I Answers to Odd-Numbered Exercises

CHAPTER 1

EXERCISES 1.1 ■ PAGE 19

1. Yes

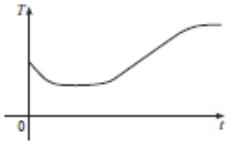
3. (a) 3 (b) −0.2 (c) 0, 3 (d) −0.8
(e) $[-2, 4]$, $[-1, 3]$ (f) $[-2, 1]$

5. $[-85, 115]$ **7.** No

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

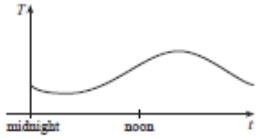
11. Diet, exercise, or illness

13.



15. (a) 500 MW; 730 MW (b) 4 AM; noon

17.



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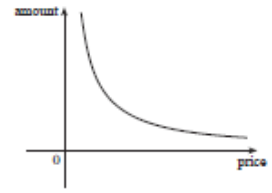

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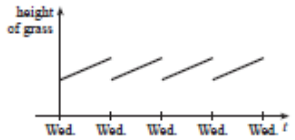
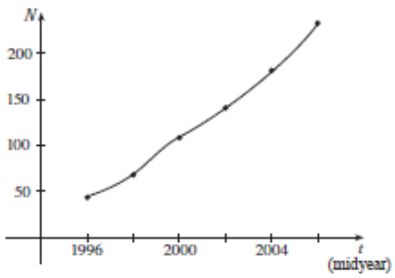


23. (a)



(b) 126 million; 207 million

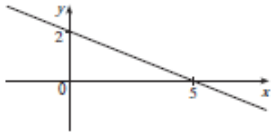
25. $12, 16, 3a^2 - a + 2, 3a^2 + a + 2, 3a^2 + 5a + 4, 6a^2 - 2a + 4, 12a^2 - 2a + 2, 3a^4 - a^2 + 2, 9a^4 - 6a^3 + 13a^2 - 4a + 4, 3a^2 + 6ah + 3h^2 - a - h + 2$

27. $-3 - h$ **29.** $-1/(ax)$

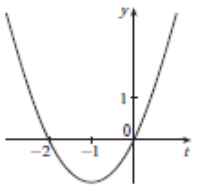
31. $(-\infty, -3) \cup (-3, 3) \cup (3, \infty)$ **33.** $(-\infty, \infty)$

35. $(-\infty, 0) \cup (5, \infty)$ **37.** $[0, 4]$

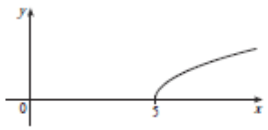
39. $(-\infty, \infty)$



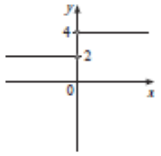
41. $(-\infty, \infty)$



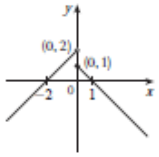
43. $[5, \infty)$



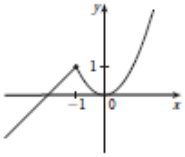
45. $(-\infty, 0) \cup (0, \infty)$



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



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



51. $f(x) = \frac{5}{2}x - \frac{11}{2}$, $1 \leq x \leq 5$ **53.** $f(x) = 1 - \sqrt{-x}$

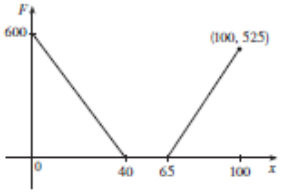
55. $f(x) = \begin{cases} -x + 3 & \text{if } 0 \leq x \leq 3 \\ 2x - 6 & \text{if } 3 < x \leq 5 \end{cases}$

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

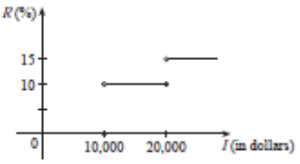
59. $A(x) = \sqrt{3}x^2/4$, $x > 0$ **61.** $S(x) = x^2 + (8/x)$, $x > 0$

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

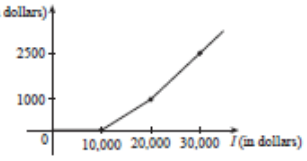
65. $F(x) = \begin{cases} 15(40 - x) & \text{if } 0 \leq x < 40 \\ 0 & \text{if } 40 \leq x \leq 65 \\ 15(x - 65) & \text{if } x > 65 \end{cases}$



67. (a)



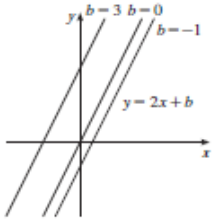
(b) $400, $1900

(c) 

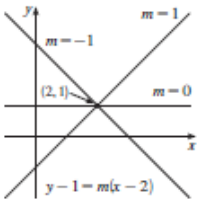
69. f is odd, g is even **71.** (a) $(-5, 3)$ (b) $(-5, -3)$
73. Odd **75.** Neither **77.** Even
79. Even; odd; neither (unless $f = 0$ or $g = 0$)

EXERCISES 1.2 ■ PAGE 33

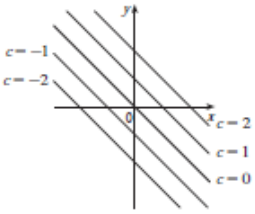
1. (a) Logarithmic (b) Root (c) Rational
(d) Polynomial, degree 2 (e) Exponential (f) Trigonometric
3. (a) h (b) f (c) g
5. (a) $y = 2x + b$, where b is the y-intercept.



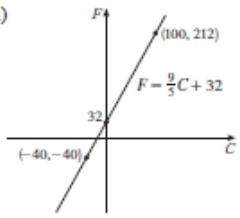
(b) $y = mx + 1 - 2m$, where m is the slope.
(c) $y = 2x - 3$



7. Their graphs have slope -1.

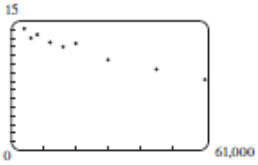


9. $f(x) = -3x(x + 1)(x - 2)$
11. (a) 8.34, change in mg for every 1 year change
(b) 8.34 mg
13. (a)



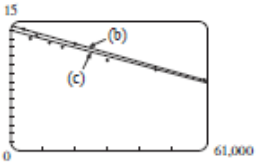
(b) $\frac{9}{5}$, change in °F for every 1°C change; 32, Fahrenheit temperature corresponding to 0°C

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)

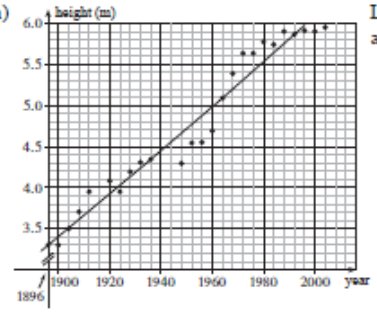


Linear model is appropriate.

(b) $y = -0.000105x + 14.521$
(c) $y = -0.00009979x + 13.951$



(d) About 11.5 per 100 population (e) About 6% (f) No
23. (a)

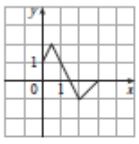


Linear model is appropriate.

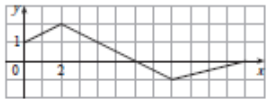
(b) $y = 0.0265x - 46.8759$ (c) 6.27 m; higher (d) No
25. Four times as bright
27. (a) $N = 3.1046A^{0.308}$ (b) 18

EXERCISES 1.3 ■ PAGE 42

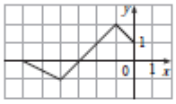
1. (a) $y = f(x) + 3$ (b) $y = f(x) - 3$ (c) $y = f(x - 3)$
(d) $y = f(x + 3)$ (e) $y = -f(x)$ (f) $y = f(-x)$
(g) $y = 3f(x)$ (h) $y = \frac{1}{3}f(x)$
3. (a) 3 (b) 1 (c) 4 (d) 5 (e) 2
5. (a)



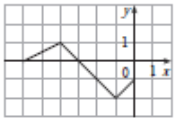
(b)



(c)

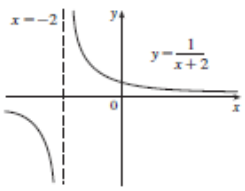


(d)



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

9.



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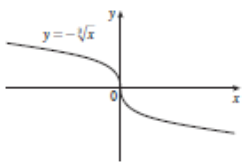

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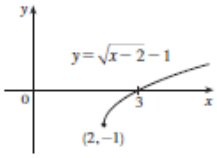

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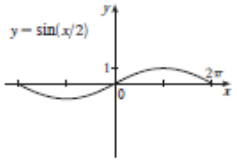

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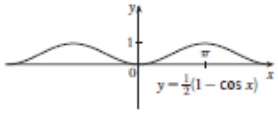

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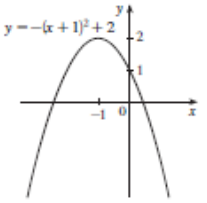

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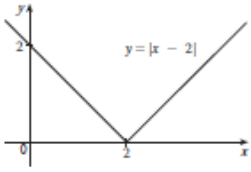

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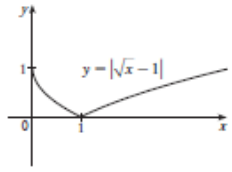
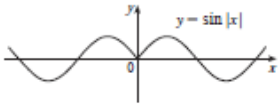


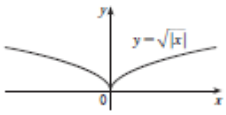
25. $L(t) = 12 + 2\sin\left[\dfrac{2\pi}{365}(t - 80)\right]$

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

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) $(f \circ g)(x) = \dfrac{2x^2 + 6x + 5}{(x + 2)(x + 1)}, \{x \mid x \neq -2, -1\}$

(b) $(g \circ f)(x) = \dfrac{x^2 + x + 1}{(x + 1)^2}, \{x \mid x \neq -1, 0\}$

(c) $(f \circ f)(x) = \dfrac{x^4 + 3x^2 + 1}{x(x^2 + 1)}, \{x \mid x \neq 0\}$

(d) $(g \circ g)(x) = \dfrac{2x + 3}{3x + 5}, \left\{x \mid x \neq -2, -\frac{5}{3}\right\}$

37. $(f \circ g \circ h)(x) = 3\sin(x^2) - 2$

39. $(f \circ g \circ h)(x) = \sqrt{x^8 + 4x^4 + 1}$

41. $g(x) = 2x + x^2, f(x) = x^4$

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

45. $g(t) = t^2, f(t) = \sec t \tan t$

47. $h(x) = \sqrt{x}, g(x) = x - 1, f(x) = \sqrt{x}$

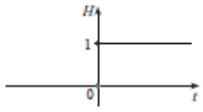
49. $h(x) = \sqrt{x}, g(x) = \sec x, f(x) = x^4$

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

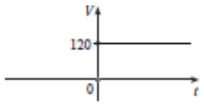
53. (a) $r(t) = 60t$ (b) $(A \circ r)(t) = 3600\pi t^2$; the area of the circle as a function of time

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

57. (a)

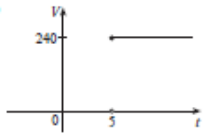


(b)



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

(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. Yes

EXERCISES 1.4 ■ PAGE 49

1. (a) $-44.4, -38.8, -27.8, -22.2, -16.\overline{6}$
(b) -33.3 (c) $-33\frac{1}{3}$

3. (a) (i) 2 (ii) 1.111111 (iii) 1.010101 (iv) 1.001001
(v) 0.666667 (vi) 0.909091 (vii) 0.990099
(viii) 0.999001 (b) 1 (c) $y = x - 3$

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 1.5 ■ PAGE 59

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) 1 (c) 4 (d) Does not exist (e) 3

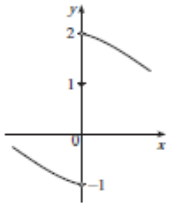
7. (a) −1 (b) −2 (c) Does not exist (d) 2 (e) 0
(f) Does not exist (g) 1 (h) 3

9. (a) $-\infty$ (b) ∞ (c) ∞ (d) $-\infty$ (e) ∞
(f) $x = -7$, $x = -3$, $x = 0$, $x = 6$

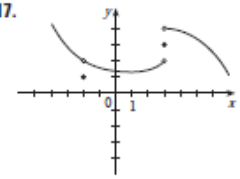
11. $\lim_{x\to a} f(x)$ exists for all a except $a = -1$.

13. (a) 1 (b) 0 (c) Does not exist

15.



17.



19. $\frac{2}{3}$ **21.** $\frac{1}{2}$ **23.** $\frac{1}{4}$ **25.** $\frac{3}{5}$ **27.** (a) −1.5
29. $-\infty$ **31.** ∞ **33.** $-\infty$ **35.** $-\infty$ **37.** ∞
39. $-\infty$; ∞

41. (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

43. 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 $x \to 0$.

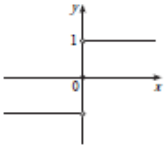
45. $x \approx \pm 0.90, \pm 2.24$; $x = \pm \sin^{-1}(\pi/4), \pm(\pi - \sin^{-1}(\pi/4))$

EXERCISES 1.6 ■ PAGE 69

1. (a) −6 (b) −8 (c) 2 (d) −6
(e) Does not exist (f) 0

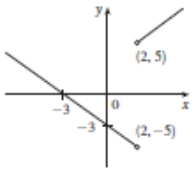
3. 105 **5.** $\frac{7}{8}$ **7.** 390 **9.** $\frac{3}{2}$ **11.** 4
13. Does not exist **15.** $\frac{6}{5}$ **17.** −10 **19.** $\frac{1}{12}$
21. $\frac{1}{6}$ **23.** $-\frac{1}{16}$ **25.** 1 **27.** $\frac{1}{128}$ **29.** $-\frac{1}{2}$
31. $3x^2$ **33.** $\frac{2}{3}$ **37.** 7 **41.** 6 **43.** −4
45. Does not exist

47. (a)



(b) (i) 1
(ii) −1
(iii) Does not exist
(iv) 1

49. (a) (i) 5 (ii) −5 (b) Does not exist
(c)



51. (a) (i) −2 (ii) Does not exist (iii) −3
(b) (i) $n - 1$ (ii) n (c) a is not an integer.

57. 8 **63.** 15; −1

EXERCISES 1.7 ■ PAGE 80

1. 0.1 (or any smaller positive number)

3. 1.44 (or any smaller positive number)

5. 0.0906 (or any smaller positive number)

7. 0.011 (or any smaller positive number)

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 $B = 216 + 108\varepsilon + 12\sqrt{336 + 324\varepsilon + 81\varepsilon^2}$

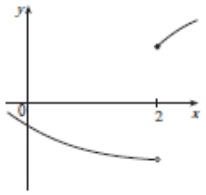
41. Within 0.1

EXERCISES 1.8 ■ PAGE 90

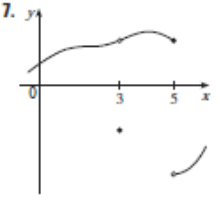
1. $\lim_{x\to 4} f(x) = f(4)$

3. (a) $f(-4)$ is not defined and $\lim_{x\to a} f(x)$ [for $a = -2$, 2, and 4] does not exist
(b) −4, neither; −2, left; 2, right; 4, right

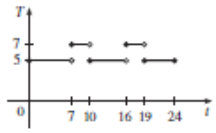
5.



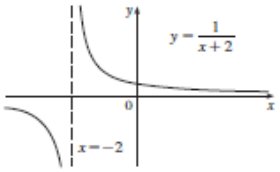
7.



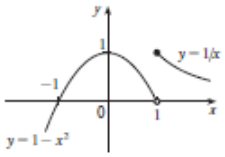
9. (a)

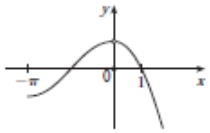


11. 4 **17.** $f(-2)$ is undefined.

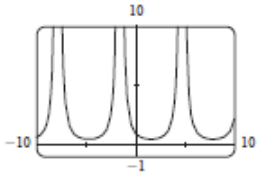


19. $\lim_{x\to 1} f(x)$ does not exist. **21.** $\lim_{x\to 0} f(x) \neq f(0)$

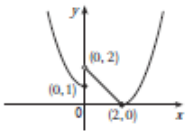


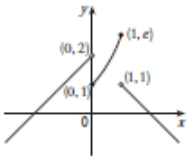


23. Define $f(2) = 3$. **25.** $(-\infty, \infty)$
27. $(-\infty, \sqrt[3]{2}) \cup (\sqrt[3]{2}, \infty)$ **29.** $\mathbb{R}$ **31.** $(-\infty, -1] \cup (0, \infty)$
33. $x = (-\pi/2) + 2n\pi$, n an integer



35. $\frac{7}{3}$ **37.** $\pi/8$
41. 0, left **43.** 0, right; 1, left





45. $\frac{2}{3}$ **47.** (a) $g(x) = x^3 + x^2 + x + 1$ (b) $g(x) = x^2 + x$
55. (b) (0.86, 0.87) **57.** (b) 1.434 **63.** None
65. Yes

CHAPTER 1 REVIEW ■ PAGE 94

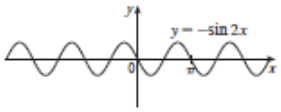
True-False Quiz

1. False **3.** False **5.** True **7.** False **9.** True
11. False **13.** True **15.** True **17.** False **19.** True
21. True **23.** True **25.** False

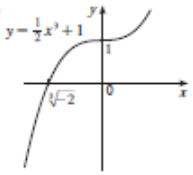
Exercises

1. (a) 2.7 (b) 2.3, 5.6 (c) $[-6, 6]$ (d) $[-4, 4]$
(e) $[-4, 4]$ (f) Odd; its graph is symmetric about the origin.
3. $2a + h - 2$ **5.** $(-\infty, \frac{1}{3}) \cup (\frac{1}{3}, \infty)$, $(-\infty, 0) \cup (0, \infty)$
7. $\mathbb{R}$, $[0, 2]$
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 x-axis, then shift 3 units upward.

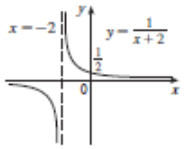
11.



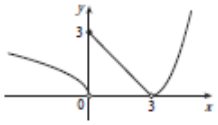
13.



15.



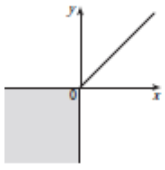
17. (a) Neither (b) Odd (c) Even (d) Neither
19. (a) $(f \circ g)(x) = \sqrt{\sin x}$, $\{x \mid x \in [2n\pi, \pi + 2n\pi], n \text{ an integer}\}$
(b) $(g \circ f)(x) = \sin\sqrt{x}$, $[0, \infty)$
(c) $(f \circ f)(x) = \sqrt[4]{x}$, $[0, \infty)$
(d) $(g \circ g)(x) = \sin(\sin x)$, $\mathbb{R}$
21. $y = 0.2493x - 423.4818$; about 77.6 years
23. (a) (i) 3 (ii) 0 (iii) Does not exist (iv) 2
(v) ∞ (vi) $-\infty$ (b) $x = 0$, $x = 2$ (c) -3, 0, 2, 4
25. 1 **27.** $\frac{3}{2}$ **29.** 3 **31.** ∞ **33.** $\frac{4}{7}$
35. $-\frac{1}{8}$ **37.** 0 **39.** 1
45. (a) (i) 3 (ii) 0 (iii) Does not exist (iv) 0 (v) 0 (vi) 0
(b) At 0 and 3 (c)



47. $[0, \infty)$

PRINCIPLES OF PROBLEM SOLVING ■ PAGE 102

1.



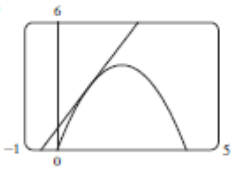
3. $f_n(x) = x^{2^{n+1}}$ **5.** $\frac{2}{3}$ **7.** -4
9. (a) Does not exist (b) 1
11. $a = \frac{1}{2} \pm \frac{1}{2}\sqrt{5}$ **13.** $\frac{3}{4}$ **15.** (b) Yes (c) Yes; no

CHAPTER 2

EXERCISES 2.1 ■ PAGE 110

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

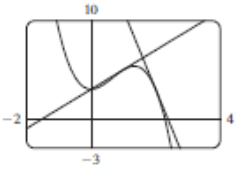
3. (a) 2 (b) $y=2x+1$ (c)



5. $y=-8x+12$ **7.** $y=\frac{1}{2}x+\frac{1}{2}$

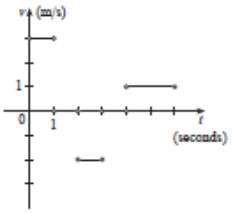
9. (a) $8a-6a^2$ (b) $y=2x+3$, $y=-8x+19$

(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)



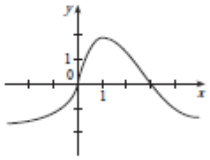
13. −24 ft/s

15. $-2/a^3$ m/s; −2 m/s; $-\frac{1}{4}$ m/s; $-\frac{2}{27}$ m/s

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

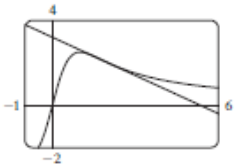
19. $f(2)=3$; $f'(2)=4$

21.



23. $y=3x-1$

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



27. $6a-4$ **29.** $\dfrac{5}{(a+3)^2}$ **31.** $-\dfrac{1}{\sqrt{1-2a}}$

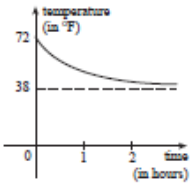
33. $f(x)=x^{10}$, $a=1$ or $f(x)=(1+x)^{10}$, $a=0$

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

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

39. 1 m/s; 1 m/s

41.



Greater (in magnitude)

43. (a) (i) 23 million/year (ii) 20.5 million/year (iii) 16 million/year
(b) 18.25 million/year (c) 17 million/year

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

47. (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

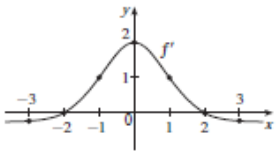
49. The rate at which the temperature is changing at 8:00 AM; 3.75°F/h

51. (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.

53. Does not exist

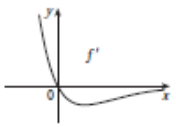
EXERCISES 2.2 ■ PAGE 122

1. (a) −0.2 (b) 0 (c) 1 (d) 2
(e) 1 (f) 0 (g) −0.2

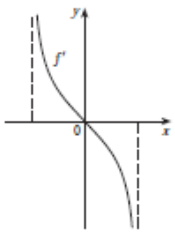


3. (a) II (b) IV (c) I (d) III

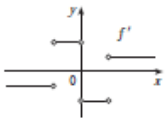
5.



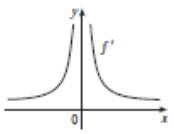
7.



9.

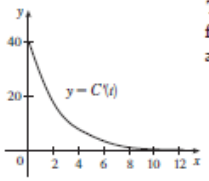


11.



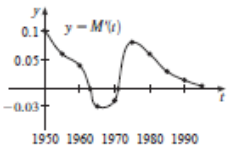
13. (a) The instantaneous rate of change of percentage of full capacity with respect to elapsed time in hours

(b)



The rate of change of percentage of full capacity is decreasing and approaching 0.

15.



1963 to 1971

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. $f'(x) = 2x - 6x^2$, $\mathbb{R}$, $\mathbb{R}$

25. $g'(x) = -\dfrac{1}{2\sqrt{9 - x}}$, $(-\infty, 9]$, $(-\infty, 9)$

27. $G'(t) = \dfrac{-7}{(3 + t)^2}$, $(-\infty, -3) \cup (-3, \infty)$, $(-\infty, -3) \cup (-3, \infty)$

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

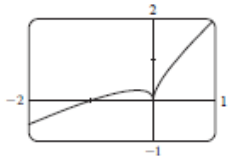
(b)

t	$U'(t)$	t	$U'(t)$
1999	−0.2	2004	−0.45
2000	0.25	2005	−0.45
2001	0.9	2006	−0.25
2002	0.65	2007	0.6
2003	−0.15	2008	1.2

35. −4 (corner); 0 (discontinuity)

37. −1 (vertical tangent); 4 (corner)

39.

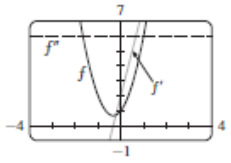


Differentiable at −1; not differentiable at 0

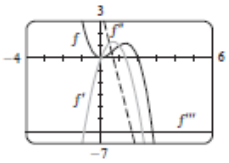
41. $a = f$, $b = f'$, $c = f''$

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

45. $6x + 2$; 6



47.

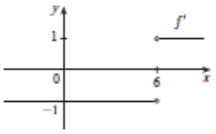


$f'(x) = 4x - 3x^2$,
$f''(x) = 4 - 6x$,
$f'''(x) = -6$,
$f^{(4)}(x) = 0$

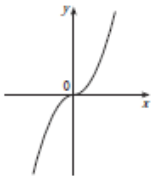
49. (a) $\frac{1}{3}a^{-2/3}$

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°

EXERCISES 2.3 ■ PAGE 136

1. $f'(x) = 0$ **3.** $f'(t) = -\frac{2}{3}$ **5.** $f'(x) = 3x^2 - 4$

7. $g'(x) = 2x - 6x^2$ **9.** $g'(t) = -\frac{3}{2}t^{-7/4}$ **11.** $A'(s) = 60/s^6$

13. $S'(p) = \frac{1}{2}p^{-1/2} - 1$ **15.** $R'(a) = 18a + 6$

17. $y' = \frac{3}{2}\sqrt{x} + \dfrac{2}{\sqrt{x}} - \dfrac{3}{2x\sqrt{x}}$

19. $H'(x) = 3x^2 + 3 - 3x^{-2} - 3x^{-4}$

21. $u' = \frac{1}{5}t^{-4/5} + 10t^{3/2}$ **23.** $1 - 2x + 6x^2 - 8x^3$

25. $V'(x) = 14x^6 - 4x^3 - 6$ **27.** $F'(y) = 5 + \dfrac{14}{y^2} + \dfrac{9}{y^4}$

29. $g'(x) = \dfrac{10}{(3 - 4x)^2}$ **31.** $y' = \dfrac{x^2(3 - x^2)}{(1 - x^2)^2}$

33. $y' = 2v - 1/\sqrt{v}$ **35.** $y' = \dfrac{2t(-t^4 - 4t^2 + 7)}{(t^4 - 3t^2 + 1)^2}$

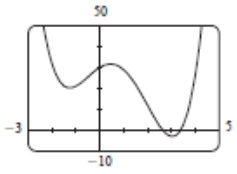
37. $y' = 2ax + b$ **39.** $f'(t) = \dfrac{4 + t^{1/2}}{(2 + \sqrt{t})^2}$

41. $y' = (7t^3 + 4t^2 - 2)/(3t^{5/3})$ **43.** $f'(x) = \dfrac{2cx}{(x^2 + c)^2}$

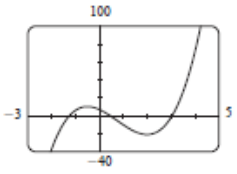
45. $P'(x) = na_n x^{n-1} + (n-1)a_{n-1}x^{n-2} + \cdots + 2a_2 x + a_1$

47. $45x^{14} - 15x^2$

49. (a)

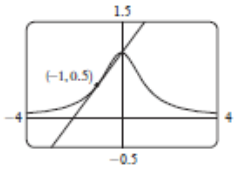


(c) $4x^3 - 9x^2 - 12x + 7$



51. $y = \frac{1}{2}x + \frac{1}{2}$

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



55. $y = \frac{3}{2}x + \frac{1}{2}$, $y = -\frac{2}{3}x + \frac{8}{3}$ **57.** $y = -\frac{1}{2}x + \frac{5}{2}$, $y = 2x$

59. $f'(x) = 4x^3 - 9x^2 + 16$, $f''(x) = 12x^2 - 18x$

61. $\dfrac{2x^2 + 2x}{(1 + 2x)^2}$, $\dfrac{2}{(1 + 2x)^3}$

63. (a) $v(t) = 3t^2 - 3$, $a(t) = 6t$ (b) 12 m/s²

(c) $a(1) = 6$ m/s²

65. (a) $V = 5.3/P$

(b) −0.00212; instantaneous rate of change of the volume with respect to the pressure at 25°C; m³/kPa

67. (a) −16 (b) $-\frac{20}{9}$ (c) 20 **69.** 16

71. (a) 0 (b) $-\frac{2}{3}$

73. (a) $y' = xg'(x) + g(x)$

(b) $y' = \dfrac{g(x) - xg'(x)}{[g(x)]^2}$ (c) $y' = \dfrac{xg'(x) - g(x)}{x^2}$

75. (−2, 21), (1, −6)

79. $y = 12x - 15$, $y = 12x + 17$ **81.** $y = \frac{1}{3}x - \frac{1}{3}$

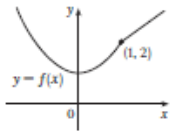
83. (±2, 4)

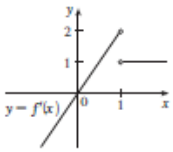
85. (c) $3(x^4 + 3x^3 + 17x + 82)^2(4x^3 + 9x^2 + 17)$

87. $P(x) = x^2 - x + 3$ **89.** $y = \frac{3}{16}x^3 - \frac{9}{4}x + 3$

91. $1.627 billion/year

93. No

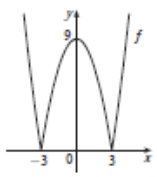


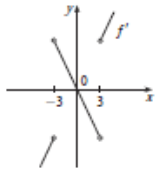


95. (a) Not differentiable at 3 or −3

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

(b)





97. $a = -\frac{1}{2}$, $b = 2$ **99.** 6 **103.** 1000 **105.** 3; 1

EXERCISES 2.4 ■ PAGE 146

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

5. $y' = \sec\theta\,(\sec^2\theta + \tan^2\theta)$

7. $y' = -c\sin t + t(t\cos t + 2\sin t)$

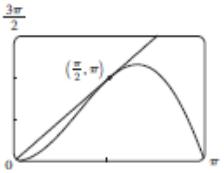
9. $y' = \dfrac{2 - \tan x + x\sec^2 x}{(2 - \tan x)^2}$ **11.** $f'(\theta) = \dfrac{\sec\theta\,\tan\theta}{(1 + \sec\theta)^2}$

13. $y' = \dfrac{(t^2 + t)\cos t + \sin t}{(1 + t)^2}$

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

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

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.** $-\frac{3}{4}$

45. $\frac{1}{2}$ **47.** $-\sqrt{2}$ **49.** $-\cos x$ **51.** $A = -\frac{3}{10}$, $B = -\frac{1}{10}$

53. (a) $\sec^2 x = \dfrac{1}{\cos^2 x}$ (b) $\sec x\tan x = \dfrac{\sin x}{\cos^2 x}$

(c) $\cos x - \sin x = \dfrac{\cot x - 1}{\csc x}$

55. 1

EXERCISES 2.5 ■ PAGE 154

1. $\dfrac{4}{3\sqrt[3]{(1 + 4x)^2}}$ **3.** $\pi\sec^2\pi x$ **5.** $\dfrac{\cos x}{2\sqrt{\sin x}}$

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

9. $F'(x) = -\dfrac{1}{\sqrt{1 - 2x}}$ **11.** $f'(z) = -\dfrac{2z}{(z^2 + 1)^2}$

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

17. $f'(x) = (2x - 3)^3(x^2 + x + 1)^4(28x^2 - 12x - 7)$

19. $h'(t) = \frac{2}{3}(t + 1)^{-1/3}(2t^2 - 1)^2(20t^2 + 18t - 1)$

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

23. $y' = (\cos x - x\sin x)\cos(x\cos x)$

25. $F'(z) = 1/[(z-1)^{1/2}(z+1)^{3/2}]$ **27.** $y' = (r^2+1)^{-3/2}$

29. $y' = \left(x\cos\sqrt{1+x^2}\right)/\sqrt{1+x^2}$

31. $y' = 2\cos(\tan 2x)\sec^2(2x)$ **33.** $y' = 4\sec^2 x\tan x$

35. $y' = \dfrac{16\sin 2x(1-\cos 2x)^3}{(1+\cos 2x)^5}$

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

39. $y' = 3[x^2+(1-3x)^5]^2[2x-15(1-3x)^4]$

41. $y' = \dfrac{1+1/(2\sqrt{x})}{2\sqrt{x+\sqrt{x}}}$

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

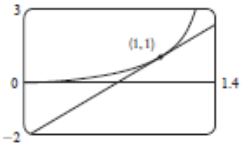
45. $y' = \dfrac{-\pi\cos(\tan\pi x)\sec^2(\pi x)\sin\sqrt{\sin(\tan\pi x)}}{2\sqrt{\sin(\tan\pi x)}}$

47. $y' = -2x\sin(x^2)$; $y'' = -4x^2\cos(x^2) - 2\sin(x^2)$

49. $H'(t) = 3\sec^2 3t$, $H''(t) = 18\sec^2 3t\tan 3t$

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

55. (a) $y = \pi x - \pi + 1$ (b)



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

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. $-\frac{1}{6}\sqrt{2}$ **69.** 120 **71.** 96 **73.** $2^{103}\sin 2x$

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

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

79. 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

81. (b) The factored form **85.** (b) $-n\cos^{n-1}x\sin[(n+1)x]$

EXERCISES 2.6 ■ PAGE 161

1. (a) $y' = 9x/y$ (b) $y = \pm\sqrt{9x^2-1}$, $y' = \pm 9x/\sqrt{9x^2-1}$

3. (a) $y' = -y^2/x^2$ (b) $y = x/(x-1)$, $y' = -1/(x-1)^2$

5. $y' = -\dfrac{x^2}{y^2}$ **7.** $y' = \dfrac{2x+y}{2y-x}$

9. $y' = \dfrac{3y^2-5x^4-4x^3y}{x^4+3y^2-6xy}$ **11.** $y' = \dfrac{2x+y\sin x}{\cos x - 2y}$

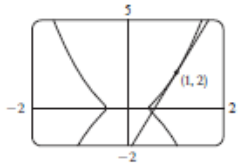
13. $y' = \tan x\tan y$ **15.** $y' = \dfrac{y\sec^2(x/y)-y^2}{y^2+x\sec^2(x/y)}$

17. $y' = \dfrac{4xy\sqrt{xy}-y}{x-2x^2\sqrt{xy}}$ **19.** $y' = \dfrac{y\sin x + y\cos(xy)}{\cos x - x\cos(xy)}$

21. $-\frac{16}{13}$ **23.** $x' = \dfrac{-2x^4y+x^3-6xy^2}{4x^3y^2-3x^2y+2y^3}$ **25.** $y = \frac{1}{2}x$

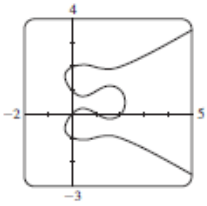
27. $y = -x + 2$ **29.** $y = x + \frac{1}{2}$ **31.** $y = -\frac{9}{13}x + \frac{40}{13}$

33. (a) $y = \frac{9}{2}x - \frac{5}{2}$ (b)



35. $-81/y^3$ **37.** $-2x/y^5$ **39.** 0

41. (a)

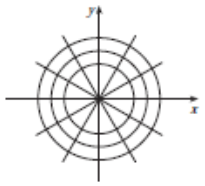


Eight; $x \approx 0.42, 1.58$

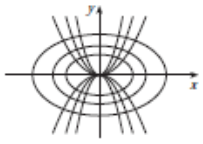
(b) $y = -x + 1$, $y = \frac{1}{3}x + 2$ (c) $1 \mp \frac{1}{3}\sqrt{3}$

43. $\left(\pm\frac{5}{4}\sqrt{3}, \pm\frac{5}{4}\right)$ **45.** $(x_0x/a^2) - (y_0y/b^2) = 1$

49.



51.



55. (a) $\dfrac{V^3(nb-V)}{PV^3 - n^2aV + 2n^3ab}$ (b) -4.04 L/atm

57. $\left(\pm\sqrt{3}, 0\right)$ **59.** $(-1,-1)$, $(1,1)$

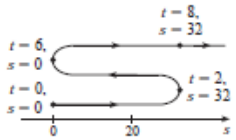
61. (a) 0 (b) $-\frac{1}{2}$

EXERCISES 2.7 ■ PAGE 173

1. (a) $3t^2 - 24t + 36$ (b) -9 ft/s (c) $t = 2, 6$

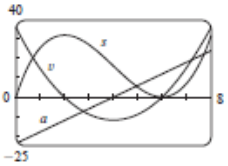
(d) $0 \le t < 2$, $t > 6$ (e) 96 ft

(f)



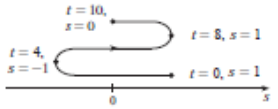
(g) $6t - 24$; -6 ft/s^2

(h)

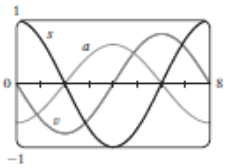


(i) Speeding up when $2 < t < 4$ or $t > 6$; slowing down when $0 \le t < 2$ or $4 < t < 6$

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 $0 < t < 2$, $4 < t < 6$, $8 < t < 10$; 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) 4.9 m/s; −14.7 m/s (b) After 2.5 s (c) $32\frac{5}{8}$ m
(d) ≈5.08 s (e) ≈−25.3 m/s

9. (a) 7.56 m/s (b) 6.24 m/s; −6.24 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

23. (a) $dV/dP = -C/P^2$ (b) At the beginning

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.

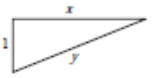
33. −0.2436 K/min

35. (a) 0 and 0 (b) $C = 0$
(c) (0, 0), (500, 50); it is possible for the species to coexist.

EXERCISES 2.8 ■ PAGE 180

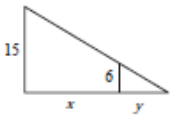
1. $dV/dt = 3x^2\,dx/dt$ **3.** 48 cm^2/s
5. $3/(25\pi)$ m/min **7.** (a) 1 (b) 25 **9.** −18

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)

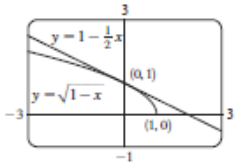


(d) $\frac{15}{6} = \frac{x+y}{y}$ (e) $\frac{25}{3}$ ft/s

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. 5 m **33.** 80 cm^3/min **35.** $\frac{107}{810} \approx 0.132\ \Omega$/s
37. 0.396 m/min **39.** (a) 360 ft/s (b) 0.096 rad/s
41. $\frac{10}{9}\pi$ km/min **43.** $1650/\sqrt{31} \approx 296$ km/h
45. $\frac{7}{4}\sqrt{15} \approx 6.78$ m/s

EXERCISES 2.9 ■ PAGE 187

1. $L(x) = -10x - 6$ **3.** $L(x) = \frac{1}{4}x + 1$
5. $\sqrt{1-x} \approx 1 - \frac{1}{2}x$;
$\sqrt{0.9} \approx 0.95$,
$\sqrt{0.99} \approx 0.995$



7. $-0.368 < x < 0.677$
9. $-0.045 < x < 0.055$

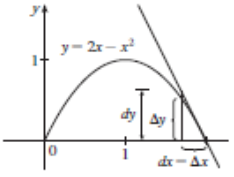
11. (a) $dy = 2x(x\cos 2x + \sin 2x)\,dx$ (b) $dy = \dfrac{t}{\sqrt{1+t^2}}\,dt$

13. (a) $dy = \dfrac{\sec^2\sqrt{t}}{2\sqrt{t}}\,dt$ (b) $dy = \dfrac{-4v}{(1+v^2)^2}\,dv$

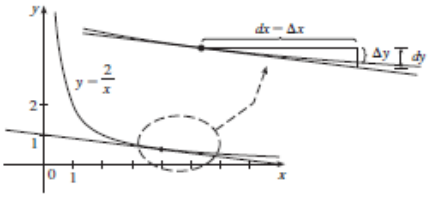
15. (a) $dy = \sec^2 x\,dx$ (b) −0.2

17. (a) $dy = \dfrac{x}{\sqrt{3+x^2}}\,dx$ (b) −0.05

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



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



23. 15.968 **25.** $10.00\overline{3}$ **27.** $1 - \pi/90 \approx 0.965$

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

33. (a) $84/\pi \approx 27$ cm^2; $\frac{1}{84} \approx 0.012 = 1.2\%$

(b) $1764/\pi^2 \approx 179$ cm^3; $\frac{1}{56} \approx 0.018 = 1.8\%$

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

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

CHAPTER 2 REVIEW ■ PAGE 190

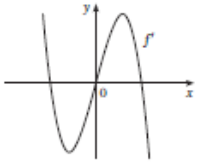
True-False Quiz

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

Exercises

1. (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

3.



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

7. (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

9. The rate at which the total value of US currency in circulation is changing in billions of dollars per year; \$22.2 billion/year

11. $f'(x) = 3x^2 + 5$ **13.** $4x^7(x+1)^3(3x+2)$

15. $\frac{3}{2}\sqrt{x} - \dfrac{1}{2\sqrt{x}} - \dfrac{1}{\sqrt{x^3}}$ **17.** $x(\pi x \cos \pi x + 2 \sin \pi x)$

19. $\dfrac{8t^3}{(t^4+1)^2}$ **21.** $-\dfrac{\sec^2\sqrt{1-x}}{2\sqrt{1-x}}$

23. $\dfrac{1 - y^4 - 2xy}{4xy^3 + x^2 - 3}$ **25.** $\dfrac{2\sec 2\theta\,(\tan 2\theta - 1)}{(1 + \tan 2\theta)^2}$

27. $-(x-1)^{-2}$ **29.** $\dfrac{2x - y\cos(xy)}{x\cos(xy) + 1}$ **31.** $-6x\csc^2(3x^2+5)$

33. $\dfrac{\cos\sqrt{x} - \sqrt{x}\sin\sqrt{x}}{2\sqrt{x}}$ **35.** $2\cos\theta\tan(\sin\theta)\sec^2(\sin\theta)$

37. $\frac{1}{5}(x\tan x)^{-4/5}(\tan x + x\sec^2 x)$

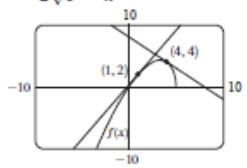
39. $\cos\left(\tan\sqrt{1+x^3}\right)\left(\sec^2\sqrt{1+x^3}\right)\dfrac{3x^2}{2\sqrt{1+x^3}}$

41. $-\frac{4}{27}$ **43.** $-5x^4/y^{11}$ **45.** 1

47. $y = 2\sqrt{3}x + 1 - \pi\sqrt{3}/3$ **49.** $y = 2x + 1$, $y = -\frac{1}{2}x + 1$

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

(c)



53. $(\pi/4, \sqrt{2})$, $(5\pi/4, -\sqrt{2})$ **55.** $y = -\frac{3}{5}x^2 + \frac{14}{5}x$

59. (a) 2 (b) 44

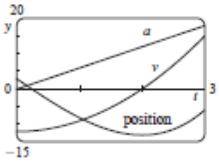
61. $2xg(x) + x^2 g'(x)$ **63.** $2g(x)g'(x)$ **65.** $g'(g(x))g'(x)$

67. $f'(x) = g'(\sin x) \cdot \cos x$

69. $\dfrac{f'(x)[g(x)]^2 + g'(x)\,[f(x)]^2}{[\,f(x) + g(x)]^2}$

71. $f'(g(\sin 4x))g'(\sin 4x)(\cos 4x)(4)$

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



75. 4 kg/m **77.** $\frac{4}{3}$ cm^2/min

79. 13 ft/s **81.** 400 ft/h

83. (a) $L(x) = 1 + x$; $\sqrt[3]{1+3x} \approx 1 + x$; $\sqrt[3]{1.03} \approx 1.01$
(b) $-0.235 < x < 0.401$

85. $12 + \frac{3}{2}\pi \approx 16.7$ cm^2 **87.** $\frac{1}{32}$ **89.** $\frac{1}{4}$ **91.** $\frac{1}{8}x^2$

PROBLEMS PLUS ■ PAGE 194

1. $\left(\pm\sqrt{3}/2, \frac{1}{4}\right)$ **5.** $3\sqrt{2}$ **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

13. $x_T \in (3, \infty)$, $y_T \in (2, \infty)$, $x_N \in \left(0, \frac{5}{3}\right)$, $y_N \in \left(-\frac{5}{2}, 0\right)$

15. (b) (i) 53° (or 127°) (ii) 63° (or 117°)

17. R approaches the midpoint of the radius AO.

19. $-\sin a$ **21.** $(1, -2)$, $(-1, 0)$

23. $\sqrt{29}/58$ **25.** $2 + \frac{375}{128}\pi \approx 11.204$ cm^3/min

CHAPTER 3

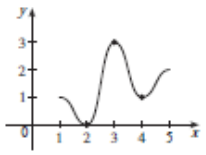
EXERCISES 3.1 ■ PAGE 204

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

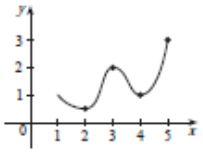
1. Abs min: smallest function value on the entire domain of the function; loc min at c: smallest function value when x is near c
3. Abs max at s, abs min at r, loc max at c, loc min at b and r, neither a max nor a min at a and d

5. Abs max $f(4) = 5$, loc max $f(4) = 5$ and $f(6) = 4$, loc min $f(2) = 2$ and $f(1) = f(5) = 3$

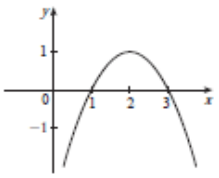
7.



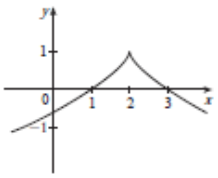
9.



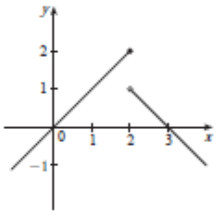
11. (a)



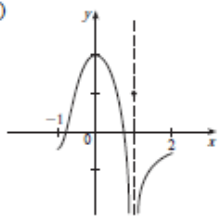
(b)



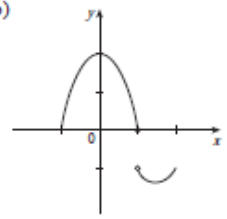
(c)



13. (a)



(b)



15. Abs max $f(3) = 4$ **17.** Abs max $f(1) = 1$

19. Abs min $f(0) = 0$

21. Abs max $f(\pi/2) = 1$; abs min $f(-\pi/2) = -1$

23. Abs min $f(-1) = 1$; loc min $f(-1) = 1$

25. Abs max $f(0) = 1$ **27.** Abs max $f(3) = 2$

29. $\frac{1}{3}$ **31.** $-2, 3$ **33.** 0

35. $0, 2$ **37.** $0, \frac{4}{9}$ **39.** $0, \frac{8}{7}, 4$ **41.** $n\pi$ (n an integer)

43. 10 **45.** $f(2) = 16$, $f(5) = 7$

47. $f(-1) = 8$, $f(2) = -19$ **49.** $f(-2) = 33$, $f(2) = -31$

51. $f(0.2) = 5.2$, $f(1) = 2$ **53.** $f(\sqrt{2}) = 2$, $f(-1) = -\sqrt{3}$

55. $f(\pi/6) = \frac{3}{2}\sqrt{3}$, $f(\pi/2) = 0$ **57.** $f\left(\dfrac{a}{a+b}\right) = \dfrac{a^a b^b}{(a+b)^{a+b}}$

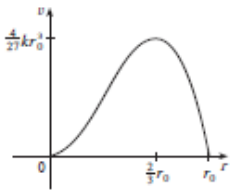
59. (a) 2.19, 1.81 (b) $\frac{6}{25}\sqrt{\frac{3}{5}} + 2$, $-\frac{6}{25}\sqrt{\frac{3}{5}} + 2$

61. (a) 0.32, 0.00 (b) $\frac{3}{16}\sqrt{3}$, 0 **63.** $\approx 3.9665°$C

65. Cheapest, $t \approx 0.855$ (June 1994); most expensive, $t \approx 4.618$ (March 1998)

67. (a) $r = \frac{2}{3}r_0$ (b) $v = \frac{4}{27}kr_0^3$

(c)



EXERCISES 3.2 ■ PAGE 212

1. 2 **3.** $\frac{9}{4}$ **5.** f is not differentiable on $(-1, 1)$

7. 0.3, 3, 6.3 **9.** 1 **11.** $\sqrt{3}/9$ **13.** 1

15. f is not continous at 3 **23.** 16 **25.** No **31.** No

EXERCISES 3.3 ■ PAGE 220

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. (a) 3, 5 (b) 2, 4, 6 (c) 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 $\left(-\frac{1}{2}, \frac{32}{2}\right)$

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 $\left(-\infty, -\sqrt{3}/3\right)$, $\left(\sqrt{3}/3, \infty\right)$;
CD on $\left(-\sqrt{3}/3, \sqrt{3}/3\right)$; IP $\left(\pm\sqrt{3}/3, \frac{22}{9}\right)$

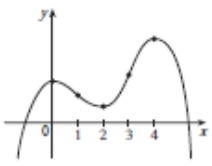
13. (a) Inc on $(0, \pi/4)$, $(5\pi/4, 2\pi)$; dec on $(\pi/4, 5\pi/4)$
(b) Loc max $f(\pi/4) = \sqrt{2}$; loc min $f(5\pi/4) = -\sqrt{2}$
(c) CU on $(3\pi/4, 7\pi/4)$; CD on $(0, 3\pi/4)$, $(7\pi/4, 2\pi)$;
IP $(3\pi/4, 0)$, $(7\pi/4, 0)$

15. Loc max $f(1) = 2$; loc min $f(0) = 1$

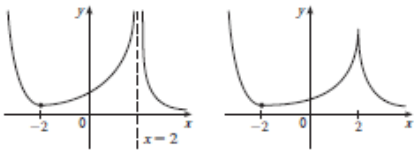
17. Loc min $f(\frac{1}{16}) = -\frac{1}{4}$

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

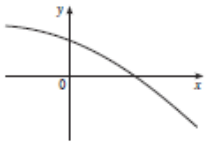
21.



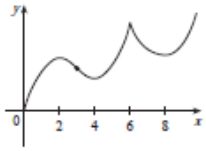
23.



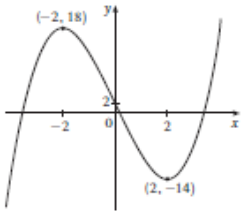
25.



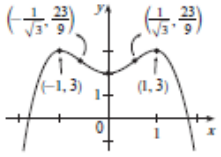
27. (a) Inc on $(0, 2)$, $(4, 6)$, $(8, \infty)$; dec on $(2, 4)$, $(6, 8)$
(b) Loc max at $x = 2, 6$; loc min at $x = 4, 8$
(c) CU on $(3, 6)$, $(6, \infty)$; CD on $(0, 3)$
(d) 3
(e) See graph at right.



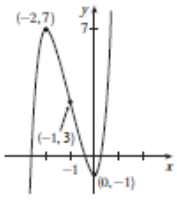
29. (a) Inc on $(-\infty, -2)$, $(2, \infty)$; dec on $(-2, 2)$
(b) Loc max $f(-2) = 18$; loc min $f(2) = -14$
(c) CU on $(0, \infty)$, CD on $(-\infty, 0)$; IP $(0, 2)$
(d)



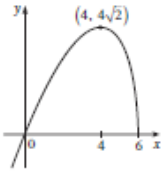
31. (a) Inc on $(-\infty, -1)$, $(0, 1)$; dec on $(-1, 0)$, $(1, \infty)$
(b) Loc max $f(-1) = 3$, $f(1) = 3$; loc min $f(0) = 2$
(c) CU on $\left(-1/\sqrt{3}, 1/\sqrt{3}\right)$; CD on $\left(-\infty, -1/\sqrt{3}\right)$, $\left(1/\sqrt{3}, \infty\right)$; IP $\left(\pm 1/\sqrt{3}, \frac{23}{9}\right)$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



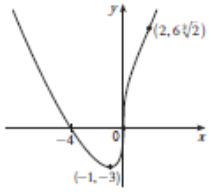
33. (a) Inc on $(-\infty, -2)$, $(0, \infty)$; dec on $(-2, 0)$
(b) Loc max $h(-2) = 7$; loc min $h(0) = -1$
(c) CU on $(-1, \infty)$; CD on $(-\infty, -1)$; IP $(-1, 3)$
(d) See graph at right.



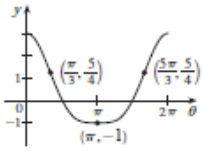
35. (a) Inc on $(-\infty, 4)$; dec on $(4, 6)$
(b) Loc max $f(4) = 4\sqrt{2}$
(c) CD on $(-\infty, 6)$; No IP
(d) See graph at right.



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



39. (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 $\left(\pi/3, \frac{5}{4}\right)$, $\left(5\pi/3, \frac{5}{4}\right)$
(d) See graph at right.

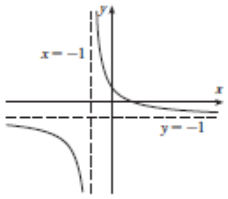


41. $(3, \infty)$
43. (a) Loc and abs max $f(1) = \sqrt{2}$, no min
(b) $\frac{1}{4}\left(3 - \sqrt{17}\right)$
45. (b) CU on $(0.94, 2.57)$, $(3.71, 5.35)$; CD on $(0, 0.94)$, $(2.57, 3.71)$, $(5.35, 2\pi)$; IP $(0.94, 0.44)$, $(2.57, -0.63)$, $(3.71, -0.63)$, $(5.35, 0.44)$
47. CU on $(-\infty, -0.6)$, $(0.0, \infty)$; CD on $(-0.6, 0.0)$
49. (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) $(8, 350)$
51. $K(3) - K(2)$; CD
53. $f(x) = \frac{1}{9}(2x^3 + 3x^2 - 12x + 7)$
55. (a) $a = 0, b = -1$ (b) $y = -x$ at $(0, 0)$

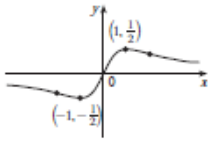
EXERCISES 3.4 ■ PAGE 234

1. (a) As x becomes large, $f(x)$ approaches 5.
(b) As x becomes large negative, $f(x)$ approaches 3.
3. (a) -2 (b) 2 (c) ∞ (d) $-\infty$
(e) $x = 1$, $x = 3$, $y = -2$, $y = 2$
5. 0 **7.** $\frac{3}{2}$ **9.** $\frac{3}{2}$ **11.** 0 **13.** -1 **15.** 4
17. 3 **19.** $\frac{1}{6}$ **21.** $\frac{1}{2}(a - b)$ **23.** ∞
25. $-\infty$ **27.** ∞ **29.** 1
31. (a), (b) $-\frac{1}{2}$ **33.** $y = 2$; $x = 2$
35. $y = 2$; $x = -2$, $x = 1$ **37.** $x = 5$ **39.** $y = 3$
41. $f(x) = \dfrac{2 - x}{x^2(x - 3)}$ **43.** (a) $\frac{5}{4}$ (b) 5

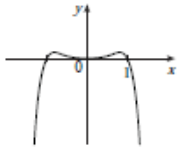
45. $y = -1$



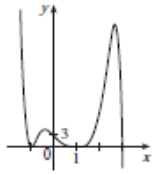
47. $y = 0$



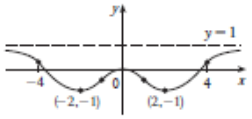
49. $-\infty, -\infty$



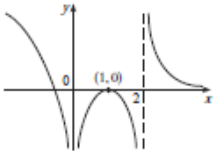
51. $-\infty, \infty$



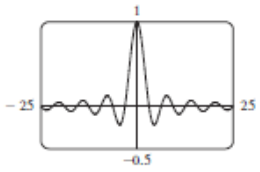
53.



55.



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

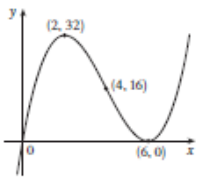


59. (a) 0 (b) $\pm\infty$ **61.** 4
63. $N \geqslant 15$ **65.** $N \leqslant -6$, $N \leqslant -22$
67. (a) $x > 100$

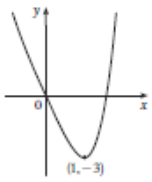
EXERCISES 3.5 ■ PAGE 242

Abbreviation: int, intercept; SA, slant asymptote

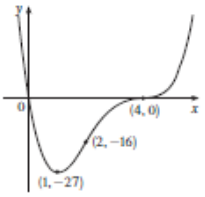
1. A. $\mathbb{R}$ B. y-int 0; x-int 0, 6
C. None D. None
E. Inc on $(-\infty, 2)$, $(6, \infty)$; dec on $(2, 6)$
F. Loc max $f(2) = 32$; loc min $f(6) = 0$
G. CU on $(4, \infty)$; CD on $(-\infty, 4)$; IP $(4, 16)$
H. See graph at right.



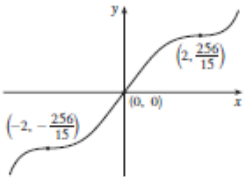
3. A. $\mathbb{R}$ B. y-int 0; x-int 0, $\sqrt[3]{4}$
C. None D. None
E. Inc on $(1, \infty)$; dec on $(-\infty, 1)$
F. Loc min $f(1) = -3$
G. CU on $(-\infty, \infty)$
H. See graph at right.



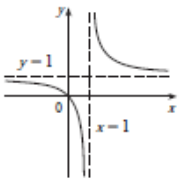
5. A. $\mathbb{R}$ B. y-int 0; x-int 0, 4
C. None D. None
E. Inc on $(1, \infty)$; dec on $(-\infty, 1)$
F. Loc min $f(1) = -27$
G. CU on $(-\infty, 2)$, $(4, \infty)$; CD on $(2, 4)$; IP $(2, -16)$, $(4, 0)$
H. See graph at right.



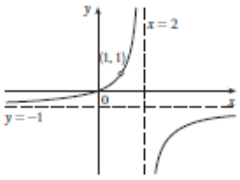
7. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About (0, 0) D. None
E. Inc on $(-\infty, \infty)$
F. None
G. CU on $(-2, 0)$, $(2, \infty)$; CD on $(-\infty, -2)$, $(0, 2)$; IP $\left(-2, -\frac{256}{15}\right)$, $(0, 0)$, $\left(2, \frac{256}{15}\right)$
H. See graph at right.



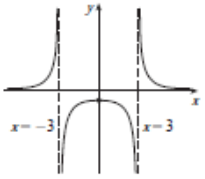
9. A. $\{x \mid x \neq 1\}$ B. y-int 0; x-int 0
C. None D. VA $x = 1$, HA $y = 1$
E. Dec on $(-\infty, 1)$, $(1, \infty)$
F. None
G. CU on $(1, \infty)$; CD on $(-\infty, 1)$
H. See graph at right.



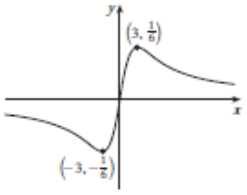
11. A. $(-\infty, 1) \cup (1, 2) \cup (2, \infty)$
B. y-int 0; x-int 0 C. None
D. HA $y = -1$; VA $x = 2$
E. Inc on $(-\infty, 1)$, $(1, 2)$, $(2, \infty)$
F. None
G. CU on $(-\infty, 1)$, $(1, 2)$; CD on $(2, \infty)$
H. See graph at right.



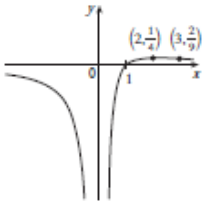
13. A. $\{x \mid x \neq \pm 3\}$ B. y-int $-\frac{1}{9}$
C. About y-axis D. VA $x = \pm 3$, HA $y = 0$
E. Inc on $(-\infty, -3)$, $(-3, 0)$; dec on $(0, 3)$, $(3, \infty)$
F. Loc max $f(0) = -\frac{1}{9}$
G. CU on $(-\infty, -3)$, $(3, \infty)$; CD on $(-3, 3)$
H. See graph at right.



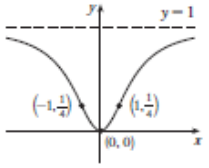
15. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About (0, 0) D. HA $y = 0$
E. Inc on $(-3, 3)$;
dec on $(-\infty, -3)$, $(3, \infty)$
F. Loc min $f(-3) = -\frac{1}{6}$;
loc max $f(3) = \frac{1}{6}$;
G. CU on $\left(-3\sqrt{3}, 0\right)$, $\left(3\sqrt{3}, \infty\right)$;
CD on $\left(-\infty, -3\sqrt{3}\right)$,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



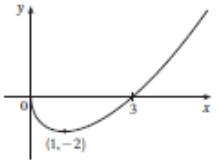
17. A. $(-\infty, 0) \cup (0, \infty)$ B. x-int 1
C. None D. HA $y = 0$; VA $x = 0$
E. Inc on $(0, 2)$;
dec on $(-\infty, 0)$, $(2, \infty)$
F. Loc max $f(2) = \frac{1}{4}$
G. CU on $(3, \infty)$;
CD on $(-\infty, 0)$, $(0, 3)$; IP $\left(3, \frac{2}{9}\right)$



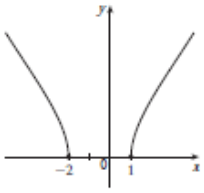
19. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About y-axis D. HA $y = 1$
E. Inc on $(0, \infty)$; dec on $(-\infty, 0)$
F. Loc min $f(0) = 0$
G. CU on $(-1, 1)$;
CD on $(-\infty, -1)$, $(1, \infty)$; IP $\left(\pm 1, \frac{1}{4}\right)$
H. See graph at right.



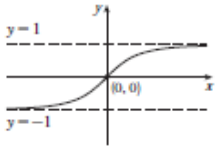
21. A. $[0, \infty)$ B. y-int 0; x-int 0, 3
C. None D. None
E. Inc on $(1, \infty)$; dec on $(0, 1)$
F. Loc min $f(1) = -2$
G. CU on $(0, \infty)$
H. See graph at right.



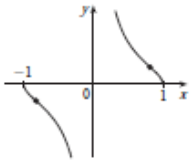
23. A. $(-\infty, -2] \cup [1, \infty)$
B. x-int -2, 1
C. None D. None
E. Inc on $(1, \infty)$; dec on $(-\infty, -2)$
F. None
G. CD on $(-\infty, -2)$, $(1, \infty)$
H. See graph at right.



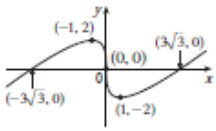
25. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About the origin
D. HA $y = \pm 1$
E. Inc on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$;
CD on $(0, \infty)$; IP $(0, 0)$
H. See graph at right.



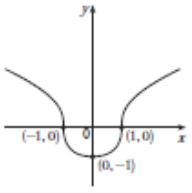
27. A. $\{x \mid |x| \leq 1, x \neq 0\} = [-1, 0) \cup (0, 1]$
B. x-int ± 1 C. About (0, 0)
D. VA $x = 0$
E. Dec on $(-1, 0)$, $(0, 1)$
F. None
G. CU on $\left(-1, -\sqrt{2/3}\right)$, $\left(0, \sqrt{2/3}\right)$;
CD on $\left(-\sqrt{2/3}, 0\right)$, $\left(\sqrt{2/3}, 1\right)$;
IP $\left(\pm\sqrt{2/3},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



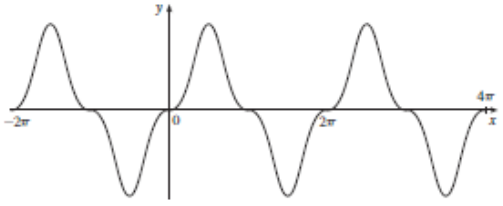
29. A. $\mathbb{R}$ B. y-int 0; x-int 0, $\pm 3\sqrt{3}$ C. About the origin
D. None E. Inc on $(-\infty, -1)$, $(1, \infty)$; dec on $(-1, 1)$
F. Loc max $f(-1) = 2$;
loc min $f(1) = -2$
G. CU on $(0, \infty)$; CD on $(-\infty, 0)$;
IP $(0, 0)$
H. See graph at right.



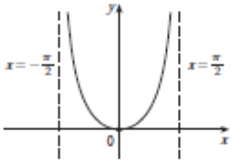
31. A. $\mathbb{R}$ B. y-int -1; x-int ± 1
C. About y-axis D. None
E. Inc on $(0, \infty)$; dec on $(-\infty, 0)$
F. Loc min $f(0) = -1$
G. CU on $(-1, 1)$;
CD on $(-\infty, -1)$, $(1, \infty)$;
IP $(\pm 1, 0)$
H. See graph at right.



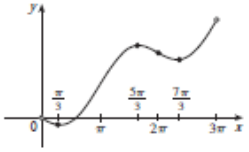
33. A. $\mathbb{R}$ B. y-int 0; x-int $n\pi$ (n an integer)
C. About (0, 0), period 2π D. None
E–G answers for $0 \leq x \leq \pi$:
E. Inc on $(0, \pi/2)$; dec on $(\pi/2, \pi)$ F. Loc max $f(\pi/2) = 1$
G. Let $\alpha = \sin^{-1}\sqrt{2/3}$; CU on $(0, \alpha)$, $(\pi - \alpha, \pi)$;
CD on $(\alpha, \pi - \alpha)$; IP at $x = 0, \pi, \alpha, \pi - \alpha$
H.



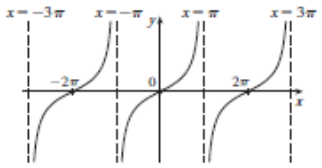
35. A. $(-\pi/2, \pi/2)$ B. y-int 0; x-int 0 C. About y-axis
D. VA $x = \pm\pi/2$
E. Inc on $(0, \pi/2)$;
dec on $(-\pi/2, 0)$
F. Loc min $f(0) = 0$
G. CU on $(-\pi/2, \pi/2)$
H. See graph at right.



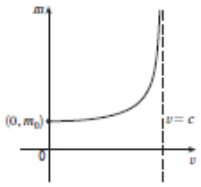
37. A. $(0, 3\pi)$ C. None D. None
E. Inc on $(\pi/3, 5\pi/3)$, $(7\pi/3, 3\pi)$;
dec on $(0, \pi/3)$, $(5\pi/3, 7\pi/3)$
F. Loc min $f(\pi/3) = (\pi/6) - \frac{1}{2}\sqrt{3}$, $f(7\pi/3) = (7\pi/6) - \frac{1}{2}\sqrt{3}$;
loc max $f(5\pi/3) = (5\pi/6) + \frac{1}{2}\sqrt{3}$
G. CU on $(0, \pi)$, $(2\pi,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



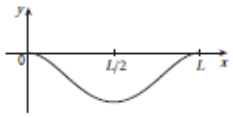
39. A. All reals except $(2n + 1)\pi$ (n an integer)
B. y-int 0; x-int $2n\pi$
C. About the origin, period 2π
D. VA $x = (2n + 1)\pi$
E. Inc on $((2n - 1)\pi, (2n + 1)\pi)$ F. None
G. CU on $(2n\pi, (2n + 1)\pi)$; CD on $((2n - 1)\pi, 2n\pi)$;
IP $(2n\pi, 0)$
H.



41.

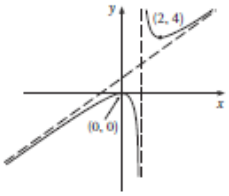


43.

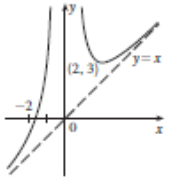


45. $y = x - 1$ **47.** $y = 2x - 2$

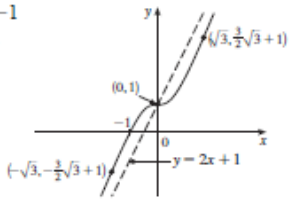
49. A. $(-\infty, 1) \cup (1, \infty)$
B. y-int 0; x-int 0 C. None
D. VA $x = 1$; SA $y = x + 1$
E. Inc on $(-\infty, 0)$, $(2, \infty)$;
dec on $(0, 1)$, $(1, 2)$
F. Loc max $f(0) = 0$;
loc min $f(2) = 4$
G. CU on $(1, \infty)$; CD on $(-\infty, 1)$
H. See graph at right.



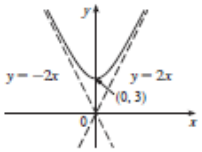
51. A. $(-\infty, 0) \cup (0, \infty)$
B. x-int $-\sqrt[3]{4}$ C. None
D. VA $x = 0$; SA $y = x$
E. Inc. on $(-\infty, 0)$, $(2, \infty)$;
dec on $(0, 2)$
F. Loc min $f(2) = 3$
G. CU on $(-\infty, 0)$, $(0, \infty)$
H. See graph at right.



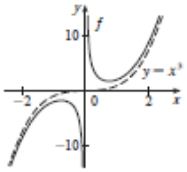
53. A. $\mathbb{R}$ B. y-int. 1; x-int. -1
C. None D. SA $y = 2x + 1$
E. Inc. on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, -\sqrt{3})$, $(0, \sqrt{3})$;
CD on $(-\sqrt{3}, 0)$, $(\sqrt{3}, \infty)$;
IP $(\pm\sqrt{3}, 1 \pm \frac{3}{2}\sqrt{3})$, $(0, 1)$
H. See graph at right.



55.

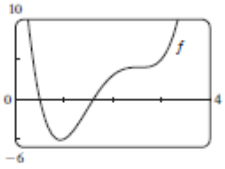


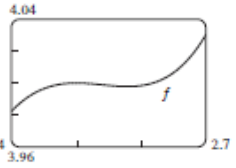
59. VA $x = 0$, asymptotic to $y = x^3$



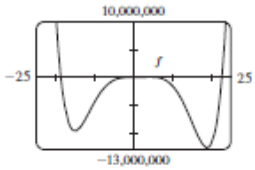
EXERCISES 3.6 ■ PAGE 249

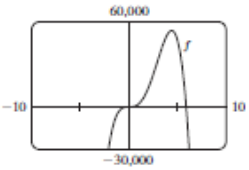
1. Inc on $(0.92, 2.5)$, $(2.58, \infty)$; dec on $(-\infty, 0.92)$, $(2.5, 2.58)$;
loc max $f(2.5) = 4$; loc min $f(0.92) \approx -5.12$, $f(2.58) \approx 3.998$;
CU on $(-\infty, 1.46)$, $(2.54, \infty)$; CD on $(1.46, 2.54)$;
IP $(1.46, -1.40)$, $(2.54, 3.999)$



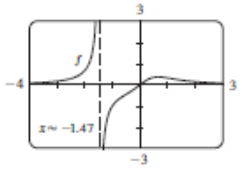


3. Inc on $(-15, 4.40)$, $(18.93, \infty)$;
dec on $(-\infty, -15)$, $(4.40, 18.93)$;
loc max $f(4.40) \approx 53{,}800$; loc min $f(-15) \approx -9{,}700{,}000$,
$f(18.93) \approx -12{,}700{,}000$; CU on $(-\infty, -11.34)$, $(0, 2.92)$,
$(15.08, \infty)$; CD on $(-11.34, 0)$, $(2.92, 15.08)$;
IP $(0,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

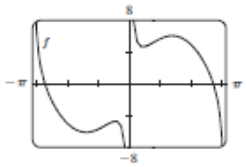




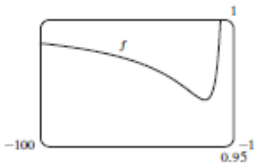
5. Inc on $(-\infty, -1.47)$, $(-1.47, 0.66)$; dec on $(0.66, \infty)$; loc max $f(0.66) \approx 0.38$; CU on $(-\infty, -1.47)$, $(-0.49, 0)$, $(1.10, \infty)$; CD on $(-1.47, -0.49)$, $(0, 1.10)$; IP $(-0.49, -0.44)$, $(1.10, 0.31)$

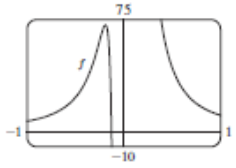


7. Inc on $(-1.40, -0.44)$, $(0.44, 1.40)$; dec on $(-\pi, -1.40)$, $(-0.44, 0)$, $(0, 0.44)$, $(1.40, \pi)$; loc max $f(-0.44) \approx -4.68$, $f(1.40) \approx 6.09$; loc min $f(-1.40) \approx -6.09$, $f(0.44) \approx 5.22$; CU on $(-\pi, -0.77)$, $(0, 0.77)$; CD on $(-0.77, 0)$, $(0.77, \pi)$; IP $(-0.77, -5.22)$, $(0.77, 5.22)$

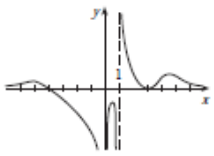


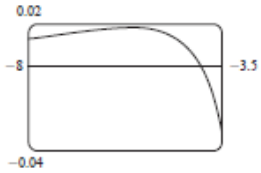
9. Inc on $\left(-8 - \sqrt{61}, -8 + \sqrt{61}\right)$; dec on $\left(-\infty, -8 - \sqrt{61}\right)$, $\left(-8 + \sqrt{61}, 0\right)$, $(0, \infty)$; CU on $\left(-12 - \sqrt{138}, -12 + \sqrt{138}\right)$, $(0, \infty)$; CD on $\left(-\infty, -12 - \sqrt{138}\right)$, $\left(-12 + \sqrt{138}, 0\right)$

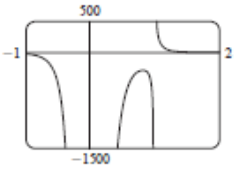


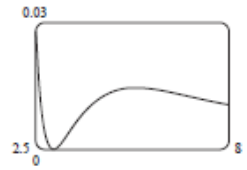


11. Loc max $f(-5.6) \approx 0.018$, $f(0.82) \approx -281.5$, $f(5.2) \approx 0.0145$; loc min $f(3) = 0$







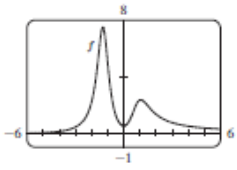


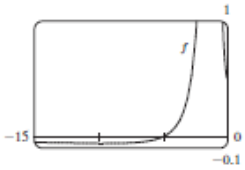
13. $f'(x) = -\dfrac{x(x+1)^2(x^3 + 18x^2 - 44x - 16)}{(x-2)^3(x-4)^5}$

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

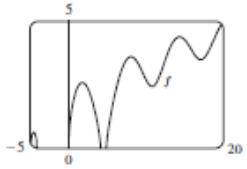
CU on $(-35.3, -5.0)$, $(-1, -0.5)$, $(-0.1, 2)$, $(2, 4)$, $(4, \infty)$; CD on $(-\infty, -35.3)$, $(-5.0, -1)$, $(-0.5, -0.1)$; IP $(-35.3, -0.015)$, $(-5.0, -0.005)$, $(-1, 0)$, $(-0.5, 0.00001)$, $(-0.1, 0.0000066)$

15. Inc on $(-9.41, -1.29)$, $(0, 1.05)$; dec on $(-\infty, -9.41)$, $(-1.29, 0)$, $(1.05, \infty)$; loc max $f(-1.29) \approx 7.49$, $f(1.05) \approx 2.35$; loc min $f(-9.41) \approx -0.056$, $f(0) = 0.5$; CU on $(-13.81, -1.55)$, $(-1.03, 0.60)$, $(1.48, \infty)$; CD on $(-\infty, -13.81)$, $(-1.55, -1.03)$, $(0.60, 1.48)$; IP $(-13.81, -0.05)$, $(-1.55, 5.64)$, $(-1.03, 5.39)$, $(0.60, 1.52)$, $(1.48, 1.93)$

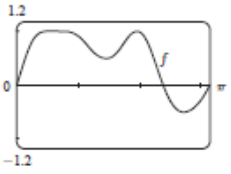


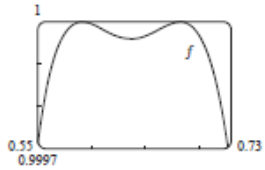


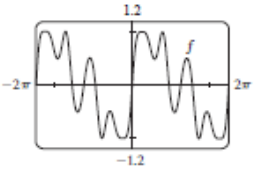
17. Inc on $(-4.91, -4.51)$, $(0, 1.77)$, $(4.91, 8.06)$, $(10.79, 14.34)$, $(17.08, 20)$; dec on $(-4.51, -4.10)$, $(1.77, 4.10)$, $(8.06, 10.79)$, $(14.34, 17.08)$; loc max $f(-4.51) \approx 0.62$, $f(1.77) \approx 2.58$, $f(8.06) \approx 3.60$, $f(14.34) \approx 4.39$; loc min $f(10.79) \approx 2.43$,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



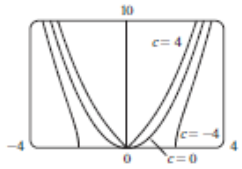
19. Max $f(0.59) \approx 1$, $f(0.68) \approx 1$, $f(1.96) \approx 1$; min $f(0.64) \approx 0.99996$, $f(1.46) \approx 0.49$, $f(2.73) \approx -0.51$; IP $(0.61, 0.99998)$, $(0.66, 0.99998)$, $(1.17, 0.72)$, $(1.75, 0.77)$, $(2.28, 0.34)$



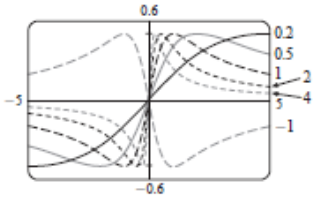




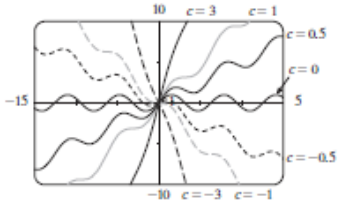
21. For $c \geqslant 0$, there is an absolute minimum at the origin. There are no other maxima or minima. The more negative c becomes, the farther the two IPs move from the origin. $c = 0$ is a transitional value.



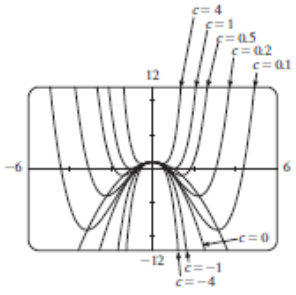
23. For $c > 0$, the maximum and minimum values are always $\pm\frac{1}{2}$, but the extreme points and IPs move closer to the y-axis as c increases. $c = 0$ is a transitional value: when c is replaced by $-c$, the curve is reflected in the x-axis.



25. For $|c| < 1$, the graph has loc max and min values; for $|c| \geqslant 1$ it does not. The function increases for $c \geqslant 1$ and decreases for $c \leqslant -1$. As c changes, the IPs move vertically but not horizontally.



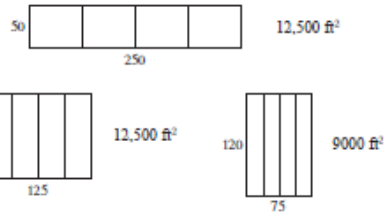
27. (a) Positive (b)



EXERCISES 3.7 ■ PAGE 256

1. (a) 11, 12 (b) 11.5, 11.5 **3.** 10, 10 **5.** $\frac{9}{4}$
7. 25 m by 25 m **9.** $N = 1$

11. (a)



(b)

(c) $A = xy$ (d) $5x + 2y = 750$ (e) $A(x) = 375x - \frac{5}{2}x^2$
(f) 14,062.5 ft²
13. 1000 ft by 1500 ft **15.** 4000 cm³ **17.** \$191.28
19. $\left(-\frac{6}{5}, \frac{3}{5}\right)$ **21.** $\left(-\frac{1}{3}, \pm\frac{4}{3}\sqrt{2}\right)$ **23.** Square, side $\sqrt{2}\,r$
25. $L/2$, $\sqrt{3}\,L/4$ **27.** Base $\sqrt{3}\,r$, height $3r/2$
29. $4\pi r^3/(3\sqrt{3})$ **31.** $\pi r^2(1 + \sqrt{5})$ **33.** 24 cm, 36 cm
35. (a) Use all of the wire for the square
(b) $40\sqrt{3}/(9 + 4\sqrt{3})$ m for the square
37. Height = radius = $\sqrt[3]{V/\pi}$ cm
39. $V = 2\pi R^3/(9\sqrt{3})$ **43.** $E^2/(4r)$
45. (a) $\frac{3}{2}s^2 \csc\theta\,(\csc\theta - \sqrt{3}\cot\theta)$ (b) $\cos^{-1}(1/\sqrt{3}) \approx 55°$
(c) $6s[h + s/(2\sqrt{2})]$
47. Row directly to B **49.** ≈4.85 km east of the refinery
51. $10\sqrt[3]{3}/(1 + \sqrt[3]{3})$ ft from the stronger source
53. $(a^{2/3} + b^{2/3})^{3/2}$ **55.** $2\sqrt{6}$
57. (b) (i) \$342,491; \$342/unit; \$390/unit (ii) 400
(iii) \$320/unit
59. (a) $p(x) = 19 - \frac{1}{3000}x$ (b) \$9.50
61. (a) $p(x) = 550 - \frac{1}{10}x$ (b) \$175 (c) \$100
65. 9.35 m **69.** $x = 6$ in. **71.** $\pi/6$
73. $\frac{1}{2}(L + W)^2$
75. (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 3.8 ■ PAGE 267

1. (a) $x_2 \approx 2.3$, $x_3 \approx 3$ (b) No
3. $\frac{9}{2}$ **5.** a, b, c **7.** 1.1785 **9.** −1.25 **11.** 1.82056420
13. 1.217562 **15.** 0.876726
17. −3.637958, −1.862365, 0.889470
19. 1.412391, 3.057104 **21.** 0.641714
23. −1.93822883, −1.21997997, 1.13929375, 2.98984102
25. 0.76682579 **27.** (b) 31.622777
33. (a) −1.293227, −0.441731, 0.507854 (b) −2.0212
35. (1.519855, 2.306964) **37.** (0.410245, 0.347810)
39. 0.76286%

EXERCISES 3.9 ■ PAGE 273

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.** $F(x) = 5x^{7/5} + 40x^{1/5} + C$

9. $F(x) = \sqrt{2}x + C$ **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. $G(t) = 2t^{1/2} + \frac{2}{3}t^{3/2} + \frac{2}{5}t^{5/2} + C$

15. $H(\theta) = -2\cos\theta - \tan\theta + C_n$ on $(n\pi - \pi/2, n\pi + \pi/2)$, n an integer

17. $F(t) = 2\sec t + t^{1/2} + C_n$

19. $F(x) = x^5 - \frac{1}{3}x^6 + 4$ **21.** $f(x) = x^5 - x^4 + x^3 + Cx + D$

23. $f(x) = \frac{3}{20}x^{8/3} + Cx + D$

25. $f(t) = -\sin t + Ct^2 + Dt + E$

27. $f(x) = x + 2x^{3/2} + 5$ **29.** $f(x) = 4x^{3/2} + 2x^{5/2} + 4$

31. $f(t) = 2\sin t + \tan t + 4 - 2\sqrt{3}$

33. $f(x) = -x^2 + 2x^3 - x^4 + 12x + 4$

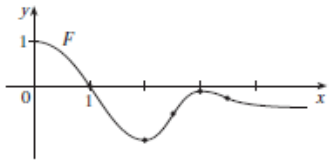
35. $f(\theta) = -\sin\theta - \cos\theta + 5\theta + 4$

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

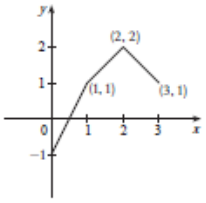
39. $f(x) = x^2 - \cos x - \frac{1}{2}\pi x$

41. 10 **43.** b

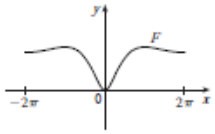
45.



47.



49.



51. $s(t) = 1 - \cos t - \sin t$

53. $s(t) = \frac{1}{3}t^3 + \frac{1}{2}t^2 - 2t + 3$

55. $s(t) = -10\sin t - 3\cos t + (6/\pi)t + 3$

57. (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

61. 225 ft **63.** \$742.08 **65.** $\frac{130}{11} \approx 11.8$ s

67. $\frac{88}{15} \approx 5.87$ ft/s^2 **69.** 62,500 km/h^2 ≈ 4.82 m/s^2

71. (a) 22.9125 mi (b) 21.675 mi (c) 30 min 33 s (d) 55.425 mi

CHAPTER 3 REVIEW ■ PAGE 276

True-False Quiz

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

Exercises

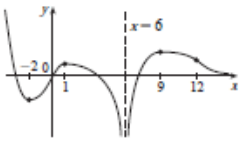
1. Abs max $f(4) = 5$, abs and loc min $f(3) = 1$

3. Abs max $f(2) = \frac{2}{5}$, abs and loc min $f\left(-\frac{1}{3}\right) = -\frac{9}{2}$

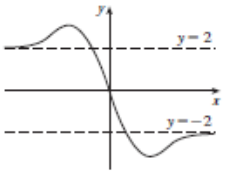
5. Abs and loc max $f(\pi/6) = \pi/6 + \sqrt{3}$, abs min $f(-\pi) = -\pi - 2$, loc min $f(5\pi/6) = 5\pi/6 - \sqrt{3}$

7. $\frac{1}{2}$ **9.** $-\frac{2}{3}$ **11.** $\frac{3}{4}$

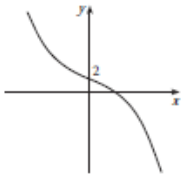
13.



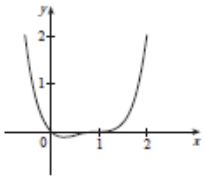
15.



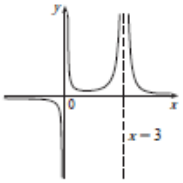
17. A. $\mathbb{R}$ B. y-int 2
C. None D. None
E. Dec on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$; CD on $(0, \infty)$; IP $(0, 2)$
H. See graph at right.



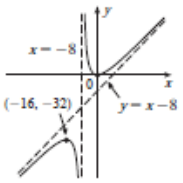
19. A. $\mathbb{R}$ B. y-int 0; x-int 0, 1
C. None D. None
E. Inc on $\left(\frac{1}{4}, \infty\right)$, dec on $\left(-\infty, \frac{1}{4}\right)$
F. Loc min $f\left(\frac{1}{4}\right) = -\frac{27}{256}$
G. CU on $\left(-\infty, \frac{1}{2}\right)$, $(1, \infty)$; CD on $\left(\frac{1}{2}, 1\right)$;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



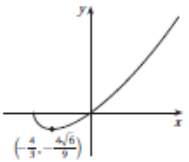
21. A. $\{x \mid x \neq 0, 3\}$
B. None C. None
D. HA $y = 0$; VA $x = 0$, $x = 3$
E. Inc on $(1, 3)$; dec on $(-\infty, 0)$, $(0, 1)$, $(3, \infty)$
F. Loc min $f(1) = \frac{1}{4}$
G. CU on $(0, 3)$, $(3, \infty)$; CD on $(-\infty, 0)$
H. See graph at right.



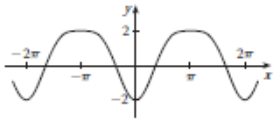
23. A. $\{x \mid x \neq -8\}$
B. y-int 0, x-int 0 C. None
D. VA $x = -8$; SA $y = x - 8$
E. Inc on $(-\infty, -16)$, $(0, \infty)$; dec on $(-16, -8)$, $(-8, 0)$
F. Loc max $f(-16) = -32$; loc min $f(0) = 0$
G. CU on $(-8, \infty)$; CD on $(-\infty, -8)$
H. See graph at right.



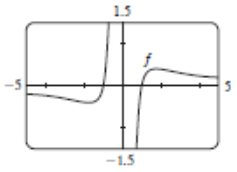
25. A. $[-2, \infty)$
B. y-int 0; x-int -2, 0
C. None D. None
E. Inc on $\left(-\frac{4}{3}, \infty\right)$, dec on $\left(-2, -\frac{4}{3}\right)$
F. Loc min $f\left(-\frac{4}{3}\right) = -\frac{4}{9}\sqrt{6}$
G. CU on $(-2, \infty)$
H. See graph at right.



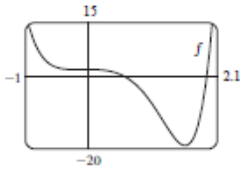
27. A. $\mathbb{R}$ B. y-int -2
C. About y-axis, period 2π D. None
E. Inc. on $(2n\pi, (2n+1)\pi)$, n an integer; dec. on $((2n-1)\pi, 2n\pi)$
F. Loc. max. $f((2n+1)\pi) = 2$; loc. min. $f(2n\pi) = -2$
G. CU on $(2n\pi - (\pi/3), 2n\pi + (\pi/3))$;
CD on $(2n\pi + (\pi/3), 2n\pi + (5\pi/3))$; IP $\left(2n\pi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

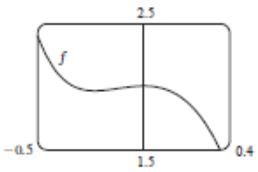


29. Inc on $(-\sqrt{3}, 0), (0, \sqrt{3})$;
dec on $(-\infty, -\sqrt{3}), (\sqrt{3}, \infty)$;
loc max $f(\sqrt{3}) = \frac{2}{9}\sqrt{3}$,
loc min $f(-\sqrt{3}) = -\frac{2}{9}\sqrt{3}$;
CU on $(-\sqrt{6}, 0), (\sqrt{6}, \infty)$;
CD on $(-\infty, -\sqrt{6}), (0, \sqrt{6})$;
IP $(\sqrt{6}, \frac{5}{36}\sqrt{6}),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

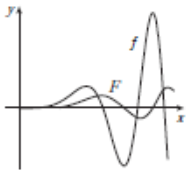


31. Inc on $(-0.23, 0), (1.62, \infty)$; dec on $(-\infty, -0.23), (0, 1.62)$;
loc max $f(0) = 2$; loc min $f(-0.23) \approx 1.96$, $f(1.62) \approx -19.2$;
CU on $(-\infty, -0.12), (1.24, \infty)$;
CD on $(-0.12, 1.24)$; IP $(-0.12, 1.98), (1.24, -12.1)$





37. (a) 0 (b) CU on $\mathbb{R}$ **41.** $3\sqrt{3}\,r^2$
43. $4/\sqrt{3}$ cm from D **45.** $L = C$ **47.** \$11.50
49. 1.297383 **51.** 1.16718557
53. $f(x) = \frac{2}{5}x^{5/2} + \frac{3}{5}x^{5/3} + C$
55. $f(t) = t^2 + 3\cos t + 2$
57. $f(x) = \frac{1}{2}x^2 - x^3 + 4x^4 + 2x + 1$
59. $s(t) = t^2 + \cos t + 2$
61.



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

PROBLEMS PLUS ■ PAGE 280

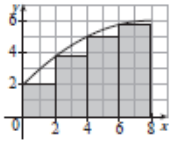
5. $(-2, 4), (2, -4)$ **7.** $\frac{4}{3}$ **9.** $(m/2, m^2/4)$
11. $-3.5 < a < -2.5$

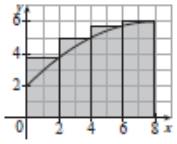
13. (a) $x/(x^2+1)$ (b) $\frac{1}{2}$
15. (a) $-\tan\theta\left[\dfrac{1}{c}\dfrac{dc}{dt} + \dfrac{1}{b}\dfrac{db}{dt}\right]$
(b) $\dfrac{b\dfrac{db}{dt} + c\dfrac{dc}{dt} - \left(b\dfrac{dc}{dt} + c\dfrac{db}{dt}\right)\sec\theta}{\sqrt{b^2 + c^2 - 2bc\cos\theta}}$
17. (a) $T_1 = D/c_1$, $T_2 = (2h\sec\theta)/c_1 + (D - 2h\tan\theta)/c_2$,
$T_3 = \sqrt{4h^2 + D^2}/c_1$
(c) $c_1 \approx 3.85$ km/s, $c_2 \approx 7.66$ km/s, $h \approx 0.42$ km
21. $3/(\sqrt[3]{2} - 1) \approx 11\frac{1}{2}$ h

CHAPTER 4

EXERCISES 4.1 ■ PAGE 293

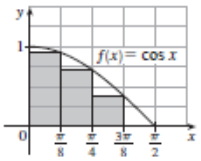
1. (a) $L_4 = 33$, $R_4 = 41$

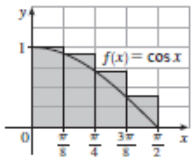




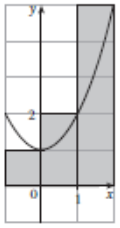
(b) $L_8 \approx 35.2$, $R_8 \approx 39.2$

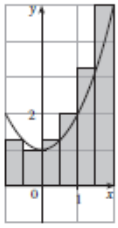
3. (a) 0.7908, underestimate (b) 1.1835, overestimate

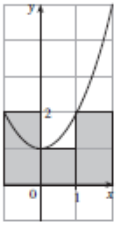


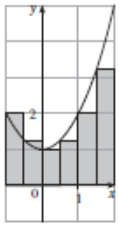


5. (a) 8, 6.875 (b) 5, 5.375

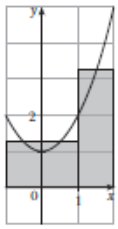


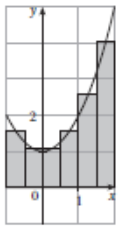






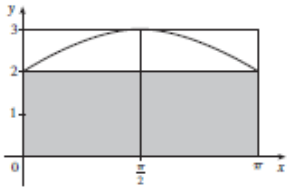
(c) 5.75, 5.9375



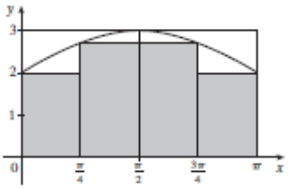


(d) M_6

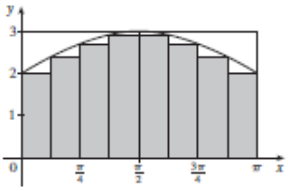
7. $n = 2$: upper $= 3\pi \approx 9.42$, lower $= 2\pi \approx 6.28$



$n = 4$: upper $= (10 + \sqrt{2})(\pi/4) \approx 8.96$,
lower $= (8 + \sqrt{2})(\pi/4) \approx 7.39$



$n = 8$: upper ≈ 8.65, lower ≈ 7.86



9. 0.2533, 0.2170, 0.2101, 0.2050; 0.2

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

13. 34.7 ft, 44.8 ft **15.** 63.2 L, 70 L **17.** 155 ft

19. $\lim_{n\to\infty} \sum_{i=1}^{n} \frac{2(1 + 2i/n)}{(1 + 2i/n)^2 + 1} \cdot \frac{2}{n}$ **21.** $\lim_{n\to\infty} \sum_{i=1}^{n} \sqrt{\sin(\pi i/n)} \cdot \frac{\pi}{n}$

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

25. (a) $L_n < A < R_n$

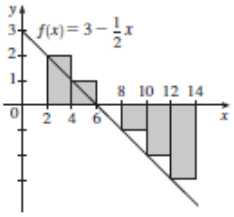
27. (a) $\lim_{n\to\infty} \frac{64}{n^6} \sum_{i=1}^{n} i^5$ (b) $\frac{n^2(n+1)^2(2n^2+2n-1)}{12}$ (c) $\frac{32}{3}$

29. $\sin b$, 1

EXERCISES 4.2 ■ PAGE 306

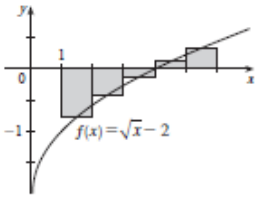
1. -6

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. -0.856759

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.



5. (a) 6 (b) 4 (c) 2

7. Lower, $L_5 = -64$; upper, $R_5 = 16$

9. 6.1820 **11.** 0.9071 **13.** 0.9029, 0.9018

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. $\int_2^6 \frac{1 - x^2}{4 + x^2}\,dx$ **19.** $\int_2^7 (5x^3 - 4x)\,dx$

21. -9 **23.** $\frac{2}{3}$ **25.** $-\frac{3}{4}$

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. $\frac{3}{2}$ **37.** $3 + \frac{9}{4}\pi$ **39.** $\frac{5}{2}$ **41.** 0 **43.** 3 **45.** 22.5

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

51. B < E < A < D < C **53.** 15

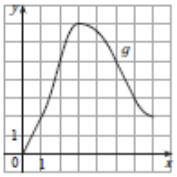
59. $3 \le \int_1^4 \sqrt{x}\,dx \le 6$ **61.** $\frac{\pi}{12} \le \int_{\pi/4}^{\pi/3} \tan x\,dx \le \frac{\pi}{12}\sqrt{3}$

63. $2 \le \int_{-1}^{1} \sqrt{1 + x^4}\,dx \le 2\sqrt{2}$ **71.** $\int_0^1 x^4\,dx$ **73.** $\frac{1}{2}$

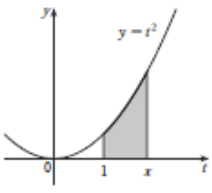
EXERCISES 4.3 ■ PAGE 318

1. One process undoes what the other one does. See the Fundamental Theorem of Calculus, page 317.

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

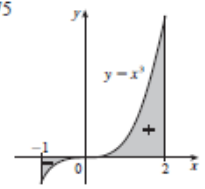


5.

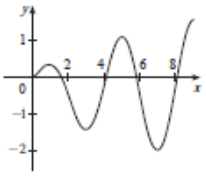


(a), (b) x^2

7. $g'(x) = 1/(x^3 + 1)$ **9.** $g'(s) = (s - s^2)^8$
11. $F'(x) = -\sqrt{1 + \sec x}$ **13.** $h'(x) = -\sin^4(1/x)/x^2$
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.** $\frac{52}{3}$
25. $1 + \sqrt{3}/2$ **27.** $-\frac{37}{6}$ **29.** $\frac{40}{3}$ **31.** 1 **33.** $\frac{49}{3}$
35. $\frac{17}{2}$ **37.** 0
39. The function $f(x) = x^{-4}$ is not continuous on the interval $[-2, 1]$, so FTC2 cannot be applied.
41. The function $f(\theta) = \sec\theta \tan\theta$ is not continuous on the interval $[\pi/3, \pi]$, so FTC2 cannot be applied.
43. $\frac{243}{4}$ **45.** 2
47. 3.75



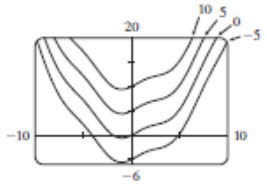
49. $g'(x) = \dfrac{-2(4x^2 - 1)}{4x^2 + 1} + \dfrac{3(9x^2 - 1)}{9x^2 + 1}$
51. $h'(x) = -\dfrac{1}{2\sqrt{x}}\cos x + 3x^2\cos(x^6)$
53. $(-4, 0)$ **55.** 29
57. (a) $-2\sqrt{n}$, $\sqrt{4n - 2}$, n an integer > 0
(b) $(0, 1)$, $\left(-\sqrt{4n - 1}, -\sqrt{4n - 3}\right)$, and $\left(\sqrt{4n - 1}, \sqrt{4n + 1}\right)$, n an integer > 0 (c) 0.74
59. (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.



61. $\frac{1}{4}$ **69.** $f(x) = x^{3/2}$, $a = 9$
71. (b) Average expenditure over $[0, t]$; minimize average expenditure
73. $\ln 3$ **75.** π **77.** $e^2 - 1$

EXERCISES 4.4 ■ PAGE 326

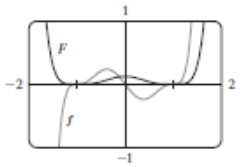
5. $\frac{1}{3}x^3 - (1/x) + C$ **7.** $\frac{1}{5}x^5 - \frac{1}{8}x^4 + \frac{1}{8}x^2 - 2x + C$
9. $\frac{2}{3}u^3 + \frac{9}{2}u^2 + 4u + C$ **11.** $\frac{1}{3}x^3 - 4\sqrt{x} + C$
13. $\frac{1}{2}\theta^2 + \csc\theta + C$ **15.** $\tan\alpha + C$
17. $\sin x + \frac{1}{4}x^2 + C$

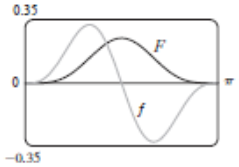


19. $-\frac{10}{3}$ **21.** $\frac{21}{5}$ **23.** -2 **25.** 8 **27.** 36
29. $2\sqrt{5}$ **31.** $\frac{256}{15}$ **33.** $1 + \pi/4$ **35.** $\frac{256}{5}$ **37.** 1
39. $\frac{5}{2}$ **41.** -3.5 **43.** ≈ 1.36 **45.** $\frac{4}{3}$
47. The increase in the child's weight (in pounds) between the ages of 5 and 10
49. Number of gallons of oil leaked in the first 2 hours
51. Increase in revenue when production is increased from 1000 to 5000 units
53. Newton-meters **55.** (a) $-\frac{3}{2}$ m (b) $\frac{41}{6}$ m
57. (a) $v(t) = \frac{1}{2}t^2 + 4t + 5$ m/s (b) $416\frac{2}{3}$ m
59. $46\frac{2}{3}$ kg **61.** 1.4 mi **63.** 28,320 L
65. 4.75×10^5 megawatt-hours
67. $-\cos x + \cosh x + C$ **69.** $\frac{1}{3}x^3 + x + \tan^{-1}x + C$
71. $\pi/6$

EXERCISES 4.5 ■ PAGE 335

1. $-(1/\pi)\cos\pi x + C$ **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. $-\frac{1}{20}(1 - 2x)^{10} + C$ **11.** $\frac{1}{3}(2x + x^2)^{3/2} + C$
13. $\frac{1}{3}\sec 3t + C$ **15.** $\frac{2}{3}\sqrt{3ax + bx^3} + C$
17. $\frac{1}{4}\tan^4\theta + C$ **19.** $\frac{1}{15}(x^3 + 3x)^5 + C$
21. $-\dfrac{1}{\sin x} + C$ **23.** $\frac{1}{2}(1 + z^3)^{2/3} + C$
25. $-\frac{2}{3}(\cot x)^{3/2} + C$ **27.** $\frac{1}{3}\sec^3 x + C$
29. $\frac{1}{40}(2x + 5)^{10} - \frac{5}{36}(2x + 5)^9 + C$
31. $\frac{1}{8}(x^2 - 1)^4 + C$ **33.** $\frac{1}{4}\sin^4 x + C$





35. $2/\pi$ **37.** $\frac{45}{28}$ **39.** 4 **41.** 0
43. 3 **45.** $\frac{1}{3}\left(2\sqrt{2} - 1\right)a^3$ **47.** $\frac{16}{15}$ **49.** $\frac{1}{2}(\sin 4 - \sin 1)$
51. $\frac{1}{6}$ **53.** $\sqrt{3} - \frac{1}{3}$ **55.** 6π
57. $\dfrac{5}{4\pi}\left(1 - \cos\dfrac{2\pi t}{5}\right)$ L **59.** 5 **67.** $-\frac{1}{3}\ln|5 - 3x| + C$
69. $\frac{1}{3}(\ln x)^3 + C$ **71.** $\frac{2}{3}(1 + e^x)^{3/2} + C$ **73.** $e^{\tan x} + C$
75. $\tan^{-1}x + \frac{1}{2}\ln(1 + x^2) + C$ **77.** $-\ln(1 + \cos^2 x) + C$
79. $\ln|\sin x| + C$ **81.** 2 **83.** $\ln(e + 1)$ **85.** $\pi^2/4$

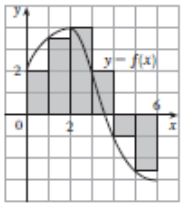
CHAPTER 4 REVIEW ■ PAGE 338

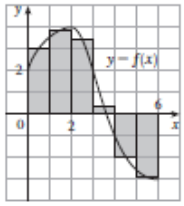
True-False Quiz

1. True **3.** True **5.** False **7.** True **9.** True
11. False **13.** True **15.** False **17.** 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.** $\dfrac{1}{2\pi}\sin^2\pi t + C$ **25.** $\frac{1}{2}\sqrt{2} - \frac{1}{2}$

27. $\frac{23}{3}$ **29.** $2\sqrt{1 + \sin x} + C$ **31.** $\frac{64}{5}$

33. $F'(x) = x^2/(1 + x^3)$ **35.** $g'(x) = 4x^3\cos(x^8)$

37. $y' = \dfrac{2\cos x - \cos\sqrt{x}}{2x}$ **39.** $4 \le \int_1^3 \sqrt{x^2 + 3}\,dx \le 4\sqrt{3}$

43. 0.280981

45. Number of barrels of oil consumed from Jan. 1, 2000, through Jan. 1, 2008

47. 72,400 **49.** 3 **51.** $(1 + x^2)(x\cos x + \sin x)/x^2$

PROBLEMS PLUS ■ PAGE 342

1. $\pi/2$ **3.** $f(x) = \frac{1}{2}x$ **5.** -1 **7.** $[-1, 2]$

9. (a) $\frac{1}{2}(n-1)n$ (b) $\frac{1}{2}[\![b]\!](2b - [\![b]\!] - 1) - \frac{1}{2}[\![a]\!](2a - [\![a]\!] - 1)$

15. $2\left(\sqrt{2} - 1\right)$

CHAPTER 5

EXERCISES 5.1 ■ PAGE 349

1. $\frac{32}{3}$ **3.** $\frac{4}{3}$ **5.** 19.5 **7.** $\frac{9}{2}$ **9.** $\frac{4}{3}$ **11.** $\frac{8}{3}$ **13.** 72

15. $6\sqrt{3}$ **17.** $\frac{32}{3}$ **19.** $2/\pi + \frac{2}{3}$ **21.** $2 - \pi/2$ **23.** $\frac{1}{2}$

25. $\frac{59}{12}$ **27.** $\frac{3}{4}$ **29.** $\frac{5}{2}$ **31.** $\frac{3}{2}\sqrt{3} - 1$ **33.** 0, 0.90; 0.04

35. -1.11, 1.25, 2.86; 8.38 **37.** 2.80123 **39.** 0.25142

41. $12\sqrt{6} - 9$ **43.** $117\frac{1}{3}$ ft **45.** 4232 cm^2

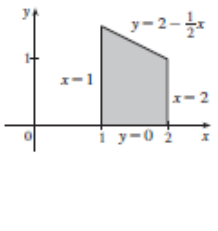
47. (a) Car A (b) The distance by which A is ahead of B after 1 minute (c) Car A (d) $t \approx 2.2$ min

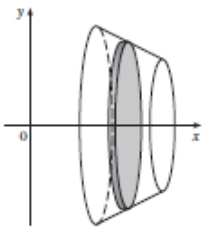
49. $\frac{24}{5}\sqrt{3}$ **51.** $4^{2/3}$ **53.** ± 6 **55.** $\ln 2 - \frac{1}{2}$

57. $2 - 2\ln 2$

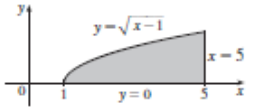
EXERCISES 5.2 ■ PAGE 360

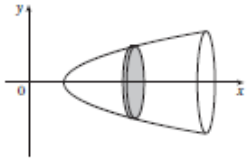
1. $19\pi/12$



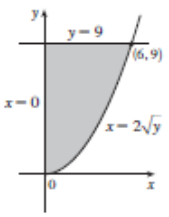


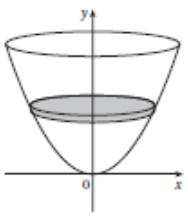
3. 8π



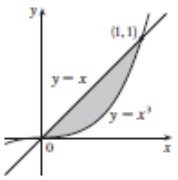


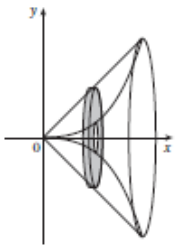
5. 162π



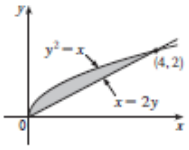


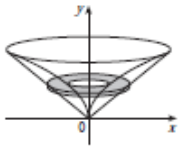
7. $4\pi/21$



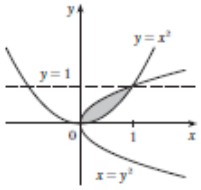


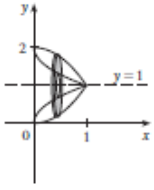
9. $64\pi/15$



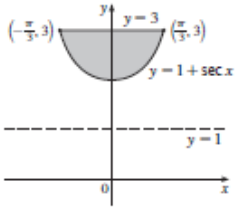


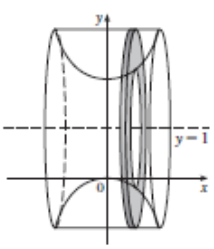
11. $11\pi/30$



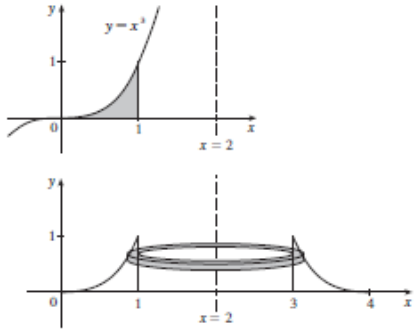


13. $2\pi\left(\frac{4}{3}\pi - \sqrt{3}\right)$

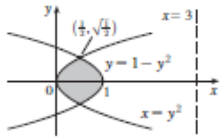


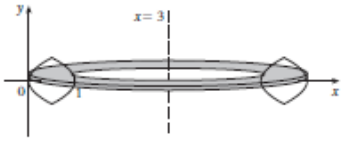


15. $3\pi/5$



17. $10\sqrt{2}\,\pi/3$





19. $\pi/3$ **21.** $\pi/3$ **23.** $\pi/3$

25. $13\pi/45$ **27.** $\pi/3$ **29.** $17\pi/45$

31. (a) 0.67419 (b) 2.85178

33. (a) $2\pi\int_0^2 8\sqrt{1 - x^2/4}\,dx \approx 78.95684$

(b) $2\pi\int_0^1 8\sqrt{4 - 4y^2}\,dy \approx 78.95684$

35. $-1.288,\ 0.884;\ 23.780$ **37.** $\frac{11}{8}\pi^2$

39. Solid obtained by rotating the region $0 \leq x \leq \pi$, $0 \leq y \leq \sqrt{\sin x}$ about the x-axis

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

43. 1110 cm³ **45.** (a) 196 (b) 838

47. $\frac{1}{3}\pi r^2 h$ **49.** $\pi l^2\left(r - \frac{1}{3}h\right)$ **51.** $\frac{2}{3}b^2 h$

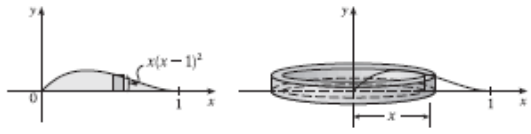
53. 10 cm³ **55.** 24 **57.** $\frac{1}{3}$ **59.** $\frac{8}{15}$

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

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

EXERCISES 5.3 ■ PAGE 366

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



3. $6\pi/7$ **5.** 8π **7.** 8π **9.** 4π **11.** $768\pi/7$

13. $16\pi/3$ **15.** $7\pi/15$ **17.** $8\pi/3$ **19.** $5\pi/14$

21. (a) $\int_{2\pi}^{3\pi} 2\pi x \sin x\,dx$ (b) 98.69604

23. (a) $4\pi\int_{-\pi/2}^{\pi/2} (\pi - x)\cos^4 x\,dx$ (b) 46.50942

25. (a) $\int_0^{\pi} 2\pi(4 - y)\sqrt{\sin y}\,dy$ (b) 36.57476

27. 3.68

29. Solid obtained by rotating the region $0 \leq y \leq x^4$, $0 \leq x \leq 3$ 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, 1.32; 4.05 **35.** $\frac{1}{32}\pi^3$ **37.** 8π **39.** $4\sqrt{3}\,\pi$

41. $4\pi/3$ **43.** $117\pi/5$ **45.** $\frac{4}{3}\pi r^3$ **47.** $\frac{1}{3}\pi r^2 h$

EXERCISES 5.4 ■ PAGE 371

1. (a) 7200 ft-lb (b) 7200 ft-lb

3. 4.5 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

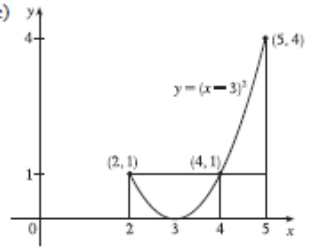
23. $\approx 1.04 \times 10^5$ ft-lb **25.** 2.0 m

29. (a) $Gm_1m_2\left(\frac{1}{a} - \frac{1}{b}\right)$ (b) $\approx 8.50 \times 10^9$ J

EXERCISES 5.5 ■ PAGE 375

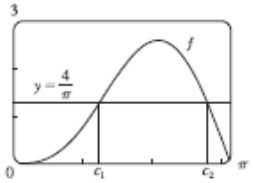
1. $\frac{8}{3}$ **3.** $\frac{45}{28}$ **5.** 29,524/15 **7.** $2/(5\pi)$

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



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

(c)



15. $\frac{9}{8}$ **17.** $(50 + 28/\pi)°\text{F} \approx 59°\text{F}$ **19.** 6 kg/m

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

CHAPTER 5 REVIEW ■ PAGE 378

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.** $\int_{-\pi/3}^{\pi/3} 2\pi\left(\pi/2 - x\right)\left(\cos^2 x - \frac{1}{4}\right) dx$

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.** $\frac{125}{3}\sqrt{3}$ 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 380

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) $V = \int_0^b \pi[f(y)]^2\, dy$

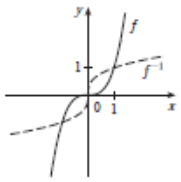
(c) $f(y) = \sqrt{kA/(\pi C)}\, y^{1/4}$. Advantage: the markings on the container are equally spaced.

13. $b = 2a$

35. (b) $\frac{1}{12}$

(c) $f^{-1}(x) = \sqrt[3]{x}$, domain $= \mathbb{R} =$ range

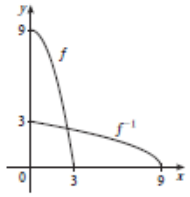
(e)



37. (b) $-\frac{1}{2}$

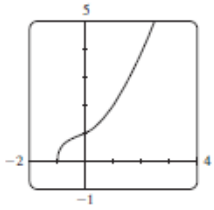
(c) $f^{-1}(x) = \sqrt{9 - x}$, domain $= [0, 9]$, range $= [0, 3]$

(e)



39. $\frac{1}{7}$ **41.** $2/\pi$ **43.** $\frac{3}{2}$ **45.** $1/\sqrt{28}$

47.



The graph passes the Horizontal Line Test.

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

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