I ANSWERS TO ODD-NUMBERED EXERCISES

CHAPTER 1

EXERCISES 1.1 ■ PAGE 20

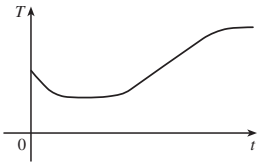
1. (a) -2 (b) 2.8 (c) $-3, 1$ (d) $-2.5, 0.3$
(e) $[-3, 3], [-2, 3]$ (f) $[-1, 3]$

3. $[-85, 115]$ **5.** No

7. Yes, $[-3, 2], [-3, -2) \cup [-1, 3]$

9. Diet, exercise, or illness

11.



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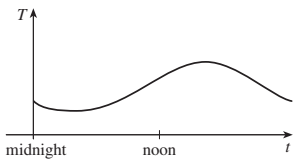

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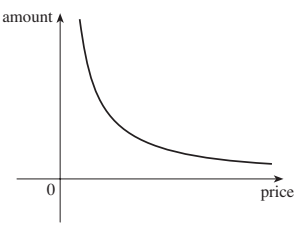

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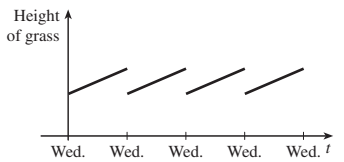
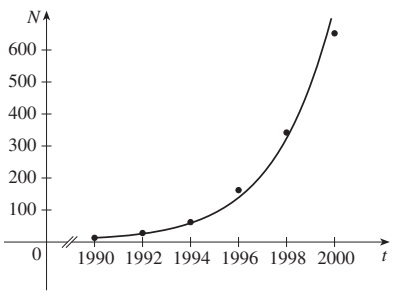


19. (a)



(b) In millions: 92; 485

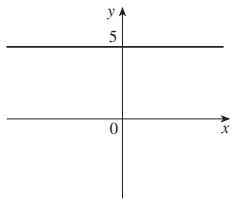
21. $12, 16, 3a^2 - a + 2, 3a^2 + a + 2, 3a^2 + 5a + 4, 6a^2 - 2a + 4, 12a^2 - 2a + 2, 3a^4 - a^2 + 2, 9a^4 - 6a^3 + 13a^2 - 4a + 4, 3a^2 + 6ah + 3h^2 - a - h + 2$

23. $-3 - h$ **25.** $-1/(ax)$

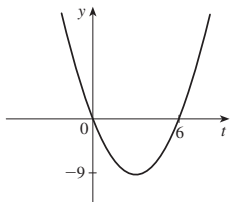
27. $\{x \mid x \neq \frac{1}{3}\} = (-\infty, \frac{1}{3}) \cup (\frac{1}{3}, \infty)$

29. $[0, \infty)$ **31.** $(-\infty, 0) \cup (5, \infty)$

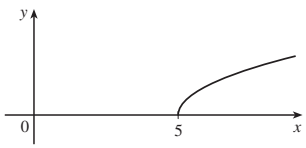
33. $(-\infty, \infty)$



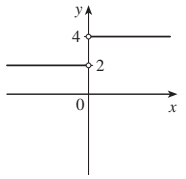
35. $(-\infty, \infty)$



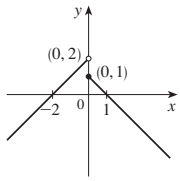
37. $[5, \infty)$



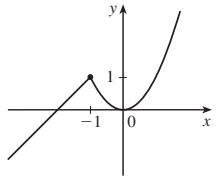
39. $(-\infty, 0) \cup (0, \infty)$



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



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



45. $f(x) = \frac{5}{2}x - \frac{11}{2}, 1 \leqslant x \leqslant 5$ **47.** $f(x) = 1 - \sqrt{-x}$

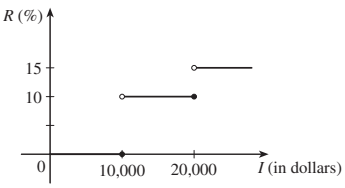
49. $f(x) = \begin{cases} -x + 3 & \text{if } 0 \leqslant x \leqslant 3 \\ 2x - 6 & \text{if } 3 < x \leqslant 5 \end{cases}$

51. $A(L) = 10L - L^2, 0 < L < 10$

53. $A(x) = \sqrt{3}x^2/4, x > 0$ **55.** $S(x) = x^2 + (8/x), x > 0$

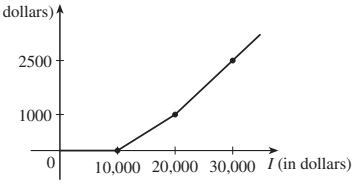
57. $V(x) = 4x^3 - 64x^2 + 240x, 0 < x < 6$

59. (a)



(b) \$400, \$1900

(c)



61. f is odd, g is even

63. (a) $(-5, 3)$ (b) $(-5, -3)$

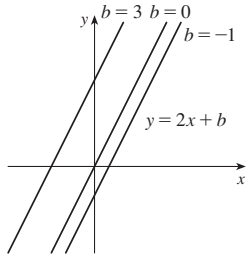
65. Odd **67.** Neither **69.** Even

EXERCISES 1.2 ■ PAGE 34

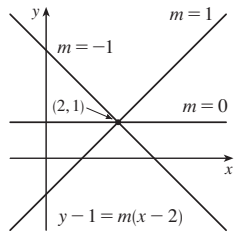
1. (a) Root (b) Algebraic (c) Polynomial (degree 9)
(d) Rational (e) Trigonometric (f) Logarithmic

3. (a) h (b) f (c) g

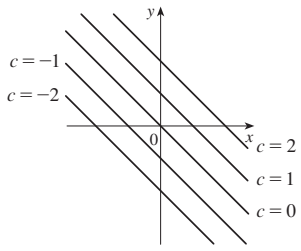
5. (a) $y = 2x + b$, where b is the y-intercept.



(b) $y = mx + 1 - 2m$, where m is the slope. See graph at right.
(c) $y = 2x - 3$



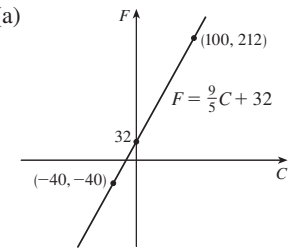
7. Their graphs have slope -1.



9. $f(x) = -3x(x + 1)(x - 2)$

11. (a) 8.34, change in mg for every 1 year change
(b) 8.34 mg

13. (a)



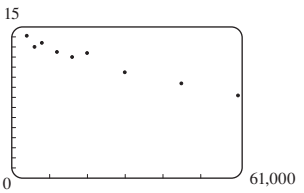
(b) $\frac{9}{5}$, change in °F for every 1°C change; 32, Fahrenheit temperature corresponding to 0°C

15. (a) $T = \frac{1}{6}N + \frac{307}{6}$ (b) $\frac{1}{6}$, change in °F for every chirp per minute change (c) 76°F

17. (a) $P = 0.434d + 15$ (b) 196 ft

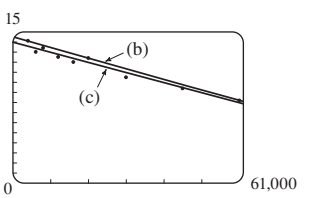
19. (a) Cosine (b) Linear

21. (a)



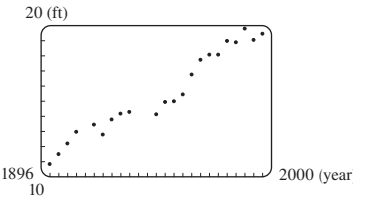
Linear model is appropriate

(b) $y = -0.000105x + 14.521$

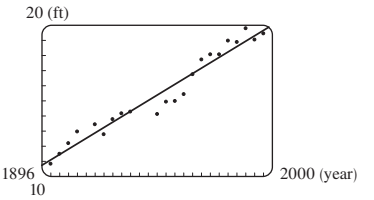


(c) $y = -0.00009979x + 13.951$ [See graph in (b).]
(d) About 11.5 per 100 population (e) About 6% (f) No

23. (a)



Linear model is appropriate
(b) $y = 0.08912x - 158.24$ (c) 20 ft (d) No



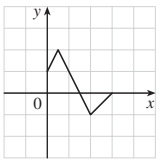
25. $y \approx 0.0012937x^3 - 7.06142x^2 + 12{,}823x - 7{,}743{,}770$; 1914 million

EXERCISES 1.3 ■ PAGE 43

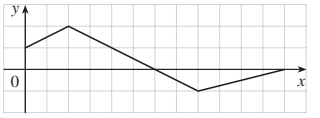
1. (a) $y = f(x) + 3$ (b) $y = f(x) - 3$ (c) $y = f(x - 3)$
(d) $y = f(x + 3)$ (e) $y = -f(x)$ (f) $y = f(-x)$
(g) $y = 3f(x)$ (h) $y = \frac{1}{3}f(x)$

3. (a) 3 (b) 1 (c) 4 (d) 5 (e) 2

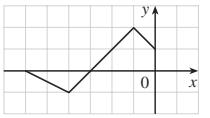
5. (a)



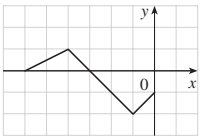
(b)



(c)

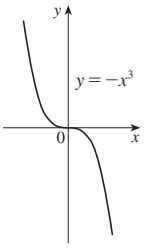


(d)



7. $y = -\sqrt{-x^2 - 5x - 4} - 1$

9.



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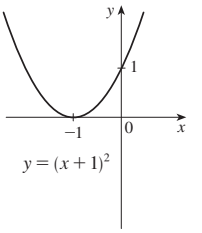

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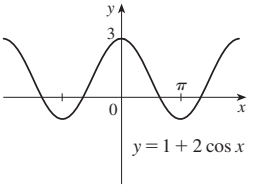

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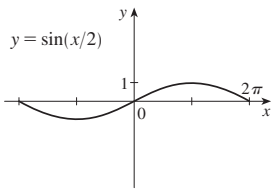

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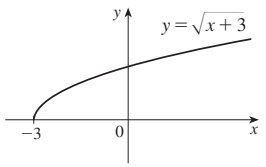

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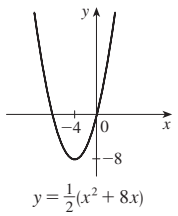

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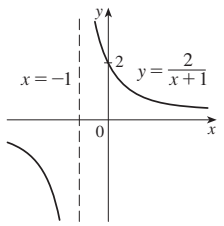

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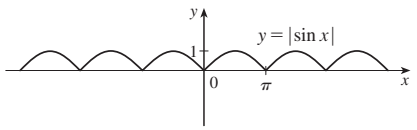
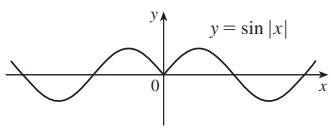


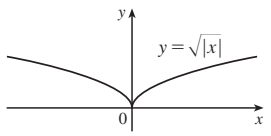
25. $L(t) = 12 + 2\sin\left[\dfrac{2\pi}{365}(t - 80)\right]$

27. (a) The portion of the graph of $y = f(x)$ to the right of the y-axis is reflected about the y-axis.

(b)



(c)



29. $(f + g)(x) = x^3 + 5x^2 - 1, (-\infty, \infty)$
$(f - g)(x) = x^3 - x^2 + 1, (-\infty, \infty)$
$(fg)(x) = 3x^5 + 6x^4 - x^3 - 2x^2, (-\infty, \infty)$
$(f/g)(x) = (x^3 + 2x^2)/(3x^2 - 1), \{x \mid x \neq \pm 1/\sqrt{3}\}$

31. (a) $(f \circ g)(x) = 4x^2 + 4x, (-\infty, \infty)$
(b) $(g \circ f)(x) = 2x^2 - 1, (-\infty, \infty)$
(c) $(f \circ f)(x) = x^4 - 2x^2, (-\infty, \infty)$
(d) $(g \circ g)(x) = 4x + 3, (-\infty, \infty)$

33. (a) $(f \circ g)(x) = 1 - 3\cos x, (-\infty, \infty)$
(b) $(g \circ f)(x) = \cos(1 - 3x), (-\infty, \infty)$
(c) $(f \circ f)(x) = 9x - 2, (-\infty, \infty)$
(d) $(g \circ g)(x) = \cos(\cos x), (-\infty, \infty)$

35. (a) $(f \circ g)(x) = (2x^2 + 6x + 5)/[(x + 2)(x + 1)]$, $\{x \mid x \neq -2, -1\}$
(b) $(g \circ f)(x) = (x^2 + x + 1)/(x + 1)^2, \{x \mid x \neq -1, 0\}$
(c) $(f \circ f)(x) = (x^4 + 3x^2 + 1)/[x(x^2 + 1)], \{x \mid x \neq 0\}$
(d) $(g \circ g)(x) = (2x + 3)/(3x + 5), \left\{x \mid x \neq -2, -\frac{5}{3}\right\}$

37. $(f \circ g \circ h)(x) = 2x - 1$

39. $(f \circ g \circ h)(x) = \sqrt{x^6 + 4x^3 + 1}$

41. $g(x) = x^2 + 1, f(x) = x^{10}$

43. $g(x) = \sqrt[3]{x}, f(x) = x/(1 + x)$

45. $g(t) = \cos t, f(t) = \sqrt{t}$

47. $h(x) = x^2, g(x) = 3^x, f(x) = 1 - x$

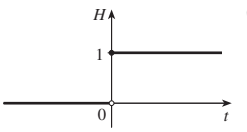
49. $h(x) = \sqrt{x}, g(x) = \sec x, f(x) = x^4$

51. (a) 4 (b) 3 (c) 0 (d) Does not exist; $f(6) = 6$ is not in the domain of g. (e) 4 (f) -2

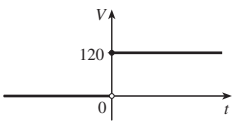
53. (a) $r(t) = 60t$ (b) $(A \circ r)(t) = 3600\pi t^2$; the area of the circle as a function of time

55. (a) $s = \sqrt{d^2 + 36}$ (b) $d = 30t$
(c) $s = \sqrt{900t^2 + 36}$; the distance between the lighthouse and the ship as a function of the time elapsed since noon

57. (a)

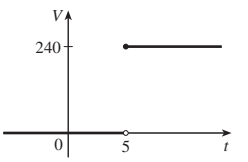


(b)



$V(t) = 120H(t)$

(c)



$V(t) = 240H(t - 5)$

59. Yes; $m_1 m_2$

61. (a) $f(x) = x^2 + 6$ (b) $g(x) = x^2 + x - 1$

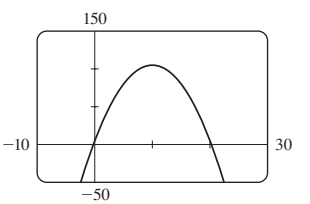
63. (a) Even; even (b) Odd; even

65. Yes

EXERCISES 1.4 ■ PAGE 51

1. (c)

3.



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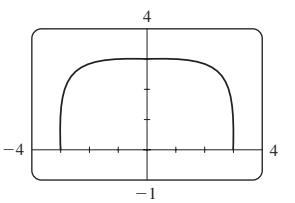

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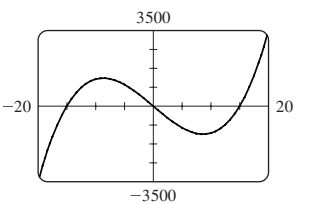

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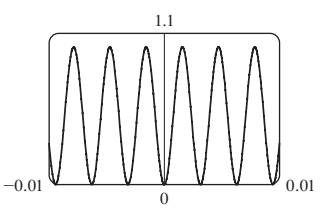

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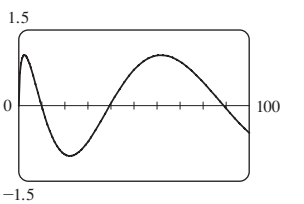
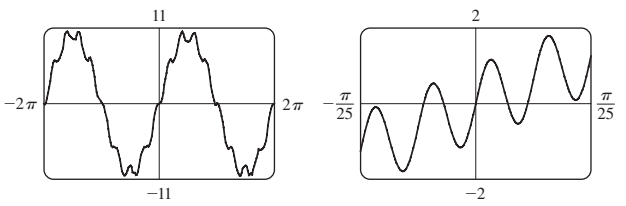
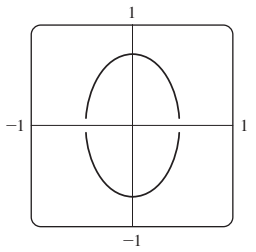


13.



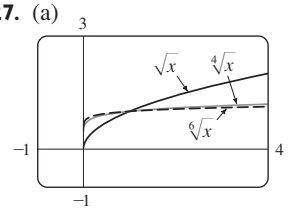
15.



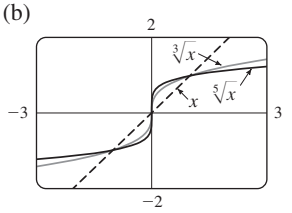
17. No **19.** 9.05 **21.** 0, 0.88 **23.** g

25. $-0.85 < x < 0.85$

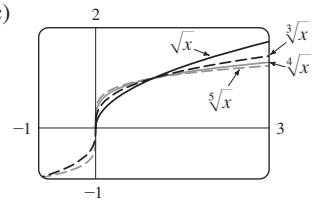
27. (a)



(b)

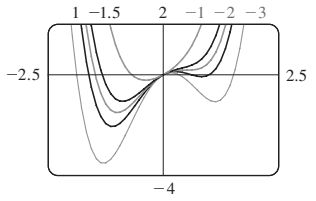


(c)



(d) Graphs of even roots are similar to $\sqrt{x}$, graphs of odd roots are similar to $\sqrt[3]{x}$. As n increases, the graph of $y = \sqrt[n]{x}$ becomes steeper near 0 and flatter for $x > 1$.

29.



If $c < -1.5$, the graph has three humps: two minimum points and a maximum point. These humps get flatter as c increases until at $c = -1.5$ two of the humps disappear and there is only one minimum point. This single hump then moves to the right and approaches the origin as c increases.

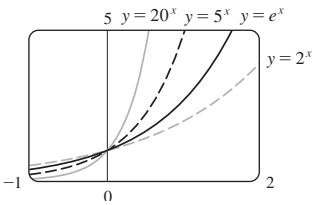
31. The hump gets larger and moves to the right.

33. If $c < 0$, the loop is to the right of the origin; if $c > 0$, the loop is to the left. The closer c is to 0, the larger the loop.

EXERCISES 1.5 ■ PAGE 58

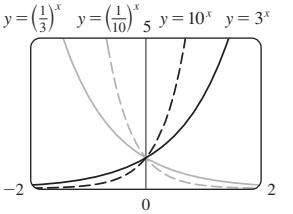
1. (a) $f(x) = a^x, a > 0$ (b) $\mathbb{R}$ (c) $(0, \infty)$
(d) See Figures 4(c), 4(b), and 4(a), respectively.

3.



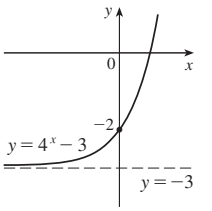
All approach 0 as $x \to -\infty$, all pass through (0, 1), and all are increasing. The larger the base, the faster the rate of increase.

5.

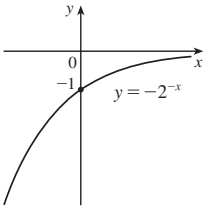


The functions with base greater than 1 are increasing and those with base less than 1 are decreasing. The latter are reflections of the former about the y-axis.

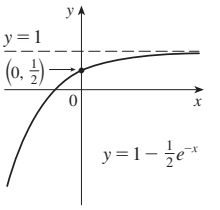
7.



9.



11.

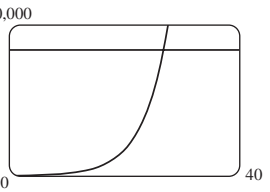


13. (a) $y = e^x - 2$ (b) $y = e^{x-2}$ (c) $y = -e^x$
(d) $y = e^{-x}$ (e) $y = -e^{-x}$

15. (a) $(-\infty, \infty)$ (b) $(-\infty, 0) \cup (0, \infty)$

17. $f(x) = 3 \cdot 2^x$ **23.** At $x \approx 35.8$

25. (a) 3200 (b) $100 \cdot 2^{t/3}$ (c) 10,159
(d)



$t \approx 26.9$ h

27. $y = ab^t$, where $a \approx 3.154832569 \times 10^{-12}$ and $b \approx 1.017764706$; 5498 million; 7417 million

EXERCISES 1.6 ■ PAGE 70

1. (a) See Definition 1.
(b) It must pass the Horizontal Line Test.

3. No **5.** Yes **7.** No **9.** No **11.** Yes

13. No **15.** 2 **17.** 0

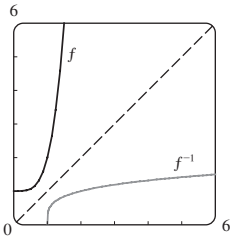
19. $F = \frac{9}{5}C + 32$; the Fahrenheit temperature as a function of the Celsius temperature; $[-273.15, \infty)$

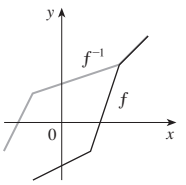
21. $f^{-1}(x) = -\frac{1}{3}x^2 + \frac{10}{3}, \ x \geqslant 0$ **23.** $f^{-1}(x) = \sqrt[3]{\ln x}$

25. $y = e^x - 3$

27. $f^{-1}(x) = \sqrt[4]{x - 1}$

29.



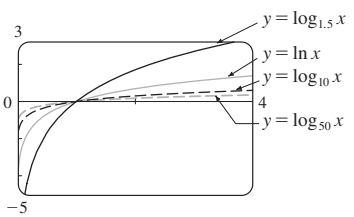


31. (a) It's defined as the inverse of the exponential function with base a, that is, $\log_a x = y \iff a^y = x$.
(b) $(0, \infty)$ (c) $\mathbb{R}$ (d) See Figure 11.

33. (a) 3 (b) -3 **35.** (a) 3 (b) -2 **37.** ln 1215

39. $\ln \dfrac{(1 + x^2)\sqrt{x}}{\sin x}$

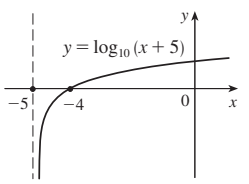
41.



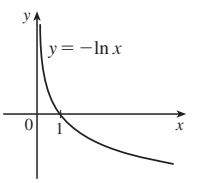
All graphs approach $-\infty$ as $x \to 0^+$, all pass through $(1, 0)$, and all are increasing. The larger the base, the slower the rate of increase.

43. About 1,084,588 mi

45. (a)



(b)



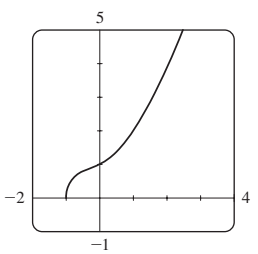
47. (a) $\sqrt{e}$ (b) $-\ln 5$

49. (a) $5 + \log_2 3$ or $5 + (\ln 3)/\ln 2$ (b) $\frac{1}{2}\left(1 + \sqrt{1 + 4e}\right)$

51. (a) $x < \ln 10$ (b) $x > 1/e$

53. (a) $\left(-\infty, \frac{1}{2}\ln 3\right]$ (b) $f^{-1}(x) = \frac{1}{2}\ln(3 - x^2)$, $\left[0, \sqrt{3}\right)$

55.



The graph passes the Horizontal Line Test.

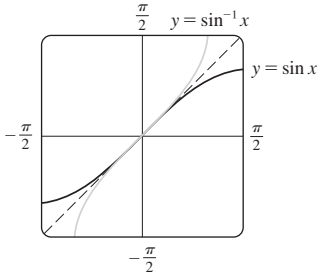
$f^{-1}(x) = -\left(\sqrt[3]{4}/6\right)\left(\sqrt[3]{D - 27x^2 + 20} - \sqrt[3]{D + 27x^2 - 20} + \sqrt[3]{2}\right)$, where $D = 3\sqrt{3}\sqrt{27x^4 - 40x^2 + 16}$; two of the expressions are complex.

57. (a) $f^{-1}(n) = (3/\ln 2)\ln(n/100)$; the time elapsed when there are n bacteria (b) After about 26.9 hours

59. (a) $\pi/3$ (b) π **61.** (a) $\pi/4$ (b) $\pi/4$

63. (a) 10 (b) $\pi/3$ **67.** $x/\sqrt{1 + x^2}$

69.



The second graph is the reflection of the first graph about the line $y = x$.

71. (a) $[-\frac{2}{3}, 0]$ (b) $[-\pi/2, \pi/2]$

73. (a) $g^{-1}(x) = f^{-1}(x) - c$ (b) $h^{-1}(x) = (1/c)f^{-1}(x)$

CHAPTER I REVIEW ■ PAGE 73

True-False Quiz

1. False **3.** False **5.** True **7.** False **9.** True
11. False **13.** False

Exercises

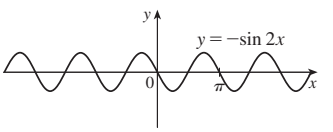
1. (a) 2.7 (b) 2.3, 5.6 (c) $[-6, 6]$ (d) $[-4, 4]$
(e) $[-4, 4]$ (f) No; it fails the Horizontal Line Test.
(g) Odd; its graph is symmetric about the origin.

3. $2a + h - 2$ **5.** $\left(-\infty, \frac{1}{3}\right) \cup \left(\frac{1}{3}, \infty\right)$, $(-\infty, 0) \cup (0, \infty)$

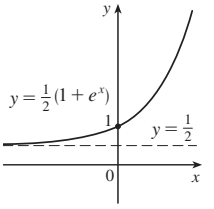
7. $(-6, \infty)$, $\mathbb{R}$

9. (a) Shift the graph 8 units upward.
(b) Shift the graph 8 units to the left.
(c) Stretch the graph vertically by a factor of 2, then shift it 1 unit upward.
(d) Shift the graph 2 units to the right and 2 units downward.
(e) Reflect the graph about the x-axis.
(f) Reflect the graph about the line $y = x$ (assuming f is one-to-one).

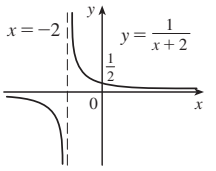
11.



13.



15.

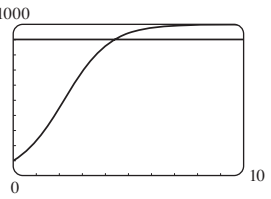


17. (a) Neither (b) Odd (c) Even (d) Neither

19. (a) $(f \circ g)(x) = \ln(x^2 - 9)$, $(-\infty, -3) \cup (3, \infty)$
(b) $(g \circ f)(x) = (\ln x)^2 - 9$, $(0, \infty)$
(c) $(f \circ f)(x) = \ln \ln x$, $(1, \infty)$
(d) $(g \circ g)(x) = (x^2 - 9)^2 - 9$, $(-\infty, \infty)$

21. $y = 0.2493x - 423.4818$; about 77.6 years

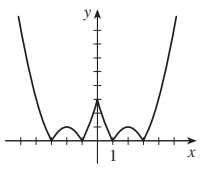
23. 1 **25.** (a) 9 (b) 2 (c) $1/\sqrt{3}$ (d) $\frac{3}{5}$

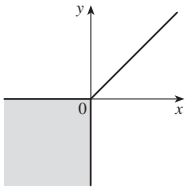
27. (a) 

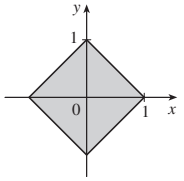
≈4.4 years

(b) $t = -\ln\left(\dfrac{1000 - P}{9P}\right)$; the time required for the population to reach a given number P.
(c) ln 81 ≈ 4.4 years

PRINCIPLES OF PROBLEM SOLVING ■ PAGE 81

1. $a = 4\sqrt{h^2 - 16}/h$, where a is the length of the altitude and h is the length of the hypotenuse
3. $-\frac{7}{3}$, 9
5. 

7. 

9. 

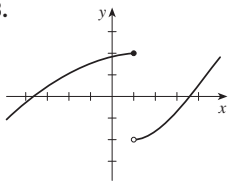
11. 5 **13.** $x \in [-1, 1 - \sqrt{3}) \cup (1 + \sqrt{3}, 3]$
15. 40 mi/h **19.** $f_n(x) = x^{2^{n+1}}$

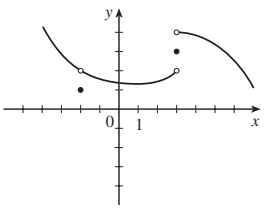
CHAPTER 2

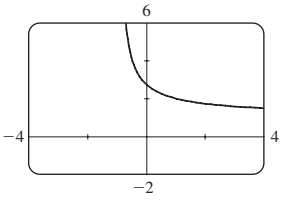
EXERCISES 2.1 ■ PAGE 87

1. (a) $-44.4, -38.8, -27.8, -22.2, -16.\overline{6}$
(b) -33.3 (c) $-33\frac{1}{3}$
3. (a) (i) 0.333333 (ii) 0.263158 (iii) 0.251256
(iv) 0.250125 (v) 0.2 (vi) 0.238095 (vii) 0.248756
(viii) 0.249875 (b) $\frac{1}{4}$ (c) $y = \frac{1}{4}x + \frac{1}{4}$
5. (a) (i) −32 ft/s (ii) −25.6 ft/s (iii) −24.8 ft/s
(iv) −24.16 ft/s (b) −24 ft/s
7. (a) (i) 4.65 m/s (ii) 5.6 m/s (iii) 7.55 m/s
(iv) 7 m/s (b) 6.3 m/s
9. (a) 0, 1.7321, −1.0847, −2.7433, 4.3301, −2.8173, 0, −2.1651, −2.6061, −5, 3.4202; no (c) −31.4

EXERCISES 2.2 ■ PAGE 96

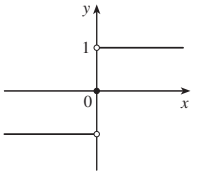
1. Yes
3. (a) $\lim_{x \to -3} f(x) = \infty$ means that the values of $f(x)$ can be made arbitrarily large (as large as we please) by taking x sufficiently close to −3 (but not equal to −3).
(b) $\lim_{x \to 4^+} f(x) = -\infty$ means that the values of $f(x)$ can be made arbitrarily large negative by taking x sufficiently close to 4 through values larger than 4.
5. (a) 2 (b) 3 (c) Does not exist (d) 4
(e) Does not exist
7. (a) −1 (b) −2 (c) Does not exist (d) 2 (e) 0
(f) Does not exist (g) 1 (h) 3
9. (a) $-\infty$ (b) ∞ (c) ∞ (d) $-\infty$ (e) ∞
(f) $x = -7, x = -3, x = 0, x = 6$
11. (a) 1 (b) 0 (c) Does not exist
13. 

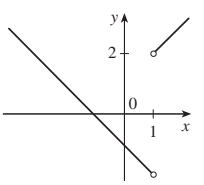
15. 

17. $\frac{2}{3}$ **19.** $\frac{1}{2}$ **21.** $\frac{1}{4}$ **23.** $\frac{3}{5}$ **25.** $-\infty$
27. ∞ **29.** $-\infty$ **31.** $-\infty$ **33.** $-\infty$; ∞
35. (a) 2.71828 (b) 

37. (a) 0.998000, 0.638259, 0.358484, 0.158680, 0.038851, 0.008928, 0.001465; 0
(b) 0.000572, −0.000614, −0.000907, −0.000978, −0.000993, −0.001000; −0.001
39. No matter how many times we zoom in toward the origin, the graph appears to consist of almost-vertical lines. This indicates more and more frequent oscillations as $x \to 0$.
41. $x \approx \pm 0.90, \pm 2.24$; $x = \pm\sin^{-1}(\pi/4), \pm(\pi - \sin^{-1}(\pi/4))$

EXERCISES 2.3 ■ PAGE 106

1. (a) −6 (b) −8 (c) 2 (d) −6
(e) Does not exist (f) 0
3. 59 **5.** 390 **7.** $\frac{1}{8}$ **9.** 0 **11.** 5
13. Does not exist **15.** $\frac{6}{5}$ **17.** 8 **19.** $\frac{1}{12}$ **21.** 6
23. $\frac{1}{6}$ **25.** $-\frac{1}{16}$ **27.** $\frac{1}{128}$ **29.** $-\frac{1}{2}$ **31.** (a), (b) $\frac{2}{3}$
35. 7 **39.** 6 **41.** −4 **43.** Does not exist
45. (a) 

(b) (i) 1
(ii) −1
(iii) Does not exist
(iv) 1
47. (a) (i) 2 (ii) −2 (b) No (c) 

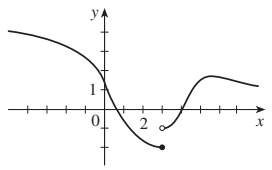
49. (a) (i) -2 (ii) Does not exist (iii) -3
(b) (i) $n-1$ (ii) n (c) a is not an integer.
55. 8 **61.** 15; -1

EXERCISES 2.4 ■ PAGE 117

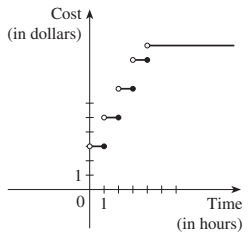
1. $\frac{4}{7}$ (or any smaller positive number)
3. 1.44 (or any smaller positive number)
5. 0.0906 (or any smaller positive number)
7. 0.11, 0.012 (or smaller positive numbers)
9. (a) 0.031 (b) 0.010
11. (a) $\sqrt{1000/\pi}$ cm (b) Within approximately 0.0445 cm
(c) Radius; area; $\sqrt{1000/\pi}$; 1000; 5; ≈ 0.0445
13. (a) 0.025 (b) 0.0025
35. (a) 0.093 (b) $\delta = (B^{2/3} - 12)/(6B^{1/3}) - 1$, where $B = 216 + 108\varepsilon + 12\sqrt{336 + 324\varepsilon + 81\varepsilon^2}$
41. Within 0.1

EXERCISES 2.5 ■ PAGE 128

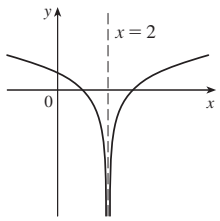
1. $\lim_{x\to 4} f(x) = f(4)$
3. (a) -4 (removable), -2 (jump), 2 (jump), 4 (infinite)
(b) -4, neither; -2, left; 2, right; 4, right
5.

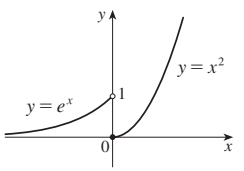


7. (a) (b) Discontinuous at $t = 1, 2, 3, 4$

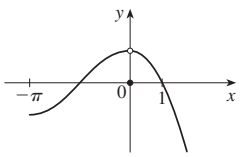


9. 6
15. $f(2)$ is not defined.
17. $\lim_{x\to 0} f(x)$ does not exist.



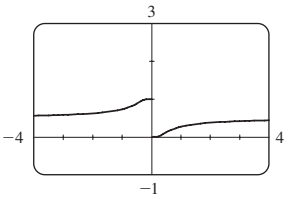


19. $\lim_{x\to 0} f(x) \neq f(0)$
21. $\{x \mid x \neq -3, -2\}$

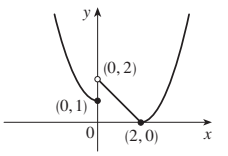


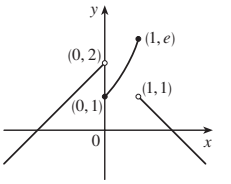
23. $\left[\frac{1}{2}, \infty\right)$ **25.** $(-\infty, \infty)$ **27.** $(-\infty, -1) \cup (1, \infty)$

29. $x = 0$



31. $\frac{7}{3}$ **33.** 1
37. 0, left **39.** 0, right; 1, left

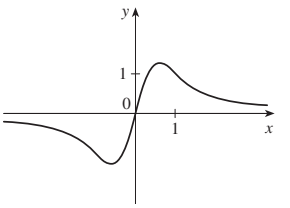


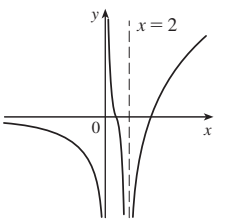


41. $\frac{2}{3}$ **43.** (a) $g(x) = x^3 + x^2 + x + 1$ (b) $g(x) = x^2 + x$
51. (b) (0.86, 0.87) **53.** (b) 70.347
59. None **61.** Yes

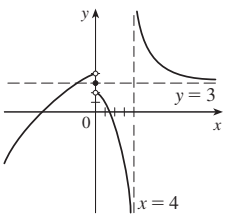
EXERCISES 2.6 ■ PAGE 140

1. (a) As x becomes large, $f(x)$ approaches 5.
(b) As x becomes large negative, $f(x)$ approaches 3.
3. (a) ∞ (b) ∞ (c) $-\infty$ (d) 1 (e) 2
(f) $x = -1, x = 2, y = 1, y = 2$
5. **7.**

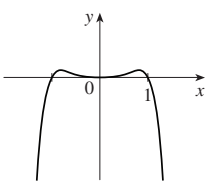


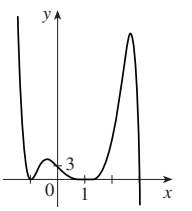


9.

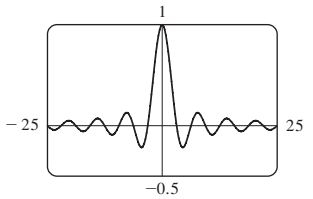


11. 0 **13.** $\frac{3}{2}$ **15.** 0 **17.** $-\frac{1}{2}$ **19.** $\frac{1}{2}$ **21.** 2
23. 3 **25.** $\frac{1}{6}$ **27.** $\frac{1}{2}(a - b)$ **29.** ∞ **31.** $-\infty$
33. $-\frac{1}{2}$ **35.** 0 **37.** (a), (b) $-\frac{1}{2}$ **39.** $y = 2; x = 2$
41. $y = 2; x = -2, x = 1$ **43.** $x = 5$ **45.** $y = 3$
47. $f(x) = \dfrac{2 - x}{x^2(x - 3)}$
49. $-\infty, -\infty$ **51.** $-\infty, \infty$



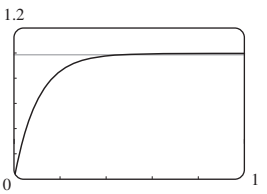


53. (a) 0 (b) An infinite number of times



55. (a) 0 (b) $\pm\infty$ **57.** 5

59. (a) v^* (b) ≈ 0.47 s

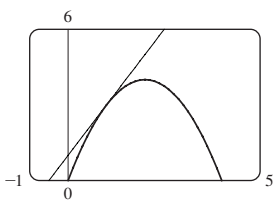


61. $N \geqslant 15$ **63.** $N \leqslant -6, N \leqslant -22$ **65.** (a) $x > 100$

EXERCISES 2.7 ■ PAGE 150

1. (a) $\dfrac{f(x)-f(3)}{x-3}$ (b) $\lim\limits_{x\to 3}\dfrac{f(x)-f(3)}{x-3}$

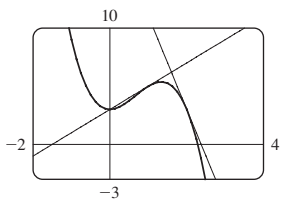
3. (a) 2 (b) $y = 2x + 1$ (c)



5. $y = -x + 5$ **7.** $y = \frac{1}{2}x + \frac{1}{2}$

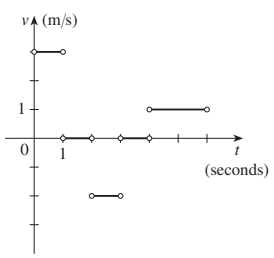
9. (a) $8a - 6a^2$ (b) $y = 2x + 3, y = -8x + 19$

(c)



11. (a) Right: $0 < t < 1$ and $4 < t < 6$; left: $2 < t < 3$; standing still: $1 < t < 2$ and $3 < t < 4$

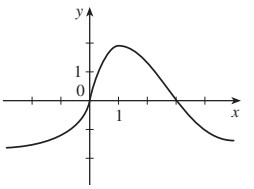
(b)



13. -24 ft/s **15.** $-2/a^3$ m/s; -2 m/s; $-\frac{1}{4}$ m/s; $-\frac{2}{27}$ m/s

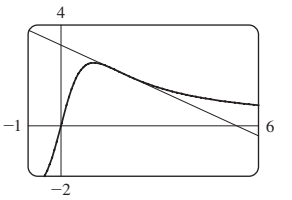
17. $g'(0), 0, g'(4), g'(2), g'(-2)$

19.



21. 7; $y = 7x - 12$

23. (a) $-\frac{3}{5}$; $y = -\frac{3}{5}x + \frac{16}{5}$ (b)



25. $-2 + 8a$ **27.** $\dfrac{5}{(a+3)^2}$ **29.** $\dfrac{-1}{2(a+2)^{3/2}}$

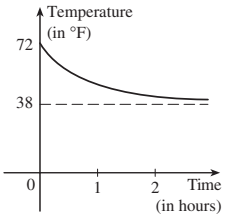
31. $f(x) = x^{10}, a = 1$ or $f(x) = (1+x)^{10}, a = 0$

33. $f(x) = 2^x, a = 5$

35. $f(x) = \cos x, a = \pi$ or $f(x) = \cos(\pi + x), a = 0$

37. 1 m/s; 1 m/s

39.



Greater (in magnitude)

41. (a) (i) 11 percent/year (ii) 13 percent/year
(iii) 16 percent/year
(b) 14.5 percent/year (c) 15 percent/year

43. (a) (i) \$20.25/unit (ii) \$20.05/unit (b) \$20/unit

45. (a) The rate at which the cost is changing per ounce of gold produced; dollars per ounce
(b) When the 800th ounce of gold is produced, the cost of production is \$17/oz.
(c) Decrease in the short term; increase in the long term

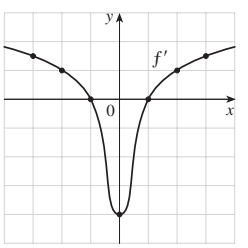
47. The rate at which the temperature is changing at 10:00 AM; 4°F/h

49. (a) The rate at which the oxygen solubility changes with respect to the water temperature; (mg/L)/°C
(b) $S'(16) \approx -0.25$; as the temperature increases past 16°C, the oxygen solubility is decreasing at a rate of 0.25 (mg/L)/°C.

51. Does not exist

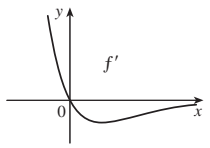
EXERCISES 2.8 ■ PAGE 162

1. (a) 1.5
(b) 1
(c) 0
(d) -4
(e) 0
(f) 1
(g) 1.5



3. (a) II (b) IV (c) I (d) III

5.



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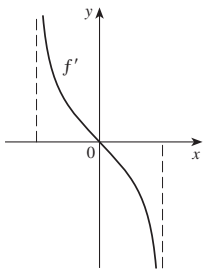

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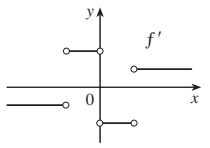
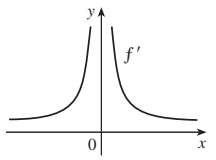
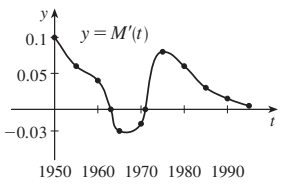


11.

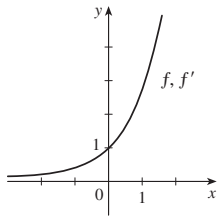


13.



1963 to 1971

15. $f'(x) = e^x$



17. (a) 0, 1, 2, 4 (b) $-1, -2, -4$ (c) $f'(x) = 2x$

19. $f'(x) = \frac{1}{2}$, $\mathbb{R}$, $\mathbb{R}$ **21.** $f'(t) = 5 - 18t$, $\mathbb{R}$, $\mathbb{R}$

23. $f'(x) = 3x^2 - 3$, $\mathbb{R}$, $\mathbb{R}$

25. $g'(x) = 1/\sqrt{1 + 2x}$, $\left[-\frac{1}{2}, \infty\right)$, $\left(-\frac{1}{2}, \infty\right)$

27. $G'(t) = \dfrac{4}{(t+1)^2}$, $(-\infty, -1) \cup (-1, \infty)$, $(-\infty, -1) \cup (-1, \infty)$

29. $f'(x) = 4x^3$, $\mathbb{R}$, $\mathbb{R}$ **31.** (a) $f'(x) = 4x^3 + 2$

33. (a) The rate at which the unemployment rate is changing, in percent unemployed per year

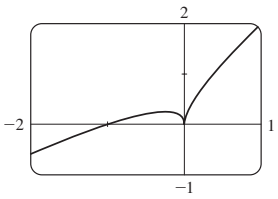
(b)

t	$U'(t)$	t	$U'(t)$
1993	−0.80	1998	−0.35
1994	−0.65	1999	−0.25
1995	−0.35	2000	0.25
1996	−0.35	2001	0.90
1997	−0.45	2002	1.10

35. -4 (corner); 0 (discontinuity)

37. -1 (vertical tangent); 4 (corner)

39.

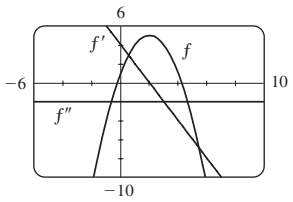


Differentiable at -1; not differentiable at 0

41. $a = f, b = f', c = f''$

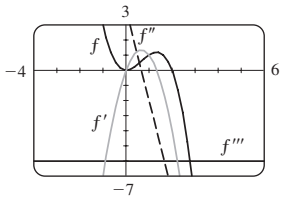
43. a = acceleration, b = velocity, c = position

45.



$f'(x) = 4 - 2x$,
$f''(x) = -2$

47.

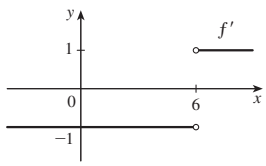


$f'(x) = 4x - 3x^2$,
$f''(x) = 4 - 6x$,
$f'''(x) = -6$,
$f^{(4)}(x) = 0$

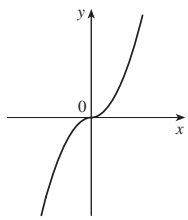
49. (a) $\frac{1}{3}a^{-2/3}$

51. $f'(x) = \begin{cases} -1 & \text{if } x < 6 \\ 1 & \text{if } x > 6 \end{cases}$

or $f'(x) = \dfrac{x - 6}{|x - 6|}$



53. (a)



(b) All x

(c) $f'(x) = 2|x|$

57. 63°

CHAPTER 2 REVIEW ■ PAGE 166

True-False Quiz

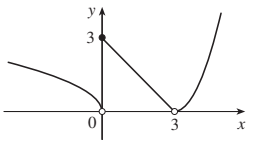
1. False **3.** True **5.** False **7.** True **9.** True
11. False **13.** True **15.** True **17.** False **19.** False

Exercises

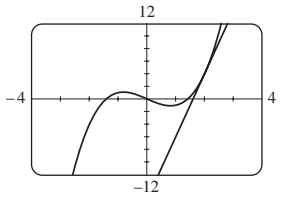
1. (a) (i) 3 (ii) 0 (iii) Does not exist (iv) 2
(v) ∞ (vi) $-\infty$ (vii) 4 (viii) -1
(b) $y = 4, y = -1$ (c) $x = 0, x = 2$ (d) $-3, 0, 2, 4$

3. 1 **5.** $\frac{3}{2}$ **7.** 3 **9.** ∞ **11.** $\frac{4}{7}$ **13.** $\frac{1}{2}$
15. $-\infty$ **17.** 2 **19.** $\pi/2$ **21.** $x = 0, y = 0$ **23.** 1
29. (a) (i) 3 (ii) 0 (iii) Does not exist (iv) 0 (v) 0 (vi) 0

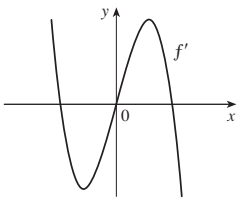
(b) At 0 and 3 (c)



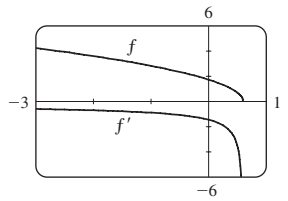
31. $\mathbb{R}$ **35.** (a) -8 (b) $y = -8x + 17$
37. (a) (i) 3 m/s (ii) 2.75 m/s (iii) 2.625 m/s
(iv) 2.525 m/s (b) 2.5 m/s
39. (a) 10 (b) $y = 10x - 16$
(c)



41. (a) The rate at which the cost changes with respect to the interest rate; dollars/(percent per year)
(b) As the interest rate increases past 10%, the cost is increasing at a rate of \$1200/(percent per year).
(c) Always positive
43.



45. (a) $f'(x) = -\frac{5}{2}(3 - 5x)^{-1/2}$ (b) $\left(-\infty, \frac{3}{5}\right], \left(-\infty, \frac{3}{5}\right)$
(c)



47. -4 (discontinuity), -1 (corner), 2 (discontinuity), 5 (vertical tangent)
49. The rate at which the total value of US currency in circulation is changing in billions of dollars per year; \$22.2 billion/year
51. 0

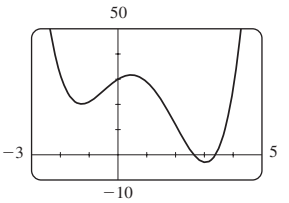
PROBLEMS PLUS ■ PAGE 170

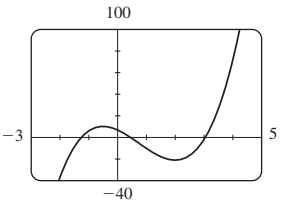
1. $\frac{2}{3}$ **3.** -4 **5.** 1 **7.** $a = \frac{1}{2} \pm \frac{1}{2}\sqrt{5}$
9. $\frac{3}{4}$ **11.** (b) Yes (c) Yes; no
13. (a) 0 (b) 1 (c) $f'(x) = x^2 + 1$

CHAPTER 3

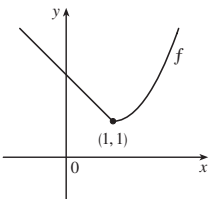
EXERCISES 3.1 ■ PAGE 180

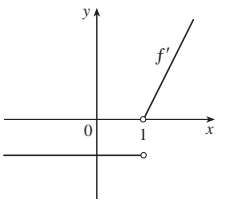
1. (a) See Definition of the Number e (page 179).
(b) 0.99, 1.03; $2.7 < e < 2.8$
3. $f'(x) = 0$ **5.** $f'(t) = -\frac{2}{3}$ **7.** $f'(x) = 3x^2 - 4$
9. $f'(t) = t^3$ **11.** $y' = -\frac{2}{5}x^{-7/5}$ **13.** $V'(r) = 4\pi r^2$
15. $A'(s) = 60/s^6$ **17.** $G'(x) = 1/(2\sqrt{x}) - 2e^x$
19. $F'(x) = \frac{5}{32}x^4$ **21.** $y' = 2ax + b$
23. $y' = \frac{3}{2}\sqrt{x} + (2/\sqrt{x}) - 3/(2x\sqrt{x})$
25. $y' = 0$ **27.** $H'(x) = 3x^2 + 3 - 3x^{-2} - 3x^{-4}$
29. $u' = \frac{1}{5}t^{-4/5} + 10t^{3/2}$ **31.** $z' = -10A/y^{11} + Be^y$
33. $y = \frac{1}{4}x + \frac{3}{4}$
35. Tangent: $y = 2x + 2$; normal: $y = -\frac{1}{2}x + 2$
37. $y = 3x - 1$ **39.** $e^x - 5$ **41.** $45x^{14} - 15x^2$
43. (a) (c) $4x^3 - 9x^2 - 12x + 7$





45. $f'(x) = 4x^3 - 9x^2 + 16$, $f''(x) = 12x^2 - 18x$
47. $f'(x) = 2 - \frac{15}{4}x^{-1/4}$, $f''(x) = \frac{15}{16}x^{-5/4}$
49. (a) $v(t) = 3t^2 - 3$, $a(t) = 6t$ (b) 12 m/s^2
(c) $a(1) = 6$ m/s^2 **51.** $(-2, 21), (1, -6)$
55. $y = 12x - 15$, $y = 12x + 17$ **57.** $y = \frac{1}{3}x - \frac{1}{3}$
59. $(\pm 2, 4)$ **63.** $P(x) = x^2 - x + 3$
65. $y = \frac{3}{16}x^3 - \frac{9}{4}x + 3$
67. No

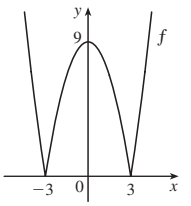


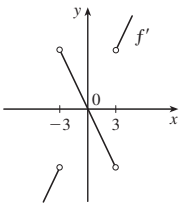


69. (a) Not differentiable at 3 or -3

$$f'(x) = \begin{cases} 2x & \text{if } |x| > 3 \\ -2x & \text{if } |x| < 3 \end{cases}$$

(b)





71. $y = 2x^2 - x$ **73.** $a = -\frac{1}{2}, b = 2$ **75.** $m = 4, b = -4$
77. 1000 **79.** 3; 1

EXERCISES 3.2 ■ PAGE 187

1. $y' = 5x^4 + 3x^2 + 2x$
3. $f'(x) = e^x(x^3 + 3x^2 + 2x + 2)$
5. $y' = (x - 2)e^x/x^3$ **7.** $g'(x) = 5/(2x + 1)^2$
9. $V'(x) = 14x^6 - 4x^3 - 6$
11. $F'(y) = 5 + 14/y^2 + 9/y^4$
13. $y' = \dfrac{x^2(3 - x^2)}{(1 - x^2)^2}$ **15.** $y' = \dfrac{2t(-t^4 - 4t^2 + 7)}{(t^4 - 3t^2 + 1)^2}$

17. $y' = (r^2 - 2)e^r$ **19.** $y' = 2v - 1/\sqrt{v}$

21. $f'(t) = \dfrac{4 + t^{1/2}}{(2 + \sqrt{t})^2}$ **23.** $f'(x) = -ACe^x/(B + Ce^x)^2$

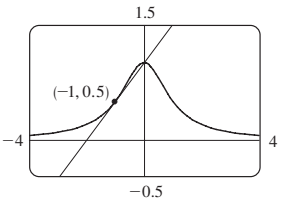
25. $f'(x) = 2cx/(x^2 + c)^2$

27. $(x^4 + 4x^3)e^x$; $(x^4 + 8x^3 + 12x^2)e^x$

29. $\dfrac{2x^2 + 2x}{(1 + 2x)^2}$; $\dfrac{2}{(1 + 2x)^3}$

31. $y = \frac{1}{2}x + \frac{1}{2}$ **33.** $y = 2x$; $y = -\frac{1}{2}x$

35. (a) $y = \frac{1}{2}x + 1$ (b)



37. (a) $e^x(x - 3)/x^4$ **39.** xe^x, $(x + 1)e^x$

41. $\frac{1}{4}$ **43.** (a) -16 (b) $-\frac{20}{9}$ (c) 20

45. 7 **47.** (a) 0 (b) $-\frac{2}{3}$

49. (a) $y' = xg'(x) + g(x)$ (b) $y' = [g(x) - xg'(x)]/[g(x)]^2$
(c) $y' = [xg'(x) - g(x)]/x^2$

51. Two, $(-2 \pm \sqrt{3}, (1 \mp \sqrt{3})/2)$

53. \$1.627 billion/year **55.** (c) $3e^{3x}$

57. $f'(x) = (x^2 + 2x)e^x$, $f''(x) = (x^2 + 4x + 2)e^x$,
$f'''(x) = (x^2 + 6x + 6)e^x$, $f^{(4)}(x) = (x^2 + 8x + 12)e^x$,
$f^{(5)}(x) = (x^2 + 10x + 20)e^x$; $f^{(n)}(x) = [x^2 + 2nx + n(n - 1)]e^x$

EXERCISES 3.3 ■ PAGE 195

1. $f'(x) = 6x + 2\sin x$ **3.** $f'(x) = \cos x - \frac{1}{2}\csc^2 x$

5. $g'(t) = 3t^2\cos t - t^3\sin t$

7. $h'(\theta) = -\csc\theta\cot\theta + e^\theta(\cot\theta - \csc^2\theta)$

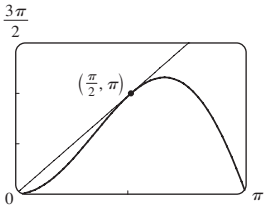
9. $y' = \dfrac{2 - \tan x + x\sec^2 x}{(2 - \tan x)^2}$ **11.** $f'(\theta) = \dfrac{\sec\theta\tan\theta}{(1 + \sec\theta)^2}$

13. $y' = (x\cos x - 2\sin x)/x^3$

15. $f'(x) = e^x\csc x(-x\cot x + x + 1)$

21. $y = 2\sqrt{3}x - \frac{2}{3}\sqrt{3}\pi + 2$ **23.** $y = x + 1$

25. (a) $y = 2x$ (b)



27. (a) $\sec x\tan x - 1$

29. $\theta\cos\theta + \sin\theta$; $2\cos\theta - \theta\sin\theta$

31. (a) $f'(x) = (1 + \tan x)/\sec x$ (b) $f'(x) = \cos x + \sin x$

33. $(2n + 1)\pi \pm \frac{1}{3}\pi$, n an integer

35. (a) $v(t) = 8\cos t$, $a(t) = -8\sin t$
(b) $4\sqrt{3}$, -4, $-4\sqrt{3}$; to the left

37. 5 ft/rad **39.** 3 **41.** 3 **43.** $\sin 1$

45. $\frac{1}{2}$ **47.** $-\sqrt{2}$

49. (a) $\sec^2 x = 1/\cos^2 x$ (b) $\sec x\tan x = (\sin x)/\cos^2 x$
(c) $\cos x - \sin x = (\cot x - 1)/\csc x$

51. 1

EXERCISES 3.4 ■ PAGE 203

1. $4\cos 4x$ **3.** $-20x(1 - x^2)^9$ **5.** $e^{\sqrt{x}}/(2\sqrt{x})$

7. $F'(x) = 10x(x^4 + 3x^2 - 2)^4(2x^2 + 3)$

9. $F'(x) = \dfrac{2 + 3x^2}{4(1 + 2x + x^3)^{3/4}}$ **11.** $g'(t) = -\dfrac{12t^3}{(t^4 + 1)^4}$

13. $y' = -3x^2\sin(a^3 + x^3)$ **15.** $y' = e^{-kx}(-kx + 1)$

17. $g'(x) = 4(1 + 4x)^4(3 + x - x^2)^7(17 + 9x - 21x^2)$

19. $y' = 8(2x - 5)^3(8x^2 - 5)^{-4}(-4x^2 + 30x - 5)$

21. $y' = \dfrac{-12x(x^2 + 1)^2}{(x^2 - 1)^4}$ **23.** $y' = (\cos x - x\sin x)e^{x\cos x}$

25. $F'(z) = 1/[(z - 1)^{1/2}(z + 1)^{3/2}]$

27. $y' = (r^2 + 1)^{-3/2}$ **29.** $y' = 2\cos(\tan 2x)\sec^2(2x)$

31. $y' = 2^{\sin\pi x}(\pi\ln 2)\cos\pi x$ **33.** $y' = 4\sec^2 x\tan x$

35. $y' = \dfrac{4e^{2x}}{(1 + e^{2x})^2}\sin\dfrac{1 - e^{2x}}{1 + e^{2x}}$

37. $y' = -2\cos\theta\cot(\sin\theta)\csc^2(\sin\theta)$

39. $f'(t) = \sec^2(e^t)e^t + e^{\tan t}\sec^2 t$

41. $f'(t) = 4\sin(e^{\sin^2 t})\cos(e^{\sin^2 t})\,e^{\sin^2 t}\sin t\cos t$

43. $g'(x) = 2r^2p(\ln a)(2ra^{rx} + n)^{p-1}a^{rx}$

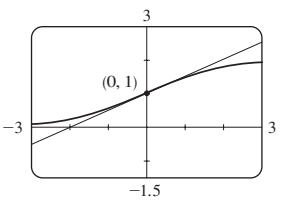
45. $y' = \dfrac{-\pi\cos(\tan\pi x)\sec^2(\pi x)\sin\sqrt{\sin(\tan\pi x)}}{2\sqrt{\sin(\tan\pi x)}}$

47. $h'(x) = x/\sqrt{x^2 + 1}$, $h''(x) = 1/(x^2 + 1)^{3/2}$

49. $e^{\alpha x}(\beta\cos\beta x + \alpha\sin\beta x)$; $e^{\alpha x}[(\alpha^2 - \beta^2)\sin\beta x + 2\alpha\beta\cos\beta x]$

51. $y = 20x + 1$ **53.** $y = -x + \pi$

55. (a) $y = \frac{1}{2}x + 1$ (b)



57. (a) $f'(x) = (2 - 2x^2)/\sqrt{2 - x^2}$

59. $((\pi/2) + 2n\pi, 3)$, $((3\pi/2) + 2n\pi, -1)$, n an integer

61. 24 **63.** (a) 30 (b) 36

65. (a) $\frac{3}{4}$ (b) Does not exist (c) -2

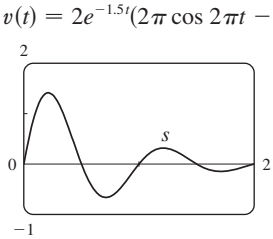
67. (a) $F'(x) = e^x f'(e^x)$ (b) $G'(x) = e^{f(x)}f'(x)$

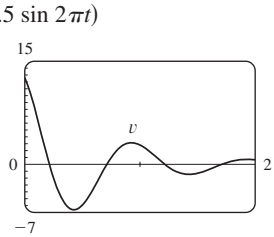
69. 120 **71.** 96 **75.** $-2^{50}\cos 2x$

77. $v(t) = \frac{5}{2}\pi\cos(10\pi t)$ cm/s

79. (a) $\dfrac{dB}{dt} = \dfrac{7\pi}{54}\cos\dfrac{2\pi t}{5.4}$ (b) 0.16

81. $v(t) = 2e^{-1.5t}(2\pi\cos 2\pi t - 1.5\sin 2\pi t)$

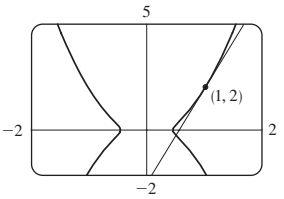




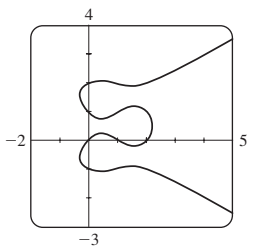
83. dv/dt is the rate of change of velocity with respect to time; dv/ds is the rate of change of velocity with respect to displacement
85. (a) $y = ab^t$ where $a \approx 100.01244$ and $b \approx 0.000045146$
(b) $-670.63\ \mu A$
87. (b) The factored form
91. (b) $-n\cos^{n-1}x\sin[(n+1)x]$

EXERCISES 3.5 ■ PAGE 213

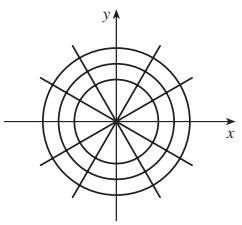
1. (a) $y' = -(y + 2 + 6x)/x$
(b) $y = (4/x) - 2 - 3x$, $y' = -(4/x^2) - 3$
3. (a) $y' = -y^2/x^2$ (b) $y = x/(x-1)$, $y' = -1/(x-1)^2$
5. $y' = -x^2/y^2$
7. $y' = \dfrac{2x + y}{2y - x}$ **9.** $y' = \dfrac{3y^2 - 5x^4 - 4x^3y}{x^4 + 3y^2 - 6xy}$
11. $y' = \dfrac{-2xy^2 - \sin y}{2x^2y + x\cos y}$ **13.** $y' = \tan x \tan y$
15. $y' = \dfrac{y(y - e^{x/y})}{y^2 - xe^{x/y}}$ **17.** $y' = \dfrac{4xy\sqrt{xy} - y}{x - 2x^2\sqrt{xy}}$
19. $y' = \dfrac{e^y\sin x + y\cos(xy)}{e^y\cos x - x\cos(xy)}$ **21.** $-\frac{16}{13}$
23. $x' = \dfrac{-2x^4y + x^3 - 6xy^2}{4x^3y^2 - 3x^2y + 2y^3}$ **25.** $y = -x + 2$
27. $y = x + \frac{1}{2}$ **29.** $y = -\frac{9}{13}x + \frac{40}{13}$
31. (a) $y = \frac{9}{2}x - \frac{5}{2}$ (b)



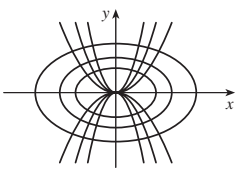
33. $-81/y^3$ **35.** $-2x/y^5$
37. (a)



Eight; $x \approx 0.42, 1.58$
(b) $y = -x + 1$, $y = \frac{1}{3}x + 2$ (c) $1 \mp \frac{1}{3}\sqrt{3}$
39. $\left(\pm\frac{5}{4}\sqrt{3}, \pm\frac{5}{4}\right)$ **41.** $(x_0x/a^2) - (y_0y/b^2) = 1$
45. $y' = \dfrac{1}{2\sqrt{x}(1+x)}$ **47.** $y' = \dfrac{1}{\sqrt{-x^2 - x}}$
49. $G'(x) = -1 - \dfrac{x\arccos x}{\sqrt{1-x^2}}$ **51.** $h'(t) = 0$
53. $y' = -2e^{2x}/\sqrt{1 - e^{4x}}$ **55.** $1 - \dfrac{x\arcsin x}{\sqrt{1-x^2}}$
59.



61.



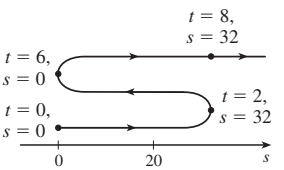
63. $(\pm\sqrt{3}, 0)$ **65.** $(-1,-1), (1,1)$ **67.** (b) $\frac{3}{2}$ **69.** 2

EXERCISES 3.6 ■ PAGE 220

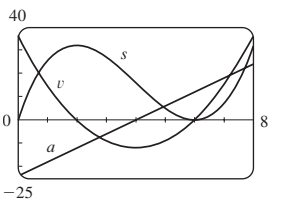
1. The differentiation formula is simplest.
3. $f'(x) = \dfrac{\cos(\ln x)}{x}$ **5.** $f'(x) = \dfrac{3}{(3x-1)\ln 2}$
7. $f'(x) = \dfrac{1}{5x\sqrt[5]{(\ln x)^4}}$ **9.** $f'(x) = \dfrac{\sin x}{x} + \cos x\ln(5x)$
11. $F'(t) = \dfrac{6}{2t+1} - \dfrac{12}{3t-1}$ **13.** $g'(x) = \dfrac{2x^2 - 1}{x(x^2-1)}$
15. $f'(u) = \dfrac{1 + \ln 2}{u[1 + \ln(2u)]^2}$ **17.** $y' = \dfrac{10x + 1}{5x^2 + x - 2}$
19. $y' = \dfrac{-x}{1+x}$ **21.** $y' = \dfrac{1}{\ln 10} + \log_{10}x$
23. $y' = x + 2x\ln(2x)$; $y'' = 3 + 2\ln(2x)$
25. $y' = \dfrac{1}{\sqrt{1+x^2}}$; $y'' = \dfrac{-x}{(1+x^2)^{3/2}}$
27. $f'(x) = \dfrac{2x - 1 - (x-1)\ln(x-1)}{(x-1)[1 - \ln(x-1)]^2}$;
$(1, 1+e) \cup (1+e, \infty)$
29. $f'(x) = \dfrac{2(x-1)}{x(x-2)}$; $(-\infty, 0) \cup (2, \infty)$
31. 1 **33.** $y = 3x - 2$ **35.** $\cos x + 1/x$
37. $y' = (2x+1)^5(x^4-3)^6\left(\dfrac{10}{2x+1} + \dfrac{24x^3}{x^4-3}\right)$
39. $y' = \dfrac{\sin^2x\tan^4x}{(x^2+1)^2}\left(2\cot x + \dfrac{4\sec^2x}{\tan x} - \dfrac{4x}{x^2+1}\right)$
41. $y' = x^x(1 + \ln x)$
43. $y' = x^{\sin x}\left(\dfrac{\sin x}{x} + \cos x\ln x\right)$
45. $y' = (\cos x)^x(-x\tan x + \ln\cos x)$
47. $y' = (\tan x)^{1/x}\left(\dfrac{\sec^2x}{x\tan x} - \dfrac{\ln\tan x}{x^2}\right)$
49. $y' = \dfrac{2x}{x^2 + y^2 - 2y}$ **51.** $f^{(n)}(x) = \dfrac{(-1)^{n-1}(n-1)!}{(x-1)^n}$

EXERCISES 3.7 ■ PAGE 230

1. (a) $3t^2 - 24t + 36$ (b) -9 ft/s (c) $t = 2, 6$
(d) $0 \leqslant t < 2$, $t > 6$
(e) 96 ft
(f)

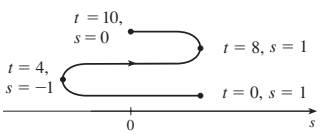


(g) $6t - 24$; -6 m/s²
(h)

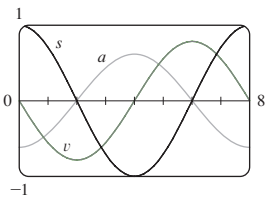


(i) Speeding up when $2 < t < 4$ or $t > 6$; slowing down when $0 \leqslant t < 2$ or $4 < t < 6$

3. (a) $-\frac{\pi}{4}\sin\left(\frac{\pi t}{4}\right)$ (b) $-\frac{1}{8}\pi\sqrt{2}$ ft/s (c) $t = 0, 4, 8$
(d) $4 < t < 8$ (e) 4 ft
(f)



(g) $-\frac{1}{16}\pi^2\cos(\pi t/4)$; $\frac{1}{32}\pi^2\sqrt{2}$ ft/s^2
(h)



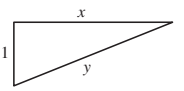
(i) Speeding up when $0 < t < 2$, $4 < t < 6$; slowing down when $2 < t < 4$, $6 < t < 8$
5. (a) Speeding up when $0 < t < 1$ or $2 < t < 3$; slowing down when $1 < t < 2$
(b) Speeding up when $1 < t < 2$ or $3 < t < 4$; slowing down when $0 < t < 1$ or $2 < t < 3$
7. (a) $t = 4$ s
(b) $t = 1.5$ s; the velocity has an absolute minimum.
9. (a) 5.02 m/s (b) $\sqrt{17}$ m/s
11. (a) 30 mm^2/mm; the rate at which the area is increasing with respect to side length as x reaches 15 mm
(b) $\Delta A \approx 2x\,\Delta x$
13. (a) (i) 5π (ii) 4.5π (iii) 4.1π
(b) 4π (c) $\Delta A \approx 2\pi r\,\Delta r$
15. (a) 8π ft^2/ft (b) 16π ft^2/ft (c) 24π ft^2/ft
The rate increases as the radius increases.
17. (a) 6 kg/m (b) 12 kg/m (c) 18 kg/m
At the right end; at the left end
19. (a) 4.75 A (b) 5 A; $t = \frac{2}{3}$ s
21. (a) $dV/dP = -C/P^2$ (b) At the beginning
23. $400(3^t)\ln 3$; ≈ 6850 bacteria/h
25. (a) 16 million/year; 78.5 million/year
(b) $P(t) = at^3 + bt^2 + ct + d$, where $a \approx 0.00129371$, $b \approx -7.061422$, $c \approx 12{,}822.979$, $d \approx -7{,}743{,}770$
(c) $P'(t) = 3at^2 + 2bt + c$
(d) 14.48 million/year; 75.29 million/year (smaller)
(e) 81.62 million/year
27. (a) 0.926 cm/s; 0.694 cm/s; 0
(b) 0; -92.6 (cm/s)/cm; -185.2 (cm/s)/cm
(c) At the center; at the edge
29. (a) $C'(x) = 12 - 0.2x + 0.0015x^2$
(b) \$32/yard; the cost of producing the 201st yard
(c) \$32.20
31. (a) $[xp'(x) - p(x)]/x^2$; the average productivity increases as new workers are added.
33. -0.2436 K/min
35. (a) 0 and 0 (b) $C = 0$
(c) (0, 0), (500, 50); it is possible for the species to coexist.

EXERCISES 3.8 ■ PAGE 239

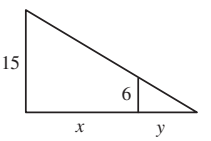
1. About 235
3. (a) $100(4.2)^t$ (b) ≈ 7409 (c) $\approx 10{,}632$ bacteria/h
(d) $(\ln 100)/(\ln 4.2) \approx 3.2$ h
5. (a) 1508 million, 1871 million (b) 2161 million
(c) 3972 million; wars in the first half of century, increased life expectancy in second half
7. (a) $Ce^{-0.0005t}$ (b) $-2000\ln 0.9 \approx 211$ s
9. (a) $100 \times 2^{-t/30}$ mg (b) ≈ 9.92 mg (c) ≈ 199.3 years
11. ≈ 2500 years **13.** (a) $\approx 137°$F (b) ≈ 116 min
15. (a) $13.\overline{3}°$C (b) ≈ 67.74 min
17. (a) ≈ 64.5 kPa (b) ≈ 39.9 kPa
19. (a) (i) \$3828.84 (ii) \$3840.25 (iii) \$3850.08
(iv) \$3851.61 (v) \$3852.01 (vi) \$3852.08
(b) $dA/dt = 0.05A$, $A(0) = 3000$

EXERCISES 3.9 ■ PAGE 245

1. $dV/dt = 3x^2\,dx/dt$ **3.** 48 cm^2/s **5.** $3/(25\pi)$ m/min
7. 70 **9.** $\pm\frac{46}{13}$
11. (a) The plane's altitude is 1 mi and its speed is 500 mi/h.
(b) The rate at which the distance from the plane to the station is increasing when the plane is 2 mi from the station
(c)



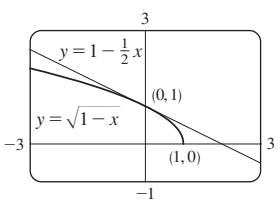
(d) $y^2 = x^2 + 1$
(e) $250\sqrt{3}$ mi/h
13. (a) The height of the pole (15 ft), the height of the man (6 ft), and the speed of the man (5 ft/s)
(b) The rate at which the tip of the man's shadow is moving when he is 40 ft from the pole
(c)



(d) $\frac{15}{6} = \frac{x+y}{y}$ (e) $\frac{25}{3}$ ft/s
15. 65 mi/h **17.** $837/\sqrt{8674} \approx 8.99$ ft/s
19. -1.6 cm/min **21.** $\frac{720}{13} \approx 55.4$ km/h
23. $(10{,}000 + 800{,}000\pi/9) \approx 2.89 \times 10^5$ cm^3/min
25. $\frac{10}{3}$ cm/min **27.** $6/(5\pi) \approx 0.38$ ft/min **29.** 0.3 m^2/s
31. 80 cm^3/min **33.** $\frac{107}{810} \approx 0.132\ \Omega$/s **35.** 0.396 m/min
37. (a) 360 ft/s (b) 0.096 rad/s **39.** $\frac{10}{9}\pi$ km/min
41. $1650/\sqrt{31} \approx 296$ km/h **43.** $\frac{7}{4}\sqrt{15} \approx 6.78$ m/s

EXERCISES 3.10 ■ PAGE 252

1. $L(x) = -10x - 6$ **3.** $L(x) = -x + \pi/2$
5. $\sqrt{1-x} \approx 1 - \frac{1}{2}x$;
$\sqrt{0.9} \approx 0.95$,
$\sqrt{0.99} \approx 0.995$



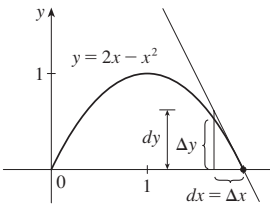
7. $-1.204 < x < 0.706$ **9.** $-0.045 < x < 0.055$
11. (a) $dy = 2x(x\cos 2x + \sin 2x)\,dx$ (b) $dy = \dfrac{t}{1+t^2}\,dt$

13. (a) $dy = \dfrac{-2}{(u-1)^2}\,du$ (b) $dy = -\dfrac{6r^2}{(1+r^3)^3}\,dr$

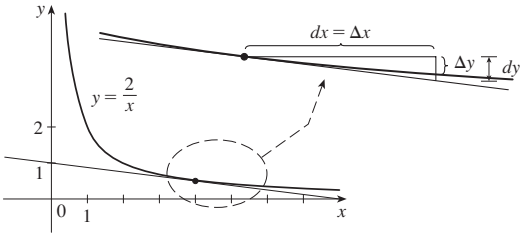
15. (a) $dy = \frac{1}{10}e^{x/10}\,dx$ (b) 0.01; 0.0101

17. (a) $dy = \sec^2 x\,dx$ (b) -0.2

19. $\Delta y = 0.64$, $dy = 0.8$



21. $\Delta y = -0.1$, $dy = -0.125$



23. 32.08 **25.** 4.02 **27.** $1 - \pi/90 \approx 0.965$

33. (a) 270 cm^3, 0.01, 1% (b) 36 cm^2, 0.00$\overline{6}$, 0.$\overline{6}$%

35. (a) $84/\pi \approx 27$ cm^2; $\frac{1}{84} \approx 0.012$

(b) $1764/\pi^2 \approx 179$ cm^3; $\frac{1}{56} \approx 0.018$

37. (a) $2\pi rh\,\Delta r$ (b) $\pi(\Delta r)^2 h$

43. (a) 4.8, 5.2 (b) Too large

EXERCISES 3.11 ■ PAGE 259

1. (a) 0 (b) 1 **3.** (a) $\frac{3}{4}$ (b) $\frac{1}{2}(e^2 - e^{-2}) \approx 3.62686$

5. (a) 1 (b) 0

21. $\operatorname{sech} x = \frac{3}{5}$, $\sinh x = \frac{4}{3}$, $\operatorname{csch} x = \frac{3}{4}$, $\tanh x = \frac{4}{5}$, $\coth x = \frac{5}{4}$

23. (a) 1 (b) -1 (c) ∞ (d) $-\infty$ (e) 0 (f) 1
(g) ∞ (h) $-\infty$ (i) 0

31. $f'(x) = x\cosh x$ **33.** $h'(x) = \tanh x$

35. $y' = 3e^{\cosh 3x}\sinh 3x$ **37.** $f'(t) = -2e^t \operatorname{sech}^2(e^t)\tanh(e^t)$

39. $y' = \dfrac{\operatorname{sech}^2 x}{1 + \tanh^2 x}$ **41.** $G'(x) = \dfrac{-2\sinh x}{(1+\cosh x)^2}$

43. $y' = \dfrac{1}{2\sqrt{x}(1-x)}$ **45.** $y' = \sinh^{-1}(x/3)$

47. $y' = \dfrac{-1}{x\sqrt{x^2+1}}$

51. (a) 0.3572 (b) 70.34°

53. (b) $y = 2\sinh 3x - 4\cosh 3x$

55. $\left(\ln(1+\sqrt{2}), \sqrt{2}\right)$

CHAPTER 3 REVIEW ■ PAGE 261

True-False Quiz

1. True **3.** True **5.** False **7.** False **9.** True
11. True

Exercises

1. $6x(x^4 - 3x^2 + 5)^2(2x^2 - 3)$ **3.** $\dfrac{1}{2\sqrt{x}} - \dfrac{4}{3\sqrt[3]{x^7}}$

5. $\dfrac{2(2x^2+1)}{\sqrt{x^2+1}}$ **7.** $2\cos 2\theta\, e^{\sin 2\theta}$

9. $\dfrac{t^2+1}{(1-t^2)^2}$ **11.** $\dfrac{\cos\sqrt{x} - \sqrt{x}\sin\sqrt{x}}{2\sqrt{x}}$

13. $-\dfrac{e^{1/x}(1+2x)}{x^4}$ **15.** $\dfrac{1 - y^4 - 2xy}{4xy^3 + x^2 - 3}$

17. $\dfrac{2\sec 2\theta\,(\tan 2\theta - 1)}{(1+\tan 2\theta)^2}$ **19.** $(1+c^2)e^{cx}\sin x$

21. $3^{x\ln x}(\ln 3)(1 + \ln x)$ **23.** $-(x-1)^{-2}$

25. $\dfrac{2x - y\cos(xy)}{x\cos(xy) + 1}$ **27.** $\dfrac{2}{(1+2x)\ln 5}$

29. $\cot x - \sin x\cos x$ **31.** $\dfrac{4x}{1+16x^2} + \tan^{-1}(4x)$

33. $5\sec 5x$ **35.** $-6x\csc^2(3x^2+5)$

37. $\cos\left(\tan\sqrt{1+x^3}\right)\left(\sec^2\sqrt{1+x^3}\right)\dfrac{3x^2}{2\sqrt{1+x^3}}$

39. $2\cos\theta\tan(\sin\theta)\sec^2(\sin\theta)$

41. $\dfrac{(x-2)^4(3x^2 - 55x - 52)}{2\sqrt{x+1}\,(x+3)^8}$ **43.** $2x^2\cosh(x^2) + \sinh(x^2)$

45. $3\tanh 3x$ **47.** $\dfrac{\cosh x}{\sqrt{\sinh^2 x - 1}}$

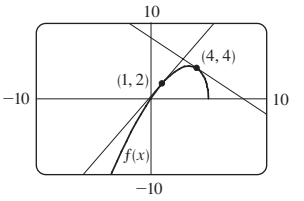
49. $\dfrac{-3\sin\left(e^{\sqrt{\tan 3x}}\right)e^{\sqrt{\tan 3x}}\sec^2(3x)}{2\sqrt{\tan 3x}}$ **51.** $-\frac{4}{27}$ **53.** $-5x^4/y^{11}$

57. $y = 2\sqrt{3}x + 1 - \pi\sqrt{3}/3$ **59.** $y = 2x + 1$

61. $y = -x + 2$; $y = x + 2$

63. (a) $\dfrac{10 - 3x}{2\sqrt{5-x}}$ (b) $y = \frac{7}{4}x + \frac{1}{4}$, $y = -x + 8$

(c)



65. $(\pi/4, \sqrt{2}), (5\pi/4, -\sqrt{2})$ **69.** (a) 2 (b) 44

71. $2xg(x) + x^2 g'(x)$ **73.** $2g(x)g'(x)$ **75.** $g'(e^x)e^x$

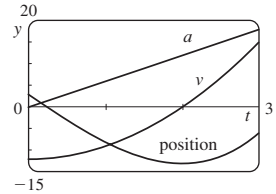
77. $g'(x)/g(x)$ **79.** $\dfrac{f'(x)[g(x)]^2 + g'(x)[f(x)]^2}{[f(x)+g(x)]^2}$

81. $f'(g(\sin 4x))g'(\sin 4x)(\cos 4x)(4)$ **83.** $(-3, 0)$

85. $y = -\frac{2}{3}x^2 + \frac{14}{3}x$

87. $v(t) = -Ae^{-ct}[c\cos(\omega t + \delta) + \omega\sin(\omega t + \delta)]$,
$a(t) = Ae^{-ct}[(c^2 - \omega^2)\cos(\omega t + \delta) + 2c\omega\sin(\omega t + \delta)]$

89. (a) $v(t) = 3t^2 - 12$; $a(t) = 6t$ (b) $t > 2$; $0 \leqslant t < 2$
(c) 23 (d) (e) $t > 2$; $0 < t < 2$



91. 4 kg/m **93.** (a) $200(3.24)^t$ (b) $\approx 22{,}040$
(c) $\approx 25{,}910$ bacteria/h (d) $(\ln 50)/(\ln 3.24) \approx 3.33$ h
95. (a) $C_0 e^{-kt}$ (b) ≈ 100 h **97.** $\frac{4}{3}$ cm^2/min
99. 13 ft/s **101.** 400 ft/h
103. (a) $L(x) = 1 + x$; $\sqrt[3]{1+3x} \approx 1 + x$; $\sqrt[3]{1.03} \approx 1.01$
(b) $-0.23 < x < 0.40$
105. $12 + \frac{3}{2}\pi \approx 16.7$ cm^2 **107.** $\frac{1}{32}$ **109.** $\frac{1}{4}$ **111.** $\frac{1}{8}x^2$

PROBLEMS PLUS ■ PAGE 266

1. $\left(\pm\frac{1}{2}\sqrt{3}, \frac{1}{4}\right)$ **9.** $\left(0, \frac{5}{4}\right)$
11. (a) $4\pi\sqrt{3}/\sqrt{11}$ rad/s (b) $40\left(\cos\theta + \sqrt{8 + \cos^2\theta}\right)$ cm
(c) $-480\pi \sin\theta\left(1 + \cos\theta/\sqrt{8 + \cos^2\theta}\right)$ cm/s
15. $x_T \in (3, \infty)$, $y_T \in (2, \infty)$, $x_N \in \left(0, \frac{5}{3}\right)$, $y_N \in \left(-\frac{5}{2}, 0\right)$
17. (b) (i) 53° (or 127°) (ii) 63° (or 117°)
19. R approaches the midpoint of the radius AO.
21. $-\sin a$ **23.** $2\sqrt{e}$ **27.** $(1, -2)$, $(-1, 0)$
29. $\sqrt{29}/58$ **31.** $2 + \frac{375}{128}\pi \approx 11.204$ cm^3/min

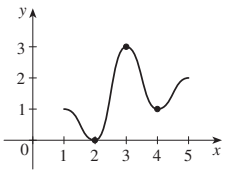
CHAPTER 4

EXERCISES 4.1 ■ PAGE 277

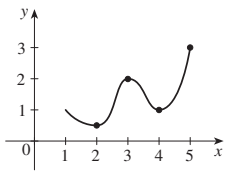
Abbreviations: abs., absolute; loc., local; max., maximum; min., minimum

1. Absolute minimum: smallest function value on the entire domain of the function; local minimum at c: smallest function value when x is near c
3. Abs. max. at s, abs. min. at r, loc. max. at c, loc. min. at b and r
5. Abs. max. $f(4) = 5$, loc. max. $f(4) = 5$ and $f(6) = 4$, loc. min. $f(2) = 2$ and $f(5) = 3$

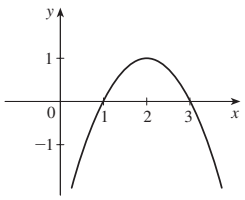
7.



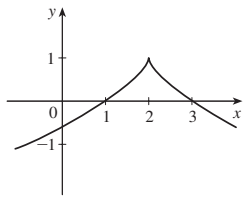
9.



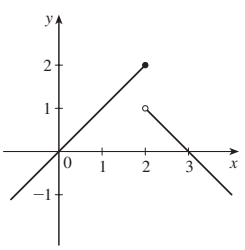
11. (a)



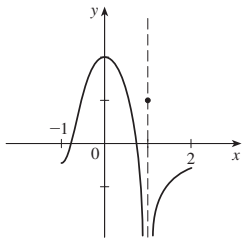
(b)



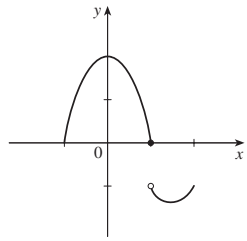
(c)



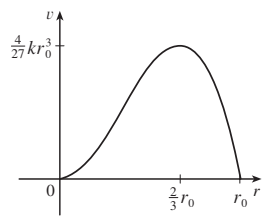
13. (a)



(b)

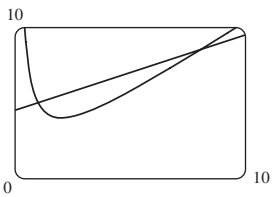


15. Abs. max. $f(1) = 5$ **17.** None
19. Abs. min. $f(0) = 0$
21. Abs. max. $f(-3) = 9$, abs. and loc. min. $f(0) = 0$
23. Abs. max. $f(2) = \ln 2$
25. Abs. max. $f(0) = 1$ **27.** Abs. max. $f(3) = 2$
29. $-\frac{2}{5}$ **31.** $-4, 2$ **33.** $0, \frac{1}{2}\left(-1 \pm \sqrt{5}\right)$ **35.** $0, 2$
37. $0, \frac{4}{9}$ **39.** $0, \frac{8}{7}, 4$ **41.** $n\pi$ (n an integer) **43.** $0, \frac{2}{3}$
45. 10 **47.** $f(0) = 5$, $f(2) = -7$
49. $f(-1) = 8$, $f(2) = -19$
51. $f(3) = 66$, $f(\pm 1) = 2$ **53.** $f(1) = \frac{1}{2}$, $f(0) = 0$
55. $f\left(\sqrt{2}\right) = 2$, $f(-1) = -\sqrt{3}$
57. $f(\pi/6) = \frac{3}{2}\sqrt{3}$, $f(\pi/2) = 0$
59. $f(2) = 2/\sqrt{e}$, $f(-1) = -1/\sqrt[8]{e}$
61. $f(1) = \ln 3$, $f\left(-\frac{1}{2}\right) = \ln\frac{3}{4}$
63. $f\left(\dfrac{a}{a+b}\right) = \dfrac{a^a b^b}{(a+b)^{a+b}}$
65. (a) 2.19, 1.81 (b) $\frac{6}{25}\sqrt{\frac{3}{5}} + 2$, $-\frac{6}{25}\sqrt{\frac{3}{5}} + 2$
67. (a) 0.32, 0.00 (b) $\frac{3}{16}\sqrt{3}, 0$ **69.** ≈ 3.9665°C
71. Cheapest, $t \approx 0.855$ (June 1994);
most expensive, $t \approx 4.618$ (March 1998)
73. (a) $r = \frac{2}{3}r_0$ (b) $v = \frac{4}{27}kr_0^3$
(c)

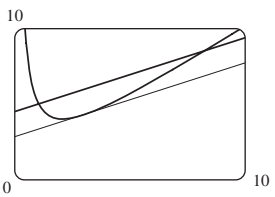


EXERCISES 4.2 ■ PAGE 285

1. 2 **3.** $\frac{9}{4}$ **5.** f is not differentiable on $(-1, 1)$
7. 0.8, 3.2, 4.4, 6.1
9. (a), (b)



(c) $2\sqrt{2}$



11. 0 **13.** $-\frac{1}{2}\ln\left[\frac{1}{6}\left(1 - e^{-6}\right)\right]$ **15.** f is not continous at 3
23. 16 **25.** No **31.** No

EXERCISES 4.3 ■ PAGE 295

Abbreviations: inc., increasing; dec., decreasing; CD, concave downward; CU, concave upward; HA, horizontal asymptote; VA, vertical asymptote; IP, inflection point(s)

1. (a) (1, 3), (4, 6) (b) (0, 1), (3, 4) (c) (0, 2) (d) (2, 4), (4, 6) (e) (2, 3)

3. (a) I/D Test (b) Concavity Test
(c) Find points at which the concavity changes.

5. (a) Inc. on (1, 5); dec. on (0, 1) and (5, 6)
(b) Loc. max. at $x = 5$, loc. min. at $x = 1$

7. $x = 1, 7$

9. (a) Inc. on $(-\infty, 3)$, $(2, \infty)$; dec. on $(-3, 2)$
(b) Loc. max. $f(-3) = 81$; loc. min. $f(2) = -44$
(c) CU on $(-\frac{1}{2}, \infty)$; CD on $(-\infty, -\frac{1}{2})$; IP $(-\frac{1}{2}, \frac{37}{2})$

11. (a) Inc. on $(-1, 0)$, $(1, \infty)$; dec. on $(-\infty, -1)$, $(0, 1)$
(b) Loc. max. $f(0) = 3$; loc. min. $f(\pm 1) = 2$
(c) CU on $(-\infty, -\sqrt{3}/3)$, $(\sqrt{3}/3, \infty)$;
CD on $(-\sqrt{3}/3, \sqrt{3}/3)$; IP $(\pm\sqrt{3}/3, \frac{22}{9})$

13. (a) Inc. on $(0, \pi/4)$, $(5\pi/4, 2\pi)$; dec. on $(\pi/4, 5\pi/4)$
(b) Loc. max. $f(\pi/4) = \sqrt{2}$; loc. min. $f(5\pi/4) = -\sqrt{2}$
(c) CU on $(3\pi/4, 7\pi/4)$; CD on $(0, 3\pi/4)$, $(7\pi/4, 2\pi)$;
IP $(3\pi/4, 0)$, $(7\pi/4, 0)$

15. (a) Inc. on $(-\frac{1}{3}\ln 2, \infty)$; dec. on $(-\infty, -\frac{1}{3}\ln 2)$
(b) Loc. min. $f(-\frac{1}{3}\ln 2) = 2^{-2/3} + 2^{1/3}$ (c) CU on $(-\infty, \infty)$

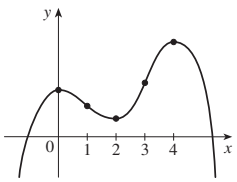
17. (a) Inc. on $(0, e^2)$; dec. on (e^2, ∞)
(b) Loc. max. $f(e^2) = 2/e$
(c) CU on $(e^{8/3}, \infty)$; CD on $(0, e^{8/3})$; IP $(e^{8/3}, \frac{8}{3}e^{-4/3})$

19. Loc. max. $f(-1) = 7$, loc. min. $f(1) = -1$

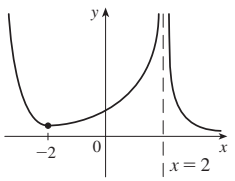
21. Loc. max. $f(\frac{3}{4}) = \frac{5}{4}$

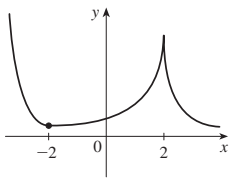
23. (a) f has a local maximum at 2.
(b) f has a horizontal tangent at 6.

25.



27.





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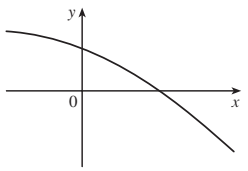
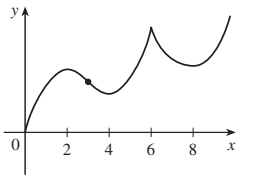
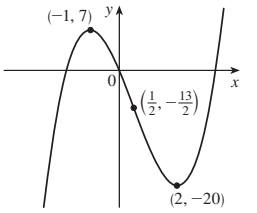


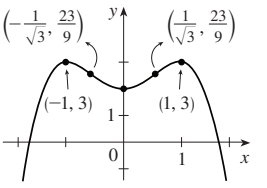
31. (a) Inc. on (0, 2), (4, 6), (8, ∞); dec. on (2, 4), (6, 8)
(b) Loc. max. at $x = 2, 6$; loc. min. at $x = 4, 8$
(c) CU on (3, 6), (6, ∞); CD on (0, 3)
(d) 3 (e) See graph at right.



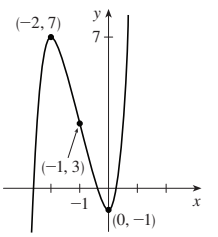
33. (a) Inc. on $(-\infty, -1)$, $(2, \infty)$; dec. on $(-1, 2)$
(b) Loc. max. $f(-1) = 7$; loc. min. $f(2) = -20$
(c) CU on $(\frac{1}{2}, \infty)$; CD on $(-\infty, \frac{1}{2})$; IP $(\frac{1}{2}, -\frac{13}{2})$
(d) See graph at right.



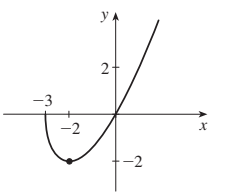
35. (a) Inc. on $(-\infty, -1)$, $(0, 1)$; dec. on $(-1, 0)$, $(1, \infty)$
(b) Loc. max. $f(-1) = 3, f(1) = 3$; loc. min. $f(0) = 2$
(c) CU on $(-1/\sqrt{3}, 1/\sqrt{3})$; CD on $(-\infty, -1/\sqrt{3})$, $(1/\sqrt{3}, \infty)$; IP $(\pm 1/\sqrt{3}, \frac{23}{9})$
(d) See graph at right.



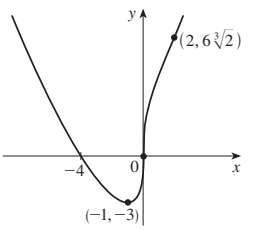
37. (a) Inc. on $(-\infty, -2)$, $(0, \infty)$; dec. on $(-2, 0)$
(b) Loc. max. $h(-2) = 7$; loc. min. $h(0) = -1$
(c) CU on $(-1, \infty)$; CD on $(-\infty, -1)$; IP $(-1, 3)$
(d) See graph at right.



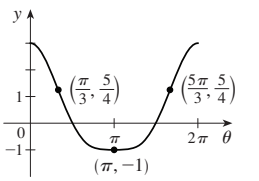
39. (a) Inc. on $(-2, \infty)$; dec. on $(-3, -2)$
(b) Loc. min. $A(-2) = -2$
(c) CU on $(-3, \infty)$
(d) See graph at right.



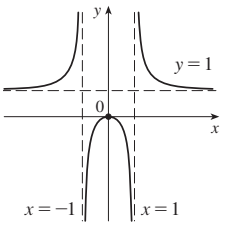
41. (a) Inc. on $(-1, \infty)$; dec. on $(-\infty, -1)$
(b) Loc. min. $C(-1) = -3$
(c) CU on $(-\infty, 0)$, $(2, \infty)$; CD on $(0, 2)$;
IPs $(0, 0)$, $(2, 6\sqrt[3]{2})$
(d) See graph at right.



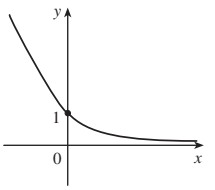
43. (a) Inc. on $(\pi, 2\pi)$; dec. on $(0, \pi)$
(b) Loc. min. $f(\pi) = -1$
(c) CU on $(\pi/3, 5\pi/3)$; CD on $(0, \pi/3)$, $(5\pi/3, 2\pi)$;
IP $(\pi/3, \frac{5}{4})$, $(5\pi/3, \frac{5}{4})$
(d) See graph at right.



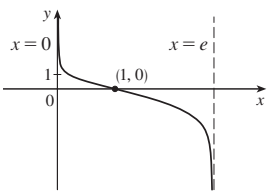
45. (a) HA $y = 1$, VA $x = -1$, $x = 1$
(b) Inc. on $(-\infty, -1)$, $(-1, 0)$;
dec. on $(0, 1)$, $(1, \infty)$
(c) Loc. max. $f(0) = 0$
(d) CU on $(-\infty, -1)$, $(1, \infty)$;
CD on $(-1, 1)$
(e) See graph at right.



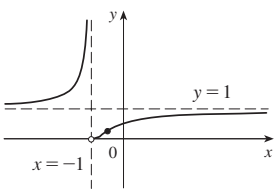
47. (a) HA $y = 0$
(b) Dec. on $(-\infty, \infty)$
(c) None
(d) CU on $(-\infty, \infty)$
(e) See graph at right.



49. (a) VA $x = 0$, $x = e$
(b) Dec. on $(0, e)$
(c) None
(d) CU on $(0, 1)$; CD on $(1, e)$;
IP $(1, 0)$
(e) See graph at right.



51. (a) HA $y = 1$, VA $x = -1$
(b) Inc. on $(-\infty, -1)$, $(-1, \infty)$
(c) None
(d) CU on $(-\infty, -1)$, $\left(-1, -\frac{1}{2}\right)$;
CD on $\left(-\frac{1}{2}, \infty\right)$; IP $\left(-\frac{1}{2}, 1/e^2\right)$
(e) See graph at right.



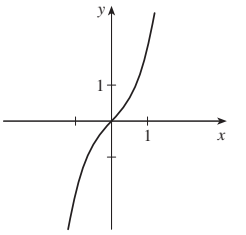
53. $(3, \infty)$
55. (a) Loc. and abs. max. $f(1) = \sqrt{2}$, no min.
(b) $\frac{1}{4}\left(3 - \sqrt{17}\right)$
57. (b) CU on $(0.94, 2.57)$, $(3.71, 5.35)$;
CD on $(0, 0.94)$, $(2.57, 3.71)$, $(5.35, 2\pi)$;
IP $(0.94, 0.44)$, $(2.57, -0.63)$, $(3.71, -0.63)$, $(5.35, 0.44)$
59. CU on $(-\infty, -0.6)$, $(0.0, \infty)$; CD on $(-0.6, 0.0)$
61. (a) The rate of increase is initially very small, increases to a maximum at $t \approx 8$ h, then decreases toward 0.
(b) When $t = 8$ (c) CU on $(0, 8)$; CD on $(8, 18)$ (d) $(8, 350)$
63. $K(3) - K(2)$; CD
65. 28.57 min, when the rate of increase of drug level in the bloodstream is greatest; 85.71 min, when rate of decrease is greatest
67. $f(x) = \frac{1}{9}(2x^3 + 3x^2 - 12x + 7)$

EXERCISES 4.4 ■ PAGE 304

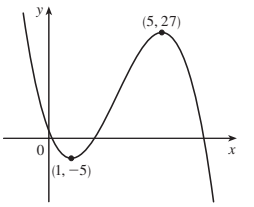
1. (a) Indeterminate (b) 0 (c) 0
(d) ∞, $-\infty$, or does not exist (e) Indeterminate
3. (a) $-\infty$ (b) Indeterminate (c) ∞
5. 2 **7.** $\frac{9}{5}$ **9.** $-\infty$ **11.** ∞ **13.** p/q
15. 0 **17.** $-\infty$ **19.** ∞ **21.** $\frac{1}{2}$ **23.** 1
25. $\ln \frac{5}{3}$ **27.** 1 **29.** $\frac{1}{2}$ **31.** 0 **33.** $-1/\pi^2$
35. $\frac{1}{2}a(a - 1)$ **37.** $\frac{1}{24}$ **39.** π **41.** 3 **43.** 0
45. $-2/\pi$ **47.** $\frac{1}{2}$ **49.** $\frac{1}{2}$ **51.** ∞ **53.** 1
55. e^{-2} **57.** e^3 **59.** 1 **61.** e^4
63. $1/\sqrt{e}$ **65.** e^2 **67.** $\frac{1}{4}$ **71.** 1 **77.** $\frac{16}{9}a$ **79.** 56
83. (a) 0

EXERCISES 4.5 ■ PAGE 314

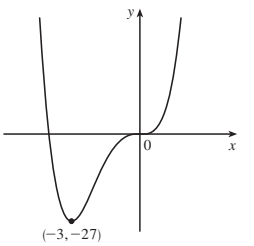
1. A. $\mathbb{R}$ B. y-int. 0; x-int. 0
C. About (0, 0) D. None
E. Inc. on $(-\infty, \infty)$ F. None
G. CU on $(0, \infty)$; CD on $(-\infty, 0)$;
IP $(0, 0)$
H. See graph at right.



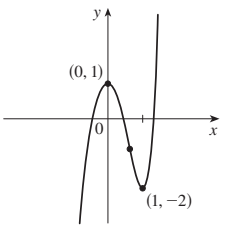
3. A. $\mathbb{R}$ B. y-int. 2; x-int. 2, $\frac{1}{2}\left(7 \pm 3\sqrt{5}\right)$
C. None D. None
E. Inc. on $(1, 5)$;
dec. on $(-\infty, 1)$, $(5, \infty)$
F. Loc. min. $f(1) = -5$;
loc. max. $f(5) = 27$
G. CU on $(-\infty, 3)$;
CD on $(3, \infty)$; IP $(3, 11)$
H. See graph at right.



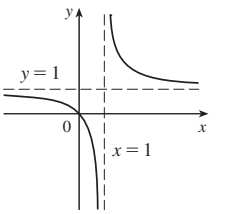
5. A. $\mathbb{R}$ B. y-int. 0; x-int. -4, 0
C. None D. None
E. Inc. on $(-3, \infty)$;
dec. on $(-\infty, -3)$
F. Loc. min. $f(-3) = -27$
G. CU on $(-\infty, -2)$, $(0, \infty)$;
CD on $(-2, 0)$; IP $(0, 0)$, $(-2, -16)$
H. See graph at right.



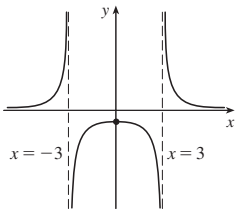
7. A. $\mathbb{R}$ B. y-int. 1
C. None D. None
E. Inc. on $(-\infty, 0)$, $(1, \infty)$;
dec. on $(0, 1)$
F. Loc. max. $f(0) = 1$;
loc. min. $f(1) = -2$
G. CU on $\left(1/\sqrt[3]{4}, \infty\right)$;
CD on $\left(-\infty, 1/\sqrt[3]{4}\right)$;
IP $\left(1/\sqrt[3]{4}, 1 - 9/\left(2\sqrt[3]{16}\right)\right)$
H. See graph at right.



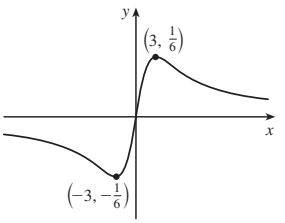
9. A. $\{x \mid x \neq 1\}$ B. y-int. 0; x-int. 0
C. None D. VA $x = 1$, HA $y = 1$
E. Dec. on $(-\infty, 1)$, $(1, \infty)$
F. None
G. CU on $(1, \infty)$; CD on $(-\infty, 1)$
H. See graph at right.



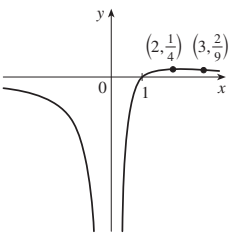
11. A. $\{x \mid x \neq \pm 3\}$ B. y-int. $-\frac{1}{9}$
C. About y-axis D. VA $x = \pm 3$, HA $y = 0$
E. Inc. on $(-\infty, -3)$, $(-3, 0)$;
dec. on $(0, 3)$, $(3, \infty)$
F. Loc. max. $f(0) = -\frac{1}{9}$
G. CU on $(-\infty, -3)$, $(3, \infty)$;
CD on $(-3, 3)$
H. See graph at right.



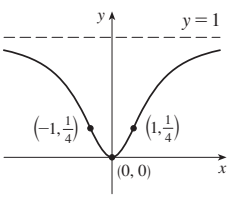
13. A. $\mathbb{R}$ B. y-int. 0; x-int. 0
C. About $(0, 0)$ D. HA $y = 0$
E. Inc. on $(-3, 3)$;
dec. on $(-\infty, -3)$, $(3, \infty)$
F. Loc. min. $f(-3) = -\frac{1}{6}$;
loc. max. $f(3) = \frac{1}{6}$;
G. CU on $(-3\sqrt{3}, 0)$, $(3\sqrt{3}, \infty)$;
CD on $(-\infty, -3\sqrt{3})$, $(0, 3\sqrt{3})$;
IP $(0, 0)$, $(\pm 3\sqrt{3}, \pm\sqrt{3}/12)$
H. See graph at right.



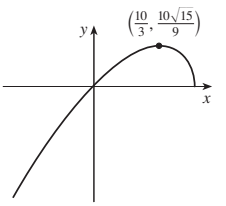
15. A. $(-\infty, 0) \cup (0, \infty)$ B. x-int. 1
C. None D. HA $y = 0$; VA $x = 0$
E. Inc. on $(0, 2)$;
dec. on $(-\infty, 0)$, $(2, \infty)$
F. Loc. max. $f(2) = \frac{1}{4}$
G. CU on $(3, \infty)$;
CD on $(-\infty, 0)$, $(0, 3)$; IP $(3, \frac{2}{9})$
H. See graph at right



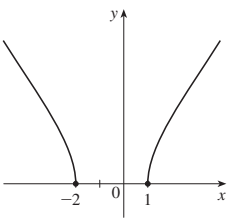
17. A. $\mathbb{R}$ B. y-int. 0, x-int. 0
C. About y-axis D. HA $y = 1$
E. Inc. on $(0, \infty)$; dec. on $(-\infty, 0)$
F. Loc. min. $f(0) = 0$
G. CU on $(-1, 1)$;
CD on $(-\infty, -1)$, $(1, \infty)$; IP $(\pm 1, \frac{1}{4})$
H. See graph at right



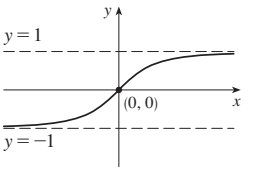
19. A. $(-\infty, 5]$ B. y-int. 0; x-int. 0, 5
C. None D. None
E. Inc. on $(-\infty, \frac{10}{3})$; dec. on $(\frac{10}{3}, 5)$
F. Loc. max. $f(\frac{10}{3}) = \frac{10}{9}\sqrt{15}$
G. CD on $(-\infty, 5)$
H. See graph at right.



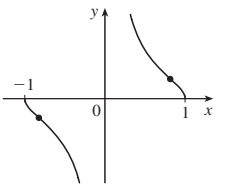
21. A. $(-\infty, -2) \cup (1, \infty)$
B. x-int. -2, 1
C. None D. None
E. Inc. on $(1, \infty)$; dec. on $(-\infty, -2)$
F. None
G. CD on $(-\infty, -2)$, $(1, \infty)$
H. See graph at right.



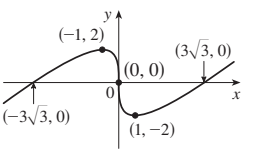
23. A. $\mathbb{R}$ B. y-int. 0; x-int. 0
C. About the origin
D. HA $y = \pm 1$
E. Inc. on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$;
CD on $(0, \infty)$; IP $(0, 0)$
H. See graph at right.



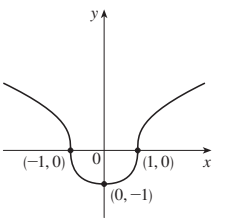
25. A. $\{x \mid |x| \leq 1, x \neq 0\} = [-1, 0) \cup (0, 1]$
B. x-int. ± 1 C. About $(0, 0)$
D. VA $x = 0$
E. Dec. on $(-1, 0)$, $(0, 1)$
F. None
G. CU on $(-1, -\sqrt{2/3})$, $(0, \sqrt{2/3})$;
CD on $(-\sqrt{2/3}, 0)$, $(\sqrt{2/3}, 1)$;
IP $(\pm\sqrt{2/3}, \pm 1/\sqrt{2})$
H. See graph at right.



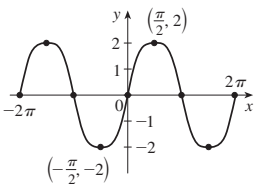
27. A. $\mathbb{R}$ B. y-int. 0; x-int. 0, $\pm 3\sqrt{3}$ C. About the origin
D. None E. Inc. on $(-\infty, -1)$, $(1, \infty)$; dec. on $(-1, 1)$
F. Loc. max. $f(-1) = 2$;
loc. min. $f(1) = -2$
G. CU on $(0, \infty)$; CD on $(-\infty, 0)$;
IP $(0, 0)$
H. See graph at right.



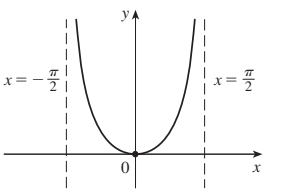
29. A. $\mathbb{R}$ B. y-int. -1; x-int. ± 1
C. About y-axis D. None
E. Inc. on $(0, \infty)$; dec. on $(-\infty, 0)$
F. Loc. min. $f(0) = -1$
G. CU on $(-1, 1)$;
CD on $(-\infty, -1)$, $(1, \infty)$;
IP $(\pm 1, 0)$
H. See graph at right.



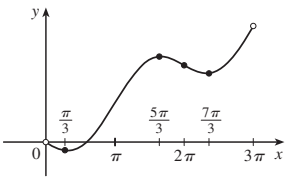
31. A. $\mathbb{R}$ B. y-int. 0; x-int. $n\pi$ (n an integer)
C. About the origin, period 2π D. None
E. Inc. on $(2n\pi - \pi/2, 2n\pi + \pi/2)$;
dec. on $(2n\pi + \pi/2, 2n\pi + 3\pi/2)$
F. Loc. max. $f(2n\pi + \pi/2) = 2$;
loc. min. $f(2n\pi + 3\pi/2) = -2$
G. CU on $((2n - 1)\pi, 2n\pi)$;
CD on $(2n\pi, (2n + 1)\pi)$; IP $(n\pi, 0)$
H. See graph at right.



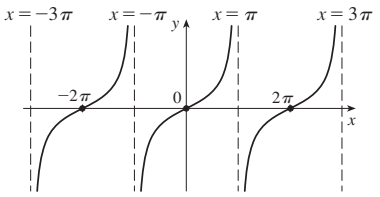
33. A. $(-\pi/2, \pi/2)$ B. y-int. 0; x-int. 0 C. About y-axis
D. VA $x = \pm\pi/2$
E. Inc. on $(0, \pi/2)$;
dec. on $(-\pi/2, 0)$
F. Loc. min. $f(0) = 0$
G. CU on $(-\pi/2, \pi/2)$
H. See graph at right.



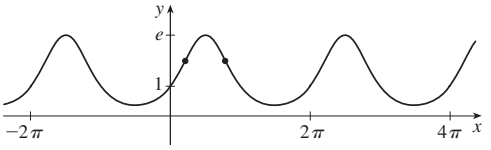
35. A. $(0, 3\pi)$ C. None D. None
E. Inc. on $(\pi/3, 5\pi/3)$, $(7\pi/3, 3\pi)$;
dec. on $(0, \pi/3)$, $(5\pi/3, 7\pi/3)$
F. Loc. min. $f(\pi/3) = (\pi/6) - \frac{1}{2}\sqrt{3}, f(7\pi/3) = (7\pi/6) - \frac{1}{2}\sqrt{3}$;
loc. max. $f(5\pi/3) = (5\pi/6) + \frac{1}{2}\sqrt{3}$
G. CU on $(0, \pi)$, $(2\pi, 3\pi)$;
CD on $(\pi, 2\pi)$;
IP $(\pi, \pi/2)$, $(2\pi, \pi)$
H. See graph at right.



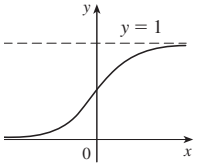
37. A. All reals except $(2n + 1)\pi$ (n an integer)
B. y-int. 0; x-int. $2n\pi$
C. About the origin, period 2π
D. VA $x = (2n + 1)\pi$
E. Inc. on $((2n - 1)\pi, (2n + 1)\pi)$ F. None
G. CU on $(2n\pi, (2n + 1)\pi)$; CD on $((2n - 1)\pi, 2n\pi)$;
IP $(2n\pi, 0)$
H.



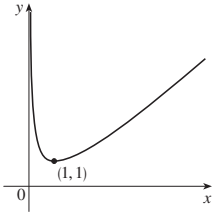
39. A. $\mathbb{R}$ B. y-int. 1 C. Period 2π D. None
Answers for E–G are for the interval $[0, 2\pi]$.
E. Inc. on $(0, \pi/2)$, $(3\pi/2, 2\pi)$; dec. on $(\pi/2, 3\pi/2)$
F. Loc. max. $f(\pi/2) = e$; loc. min. $f(3\pi/2) = e^{-1}$
G. CU on $(0, \alpha)$, $(\beta, 2\pi)$ where $\alpha = \sin^{-1}\left(\frac{1}{2}(-1 + \sqrt{5})\right)$,
$\beta = \pi - \alpha$; CD on (α, β); IP when $x = \alpha, \beta$
H.



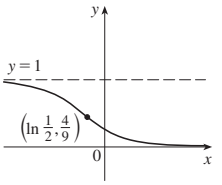
41. A. $\mathbb{R}$ B. y-int. $\frac{1}{2}$ C. None
D. HA $y = 0$, $y = 1$
E. Inc. on $\mathbb{R}$ F. None
G. CU on $(-\infty, 0)$; CD on $(0, \infty)$;
IP $\left(0, \frac{1}{2}\right)$ H. See graph at right.



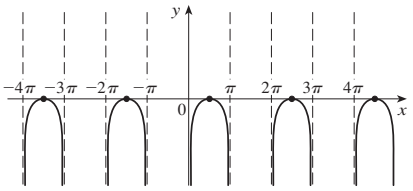
43. A. $(0, \infty)$ B. None
C. None D. VA $x = 0$
E. Inc. on $(1, \infty)$; dec. on $(0, 1)$
F. Loc. min. $f(1) = 1$
G. CU on $(0, \infty)$
H. See graph at right.



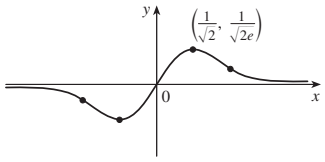
45. A. $\mathbb{R}$ B. y-int. $\frac{1}{4}$ C. None
D. HA $y = 0$, $y = 1$
E. Dec. on $\mathbb{R}$ F. None
G. CU on $\left(\ln \frac{1}{2}, \infty\right)$; CD on $\left(-\infty, \ln \frac{1}{2}\right)$;
IP $\left(\ln \frac{1}{2}, \frac{4}{9}\right)$
H. See graph at right.



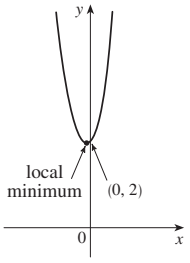
47. A. All x in $(2n\pi, (2n + 1)\pi)$ (n an integer)
B. x-int. $\pi/2 + 2n\pi$ C. Period 2π D. VA $x = n\pi$
E. Inc. on $(2n\pi, \pi/2 + 2n\pi)$; dec. on $(\pi/2 + 2n\pi, (2n + 1)\pi)$
F. Loc. max. $f(\pi/2 + 2n\pi) = 0$ G. CD on $(2n\pi, (2n + 1)\pi)$
H.



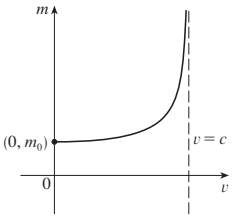
49. A. $\mathbb{R}$ B. y-int. 0; x-int. 0 C. About (0, 0) D. HA $y = 0$
E. Inc. on $\left(-1/\sqrt{2}, 1/\sqrt{2}\right)$; dec. on $\left(-\infty, -1/\sqrt{2}\right)$, $\left(1/\sqrt{2}, \infty\right)$
F. Loc. min. $f\left(-1/\sqrt{2}\right) = -1/\sqrt{2e}$; loc. max. $f\left(1/\sqrt{2}\right) = 1/\sqrt{2e}$
G. CU on $\left(-\sqrt{3/2}, 0\right)$, $\left(\sqrt{3/2}, \infty\right)$; CD on $\left(-\infty, -\sqrt{3/2}\right)$, $\left(0, \sqrt{3/2}\right)$;
IP $\left(\pm\sqrt{3/2}, \pm\sqrt{3/2}e^{-3/2}\right)$, (0, 0)
H.



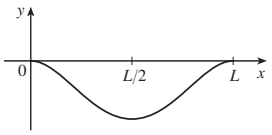
51. A. $\mathbb{R}$ B. y-int. 2
C. None D. None
E. Inc. on $\left(\frac{1}{5}\ln\frac{2}{3}, \infty\right)$; dec. on $\left(-\infty, \frac{1}{5}\ln\frac{2}{3}\right)$
F. Loc. min. $f\left(\frac{1}{5}\ln\frac{2}{3}\right) = \left(\frac{2}{3}\right)^{3/5} + \left(\frac{2}{3}\right)^{-2/5}$
G. CU on $(-\infty, \infty)$
H. See graph at right.



53.

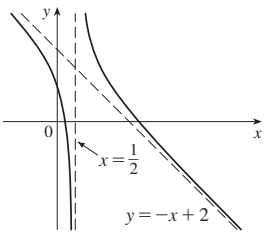


55.

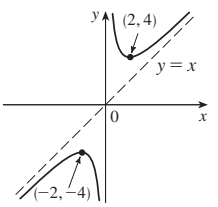


57. $y = x - 1$ **59.** $y = 2x - 2$

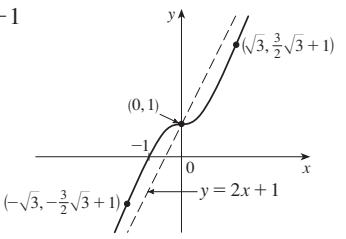
61. A. $(-\infty, \frac{1}{2}) \cup (\frac{1}{2}, \infty)$
B. y-int. 1; x-int. $\frac{1}{4}(5 \pm \sqrt{17})$
C. None
D. VA $x = \frac{1}{2}$; SA $y = -x + 2$
E. Dec. on $(-\infty, \frac{1}{2})$, $(\frac{1}{2}, \infty)$
F. None
G. CU on $(\frac{1}{2}, \infty)$; CD on $(-\infty, \frac{1}{2})$
H. See graph at right



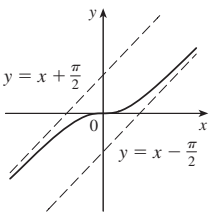
63. A. $\{x \mid x \neq 0\}$ B. None
C. About (0, 0) D. VA $x = 0$; SA $y = x$
E. Inc. on $(-\infty, -2)$, $(2, \infty)$;
dec. on $(-2, 0)$, $(0, 2)$
F. Loc. max. $f(-2) = -4$;
loc. min. $f(2) = 4$
G. CU on $(0, \infty)$; CD on $(-\infty, 0)$
H. See graph at right.



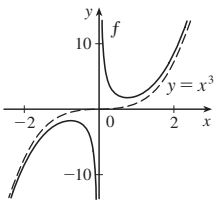
65. A. $\mathbb{R}$ B. y-int. 1; x-int. -1
C. None D. SA $y = 2x + 1$
E. Inc. on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, -\sqrt{3})$, $(0, \sqrt{3})$;
CD on $(-\sqrt{3}, 0)$, $(\sqrt{3}, \infty)$;
IP $(\pm\sqrt{3}, 1 \pm \frac{3}{2}\sqrt{3})$, (0, 1)
H. See graph at right.



67.

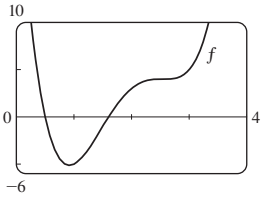


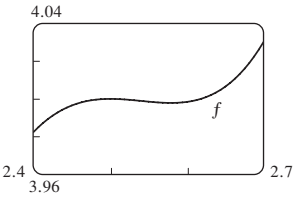
71. VA $x = 0$, asymptotic to $y = x^3$



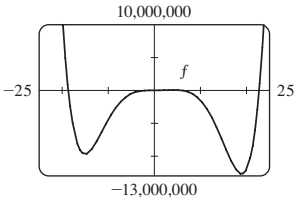
EXERCISES 4.6 ■ PAGE 320

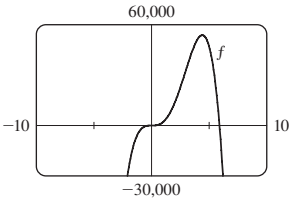
1. Inc. on (0.92, 2.5), (2.58, ∞); dec. on (−∞, 0.92), (2.5, 2.58);
loc. max. $f(2.5) \approx 4$; loc. min. $f(0.92) \approx -5.12$, $f(2.58) \approx 3.998$;
CU on (−∞, 1.46), (2.54, ∞);
CD on (1.46, 2.54); IP (1.46, −1.40), (2.54, 3.999)



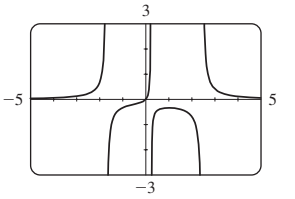


3. Inc. on (−15, 4.40), (18.93, ∞);
dec. on (−∞, −15), (4.40, 18.93);
loc. max. $f(4.40) \approx 53{,}800$; loc. min. $f(-15) \approx -9{,}700{,}000$,
$f(18.93) \approx -12{,}700{,}000$; CU on (−∞, −11.34), (0, 2.92),
(15.08, ∞); CD on (−11.34, 0), (2.92, 15.08);
IP (0, 0), ≈ (−11.34, −6,250,000), (2.92, 31,800),
(15.08, −8,150,000)

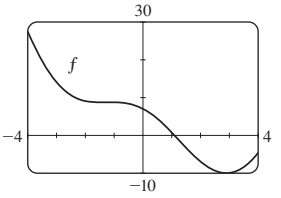


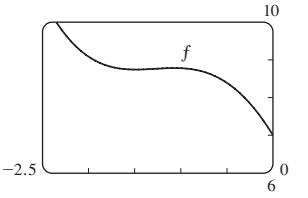


5. Inc. on (−∞, −1.7), (−1.7, 0.24), (0.24, 1);
dec. on (1, 2.46), (2.46, ∞); loc. max. $f(1) = -\frac{1}{3}$;
CU on (−∞, −1.7), (−0.506, 0.24), (2.46, ∞);
CD on (−1.7, −0.506), (0.24, 2.46); IP (−0.506, −0.192)

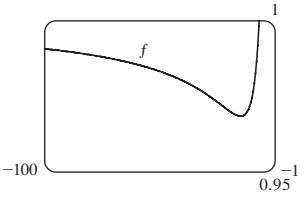


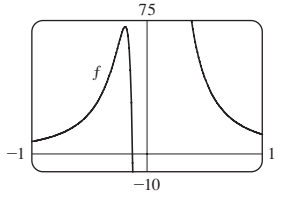
7. Inc. on (−1.49, −1.07), (2.89, 4); dec. on (−4, −1.49),
(−1.07, 2.89); loc. max. $f(-1.07) \approx 8.79$; loc. min.
$f(-1.49) \approx 8.75$, $f(2.89) \approx -9.99$; CU on (−4, −1.28),
(1.28, 4); CD on (−1.28, 1.28); IP (−1.28, 8.77), (1.28, −1.48)



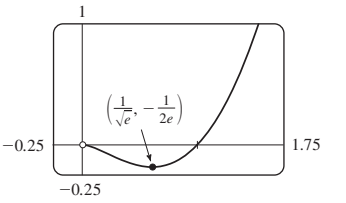


9. Inc. on $(-8 - \sqrt{61}, -8 + \sqrt{61})$; dec. on $(-\infty, -8 - \sqrt{61})$,
$(-8 + \sqrt{61}, 0)$, $(0, \infty)$; CU on $(-12 - \sqrt{138}, -12 + \sqrt{138})$,
$(0, \infty)$; CD on $(-\infty, -12 - \sqrt{138})$, $(-12 + \sqrt{138}, 0)$



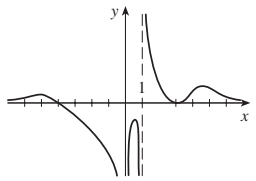


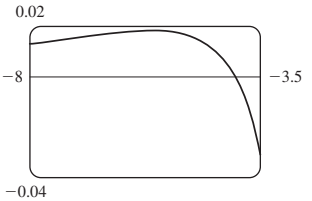
11. (a)

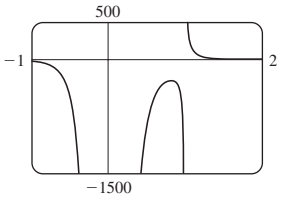


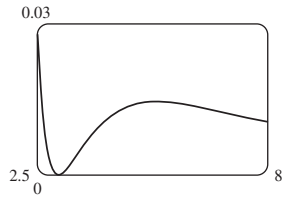
(b) $\lim_{x \to 0^+} f(x) = 0$
(c) Loc. min. $f(1/\sqrt{e}) = -1/(2e)$;
CD on $(0, e^{-3/2})$; CU on $(e^{-3/2}, \infty)$

13. Loc. max. $f(-5.6) \approx 0.018$, $f(0.82) \approx -281.5$, $f(5.2) \approx 0.0145$; loc. min. $f(3) = 0$









15. $f'(x) = -\dfrac{x(x+1)^2(x^3+18x^2-44x-16)}{(x-2)^3(x-4)^5}$

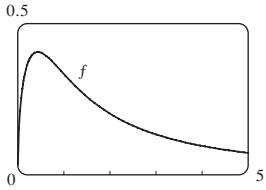
$$f''(x) = 2\frac{(x+1)(x^6+36x^5+6x^4-628x^3+684x^2+672x+64)}{(x-2)^4(x-4)^6}$$

CU on $(-35.3, -5.0)$, $(-1, -0.5)$, $(-0.1, 2)$, $(2, 4)$, $(4, \infty)$;

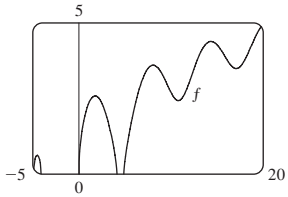
CD on $(-\infty, -35.3)$, $(-5.0, -1)$, $(-0.5, -0.1)$;

IP $(-35.3, -0.015)$, $(-5.0, -0.005)$, $(-1, 0)$, $(-0.5, 0.00001)$, $(-0.1, 0.0000066)$

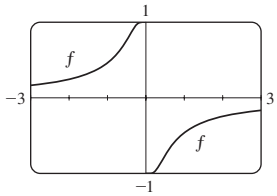
17. Inc. on $(0, 0.43)$; dec. on $(0.43, \infty)$; loc. max. $f(0.43) \approx 0.41$; CU on $(0.94, \infty)$; CD on $(0, 0.94)$;
IP $(0.94, 0.34)$



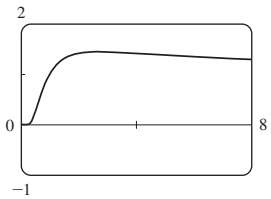
19. Inc. on $(-4.91, -4.51)$, $(0, 1.77)$, $(4.91, 8.06)$, $(10.79, 14.34)$, $(17.08, 20)$;
dec. on $(-4.51, -4.10)$, $(1.77, 4.10)$, $(8.06, 10.79)$, $(14.34, 17.08)$;
loc. max. $f(-4.51) \approx 0.62$, $f(1.77) \approx 2.58$, $f(8.06) \approx 3.60$, $f(14.34) \approx 4.39$;
loc. min. $f(10.79) \approx 2.43$, $f(17.08) \approx 3.49$; CU on $(9.60, 12.25)$, $(15.81, 18.65)$;
CD on $(-4.91, -4.10)$, $(0, 4.10)$, $(4.91, 9.60)$, $(12.25, 15.81)$, $(18.65, 20)$;
IPs at $(9.60, 2.95)$, $(12.25, 3.27)$, $(15.81, 3.91)$, $(18.65, 4.20)$



21. Inc. on $(-\infty, 0)$, $(0, \infty)$;
CU on $(-\infty, -0.4)$, $(0, 0.4)$;
CD on $(-0.4, 0)$, $(0.4, \infty)$;
IP $(\mp 0.4, \pm 0.8)$

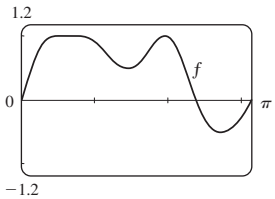


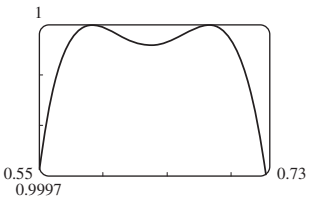
23. (a)

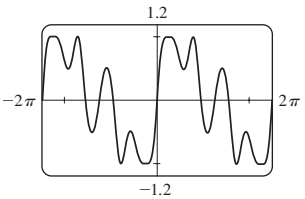


(b) $\lim_{x \to 0^+} x^{1/x} = 0$, $\lim_{x \to \infty} x^{1/x} = 1$
(c) Loc. max. $f(e) = e^{1/e}$ (d) IP at $x \approx 0.58, 4.37$

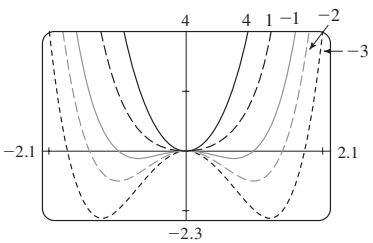
25. Max. $f(0.59) \approx 1$, $f(0.68) \approx 1$, $f(1.96) \approx 1$;
min. $f(0.64) \approx 0.99996$, $f(1.46) \approx 0.49$, $f(2.73) \approx -0.51$;
IP $(0.61, 0.99998)$, $(0.66, 0.99998)$, $(1.17, 0.72)$, $(1.75, 0.77)$, $(2.28, 0.34)$



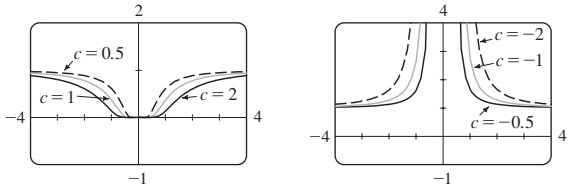




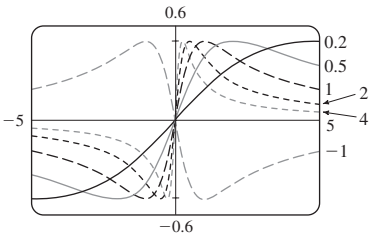
27. For $c \geqslant 0$, there is no IP and only one extreme point, the origin. For $c < 0$, there is a maximum point at the origin, two minimum points, and two IPs, which move downward and away from the origin as $c \to -\infty$.



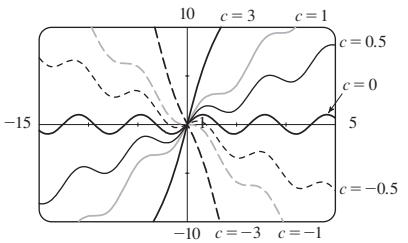
29. There is no maximum or minimum, regardless of the value of c. For $c < 0$, there is a vertical asymptote at $x = 0$, $\lim_{x\to 0} f(x) = \infty$, and $\lim_{x\to\pm\infty} f(x) = 1$.
$c = 0$ is a transitional value at which $f(x) = 1$ for $x \neq 0$.
For $c > 0$, $\lim_{x\to 0} f(x) = 0$, $\lim_{x\to\pm\infty} f(x) = 1$, and there are two IPs, which move away from the y-axis as $c \to \infty$.



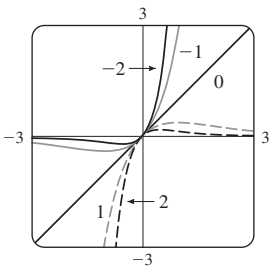
31. For $c > 0$, the maximum and minimum values are always $\pm\frac{1}{2}$, but the extreme points and IPs move closer to the y-axis as c increases. $c = 0$ is a transitional value: when c is replaced by $-c$, the curve is reflected in the x-axis.



33. For $|c| < 1$, the graph has local maximum and minimum values; for $|c| \geq 1$ it does not. The function increases for $c \geq 1$ and decreases for $c \leq -1$. As c changes, the IPs move vertically but not horizontally.

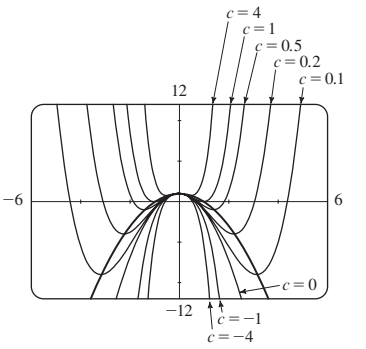


35.



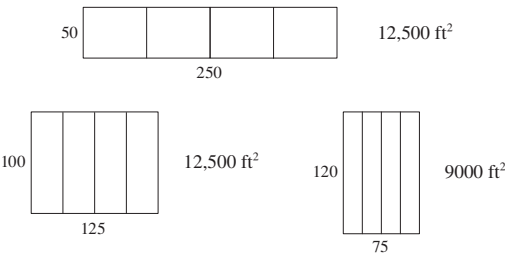
For $c > 0$, $\lim_{x\to\infty} f(x) = 0$ and $\lim_{x\to-\infty} f(x) = -\infty$.
For $c < 0$, $\lim_{x\to\infty} f(x) = \infty$ and $\lim_{x\to-\infty} f(x) = 0$.
As $|c|$ increases, the maximum and minimum points and the IPs get closer to the origin.

37. (a) Positive (b)

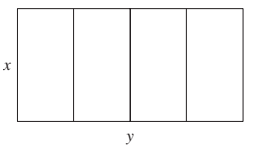


EXERCISES 4.7 ■ PAGE 328

1. (a) 11, 12 (b) 11.5, 11.5 **3.** 10, 10
5. 25 m by 25 m **7.** $N = 1$
9. (a)



(b)



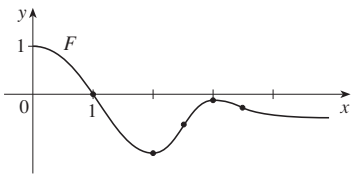
(c) $A = xy$ (d) $5x + 2y = 750$ (e) $A(x) = 375x - \frac{5}{2}x^2$
(f) 14,062.5 ft²
11. 1000 ft by 1500 ft **13.** 4000 cm³ **15.** \$191.28
17. $\left(-\frac{28}{17}, \frac{7}{17}\right)$ **19.** $\left(-\frac{1}{3}, \pm\frac{4}{3}\sqrt{2}\right)$ **21.** Square, side $\sqrt{2}r$
23. $L/2$, $\sqrt{3}\,L/4$ **25.** Base $\sqrt{3}\,r$, height $3r/2$
27. $4\pi r^3/(3\sqrt{3})$ **29.** $\pi r^2(1 + \sqrt{5})$ **31.** 24 cm, 36 cm
33. (a) Use all of the wire for the square
(b) $40\sqrt{3}/(9 + 4\sqrt{3})$ m for the square
35. Height = radius = $\sqrt[3]{V/\pi}$ cm **37.** $V = 2\pi R^3/(9\sqrt{3})$
41. $E^2/(4r)$
43. (a) $\frac{3}{2}S^2 \csc\theta\,(\csc\theta - \sqrt{3}\cot\theta)$ (b) $\cos^{-1}(1/\sqrt{3}) \approx 55°$
(c) $6s[h + s/(2\sqrt{2})]$
45. Row directly to B **47.** ≈4.85 km east of the refinery
49. $10\sqrt[3]{3}/(1 + \sqrt[3]{3})$ ft from the stronger source
51. $(a^{2/3} + b^{2/3})^{3/2}$
53. (b) (i) \$342,491; \$342/unit; \$390/unit (ii) 400
(iii) \$320/unit
55. (a) $p(x) = 19 - \frac{1}{3000}x$ (b) \$9.50
57. (a) $p(x) = 550 - \frac{1}{10}x$ (b) \$175 (c) \$100
61. 9.35 m **65.** $x = 6$ in. **67.** $\pi/6$
69. At a distance $5 - 2\sqrt{5}$ from A **71.** $\frac{1}{2}(L + W)^2$
73. (a) About 5.1 km from B (b) C is close to B; C is close to D; $W/L = \sqrt{25 + x^2}/x$, where $x = |BC|$ (c) ≈1.07; no such value (d) $\sqrt{41}/4 \approx 1.6$

EXERCISES 4.8 ■ PAGE 338

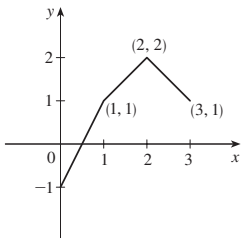
1. (a) $x_2 \approx 2.3, x_3 \approx 3$ (b) No **3.** $\frac{4}{5}$ **5.** 1.1797
7. 1.1785 **9.** -1.25 **11.** 1.82056420 **13.** 1.217562
15. 0.876726 **17.** -0.724492, 1.220744
19. 1.412391, 3.057104 **21.** 0.641714
23. -1.93822883, -1.21997997, 1.13929375, 2.98984102
25. -1.97806681, -0.82646233
27. 0.21916368, 1.08422462 **29.** (b) 31.622777
35. (a) -1.293227, -0.441731, 0.507854 (b) -2.0212
37. (0.904557, 1.855277) **39.** (0.410245, 0.347810)
41. 0.76286%

EXERCISES 4.9 ■ PAGE 345

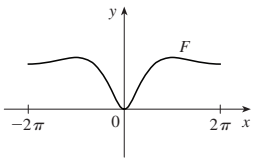
1. $F(x) = \frac{1}{2}x^2 - 3x + C$ **3.** $F(x) = \frac{1}{2}x + \frac{1}{4}x^3 - \frac{1}{5}x^4 + C$
5. $F(x) = \frac{2}{3}x^3 + \frac{1}{2}x^2 - x + C$ **7.** $F(x) = 4x^{5/4} - 4x^{7/4} + C$
9. $F(x) = 4x^{3/2} - \frac{6}{7}x^{7/6} + C$
11. $F(x) = \begin{cases} -5/(4x^8) + C_1 & \text{if } x < 0 \\ -5/(4x^8) + C_2 & \text{if } x > 0 \end{cases}$
13. $F(u) = \frac{1}{3}u^3 - 6u^{-1/2} + C$
15. $G(\theta) = \sin\theta + 5\cos\theta + C$
17. $F(x) = 5e^x - 3\sinh x + C$
19. $F(x) = \frac{1}{2}x^2 - \ln|x| - 1/x^2 + C$
21. $F(x) = x^5 - \frac{1}{3}x^6 + 4$ **23.** $x^3 + x^4 + Cx + D$
25. $\frac{3}{20}x^{8/3} + Cx + D$ **27.** $e^t + \frac{1}{2}Ct^2 + Dt + E$
29. $x - 3x^2 + 8$ **31.** $4x^{3/2} + 2x^{5/2} + 4$
33. $2\sin t + \tan t + 4 - 2\sqrt{3}$
35. $\frac{3}{2}x^{2/3} - \frac{1}{2}$ if $x > 0$; $\frac{3}{2}x^{2/3} - \frac{5}{2}$ if $x < 0$
37. $2x^4 + \frac{1}{3}x^3 + 5x^2 - 22x + \frac{59}{3}$
39. $-\sin\theta - \cos\theta + 5\theta + 4$ **41.** $x^2 - 2x^3 + 9x + 9$
43. $x^2 - \cos x - \frac{1}{2}\pi x$ **45.** $-\ln x + (\ln 2)x - \ln 2$
47. 10 **49.** b
51.



53.



55.



57. $s(t) = 1 - \cos t - \sin t$ **59.** $s(t) = \frac{1}{6}t^3 - t^2 + 3t + 1$
61. $s(t) = -10\sin t - 3\cos t + (6/\pi)t + 3$
63. (a) $s(t) = 450 - 4.9t^2$ (b) $\sqrt{450/4.9} \approx 9.58$ s
(c) $-9.8\sqrt{450/4.9} \approx -93.9$ m/s (d) About 9.09 s
67. 225 ft **69.** \$742.08 **71.** $\frac{130}{11} \approx 11.8$ s
73. $\frac{88}{15} \approx 5.87$ ft/s^2 **75.** 62,500 km/h^2 ≈ 4.82 m/s^2
77. (a) 22.9125 mi (b) 21.675 mi (c) 30 min 33 s
(d) 55.425 mi

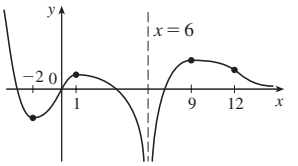
CHAPTER 4 REVIEW ■ PAGE 347

True-False Quiz

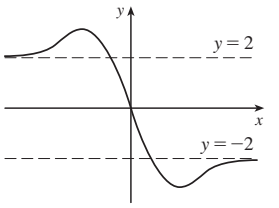
1. False **3.** False **5.** True **7.** False **9.** True
11. True **13.** False **15.** True **17.** True **19.** True

Exercises

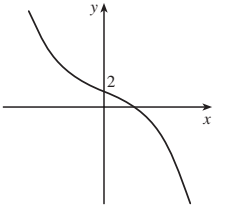
1. Abs. max. $f(4) = 5$, abs. and loc. min. $f(3) = 1$;
loc. min. $f(3) = 1$
3. Abs. max. $f(2) = \frac{2}{5}$, abs. and loc. min. $f(-\frac{1}{3}) = -\frac{9}{2}$
5. Abs. max. $f(\pi) = \pi$; abs. min. $f(0) = 0$; loc. max.
$f(\pi/3) = (\pi/3) + \frac{1}{2}\sqrt{3}$; loc. min. $f(2\pi/3) = (2\pi/3) - \frac{1}{2}\sqrt{3}$
7. π **9.** 8 **11.** 0 **13.** $\frac{1}{2}$
15.



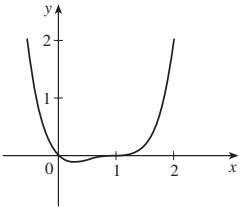
17.



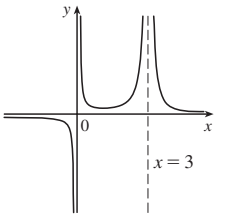
19. A. $\mathbb{R}$ B. y-int. 2
C. None D. None
E. Dec. on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$;
CD on $(0, \infty)$; IP $(0, 2)$
H. See graph at right.



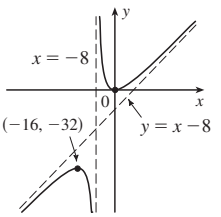
21. A. $\mathbb{R}$ B. y-int. 0; x-int. 0, 1
C. None D. None
E. Inc. on $(\frac{1}{4}, \infty)$, dec. on $(-\infty, \frac{1}{4})$
F. Loc. min. $f(\frac{1}{4}) = -\frac{27}{256}$
G. CU on $(-\infty, \frac{1}{2})$, $(1, \infty)$;
CD on $(\frac{1}{2}, 1)$; IP $(\frac{1}{2}, -\frac{1}{16})$, $(1, 0)$
H. See graph at right.



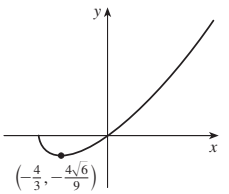
23. A. $\{x \mid x \neq 0, 3\}$
B. None C. None
D. HA $y = 0$; VA $x = 0$, $x = 3$
E. Inc. on $(1, 3)$; dec. on $(-\infty, 0)$,
$(0, 1)$, $(3, \infty)$
F. Loc. min. $f(1) = \frac{1}{4}$
G. CU on $(0, 3)$, $(3, \infty)$; CD on $(-\infty, 0)$
H. See graph at right.



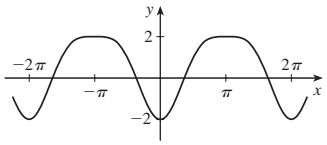
25. A. $\{x \mid x \neq -8\}$
B. y-int. 0, x-int. 0 C. None
D. VA $x = -8$; SA $y = x - 8$
E. Inc. on $(-\infty, -16)$, $(0, \infty)$; dec. on $(-16, -8)$, $(-8, 0)$
F. Loc. max. $f(-16) = -32$; loc. min. $f(0) = 0$
G. CU on $(-8, \infty)$; CD on $(-\infty, -8)$
H. See graph at right.



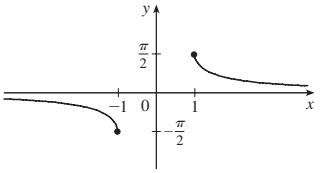
27. A. $[-2, \infty)$
B. y-int. 0; x-int. -2, 0
C. None D. None
E. Inc. on $\left(-\frac{4}{3}, \infty\right)$, dec. on $\left(-2, -\frac{4}{3}\right)$
F. Loc. min. $f\left(-\frac{4}{3}\right) = -\frac{4}{9}\sqrt{6}$
G. CU on $(-2, \infty)$
H. See graph at right.



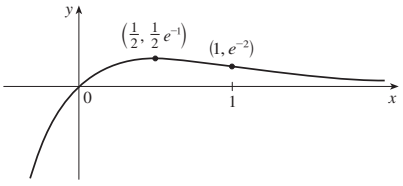
29. A. $\mathbb{R}$ B. y-int. -2
C. About y-axis, period 2π D. None
E. Inc. on $(2n\pi, (2n+1)\pi)$, n an integer; dec. on $((2n-1)\pi, 2n\pi)$
F. Loc. max. $f((2n+1)\pi) = 2$; loc. min. $f(2n\pi) = -2$
G. CU on $(2n\pi - (\pi/3), 2n\pi + (\pi/3))$; CD on $(2n\pi + (\pi/3), 2n\pi + (5\pi/3))$; IP $\left(2n\pi \pm (\pi/3), -\frac{1}{4}\right)$
H.



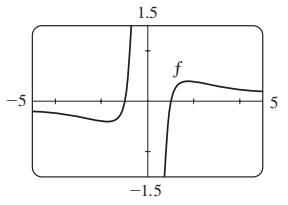
31. A. $\{x \mid |x| \geq 1\}$
B. None C. About (0, 0)
D. HA $y = 0$
E. Dec. on $(-\infty, -1)$, $(1, \infty)$
F. None
G. CU on $(1, \infty)$; CD on $(-\infty, -1)$
H. See graph at right.



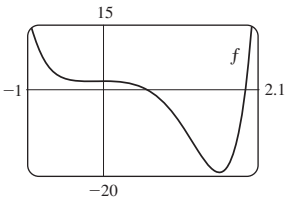
33. A. $\mathbb{R}$ B. y-int. 0, x-int. 0 C. None D. HA $y = 0$
E. Inc. on $\left(-\infty, \frac{1}{2}\right)$, dec. on $\left(\frac{1}{2}, \infty\right)$ F. Loc. max. $f\left(\frac{1}{2}\right) = 1/(2e)$
G. CU on $(1, \infty)$; CD on $(-\infty, 1)$; IP $(1, e^{-2})$
H.

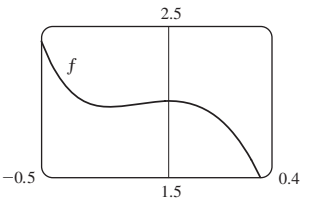


35. Inc. on $\left(-\sqrt{3}, 0\right)$, $\left(0, \sqrt{3}\right)$; dec. on $\left(-\infty, -\sqrt{3}\right)$, $\left(\sqrt{3}, \infty\right)$; loc. max. $f\left(\sqrt{3}\right) = \frac{2}{9}\sqrt{3}$, loc. min. $f\left(-\sqrt{3}\right) = -\frac{2}{9}\sqrt{3}$; CU on $\left(-\sqrt{6}, 0\right)$, $\left(\sqrt{6}, \infty\right)$; CD on $\left(-\infty, -\sqrt{6}\right)$, $\left(0, \sqrt{6}\right)$; IP $\left(\sqrt{6}, \frac{5}{36}\sqrt{6}\right)$, $\left(-\sqrt{6}, -\frac{5}{36}\sqrt{6}\right)$

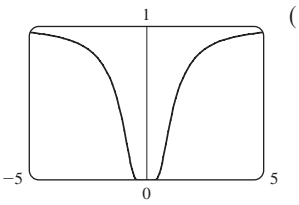


37. Inc. on $(-0.23, 0)$, $(1.62, \infty)$; dec. on $(-\infty, -0.23)$, $(0, 1.62)$; loc. max. $f(0) = 2$; loc. min. $f(-0.23) \approx 1.96$, $f(1.62) \approx -19.2$; CU on $(-\infty, -0.12)$, $(1.24, \infty)$; CD on $(-0.12, 1.24)$; IP $(-0.12, 1.98)$, $(1.24, -12.1)$





39.

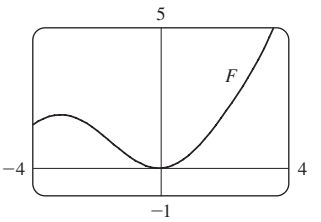


$(\pm 0.82, 0.22)$; $\left(\pm\sqrt{2/3}, e^{-3/2}\right)$

41. $-2.96, -0.18, 3.01$; $-1.57, 1.57$; $-2.16, -0.75, 0.46, 2.21$

43. For $C > -1$, f is periodic with period 2π and has local maxima at $2n\pi + \pi/2$, n an integer. For $C \leq -1$, f has no graph. For $-1 < C \leq 1$, f has vertical asymptotes. For $C > 1$, f is continuous on $\mathbb{R}$. As C increases, f moves upward and its oscillations become less pronounced.

49. (a) 0 (b) CU on $\mathbb{R}$ **53.** $3\sqrt{3}r^2$
55. $4/\sqrt{3}$ cm from D **57.** $L = C$ **59.** \$11.50
61. 1.297383 **63.** 1.16718557
65. $f(x) = \sin x - \sin^{-1}x + C$
67. $f(x) = \frac{2}{5}x^{5/2} + \frac{3}{5}x^{5/3} + C$
69. $f(t) = t^2 + 3\cos t + 2$
71. $f(x) = \frac{1}{2}x^2 - x^3 + 4x^4 + 2x + 1$
73. $s(t) = t^2 - \tan^{-1}t + 1$
75. (b) $0.1e^x - \cos x + 0.9$ (c)



77. No
79. (b) About 8.5 in. by 2 in. (c) $20/\sqrt{3}$ in., $20\sqrt{2/3}$ in.

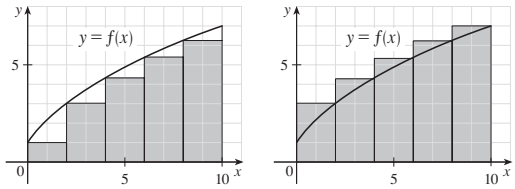
PROBLEMS PLUS ▪ PAGE 352

5. 24 **7.** $(-2, 4)$, $(2, -4)$ **11.** $-3.5 < a < -2.5$
13. $(m/2, m^2/4)$ **15.** $a \leq e^{1/e}$
19. (a) $T_1 = D/c_1$, $T_2 = (2h \sec\theta)/c_1 + (D - 2h\tan\theta)/c_2$, $T_3 = \sqrt{4h^2 + D^2}/c_1$
(c) $c_1 \approx 3.85$ km/s, $c_2 \approx 7.66$ km/s, $h \approx 0.42$ km
23. $3/\left(\sqrt[3]{2} - 1\right) \approx 11\frac{1}{2}$ h

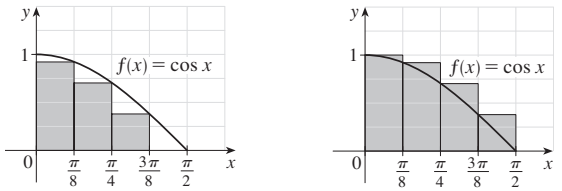
CHAPTER 5

EXERCISES 5.1 ■ PAGE 364

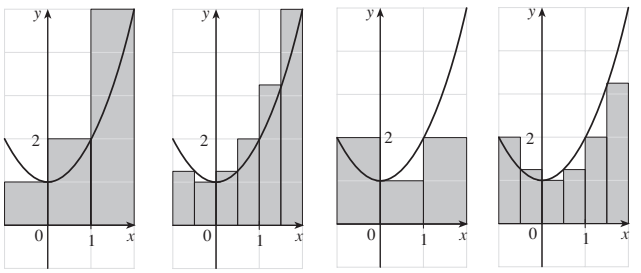
1. (a) 40, 52 (b) 43.2, 49.2



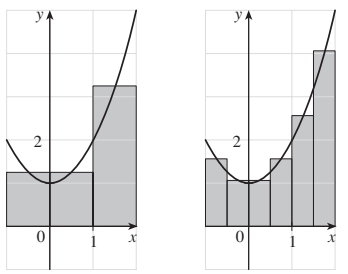
3. (a) 0.7908, underestimate (b) 1.1835, overestimate



5. (a) 8, 6.875 (b) 5, 5.375



(c) 5.75, 5.9375



(d) M_6

7. 0.2533, 0.2170, 0.2101, 0.2050; 0.2

9. (a) Left: 0.8100, 0.7937, 0.7904;
right: 0.7600, 0.7770, 0.7804

11. 34.7 ft, 44.8 ft **13.** 63.2 L, 70 L **15.** 155 ft

17. $\lim_{n\to\infty} \sum_{i=1}^{n} \sqrt[4]{1 + 15i/n} \cdot (15/n)$ **19.** $\lim_{n\to\infty} \sum_{i=1}^{n} \left(\frac{i\pi}{2n} \cos \frac{i\pi}{2n} \right) \frac{\pi}{2n}$

21. The region under the graph of $y = \tan x$ from 0 to $\pi/4$

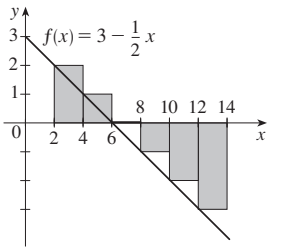
23. (a) $\lim_{n\to\infty} \frac{64}{n^6} \sum_{i=1}^{n} i^5$ (b) $\frac{n^2(n+1)^2(2n^2+2n-1)}{12}$ (c) $\frac{32}{3}$

25. $\sin b$, 1

EXERCISES 5.2 ■ PAGE 376

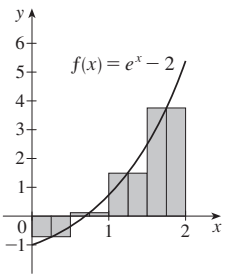
1. -6

The Riemann sum represents the sum of the areas of the two rectangles above the x-axis minus the sum of the areas of the three rectangles below the x-axis; that is, the net area of the rectangles with respect to the x-axis.



3. 2.322986

The Riemann sum represents the sum of the areas of the three rectangles above the x-axis minus the area of the rectangle below the x-axis.



5. (a) 4 (b) 6 (c) 10 **7.** $-475, -85$ **9.** 124.1644

11. 0.3084 **13.** 0.30843908, 0.30981629, 0.31015563

15.

n	R_n
5	1.933766
10	1.983524
50	1.999342
100	1.999836

The values of R_n appear to be approaching 2.

17. $\int_2^6 x \ln(1 + x^2)\, dx$ **19.** $\int_1^8 \sqrt{2x + x^2}\, dx$ **21.** 42

23. $\frac{4}{3}$ **25.** 3.75 **29.** $\lim_{n\to\infty} \sum_{i=1}^{n} \frac{2 + 4i/n}{1 + (2 + 4i/n)^5} \cdot \frac{4}{n}$

31. $\lim_{n\to\infty} \sum_{i=1}^{n} \left(\sin \frac{5\pi i}{n} \right) \frac{\pi}{n} = \frac{2}{5}$

33. (a) 4 (b) 10 (c) -3 (d) 2 **35.** $-\frac{3}{4}$

37. $3 + \frac{9}{4}\pi$ **39.** 2.5 **41.** 0 **43.** 3 **45.** $e^5 - e^3$

47. $\int_{-1}^{5} f(x)\, dx$ **49.** 122

51. $2m \leq \int_0^2 f(x)\, dx < 2M$ by Comparison Property 8

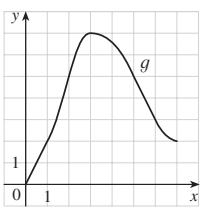
55. $3 \leq \int_1^4 \sqrt{x}\, dx \leq 6$ **57.** $\frac{\pi}{12} \leq \int_{\pi/4}^{\pi/3} \tan x\, dx \leq \frac{\pi}{12}\sqrt{3}$

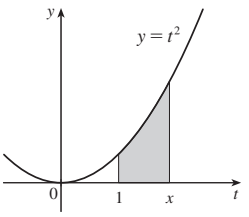
59. $0 \leq \int_0^2 xe^{-x}\, dx \leq 2/e$ **69.** $\int_0^1 x^4\, dx$ **71.** $\frac{1}{2}$

EXERCISES 5.3 ■ PAGE 387

1. One process undoes what the other one does. See the Fundamental Theorem of Calculus, page 387.

3. (a) 0, 2, 5, 7, 3
(b) (0, 3)
(c) $x = 3$
(d)



5. 

(a), (b) x^2

7. $g'(x) = 1/(x^3 + 1)$

9. $g'(y) = y^2 \sin y$ **11.** $F'(x) = -\sqrt{1 + \sec x}$

13. $h'(x) = -\dfrac{\arctan(1/x)}{x^2}$ **15.** $y' = \sqrt{\tan x + \sqrt{\tan x}}\,\sec^2 x$

17. $y' = \dfrac{3(1 - 3x)^3}{1 + (1 - 3x)^2}$ **19.** $\frac{3}{4}$ **21.** 63

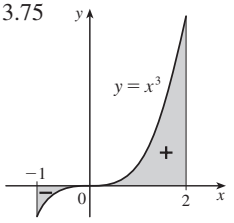
23. $\frac{5}{9}$ **25.** $\frac{7}{8}$ **27.** $\frac{156}{7}$ **29.** $\frac{40}{3}$ **31.** 1 **33.** $\frac{49}{3}$

35. $\ln 3$ **37.** π **39.** $e^2 - 1$ **41.** 0

43. The function $f(x) = x^{-4}$ is not continuous on the interval $[-2, 1]$, so FTC2 cannot be applied.

45. The function $f(\theta) = \sec\theta \tan\theta$ is not continuous on the interval $[\pi/3, \pi]$, so FTC2 cannot be applied.

47. $\frac{243}{4}$ **49.** 2

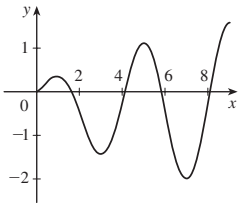
51. 3.75 

53. $g'(x) = \dfrac{-2(4x^2 - 1)}{4x^2 + 1} + \dfrac{3(9x^2 - 1)}{9x^2 + 1}$

55. $y' = 3x^{7/2}\sin(x^3) - \dfrac{\sin\sqrt{x}}{2\sqrt[4]{x}}$ **57.** $\sqrt{257}$ **59.** 29

61. (a) $-2\sqrt{n}$, $\sqrt{4n - 2}$, n an integer > 0
(b) $(0, 1)$, $\left(-\sqrt{4n - 1}, -\sqrt{4n - 3}\right)$, and $\left(\sqrt{4n - 1}, \sqrt{4n + 1}\right)$, n an integer > 0 (c) 0.74

63. (a) Loc. max. at 1 and 5; loc. min. at 3 and 7
(b) $x = 9$
(c) $\left(\frac{1}{2}, 2\right)$, (4, 6), (8, 9)
(d) See graph at right.



65. $\frac{1}{4}$ **73.** $f(x) = x^{3/2}$, $a = 9$

75. (b) Average expenditure over $[0, t]$; minimize average expenditure

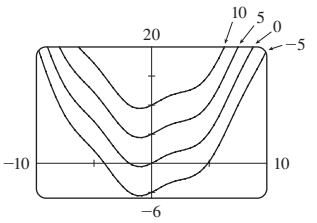
EXERCISES 5.4 ■ PAGE 397

5. $\frac{1}{3}x^3 - (1/x) + C$ **7.** $\frac{1}{5}x^5 - \frac{1}{8}x^4 + \frac{1}{8}x^2 - 2x + C$

9. $2t - t^2 + \frac{1}{3}t^3 - \frac{1}{4}t^4 + C$ **11.** $\frac{1}{3}x^3 - 4\sqrt{x} + C$

13. $-\cos x + \cosh x + C$ **15.** $\frac{1}{2}\theta^2 + \csc\theta + C$

17. $\tan\alpha + C$

19. $\sin x + \frac{1}{4}x^2 + C$ 

21. 18 **23.** $-2 + 1/e$ **25.** 52

27. $\frac{256}{15}$ **29.** $-\frac{63}{4}$ **31.** $\frac{55}{63}$ **33.** $2\sqrt{5}$ **35.** 8

37. $1 + \pi/4$ **39.** $\frac{256}{5}$ **41.** $\pi/6$ **43.** -3.5

45. 0, 1.32; 0.84 **47.** $\frac{4}{3}$

49. The increase in the child's weight (in pounds) between the ages of 5 and 10

51. Number of gallons of oil leaked in the first 2 hours

53. Increase in revenue when production is increased from 1000 to 5000 units

55. Newton-meters (or joules) **57.** (a) $-\frac{3}{2}$ m (b) $\frac{41}{6}$ m

59. (a) $v(t) = \frac{1}{2}t^2 + 4t + 5$ m/s (b) $416\frac{2}{3}$ m

61. $46\frac{2}{3}$ kg **63.** 1.4 mi **65.** \$58,000

67. (b) At most 40%; $\frac{5}{36}$

EXERCISES 5.5 ■ PAGE 406

1. $-e^{-x} + C$ **3.** $\frac{2}{9}(x^3 + 1)^{3/2} + C$ **5.** $-\frac{1}{4}\cos^4\theta + C$

7. $-\frac{1}{2}\cos(x^2) + C$ **9.** $\frac{1}{63}(3x - 2)^{21} + C$

11. $\frac{1}{3}(2x + x^2)^{3/2} + C$ **13.** $-\frac{1}{3}\ln|5 - 3x| + C$

15. $-(1/\pi)\cos\pi t + C$ **17.** $\frac{2}{3}\sqrt{3ax + bx^3} + C$

19. $\frac{1}{3}(\ln x)^3 + C$ **21.** $2\sin\sqrt{t} + C$ **23.** $\frac{1}{7}\sin^7\theta + C$

25. $\frac{2}{3}(1 + e^x)^{3/2} + C$ **27.** $\frac{1}{2}(1 + z^3)^{2/3} + C$ **29.** $e^{\tan x} + C$

31. $-1/(\sin x) + C$ **33.** $-\frac{2}{3}(\cot x)^{3/2} + C$

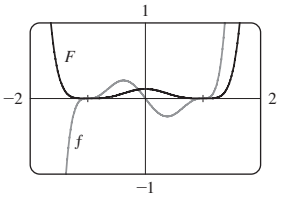
35. $-\ln(1 + \cos^2 x) + C$ **37.** $\ln|\sin x| + C$

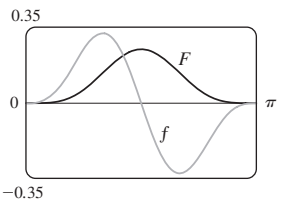
39. $\frac{1}{3}\sec^3 x + C$ **41.** $\ln|\sin^{-1}x| + C$

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

45. $\frac{4}{7}(x + 2)^{7/4} - \frac{8}{3}(x + 2)^{3/4} + C$

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





51. 0 **53.** $\frac{182}{9}$ **55.** 4

57. 0 **59.** $e - \sqrt{e}$ **61.** 3 **63.** $\frac{1}{3}(2\sqrt{2} - 1)a^3$

65. $\frac{16}{15}$ **67.** 2 **69.** $\ln(e + 1)$ **71.** $\sqrt{3} - \frac{1}{3}$

73. 6π **75.** All three areas are equal. **77.** ≈4512 L

79. $\dfrac{5}{4\pi}\left(1 - \cos\dfrac{2\pi t}{5}\right)$ L **81.** 5 **87.** $\pi^2/4$

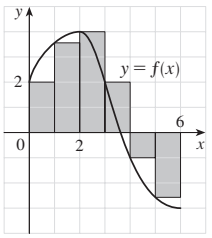
CHAPTER 5 REVIEW ■ PAGE 409

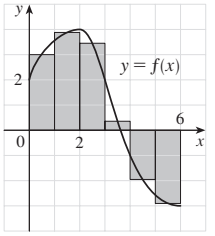
True-False Quiz

1. True **3.** True **5.** False **7.** True **9.** True
11. False **13.** False **15.** False

Exercises

1. (a) 8 (b) 5.7





3. $\frac{1}{2} + \pi/4$ **5.** 3 **7.** f is c, f' is b, $\int_0^x f(t)\,dt$ is a
9. 37 **11.** $\frac{9}{10}$ **13.** -76 **15.** $\frac{21}{4}$ **17.** Does not exist
19. $\frac{1}{3}\sin 1$ **21.** 0 **23.** $-(1/x) - 2\ln|x| + x + C$
25. $\sqrt{x^2 + 4x} + C$ **27.** $[1/(2\pi)]\sin^2\pi t + C$
29. $2e^{\sqrt{x}} + C$ **31.** $-\frac{1}{2}[\ln(\cos x)]^2 + C$
33. $\frac{1}{4}\ln(1 + x^4) + C$ **35.** $\ln|1 + \sec\theta| + C$ **37.** $\frac{23}{3}$
39. $2\sqrt{1 + \sin x} + C$ **41.** $\frac{64}{5}$ **43.** $F'(x) = x^2/(1 + x^3)$
45. $g'(x) = 4x^3\cos(x^8)$ **47.** $y' = \left(2e^x - e^{\sqrt{x}}\right)/(2x)$
49. $4 \leqslant \int_1^3 \sqrt{x^2 + 3}\,dx \leqslant 4\sqrt{3}$ **55.** 0.280981
57. Number of barrels of oil consumed from Jan. 1, 2000, through Jan. 1, 2008
59. 72,400 **61.** 3 **63.** $c \approx 1.62$
65. $f(x) = e^{2x}(1 + 2x)/(1 - e^{-x})$ **71.** $\frac{2}{3}$

PROBLEMS PLUS ■ PAGE 413

1. $\pi/2$ **3.** $f(x) = \frac{1}{2}x$ **5.** -1 **7.** e^{-2} **9.** $[-1, 2]$
11. (a) $\frac{1}{2}(n - 1)n$ (b) $\frac{1}{2}[\![b]\!](2b - [\![b]\!] - 1) - \frac{1}{2}[\![a]\!](2a - [\![a]\!] - 1)$
17. $2\left(\sqrt{2} - 1\right)$

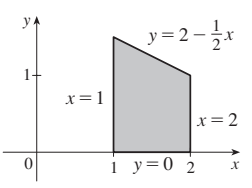
CHAPTER 6

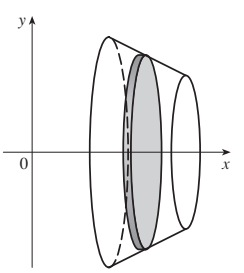
EXERCISES 6.1 ■ PAGE 420

1. $\frac{32}{3}$ **3.** $e - (1/e) + \frac{10}{3}$ **5.** 19.5 **7.** $\frac{1}{6}$ **9.** $\ln 2 - \frac{1}{2}$
11. $\frac{1}{3}$ **13.** 72 **15.** $2 - 2\ln 2$ **17.** $\frac{59}{12}$ **19.** $\frac{32}{3}$
21. $\frac{8}{3}$ **23.** $\frac{1}{2}$ **25.** $\pi - \frac{2}{3}$ **27.** $\ln 2$ **29.** 6.5
31. $\frac{3}{2}\sqrt{3} - 1$ **33.** 0.6407 **35.** 0, 0.90; 0.04 **37.** 8.38
39. $12\sqrt{6} - 9$ **41.** $117\frac{1}{3}$ ft **43.** 4232 cm^2
45. (a) Car A (b) The distance by which A is ahead of B after 1 minute (c) Car A (d) $t \approx 2.2$ min
47. $\frac{24}{5}\sqrt{3}$ **49.** $4^{2/3}$ **51.** ± 6
53. $0 < m < 1$; $m - \ln m - 1$

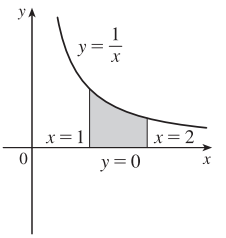
EXERCISES 6.2 ■ PAGE 430

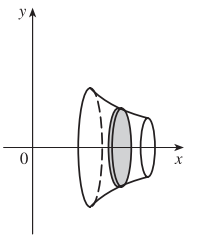
1. $19\pi/12$



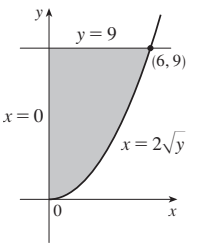


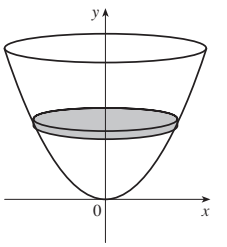
3. $\pi/2$



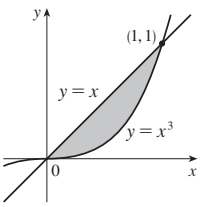


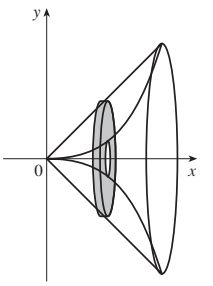
5. 162π



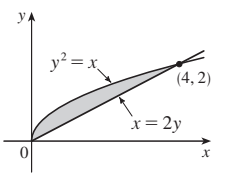


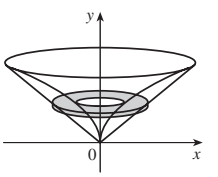
7. $4\pi/21$



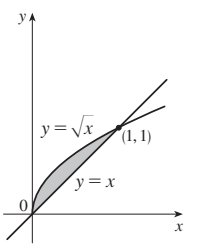


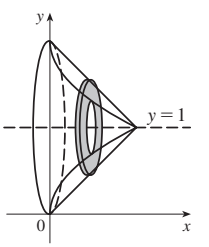
9. $64\pi/15$



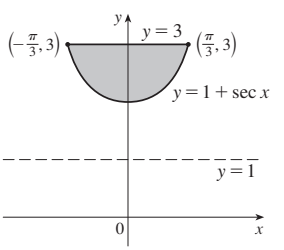


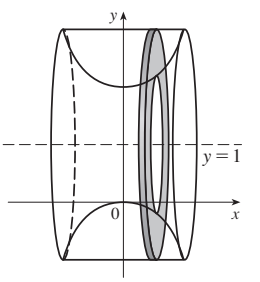
11. $\pi/6$



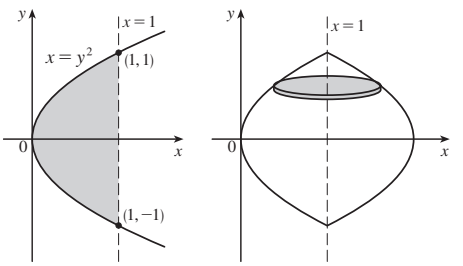


13. $2\pi\left(\frac{4}{3}\pi - \sqrt{3}\right)$

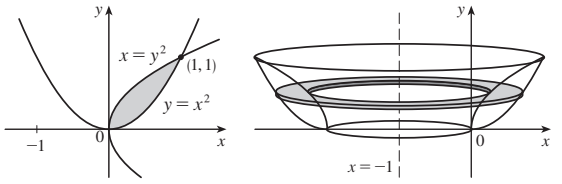




15. $16\pi/15$



17. $29\pi/30$



19. $\pi/7$ **21.** $\pi/10$ **23.** $\pi/2$ **25.** $7\pi/15$

27. $5\pi/14$ **29.** $13\pi/30$ **31.** $\pi\int_0^{\pi/4}(1-\tan^3 x)^2\,dx$

33. $\pi\int_0^{\pi}[1^2-(1-\sin x)^2]\,dx$

35. $\pi\int_{-2\sqrt{2}}^{2\sqrt{2}}\left[5^2-\left(\sqrt{1+y^2}+2\right)^2\right]dy$

37. $-1.288,\ 0.884;\ 23.780$ **39.** $\frac{11}{8}\pi^2$

41. Solid obtained by rotating the region $0 \leqslant y \leqslant \cos x$, $0 \leqslant x \leqslant \pi/2$ about the x-axis

43. Solid obtained by rotating the region above the x-axis bounded by $x = y^2$ and $x = y^4$ about the y-axis

45. 1110 cm³ **47.** (a) 196 (b) 838 **49.** $\frac{1}{3}\pi r^2 h$

51. $\pi h^2\left(r-\frac{1}{3}h\right)$ **53.** $\frac{2}{3}b^2h$ **55.** 10 cm³ **57.** 24

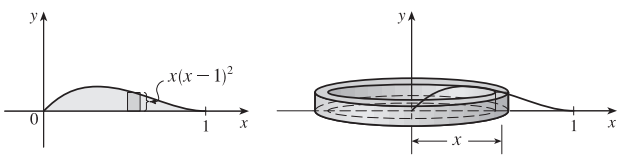
59. $\frac{1}{3}$ **61.** $\frac{8}{15}$

63. (a) $8\pi R\int_0^r\sqrt{r^2-y^2}\,dy$ (b) $2\pi^2r^2R$

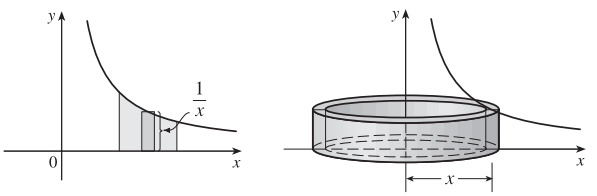
65. (b) $\pi r^2 h$ **67.** $\frac{5}{12}\pi r^3$ **69.** $8\int_0^r\sqrt{R^2-y^2}\sqrt{r^2-y^2}\,dy$

EXERCISES 6.3 ■ PAGE 436

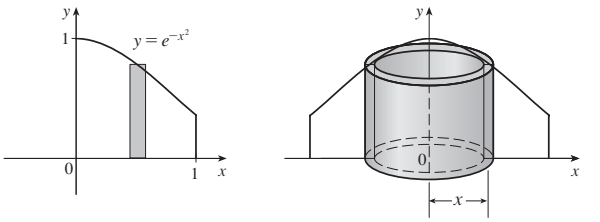
1. Circumference $= 2\pi x$, height $= x(x-1)^2$; $\pi/15$



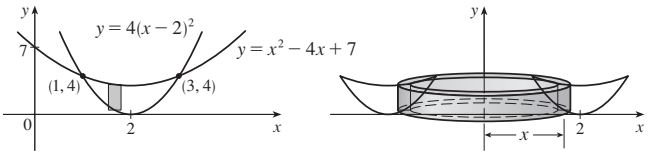
3. 2π



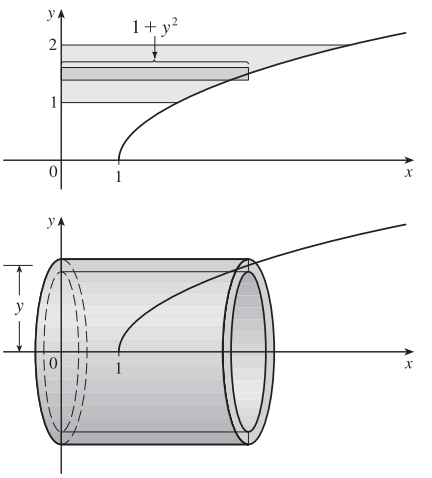
5. $\pi(1-1/e)$



7. 16π



9. $21\pi/2$



11. $768\pi/7$ **13.** $16\pi/3$ **15.** $7\pi/15$ **17.** $8\pi/3$

19. $5\pi/14$ **21.** $\int_1^2 2\pi x\ln x\,dx$

23. $\int_0^1 2\pi(x+1)[\sin(\pi x/2)-x^4]\,dx$

25. $\int_0^{\pi}2\pi(4-y)\sqrt{\sin y}\,dy$ **27.** 3.68

29. Solid obtained by rotating the region $0 \leqslant y \leqslant x^4$, $0 \leqslant x \leqslant 3$ about the y-axis

31. Solid obtained by rotating the region bounded by (i) $x = 1-y^2$, $x = 0$, and $y = 0$, or (ii) $x = y^2$, $x = 1$, and $y = 0$ about the line $y = 3$

33. 0.13 **35.** $\frac{1}{32}\pi^3$ **37.** 8π **39.** $2\pi(12-4\ln 4)$

41. $\frac{4}{3}\pi$ **43.** $\frac{4}{3}\pi r^3$ **45.** $\frac{1}{3}\pi r^2 h$

EXERCISES 6.4 ■ PAGE 441

1. 588 J **3.** 9 ft-lb **5.** 180 J **7.** $\frac{15}{4}$ ft-lb

9. (a) $\frac{25}{24}\approx 1.04$ J (b) 10.8 cm **11.** $W_2 = 3W_1$

13. (a) 625 ft-lb (b) $\frac{1875}{4}$ ft-lb **15.** 650,000 ft-lb

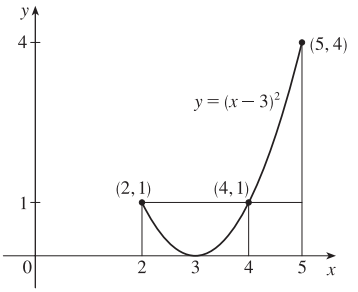
17. 3857 J **19.** 2450 J **21.** $\approx 1.06\times 10^6$ J

23. $\approx 1.04\times 10^5$ ft-lb **25.** 2.0 m **29.** $Gm_1m_2\left(\frac{1}{a}-\frac{1}{b}\right)$

EXERCISES 6.5 ■ PAGE 445

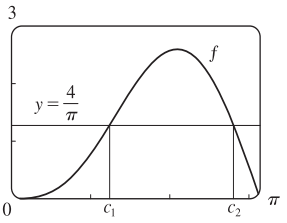
1. $\frac{8}{3}$ **3.** $\frac{45}{28}$ **5.** $\frac{1}{10}(1 - e^{-25})$ **7.** $2/(5\pi)$

9. (a) 1 (b) 2, 4 (c)



11. (a) $4/\pi$ (b) $\approx 1.24, 2.81$

(c)



15. $38\frac{1}{3}$ **17.** $(50 + 28/\pi)°\text{F} \approx 59°\text{F}$ **19.** 6 kg/m

21. $5/(4\pi) \approx 0.4$ L

CHAPTER 6 REVIEW ■ PAGE 446

Exercises

1. $\frac{8}{3}$ **3.** $\frac{7}{12}$ **5.** $\frac{4}{3} + 4/\pi$ **7.** $64\pi/15$ **9.** $1656\pi/5$

11. $\frac{4}{3}\pi(2ah + h^2)^{3/2}$ **13.** $\int_{-\pi/3}^{\pi/3} 2\pi(\pi/2 - x)(\cos^2 x - \frac{1}{4})\,dx$

15. (a) $2\pi/15$ (b) $\pi/6$ (c) $8\pi/15$

17. (a) 0.38 (b) 0.87

19. Solid obtained by rotating the region $0 \leq y \leq \cos x$, $0 \leq x \leq \pi/2$ about the y-axis

21. Solid obtained by rotating the region $0 \leq x \leq \pi$, $0 \leq y \leq 2 - \sin x$ about the x-axis

23. 36 **25.** $\frac{125}{3}\sqrt{3}\ \text{m}^3$ **27.** 3.2 J

29. (a) $8000\pi/3 \approx 8378$ ft-lb (b) 2.1 ft **31.** $f(x)$

PROBLEMS PLUS ■ PAGE 448

1. (a) $f(t) = 3t^2$ (b) $f(x) = \sqrt{2x/\pi}$ **3.** $\frac{32}{27}$

5. (b) 0.2261 (c) 0.6736 m

(d) (i) $1/(105\pi) \approx 0.003$ in/s (ii) $370\pi/3$ s ≈ 6.5 min

9. $y = \frac{32}{9}x^2$

11. (a) $V = \int_0^h \pi[f(y)]^2\,dy$ (c) $f(y) = \sqrt{kA/(\pi C)}\,y^{1/4}$

Advantage: the markings on the container are equally spaced.

13. $b = 2a$ **15.** $B = 16A$

CHAPTER 7

EXERCISES 7.1 ■ PAGE 457

1. $\frac{1}{3}x^3 \ln x - \frac{1}{9}x^3 + C$ **3.** $\frac{1}{5}x \sin 5x + \frac{1}{25}\cos 5x + C$

5. $2(r - 2)e^{r/2} + C$

7. $-\frac{1}{\pi}x^2 \cos \pi x + \frac{2}{\pi^2}x \sin \pi x + \frac{2}{\pi^3}\cos \pi x + C$

9. $\frac{1}{2}(2x + 1)\ln(2x + 1) - x + C$

11. $t \arctan 4t - \frac{1}{8}\ln(1 + 16t^2) + C$

13. $\frac{1}{2}t \tan 2t - \frac{1}{4}\ln|\sec 2t| + C$

15. $x(\ln x)^2 - 2x \ln x + 2x + C$

17. $\frac{1}{13}e^{2\theta}(2 \sin 3\theta - 3 \cos 3\theta) + C$

19. $\pi/3$ **21.** $1 - 1/e$ **23.** $\frac{1}{2} - \frac{1}{2}\ln 2$ **25.** $\frac{1}{4} - \frac{3}{4}e^{-2}$

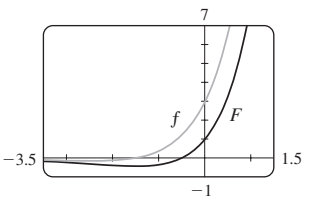
27. $\frac{1}{6}(\pi + 6 - 3\sqrt{3})$ **29.** $\sin x\,(\ln \sin x - 1) + C$

31. $\frac{32}{5}(\ln 2)^2 - \frac{64}{25}\ln 2 + \frac{62}{125}$

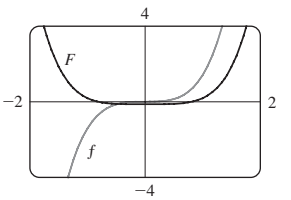
33. $2\sqrt{x} \sin \sqrt{x} + 2 \cos \sqrt{x} + C$ **35.** $-\frac{1}{2} - \pi/4$

37. $\frac{1}{2}(x^2 - 1)\ln(1 + x) - \frac{1}{4}x^2 + \frac{1}{2}x + \frac{3}{4} + C$

39. $(2x + 1)e^x + C$



41. $\frac{1}{3}x^2(1 + x^2)^{3/2} - \frac{2}{15}(1 + x^2)^{5/2} + C$



43. (b) $-\frac{1}{4}\cos x \sin^3 x + \frac{3}{8}x - \frac{3}{16}\sin 2x + C$

45. (b) $\frac{2}{3}, \frac{8}{15}$ **51.** $x(\ln x)^3 - 3x(\ln x)^2 + 6x \ln x - 6x + C$

53. $\frac{25}{4} - \frac{75}{4}e^{-2}$ **55.** 1.0475, 2.8731; 2.1828 **57.** $4 - 8/\pi$

59. $2\pi e$ **61.** $\frac{9}{2}\ln 3 - \frac{13}{9}$ **63.** $2 - e^{-t}(t^2 + 2t + 2)$ m

65. 2

EXERCISES 7.2 ■ PAGE 465

1. $\frac{1}{5}\cos^5 x - \frac{1}{3}\cos^3 x + C$ **3.** $-\frac{11}{384}$

5. $\frac{1}{3\pi}\sin^3(\pi x) - \frac{2}{5\pi}\sin^5(\pi x) + \frac{1}{7\pi}\sin^7(\pi x) + C$

7. $\pi/4$ **9.** $3\pi/8$ **11.** $\frac{3}{2}\theta + 2 \sin \theta + \frac{1}{4}\sin 2\theta + C$

13. $\pi/16$ **15.** $\frac{2}{45}\sqrt{\sin \alpha}\,(45 - 18 \sin^2\alpha + 15 \sin^4\alpha) + C$

17. $\frac{1}{2}\cos^2 x - \ln|\cos x| + C$ **19.** $\ln|\sin x| + 2 \sin x + C$

21. $\frac{1}{2}\tan^2 x + C$ **23.** $\tan x - x + C$

25. $\frac{1}{5}\tan^5 t + \frac{2}{3}\tan^3 t + \tan t + C$ **27.** $\frac{117}{8}$

29. $\frac{1}{3}\sec^3 x - \sec x + C$

31. $\frac{1}{4}\sec^4 x - \tan^2 x + \ln|\sec x| + C$

33. $\frac{1}{6}\tan^6\theta + \frac{1}{4}\tan^4\theta + C$

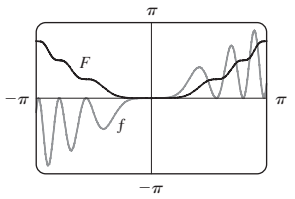
35. $x \sec x - \ln|\sec x + \tan x| + C$ **37.** $\sqrt{3} - \frac{1}{3}\pi$

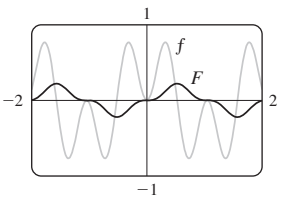
39. $\frac{1}{3}\csc^3\alpha - \frac{1}{5}\csc^5\alpha + C$ **41.** $\ln|\csc x - \cot x| + C$

43. $-\frac{1}{6}\cos 3x - \frac{1}{26}\cos 13x + C$ **45.** $\frac{1}{8}\sin 4\theta - \frac{1}{12}\sin 6\theta + C$

47. $\frac{1}{2}\sin 2x + C$ **49.** $\frac{1}{10}\tan^5(t^2) + C$

51. $\frac{1}{4}x^2 - \frac{1}{4}\sin(x^2)\cos(x^2) + C$ **53.** $\frac{1}{6}\sin 3x - \frac{1}{18}\sin 9x + C$





55. 0 **57.** 1 **59.** 0 **61.** $\pi^2/4$ **63.** $\pi(2\sqrt{2} - \frac{5}{2})$
65. $s = (1 - \cos^3\omega t)/(3\omega)$

EXERCISES 7.3 ■ PAGE 472

1. $\sqrt{x^2 - 9}/(9x) + C$ **3.** $\frac{1}{3}(x^2 - 18)\sqrt{x^2 + 9} + C$
5. $\pi/24 + \sqrt{3}/8 - \frac{1}{4}$ **7.** $-\sqrt{25 - x^2}/(25x) + C$
9. $\ln(\sqrt{x^2 + 16} + x) + C$ **11.** $\frac{1}{4}\sin^{-1}(2x) + \frac{1}{2}x\sqrt{1 - 4x^2} + C$
13. $\frac{1}{6}\sec^{-1}(x/3) - \sqrt{x^2 - 9}/(2x^2) + C$
15. $\frac{1}{16}\pi a^4$ **17.** $\sqrt{x^2 - 7} + C$
19. $\ln\left|\left(\sqrt{1 + x^2} - 1\right)/x\right| + \sqrt{1 + x^2} + C$ **21.** $\frac{9}{500}\pi$
23. $\frac{9}{2}\sin^{-1}((x - 2)/3) + \frac{1}{2}(x - 2)\sqrt{5 + 4x - x^2} + C$
25. $\sqrt{x^2 + x + 1} - \frac{1}{2}\ln\left(\sqrt{x^2 + x + 1} + x + \frac{1}{2}\right) + C$
27. $\frac{1}{2}(x + 1)\sqrt{x^2 + 2x} - \frac{1}{2}\ln\left|x + 1 + \sqrt{x^2 + 2x}\right| + C$
29. $\frac{1}{4}\sin^{-1}(x^2) + \frac{1}{4}x^2\sqrt{1 - x^4} + C$
33. $\frac{1}{6}\left(\sqrt{48} - \sec^{-1} 7\right)$ **37.** 0.81, 2; 2.10
41. $r\sqrt{R^2 - r^2} + \pi r^2/2 - R^2 \arcsin(r/R)$ **43.** $2\pi^2 Rr^2$

EXERCISES 7.4 ■ PAGE 481

1. (a) $\dfrac{A}{x + 3} + \dfrac{B}{3x + 1}$ (b) $\dfrac{A}{x} + \dfrac{B}{x + 1} + \dfrac{C}{(x + 1)^2}$

3. (a) $\dfrac{A}{x} + \dfrac{B}{x^2} + \dfrac{C}{x^3} + \dfrac{Dx + E}{x^2 + 4}$

(b) $\dfrac{A}{x + 3} + \dfrac{B}{(x + 3)^2} + \dfrac{C}{x - 3} + \dfrac{D}{(x - 3)^2}$

5. (a) $1 + \dfrac{A}{x - 1} + \dfrac{B}{x + 1} + \dfrac{Cx + D}{x^2 + 1}$

(b) $\dfrac{At + B}{t^2 + 1} + \dfrac{Ct + D}{t^2 + 4} + \dfrac{Et + F}{(t^2 + 4)^2}$

7. $x + 6\ln|x - 6| + C$
9. $2\ln|x + 5| - \ln|x - 2| + C$ **11.** $\frac{1}{2}\ln\frac{3}{2}$
13. $a\ln|x - b| + C$ **15.** $\frac{7}{6} + \ln\frac{2}{3}$
17. $\frac{27}{5}\ln 2 - \frac{9}{5}\ln 3$ $\left(\text{or } \frac{9}{5}\ln\frac{8}{3}\right)$
19. $-\dfrac{1}{36}\ln|x + 5| + \dfrac{1}{6}\dfrac{1}{x + 5} + \dfrac{1}{36}\ln|x - 1| + C$
21. $\frac{1}{2}x^2 - 2\ln(x^2 + 4) + 2\tan^{-1}(x/2) + C$
23. $2\ln|x| + (1/x) + 3\ln|x + 2| + C$
25. $\ln|x - 1| - \frac{1}{2}\ln(x^2 + 9) - \frac{1}{3}\tan^{-1}(x/3) + C$
27. $\frac{1}{2}\ln(x^2 + 1) + \left(1/\sqrt{2}\right)\tan^{-1}\left(x/\sqrt{2}\right) + C$
29. $\frac{1}{2}\ln(x^2 + 2x + 5) + \frac{3}{2}\tan^{-1}\left(\dfrac{x + 1}{2}\right) + C$
31. $\frac{1}{3}\ln|x - 1| - \frac{1}{6}\ln(x^2 + x + 1) - \dfrac{1}{\sqrt{3}}\tan^{-1}\dfrac{2x + 1}{\sqrt{3}} + C$
33. $\frac{1}{4}\ln\frac{8}{3}$ **35.** $\frac{1}{16}\ln|x| - \frac{1}{32}\ln(x^2 + 4) + \dfrac{1}{8(x^2 + 4)} + C$
37. $\frac{7}{8}\sqrt{2}\tan^{-1}\left(\dfrac{x - 2}{\sqrt{2}}\right) + \dfrac{3x - 8}{4(x^2 - 4x + 6)} + C$
39. $\ln\left|\dfrac{\sqrt{x + 1} - 1}{\sqrt{x + 1} + 1}\right| + C$
41. $2 + \ln\frac{25}{9}$ **43.** $\frac{3}{10}(x^2 + 1)^{5/3} - \frac{3}{4}(x^2 + 1)^{2/3} + C$
45. $2\sqrt{x} + 3\sqrt[3]{x} + 6\sqrt[6]{x} + 6\ln\left|\sqrt[6]{x} - 1\right| + C$
47. $\ln\left[\dfrac{(e^x + 2)^2}{e^x + 1}\right] + C$
49. $\ln|\tan t + 1| - \ln|\tan t + 2| + C$
51. $\left(x - \frac{1}{2}\right)\ln(x^2 - x + 2) - 2x + \sqrt{7}\tan^{-1}\left(\dfrac{2x - 1}{\sqrt{7}}\right) + C$
53. $-\frac{1}{2}\ln 3 \approx -0.55$
55. $\frac{1}{2}\ln\left|\dfrac{x - 2}{x}\right| + C$ **59.** $\frac{1}{5}\ln\left|\dfrac{2\tan(x/2) - 1}{\tan(x/2) + 2}\right| + C$
61. $4\ln\frac{2}{3} + 2$ **63.** $-1 + \frac{11}{3}\ln 2$
65. $t = -\ln P - \frac{1}{9}\ln(0.9P + 900) + C$, where $C \approx 10.23$
67. (a) $\dfrac{24{,}110}{4879}\dfrac{1}{5x + 2} - \dfrac{668}{323}\dfrac{1}{2x + 1} - \dfrac{9438}{80{,}155}\dfrac{1}{3x - 7} + \dfrac{1}{260{,}015}\dfrac{22{,}098x + 48{,}935}{x^2 + x + 5}$

(b) $\dfrac{4822}{4879}\ln|5x + 2| - \dfrac{334}{323}\ln|2x + 1| - \dfrac{3146}{80{,}155}\ln|3x - 7| + \dfrac{11{,}049}{260{,}015}\ln(x^2 + x + 5) + \dfrac{75{,}772}{260{,}015\sqrt{19}}\tan^{-1}\dfrac{2x + 1}{\sqrt{19}} + C$

The CAS omits the absolute value signs and the constant of integration.

EXERCISES 7.5 ■ PAGE 488

1. $\sin x + \frac{1}{3}\sin^3 x + C$
3. $\sin x + \ln|\csc x - \cot x| + C$
5. $4 - \ln 9$ **7.** $e^{\pi/4} - e^{-\pi/4}$
9. $\frac{243}{5}\ln 3 - \frac{242}{25}$ **11.** $\frac{1}{2}\ln(x^2 - 4x + 5) + \tan^{-1}(x - 2) + C$
13. $\frac{1}{8}\cos^8\theta - \frac{1}{6}\cos^6\theta + C$ $\left(\text{or } \frac{1}{4}\sin^4\theta - \frac{1}{3}\sin^6\theta + \frac{1}{8}\sin^8\theta + C\right)$
15. $x/\sqrt{1 - x^2} + C$
17. $\frac{1}{4}x^2 - \frac{1}{2}x\sin x\cos x + \frac{1}{4}\sin^2 x + C$
$\left(\text{or } \frac{1}{4}x^2 - \frac{1}{4}x\sin 2x - \frac{1}{8}\cos 2x + C\right)$
19. $e^{e^x} + C$ **21.** $(x + 1)\arctan\sqrt{x} - \sqrt{x} + C$
23. $\frac{4097}{45}$ **25.** $3x + \frac{23}{3}\ln|x - 4| - \frac{5}{3}\ln|x + 2| + C$
27. $x - \ln(1 + e^x) + C$ **29.** $15 + 7\ln\frac{2}{7}$
31. $\sin^{-1}x - \sqrt{1 - x^2} + C$
33. $2\sin^{-1}\left(\dfrac{x + 1}{2}\right) + \dfrac{x + 1}{2}\sqrt{3 - 2x - x^2} + C$
35. 0 **37.** $\pi/8 - \frac{1}{4}$ **39.** $\ln|\sec\theta - 1| - \ln|\sec\theta| + C$
41. $\theta\tan\theta - \frac{1}{2}\theta^2 - \ln|\sec\theta| + C$ **43.** $\frac{2}{3}(1 + e^x)^{3/2} + C$
45. $-\frac{1}{3}(x^3 + 1)e^{-x^3} + C$
47. $\ln|x - 1| - 3(x - 1)^{-1} - \frac{3}{2}(x - 1)^{-2} - \frac{1}{3}(x - 1)^{-3} + C$
49. $\ln\left|\dfrac{\sqrt{4x + 1} - 1}{\sqrt{4x + 1} + 1}\right| + C$ **51.** $-\ln\left|\dfrac{\sqrt{4x^2 + 1} + 1}{2x}\right| + C$
53. $\dfrac{1}{m}x^2\cosh(mx) - \dfrac{2}{m^2}x\sinh(mx) + \dfrac{2}{m^3}\cosh(mx) + C$

55. $2\ln\sqrt{x} - 2\ln(1+\sqrt{x}) + C$

57. $\frac{3}{7}(x+c)^{7/3} - \frac{3}{4}c(x+c)^{4/3} + C$

59. $\sin(\sin x) - \frac{1}{3}\sin^3(\sin x) + C$ **61.** $2(x - 2\sqrt{x} + 2)e^{\sqrt{x}} + C$

63. $-\tan^{-1}(\cos^2 x) + C$ **65.** $\frac{2}{3}[(x+1)^{3/2} - x^{3/2}] + C$

67. $\sqrt{2} - 2/\sqrt{3} + \ln(2+\sqrt{3}) - \ln(1+\sqrt{2})$

69. $e^x - \ln(1+e^x) + C$

71. $-\sqrt{1-x^2} + \frac{1}{2}(\arcsin x)^2 + C$

73. $\frac{1}{8}\ln|x-2| - \frac{1}{16}\ln(x^2+4) - \frac{1}{8}\tan^{-1}(x/2) + C$

75. $2(x-2)\sqrt{1+e^x} + 2\ln\dfrac{\sqrt{1+e^x}+1}{\sqrt{1+e^x}-1} + C$

77. $\frac{2}{3}\tan^{-1}(x^{3/2}) + C$

79. $\frac{1}{3}x\sin^3 x + \frac{1}{3}\cos x - \frac{1}{9}\cos^3 x + C$ **81.** $xe^{x^2} + C$

EXERCISES 7.6 ■ PAGE 493

1. $(-1/x)\sqrt{7-2x^2} - \sqrt{2}\sin^{-1}(\sqrt{2}x/\sqrt{7}) + C$

3. $\dfrac{1}{2\pi}\sec(\pi x)\tan(\pi x) + \dfrac{1}{2\pi}\ln|\sec(\pi x) + \tan(\pi x)| + C$

5. $\pi/4$ **7.** $\dfrac{1}{2\pi}\tan^2(\pi x) + \dfrac{1}{\pi}\ln|\cos(\pi x)| + C$

9. $-\sqrt{4x^2+9}/(9x) + C$ **11.** $e - 2$

13. $-\frac{1}{2}\tan^2(1/z) - \ln|\cos(1/z)| + C$

15. $\frac{1}{2}(e^{2x}+1)\arctan(e^x) - \frac{1}{2}e^x + C$

17. $\dfrac{2y-1}{8}\sqrt{6+4y-4y^2} + \frac{7}{8}\sin^{-1}\left(\dfrac{2y-1}{\sqrt{7}}\right)$
$- \frac{1}{12}(6+4y-4y^2)^{3/2} + C$

19. $\frac{1}{9}\sin^3 x\,[3\ln(\sin x) - 1] + C$

21. $\dfrac{1}{2\sqrt{3}}\ln\left|\dfrac{e^x+\sqrt{3}}{e^x-\sqrt{3}}\right| + C$

23. $\frac{1}{4}\tan x\sec^3 x + \frac{3}{8}\tan x\sec x + \frac{3}{8}\ln|\sec x + \tan x| + C$

25. $\frac{1}{2}(\ln x)\sqrt{4+(\ln x)^2} + 2\ln\left[\ln x + \sqrt{4+(\ln x)^2}\right] + C$

27. $\sqrt{e^{2x}-1} - \cos^{-1}(e^{-x}) + C$

29. $\frac{1}{5}\ln|x^5 + \sqrt{x^{10}-2}| + C$ **31.** $2\pi^2$

35. $\frac{1}{3}\tan x\sec^2 x + \frac{2}{3}\tan x + C$

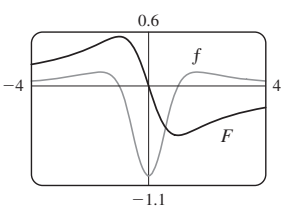
37. $\frac{1}{4}x(x^2+2)\sqrt{x^2+4} - 2\ln(\sqrt{x^2+4} + x) + C$

39. $\frac{1}{10}(1+2x)^{5/2} - \frac{1}{6}(1+2x)^{3/2} + C$

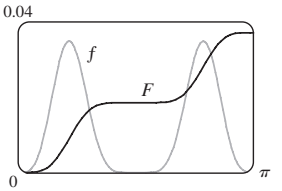
41. $-\ln|\cos x| - \frac{1}{2}\tan^2 x + \frac{1}{4}\tan^4 x + C$

43. (a) $-\ln\left|\dfrac{1+\sqrt{1-x^2}}{x}\right| + C$;
both have domain $(-1, 0) \cup (0, 1)$

45. $F(x) = \frac{1}{2}\ln(x^2 - x + 1) - \frac{1}{2}\ln(x^2 + x + 1)$;
max. at -1, min. at 1; IP at -1.7, 0, and 1.7



47. $F(x) = -\frac{1}{10}\sin^3 x\cos^7 x - \frac{3}{80}\sin x\cos^7 x + \frac{1}{160}\sin x\cos^5 x$
$+ \frac{1}{128}\sin x\cos^3 x + \frac{3}{256}\sin x\cos x + \frac{3}{256}x$;
max. at π, min. at 0; IP at 0.7, $\pi/2$, and 2.5



EXERCISES 7.7 ■ PAGE 505

1. (a) $L_2 = 6$, $R_2 = 12$, $M_2 \approx 9.6$
(b) L_2 is an underestimate, R_2 and M_2 are overestimates.
(c) $T_2 = 9 < I$ (d) $L_n < T_n < I < M_n < R_n$

3. (a) $T_4 \approx 0.895759$ (underestimate)
(b) $M_4 \approx 0.908907$ (overestimate)
$T_4 < I < M_4$

5. (a) 5.932957, $E_M \approx -0.063353$
(b) 5.869247, $E_S \approx 0.000357$

7. (a) 2.413790 (b) 2.411453 (c) 2.412232

9. (a) 0.146879 (b) 0.147391 (c) 0.147219

11. (a) 0.451948 (b) 0.451991 (c) 0.451976

13. (a) 4.513618 (b) 4.748256 (c) 4.675111

15. (a) -0.495333 (b) -0.543321 (c) -0.526123

17. (a) 1.064275 (b) 1.067416 (c) 1.074915

19. (a) $T_8 \approx 0.902333$, $M_8 \approx 0.905620$
(b) $|E_T| \leq 0.0078$, $|E_M| \leq 0.0039$
(c) $n = 71$ for T_n, $n = 50$ for M_n

21. (a) $T_{10} \approx 1.983524$, $E_T \approx 0.016476$;
$M_{10} \approx 2.008248$, $E_M \approx -0.008248$;
$S_{10} \approx 2.000110$, $E_S \approx -0.000110$
(b) $|E_T| \leq 0.025839$, $|E_M| \leq 0.012919$, $|E_S| \leq 0.000170$
(c) $n = 509$ for T_n, $n = 360$ for M_n, $n = 22$ for S_n

23. (a) 2.8 (b) 7.954926518 (c) 0.2894
(d) 7.954926521 (e) The actual error is much smaller.
(f) 10.9 (g) 7.953789422 (h) 0.0593
(i) The actual error is smaller. (j) $n \geq 50$

25.

n	L_n	R_n	T_n	M_n
5	0.742943	1.286599	1.014771	0.992621
10	0.867782	1.139610	1.003696	0.998152
20	0.932967	1.068881	1.000924	0.999538

n	E_L	E_R	E_T	E_M
5	0.257057	−0.286599	−0.014771	0.007379
10	0.132218	−0.139610	−0.003696	0.001848
20	0.067033	−0.068881	−0.000924	0.000462

Observations are the same as after Example 1.

27.

n	T_n	M_n	S_n
6	6.695473	6.252572	6.403292
12	6.474023	6.363008	6.400206

n	E_T	E_M	E_S
6	−0.295473	0.147428	−0.003292
12	−0.074023	0.036992	−0.000206

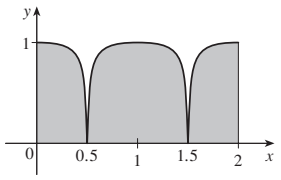
Observations are the same as after Example 1.

29. (a) 19.8 (b) 20.6 (c) $20.5\overline{3}$

31. (a) 23.44 (b) $0.341\overline{3}$ **33.** $37.7\overline{3}$ ft/s

35. 10,177 megawatt-hours **37.** 828 **39.** 6.0 **41.** 59.4

43.



EXERCISES 7.8 ■ PAGE 515

Abbreviations: C, convergent; D, divergent

1. (a) Infinite interval (b) Infinite discontinuity
(c) Infinite discontinuity (d) Infinite interval

3. $\frac{1}{2} - 1/(2t^2)$; 0.495, 0.49995, 0.4999995; 0.5

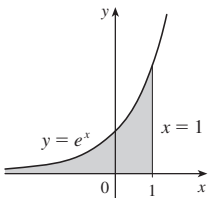
5. $\frac{1}{12}$ **7.** D **9.** $2e^{-2}$ **11.** D **13.** 0 **15.** D

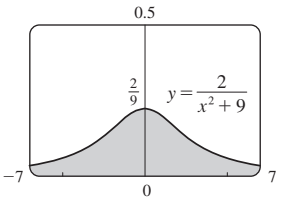
17. D **19.** $\frac{1}{25}$ **21.** D **23.** $\pi/9$

25. $\frac{1}{2}$ **27.** D **29.** $\frac{32}{3}$ **31.** D **33.** $\frac{75}{4}$

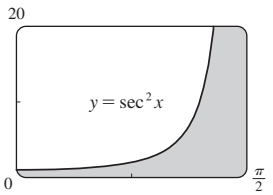
35. D **37.** $-2/e$ **39.** $\frac{8}{3}\ln 2 - \frac{8}{9}$

41. e **43.** $2\pi/3$





45. Infinite area

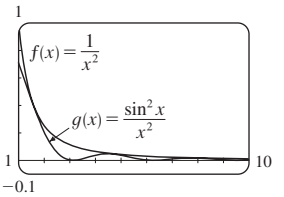


47. (a)

t	$\int_1^t [(\sin^2 x)/x^2]\,dx$
2	0.447453
5	0.577101
10	0.621306
100	0.668479
1,000	0.672957
10,000	0.673407

It appears that the integral is convergent.

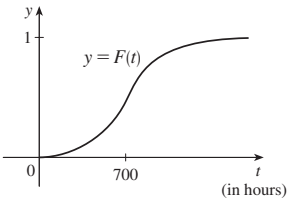
(c)



49. C **51.** D **53.** D **55.** π **57.** $p < 1$, $1/(1-p)$

59. $p > -1$, $-1/(p+1)^2$ **65.** $\sqrt{2GM/R}$

67. (a)



(b) The rate at which the fraction $F(t)$ increases as t increases
(c) 1; all bulbs burn out eventually

69. 1000

71. (a) $F(s) = 1/s$, $s > 0$ (b) $F(s) = 1/(s-1)$, $s > 1$
(c) $F(s) = 1/s^2$, $s > 0$

77. $C = 1$; $\ln 2$ **79.** No

CHAPTER 7 REVIEW ■ PAGE 518

True-False Quiz

1. False **3.** False **5.** False **7.** False
9. (a) True (b) False **11.** False **13.** False

Exercises

1. $5 + 10\ln\frac{2}{3}$ **3.** $\ln 2$ **5.** $\frac{2}{15}$

7. $-\cos(\ln t) + C$ **9.** $\frac{64}{5}\ln 4 - \frac{124}{25}$

11. $\sqrt{3} - \frac{1}{3}\pi$ **13.** $3e^{\sqrt[3]{x}}\left(\sqrt[3]{x^2} - 2\sqrt[3]{x} + 2\right) + C$

15. $-\frac{1}{2}\ln|x| + \frac{3}{2}\ln|x+2| + C$

17. $x\sec x - \ln|\sec x + \tan x| + C$

19. $\frac{1}{18}\ln(9x^2 + 6x + 5) + \frac{1}{9}\tan^{-1}\left[\frac{1}{2}(3x+1)\right] + C$

21. $\ln|x - 2 + \sqrt{x^2 - 4x}| + C$

23. $\ln\left|\dfrac{\sqrt{x^2+1}-1}{x}\right| + C$

25. $\frac{3}{2}\ln(x^2+1) - 3\tan^{-1}x + \sqrt{2}\tan^{-1}(x/\sqrt{2}) + C$

27. $\frac{2}{5}$ **29.** 0 **31.** $6 - \frac{3}{2}\pi$

33. $\dfrac{x}{\sqrt{4-x^2}} - \sin^{-1}\left(\dfrac{x}{2}\right) + C$

35. $4\sqrt{1+\sqrt{x}} + C$ **37.** $\frac{1}{2}\sin 2x - \frac{1}{8}\cos 4x + C$

39. $\frac{1}{8}e - \frac{1}{4}$ **41.** $\frac{1}{36}$ **43.** D

45. $4\ln 4 - 8$ **47.** $-\frac{4}{3}$ **49.** $\pi/4$

51. $(x+1)\ln(x^2+2x+2) + 2\arctan(x+1) - 2x + C$

53. 0

55. $\frac{1}{4}(2x-1)\sqrt{4x^2-4x-3} - \ln\left|2x - 1 + \sqrt{4x^2-4x-3}\right| + C$

57. $\frac{1}{2}\sin x\sqrt{4+\sin^2 x}+2\ln\left(\sin x+\sqrt{4+\sin^2 x}\right)+C$
61. No
63. (a) 1.925444 (b) 1.920915 (c) 1.922470
65. (a) 0.01348, $n \geqslant 368$ (b) 0.00674, $n \geqslant 260$
67. 8.6 mi
69. (a) 3.8 (b) 1.7867, 0.000646 (c) $n \geqslant 30$
71. C **73.** 2 **75.** $\frac{3}{16}\pi^2$

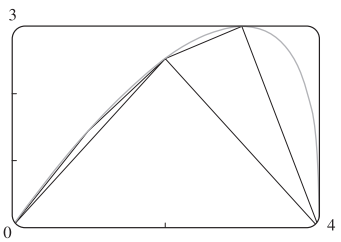
PROBLEMS PLUS ■ PAGE 521

1. About 1.85 inches from the center **3.** 0
7. $f(\pi) = -\pi/2$ **11.** $(b^b a^{-a})^{1/(b-a)} e^{-1}$
13. $2-\sin^{-1}\left(2/\sqrt{5}\right)$

CHAPTER 8

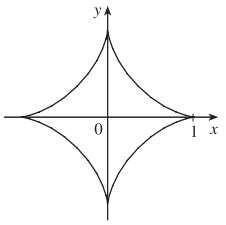
EXERCISES 8.1 ■ PAGE 530

1. $4\sqrt{5}$ **3.** $\int_0^{2\pi}\sqrt{1+\sin^2 x}\,dx$ **5.** $\int_1^4\sqrt{9y^4+6y^2+2}\,dy$
7. $\frac{2}{243}\left(82\sqrt{82}-1\right)$ **9.** $\frac{1261}{240}$ **11.** $\frac{32}{3}$
13. $\ln\left(\sqrt{2}+1\right)$ **15.** $\ln 3-\frac{1}{2}$
17. $\sqrt{1+e^2}-\sqrt{2}+\ln\left(\sqrt{1+e^2}-1\right)-1-\ln\left(\sqrt{2}-1\right)$
19. $\sqrt{2}+\ln\left(1+\sqrt{2}\right)$ **21.** $\frac{46}{3}$ **23.** 5.115840
25. 1.569619
27. (a), (b)



$L_1 = 4$,
$L_2 \approx 6.43$,
$L_4 \approx 7.50$

(c) $\int_0^4\sqrt{1+[4(3-x)/(3(4-x)^{2/3})]^2}\,dx$ (d) 7.7988
29. $\sqrt{5}-\ln\left(\frac{1}{2}\left(1+\sqrt{5}\right)\right)-\sqrt{2}+\ln\left(1+\sqrt{2}\right)$
31. 6



33. $s(x) = \frac{2}{27}\left[(1+9x)^{3/2}-10\sqrt{10}\right]$ **35.** $2\sqrt{2}\left(\sqrt{1+x}-1\right)$
37. 209.1 m **39.** 29.36 in. **41.** 12.4

EXERCISES 8.2 ■ PAGE 537

1. (a) $\int_0^1 2\pi x^4\sqrt{1+16x^6}\,dx$ (b) $\int_0^1 2\pi x\sqrt{1+16x^6}\,dx$
3. (a) $\int_0^1 2\pi\tan^{-1}x\sqrt{1+\dfrac{1}{(1+x^2)^2}}\,dx$
(b) $\int_0^1 2\pi x\sqrt{1+\dfrac{1}{(1+x^2)^2}}\,dx$
5. $\frac{1}{27}\pi\left(145\sqrt{145}-1\right)$ **7.** $\frac{98}{3}\pi$
9. $2\sqrt{1+\pi^2}+(2/\pi)\ln\left(\pi+\sqrt{1+\pi^2}\right)$ **11.** $\frac{21}{2}\pi$
13. $\frac{1}{27}\pi\left(145\sqrt{145}-10\sqrt{10}\right)$ **15.** πa^2
17. 9.023754 **19.** 13.527296
21. $\frac{1}{4}\pi\left[4\ln\left(\sqrt{17}+4\right)-4\ln\left(\sqrt{2}+1\right)-\sqrt{17}+4\sqrt{2}\right]$
23. $\frac{1}{6}\pi\left[\ln\left(\sqrt{10}+3\right)+3\sqrt{10}\right]$
27. (a) $\frac{1}{3}\pi a^2$ (b) $\frac{56}{45}\pi\sqrt{3}a^2$
29. (a) $2\pi\left[b^2+\dfrac{a^2 b\sin^{-1}\left(\sqrt{a^2-b^2}/a\right)}{\sqrt{a^2-b^2}}\right]$
(b) $2\pi\left[a^2+\dfrac{ab^2\sin^{-1}\left(\sqrt{b^2-a^2}/b\right)}{\sqrt{b^2-a^2}}\right]$
31. $\int_a^b 2\pi[c-f(x)]\sqrt{1+[f'(x)]^2}\,dx$ **33.** $4\pi^2 r^2$

EXERCISES 8.3 ■ PAGE 547

1. (a) 187.5 lb/ft^2 (b) 1875 lb (c) 562.5 lb
3. 6000 lb **5.** 6.7×10^4 N **7.** 9.8×10^3 N
9. 1.2×10^4 lb **11.** $\frac{2}{3}\delta ah$ **13.** 5.27×10^5 N
15. (a) 314 N (b) 353 N
17. (a) 5.63×10^3 lb (b) 5.06×10^4 lb
(c) 4.88×10^4 lb (d) 3.03×10^5 lb
19. 2.5×10^5 N **21.** 230; $\frac{23}{7}$ **23.** 10; 1; $\left(\frac{1}{21},\frac{10}{21}\right)$
25. (0, 1.6) **27.** $\left(\dfrac{1}{e-1},\dfrac{e+1}{4}\right)$ **29.** $\left(\frac{9}{20},\frac{9}{20}\right)$
31. $\left(\dfrac{\pi\sqrt{2}-4}{4\left(\sqrt{2}-1\right)},\dfrac{1}{4\left(\sqrt{2}-1\right)}\right)$ **33.** (2, 0)
35. 60; 160; $\left(\frac{8}{3},1\right)$ **37.** (0.781, 1.330) **41.** $\left(0,\frac{1}{12}\right)$
45. $\frac{1}{3}\pi r^2 h$

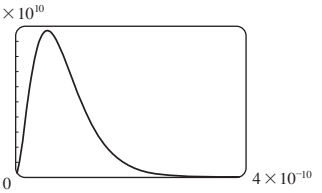
EXERCISES 8.4 ■ PAGE 553

1. \$38,000 **3.** \$43,866,933.33 **5.** \$407.25
7. \$12,000 **9.** 3727; \$37,753
11. $\frac{2}{3}\left(16\sqrt{2}-8\right)\approx$ \$9.75 million **13.** $\dfrac{(1-k)\left(b^{2-k}-a^{2-k}\right)}{(2-k)\left(b^{1-k}-a^{1-k}\right)}$
15. 1.19×10^{-4} cm^3/s
17. 6.60 L/min **19.** 5.77 L/min

EXERCISES 8.5 ■ PAGE 560

1. (a) The probability that a randomly chosen tire will have a lifetime between 30,000 and 40,000 miles
(b) The probability that a randomly chosen tire will have a lifetime of at least 25,000 miles
3. (a) $f(x) \geqslant 0$ for all x and $\int_{-\infty}^{\infty} f(x)\,dx = 1$
(b) $1-\frac{3}{8}\sqrt{3}\approx 0.35$
5. (a) $1/\pi$ (b) $\frac{1}{2}$
7. (a) $f(x) \geqslant 0$ for all x and $\int_{-\infty}^{\infty} f(x)\,dx = 1$ (b) 5
11. (a) $e^{-4/2.5}\approx 0.20$ (b) $1-e^{-2/2.5}\approx 0.55$ (c) If you aren't served within 10 minutes, you get a free hamburger.
13. ≈44%
15. (a) 0.0668 (b) ≈5.21%
17. ≈0.9545

19. (b) 0; a_0 (c)



(d) $1 - 41e^{-8} \approx 0.986$ (e) $\frac{3}{2}a_0$

CHAPTER 8 REVIEW ■ PAGE 562

Exercises

1. $\frac{15}{2}$ **3.** (a) $\frac{21}{16}$ (b) $\frac{41}{10}\pi$ **5.** 3.292287 **7.** $\frac{124}{5}$

9. ≈458 lb **11.** $\left(\frac{8}{5}, 1\right)$ **13.** $\left(2, \frac{2}{3}\right)$ **15.** $2\pi^2$

17. \$7166.67

19. (a) $f(x) \geqslant 0$ for all x and $\int_{-\infty}^{\infty} f(x)\,dx = 1$
(b) ≈0.3455 (c) 5, yes

21. (a) $1 - e^{-3/8} \approx 0.31$ (b) $e^{-5/4} \approx 0.29$
(c) $8 \ln 2 \approx 5.55$ min

PROBLEMS PLUS ■ PAGE 564

1. $\frac{2}{3}\pi - \frac{1}{2}\sqrt{3}$

3. (a) $2\pi r(r \pm d)$ (b) $\approx 3.36 \times 10^6$ mi^2
(d) $\approx 7.84 \times 10^7$ mi^2

5. (a) $P(z) = P_0 + g\int_0^z \rho(x)\,dx$
(b) $(P_0 - \rho_0 gH)(\pi r^2) + \rho_0 gHe^{L/H}\int_{-r}^{r} e^{x/H} \cdot 2\sqrt{r^2 - x^2}\,dx$

7. Height $\sqrt{2}\,b$, volume $\left(\frac{28}{27}\sqrt{6} - 2\right)\pi b^3$ **9.** 0.14 m

11. $2/\pi$, $1/\pi$

CHAPTER 9

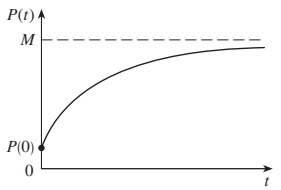
EXERCISES 9.1 ■ PAGE 571

3. (a) $\frac{1}{2}$, -1 **5.** (d)

7. (a) It must be either 0 or decreasing
(c) $y = 0$ (d) $y = 1/(x + 2)$

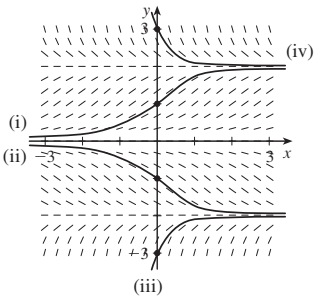
9. (a) $0 < P < 4200$ (b) $P > 4200$
(c) $P = 0$, $P = 4200$

13. (a) At the beginning; stays positive, but decreases
(c)



EXERCISES 9.2 ■ PAGE 578

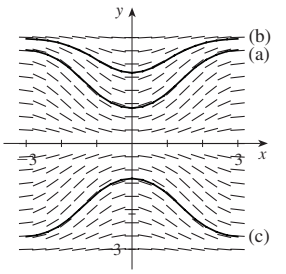
1. (a)



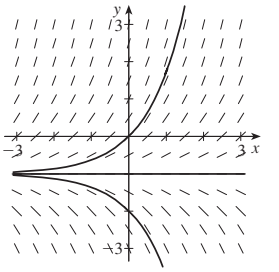
(b) $y = 0$, $y = 2$, $y = -2$

3. III **5.** IV

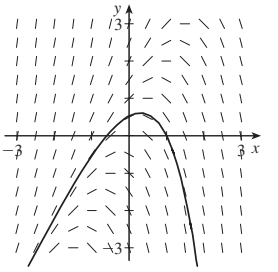
7.



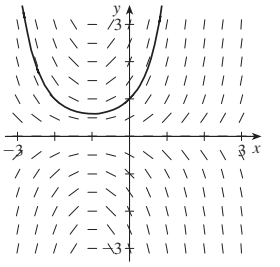
9.



11.



13.



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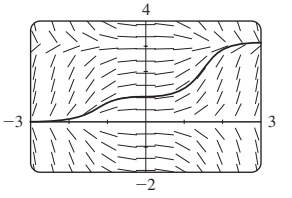

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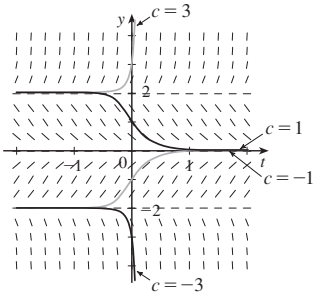

$-2 \leqslant c \leqslant 2$; -2, 0, 2