) No change in direction

5. **(a)** -20 m, -5 m/sec
(b) 45 m/sec, $(1/5)$ m/sec; 140 m/sec^2, $(4/25)$ m/sec^2
(c) No change in direction

7. **(a)** $a(1) = -6$ m/sec^2, $a(3) = 6$ m/sec^2
(b) $v(2) = 3$ m/sec **(c)** 6 m

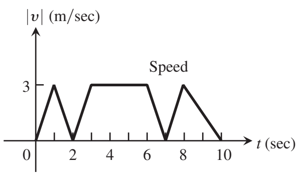
9. Mars: ≈ 7.5 sec, Jupiter: ≈ 1.2 sec

11. $g_s = 0.75$ m/sec^2

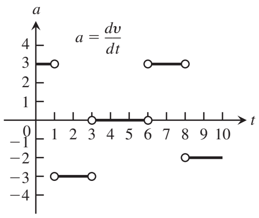
13. **(a)** $v = -32t$, $|v| = 32t$ ft/sec, $a = -32$ ft/sec^2
(b) $t \approx 3.3$ sec
(c) $v \approx -107.0$ ft/sec

15. **(a)** $t = 2, t = 7$ **(b)** $3 \le t \le 6$

(c)



(d)



17. **(a)** 190 ft/sec **(b)** 2 sec **(c)** 8 sec, 0 ft/sec
(d) 10.8 sec, 90 ft/sec **(e)** 2.8 sec
(f) Greatest acceleration happens 2 sec after launch
(g) Constant acceleration between 2 and 10.8 sec, -32 ft/sec^2

19. **(a)** $\frac{4}{7}$ sec, 280 cm/sec **(b)** 560 cm/sec, 980 cm/sec^2
(c) 29.75 flashes/sec

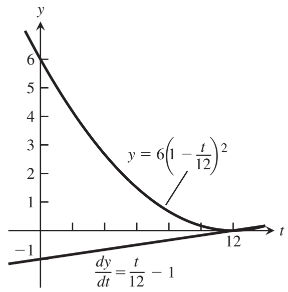
21. C = position, A = velocity, B = acceleration

23. **(a)** \$110/machine **(b)** \$80 **(c)** \$79.90

25. **(a)** $b'(0) = 10^4$ bacteria/h **(b)** $b'(5) = 0$ bacteria/h
(c) $b'(10) = -10^4$ bacteria/h

27. **(a)** $\frac{dy}{dt} = \frac{t}{12} - 1$
(b) The largest value of $\frac{dy}{dt}$ is 0 m/h when $t = 12$ and the smallest value of $\frac{dy}{dt}$ is -1 m/h when $t = 0$.

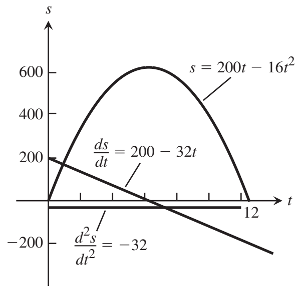
(c)



29. 4.88 ft, 8.66 ft, additional ft to stop car for 1 mph speed increase

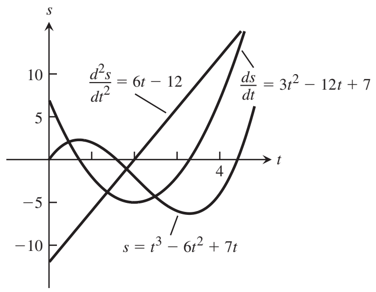
31. $t = 25$ sec, $D = \frac{6250}{9}$ m

33.



(a) $v = 0$ when $t = 6.25$ sec
(b) $v > 0$ when $0 \le t < 6.25 \Rightarrow$ the object moves up; $v < 0$ when $6.25 < t \le 12.5 \Rightarrow$ the object moves down.
(c) The object changes direction at $t = 6.25$ sec.
(d) The object speeds up on $(6.25, 12.5]$ and slows down on $[0, 6.25)$.
(e) The object is moving fastest at the endpoints $t = 0$ and $t = 12.5$ when it is traveling 200 ft/sec. It's moving slowest at $t = 6.25$ when the speed is 0.
(f) When $t = 6.25$ the object is $s = 625$ m from the origin and farthest away.

35.



(a) $v = 0$ when $t = \frac{6 \pm \sqrt{15}}{3}$ sec

(b) $v < 0$ when $\frac{6-\sqrt{15}}{3} < t < \frac{6+\sqrt{15}}{3} \Rightarrow$ the object moves left; $v > 0$ when $0 \le t < \frac{6-\sqrt{15}}{3}$ or $\frac{6+\sqrt{15}}{3} < t \le 4 \Rightarrow$ the object moves right.

(c) The object changes direction at $t = \frac{6 \pm \sqrt{15}}{3}$ sec.

(d) The object speeds up on $\left(\frac{6-\sqrt{15}}{3}, 2\right) \cup \left(\frac{6+\sqrt{15}}{3}, 4\right]$ and slows down on $\left[0, \frac{6-\sqrt{15}}{3}\right) \cup \left(2, \frac{6+\sqrt{15}}{3}\right)$.

(e) The object is moving fastest at $t = 0$ and $t = 4$ when it is moving 7 units/sec and slowest at $t = \frac{6 \pm \sqrt{15}}{3}$ sec.

(f) When $t = \frac{6+\sqrt{15}}{3}$ the object is at position $s \approx -6.303$ units and farthest from the origin.

SECTION 3.5, pp. 138–140

1. $-10 - 3\sin x$ **3.** $2x\cos x - x^2 \sin x$

5. $-\csc x \cot x - \frac{2}{\sqrt{x}}$ **7.** $\sin x \sec^2 x + \sin x$

9. $\sec x + x\sec x \tan x - \frac{1}{x^2}$ **11.** $\frac{-\csc^2 x}{(1+\cot x)^2}$

13. $4\tan x \sec x - \csc^2 x$ **15.** 0

17. $3x^2 \sin x \cos x + x^3 \cos^2 x - x^3 \sin^2 x$

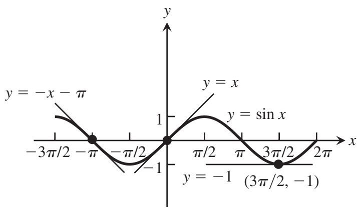
19. $\sec^2 t - 1$ **21.** $\frac{-2\csc t \cot t}{(1-\csc t)^2}$ **23.** $-\theta(\theta\cos\theta + 2\sin\theta)$

25. $\sec\theta\csc\theta(\tan\theta - \cot\theta) = \sec^2\theta - \csc^2\theta$ **27.** $\sec^2 q$

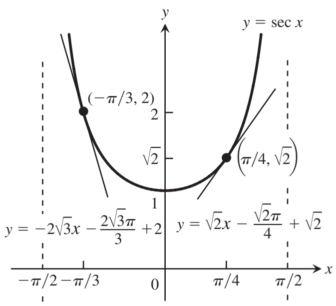
29. $\sec^2 q$ **31.** $\frac{q^3\cos q - q^2 \sin q - q\cos q - \sin q}{(q^2-1)^2}$

33. (a) $2\csc^3 x - \csc x$ **(b)** $2\sec^3 x - \sec x$

35.

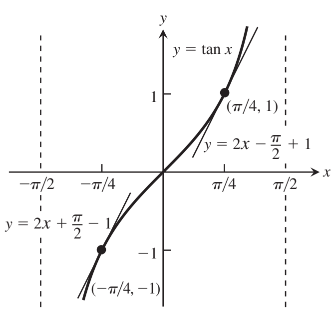


37.



39. Yes, at $x = \pi$ **41.** No **43.** Yes, at $x = 0, \pi$, and 2π

45. $\left(-\frac{\pi}{4}, -1\right); \left(\frac{\pi}{4}, 1\right)$



47. (a) $y = -x + \pi/2 + 2$ **(b)** $y = 4 - \sqrt{3}$

49. 0 **51.** $\sqrt{3}/2$ **53.** -1 **55.** 0

57. $-\sqrt{2}$ m/sec, $\sqrt{2}$ m/sec, $\sqrt{2}$ m/sec^2, $\sqrt{2}$ m/sec^3

59. $c = 9$ **61. (a)** $\sin x$ **(b)** $3\cos x - \sin x$ **(c)** $73\sin x + x\cos x$

63. (a) i) 10 cm **ii)** 5 cm **iii)** $-5\sqrt{2} \approx -7.1$ cm
(b) i) 0 cm/sec **ii)** $-5\sqrt{3} \approx -8.7$ cm/sec
iii) $-5\sqrt{2} \approx -7.1$ cm/sec

SECTION 3.6, pp. 145–148

1. $12x^3$ **3.** $3\cos(3x+1)$ **5.** $\frac{\cos x}{2\sqrt{\sin x}}$

7. $2\pi x \sec^2(\pi x^2)$

9. With $u = (2x+1)$, $y = u^5$: $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = 5u^4 \cdot 2 = 10(2x+1)^4$

11. With $u = (1 - (x/7))$, $y = u^{-7}$: $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = -7u^{-8} \cdot \left(-\frac{1}{7}\right) = \left(1 - \frac{x}{7}\right)^{-8}$

13. With $u = ((x^2/8) + x - (1/x))$, $y = u^4$: $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = 4u^3 \cdot \left(\frac{x}{4} + 1 + \frac{1}{x^2}\right) = 4\left(\frac{x^2}{8} + x - \frac{1}{x}\right)^3\left(\frac{x}{4} + 1 + \frac{1}{x^2}\right)$

15. With $u = \tan x$, $y = \sec u$: $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = (\sec u \tan u)(\sec^2 x) = \sec(\tan x)\tan(\tan x)\sec^2 x$

17. With $u = \tan x$, $y = u^3$: $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx} = 3u^2 \sec^2 x = 3\tan^2 x(\sec^2 x)$

19. $-\frac{1}{2\sqrt{3-t}}$ **21.** $\frac{4}{\pi}(\cos 3t - \sin 5t)$ **23.** $\frac{\csc\theta}{\cot\theta + \csc\theta}$

25. $2x\sin^4 x + 4x^2 \sin^3 x \cos x + \cos^{-2} x + 2x\cos^{-3} x \sin x$

27. $(3x-2)^5 - \frac{1}{x^3\left(4 - \frac{1}{2x^2}\right)^2}$ **29.** $\frac{(4x+3)^3(4x+7)}{(x+1)^4}$

31. $\sqrt{x}\sec^2(2\sqrt{x}) + \tan(2\sqrt{x})$ **33.** $\frac{x\sec x \tan x + \sec x}{2\sqrt{7 + x\sec x}}$

35. $\frac{2\sin\theta}{(1+\cos\theta)^2}$ **37.** $-2\sin(\theta^2)\sin 2\theta + 2\theta\cos(2\theta)\cos(\theta^2)$

39. $\left(\frac{t+2}{2(t+1)^{3/2}}\right)\cos\left(\frac{t}{\sqrt{t+1}}\right)$

41. $2\pi\sin(\pi t - 2)\cos(\pi t - 2)$ **43.** $\frac{8\sin(2t)}{(1+\cos 2t)^5}$

45. $10t^{10}\tan^9 t \sec^2 t + 10t^9 \tan^{10} t$

47. $\frac{-3t^6(t^2+4)}{(t^3-4t)^4}$ **49.** $-2\cos(\cos(2t-5))(\sin(2t-5))$

51. $\left(1 + \tan^4\left(\frac{t}{12}\right)\right)^2\left(\tan^3\left(\frac{t}{12}\right)\sec^2\left(\frac{t}{12}\right)\right)$

53. $-\frac{t\sin(t^2)}{\sqrt{1+\cos(t^2)}}$ **55.** $6\tan(\sin^3 t)\sec^2(\sin^3 t)\sin^2 t\cos t$

57. $3(2t^2-5)^3(18t^2-5)$ **59.** $\frac{6}{x^3}\left(1 + \frac{1}{x}\right)\left(1 + \frac{2}{x}\right)$

61. $2\csc^2(3x-1)\cot(3x-1)$ **63.** $16(2x+1)^2(5x+1)$

65. $f'(x) = 0$ for $x = 1, 4$; $f''(x) = 0$ for $x = 2, 4$

67. $5/2$ **69.** $-\pi/4$ **71.** 0 **73.** -5

75. **(a)** $2/3$ **(b)** $2\pi + 5$ **(c)** $15 - 8\pi$ **(d)** $37/6$ **(e)** -1
(f) $\sqrt{2}/24$ **(g)** $5/32$ **(h)** $-5/(3\sqrt{17})$

77. 5 **79.** **(a)** 1 **(b)** 1 **81.** $y = 1 - 4x$

83. **(a)** $y = \pi x + 2 - \pi$ **(b)** $\pi/2$

85. It multiplies the velocity, acceleration, and jerk by 2, 4, and 8, respectively.

87. $v(6) = \frac{2}{5}\text{m/sec}, a(6) = -\frac{4}{125}\text{m/sec}^2$

SECTION 3.7, pp. 151–153

1. $\dfrac{-2xy - y^2}{x^2 + 2xy}$ **3.** $\dfrac{1 - 2y}{2x + 2y - 1}$

5. $\dfrac{-2x^3 + 3x^2y - xy^2 + x}{x^2y - x^3 + y}$ **7.** $\dfrac{1}{y(x + 1)^2}$ **9.** $\cos y \cot y$

11. $\dfrac{-\cos^2(xy) - y}{x}$ **13.** $\dfrac{-y^2}{y\sin\left(\frac{1}{y}\right) - \cos\left(\frac{1}{y}\right) + xy}$

15. $-\dfrac{\sqrt{r}}{\sqrt{\theta}}$ **17.** $\dfrac{-r}{\theta}$ **19.** $y' = -\dfrac{x}{y}, y'' = \dfrac{-y^2 - x^2}{y^3}$

21. $\dfrac{dy}{dx} = \dfrac{x + 1}{y}, \dfrac{d^2y}{dx^2} = \dfrac{x^2 + 2x}{y^3}$

23. $y' = \dfrac{\sqrt{y}}{\sqrt{y} + 1}, y'' = \dfrac{1}{2(\sqrt{y} + 1)^3}$

25. $y' = \dfrac{3x^2}{1 - \cos y}, y'' = \dfrac{6x(1 - \cos y)^2 - 9x^4 \sin y}{(1 - \cos y)^3}$

27. -2 **29.** $(-2, 1): m = -1, (-2, -1): m = 1$

31. **(a)** $y = \frac{7}{4}x - \frac{1}{2}$ **(b)** $y = -\frac{4}{7}x + \frac{29}{7}$

33. **(a)** $y = 3x + 6$ **(b)** $y = -\frac{1}{3}x + \frac{8}{3}$

35. **(a)** $y = \frac{6}{7}x + \frac{6}{7}$ **(b)** $y = -\frac{7}{6}x - \frac{7}{6}$

37. **(a)** $y = -\frac{\pi}{2}x + \pi$ **(b)** $y = \frac{2}{\pi}x - \frac{2}{\pi} + \frac{\pi}{2}$

39. **(a)** $y = 2\pi x - 2\pi$ **(b)** $y = -\frac{x}{2\pi} + \frac{1}{2\pi}$

41. Points: $(-\sqrt{7}, 0)$ and $(\sqrt{7}, 0)$, Slope: -2

43. $m = -1$ at $\left(\frac{\sqrt{3}}{4}, \frac{\sqrt{3}}{2}\right)$, $m = \sqrt{3}$ at $\left(\frac{\sqrt{3}}{4}, \frac{1}{2}\right)$

45. $(-3, 2): m = -\frac{27}{8}; (-3, -2): m = \frac{27}{8}; (3, 2): m = \frac{27}{8};$
$(3, -2): m = -\frac{27}{8}$

47. $(3, -1)$

53. $\dfrac{dy}{dx} = -\dfrac{y^3 + 2xy}{x^2 + 3xy^2}, \quad \dfrac{dx}{dy} = -\dfrac{x^2 + 3xy^2}{y^3 + 2xy}, \quad \dfrac{dx}{dy} = \dfrac{1}{dy/dx}$

SECTION 3.8, pp. 158–162

1. $\dfrac{dA}{dt} = 2\pi r\dfrac{dr}{dt}$ **3.** 10 **5.** -6 **7.** $-3/2$

9. $31/13$ **11.** **(a)** $-180\text{ m}^2/\text{min}$ **(b)** $-135\text{ m}^3/\text{min}$

13. **(a)** $\dfrac{dV}{dt} = \pi r^2\dfrac{dh}{dt}$ **(b)** $\dfrac{dV}{dt} = 2\pi hr\dfrac{dr}{dt}$
(c) $\dfrac{dV}{dt} = \pi r^2\dfrac{dh}{dt} + 2\pi hr\dfrac{dr}{dt}$

15. **(a)** 1 volt/sec **(b)** $-\frac{1}{3}$ amp/sec
(c) $\dfrac{dR}{dt} = \dfrac{1}{I}\left(\dfrac{dV}{dt} - \dfrac{V}{I}\dfrac{dI}{dt}\right)$
(d) $3/2$ ohms/sec, R is increasing.

17. **(a)** $\dfrac{ds}{dt} = \dfrac{x}{\sqrt{x^2 + y^2}}\dfrac{dx}{dt}$
(b) $\dfrac{ds}{dt} = \dfrac{x}{\sqrt{x^2 + y^2}}\dfrac{dx}{dt} + \dfrac{y}{\sqrt{x^2 + y^2}}\dfrac{dy}{dt}$
(c) $\dfrac{dx}{dt} = -\dfrac{y}{x}\dfrac{dy}{dt}$

19. **(a)** $\dfrac{dA}{dt} = \dfrac{1}{2}ab\cos\theta\dfrac{d\theta}{dt}$
(b) $\dfrac{dA}{dt} = \dfrac{1}{2}ab\cos\theta\dfrac{d\theta}{dt} + \dfrac{1}{2}b\sin\theta\dfrac{da}{dt}$
(c) $\dfrac{dA}{dt} = \dfrac{1}{2}ab\cos\theta\dfrac{d\theta}{dt} + \dfrac{1}{2}b\sin\theta\dfrac{da}{dt} + \dfrac{1}{2}a\sin\theta\dfrac{db}{dt}$

21. **(a)** $14\text{ cm}^2/\text{sec}$, increasing **(b)** 0 cm/sec, constant
(c) $-14/13$ cm/sec, decreasing

23. **(a)** -12 ft/sec **(b)** $-59.5\text{ ft}^2/\text{sec}$ **(c)** -1 rad/sec

25. 20 ft/sec

27. **(a)** $\dfrac{dh}{dt} = 11.19$ cm/min **(b)** $\dfrac{dr}{dt} = 14.92$ cm/min

29. **(a)** $\dfrac{-1}{24\pi}$ m/min **(b)** $r = \sqrt{26y - y^2}$ m
(c) $\dfrac{dr}{dt} = -\dfrac{5}{288\pi}$ m/min

31. 1 ft/min, $40\pi\text{ ft}^2/\text{min}$ **33.** 11 ft/sec

35. Increasing at $466/1681\ L/\text{min}^2$

37. -5 m/sec **39.** -1500 ft/sec

41. $\dfrac{5}{72\pi}$ in./min, $\dfrac{10}{3}\text{ in}^2/\text{min}$

43. **(a)** $-32/\sqrt{13} \approx -8.875$ ft/sec
(b) $d\theta_1/dt = 8/65$ rad/sec, $d\theta_2/dt = -8/65$ rad/sec
(c) $d\theta_1/dt = 1/6$ rad/sec, $d\theta_2/dt = -1/6$ rad/sec

45. -5.5 deg/min **47.** 12π km/min

SECTION 3.9, pp. 171–173

1. $L(x) = 10x - 13$ **3.** $L(x) = 2$ **5.** $L(x) = x - \pi$

7. $2x$ **9.** $-x - 5$ **11.** $\frac{1}{12}x + \frac{4}{3}$

13. $f(0) = 1$. Also, $f'(x) = k(1 + x)^{k-1}$, so $f'(0) = k$. This means the linearization at $x = 0$ is $L(x) = 1 + kx$.

15. **(a)** 1.01 **(b)** 1.003

17. $\left(3x^2 - \dfrac{3}{2\sqrt{x}}\right)dx$ **19.** $\dfrac{2 - 2x^2}{(1 + x^2)^2}dx$

21. $\dfrac{1 - y}{3\sqrt{y} + x}dx$ **23.** $\dfrac{5}{2\sqrt{x}}\cos(5\sqrt{x})\,dx$

25. $(4x^2)\sec^2\left(\dfrac{x^3}{3}\right)dx$

27. $\dfrac{3}{\sqrt{x}}\left(\csc(1 - 2\sqrt{x})\cot(1 - 2\sqrt{x})\right)dx$

29. **(a)** 0.41 **(b)** 0.4 **(c)** 0.01

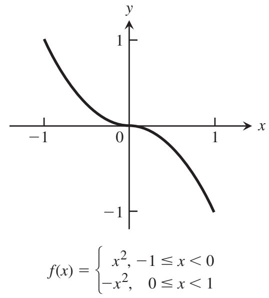
31. **(a)** 0.231 **(b)** 0.2 **(c)** 0.031

33. **(a)** $-1/3$ **(b)** $-2/5$ **(c)** $1/15$
35. $dV = 4\pi r_0^2\, dr$ **37.** $dS = 12x_0\, dx$ **39.** $dV = 2\pi r_0 h\, dr$
41. **(a)** 0.08π m^2 **(b)** 2% **43.** $dV \approx 565.5$ in^3
45. **(a)** 2% **(b)** 4% **47.** $\frac{1}{3}\%$ **49.** 3%
51. The ratio equals 37.87, so a change in the acceleration of gravity on the moon has about 38 times the effect that a change of the same magnitude has on Earth.
53. Increase $V \approx 40\%$
55. **(a)** **i)** $b_0 = f(a)$ **ii)** $b_1 = f'(a)$ **iii)** $b_2 = \dfrac{f''(a)}{2}$
(b) $Q(x) = 1 + x + x^2$ **(d)** $Q(x) = 1 - (x - 1) + (x - 1)^2$
(e) $Q(x) = 1 + \dfrac{x}{2} - \dfrac{x^2}{8}$
(f) The linearization of any differentiable function $u(x)$ at $x = a$ is $L(x) = u(a) + u'(a)(x - a) = b_0 + b_1(x - a)$, where b_0 and b_1 are the coefficients of the constant and linear terms of the quadratic approximation. Thus, the linearization for $f(x)$ at $x = 0$ is $1 + x$; the linearization for $g(x)$ at $x = 1$ is $1 - (x - 1)$ or $2 - x$; and the linearization for $h(x)$ at $x = 0$ is $1 + \dfrac{x}{2}$.

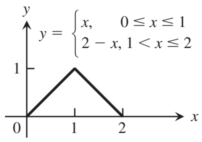
PRACTICE EXERCISES, pp. 174–179

1. $5x^4 - 0.25x + 0.25$ **3.** $3x(x - 2)$
5. $2(x + 1)(2x^2 + 4x + 1)$
7. $3(\theta^2 + \sec\theta + 1)^2(2\theta + \sec\theta\tan\theta)$
9. $\dfrac{1}{2\sqrt{t}\left(1 + \sqrt{t}\right)^2}$ **11.** $2\sec^2 x\tan x$
13. $8\cos^3(1 - 2t)\sin(1 - 2t)$ **15.** $5(\sec t)(\sec t + \tan t)^5$
17. $\dfrac{\theta\cos\theta + \sin\theta}{\sqrt{2\theta\sin\theta}}$ **19.** $\dfrac{\cos\sqrt{2\theta}}{\sqrt{2\theta}}$
21. $x\csc\left(\dfrac{2}{x}\right) + \csc\left(\dfrac{2}{x}\right)\cot\left(\dfrac{2}{x}\right)$
23. $\frac{1}{2}x^{1/2}\sec(2x)^2\left[16\tan(2x)^2 - x^{-2}\right]$
25. $-10x\csc^2(x^2)$ **27.** $8x^3\sin(2x^2)\cos(2x^2) + 2x\sin^2(2x^2)$
29. $\dfrac{-(t + 1)}{8t^3}$ **31.** $\dfrac{1 - x}{(x + 1)^3}$ **33.** $\dfrac{-1}{2x^2\left(1 + \frac{1}{x}\right)^{1/2}}$
35. $\dfrac{-2\sin\theta}{(\cos\theta - 1)^2}$ **37.** $3\sqrt{2x + 1}$ **39.** $-9\left[\dfrac{5x + \cos 2x}{(5x^2 + \sin 2x)^{5/2}}\right]$
41. $-\dfrac{y + 2}{x + 3}$ **43.** $\dfrac{-3x^2 - 4y + 2}{4x - 4y^{1/3}}$ **45.** $-\dfrac{y}{x}$
47. $\dfrac{1}{2y(x + 1)^2}$ **49.** $\dfrac{dp}{dq} = \dfrac{6q - 4p}{3p^2 + 4q}$
51. $\dfrac{dr}{ds} = (2r - 1)(\tan 2s)$
53. **(a)** $\dfrac{d^2y}{dx^2} = \dfrac{-2xy^3 - 2x^4}{y^5}$ **(b)** $\dfrac{d^2y}{dx^2} = \dfrac{-2xy^2 - 1}{x^4y^3}$
55. **(a)** 7 **(b)** -2 **(c)** $5/12$ **(d)** $1/4$ **(e)** 12 **(f)** $9/2$ **(g)** $3/4$
57. 0 **59.** $\sqrt{3}$ **61.** $-\dfrac{1}{2}$ **63.** $\dfrac{-2}{(2t + 1)^2}$

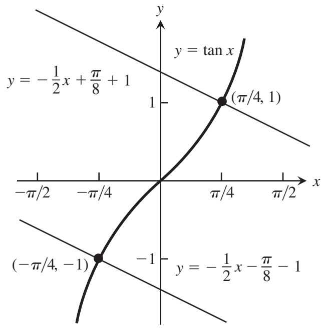
65. **(a)**



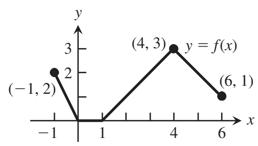
(b) Yes **(c)** Yes
67. **(a)**



(b) Yes **(c)** No
69. $\left(\dfrac{5}{2}, \dfrac{9}{4}\right)$ and $\left(\dfrac{3}{2}, -\dfrac{1}{4}\right)$
71. $(-1, 27)$ and $(2, 0)$
73. **(a)** $(-2, 16)$, $(3, 11)$ **(b)** $(0, 20)$, $(1, 7)$
75.



77. $\dfrac{1}{4}$ **79.** 4
81. Tangent: $y = -\dfrac{1}{4}x + \dfrac{9}{4}$, normal: $y = 4x - 2$
83. Tangent: $y = 2x - 4$, normal: $y = -\dfrac{1}{2}x + \dfrac{7}{2}$
85. Tangent: $y = -\dfrac{5}{4}x + 6$, normal: $y = \dfrac{4}{5}x - \dfrac{11}{5}$
87. $(1, 1)$: $m = -\dfrac{1}{2}$; $(1, -1)$: m not defined
89. B = graph of f, A = graph of f'
91.



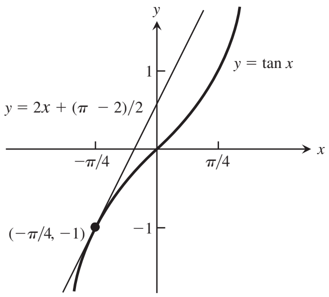
93. **(a)** 0, 0 **(b)** 1700 rabbits, $\approx$1400 rabbits
95. -1 **97.** $1/2$ **99.** 4 **101.** 1
103. To make g continuous at the origin, define $g(0) = 1$.
105. **(a)** $\dfrac{dS}{dt} = (4\pi r + 2\pi h)\dfrac{dr}{dt}$
(b) $\dfrac{dS}{dt} = 2\pi r\dfrac{dh}{dt}$
(c) $\dfrac{dS}{dt} = (4\pi r + 2\pi h)\dfrac{dr}{dt} + 2\pi r\dfrac{dh}{dt}$
(d) $\dfrac{dr}{dt} = -\dfrac{r}{2r + h}\dfrac{dh}{dt}$

107. $-40\ \text{m}^2/\text{sec}$ **109.** 0.02 ohm/sec **111.** 2 m/sec

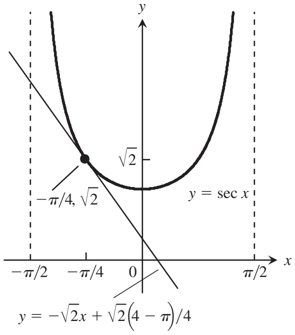
113. **(a)** $r = \frac{2}{5}h$ **(b)** $-\frac{125}{144\pi}$ ft/min

115. **(a)** $\frac{3}{5}$ km/sec or 600 m/sec **(b)** $\frac{18}{\pi}$ rpm

117. **(a)** $L(x) = 2x + \frac{\pi - 2}{2}$



(b) $L(x) = -\sqrt{2}x + \frac{\sqrt{2}(4 - \pi)}{4}$



119. $L(x) = 1.5x + 0.5$ **121.** $dS = \frac{\pi r h_0}{\sqrt{r^2 + h_0^2}}dh$

123. **(a)** 4% **(b)** 8% **(c)** 12%

ADDITIONAL AND ADVANCED EXERCISES, pp. 179–181

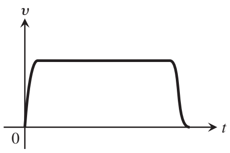
1. **(a)** $\sin 2\theta = 2\sin\theta\cos\theta$; $2\cos 2\theta = 2\sin\theta(-\sin\theta) + \cos\theta(2\cos\theta)$; $2\cos 2\theta = -2\sin^2\theta + 2\cos^2\theta$; $\cos 2\theta = \cos^2\theta - \sin^2\theta$
(b) $\cos 2\theta = \cos^2\theta - \sin^2\theta$; $-2\sin 2\theta = 2\cos\theta(-\sin\theta) - 2\sin\theta(\cos\theta)$; $\sin 2\theta = \cos\theta\sin\theta + \sin\theta\cos\theta$; $\sin 2\theta = 2\sin\theta\cos\theta$

3. **(a)** $a = 1, b = 0, c = -\frac{1}{2}$ **(b)** $b = \cos a, c = \sin a$

5. $h = -4, k = \frac{9}{2}, a = \frac{5\sqrt{5}}{2}$

7. **(a)** 0.09y **(b)** Increasing at 1% per year

9. Answers will vary. Here is one possibility.



11. **(a)** 2 sec, 64 ft/sec **(b)** 12.31 sec, 393.85 ft

15. **(a)** $m = -\frac{b}{\pi}$ **(b)** $m = -1, b = \pi$

17. **(a)** $a = \frac{3}{4}, b = \frac{9}{4}$ **19.** f odd $\Rightarrow f'$ is even

23. h' is defined but not continuous at $x = 0$; k' is defined *and* continuous at $x = 0$.

25. $\frac{43}{75}$ rad/sec

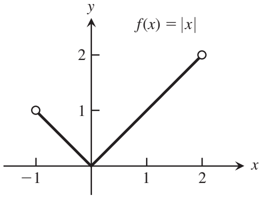
29. **(a)** 0.8156 ft **(b)** 0.00613 sec
(c) It will lose about 8.83 min/day.

Chapter 4

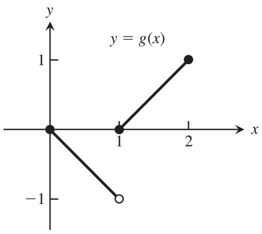
SECTION 4.1, pp. 188–190

1. Absolute minimum at $x = c_2$; absolute maximum at $x = b$
3. Absolute maximum at $x = c$; no absolute minimum
5. Absolute minimum at $x = a$; absolute maximum at $x = c$
7. No absolute minimum; no absolute maximum
9. Absolute maximum at (0, 5) **11.** (c) **13.** (d)

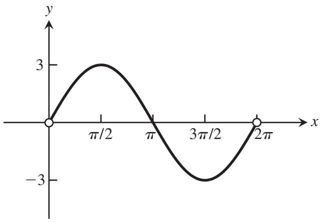
15. Absolute minimum at $x = 0$; no absolute maximum



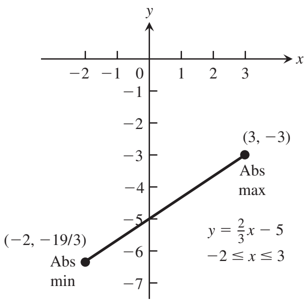
17. Absolute maximum at $x = 2$; no absolute minimum



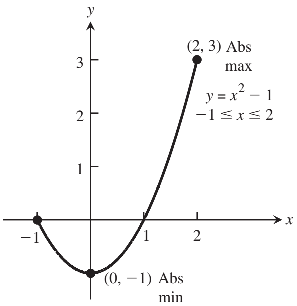
19. Absolute maximum at $x = \pi/2$; absolute minimum at $x = 3\pi/2$



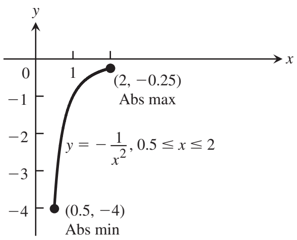
21. Absolute maximum: -3; absolute minimum: $-19/3$



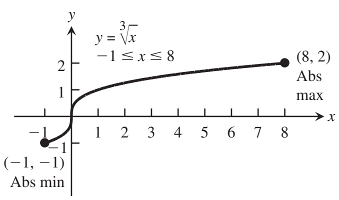
23. Absolute maximum: 3; absolute minimum: -1



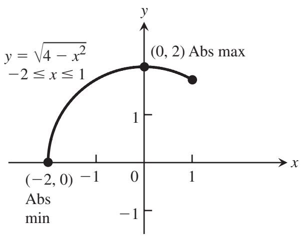
25. Absolute maximum: -0.25; absolute minimum: -4



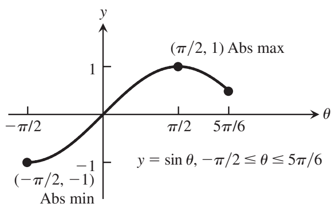
27. Absolute maximum: 2; absolute minimum: -1



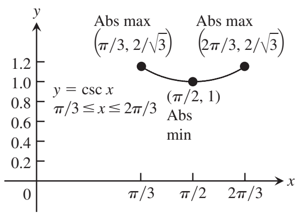
29. Absolute maximum: 2; absolute minimum: 0



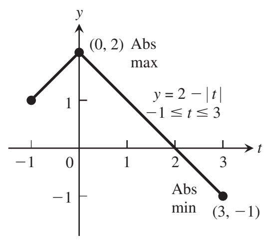
31. Absolute maximum: 1; absolute minimum: −1



33. Absolute maximum: $2/\sqrt{3}$; absolute minimum: 1



35. Absolute maximum: 2; absolute minimum: −1



37. Increasing on (0, 8), decreasing on (−1, 0); absolute maximum: 16 at $x = 8$; absolute minimum: 0 at $x = 0$

39. Increasing on (−32, 1); absolute maximum: 1 at $\theta = 1$; absolute minimum: −8 at $\theta = -32$

41. $x = 3$

43. $x = 1, x = 4$

45. $x = 1$

47. $x = 0$ and $x = 4$

49. $x = 2$ and $x = -4$

51.

Critical point or endpoint	Derivative	Extremum	Value
$x = -\frac{4}{5}$	0	Local max	$\frac{12}{25}10^{1/3} \approx 1.034$
$x = 0$	Undefined	Local min	0

53.

Critical point or endpoint	Derivative	Extremum	Value
$x = -2$	Undefined	Local max	0
$x = -\sqrt{2}$	0	Minimum	−2
$x = \sqrt{2}$	0	Maximum	2
$x = 2$	Undefined	Local min	0

55.

Critical point or endpoint	Derivative	Extremum	Value
$x = 1$	Undefined	Minimum	2

57.

Critical point or endpoint	Derivative	Extremum	Value
$x = -1$	0	Maximum	5
$x = 1$	Undefined	Local min	1
$x = 3$	0	Maximum	5

59. (a) No
(b) The derivative is defined and nonzero for $x \neq 2$. Also, $f(2) = 0$ and $f(x) > 0$ for all $x \neq 2$.
(c) No, because $(-\infty, \infty)$ is not a closed interval.
(d) The answers are the same as parts (a) and (b), with 2 replaced by a.

61. y is increasing on $(-\infty, \infty)$ and so has no extrema.

63. Yes

65. g assumes a local maximum at $-c$.

67. (a) Maximum value is 144 at $x = 2$.
(b) The largest volume of the box is 144 cubic units, and it occurs when $x = 2$.

69. $\dfrac{{v_0}^2}{2g} + s_0$

71. Maximum value is 11 at $x = 5$; minimum value is 5 on the interval $[-3, 2]$; local maximum at $(-5, 9)$.

73. Maximum value is 5 on the interval $[3, \infty)$; minimum value is −5 on the interval $(-\infty, -2]$.

SECTION 4.2, pp. 195–197

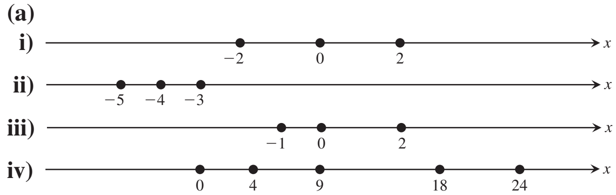
1. $1/2$ **3.** 1

5. $\frac{1}{3}(1 + \sqrt{7}) \approx 1.22, \frac{1}{3}(1 - \sqrt{7}) \approx -0.549$

7. Does not; f is not differentiable at the interior domain point $x = 0$.

9. Does **11.** Does not; f is not differentiable at $x = -1$.

15. (a)



27. Yes **29. (a)** 4 **(b)** 3 **(c)** 3

31. (a) $\dfrac{x^2}{2} + C$ **(b)** $\dfrac{x^3}{3} + C$ **(c)** $\dfrac{x^4}{4} + C$

33. (a) $\dfrac{1}{x} + C$ **(b)** $x + \dfrac{1}{x} + C$ **(c)** $5x - \dfrac{1}{x} + C$

35. (a) $-\dfrac{1}{2}\cos 2t + C$ **(b)** $2\sin\dfrac{t}{2} + C$

(c) $-\dfrac{1}{2}\cos 2t + 2\sin\dfrac{t}{2} + C$

37. $f(x) = x^2 - x$ **39.** $r(\theta) = 8\theta + \cot\theta - 2\pi - 1$

41. $s = 4.9t^2 + 5t + 10$ **43.** $s = \dfrac{1 - \cos(\pi t)}{\pi}$

45. $s = 16t^2 + 20t + 5$ **47.** $s = \sin(2t) - 3$

49. If $T(t)$ is the temperature of the thermometer at time t, then $T(0) = -19$ °C and $T(14) = 100$ °C. From the Mean Value Theorem, there exists a $0 < t_0 < 14$ such that $\dfrac{T(14) - T(0)}{14 - 0} = 8.5\ ^\circ\text{C/sec} = T'(t_0)$, the rate at which the temperature was changing at $t = t_0$ as measured by the rising mercury on the thermometer.

51. Because its average speed was approximately 7.667 knots, and by the Mean Value Theorem, it must have been going that speed at least once during the trip.

55. The conclusion of the Mean Value Theorem yields

$$\frac{\frac{1}{b}-\frac{1}{a}}{b-a} = -\frac{1}{c^2} \Rightarrow c^2\left(\frac{a-b}{ab}\right) = a-b \Rightarrow c = \sqrt{ab}.$$

59. $f(x)$ must be zero at least once between a and b by the Intermediate Value Theorem. Now suppose that $f(x)$ is zero twice between a and b. Then, by the Mean Value Theorem, $f'(x)$ would have to be zero at least once between the two zeros of $f(x)$, but this can't be true since we are given that $f'(x) \neq 0$ on this interval. Therefore, $f(x)$ is zero once and only once between a and b.

69. $1.09999 \le f(0.1) \le 1.1$

SECTION 4.3, pp. 201–202

1. **(a)** 0, 1
(b) Increasing on $(-\infty, 0)$ and $(1, \infty)$; decreasing on $(0, 1)$
(c) Local maximum at $x = 0$; local minimum at $x = 1$

3. **(a)** $-2, 1$
(b) Increasing on $(-2, 1)$ and $(1, \infty)$; decreasing on $(-\infty, -2)$
(c) No local maximum; local minimum at $x = -2$

5. **(a)** $-2, 1, 3$
(b) Increasing on $(-2, 1)$ and $(3, \infty)$; decreasing on $(-\infty, -2)$ and $(1, 3)$
(c) Local maximum at $x = 1$; local minimum at $x = -2, 3$

7. **(a)** 0, 1
(b) Increasing on $(-\infty, -2)$ and $(1, \infty)$; decreasing on $(-2, 0)$ and $(0, 1)$
(c) Local minimum at $x = 1$

9. **(a)** $-2, 2$
(b) Increasing on $(-\infty, -2)$ and $(2, \infty)$; decreasing on $(-2, 0)$ and $(0, 2)$
(c) Local maximum at $x = -2$; local minimum at $x = 2$

11. **(a)** $-2, 0$
(b) Increasing on $(-\infty, -2)$ and $(0, \infty)$; decreasing on $(-2, 0)$
(c) Local maximum at $x = -2$; local minimum at $x = 0$

13. **(a)** $\frac{\pi}{2}, \frac{2\pi}{3}, \frac{4\pi}{3}$
(b) Increasing on $\left(\frac{2\pi}{3}, \frac{4\pi}{3}\right)$; decreasing on $\left(0, \frac{\pi}{2}\right)$, $\left(\frac{\pi}{2}, \frac{2\pi}{3}\right)$, and $\left(\frac{4\pi}{3}, 2\pi\right)$
(c) Local maximum at $x = 0$ and $x = \frac{4\pi}{3}$; local minimum at $x = \frac{2\pi}{3}$ and $x = 2\pi$

15. **(a)** Increasing on $(-2, 0)$ and $(2, 4)$; decreasing on $(-4, -2)$ and $(0, 2)$
(b) Absolute maximum at $(-4, 2)$; local maximum at $(0, 1)$ and $(4, -1)$; absolute minimum at $(2, -3)$; local minimum at $(-2, 0)$

17. **(a)** Increasing on $(-4, -1)$, $(1/2, 2)$, and $(2, 4)$; decreasing on $(-1, 1/2)$
(b) Absolute maximum at $(4, 3)$; local maximum at $(-1, 2)$ and $(2, 1)$; no absolute minimum; local minimum at $(-4, -1)$ and $(1/2, -1)$

19. **(a)** Increasing on $(-\infty, -1.5)$; decreasing on $(-1.5, \infty)$
(b) Local maximum: 5.25 at $t = -1.5$; absolute maximum: 5.25 at $t = -1.5$

21. **(a)** Decreasing on $(-\infty, 0)$; increasing on $(0, 4/3)$; decreasing on $(4/3, \infty)$
(b) Local minimum at $x = 0$ $(0, 0)$; local maximum at $x = 4/3$ $(4/3, 32/27)$; no absolute extrema

23. **(a)** Decreasing on $(-\infty, 0)$; increasing on $(0, 1/2)$; decreasing on $(1/2, \infty)$
(b) Local minimum at $\theta = 0$ $(0, 0)$; local maximum at $\theta = 1/2$ $(1/2, 1/4)$; no absolute extrema

25. **(a)** Increasing on $(-\infty, \infty)$; never decreasing
(b) No local extrema; no absolute extrema

27. **(a)** Increasing on $(-2, 0)$ and $(2, \infty)$; decreasing on $(-\infty, -2)$ and $(0, 2)$
(b) Local maximum: 16 at $x = 0$; local minimum: 0 at $x = \pm 2$; no absolute maximum; absolute minimum: 0 at $x = \pm 2$

29. **(a)** Increasing on $(-\infty, -1)$; decreasing on $(-1, 0)$; increasing on $(0, 1)$; decreasing on $(1, \infty)$
(b) Local maximum: 0.5 at $x = \pm 1$; local minimum: 0 at $x = 0$; absolute maximum: $1/2$ at $x = \pm 1$; no absolute minimum

31. **(a)** Increasing on $(10, \infty)$; decreasing on $(1, 10)$
(b) Local maximum: 1 at $x = 1$; local minimum: -8 at $x = 10$; absolute minimum: -8 at $x = 10$

33. **(a)** Decreasing on $\left(-2\sqrt{2}, -2\right)$; increasing on $(-2, 2)$; decreasing on $\left(2, 2\sqrt{2}\right)$
(b) Local minima: $g(-2) = -4$, $g\left(2\sqrt{2}\right) = 0$; local maxima: $g\left(-2\sqrt{2}\right) = 0$, $g(2) = 4$; absolute maximum: 4 at $x = 2$; absolute minimum: -4 at $x = -2$

35. **(a)** Increasing on $(-\infty, 1)$; decreasing when $1 < x < 2$, decreasing when $2 < x < 3$; discontinuous at $x = 2$; increasing on $(3, \infty)$
(b) Local minimum at $x = 3$ $(3, 6)$; local maximum at $x = 1$ $(1, 2)$; no absolute extrema

37. **(a)** Increasing on $(-2, 0)$ and $(0, \infty)$; decreasing on $(-\infty, -2)$
(b) Local minimum: $-6\sqrt[3]{2}$ at $x = -2$; no absolute maximum; absolute minimum: $-6\sqrt[3]{2}$ at $x = -2$

39. **(a)** Increasing on $\left(-\infty, -2/\sqrt{7}\right)$ and $\left(2/\sqrt{7}, \infty\right)$; decreasing on $\left(-2/\sqrt{7}, 0\right)$ and $\left(0, 2/\sqrt{7}\right)$
(b) Local maximum: $24\sqrt[3]{2}/7^{7/6} \approx 3.12$ at $x = -2/\sqrt{7}$; local minimum: $-24\sqrt[3]{2}/7^{7/6} \approx -3.12$ at $x = 2/\sqrt{7}$; no absolute extrema

41. **(a)** Local maximum: 1 at $x = 1$; local minimum: 0 at $x = 2$
(b) Absolute maximum: 1 at $x = 1$; no absolute minimum

43. **(a)** Local maximum: 1 at $x = 1$; local minimum: 0 at $x = 2$
(b) No absolute maximum; absolute minimum: 0 at $x = 2$

45. **(a)** Local maxima: -9 at $t = -3$ and 16 at $t = 2$; local minimum: -16 at $t = -2$
(b) Absolute maximum: 16 at $t = 2$; no absolute minimum

47. **(a)** Local minimum: 0 at $x = 0$
(b) No absolute maximum; absolute minimum: 0 at $x = 0$

49. **(a)** Local maximum: 5 at $x = 0$; local minimum: 0 at $x = -5$ and $x = 5$
(b) Absolute maximum: 5 at $x = 0$; absolute minimum: 0 at $x = -5$ and $x = 5$

51. **(a)** Local maximum: 2 at $x = 0$;
local minimum: $\frac{\sqrt{3}}{4\sqrt{3} - 6}$ at $x = 2 - \sqrt{3}$
(b) No absolute maximum; an absolute minimum at $x = 2 - \sqrt{3}$

53. **(a)** Local maximum: 1 at $x = \pi/4$;
local maximum: 0 at $x = \pi$;
local minimum: 0 at $x = 0$;
local minimum: -1 at $x = 3\pi/4$

55. Local maximum: 2 at $x = \pi/6$;
local maximum: $\sqrt{3}$ at $x = 2\pi$;
local minimum: -2 at $x = 7\pi/6$;
local minimum: $\sqrt{3}$ at $x = 0$

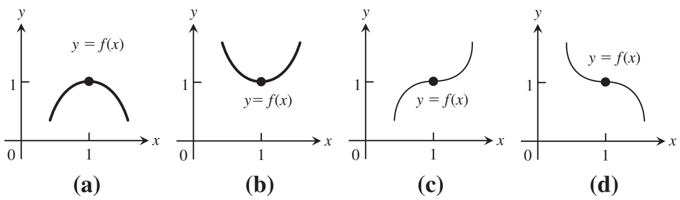
57. (a) Local minimum: $(\pi/3) - \sqrt{3}$ at $x = 2\pi/3$;
local maximum: 0 at $x = 0$;
local maximum: π at $x = 2\pi$

59. (a) Local minimum: 0 at $x = \pi/4$

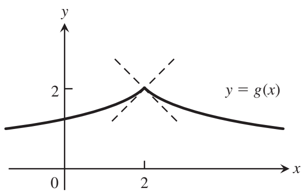
61. Local minimum at $x = 1$; no local maximum

63. Local maximum: 3 at $\theta = 0$;
local minimum: -3 at $\theta = 2\pi$

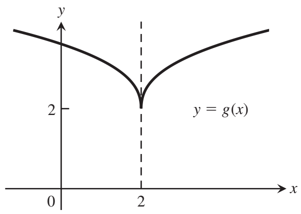
65.



67. (a)



(b)



71. $a = -2, b = 4$

SECTION 4.4, pp. 210–214

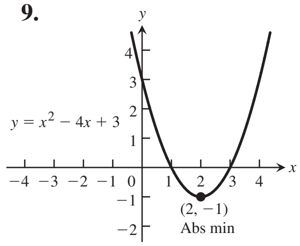
1. Local maximum: $3/2$ at $x = -1$; local minimum: -3 at $x = 2$; point of inflection at $(1/2, -3/4)$; rising on $(-\infty, -1)$ and $(2, \infty)$; falling on $(-1, 2)$; concave up on $(1/2, \infty)$; concave down on $(-\infty, 1/2)$

3. Local maximum: $3/4$ at $x = 0$; local minimum: 0 at $x = \pm 1$; points of inflection at $\left(-\sqrt{3}, \frac{3\sqrt[3]{4}}{4}\right)$ and $\left(\sqrt{3}, \frac{3\sqrt[3]{4}}{4}\right)$; rising on $(-1, 0)$ and $(1, \infty)$; falling on $(-\infty, -1)$ and $(0, 1)$; concave up on $\left(-\infty, -\sqrt{3}\right)$ and $\left(\sqrt{3}, \infty\right)$; concave down on $\left(-\sqrt{3}, \sqrt{3}\right)$

5. Local maxima: $\frac{-2\pi}{3} + \frac{\sqrt{3}}{2}$ at $x = -2\pi/3$, $\frac{\pi}{3} + \frac{\sqrt{3}}{2}$ at $x = \pi/3$; local minima: $-\frac{\pi}{3} - \frac{\sqrt{3}}{2}$ at $x = -\pi/3$, $\frac{2\pi}{3} - \frac{\sqrt{3}}{2}$ at $x = 2\pi/3$; points of inflection at $(-\pi/2, -\pi/2)$, $(0, 0)$, and $(\pi/2, \pi/2)$; rising on $(-\pi/3, \pi/3)$; falling on $(-2\pi/3, -\pi/3)$ and $(\pi/3, 2\pi/3)$; concave up on $(-\pi/2, 0)$ and $(\pi/2, 2\pi/3)$; concave down on $(-2\pi/3, -\pi/2)$ and $(0, \pi/2)$

7. Local maxima: 1 at $x = -\pi/2$ and $x = \pi/2$, 0 at $x = -2\pi$ and $x = 2\pi$; local minima: -1 at $x = -3\pi/2$ and $x = 3\pi/2$, 0 at $x = 0$; points of inflection at $(-\pi, 0)$ and $(\pi, 0)$; rising on $(-3\pi/2, -\pi/2)$, $(0, \pi/2)$, and $(3\pi/2, 2\pi)$; falling on $(-2\pi, -3\pi/2)$, $(-\pi/2, 0)$, and $(\pi/2, 3\pi/2)$; concave up on $(-2\pi, -\pi)$ and $(\pi, 2\pi)$; concave down on $(-\pi, 0)$ and $(0, \pi)$

9.



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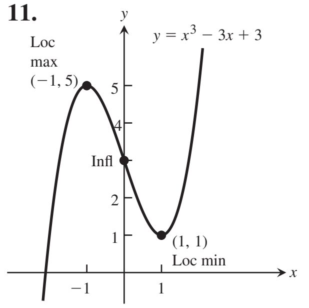

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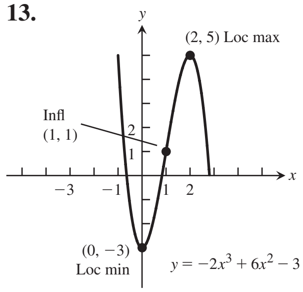

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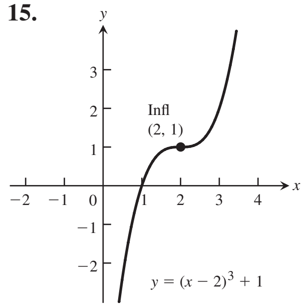

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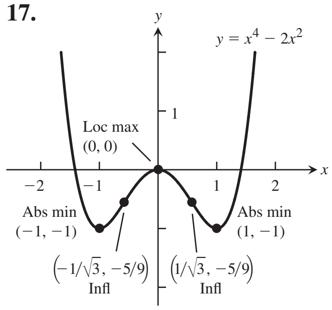

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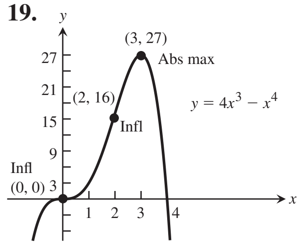

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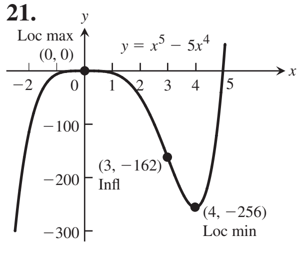

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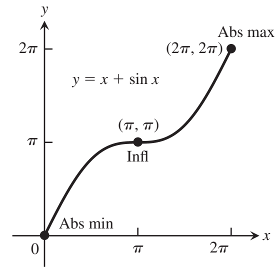

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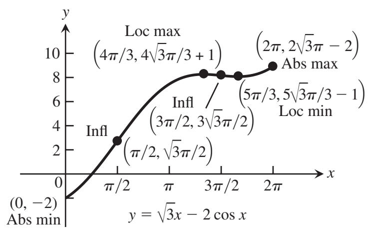

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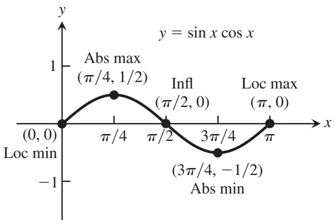

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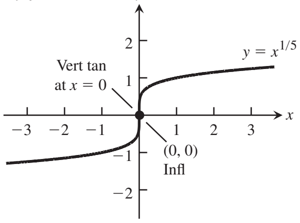

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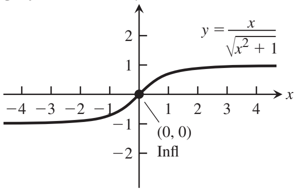

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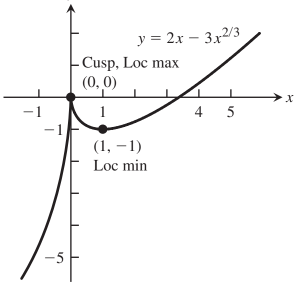

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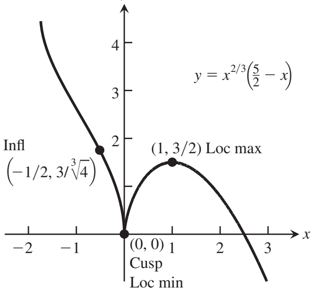

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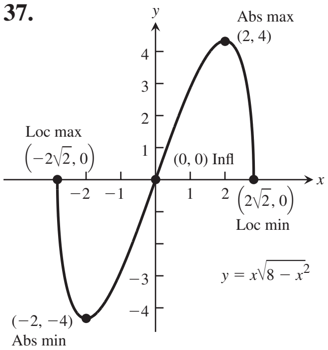

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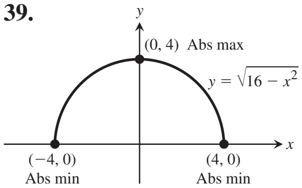

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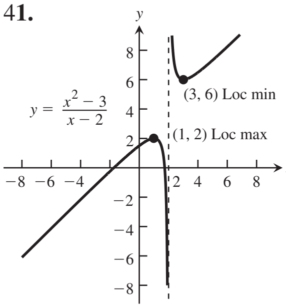

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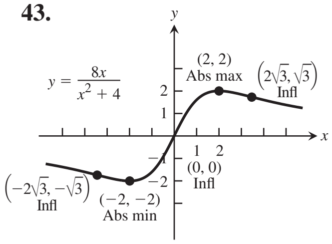

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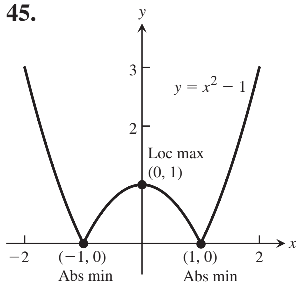

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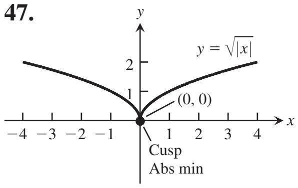

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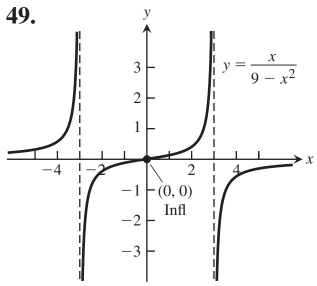
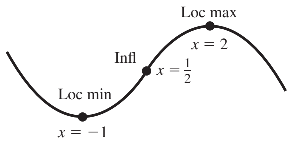
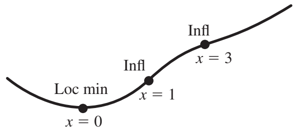


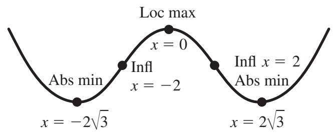
51. $y'' = 1 - 2x$



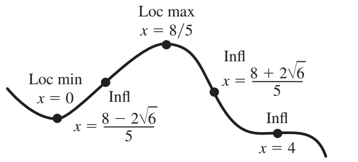
53. $y'' = 3(x - 3)(x - 1)$



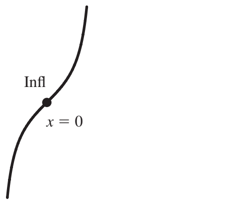
55. $y'' = 3(x - 2)(x + 2)$



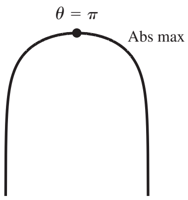
57. $y'' = 4(4 - x)(5x^2 - 16x + 8)$



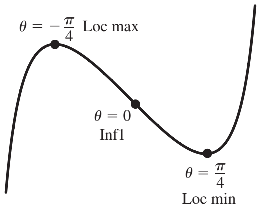
59. $y'' = 2 \sec^2 x \tan x$



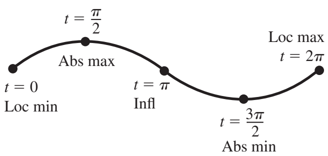
61. $y'' = -\frac{1}{2} \csc^2 \frac{\theta}{2}$, $0 < \theta < 2\pi$



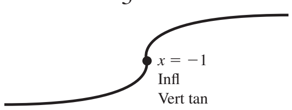
63. $y'' = 2 \tan \theta \sec^2 \theta,\ -\dfrac{\pi}{2} < \theta < \dfrac{\pi}{2}$



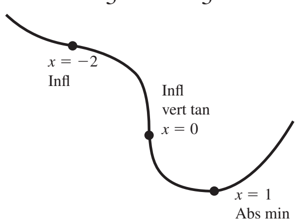
65. $y'' = -\sin t,\ 0 \le t \le 2\pi$



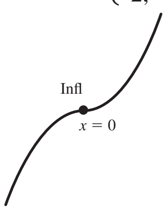
67. $y'' = -\dfrac{2}{3}(x+1)^{-5/3}$



69. $y'' = \dfrac{1}{3}x^{-2/3} + \dfrac{2}{3}x^{-5/3}$



71. $y'' = \begin{cases} -2, & x < 0 \\ 2, & x > 0 \end{cases}$



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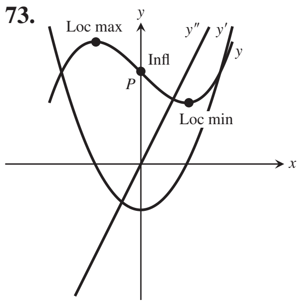

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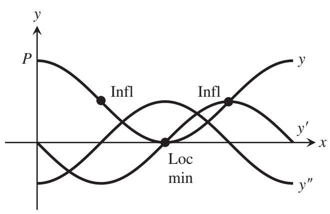

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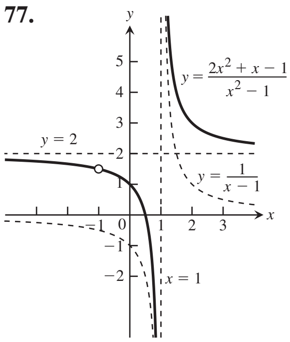

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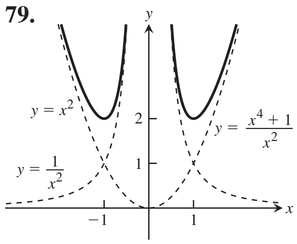

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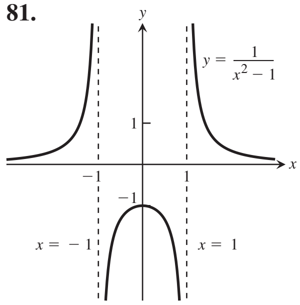

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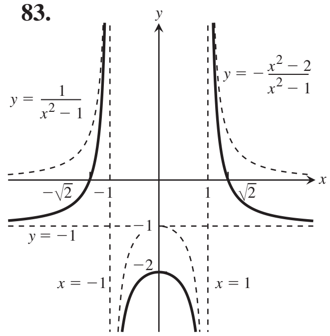

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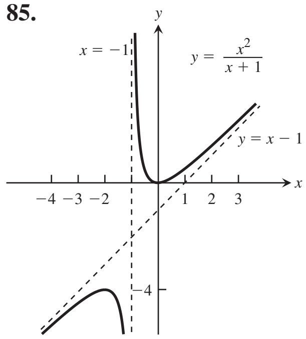

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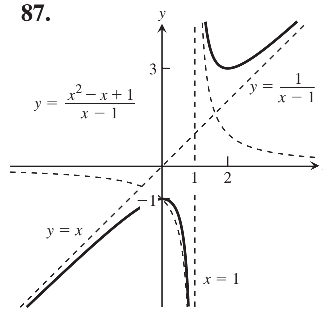

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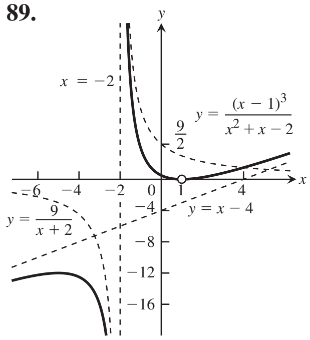

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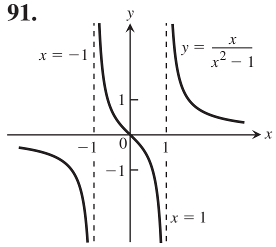

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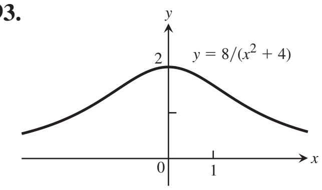
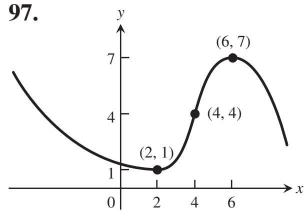


95.

Point	y'	y''
P	$-$	$+$
Q	$+$	0
R	$+$	$-$
S	0	$-$
T	$-$	$-$

97.



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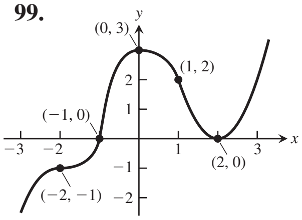

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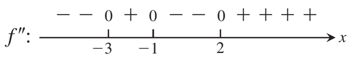
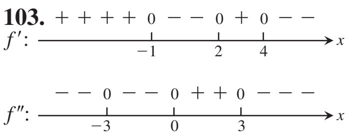


There are points of inflection at $x = -3$, $x = -1$, and $x = 2$.

103.



There are local maxima at $x = -1$ and $x = 4$. There is a local minimum at $x = 2$. There are points of inflection at $x = 0$ and $x = 3$.

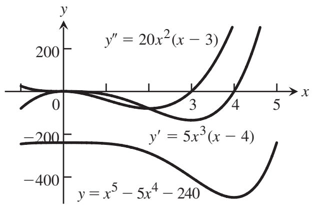
105. **(a)** Towards origin: $0 \le t < 2$ and $6 \le t \le 10$; away from origin: $2 \le t \le 6$ and $10 \le t \le 15$
(b) $t = 2, t = 6, t = 10$
(c) $t = 5, t = 7, t = 13$
(d) Positive: $5 \le t \le 7$, $13 \le t \le 15$; negative: $0 \le t \le 5, 7 \le t \le 13$

107. $\approx$60 thousand units

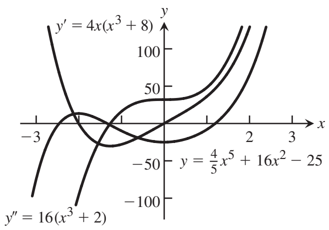
109. Local minimum at $x = 2$; inflection points at $x = 1$ and $x = 5/3$

111. $-1, 2$ **113.** $b = -3$ **119.** $a = 1, b = 3, c = 9$

121. The zeros of $y' = 0$ and $y'' = 0$ are extrema and points of inflection, respectively. Inflection at $x = 3$, local maximum at $x = 0$, local minimum at $x = 4$.



123. The zeros of $y' = 0$ and $y'' = 0$ are extrema and points of inflection, respectively. Inflection at $x = -\sqrt[3]{2}$; local maximum at $x = -2$; local minimum at $x = 0$.



SECTION 4.5, pp. 220–226

1. 16 in., 4 in. by 4 in.

3. **(a)** $(x, 1 - x)$ **(b)** $A(x) = 2x(1 - x)$
(c) $\frac{1}{2}$ square units, 1 by $\frac{1}{2}$

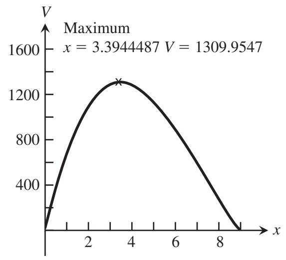
5. $\frac{14}{3} \times \frac{35}{3} \times \frac{5}{3}$ in., $\frac{2450}{27}$ in^3

7. 80,000 m^2; 400 m by 200 m

9. **(a)** The optimum dimensions of the tank are 10 ft on the base edges and 5 ft deep.
(b) Minimizing the surface area of the tank minimizes its weight for a given wall thickness. The thickness of the steel walls would likely be determined by other considerations such as structural requirements.

11. 9×18 in. **13.** $\frac{\pi}{2}$ **15.** $h:r = 8:\pi$

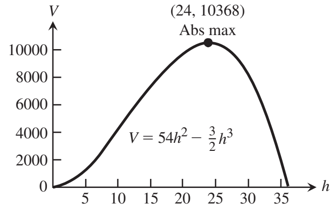
17. **(a)** $V(x) = 2x(24 - 2x)(18 - 2x)$ **(b)** Domain: $(0, 9)$



(c) Maximum volume $\approx$ 1309.95 in^3 when $x \approx 3.39$ in.
(d) $V'(x) = 24x^2 - 336x + 864$, so the critical point is at $x = 7 - \sqrt{13}$, which confirms the result in part (c).
(e) $x = 2$ in. or $x = 5$ in.

19. $\approx$2418.40 cm^3

21. **(a)** $h = 24, w = 18$
(b)



23. If r is the radius of the hemisphere, h the height of the cylinder, and V the volume, then $r = \left(\frac{3V}{8\pi}\right)^{1/3}$ and $h = \left(\frac{3V}{\pi}\right)^{1/3}$.

25. **(b)** $x = \frac{51}{8}$ **(c)** $L \approx 11$ in.

27. Radius $= \sqrt{2}$ m, height $= 1$ m, volume $= \frac{2\pi}{3}$ m^3

29. 1 **31.** $\frac{9b}{9 + \sqrt{3}\pi}$ m, triangle; $\frac{b\sqrt{3}\pi}{9 + \sqrt{3}\pi}$ m, circle

33. $\frac{3}{2} \times 2$ **35.** **(a)** 16 **(b)** -1

37. $r = \frac{2\sqrt{2}}{3}$ $h = \frac{4}{3}$ **39.** Area 8 when $a = 2$

41. **(a)** $v(0) = 96$ ft/sec **(b)** 256 ft at $t = 3$ sec
(c) Velocity when $s = 0$ is $v(7) = -128$ ft/sec.

43. $\approx$46.87 ft **45.** **(a)** $6 \times 6\sqrt{3}$ in.

47. **(a)** $4\sqrt{3} \times 4\sqrt{6}$ in.

49. **(a)** $10\pi \approx 31.42$ cm/sec; when $t = 0.5$ sec, 1.5 sec, 2.5 sec, 3.5 sec; $s = 0$, acceleration is 0.
(b) 10 cm from rest position; speed is 0.

51. **(a)** $s = ((12 - 12t)^2 + 64t^2)^{1/2}$
(b) -12 knots, 8 knots
(c) No
(d) $4\sqrt{13}$. This limit is the square root of the sums of the squares of the individual speeds.

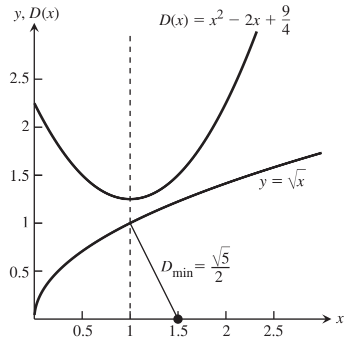
53. $x = \frac{a}{2}, v = \frac{ka^2}{4}$ **55.** $\frac{c}{2} + 50$

57. **(a)** $\sqrt{\frac{2km}{h}}$ **(b)** $\sqrt{\frac{2km}{h}}$ **61.** $4 \times 4 \times 3$ ft, \$288

63. $M = \frac{C}{2}$ **69.** **(a)** $y = -1$

71. (a) The minimum distance is $\frac{\sqrt{5}}{2}$.

(b) The minimum distance is from the point $(3/2, 0)$ to the point $(1, 1)$ on the graph of $y = \sqrt{x}$, and this occurs at the value $x = 1$, where $D(x)$, the distance squared, has its minimum value.

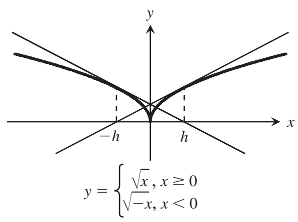


SECTION 4.6, pp. 229–231

1. $x_2 = -\frac{5}{3}, \frac{13}{21}$ **3.** $x_2 = -\frac{51}{31}, \frac{5763}{4945}$ **5.** $x_2 = \frac{2387}{2000}$

7. $x_2 = \frac{17}{14}$ **9.** x_1, and all later approximations will equal x_0.

11.



13. The points of intersection of $y = x^3$ and $y = 3x + 1$ or $y = x^3 - 3x$ and $y = 1$ have the same x-values as the roots of part (i) or the solutions of part (iv). **15.** 1.165561185
17. (a) Two **(b)** 0.35003501505249 and -1.0261731615301
19. ± 1.3065629648764, ± 0.5411961001462 **21.** $x \approx 0.45$
23. 0.8192 **25.** The root is 1.17951.
27. (a) For $x_0 = -2$ or $x_0 = -0.8$, $x_i \to -1$ as i gets large.
(b) For $x_0 = -0.5$ or $x_0 = 0.25$, $x_i \to 0$ as i gets large.
(c) For $x_0 = 0.8$ or $x_0 = 2$, $x_i \to 1$ as i gets large.
(d) For $x_0 = -\sqrt{21}/7$ or $x_0 = \sqrt{21}/7$, Newton's method does not converge. The values of x_i alternate between $-\sqrt{21}/7$ and $\sqrt{21}/7$ as i increases.
29. Answers will vary with machine speed.

SECTION 4.7, pp. 237–241

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

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

5. (a) $-\frac{1}{x}$ **(b)** $-\frac{5}{x}$ **(c)** $2x + \frac{5}{x}$

7. (a) $\sqrt{x^3}$ **(b)** $\sqrt{x}$ **(c)** $\frac{2\sqrt{x^3}}{3} + 2\sqrt{x}$

9. (a) $x^{2/3}$ **(b)** $x^{1/3}$ **(c)** $x^{-1/3}$

11. (a) $\cos(\pi x)$ **(b)** $-3\cos x$ **(c)** $-\frac{1}{\pi}\cos(\pi x) + \cos(3x)$

13. (a) $\frac{1}{2}\tan x$ **(b)** $2\tan\left(\frac{x}{3}\right)$ **(c)** $-\frac{2}{3}\tan\left(\frac{3x}{2}\right)$

15. (a) $-\csc x$ **(b)** $\frac{1}{5}\csc(5x)$ **(c)** $2\csc\left(\frac{\pi x}{2}\right)$

17. $\frac{x^2}{2} + x + C$ **19.** $t^3 + \frac{t^2}{4} + C$ **21.** $\frac{x^4}{2} - \frac{5x^2}{2} + 7x + C$

23. $-\frac{1}{x} - \frac{x^3}{3} - \frac{x}{3} + C$ **25.** $\frac{3}{2}x^{2/3} + C$

27. $\frac{2}{3}x^{3/2} + \frac{3}{4}x^{4/3} + C$ **29.** $4y^2 - \frac{8}{3}y^{3/4} + C$

31. $x^2 + \frac{2}{x} + C$ **33.** $2\sqrt{t} - \frac{2}{\sqrt{t}} + C$ **35.** $-2\sin t + C$

37. $-21\cos\frac{\theta}{3} + C$ **39.** $3\cot x + C$ **41.** $-\frac{1}{2}\csc\theta + C$

43. $4\sec x - 2\tan x + C$ **45.** $-\frac{1}{2}\cos 2x + \cot x + C$

47. $\frac{t}{2} + \frac{\sin 4t}{8} + C$ **49.** $\frac{3x^{(\sqrt{3}+1)}}{\sqrt{3} + 1} + C$

51. $\tan\theta + C$ **53.** $-\cot x - x + C$ **55.** $-\cos\theta + \theta + C$

63. (a) Wrong: $\frac{d}{dx}\left(\frac{x^2}{2}\sin x + C\right) = \frac{2x}{2}\sin x + \frac{x^2}{2}\cos x = x\sin x + \frac{x^2}{2}\cos x$

(b) Wrong: $\frac{d}{dx}(-x\cos x + C) = -\cos x + x\sin x$

(c) Right: $\frac{d}{dx}(-x\cos x + \sin x + C) = -\cos x + x\sin x + \cos x = x\sin x$

65. (a) Wrong: $\frac{d}{dx}\left(\frac{(2x+1)^3}{3} + C\right) = \frac{3(2x+1)^2(2)}{3} = 2(2x+1)^2$

(b) Wrong: $\frac{d}{dx}((2x+1)^3 + C) = 3(2x+1)^2(2) = 6(2x+1)^2$

(c) Right: $\frac{d}{dx}((2x+1)^3 + C) = 6(2x+1)^2$

67. Right **69. (b)** **71.** $y = x^2 - 7x + 10$

73. $y = -\frac{1}{x} + \frac{x^2}{2} - \frac{1}{2}$ **75.** $y = 9x^{1/3} + 4$

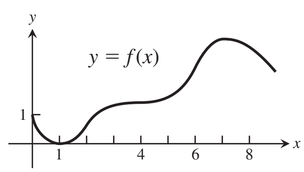
77. $s = t + \sin t + 4$ **79.** $r = \cos(\pi\theta) - 1$

81. $v = \frac{1}{2}\sec t + \frac{1}{2}$ **83.** $y = x^2 - x^3 + 4x + 1$

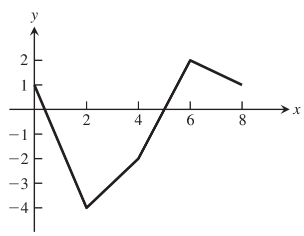
85. $r = \frac{1}{t} + 2t - 2$ **87.** $y = x^3 - 4x^2 + 5$

89. $y = -\sin t + \cos t + t^3 - 1$ **91.** $y = 2x^{3/2} - 50$

93.



95.



97. $y = x - x^{4/3} + \frac{1}{2}$ **99.** $y = -\sin x - \cos x - 2$

101. **(a)** **(i)** 33.2 units, **(ii)** 33.2 units, **(iii)** 33.2 units
(b) True

103. $t = 88/k, k = 16$

105. **(a)** $v = 10t^{3/2} - 6t^{1/2}$ **(b)** $s = 4t^{5/2} - 4t^{3/2}$

109. **(a)** $-\sqrt{x} + C$ **(b)** $x + C$ **(c)** $\sqrt{x} + C$
(d) $-x + C$ **(e)** $x - \sqrt{x} + C$ **(f)** $-x - \sqrt{x} + C$

PRACTICE EXERCISES, pp. 241–244

1. Minimum value is 1 at $x = 2$.

3. Local maximum at $(-2, 17)$; local minimum at $\left(\frac{4}{3}, -\frac{41}{27}\right)$

5. Minimum value is 0 at $x = -1$ and $x = 1$.

7. There is a local minimum at $(0, 1)$.

9. Maximum value is $\frac{1}{2}$ at $x = 1$; minimum value is $-\frac{1}{2}$ at $x = -1$.

11. No **13.** No minimum; absolute maximum: $f(1) = 16$; critical points: $x = 1$ and $11/3$

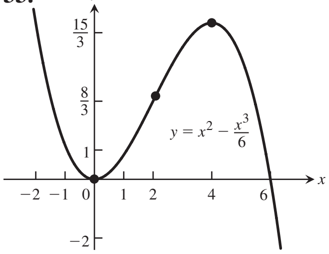
15. Yes, except at $x = 0$ **17.** No **21.** **(b)** one

23. **(b)** 0.8555 99677 2

29. Global minimum value of $\frac{1}{2}$ at $x = 2$

31. **(a)** $t = 0, 6, 12$ **(b)** $t = 3, 9$ **(c)** $6 < t < 12$
(d) $0 < t < 6, 12 < t < 14$

33.



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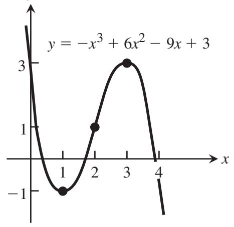
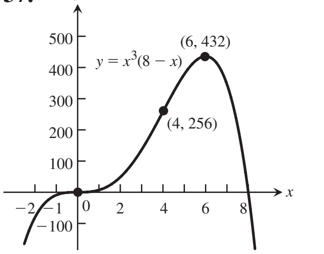


37.



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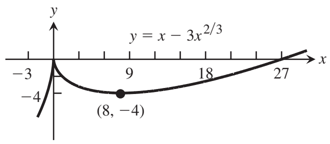

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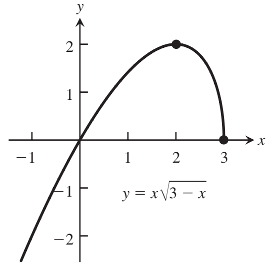
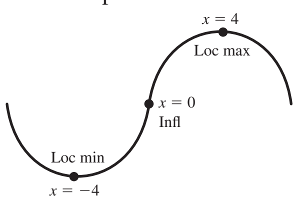
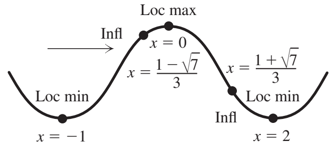


43. **(a)** Local maximum at $x = 4$, local minimum at $x = -4$, inflection point at $x = 0$

(b)

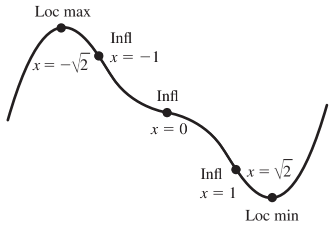


45. **(a)** Local maximum at $x = 0$, local minima at $x = -1$ and $x = 2$, inflection points at $x = (1 \pm \sqrt{7})/3$

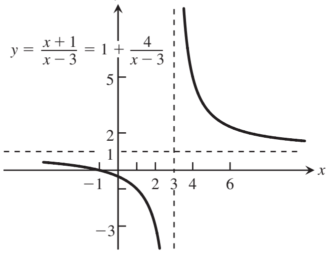


47. **(a)** Local maximum at $x = -\sqrt{2}$, local minimum at $x = \sqrt{2}$, inflection points at $x = \pm 1$ and 0

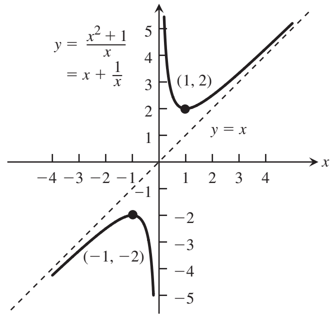
(b)



53.



55.



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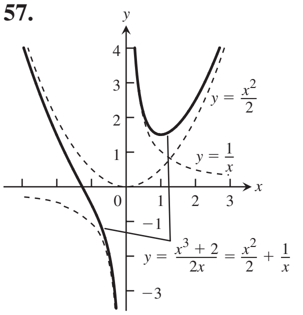

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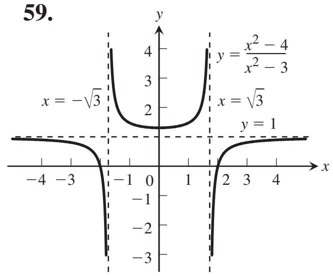


61. **(a)** 0, 36 **(b)** 18, 18 **63.** 54 square units

65. height $= 2$, radius $= \sqrt{2}$

67. $x = 5 - \sqrt{5}$ hundred $\approx$ 276 tires,
$y = 2(5 - \sqrt{5})$ hundred $\approx$ 553 tires

69. Dimensions: base is 6 in. by 12 in., height = 2 in.; maximum volume = 144 in^3

71. $x_5 = 2.1958\ 23345$ **73.** $\frac{x^4}{4} + \frac{5}{2}x^2 - 7x + C$

75. $2t^{3/2} - \frac{4}{t} + C$ **77.** $-\frac{1}{r + 5} + C$

79. $(\theta^2 + 1)^{3/2} + C$ **81.** $\frac{1}{3}(1 + x^4)^{3/4} + C$

83. $10 \tan \frac{s}{10} + C$ **85.** $-\frac{1}{\sqrt{2}} \csc \sqrt{2}\theta + C$

87. $\frac{1}{2}x - \sin \frac{x}{2} + C$ **89.** $y = x - \frac{1}{x} - 1$

91. $r = 4t^{5/2} + 4t^{3/2} - 8t$

ADDITIONAL AND ADVANCED EXERCISES, pp. 244–247

1. The function is constant on the interval.
3. The extreme points will not be at the end of an open interval.
5. **(a)** A local minimum at $x = -1$, points of inflection at $x = 0$ and $x = 2$
(b) A local maximum at $x = 0$ and local minima at $x = -1$ and $x = 2$, points of inflection at $x = \frac{1 \pm \sqrt{7}}{3}$
9. No **11.** $a = 1, b = 0, c = 1$ **13.** Yes
15. Drill the hole at $y = h/2$.
17. $r = \frac{RH}{2(H - R)}$ for $H > 2R$, $r = R$ if $H \leq 2R$
19. $\frac{12}{5}$ and 5
21. **(a)** $\frac{c - b}{2e}$ **(b)** $\frac{c + b}{2}$ **(c)** $\frac{b^2 - 2bc + c^2 + 4ae}{4e}$
(d) $\frac{c + b + t}{2}$
23. $m_0 = 1 - \frac{1}{q}, m_1 = \frac{1}{q}$
25. **(a)** $k = -38.72$ **(b)** 25 ft
27. Yes, $y = x + C$ **29.** $v_0 = \frac{2\sqrt{2}}{3} b^{3/4}$ **33.** 3

Chapter 5

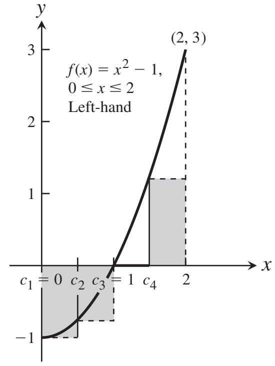
SECTION 5.1, pp. 256–258

1. **(a)** 0.125 **(b)** 0.21875 **(c)** 0.625 **(d)** 0.46875
3. **(a)** 1.066667 **(b)** 1.283333 **(c)** 2.666667 **(d)** 2.083333
5. 0.3125, 0.328125 **7.** 1.5, 1.574603
9. **(a)** 245 cm **(b)** 245 cm **11.** **(a)** 3490 ft **(b)** 3840 ft
13. **(a)** 74.65 ft/sec **(b)** 45.28 ft/sec **(c)** 146.59 ft
15. $\frac{31}{16}$ **17.** 1
19. **(a)** Upper = 758 gal, lower = 543 gal
(b) Upper = 2363 gal, lower = 1693 gal
(c) $\approx$31.4 h, $\approx$32.4 h
21. **(a)** 2 **(b)** $2\sqrt{2} \approx 2.828$ **(c)** $8 \sin\left(\frac{\pi}{8}\right) \approx 3.061$
(d) Each area is less than the area of the circle, π. As n increases, the polygon area approaches π.

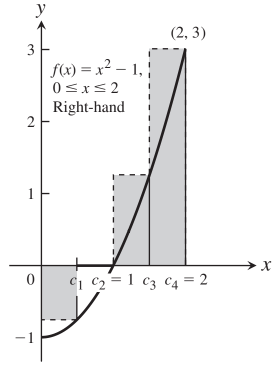
SECTION 5.2, pp. 264–265

1. $\frac{6(1)}{1 + 1} + \frac{6(2)}{2 + 1} = 7$
3. $\cos(1)\pi + \cos(2)\pi + \cos(3)\pi + \cos(4)\pi = 0$
5. $\sin \pi - \sin \frac{\pi}{2} + \sin \frac{\pi}{3} = \frac{\sqrt{3} - 2}{2}$
7. All of them **9.** b
11. $\sum_{k=1}^{6} k$ **13.** $\sum_{k=1}^{4} \frac{1}{2^k}$ **15.** $\sum_{k=1}^{5} (-1)^{k+1} \frac{1}{k}$
17. **(a)** -15 **(b)** 1 **(c)** 1 **(d)** -11 **(e)** 16
19. **(a)** 55 **(b)** 385 **(c)** 3025 **21.** -56 **23.** -73
25. 240 **27.** 3376 **29.** **(a)** 21 **(b)** 3500 **(c)** 2620
31. **(a)** $4n$ **(b)** cn **(c)** $(n^2 - n)/2$ **33.** 2600 **35.** $-2\sqrt{3}$

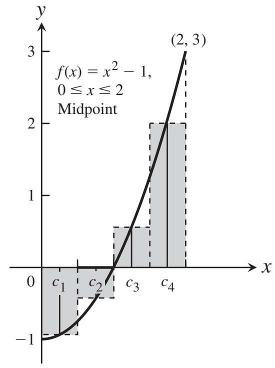
37. **(a)**



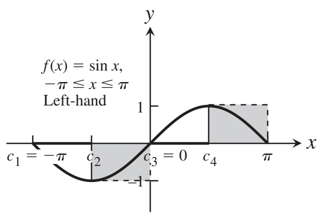
(b)



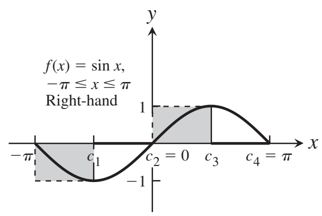
(c)



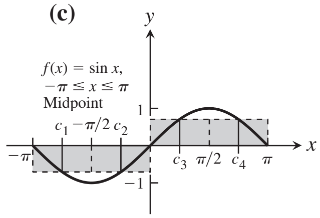
39. **(a)**



(b)



(c)



41. 1.2
43. $\frac{2}{3} - \frac{1}{2n} - \frac{1}{6n^2}, \frac{2}{3}$
45. $12 + \frac{27n + 9}{2n^2}$, 12
47. $\frac{5}{6} + \frac{6n + 1}{6n^2}, \frac{5}{6}$
49. $\frac{1}{2} + \frac{1}{n} + \frac{1}{2n^2}, \frac{1}{2}$

SECTION 5.3, pp. 274–277

1. $\int_0^2 x^2\, dx$ **3.** $\int_{-7}^{5} (x^2 - 3x)\, dx$ **5.** $\int_2^3 \frac{1}{1 - x}\, dx$
7. $\int_{-\pi/4}^{0} \sec x\, dx$
9. **(a)** 0 **(b)** -8 **(c)** -12 **(d)** 10 **(e)** -2 **(f)** 16
11. **(a)** 5 **(b)** $5\sqrt{3}$ **(c)** -5 **(d)** -5
13. **(a)** 4 **(b)** -4 **15.** Area = 21 square units

17. Area $= 9\pi/2$ square units **19.** Area $= 2.5$ square units
21. Area $= 3$ square units **23.** $b^2/4$ **25.** $b^2 - a^2$
27. (a) 2π **(b)** π **29.** $1/2$ **31.** $3\pi^2/2$ **33.** $7/3$
35. $1/24$ **37.** $3a^2/2$ **39.** $b/3$ **41.** -14
43. -2 **45.** $-7/4$ **47.** 7 **49.** 0
51. Using n subintervals of length $\Delta x = b/n$ and right-endpoint values:

$$\text{Area} = \int_0^b 3x^2\,dx = b^3$$

53. Using n subintervals of length $\Delta x = b/n$ and right-endpoint values:

$$\text{Area} = \int_0^b 2x\,dx = b^2$$

55. $\text{av}(f) = 0$ **57.** $\text{av}(f) = -2$ **59.** $\text{av}(f) = 1$
61. (a) $\text{av}(g) = -1/2$ **(b)** $\text{av}(g) = 1$ **(c)** $\text{av}(g) = 1/4$
63. $c(b - a)$ **65.** $b^3/3 - a^3/3$ **67.** 9
69. $b^4/4 - a^4/4$ **71.** $a = 0$ and $b = 1$ maximize the integral.
73. Upper bound $= 1$, lower bound $= 1/2$
75. For example, $\int_0^1 \sin(x^2)\,dx \le \int_0^1 dx = 1$
77. $\int_a^b f(x)\,dx \ge \int_a^b 0\,dx = 0$ **79.** Upper bound $= 1/2$

SECTION 5.4, pp. 287–289

1. $-10/3$ **3.** $124/125$ **5.** $753/16$ **7.** 1 **9.** $2\sqrt{3}$
11. 0 **13.** $-\pi/4$ **15.** $1 - \frac{\pi}{4}$ **17.** $\frac{2 - \sqrt{2}}{4}$ **19.** $-8/3$
21. $-3/4$ **23.** $\sqrt{2} - \sqrt[4]{8} + 1$ **25.** -1 **27.** 16
29. $1/2$ **31.** $\sqrt{26} - \sqrt{5}$ **33.** $(\cos\sqrt{x})\left(\frac{1}{2\sqrt{x}}\right)$
35. $4t^5$ **37.** 3 **39.** $\sqrt{1 + x^2}$ **41.** $-\frac{1}{2}x^{-1/2}\sin x$
43. 0 **45.** 1 **47.** $28/3$
49. $1/2$ **51.** π **53.** $\frac{\sqrt{2}\pi}{2}$
55. d, since $y' = \frac{1}{x}$ and $y(\pi) = \int_\pi^\pi \frac{1}{t}\,dt - 3 = -3$
57. b, since $y' = \sec x$ and $y(0) = \int_0^0 \sec t\,dt + 4 = 4$
59. $y = \int_2^x \sec t\,dt + 3$ **61.** $\frac{2}{3}bh$ **63.** \$9.00
65. (a) $T(0) = 70°\text{F}, T(16) = 76°\text{F}, T(25) = 85°\text{F}$
(b) $\text{av}(T) = 75°\text{F}$
67. $2x - 2$ **69.** $-3x + 5$
71. (a) True. Since f is continuous, g is differentiable by Part 1 of the Fundamental Theorem of Calculus.
(b) True: g is continuous because it is differentiable.
(c) True, since $g'(1) = f(1) = 0$.
(d) False, since $g''(1) = f'(1) > 0$.
(e) True, since $g'(1) = 0$ and $g''(1) = f'(1) > 0$.
(f) False: $g''(x) = f'(x) > 0$, so g'' never changes sign.
(g) True, since $g'(1) = f(1) = 0$ and $g'(x) = f(x)$ is an increasing function of x (because $f'(x) > 0$).

73. (a) $v = \frac{ds}{dt} = \frac{d}{dt}\int_0^t f(x)\,dx = f(t) \Rightarrow v(5) = f(5) = 2\text{ m/sec}$
(b) $a = df/dt$ is negative, since the slope of the tangent line at $t = 5$ is negative.
(c) $s = \int_0^3 f(x)\,dx = \frac{1}{2}(3)(3) = \frac{9}{2}\text{m}$, since the integral is the area of the triangle formed by $y = f(x)$, the x-axis, and $x = 3$.
(d) $t = 6$, since after $t = 6$ to $t = 9$, the region lies below the x-axis.
(e) At $t = 4$ and $t = 7$, since there are horizontal tangents there.
(f) Toward the origin between $t = 6$ and $t = 9$, since the velocity is negative on this interval. Away from the origin between $t = 0$ and $t = 6$, since the velocity is positive there.
(g) Right or positive side, because the integral of f from 0 to 9 is positive, there being more area above the x-axis than below.

SECTION 5.5, pp. 295–296

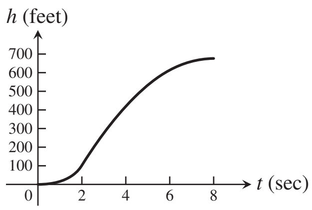
1. $\frac{1}{6}(2x + 4)^6 + C$ **3.** $-\frac{1}{3}(x^2 + 5)^{-3} + C$
5. $\frac{1}{10}(3x^2 + 4x)^5 + C$ **7.** $-\frac{1}{3}\cos 3x + C$
9. $\frac{1}{2}\sec 2t + C$ **11.** $-6(1 - r^3)^{1/2} + C$
13. $\frac{1}{3}(x^{3/2} - 1) - \frac{1}{6}\sin(2x^{3/2} - 2) + C$
15. (a) $-\frac{1}{4}(\cot^2 2\theta) + C$ **(b)** $-\frac{1}{4}(\csc^2 2\theta) + C$
17. $-\frac{1}{3}(3 - 2s)^{3/2} + C$ **19.** $-\frac{2}{5}(1 - \theta^2)^{5/4} + C$
21. $\left(-2/(1 + \sqrt{x})\right) + C$ **23.** $\frac{1}{3}\tan(3x + 2) + C$
25. $\frac{1}{2}\sin^6\left(\frac{x}{3}\right) + C$ **27.** $\left(\frac{r^3}{18} - 1\right)^6 + C$
29. $-\frac{2}{3}\cos(x^{3/2} + 1) + C$ **31.** $\frac{1}{2\cos(2t + 1)} + C$
33. $-\sin\left(\frac{1}{t} - 1\right) + C$ **35.** $-\frac{\sin^2(1/\theta)}{2} + C$
37. $\frac{2}{3}(1 + x)^{3/2} - 2(1 + x)^{1/2} + C$ **39.** $\frac{2}{3}\left(2 - \frac{1}{x}\right)^{3/2} + C$
41. $\frac{2}{27}\left(1 - \frac{3}{x^3}\right)^{3/2} + C$ **43.** $\frac{1}{12}(x - 1)^{12} + \frac{1}{11}(x - 1)^{11} + C$
45. $-\frac{1}{8}(1 - x)^8 + \frac{4}{7}(1 - x)^7 - \frac{2}{3}(1 - x)^6 + C$
47. $\frac{1}{5}(x^2 + 1)^{5/2} - \frac{1}{3}(x^2 + 1)^{3/2} + C$ **49.** $\frac{-1}{4(x^2 - 4)^2} + C$
51. (a) $-\frac{6}{2 + \tan^3 x} + C$ **(b)** $-\frac{6}{2 + \tan^3 x} + C$
(c) $-\frac{6}{2 + \tan^3 x} + C$
53. $\frac{1}{6}\sin\sqrt{3(2r - 1)^2 + 6} + C$ **55.** $s = \frac{1}{2}(3t^2 - 1)^4 - 5$
57. $s = 4t - 2\sin\left(2t + \frac{\pi}{6}\right) + 9$
59. $s = \sin\left(2t - \frac{\pi}{2}\right) + 100t + 1$ **61.** 6 m

SECTION 5.6, pp. 303–306

1. **(a)** $14/3$ **(b)** $2/3$ **3.** **(a)** $1/2$ **(b)** $-1/2$
5. **(a)** $15/16$ **(b)** 0 **7.** **(a)** 0 **(b)** $1/8$ **9.** **(a)** 4 **(b)** 0
11. **(a)** $506/375$ **(b)** $86{,}744/375$ **13.** **(a)** 0 **(b)** 0
15. $2\sqrt{3}$ **17.** $3/4$ **19.** $3^{5/2} - 1$ **21.** 3 **23.** $\pi/3$
25. $16/3$ **27.** $2^{5/2}$ **29.** $\pi/2$ **31.** $128/15$ **33.** $4/3$
35. $5/6$ **37.** $38/3$ **39.** $49/6$ **41.** $32/3$ **43.** $48/5$
45. $8/3$ **47.** 8 **49.** $5/3$ (There are three intersection points.)
51. 18 **53.** $243/8$ **55.** $8/3$ **57.** 2 **59.** $104/15$
61. $56/15$ **63.** 4 **65.** $\dfrac{4}{3} - \dfrac{4}{\pi}$ **67.** $\pi/2$ **69.** 2
71. $1/2$ **73.** 1
75. **(a)** $(\pm\sqrt{c}, c)$ **(b)** $c = 4^{2/3}$ **(c)** $c = 4^{2/3}$
77. $11/3$ **79.** $3/4$ **81.** Neither **83.** $F(6) - F(2)$
85. **(a)** -3 **(b)** 3 **87.** $I = a/2$

PRACTICE EXERCISES, pp. 307–309

1. **(a)** About 680 ft **(b)** h (feet)

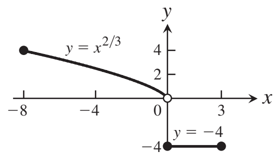


3. **(a)** $-1/2$ **(b)** 31 **(c)** 13 **(d)** 0
5. $\displaystyle\int_1^5 (2x - 1)^{-1/2}\,dx = 2$ **7.** $\displaystyle\int_{-\pi}^{0} \cos\frac{x}{2}\,dx = 2$
9. **(a)** 4 **(b)** 2 **(c)** -2 **(d)** -2π **(e)** $8/5$
11. $8/3$ **13.** 62 **15.** 1 **17.** $1/6$ **19.** 18
21. $9/8$ **23.** $\dfrac{\pi^2}{32} + \dfrac{\sqrt{2}}{2} - 1$ **25.** 4 **27.** $\dfrac{8\sqrt{2} - 7}{6}$
29. Min: -4, max: 0, area: $27/4$ **31.** $6/5$
35. $y = \displaystyle\int_5^x \left(\frac{\sin t}{t}\right) dt - 3$ **37.** $-4(\cos x)^{1/2} + C$
39. $\theta^2 + \theta + \sin(2\theta + 1) + C$ **41.** $\dfrac{t^3}{3} + \dfrac{4}{t} + C$
43. $-\dfrac{1}{3}\cos(2t^{3/2}) + C$ **45.** $\dfrac{1}{4(\sin 2\theta + \cos 2\theta)^2} + C$
47. 16 **49.** 2 **51.** 1 **53.** 8 **55.** $27\sqrt{3}/160$
57. $\pi/2$ **59.** $\sqrt{3}$ **61.** $6\sqrt{3} - 2\pi$ **63.** -1 **65.** 2
67. 1 **69.** **(a)** b **(b)** b **73.** $25°$F
75. $\sqrt{2 + \cos^3 x}$ **77.** $\dfrac{-6}{3 + x^4}$
79. Yes **81.** $-\sqrt{1 + x^2}$
83. Cost $\approx$ \$10,899 using a lower sum estimate

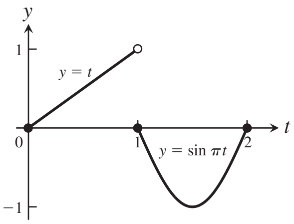
ADDITIONAL AND ADVANCED EXERCISES, pp. 310–312

1. **(a)** Yes **(b)** No **5.** **(a)** $1/4$ **(b)** $\sqrt[3]{12}$
7. $f(x) = \dfrac{x}{\sqrt{x^2 + 1}}$ **9.** $y = x^3 + 2x - 4$

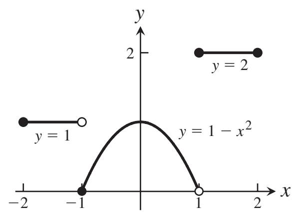
11. $36/5$



13. $\dfrac{1}{2} - \dfrac{2}{\pi}$



15. $13/3$



17. $1/2$ **19.** $1/6$

21. $\displaystyle\int_0^1 f(x)\,dx$ **23.** **(b)** πr^2
25. **(a)** 0 **(b)** -1
(c) $-\pi$ **(d)** $x = 1$
(e) $y = 2x + 2 - \pi$
(f) $x = -1, x = 2$
(g) $[-2\pi, 0]$
27. $2/x$ **29.** $\dfrac{\sin 4y}{\sqrt{y}} - \dfrac{\sin y}{2\sqrt{y}}$

Chapter 6

SECTION 6.1, pp. 321–325

1. 16 **3.** $16/3$ **5.** **(a)** $2\sqrt{3}$ **(b)** 8 **7.** **(a)** 60 **(b)** 36
9. 8π **11.** 10 **13.** **(a)** s^2h **(b)** s^2h **15.** $8/3$
17. $\dfrac{2\pi}{3}$ **19.** $4 - \pi$ **21.** $\dfrac{32\pi}{5}$ **23.** 36π **25.** π
27. $\pi\left(\dfrac{\pi}{2} + 2\sqrt{2} - \dfrac{11}{3}\right)$ **29.** 2π **31.** 2π
33. $4\pi \ln 4$ **35.** $\pi^2 - 2\pi$ **37.** $\dfrac{2\pi}{3}$ **39.** $\dfrac{117\pi}{5}$
41. $\pi(\pi - 2)$ **43.** $\dfrac{4\pi}{3}$ **45.** 8π **47.** $\dfrac{7\pi}{6}$
49. **(a)** 8π **(b)** $\dfrac{32\pi}{5}$ **(c)** $\dfrac{8\pi}{3}$ **(d)** $\dfrac{224\pi}{15}$
51. **(a)** $\dfrac{16\pi}{15}$ **(b)** $\dfrac{56\pi}{15}$ **(c)** $\dfrac{64\pi}{15}$ **53.** $V = 2a^2b\pi^2$
55. **(a)** $V = \dfrac{\pi h^2(3a - h)}{3}$ **(b)** $\dfrac{1}{120\pi}$ m/sec
59. $V = 3308$ cm^3 **61.** $\dfrac{4 - b + a}{2}$

SECTION 6.2, pp. 330–332

1. 6π **3.** 2π **5.** $14\pi/3$ **7.** 8π **9.** $5\pi/6$
11. $\dfrac{7\pi}{15}$ **13.** **(b)** 4π **15.** $\dfrac{16\pi}{15}(3\sqrt{2} + 5)$
17. $\dfrac{8\pi}{3}$ **19.** $\dfrac{4\pi}{3}$ **21.** $\dfrac{16\pi}{3}$
23. **(a)** 16π **(b)** 32π **(c)** 28π
(d) 24π **(e)** 60π **(f)** 48π
25. **(a)** $\dfrac{27\pi}{2}$ **(b)** $\dfrac{27\pi}{2}$ **(c)** $\dfrac{72\pi}{5}$ **(d)** $\dfrac{108\pi}{5}$

27. **(a)** $\frac{6\pi}{5}$ **(b)** $\frac{4\pi}{5}$ **(c)** 2π **(d)** 2π

29. **(a)** About the x-axis: $V = \frac{2\pi}{15}$; about the y-axis: $V = \frac{\pi}{6}$

(b) About the x-axis: $V = \frac{2\pi}{15}$; about the y-axis: $V = \frac{\pi}{6}$

31. **(a)** $\frac{5\pi}{3}$ **(b)** $\frac{4\pi}{3}$ **(c)** 2π **(d)** $\frac{2\pi}{3}$

33. **(a)** $\frac{4\pi}{15}$ **(b)** $\frac{7\pi}{30}$ **35.** **(a)** $\frac{24\pi}{5}$ **(b)** $\frac{48\pi}{5}$

37. **(a)** $\frac{9\pi}{16}$ **(b)** $\frac{9\pi}{16}$

39. Disk: 2 integrals; washer: 2 integrals; shell: 1 integral

41. **(a)** $\frac{256\pi}{3}$ **(b)** $\frac{244\pi}{3}$ **45.** 2

SECTION 6.3, pp. 337–338

1. 12 **3.** $\frac{53}{6}$ **5.** $\frac{123}{32}$ **7.** $\frac{99}{8}$ **9.** $\frac{53}{6}$ **11.** 2

13. **(a)** $\int_{-1}^{2} \sqrt{1 + 4x^2}\, dx$ **(c)** ≈ 6.13

15. **(a)** $\int_{0}^{\pi} \sqrt{1 + \cos^2 y}\, dy$ **(c)** ≈ 3.82

17. **(a)** $\int_{-1}^{3} \sqrt{1 + (y+1)^2}\, dy$ **(c)** ≈ 9.29

19. **(a)** $\int_{0}^{\pi/6} \sec x\, dx$ **(c)** ≈ 0.55

21. **(a)** $y = \sqrt{x}$ from $(1, 1)$ to $(4, 2)$

(b) Only one. We know the derivative of the function and the value of the function at one value of x.

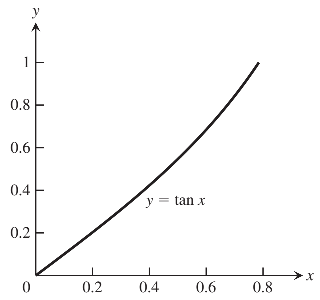
23. 1 **27.** Yes, $f(x) = \pm x + C$ where C is any real number.

33. $\int_{0}^{x} \sqrt{1 + 9t}\, dt$, $\frac{2}{27}(10^{3/2} - 1)$

SECTION 6.4, pp. 342–343

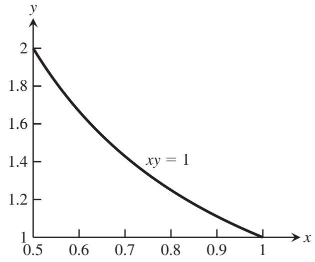
1. **(a)** $2\pi \int_{0}^{\pi/4} (\tan x)\sqrt{1 + \sec^4 x}\, dx$ **(c)** $S \approx 3.84$

(b)



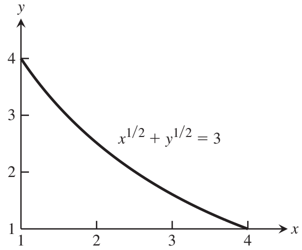
3. **(a)** $2\pi \int_{1}^{2} \frac{1}{y}\sqrt{1 + y^{-4}}\, dy$ **(c)** $S \approx 5.02$

(b)



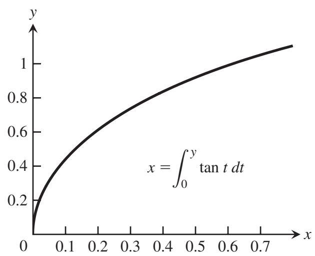
5. **(a)** $2\pi \int_{1}^{4} (3 - x^{1/2})^2 \sqrt{1 + (1 - 3x^{-1/2})^2}\, dx$ **(c)** $S \approx 63.37$

(b)



7. **(a)** $2\pi \int_{0}^{\pi/3} \left(\int_{0}^{y} \tan t\, dt\right) \sec y\, dy$ **(c)** $s \approx 2.08$

(b)



9. $4\pi\sqrt{5}$ **11.** $3\pi\sqrt{5}$ **13.** $98\pi/81$ **15.** 2π

17. $\pi(\sqrt{8} - 1)/9$ **19.** $35\pi\sqrt{5}/3$ **21.** $(2\pi/3)(2\sqrt{2} - 1)$

23. $253\pi/20$ **27.** Order 226.2 liters of each color.

SECTION 6.5, pp. 349–353

1. 116 J **3.** 400 N/m **5.** 4 cm, 0.08 J

7. **(a)** 7238 lb/in. **(b)** 905 in.-lb, 2714 in.-lb

9. 780 J **11.** 72,900 ft-lb **13.** 490 J

15. **(a)** 1,497,600 ft-lb **(b)** 1 hr, 40 min

(d) At 62.26 lb/ft^3: a) 1,494,240 ft-lb b) 1 hr, 40 min

At 62.59 lb/ft^3: a) 1,502,160 ft-lb b) 1 hr, 40.1 min

17. 37,306 ft-lb **19.** 7,238,299.47 ft-lb **21.** 2446.25 ft-lb

23. 15,073,099.75 J **27.** 85.1 ft-lb **29.** 151.3 J

31. 91.32 in.-oz **33.** 5.144×10^{10} J **35.** 1684.8 lb

37. **(a)** 6364.8 lb **(b)** 5990.4 lb **39.** 1164.8 lb **41.** 1309 lb

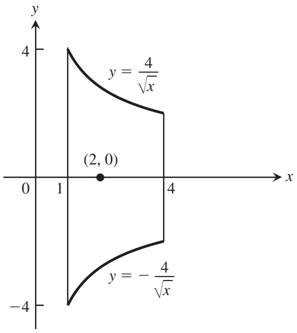
43. **(a)** 12,480 lb **(b)** 8580 lb **(c)** 9722.3 lb

45. **(a)** 93.33 lb **(b)** 3 ft **47.** $\frac{wb}{2}$

49. No. The tank will overflow because the movable end will have moved only $3\frac{1}{3}$ ft by the time the tank is full.

SECTION 6.6, pp. 363–365

1. $M = 14/3,\ \bar{x} = 93/35$ **3.** $M = \ln 4,\ \bar{x} = (3 - \ln 4)/(\ln 4)$
5. $M = 13,\ \bar{x} = 41/26$ **7.** $\bar{x} = 0,\ \bar{y} = 12/5$
9. $\bar{x} = 1,\ \bar{y} = -3/5$ **11.** $\bar{x} = 16/105,\ \bar{y} = 8/15$
13. $\bar{x} = 0,\ \bar{y} = \pi/8$ **15.** **(a)** $(4/\pi, 4/\pi)$ **(b)** $(0, 4/\pi)$
17. $\bar{x} = 7,\ \bar{y} = \dfrac{\ln 16}{12}$
19. $\bar{x} = 5/7,\ \bar{y} = 10/33$. $(\bar{x})^4 < \bar{y}$, so the center of mass is outside the region.
21. $\bar{x} = 3/2,\ \bar{y} = 1/2$
23. **(a)** $\dfrac{224\pi}{3}$ **(b)** $\bar{x} = 2,\ \bar{y} = 0$
(c)



27. $\bar{x} = \bar{y} = 1/3$ **29.** $\bar{x} = a/3,\ \bar{y} = b/3$ **31.** $13\delta/6$
33. $\bar{x} = 0,\ \bar{y} = \dfrac{a\pi}{4}$ **35.** $\bar{x} = 1/2,\ \bar{y} = 4$
37. $\bar{x} = 6/5,\ \bar{y} = 8/7$ **39.** $V = 32\pi,\ S = 32\sqrt{2}\pi$ **43.** $4\pi^2$
45. $\bar{x} = 0,\ \bar{y} = \dfrac{2a}{\pi}$ **47.** $\bar{x} = 0,\ \bar{y} = \dfrac{4b}{3\pi}$
49. $\sqrt{2}\pi a^3(4 + 3\pi)/6$ **51.** $\bar{x} = \dfrac{a}{3},\ \bar{y} = \dfrac{b}{3}$

PRACTICE EXERCISES, pp. 366–368

1. $\dfrac{9\pi}{280}$ **3.** π^2 **5.** $\dfrac{72\pi}{35}$
7. **(a)** 2π **(b)** π **(c)** $12\pi/5$ **(d)** $26\pi/5$
9. **(a)** 8π **(b)** $1088\pi/15$ **(c)** $512\pi/15$
11. $\pi\left(3\sqrt{3} - \pi\right)/3$
13. **(a)** $16\pi/15$ **(b)** $8\pi/5$ **(c)** $8\pi/3$ **(d)** $32\pi/5$
15. $\dfrac{28\pi}{3}$ ft^3 **17.** $(\pi/3)(a^2 + ab + b^2)h$ **19.** $\dfrac{10}{3}$ **21.** $\dfrac{285}{5}$
23. $28\pi\sqrt{2}/3$ **25.** 4π **27.** 4640 J
29. $\dfrac{w}{2}(2ar - a^2)$ **31.** 418,208.81 ft-lb
33. $22{,}500\pi$ ft-lb, 257 sec **35.** **(a)** 128 ft-lb **(b)** 219.6 ft-lb
37. $\bar{x} = 0,\ \bar{y} = 8/5$ **39.** $\bar{x} = 3/2,\ \bar{y} = 12/5$
41. $\bar{x} = 9/5,\ \bar{y} = 11/10$ **43.** 332.8 lb **45.** 2196.48 lb

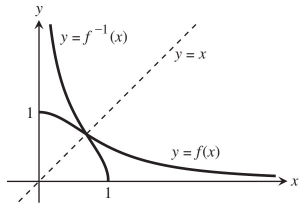
ADDITIONAL AND ADVANCED EXERCISES, pp. 368–369

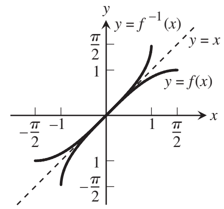
1. $f(x) = \sqrt{\dfrac{2x - a}{\pi}}$ **3.** $f(x) = \sqrt{C^2 - 1}\,x + a$, where $C \ge 1$
5. $\dfrac{\pi}{30\sqrt{2}}$ **7.** $28/3$ **9.** $\dfrac{4h\sqrt{3mh}}{3}$
11. $\bar{x} = 0,\ \bar{y} = \dfrac{n}{2n + 1}$, $(0, 1/2)$
15. **(a)** $\bar{x} = \bar{y} = 4(a^2 + ab + b^2)/(3\pi(a + b))$
(b) $(2a/\pi, 2a/\pi)$
17. ≈ 2329.6 lb

Chapter 7

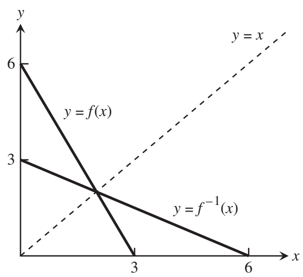
SECTION 7.1, pp. 376–378

1. One-to-one **3.** Not one-to-one **5.** One-to-one
7. Not one-to-one **9.** One-to-one
11. D: $(0, 1]$ R: $[0, \infty)$ **13.** D: $[-1, 1]$ R: $[-\pi/2, \pi/2]$

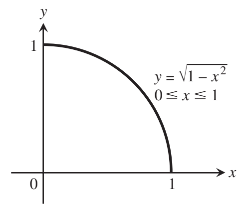




15. D: $[0, 6]$ R: $[0, 3]$

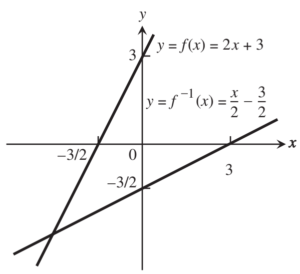


17. **(a)** Symmetric about the line $y = x$



19. $f^{-1}(x) = \sqrt{x - 1}$ **21.** $f^{-1}(x) = \sqrt[3]{x + 1}$
23. $f^{-1}(x) = \sqrt{x} - 1$
25. $f^{-1}(x) = \sqrt[5]{x}$; domain: $-\infty < x < \infty$; range: $-\infty < y < \infty$
27. $f^{-1}(x) = 5\sqrt{x - 1}$; domain: $-\infty < x < \infty$; range: $-\infty < y < \infty$
29. $f^{-1}(x) = \dfrac{1}{\sqrt{x}}$; domain: $x > 0$; range: $y > 0$
31. $f^{-1}(x) = \dfrac{2x + 3}{x - 1}$; domain: $-\infty < x < \infty,\ x \ne 1$; range: $-\infty < y < \infty,\ y \ne 2$
33. $f^{-1}(x) = 1 - \sqrt{x + 1}$; domain: $-1 \le x < \infty$; range: $-\infty < y \le 1$
35. **(a)** $f^{-1}(x) = \dfrac{x}{2} - \dfrac{3}{2}$

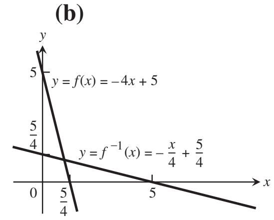
(b)



(c) 2, 1/2

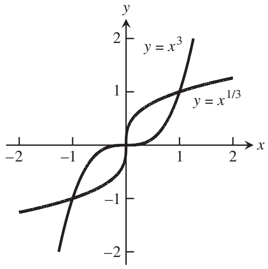
37. **(a)** $f^{-1}(x) = -\dfrac{x}{4} + \dfrac{5}{4}$

(b)



(c) $-4, -1/4$

39. (b)



(c) Slope of f at $(1, 1)$: 3; slope of g at $(1, 1)$: $1/3$; slope of f at $(-1, -1)$: 3; slope of g at $(-1, -1)$: $1/3$

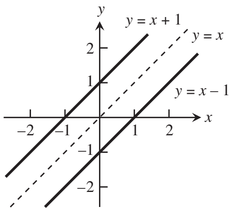
(d) $y = 0$ is tangent to $y = x^3$ at $x = 0$; $x = 0$ is tangent to $y = \sqrt[3]{x}$ at $x = 0$.

41. $1/9$ **43.** 3

45. (a) $f^{-1}(x) = \frac{1}{m}x$

(b) The graph of f^{-1} is the line through the origin with slope $1/m$.

47. (a) $f^{-1}(x) = x - 1$



(b) $f^{-1}(x) = x - b$. The graph of f^{-1} is a line parallel to the graph of f. The graphs of f and f^{-1} lie on opposite sides of the line $y = x$ and are equidistant from that line.

(c) Their graphs will be parallel to one another and lie on opposite sides of the line $y = x$ equidistant from that line.

51. Increasing, therefore one-to-one; $df^{-1}/dx = \frac{1}{9}x^{-2/3}$

53. Decreasing, therefore one-to-one; $df^{-1}/dx = -\frac{1}{3}x^{-2/3}$

SECTION 7.2, pp. 385–386

1. (a) $\ln 3 - 2\ln 2$ **(b)** $2(\ln 2 - \ln 3)$ **(c)** $-\ln 2$
(d) $\frac{2}{3}\ln 3$ **(e)** $\ln 3 + \frac{1}{2}\ln 2$ **(f)** $\frac{1}{2}(3\ln 3 - \ln 2)$

3. (a) $\ln 5$ **(b)** $\ln(x - 3)$ **(c)** $\ln(t^2)$

5. $t = e^2/(e^2 - 1)$ **7.** $1/x$ **9.** $2/t$ **11.** $-1/x$

13. $\dfrac{1}{\theta + 1}$ **15.** $3/x$ **17.** $2(\ln t) + (\ln t)^2$ **19.** $x^3 \ln x$

21. $\dfrac{1 - \ln t}{t^2}$ **23.** $\dfrac{1}{x(1 + \ln x)^2}$ **25.** $\dfrac{1}{x \ln x}$ **27.** $2\cos(\ln\theta)$

29. $-\dfrac{3x + 2}{2x(x + 1)}$ **31.** $\dfrac{2}{t(1 - \ln t)^2}$ **33.** $\dfrac{\tan(\ln\theta)}{\theta}$

35. $\dfrac{10x}{x^2 + 1} + \dfrac{1}{2(1 - x)}$ **37.** $2x\ln|x| - x\ln\dfrac{|x|}{\sqrt{2}}$

39. $\ln\left(\dfrac{2}{3}\right)$ **41.** $\ln|y^2 - 25| + C$ **43.** $\ln 3$

45. $(\ln 2)^2$ **47.** $\dfrac{1}{\ln 4}$ **49.** $\ln|6 + 3\tan t| + C$

51. $\ln 2$ **53.** $\ln 27$ **55.** $\ln(1 + \sqrt{x}) + C$

57. $\left(\dfrac{1}{2}\right)\sqrt{x(x + 1)}\left(\dfrac{1}{x} + \dfrac{1}{x + 1}\right) = \dfrac{2x + 1}{2\sqrt{x(x + 1)}}$

59. $\left(\dfrac{1}{2}\right)\sqrt{\dfrac{t}{t + 1}}\left(\dfrac{1}{t} - \dfrac{1}{t + 1}\right) = \dfrac{1}{2\sqrt{t}(t + 1)^{3/2}}$

61. $\sqrt{\theta + 3}(\sin\theta)\left(\dfrac{1}{2(\theta + 3)} + \cot\theta\right)$

63. $t(t + 1)(t + 2)\left[\dfrac{1}{t} + \dfrac{1}{t + 1} + \dfrac{1}{t + 2}\right] = 3t^2 + 6t + 2$

65. $\dfrac{\theta + 5}{\theta\cos\theta}\left[\dfrac{1}{\theta + 5} - \dfrac{1}{\theta} + \tan\theta\right]$

67. $\dfrac{x\sqrt{x^2 + 1}}{(x + 1)^{2/3}}\left[\dfrac{1}{x} + \dfrac{x}{x^2 + 1} - \dfrac{2}{3(x + 1)}\right]$

69. $\dfrac{1}{3}\sqrt[3]{\dfrac{x(x - 2)}{x^2 + 1}}\left(\dfrac{1}{x} + \dfrac{1}{x - 2} - \dfrac{2x}{x^2 + 1}\right)$

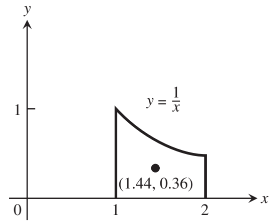
71. (a) Max $= 0$ at $x = 0$, min $= -\ln 2$ at $x = \pi/3$
(b) Max $= 1$ at $x = 1$, min $= \cos(\ln 2)$ at $x = 1/2$ and $x = 2$

73. $\ln 16$ **75. (a)** Increasing on $(0, e^{-2})$ and $(1, \infty)$; decreasing on $(e^{-2}, 1)$ **(b)** local maximum is $4/e^2$ at $x = e^{-2}$; absolute minimum is 0 at $x = 1$; no absolute maximum **77.** $4\pi\ln 4$

79. $\pi\ln 16$ **81. (a)** $6 + \ln 2$ **(b)** $8 + \ln 9$

83. (a) $\bar{x} \approx 1.44$, $\bar{y} \approx 0.36$

(b)



87. $y = x + \ln|x| + 2$ **89. (b)** 0.00469

SECTION 7.3, pp. 394–397

1. (a) $t = -10\ln 3$ **(b)** $t = -\dfrac{\ln 2}{k}$ **(c)** $t = \dfrac{\ln .4}{\ln .2}$

3. $4(\ln x)^2$ **5.** $\ln 3$ **7.** $-5e^{-5x}$ **9.** $-7e^{(5-7x)}$ **11.** xe^x

13. x^2e^x **15.** $2e^{\theta}\cos\theta$ **17.** $2\theta e^{-\theta^2}\sin(e^{-\theta^2})$ **19.** $\dfrac{1 - t}{t}$

21. $1/(1 + e^{\theta})$ **23.** $e^{\cos t}(1 - t\sin t)$ **25.** $(\sin x)/x$

27. $\dfrac{ye^y\cos x}{1 - ye^y\sin x}$ **29.** $\dfrac{2e^{2x} - \cos(x + 3y)}{3\cos(x + 3y)}$

31. $y' = \dfrac{3x^2}{1 - \cos y}$, $y'' = \dfrac{6x(1 - \cos y)^2 - 9x^4\sin y}{(1 - \cos y)^3}$

33. $\frac{1}{3}e^{3x} - 5e^{-x} + C$ **35.** 1 **37.** $8e^{(x+1)} + C$

39. 2 **41.** $2e^{\sqrt{r}} + C$ **43.** $-e^{-t^2} + C$ **45.** $-e^{1/x} + C$

47. e **49.** $\dfrac{1}{\pi}e^{\sec\pi t} + C$ **51.** 1 **53.** $\ln(1 + e^r) + C$

55. $y = 1 - \cos(e^t - 2)$ **57.** $y = 2(e^{-x} + x) - 1$

59. $2^x\ln 2$ **61.** $\left(\dfrac{\ln 5}{2\sqrt{s}}\right)5^{\sqrt{s}}$ **63.** $\pi x^{(\pi-1)}$

65. $-\sqrt{2}\cos\theta^{(\sqrt{2}-1)}\sin\theta$ **67.** $7^{\sec\theta}(\ln 7)^2(\sec\theta\tan\theta)$

69. $(3\cos 3t)(2^{\sin 3t})\ln 2$ **71.** $\dfrac{1}{\theta\ln 2}$ **73.** $\dfrac{3}{x\ln 4}$

75. $\dfrac{x^2}{\ln 10} + 3x^2 \log_{10} x$ **77.** $\dfrac{-2}{(x+1)(x-1)}$

79. $\sin(\log_7 \theta) + \dfrac{1}{\ln 7}\cos(\log_7 \theta)$ **81.** $\dfrac{1}{\ln 10}$

83. $\dfrac{1}{t}(\log_2 3)3^{\log_2 t}$ **85.** $\dfrac{1}{t}$ **87.** $\dfrac{5^x}{\ln 5} + C$ **89.** $\dfrac{1}{2\ln 2}$

91. $\dfrac{1}{\ln 2}$ **93.** $\dfrac{6}{\ln 7}$ **95.** 32760 **97.** $\dfrac{3x^{(\sqrt{3}+1)}}{\sqrt{3}+1} + C$

99. $3^{\sqrt{2}+1}$ **101.** $\dfrac{1}{\ln 10}\left(\dfrac{(\ln x)^2}{2}\right) + C$ **103.** $2(\ln 2)^2$

105. $\dfrac{3\ln 2}{2}$ **107.** $\ln 10$ **109.** $(\ln 10)\ln|\ln x| + C$

111. $\ln(\ln x), x > 1$ **113.** $-\ln x$

115. $(x+1)^x\left(\dfrac{x}{x+1} + \ln(x+1)\right)$ **117.** $(\sqrt{t})^t\left(\dfrac{\ln t}{2} + \dfrac{1}{2}\right)$

119. $(\sin x)^x(\ln \sin x + x\cot x)$ **121.** $\cos x^x \cdot x^x(1 + \ln x)$

123. $\dfrac{3y - xy\ln y}{x^2 - x}$ **125.** $\dfrac{1 - xy\ln y}{x^2(1 + \ln y)}$ **127.** $(1 + \ln t)^2$

129. Maximum: 1 at $x = 0$, minimum: $2 - 2\ln 2$ at $x = \ln 2$

131. **(a)** Abs max: $\dfrac{1}{e}$ at $x = 1$ **(b)** $\left(2, \dfrac{2}{e^2}\right)$

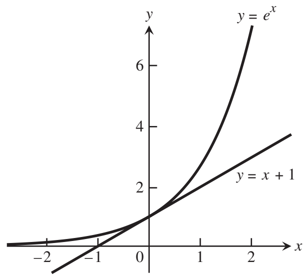
133. Abs max of $1/(2e)$ assumed at $x = 1/\sqrt{e}$ **135.** 2

137. $y = e^{x/2} - 1$ **139.** $\dfrac{e^2 - 1}{2e}$ **141.** $\ln(\sqrt{2} + 1)$

143. **(a)** $\dfrac{d}{dx}(x\ln x - x + C) = x \cdot \dfrac{1}{x} + \ln x - 1 + 0 = \ln x$

(b) $\dfrac{1}{e - 1}$

145. **(b)** $|\text{error}| \approx 0.02140$
(c) $L(x) = x + 1$ never overestimates e^x.



147. $2\ln 5$ **149.** **(a)** $4 + \ln 2$ **(b)** $\left(\dfrac{1}{2}\right)(4 + \ln 2)$

151. $x \approx -0.76666$
153. **(a)** $L(x) = 1 + (\ln 2)x \approx 0.69x + 1$

SECTION 7.4, pp. 405–407

9. $\dfrac{2}{3}y^{3/2} - x^{1/2} = C$ **11.** $e^y - e^x = C$

13. $-x + 2\tan\sqrt{y} = C$ **15.** $e^{-y} + 2e^{\sqrt{x}} = C$

17. $y = \sin(x^2 + C)$ **19.** $\dfrac{1}{3}\ln|y^3 - 2| = x^3 + C$

21. $4\ln\left(\sqrt{y} + 2\right) = e^{x^2} + C$

23. **(a)** -0.00001 **(b)** 10,536 years **(c)** 82%
25. 54.88 g **27.** 59.8 ft **29.** 2.8147498×10^{14}
31. **(a)** 8 years **(b)** 32.02 years **33.** Yes, $y(20) < 1$
35. 15.28 years **37.** 56,562 years

41. **(a)** 17.5 min **(b)** 13.26 min
43. -3°C **45.** About 6693 years **47.** 54.62%
49. $\approx$15,683 years

SECTION 7.5, pp. 414–415

1. $-1/4$ **3.** $5/7$ **5.** $1/2$ **7.** $1/4$ **9.** $-23/7$
11. $5/7$ **13.** 0 **15.** -16 **17.** -2 **19.** $1/4$

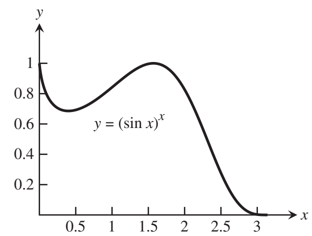
21. 2 **23.** 3 **25.** -1 **27.** $\ln 3$ **29.** $\dfrac{1}{\ln 2}$ **31.** $\ln 2$

33. 1 **35.** $1/2$ **37.** $\ln 2$ **39.** $-\infty$ **41.** $-1/2$
43. -1 **45.** 1 **47.** 0 **49.** 2 **51.** $1/e$ **53.** 1
55. $1/e$ **57.** $e^{1/2}$ **59.** 1 **61.** e^3 **63.** 0 **65.** $+1$
67. 3 **69.** 1 **71.** 0 **73.** ∞ **75.** **(b)** is correct.

77. **(d)** is correct. **79.** $c = \dfrac{27}{10}$ **81.** **(b)** $\dfrac{-1}{2}$ **83.** -1

87. **(a)** $y = 1$ **(b)** $y = 0, y = \dfrac{3}{2}$

89. **(a)** We should assign the value 1 to $f(x) = (\sin x)^x$ to make it continuous at $x = 0$.



(c) The maximum value of $f(x)$ is close to 1 near the point $x \approx 1.55$ (see the graph in part (a)).

SECTION 7.6, pp. 424–428

1. **(a)** $\pi/4$ **(b)** $-\pi/3$ **(c)** $\pi/6$
3. **(a)** $-\pi/6$ **(b)** $\pi/4$ **(c)** $-\pi/3$
5. **(a)** $\pi/3$ **(b)** $3\pi/4$ **(c)** $\pi/6$
7. **(a)** $3\pi/4$ **(b)** $\pi/6$ **(c)** $2\pi/3$
9. $1/\sqrt{2}$ **11.** $-1/\sqrt{3}$ **13.** $\pi/2$ **15.** $\pi/2$ **17.** $\pi/2$

19. 0 **21.** $\dfrac{-2x}{\sqrt{1 - x^4}}$ **23.** $\dfrac{\sqrt{2}}{\sqrt{1 - 2t^2}}$

25. $\dfrac{1}{|2s + 1|\sqrt{s^2 + s}}$ **27.** $\dfrac{-2x}{(x^2 + 1)\sqrt{x^4 + 2x^2}}$

29. $\dfrac{-1}{\sqrt{1 - t^2}}$ **31.** $\dfrac{-1}{2\sqrt{t}(1 + t)}$ **33.** $\dfrac{1}{(\tan^{-1}x)(1 + x^2)}$

35. $\dfrac{-e^t}{|e^t|\sqrt{(e^t)^2 - 1}} = \dfrac{-1}{\sqrt{e^{2t} - 1}}$ **37.** $\dfrac{-2s^n}{\sqrt{1 - s^2}}$ **39.** 0

41. $\sin^{-1}x$ **43.** 0 **45.** $\dfrac{8\sqrt{2}}{4 + 3\pi}$ **47.** $\sin^{-1}\dfrac{x}{3} + C$

49. $\dfrac{1}{\sqrt{17}}\tan^{-1}\dfrac{x}{\sqrt{17}} + C$ **51.** $\dfrac{1}{\sqrt{2}}\sec^{-1}\left|\dfrac{5x}{\sqrt{2}}\right| + C$

53. $2\pi/3$ **55.** $\pi/16$ **57.** $-\pi/12$

59. $\dfrac{3}{2}\sin^{-1}2(r - 1) + C$ **61.** $\dfrac{\sqrt{2}}{2}\tan^{-1}\left(\dfrac{x - 1}{\sqrt{2}}\right) + C$

63. $\dfrac{1}{4}\sec^{-1}\left|\dfrac{2x - 1}{2}\right| + C$ **65.** π **67.** $\pi/12$

69. $\frac{1}{2}\sin^{-1} y^2 + C$ **71.** $\sin^{-1}(x - 2) + C$ **73.** π

75. $\frac{1}{2}\tan^{-1}\left(\frac{y-1}{2}\right) + C$ **77.** 2π

79. $\frac{1}{2}\ln(x^2 + 4) + 2\tan^{-1}\frac{x}{2} + C$

81. $x + \ln(x^2 + 9) - \frac{10}{3}\tan^{-1}\frac{x}{3} + C$

83. $\sec^{-1}|x + 1| + C$ **85.** $e^{\sin^{-1} x} + C$

87. $\frac{1}{3}(\sin^{-1} x)^3 + C$ **89.** $\ln|\tan^{-1} y| + C$ **91.** $\sqrt{3} - 1$

93. $\frac{2}{3}\tan^{-1}\left(\frac{\tan^{-1}\sqrt{x}}{3}\right) + C$ **95.** $\pi^2/32$ **97.** 5

99. 2 **101.** 1 **103.** 1 **109.** $y = \sin^{-1} x$

111. $y = \sec^{-1} x + \frac{2\pi}{3}, x > 1$ **113.** **(b)** $x = 3\sqrt{5}$

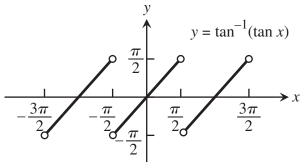
115. $\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right) \approx 54.7°$

127. $\pi^2/2$ **129.** **(a)** $\pi^2/2$ **(b)** 2π

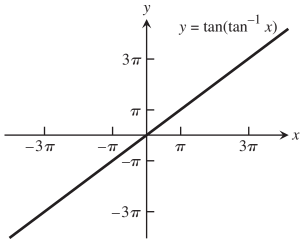
131. **(a)** 0.84107 **(b)** -0.72973 **(c)** 0.46365

133. **(a)** Domain: all real numbers except those having the form $\frac{\pi}{2} + k\pi$, where k is an integer

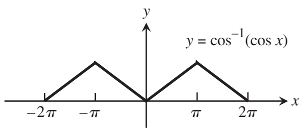
Range: $-\frac{\pi}{2} < y < \frac{\pi}{2}$



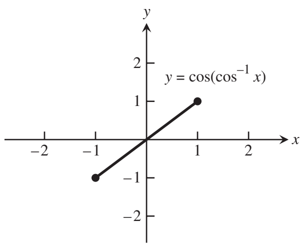
(b) Domain: $-\infty < x < \infty$; Range: $-\infty < y < \infty$



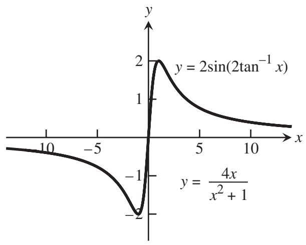
135. **(a)** Domain: $-\infty < x < \infty$;
Range: $0 \le y \le \pi$



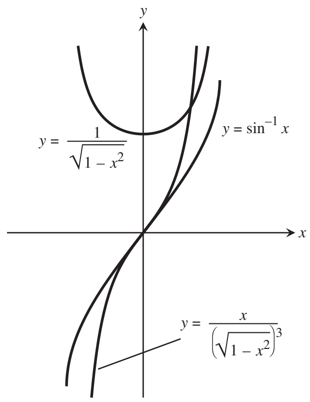
(b) Domain: $-1 \le x \le 1$;
Range: $-1 \le y \le 1$



137. The graphs are identical.



139.



SECTION 7.7, pp. 433–436

1. $\cosh x = 5/4, \tanh x = -3/5, \coth x = -5/3, \operatorname{sech} x = 4/5, \operatorname{csch} x = -4/3$

3. $\sinh x = 8/15, \tanh x = 8/17, \coth x = 17/8, \operatorname{sech} x = 15/17, \operatorname{csch} x = 15/8$

5. $x + \frac{1}{x}$ **7.** e^{5x} **9.** e^{4x} **13.** $2\cosh\frac{x}{3}$

15. $\operatorname{sech}^2\sqrt{t} + \frac{\tanh\sqrt{t}}{\sqrt{t}}$ **17.** $\coth z$

19. $(\ln \operatorname{sech}\theta)(\operatorname{sech}\theta \tanh\theta)$ **21.** $\tanh^3 v$ **23.** 2

25. $\frac{1}{2\sqrt{x(1 + x)}}$ **27.** $\frac{1}{1 + \theta} - \tanh^{-1}\theta$

29. $\frac{1}{2\sqrt{t}} - \coth^{-1}\sqrt{t}$ **31.** $-\operatorname{sech}^{-1} x$ **33.** $\frac{\ln 2}{\sqrt{1 + \left(\frac{1}{2}\right)^{2\theta}}}$

35. $|\sec x|$ **41.** $\frac{\cosh 2x}{2} + C$ **43.** $12\sinh\left(\frac{x}{2} - \ln 3\right) + C$

45. $7\ln|e^{x/7} + e^{-x/7}| + C$ **47.** $\tanh\left(x - \frac{1}{2}\right) + C$

49. $-2\operatorname{sech}\sqrt{t} + C$ **51.** $\ln\frac{5}{2}$ **53.** $\frac{3}{32} + \ln 2$

55. $e - e^{-1}$ **57.** $3/4$ **59.** $\frac{3}{8} + \ln\sqrt{2}$

61. $\ln(2/3)$ **63.** $\frac{-\ln 3}{2}$ **65.** $\ln 3$

67. **(a)** $\sinh^{-1}(\sqrt{3})$ **(b)** $\ln(\sqrt{3} + 2)$

69. **(a)** $\coth^{-1}(2) - \coth^{-1}(5/4)$ **(b)** $\left(\frac{1}{2}\right)\ln\left(\frac{1}{3}\right)$

71. **(a)** $-\operatorname{sech}^{-1}\left(\frac{12}{13}\right) + \operatorname{sech}^{-1}\left(\frac{4}{5}\right)$

(b) $-\ln\left(\frac{1 + \sqrt{1 - (12/13)^2}}{(12/13)}\right) + \ln\left(\frac{1 + \sqrt{1 - (4/5)^2}}{(4/5)}\right)$

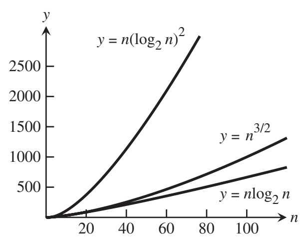
$= -\ln\left(\frac{3}{2}\right) + \ln(2) = \ln(4/3)$

73. **(a)** 0 **(b)** 0

77. **(b)** $\sqrt{\frac{mg}{k}}$ **(c)** $80\sqrt{5} \approx 178.89$ ft/sec **79.** 2π **81.** $\frac{6}{5}$

SECTION 7.8, pp. 440–441

1. **(a)** Slower **(b)** Slower **(c)** Slower **(d)** Faster **(e)** Slower **(f)** Slower **(g)** Same **(h)** Slower
3. **(a)** Same **(b)** Faster **(c)** Same **(d)** Same **(e)** Slower **(f)** Faster **(g)** Slower **(h)** Same
5. **(a)** Same **(b)** Same **(c)** Same **(d)** Faster **(e)** Faster **(f)** Same **(g)** Slower **(h)** Faster
7. d, a, c, b
9. **(a)** False **(b)** False **(c)** True **(d)** True **(e)** True **(f)** True **(g)** False **(h)** True
13. When the degree of f is less than or equal to the degree of g.
15. 1, 1
21. **(b)** $\ln(e^{17000000}) = 17{,}000{,}000 < (e^{17\times10^6})^{1/10^6} = e^{17} \approx 24{,}154{,}952.75$
(c) $x \approx 3.4306311 \times 10^{15}$
(d) They cross at $x \approx 3.4306311 \times 10^{15}$.
23. **(a)** The algorithm that takes $O(n\log_2 n)$ steps
(b)



25. It could take one million for a sequential search; at most 20 steps for a binary search.

PRACTICE EXERCISES, pp. 442–444

1. $-2e^{-x/5}$ **3.** xe^{4x} **5.** $\dfrac{2\sin\theta\cos\theta}{\sin^2\theta} = 2\cot\theta$ **7.** $\dfrac{2}{(\ln 2)x}$

9. $-8^{-t}(\ln 8)$ **11.** $18x^{2.6}$

13. $(x+2)^{x+2}(\ln(x+2)+1)$ **15.** $-\dfrac{1}{\sqrt{1-u^2}}$

17. $\dfrac{-1}{\sqrt{1-x^2}\cos^{-1}x}$ **19.** $\tan^{-1}(t) + \dfrac{t}{1+t^2} - \dfrac{1}{2t}$

21. $\dfrac{1-z}{\sqrt{z^2-1}} + \sec^{-1}z$ **23.** -1

25. $\dfrac{2(x^2+1)}{\sqrt{\cos 2x}}\left[\dfrac{2x}{x^2+1} + \tan 2x\right]$

27. $5\left[\dfrac{(t+1)(t-1)}{(t-2)(t+3)}\right]^5\left[\dfrac{1}{t+1} + \dfrac{1}{t-1} - \dfrac{1}{t-2} - \dfrac{1}{t+3}\right]$

29. $\dfrac{1}{\sqrt{\theta}}(\sin\theta)^{\sqrt{\theta}}\left(\dfrac{\ln\sqrt{\sin\theta}}{2} + \theta\cot\theta\right)$ **31.** $-\cos e^x + C$

33. $\tan(e^x - 7) + C$ **35.** $e^{\tan x} + C$ **37.** $\dfrac{-\ln 7}{3}$

39. $\ln 8$ **41.** $\ln(9/25)$ **43.** $-[\ln|\cos(\ln v)|] + C$

45. $-\dfrac{1}{2}(\ln x)^{-2} + C$ **47.** $-\cot(1+\ln r) + C$

49. $\dfrac{1}{2\ln 3}(3^{x^2}) + C$ **51.** $3\ln 7$ **53.** $15/16 + \ln 2$

55. $e - 1$ **57.** $1/6$ **59.** $9/14$

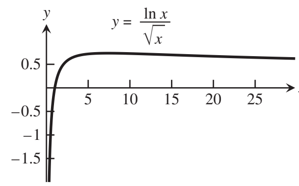
61. $\dfrac{1}{3}[(\ln 4)^3 - (\ln 2)^3]$ or $\dfrac{7}{3}(\ln 2)^3$ **63.** $\dfrac{9\ln 2}{4}$ **65.** π

67. $\pi/\sqrt{3}$ **69.** $\sec^{-1}|2y| + C$ **71.** $\pi/12$

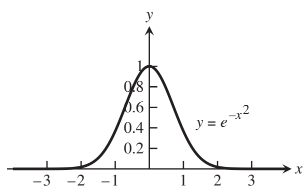
73. $\sin^{-1}(x+1) + C$ **75.** $\pi/2$ **77.** $\dfrac{1}{3}\sec^{-1}\left(\dfrac{t+1}{3}\right) + C$

79. $y = \dfrac{\ln 2}{\ln(3/2)}$ **81.** $y = \ln x - \ln 3$ **83.** $y = \dfrac{1}{1-e^x}$

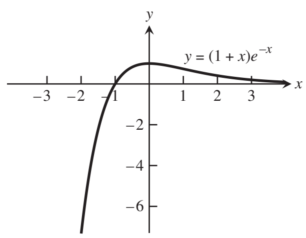
85. 5 **87.** 0 **89.** 1 **91.** $3/7$ **93.** 0 **95.** 1
97. $\ln 10$ **99.** $\ln 2$ **101.** 5 **103.** $-\infty$ **105.** 1
107. 1 **109.** **(a)** Same rate **(b)** Same rate **(c)** Faster **(d)** Faster **(e)** Same rate **(f)** Same rate
111. **(a)** True **(b)** False **(c)** False **(d)** True **(e)** True **(f)** True
113. $1/3$
115. Absolute maximum $= 0$ at $x = e/2$, absolute minimum $= -0.5$ at $x = 0.5$
117. 1
119. $1/e$ m/sec
121. $1/\sqrt{2}$ units long by $1/\sqrt{e}$ units high, $A = 1/\sqrt{2e} \approx 0.43$ units^2
123. **(a)** Absolute maximum of $2/e$ at $x = e^2$; inflection point $(e^{8/3}, (8/3)e^{-4/3})$; concave up on $(e^{8/3}, \infty)$; concave down on $(0, e^{8/3})$



(b) Absolute maximum of 1 at $x = 0$; inflection points $(\pm 1/\sqrt{2}, 1/\sqrt{e})$; concave up on $(-\infty, -1/\sqrt{2}) \cup (1/\sqrt{2}, \infty)$; concave down on $(-1/\sqrt{2}, 1/\sqrt{2})$



(c) Absolute maximum of 1 at $x = 0$; inflection point $(1, 2/e)$; concave up on $(1, \infty)$; concave down on $(-\infty, 1)$



125. $y = \left(\tan^{-1}\left(\dfrac{x+C}{2}\right)\right)^2$ **127.** $y^2 = \sin^{-1}(2\tan x + C)$

129. $y = -2 + \ln(2 - e^{-x})$ **131.** $y = 4x - 4\sqrt{x} + 1$

133. 18,935 years **135.** $20(5 - \sqrt{17})$ m

ADDITIONAL AND ADVANCED EXERCISES, pp. 445–446

1. $\pi/2$ **3.** $1/\sqrt{e}$ **5.** $\ln 2$
7. **(a)** 1 **(b)** $\pi/2$ **(c)** π

9. $y' = \dfrac{x^{y-1}y^2 - ye^x(x^y+1)\ln y}{e^x(x^y+1) - x^y y\ln x}$ **11.** $\dfrac{1}{\ln 2}, \dfrac{1}{2\ln 2}, 2:1$

13. $x = 2$ **15.** $2/17$ **19.** $\bar{x} = \dfrac{\ln 4}{\pi}, \bar{y} = 0$ **21.** **(b)** 61°

Chapter 8

SECTION 8.1, pp. 451–452

1. $\ln 5$ **3.** $2\tan x - 2\sec x - x + C$
5. $\sin^{-1} x + \sqrt{1-x^2} + C$ **7.** $e^{-\cot z} + C$
9. $\tan^{-1}(e^z) + C$ **11.** π **13.** $t + \cot t + \csc t + C$
15. $\sqrt{2}$ **17.** $\frac{1}{8}\ln(1 + 4\ln^2 y) + C$
19. $\ln\lvert 1 + \sin\theta\rvert + C$ **21.** $2t^2 - t + 2\tan^{-1}\left(\frac{t}{2}\right) + C$
23. $2(\sqrt{2} - 1) \approx 0.82843$ **25.** $\sec^{-1}(e^y) + C$
27. $\sin^{-1}(2\ln x) + C$ **29.** $\ln\lvert\sin x\rvert + \ln\lvert\cos x\rvert + C$
31. $7 + \ln 8$ **33.** $\left(\sin^{-1} y - \sqrt{1-y^2}\right]_{-1}^{0} = \frac{\pi}{2} - 1$
35. $\sec^{-1}\left\lvert\frac{x-1}{7}\right\rvert + C$ **37.** $\frac{\theta^3}{3} - \frac{\theta^2}{2} + \theta + \frac{5}{2}\ln\lvert 2\theta - 5\rvert + C$
39. $x - \ln(1 + e^x) + C$ **41.** $(1/2)e^{2x} - e^x + \ln(1 + e^x) + C$
43. $2\arctan(\sqrt{x}) + \mathrm{C}$ **45.** $2\sqrt{2} - \ln(3 + 2\sqrt{2})$
47. $\ln(2 + \sqrt{3})$ **49.** $\bar{x} = 0,\quad \bar{y} = \dfrac{1}{\ln(3 + 2\sqrt{2})}$
51. $xe^{x^3} + C$ **53.** $\frac{1}{30}(x^4 + 1)^{3/2}(3x^4 - 2) + C$

SECTION 8.2, pp. 457–460

1. $-2x\cos(x/2) + 4\sin(x/2) + C$
3. $t^2\sin t + 2t\cos t - 2\sin t + C$
5. $\ln 4 - \frac{3}{4}$ **7.** $xe^x - e^x + C$
9. $-(x^2 + 2x + 2)e^{-x} + C$
11. $y\tan^{-1}(y) - \ln\sqrt{1+y^2} + C$
13. $x\tan x + \ln\lvert\cos x\rvert + C$
15. $(x^3 - 3x^2 + 6x - 6)e^x + C$ **17.** $(x^2 - 7x + 7)e^x + C$
19. $(x^5 - 5x^4 + 20x^3 - 60x^2 + 120x - 120)e^x + C$
21. $\frac{1}{2}(-e^\theta\cos\theta + e^\theta\sin\theta) + C$
23. $\frac{e^{2x}}{13}(3\sin 3x + 2\cos 3x) + C$
25. $\frac{2}{3}\left(\sqrt{3s+9}\,e^{\sqrt{3s+9}} - e^{\sqrt{3s+9}}\right) + C$
27. $\frac{\pi\sqrt{3}}{3} - \ln(2) - \frac{\pi^2}{18}$
29. $\frac{1}{2}[-x\cos(\ln x) + x\sin(\ln x)] + C$
31. $\frac{1}{2}\ln\lvert\sec x^2 + \tan x^2\rvert + C$
33. $\frac{1}{2}x^2(\ln x)^2 - \frac{1}{2}x^2\ln x + \frac{1}{4}x^2 + C$
35. $-\frac{1}{x}\ln x - \frac{1}{x} + C$ **37.** $\frac{1}{4}e^{x^4} + C$
39. $\frac{1}{3}x^2(x^2 + 1)^{3/2} - \frac{2}{15}(x^2 + 1)^{5/2} + C$
41. $-\frac{2}{5}\sin 3x\sin 2x - \frac{3}{5}\cos 3x\cos 2x + C$
43. $\frac{2}{9}x^{3/2}(3\ln x - 2) + C$
45. $2\sqrt{x}\sin\sqrt{x} + 2\cos\sqrt{x} + C$
47. $\frac{\pi^2 - 4}{8}$ **49.** $\frac{5\pi - 3\sqrt{3}}{9}$
51. $\frac{1}{2}(x^2 + 1)\tan^{-1} x - \frac{x}{2} + C$ **53.** $xe^{x^2} + C$
55. $(2/3)x^{3/2}\arcsin(\sqrt{x}) + (2/9)x\sqrt{1-x} + (4/9)\sqrt{1-x} + C$
57. **(a)** π **(b)** 3π **(c)** 5π **(d)** $(2n+1)\pi$
59. $2\pi(1 - \ln 2)$ **61.** **(a)** $\pi(\pi - 2)$ **(b)** 2π
63. **(a)** 1 **(b)** $(e - 2)\pi$ **(c)** $\frac{\pi}{2}(e^2 + 9)$
(d) $\bar{x} = \frac{1}{4}(e^2 + 1), \bar{y} = \frac{1}{2}(e - 2)$
65. $\frac{1}{2\pi}(1 - e^{-2\pi})$ **67.** $u = x^n, dv = \cos x\,dx$
69. $u = x^n, dv = e^{ax}\,dx$ **73.** $u = x^n, dv = (x + 1)^{-(1/2)}\,dx$
77. $x\sin^{-1} x + \cos(\sin^{-1} x) + C$
79. $x\sec^{-1} x - \ln\lvert x + \sqrt{x^2 - 1}\rvert + C$ **81.** Yes
83. **(a)** $x\sinh^{-1} x - \cosh(\sinh^{-1} x) + C$
(b) $x\sinh^{-1} x - (1 + x^2)^{1/2} + C$

SECTION 8.3, pp. 465–466

1. $\frac{1}{2}\sin 2x + C$ **3.** $-\frac{1}{4}\cos^4 x + C$
5. $\frac{1}{3}\cos^3 x - \cos x + C$ **7.** $-\cos x + \frac{2}{3}\cos^3 x - \frac{1}{5}\cos^5 x + C$
9. $\sin x - \frac{1}{3}\sin^3 x + C$ **11.** $\frac{1}{4}\sin^4 x - \frac{1}{6}\sin^6 x + C$
13. $\frac{1}{2}x + \frac{1}{4}\sin 2x + C$ **15.** $16/35$ **17.** 3π
19. $-4\sin x\cos^3 x + 2\cos x\sin x + 2x + C$
21. $-\cos^4 2\theta + C$ **23.** 4 **25.** 2
27. $\sqrt{\frac{3}{2}} - \frac{2}{3}$ **29.** $\frac{4}{5}\left(\frac{3}{2}\right)^{5/2} - \frac{18}{35} - \frac{2}{7}\left(\frac{3}{2}\right)^{7/2}$ **31.** $\sqrt{2}$
33. $\frac{1}{2}\tan^2 x + C$ **35.** $\frac{1}{3}\sec^3 x + C$ **37.** $\frac{1}{3}\tan^3 x + C$
39. $2\sqrt{3} + \ln(2 + \sqrt{3})$ **41.** $\frac{2}{3}\tan\theta + \frac{1}{3}\sec^2\theta\tan\theta + C$
43. $4/3$ **45.** $2\tan^2 x - 2\ln(1 + \tan^2 x) + C$
47. $\frac{1}{4}\tan^4 x - \frac{1}{2}\tan^2 x + \ln\lvert\sec x\rvert + C$ **49.** $\frac{4}{3} - \ln\sqrt{3}$
51. $-\frac{1}{10}\cos 5x - \frac{1}{2}\cos x + C$ **53.** π
55. $\frac{1}{2}\sin x + \frac{1}{14}\sin 7x + C$
57. $\frac{1}{6}\sin 3\theta - \frac{1}{4}\sin\theta - \frac{1}{20}\sin 5\theta + C$
59. $-\frac{2}{5}\cos^5\theta + C$ **61.** $\frac{1}{4}\cos\theta - \frac{1}{20}\cos 5\theta + C$
63. $\sec x - \ln\lvert\csc x + \cot x\rvert + C$ **65.** $\cos x + \sec x + C$
67. $\frac{1}{4}x^2 - \frac{1}{4}x\sin 2x - \frac{1}{8}\cos 2x + C$ **69.** $\ln(2 + \sqrt{3})$
71. $\pi^2/2$ **73.** $\bar{x} = \frac{4\pi}{3}, \bar{y} = \frac{8\pi^2 + 3}{12\pi}$ **75.** $(\pi/4)(4 - \pi)$

SECTION 8.4, pp. 470–471

1. $\ln\lvert\sqrt{9 + x^2} + x\rvert + C$ **3.** $\pi/4$ **5.** $\pi/6$
7. $\frac{25}{2}\sin^{-1}\left(\frac{t}{5}\right) + \frac{t\sqrt{25 - t^2}}{2} + C$
9. $\frac{1}{2}\ln\left\lvert\frac{2x}{7} + \frac{\sqrt{4x^2 - 49}}{7}\right\rvert + C$

11. $7\left[\dfrac{\sqrt{y^2-49}}{7} - \sec^{-1}\left(\dfrac{y}{7}\right)\right] + C$ **13.** $\dfrac{\sqrt{x^2-1}}{x} + C$

15. $-\sqrt{9-x^2} + C$ **17.** $\frac{1}{3}(x^2+4)^{3/2} - 4\sqrt{x^2+4} + C$

19. $\dfrac{-2\sqrt{4-w^2}}{w} + C$ **21.** $\sin^{-1} x - \sqrt{1-x^2} + C$

23. $4\sqrt{3} - \dfrac{4\pi}{3}$ **25.** $-\dfrac{x}{\sqrt{x^2-1}} + C$

27. $-\dfrac{1}{5}\left(\dfrac{\sqrt{1-x^2}}{x}\right)^5 + C$ **29.** $2\tan^{-1}2x + \dfrac{4x}{(4x^2+1)} + C$

31. $\frac{1}{2}x^2 + \frac{1}{2}\ln|x^2-1| + C$ **33.** $\dfrac{1}{3}\left(\dfrac{v}{\sqrt{1-v^2}}\right)^3 + C$

35. $\ln 9 - \ln\left(1+\sqrt{10}\right)$ **37.** $\pi/6$ **39.** $\sec^{-1}|x| + C$

41. $\sqrt{x^2-1} + C$ **43.** $\frac{1}{2}\ln\left|\sqrt{1+x^4} + x^2\right| + C$

45. $4\sin^{-1}\dfrac{\sqrt{x}}{2} + \sqrt{x}\sqrt{4-x} + C$

47. $\frac{1}{4}\sin^{-1}\sqrt{x} - \frac{1}{4}\sqrt{x}\sqrt{1-x}\,(1-2x) + C$

49. $(9/2)\arcsin\left(\dfrac{x+1}{3}\right) + (1/2)(x+1)\sqrt{8-2x-x^2} + C$

51. $\sqrt{x^2+4x+3} - \operatorname{arcsec}(x+2) + C$

53. $y = 2\left[\dfrac{\sqrt{x^2-4}}{2} - \sec^{-1}\left(\dfrac{x}{2}\right)\right]$

55. $y = \dfrac{3}{2}\tan^{-1}\left(\dfrac{x}{2}\right) - \dfrac{3\pi}{8}$ **57.** $3\pi/4$

59. (a) $\dfrac{1}{12}(\pi + 6\sqrt{3} - 12)$

(b) $\bar{x} = \dfrac{3\sqrt{3}-\pi}{4(\pi+6\sqrt{3}-12)}$, $\bar{y} = \dfrac{\pi^2+12\sqrt{3}\pi-72}{12(\pi+6\sqrt{3}-12)}$

61. (a) $-\frac{1}{3}x^2(1-x^2)^{3/2} - \frac{2}{15}(1-x^2)^{5/2} + C$

(b) $-\frac{1}{3}(1-x^2)^{3/2} + \frac{1}{5}(1-x^2)^{5/2} + C$

(c) $\frac{1}{5}(1-x^2)^{5/2} - \frac{1}{3}(1-x^2)^{3/2} + C$

63. $\sqrt{3} - \dfrac{\sqrt{2}}{2} + \dfrac{1}{2}\ln\left(\dfrac{2+\sqrt{3}}{\sqrt{2}+1}\right)$

SECTION 8.5, pp. 477–479

1. $\dfrac{2}{x-3} + \dfrac{3}{x-2}$ **3.** $\dfrac{1}{x+1} + \dfrac{3}{(x+1)^2}$

5. $\dfrac{-2}{z} + \dfrac{-1}{z^2} + \dfrac{2}{z-1}$ **7.** $1 + \dfrac{17}{t-3} + \dfrac{-12}{t-2}$

9. $\frac{1}{2}[\ln|1+x| - \ln|1-x|] + C$

11. $\frac{1}{7}\ln|(x+6)^2(x-1)^5| + C$ **13.** $(\ln 15)/2$

15. $-\frac{1}{2}\ln|t| + \frac{1}{6}\ln|t+2| + \frac{1}{3}\ln|t-1| + C$ **17.** $3\ln 2 - 2$

19. $\dfrac{1}{4}\ln\left|\dfrac{x+1}{x-1}\right| - \dfrac{x}{2(x^2-1)} + C$ **21.** $(\pi + 2\ln 2)/8$

23. $\tan^{-1}y - \dfrac{1}{y^2+1} + C$

25. $-(s-1)^{-2} + (s-1)^{-1} + \tan^{-1}s + C$

27. $\frac{2}{3}\ln|x-1| + \frac{1}{6}\ln|x^2+x+1| - \sqrt{3}\tan^{-1}\left(\dfrac{2x+1}{\sqrt{3}}\right) + C$

29. $\dfrac{1}{4}\ln\left|\dfrac{x-1}{x+1}\right| + \dfrac{1}{2}\tan^{-1}x + C$

31. $\dfrac{-1}{\theta^2+2\theta+2} + \ln(\theta^2+2\theta+2) - \tan^{-1}(\theta+1) + C$

33. $x^2 + \ln\left|\dfrac{x-1}{x}\right| + C$

35. $9x + 2\ln|x| + \dfrac{1}{x} + 7\ln|x-1| + C$

37. $\dfrac{y^2}{2} - \ln|y| + \dfrac{1}{2}\ln(1+y^2) + C$ **39.** $\ln\left(\dfrac{e^t+1}{e^t+2}\right) + C$

41. $\dfrac{1}{5}\ln\left|\dfrac{\sin y - 2}{\sin y + 3}\right| + C$

43. $\dfrac{(\tan^{-1}2x)^2}{4} - 3\ln|x-2| + \dfrac{6}{x-2} + C$

45. $\ln\left|\dfrac{\sqrt{x}-1}{\sqrt{x}+1}\right| + C$

47. $2\sqrt{1+x} + \ln\left|\dfrac{\sqrt{x+1}-1}{\sqrt{x+1}+1}\right| + C$

49. $\dfrac{1}{4}\ln\left|\dfrac{x^4}{x^4+1}\right| + C$

51. $\dfrac{1}{\sqrt{2}}\ln\left|\dfrac{\sqrt{2}\cos\theta+1}{\sqrt{2}\cos\theta-1}\right| + \dfrac{1}{2}\ln\left|\dfrac{1-\cos\theta}{1+\cos\theta}\right| + C$

53. $4\sqrt{1+\sqrt{x}} + 2\ln\left|\dfrac{\sqrt{1+\sqrt{x}}-1}{\sqrt{1+\sqrt{x}}+1}\right| + C$

55. $\frac{1}{3}x^3 - 2x^2 + 5x - 10\ln|x+2| + C$

57. $\dfrac{1}{\ln 2}\ln(2^x + 2^{-x}) + C$ **59.** $\dfrac{1}{4}\ln\left|\dfrac{x-1}{x+1}\right| - \dfrac{1}{2}\arctan x + C$

61. $\frac{1}{2}\ln|(\ln x + 1)(\ln x + 3)| + C$

63. $\ln\left|x + \sqrt{x^2-1}\right| + C$

65. $\frac{2}{9}x^3(x^3+1)^{3/2} - \frac{4}{45}(x^3+1)^{5/2} + C$

67. $x = \ln|t-2| - \ln|t-1| + \ln 2$

69. $x = \dfrac{6t}{t+2} - 1$ **71.** $3\pi\ln 25$

73. $\ln(3) - \dfrac{1}{2}$ **75.** 1.10

77. (a) $x = \dfrac{1000e^{4t}}{499+e^{4t}}$ **(b)** 1.55 days

SECTION 8.6, pp. 483–485

1. $\dfrac{2}{\sqrt{3}}\left(\tan^{-1}\sqrt{\dfrac{x-3}{3}}\right) + C$

3. $\sqrt{x-2}\left(\dfrac{2(x-2)}{3} + 4\right) + C$ **5.** $\dfrac{(2x-3)^{3/2}(x+1)}{5} + C$

7. $\dfrac{-\sqrt{9-4x}}{x} - \dfrac{2}{3}\ln\left|\dfrac{\sqrt{9-4x}-3}{\sqrt{9-4x}+3}\right| + C$

9. $\dfrac{(x+2)(2x-6)\sqrt{4x-x^2}}{6} + 4\sin^{-1}\left(\dfrac{x-2}{2}\right) + C$

11. $-\dfrac{1}{\sqrt{7}}\ln\left|\dfrac{\sqrt{7}+\sqrt{7+x^2}}{x}\right| + C$

13. $\sqrt{4-x^2} - 2\ln\left|\dfrac{2+\sqrt{4-x^2}}{x}\right| + C$

15. $\dfrac{e^{2t}}{13}(2\cos 3t + 3\sin 3t) + C$

17. $\dfrac{x^2}{2}\cos^{-1}x + \dfrac{1}{4}\sin^{-1}x - \dfrac{1}{4}x\sqrt{1-x^2} + C$

19. $\dfrac{x^3}{3}\tan^{-1}x - \dfrac{x^2}{6} + \dfrac{1}{6}\ln(1+x^2) + C$

21. $-\dfrac{\cos 5x}{10} - \dfrac{\cos x}{2} + C$

23. $8\left[\dfrac{\sin(7t/2)}{7} - \dfrac{\sin(9t/2)}{9}\right] + C$

25. $6\sin(\theta/12) + \dfrac{6}{7}\sin(7\theta/12) + C$

27. $\dfrac{1}{2}\ln(x^2+1) + \dfrac{x}{2(1+x^2)} + \dfrac{1}{2}\tan^{-1}x + C$

29. $\left(x - \dfrac{1}{2}\right)\sin^{-1}\sqrt{x} + \dfrac{1}{2}\sqrt{x-x^2} + C$

31. $\sin^{-1}\sqrt{x} - \sqrt{x-x^2} + C$

33. $\sqrt{1-\sin^2 t} - \ln\left|\dfrac{1+\sqrt{1-\sin^2 t}}{\sin t}\right| + C$

35. $\ln\left|\ln y + \sqrt{3+(\ln y)^2}\right| + C$

37. $\ln\left|x + 1 + \sqrt{x^2+2x+5}\right| + C$

39. $\dfrac{x+2}{2}\sqrt{5-4x-x^2} + \dfrac{9}{2}\sin^{-1}\left(\dfrac{x+2}{3}\right) + C$

41. $-\dfrac{\sin^4 2x\cos 2x}{10} - \dfrac{2\sin^2 2x\cos 2x}{15} - \dfrac{4\cos 2x}{15} + C$

43. $\dfrac{\sin^3 2\theta\cos^2 2\theta}{10} + \dfrac{\sin^3 2\theta}{15} + C$

45. $\tan^2 2x - 2\ln|\sec 2x| + C$

47. $\dfrac{(\sec\pi x)(\tan\pi x)}{\pi} + \dfrac{1}{\pi}\ln|\sec\pi x + \tan\pi x| + C$

49. $\dfrac{-\csc^3 x\cot x}{4} - \dfrac{3\csc x\cot x}{8} - \dfrac{3}{8}\ln|\csc x + \cot x| + C$

51. $\dfrac{1}{2}\left[\sec(e^t-1)\tan(e^t-1) + \ln|\sec(e^t-1) + \tan(e^t-1)|\right] + C$

53. $\sqrt{2} + \ln\left(\sqrt{2}+1\right)$ **55.** $\pi/3$

57. $2\pi\sqrt{3} + \pi\sqrt{2}\ln\left(\sqrt{2}+\sqrt{3}\right)$ **59.** $\bar{x} = 4/3, \bar{y} = \ln\sqrt{2}$

61. 7.62 **63.** $\pi/8$ **67.** $\pi/4$

SECTION 8.7, pp. 492–494

1. I: **(a)** 1.5, 0 **(b)** 1.5, 0 **(c)** 0%
II: **(a)** 1.5, 0 **(b)** 1.5, 0 **(c)** 0%

3. I: **(a)** 2.75, 0.08 **(b)** 2.67, 0.08 **(c)** $0.0312 \approx 3\%$
II: **(a)** 2.67, 0 **(b)** 2.67, 0 **(c)** 0%

5. I: 6.25, 0.5 **(b)** 6, 0.25 **(c)** $0.0417 \approx 4\%$
II: **(a)** 6, 0 **(b)** 6, 0 **(c)** 0%

7. I: **(a)** 0.509, 0.03125 **(b)** 0.5, 0.009 **(c)** $0.018 \approx 2\%$
II: **(a)** 0.5, 0.002604 **(b)** 0.5, 0.4794 **(c)** 0%

9. I: **(a)** 1.8961, 0.161 **(b)** 2, 0.1039 **(c)** $0.052 \approx 5\%$
II: **(a)** 2.0045, 0.0066 **(b)** 2, 0.00454 **(c)** 0.2%

11. **(a)** 1 **(b)** 2 **13.** **(a)** 116 **(b)** 2

15. **(a)** 283 **(b)** 2 **17.** **(a)** 71 **(b)** 10

19. **(a)** 76 **(b)** 12 **21.** **(a)** 82 **(b)** 8

23. 15,990 ft^3 **25.** ≈ 10.63 ft

27. **(a)** ≈ 0.00021 **(b)** ≈ 1.37079 **(c)** $\approx 0.015\%$

31. **(a)** ≈ 5.870 **(b)** $|E_T| \le 0.0032$

33. 21.07 in. **35.** 14.4 **39.** ≈ 28.7 mg

SECTION 8.8, pp. 503–505

1. $\pi/2$ **3.** 2 **5.** 6 **7.** $\pi/2$ **9.** ln 3 **11.** ln 4

13. 0 **15.** $\sqrt{3}$ **17.** π **19.** $\ln\left(1+\dfrac{\pi}{2}\right)$

21. -1 **23.** 1 **25.** $-1/4$ **27.** $\pi/2$ **29.** $\pi/3$

31. 6 **33.** ln 2 **35.** Diverges **37.** Diverges

39. Diverges **41.** Diverges **43.** Converges

45. Converges **47.** Diverges **49.** Converges

51. Converges **53.** Diverges **55.** Converges

57. Converges **59.** Diverges **61.** Converges

63. Diverges **65.** Converges **67.** Converges

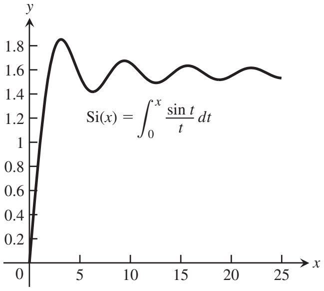
69. **(a)** Converges when $p < 1$ **(b)** Converges when $p > 1$

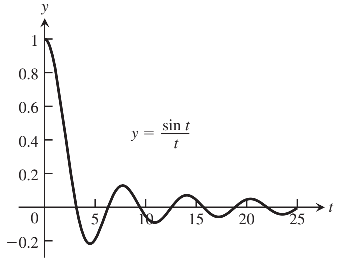
71. 1 **73.** 2π **75.** ln 2

77. **(a)** 1 **(b)** $\pi/3$ **(c)** Diverges

79. **(a)** $\pi/2$ **(b)** π **81.** **(b)** ≈ 0.88621

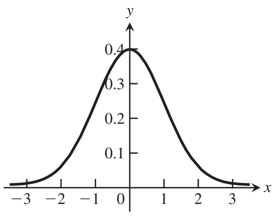
83. **(a)**





(b) $\pi/2$

85. **(a)**



(b) $\approx 0.683, \approx 0.954, \approx 0.997$

91. ≈ 0.16462

SECTION 8.9, pp. 516–518

1. No **3.** Yes **5.** Yes **7.** Yes **11.** ≈ 0.537

13. ≈ 0.688 **15.** ≈ 0.0502 **17.** $\sqrt{21}$ **19.** $\dfrac{1}{2}\ln 2$

21. $\dfrac{1}{\pi}, \dfrac{1}{\pi}\left(\tan^{-1}2 - \dfrac{\pi}{4}\right) \approx 0.10242$

25. mean $= \dfrac{8}{3} \approx 2.67$, median $= \sqrt{8} \approx 2.83$

27. mean $= 2$, median $= \sqrt{2} \approx 1.41$

29. $P\left(X < \frac{1}{2}\right) \approx 0.3935$

31. **(a)** ≈ 0.57, so about 57 in every 100 bulbs will fail.
(b) ≈ 832 hr

33. ≈ 60 hydra **35.** **(a)** ≈ 0.393 **(b)** ≈ 0.135 **(c)** 0
(d) The probability that any customer waits longer than 3 minutes is $1 - (0.997521)^{200} \approx 0.391 < 1/2$. So the most likely outcome is that all 200 would be served within 3 minutes.

37. \$10, 256 **39.** $\approx 323, \approx 262$ **41.** ≈ 0.89435

43. **(a)** $\approx 16\%$ **(b)** ≈ 0.23832 **45.** ≈ 618 females

47. ≈ 61 adults **49.** ≈ 289 shafts

51. (a) ≈ 0.977 **(b)** ≈ 0.159 **(c)** ≈ 0.838

55. (a) {LLL, LLD, LDL, DLL, LLU, LUL, ULL, LDD, LDU, LUD, LUU, DLD, DLU, ULD, ULU, DDL, DUL, UDL, UUL, DDD, DDU, DUD, UDD, DUU, UDU, UUD, UUU} **(c)** $7/27 \approx 0.26$ **(d)** $20/27 \approx 0.74$

PRACTICE EXERCISES, pp. 519–521

1. $(x+1)(\ln(x+1)) - (x+1) + C$

3. $x\tan^{-1}(3x) - \frac{1}{6}\ln(1+9x^2) + C$

5. $(x+1)^2e^x - 2(x+1)e^x + 2e^x + C$

7. $\dfrac{2e^x\sin 2x}{5} + \dfrac{e^x\cos 2x}{5} + C$

9. $2\ln|x-2| - \ln|x-1| + C$

11. $\ln|x| - \ln|x+1| + \dfrac{1}{x+1} + C$

13. $-\dfrac{1}{3}\ln\left|\dfrac{\cos\theta - 1}{\cos\theta + 2}\right| + C$

15. $4\ln|x| - \frac{1}{2}\ln(x^2+1) + 4\tan^{-1}x + C$

17. $\dfrac{1}{16}\ln\left|\dfrac{(v-2)^5(v+2)}{v^6}\right| + C$

19. $\dfrac{1}{2}\tan^{-1}t - \dfrac{\sqrt{3}}{6}\tan^{-1}\dfrac{t}{\sqrt{3}} + C$

21. $\dfrac{x^2}{2} + \dfrac{4}{3}\ln|x+2| + \dfrac{2}{3}\ln|x-1| + C$

23. $\dfrac{x^2}{2} - \dfrac{9}{2}\ln|x+3| + \dfrac{3}{2}\ln|x+1| + C$

25. $\dfrac{1}{3}\ln\left|\dfrac{\sqrt{x+1}-1}{\sqrt{x+1}+1}\right| + C$ **27.** $\ln|1-e^{-s}| + C$

29. $-\sqrt{16-y^2} + C$ **31.** $-\frac{1}{2}\ln|4-x^2| + C$

33. $\ln\dfrac{1}{\sqrt{9-x^2}} + C$ **35.** $\dfrac{1}{6}\ln\left|\dfrac{x+3}{x-3}\right| + C$

37. $-\dfrac{\cos^5 x}{5} + \dfrac{\cos^7 x}{7} + C$ **39.** $\dfrac{\tan^5 x}{5} + C$

41. $\dfrac{\cos\theta}{2} - \dfrac{\cos 11\theta}{22} + C$ **43.** $4\sqrt{1-\cos(t/2)} + C$

45. At least 16 **47.** $T = \pi, S = \pi$ **49.** 25°F

51. (a) ≈ 2.42 gal **(b)** ≈ 24.83 mi/gal

53. $\pi/2$ **55.** 6 **57.** $\ln 3$ **59.** 2 **61.** $\pi/6$

63. Diverges **65.** Diverges **67.** Converges

69. $\frac{1}{2}xe^{2x} - \frac{1}{4}e^{2x} + C$ **71.** $2\tan x - x + C$

73. $x\tan x - \ln|\sec x| + C$ **75.** $-\frac{1}{3}(\cos x)^3 + C$

77. $1 + \dfrac{1}{2}\ln\left(\dfrac{2}{1+e^2}\right)$ **79.** $2\ln\left|1 - \dfrac{1}{x}\right| + \dfrac{4x+1}{2x^2} + C$

81. $\dfrac{e^{2x}-1}{e^x} + C$ **83.** $9/4$ **85.** $256/15$

87. $-\frac{1}{3}\csc^3 x + C$

89. $\dfrac{2x^{3/2}}{3} - x + 2\sqrt{x} - 2\ln\left(\sqrt{x}+1\right) + C$

91. $\frac{1}{2}\sin^{-1}(x-1) + \frac{1}{2}(x-1)\sqrt{2x-x^2} + C$

93. $-2\cot x - \ln|\csc x + \cot x| + \csc x + C$

95. $\dfrac{1}{12}\ln\left|\dfrac{3+v}{3-v}\right| + \dfrac{1}{6}\tan^{-1}\dfrac{v}{3} + C$

97. $\dfrac{\theta\sin(2\theta+1)}{2} + \dfrac{\cos(2\theta+1)}{4} + C$

99. $\frac{1}{4}\sec^2\theta + C$ **101.** $2\left(\dfrac{\left(\sqrt{2-x}\right)^3}{3} - 2\sqrt{2-x}\right) + C$

103. $\tan^{-1}(y-1) + C$

105. $\dfrac{1}{4}\ln|z| - \dfrac{1}{4z} - \dfrac{1}{4}\left[\dfrac{1}{2}\ln(z^2+4) + \dfrac{1}{2}\tan^{-1}\left(\dfrac{z}{2}\right)\right] + C$

107. $-\frac{1}{4}\sqrt{9-4t^2} + C$ **109.** $\ln\left(\dfrac{e^t+1}{e^t+2}\right) + C$

111. $1/4$ **113.** $\frac{2}{3}x^{3/2} + C$ **115.** $-\frac{1}{5}\tan^{-1}(\cos 5t) + C$

117. $2\sqrt{r} - 2\ln\left(1+\sqrt{r}\right) + C$

119. $\frac{1}{2}x^2 - \frac{1}{2}\ln(x^2+1) + C$

121. $\dfrac{2}{3}\ln|x+1| + \dfrac{1}{6}\ln|x^2-x+1| + \dfrac{1}{\sqrt{3}}\tan^{-1}\left(\dfrac{2x-1}{\sqrt{3}}\right) + C$

123. $\frac{4}{7}\left(1+\sqrt{x}\right)^{7/2} - \frac{8}{5}\left(1+\sqrt{x}\right)^{5/2} + \frac{4}{3}\left(1+\sqrt{x}\right)^{3/2} + C$

125. $2\ln\left|\sqrt{x} + \sqrt{1+x}\right| + C$

127. $\ln x - \ln|1 + \ln x| + C$

129. $\frac{1}{2}x^{\ln x} + C$ **131.** $\dfrac{1}{2}\ln\left|\dfrac{1-\sqrt{1-x^4}}{x^2}\right| + C$

133. (b) $\dfrac{\pi}{4}$ **135.** $x - \dfrac{1}{\sqrt{2}}\tan^{-1}\left(\sqrt{2}\tan x\right) + C$

ADDITIONAL AND ADVANCED EXERCISES, pp. 522–524

1. $x(\sin^{-1}x)^2 + 2(\sin^{-1}x)\sqrt{1-x^2} - 2x + C$

3. $\dfrac{x^2\sin^{-1}x}{2} + \dfrac{x\sqrt{1-x^2} - \sin^{-1}x}{4} + C$

5. $\dfrac{1}{2}\left(\ln\left(t - \sqrt{1-t^2}\right) - \sin^{-1}t\right) + C$ **7.** 0

9. $\ln(4) - 1$ **11.** 1 **13.** $32\pi/35$ **15.** 2π

17. (a) π **(b)** $\pi(2e-5)$

19. (b) $\pi\left(\dfrac{8(\ln 2)^2}{3} - \dfrac{16(\ln 2)}{9} + \dfrac{16}{27}\right)$

21. $\left(\dfrac{e^2+1}{4}, \dfrac{e-2}{2}\right)$

23. $\sqrt{1+e^2} - \ln\left(\dfrac{\sqrt{1+e^2}}{e} + \dfrac{1}{e}\right) - \sqrt{2} + \ln\left(1+\sqrt{2}\right)$

25. $\dfrac{12\pi}{5}$ **27.** $a = \dfrac{1}{2}, -\dfrac{\ln 2}{4}$ **29.** $\dfrac{1}{2} < p \le 1$

33. $\dfrac{2}{1-\tan(x/2)} + C$ **35.** 1 **37.** $\dfrac{\sqrt{3}\pi}{9}$

39. $\dfrac{1}{\sqrt{2}}\ln\left|\dfrac{\tan(t/2) + 1 - \sqrt{2}}{\tan(t/2) + 1 + \sqrt{2}}\right| + C$

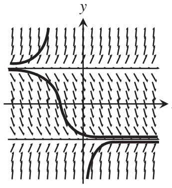
41. $\ln\left|\dfrac{1+\tan(\theta/2)}{1-\tan(\theta/2)}\right| + C$

Chapter 9

SECTION 9.1, pp. 532–534

1. (d) **3.** (a)

5.



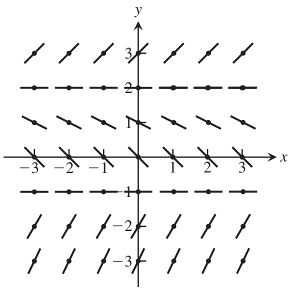
7. $y' = x - y;\ y(1) = -1$

9. $y' = -(1 + y)\sin x;\ y(0) = 2$

11. $y' = 1 + x\,e^{y};\ y(-2) = 2$

13.

y	$f(y) = \dfrac{dy}{dx}$
-3	2
-2	1.5
-1	0
0	-1
1	-0.75
2	0
3	1



15. $y(\text{exact}) = -x^2,\ y_1 = -2,\ y_2 = -3.3333,\ y_3 = -5$

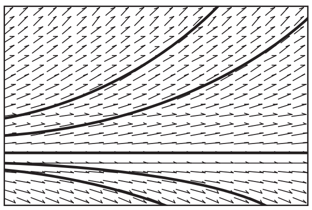
17. $y(\text{exact}) = 3e^{x(x+2)},\ y_1 = 4.2,\ y_2 = 6.216,\ y_3 = 9.697$

19. $y(\text{exact}) = e^{x^2} + 1,\ y_1 = 2.0,\ y_2 = 2.0202,\ y_3 = 2.0618$

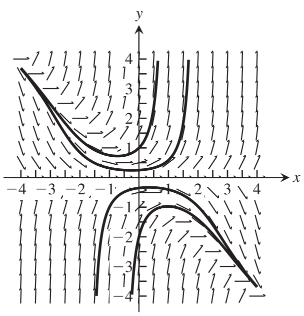
21. $y \approx 2.48832$, exact value is e.

23. $y \approx -0.2272$, exact value is $1/\left(1 - 2\sqrt{5}\right) \approx -0.2880$.

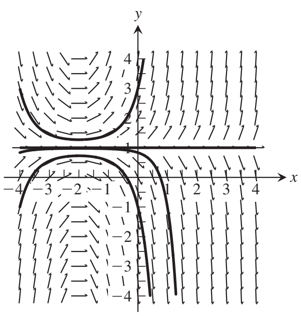
27.



29.



31.



39. Euler's method gives $y \approx 3.45835$; the exact solution is $y = 1 + e \approx 3.71828$.

41. $y \approx 1.5000$; exact value is 1.5275.

SECTION 9.2, pp. 538–540

1. $y = \dfrac{e^x + C}{x},\quad x > 0$ **3.** $y = \dfrac{C - \cos x}{x^3},\quad x > 0$

5. $y = \dfrac{1}{2} - \dfrac{1}{x} + \dfrac{C}{x^2},\quad x > 0$ **7.** $y = \dfrac{1}{2}xe^{x/2} + Ce^{x/2}$

9. $y = x(\ln x)^2 + Cx$

11. $s = \dfrac{t^3}{3(t-1)^4} - \dfrac{t}{(t-1)^4} + \dfrac{C}{(t-1)^4}$

13. $r = (\csc\theta)(\ln|\sec\theta| + C),\quad 0 < \theta < \pi/2$

15. $y = \dfrac{3}{2} - \dfrac{1}{2}e^{-2t}$ **17.** $y = -\dfrac{1}{\theta}\cos\theta + \dfrac{\pi}{2\theta}$

19. $y = 6e^{x^2} - \dfrac{e^{x^2}}{x+1}$ **21.** $y = y_0e^{kt}$

23. (b) is correct, but (a) is not. **25.** $t = \dfrac{L}{R}\ln 2$ sec

27. **(a)** $i = \dfrac{V}{R} - \dfrac{V}{R}e^{-3} = \dfrac{V}{R}\left(1 - e^{-3}\right) \approx 0.95\dfrac{V}{R}$ amp **(b)** 86%

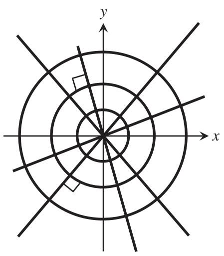
29. $y = \dfrac{1}{1 + Ce^{-x}}$ **31.** $y^3 = 1 + Cx^{-3}$

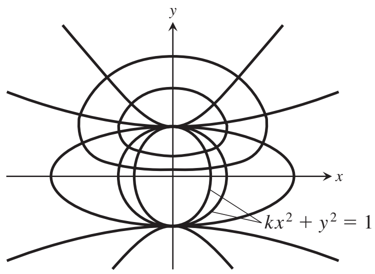
SECTION 9.3, pp. 545–546

1. **(a)** 168.5 m **(b)** 41.13 sec

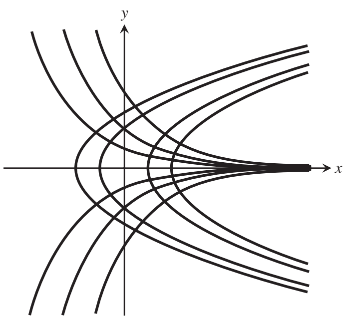
3. $s(t) = 4.91\left(1 - e^{-(22.36/39.92)t}\right)$

5. $x^2 + y^2 = C$ **7.** $\ln|y| - \dfrac{1}{2}y^2 = \dfrac{1}{2}x^2 + C$





9. $y = \pm\sqrt{2x + C}$



13. **(a)** 10 lb/min **(b)** $(100 + t)$ gal **(c)** $4\left(\dfrac{y}{100 + t}\right)$ lb/min

(d) $\dfrac{dy}{dt} = 10 - \dfrac{4y}{100 + t},\quad y(0) = 50,$

$$y = 2(100 + t) - \frac{150}{\left(1 + \dfrac{t}{100}\right)^4}$$

(e) Concentration $= \dfrac{y(25)}{\text{amt. brine in tank}} = \dfrac{188.6}{125} \approx 1.5$ lb/gal

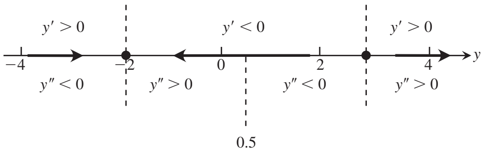
15. $y(27.8) \approx 14.8$ lb, $t \approx 27.8$ min

SECTION 9.4, pp. 552–553

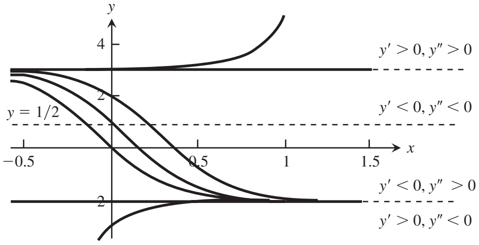
1. $y' = (y + 2)(y - 3)$

(a) $y = -2$ is a stable equilibrium value and $y = 3$ is an unstable equilibrium.

(b) $y'' = 2(y + 2)\left(y - \frac{1}{2}\right)(y - 3)$



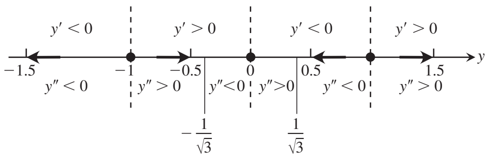
(c)



3. $y' = y^3 - y = (y + 1)y(y - 1)$

(a) $y = -1$ and $y = 1$ are unstable equilibria and $y = 0$ is a stable equilibrium.

(b) $y'' = (3y^2 - 1)y'$
$= 3(y + 1)\left(y + 1/\sqrt{3}\right)y\left(y - 1/\sqrt{3}\right)(y - 1)$



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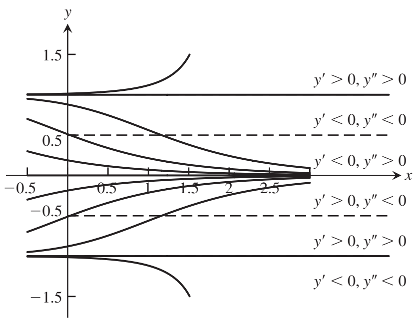
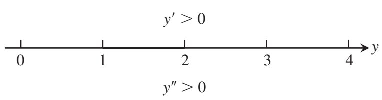


5. $y' = \sqrt{y}, y > 0$

(a) There are no equilibrium values.

(b) $y'' = \frac{1}{2}$



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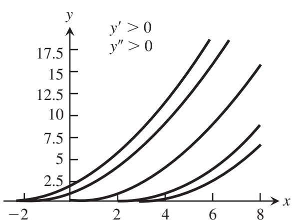
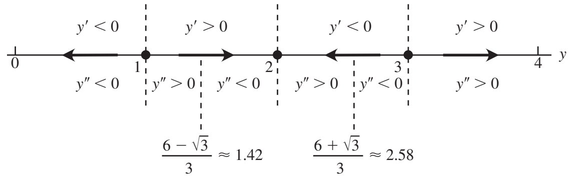


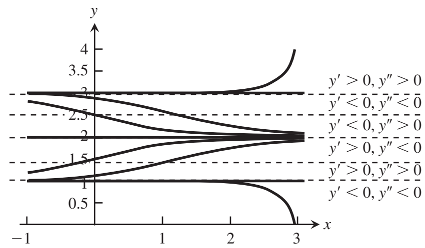
7. $y' = (y - 1)(y - 2)(y - 3)$

(a) $y = 1$ and $y = 3$ are unstable equilibria and $y = 2$ is a stable equilibrium.

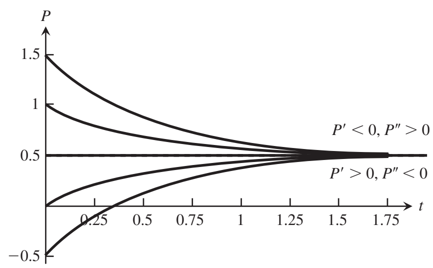
(b) $y'' = (3y^2 - 12y + 11)(y - 1)(y - 2)(y - 3) =$
$3(y - 1)\left(y - \frac{6 - \sqrt{3}}{3}\right)(y - 2)\left(y - \frac{6 + \sqrt{3}}{3}\right)(y - 3)$



(c)



9. $\frac{dP}{dt} = 1 - 2P$ has a stable equilibrium at $P = \frac{1}{2}$; $\frac{d^2P}{dt^2} = -2\frac{dP}{dt} = -2(1 - 2P)$.



11. $\frac{dP}{dt} = 2P(P - 3)$ has a stable equilibrium at $P = 0$ and an unstable equilibrium at $P = 3$; $\frac{d^2P}{dt^2} = 2(2P - 3)\frac{dP}{dt} = 4P(2P - 3)(P - 3)$.