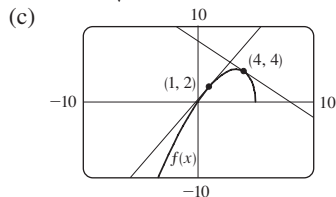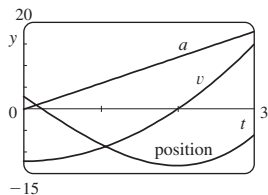**49.** $3 \tanh 3x$ **51.** $\dfrac{\cosh x}{\sqrt{\sinh^2 x - 1}}$

53. $\dfrac{-3 \sin\left(e^{\sqrt{\tan 3x}}\right) e^{\sqrt{\tan 3x}} \sec^2(3x)}{2\sqrt{\tan 3x}}$ **55.** $-\frac{4}{27}$

57. $-5x^4/y^{11}$ **61.** $y = 2\sqrt{3}\,x + 1 - \pi\sqrt{3}/3$

63. $y = 2x + 1$ **65.** $y = -x + 2; y = x + 2$

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

(c)

69. $\left(\pi/4, \sqrt{2}\,\right), \left(5\pi/4, -\sqrt{2}\,\right)$

73. (a) 4   (b) 6   (c) $\frac{7}{9}$ (d) 12

75. $x^2 g'(x) + 2xg(x)$ **77.** $2g(x)g'(x)$ **79.** $g'(e^x)e^x$

81. $g'(x)/g(x)$ **83.** $\dfrac{f'(x)[g(x)]^2 + g'(x)\,[f(x)]^2}{[f(x) + g(x)]^2}$

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

87. $(-3, 0)$ **89.** $y = -\frac{2}{3}x^2 + \frac{14}{3}x$

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

93. (a) $v(t) = 3t^2 - 12; a(t) = 6t$ (b) $t > 2; 0 \leqslant t < 2$

(c) 23   (d)

(e) $t > 2; 0 < t < 2$

95. 4 kg/m

97. (a) $200(3.24)^t$ (b) $\approx 22{,}040$
(c) $\approx 25{,}910$ cells/h   (d) $(\ln 50)/(\ln 3.24) \approx 3.33$ h

99. (a) $C_0 e^{-kt}$ (b) ≈ 100 h   **101.** $\frac{4}{3}$ cm²/min

103. 13 ft/s   **105.** 400 ft/h

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

109. $12 + \frac{3}{2}\pi \approx 16.7$ cm²   **111.** $\left[\dfrac{d}{dx}\sqrt[4]{x}\right]_{x=16} = \dfrac{1}{32}$

113. $\frac{1}{4}$ **115.** $\frac{1}{8}x^2$

PROBLEMS PLUS ■ **PAGE 275**

1. $\left(\pm\sqrt{3}/2, \frac{1}{4}\right)$ **5.** $3\sqrt{2}$ **11.** $\left(0, \frac{5}{4}\right)$

13. 3 lines; $(0, 2)$, $\left(\frac{4}{3}\sqrt{2}, \frac{2}{3}\right)$ and $\left(\frac{2}{3}\sqrt{2}, \frac{10}{3}\right)$, $\left(-\frac{4}{3}\sqrt{2}, \frac{2}{3}\right)$ and $\left(-\frac{2}{3}\sqrt{2}, \frac{10}{3}\right)$

15. (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

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

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

23. R approaches the midpoint of the radius AO.

25. $-\sin a$ **27.** $2\sqrt{e}$ **31.** $(1, -2), (-1, 0)$

33. $\sqrt{29}/58$ **35.** $2 + \frac{375}{128}\pi \approx 11.204$ cm³/min

CHAPTER 4
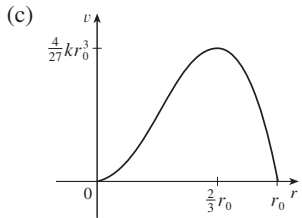
EXERCISES 4.1 ■ PAGE 286

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)
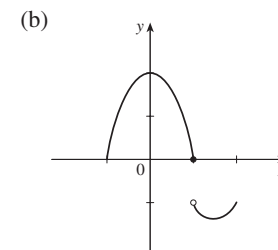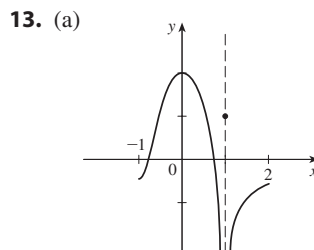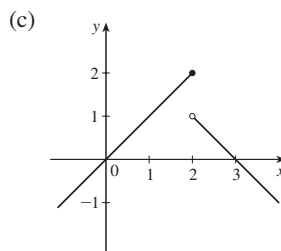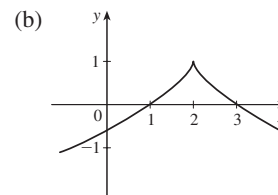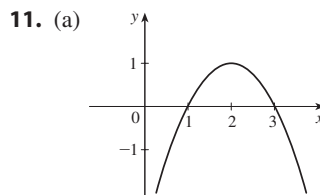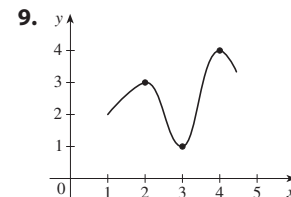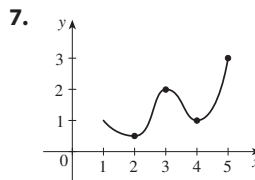
15. Abs max $f(-1) = 5$ **17.** Abs max $f(1) = 1$

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

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

23. Abs max $f(2) = \ln 2$ **25.** Abs max $f(0) = 1$
27. Abs min $f(1) = -1$; loc min $f(0) = 0$ **29.** $-\frac{1}{6}$
31. $-4, 0, 2$ **33.** None   **35.** $0, 2$ **37.** $-1, 2$
39. $0, \frac{4}{9}$ **41.** $0, \frac{8}{7}, 4$ **43.** $0, \frac{4}{3}, 4$
45. $n\pi$ (n an integer)   **47.** $1/\sqrt{e}$ **49.** 10
51. $f(2) = 16, f(5) = 7$ **53.** $f(-1) = 8, f(2) = -19$
55. $f(-2) = 33, f(2) = -31$ **57.** $f(0.2) = 5.2, f(1) = 2$
59. $f(4) = 4 - \sqrt[3]{4}, f(\sqrt{3}/9) = -2\sqrt{3}/9$
61. $f(\pi/6) = \frac{3}{2}\sqrt{3}, f(\pi/2) = 0$
63. $f(e^{1/2}) = 1/(2e), f(\frac{1}{2}) = -4\ln 2$
65. $f(1) = \ln 3, f(-\frac{1}{2}) = \ln \frac{3}{4}$

67. $f\left(\dfrac{a}{a+b}\right) = \dfrac{a^a b^b}{(a+b)^{a+b}}$

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

71. (a) $0.32, 0.00$ (b) $\frac{3}{16}\sqrt{3}, 0$
73. 0.0177 g/dL; 21.4 min   **75.** $\approx 3.9665°C$
77. About 4.1 months after Jan. 1
79. (a) $r = \frac{2}{3}r_0$ (b) $v = \frac{4}{27}kr_0^3$

(c)

EXERCISES 4.2 ■ PAGE 295

1. $1, 5$
3. (a) g is continuous on $[0, 8]$ and differentiable on $(0, 8)$.
(b) $2.2, 6.4$ (c) $3.7, 5.5$
5. No   **7.** Yes; ≈ 3.8
9. 1 **11.** π
13. f is not differentiable on $(-1, 1)$ **15.** 1
**17.** $3/\ln 4$ **19.** 1; yes
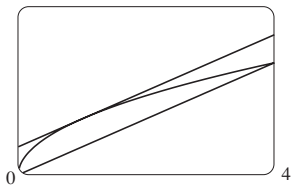
**21.** f is not continous at 3   **29.** 16   **31.** No   **37.** No

EXERCISES 4.3 ■ PAGE 305

Abbreviations: CD, concave downward; CU, concave upward;
dec, decreasing; inc, increasing; HA, horizontal asymptote;
IP, inflection point; VA, vertical asymptote
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 $(0,1), (3,5)$; dec on $(1,3), (5,6)$
(b) Loc max at $x = 1$, $x = 5$; loc min at $x = 3$
7. (a) $3, 5$ (b) $2, 4, 6$ (c) $1, 7$
9. Inc on $(-\infty,1), (4, \infty)$; dec on $(1, 4)$; loc max $f(1) = 6$;
loc min $f(4) = -21$
11. Inc on $(2, \infty)$; dec on $(-\infty, 2)$; loc min $f(2) = -31$
13. Inc on $(-\infty, 4), (6, \infty)$; dec on $(4, 5), (5, 6)$;
loc max $f(4) = 8$; loc min $f(6) = 12$
15. Inc on $(0, \pi/4), (5\pi/4, 2\pi)$; dec on $(\pi/4, 5\pi/4)$;
loc max $f(\pi/4) = \sqrt{2}$; loc min $f(5\pi/4) = -\sqrt{2}$
17. CU on $(1, \infty)$; CD on $(-\infty, 1)$; IP $(1, -7)$
19. CU on $(0, \pi/4), (3\pi/4, \pi)$; CD on $(\pi/4, 3\pi/4)$;
IP $\left(\pi/4, \frac{1}{2}\right), \left(3\pi/4, \frac{1}{2}\right)$
21. CU on $(-\sqrt{5}, \sqrt{5})$; CD on $(-\infty, -\sqrt{5}), (\sqrt{5}, \infty)$;
IP $(\pm\sqrt{5}, \ln 10)$
23. (a) Inc on $(-1, 0), (1, \infty)$; dec on $(-\infty, -1), (0, 1)$
(b) Loc max $f(0) = 3$; loc min $f(\pm 1) = 2$
(c) CU on $(-\infty, -\sqrt{3}/3), (\sqrt{3}/3, \infty)$;
CD on $(-\sqrt{3}/3, \sqrt{3}/3)$; IP $\left(\pm\sqrt{3}/3, \frac{22}{9}\right)$
25. (a) Inc on $(1, \infty)$; dec on $(0, 1)$ (b) Loc min $f(1) = 0$
(c) CU on $(0, \infty)$; No IP
27. (a) Inc on $\left(-\frac{1}{2}, \infty\right)$; dec on $\left(-\infty, -\frac{1}{2}\right)$

(b) Loc min $f\left(-\frac{1}{2}\right) = -\dfrac{1}{2e}$

(c) CU on $(-1, \infty)$; CD on $(-\infty, -1)$; IP $\left(-1, -\dfrac{1}{e^2}\right)$
29. Loc max $f(1) = 2$; loc min $f(0) = 1$ **31.** $(-3, \infty)$
33. (a) f has a local maximum at 2.
(b) f has a horizontal tangent at 6.
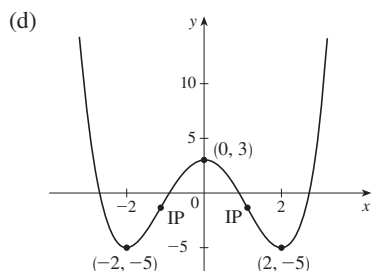**35.** (a)

(b)

37.

39.

41.
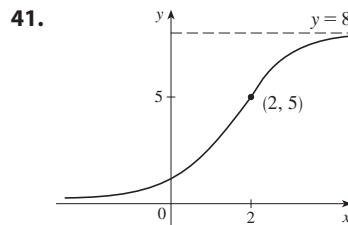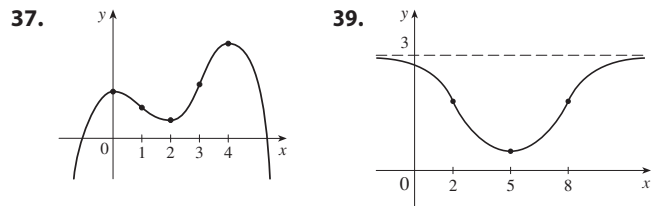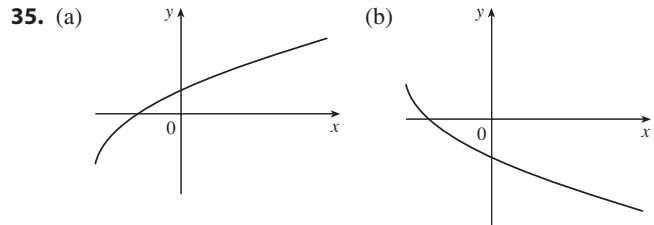
43. (a) Inc on $(0, 2)$, $(4, 6)$, $(8, \infty)$;
dec on $(2, 4)$, $(6, 8)$
(b) Loc max at $x = 2, 6$;
loc min at $x = 4, 8$
(c) CU on $(3, 6)$, $(6, \infty)$;
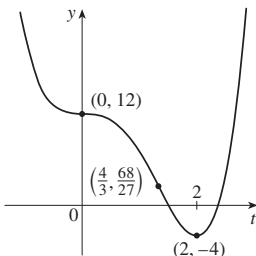CD on $(0, 3)$ (d) 3
(e) See graph at right.
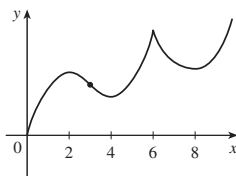
45. (a) Inc on $(-\infty, 0)$, $(2, \infty)$;
dec on $(0, 2)$
(b) Loc max $f(0) = 4$; loc min
$f(2) = 0$
(c) CU on $(1, \infty)$; CD on $(-\infty, 1)$;
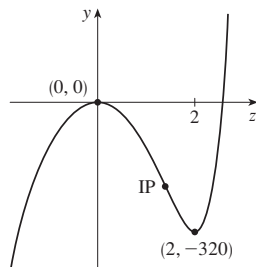IP $(1, 2)$
(d) See graph at right.
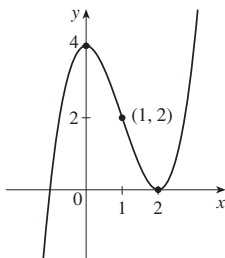
47. (a) Inc on $(-2, 0)$, $(2, \infty)$; dec on $(-\infty, -2)$, $(0, 2)$
(b) Loc max $f(0) = 3$; loc min $f(\pm 2) = -5$

(c) CU on $\left(-\infty, -\dfrac{2}{\sqrt{3}}\right)$, $\left(\dfrac{2}{\sqrt{3}}, \infty\right)$; CD on $\left(-\dfrac{2}{\sqrt{3}}, \dfrac{2}{\sqrt{3}}\right)$;

IPs $\left(\pm\dfrac{2}{\sqrt{3}}, -\dfrac{13}{9}\right)$

(d)

49. (a) Inc on $(2, \infty)$; dec on $(-\infty, 2)$
(b) Loc min $g(2) = -4$
(c) CU on $(-\infty, 0)$, $\left(\frac{4}{3}, \infty\right)$;
CD on $\left(0, \frac{4}{3}\right)$; IPs $(0, 12)$, $\left(\frac{4}{3}, \frac{68}{27}\right)$
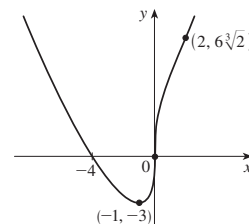(d) See graph at right.

51. (a) Inc on $(-\infty, 0)$, $(2, \infty)$;
dec on $(0, 2)$
(b) Loc max $f(0) = 0$; loc min
$f(2) = -320$
(c) CU on $\left(\sqrt[5]{\frac{16}{3}}, \infty\right)$;
CD on $\left(-\infty, \sqrt[5]{\frac{16}{3}}\right)$;
IP $\left(\sqrt[5]{\frac{16}{3}}, -\frac{320}{3}\sqrt[5]{\frac{256}{9}}\right) \approx (1.398, -208.4)$
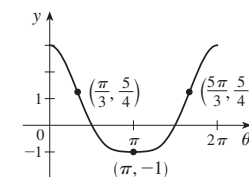(d) See graph at right.

53. (a) Inc on $(-\infty, 4)$;
dec on $(4, 6)$
(b) Loc max $F(4) = 4\sqrt{2}$
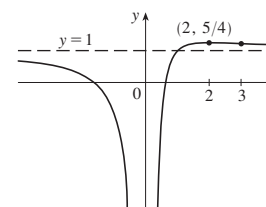(c) CD on $(-\infty, 6)$; No IP
(d) See graph at right.
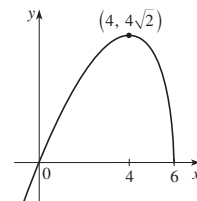
55. (a) Inc on $(-1, \infty)$;
dec on $(-\infty, -1)$
(b) Loc min $C(-1) = -3$
(c) CU on $(-\infty, 0)$, $(2, \infty)$;
CD on $(0, 2)$;
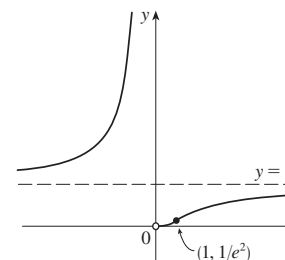IPs $(0, 0)$, $\left(2, 6\sqrt[3]{2}\right)$
(d) See graph at right.

57. (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 $(0, \pi/3)$, $(5\pi/3, 2\pi)$;
IPs $\left(\pi/3, \frac{5}{4}\right)$, $\left(5\pi/3, \frac{5}{4}\right)$
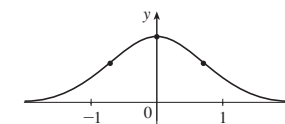(d) See graph at right.

59. (a) VA $x = 0$; HA $y = 1$
(b) Inc on $(0, 2)$;
dec on $(-\infty, 0)$, $(2, \infty)$
(c) Loc max $f(2) = \frac{5}{4}$
(d) CU on $(3, \infty)$;
CD on $(-\infty, 0)$, $(0, 3)$; IP $\left(3, \frac{11}{9}\right)$
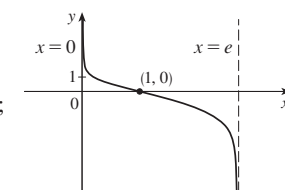(e) See graph at right.

61. (a) VA $x = 0$; HA $y = 1$
(b) Inc on $(-\infty, 0)$, $(0, \infty)$
(c) None
(d) CU on $(-\infty, 0)$, $(0, 1)$;
CD on $(1, \infty)$;
IP $(1, 1/e^2)$
(e) See graph at right.

63. (a) HA $y = 0$
(b) Inc on $(-\infty, 0)$;
dec on $(0, \infty)$
(c) Loc max $f(0) = 1$
(d) CU on $\left(-\infty, -1/\sqrt{2}\right)$,
$\left(1/\sqrt{2}, \infty\right)$; CD on $\left(-1/\sqrt{2}, 1/\sqrt{2}\right)$; IPs $\left(\pm 1/\sqrt{2}, e^{-1/2}\right)$
(e) See graph at right.

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

67. f is CU on $(-\infty, \infty)$ for all $c > 0$. As c increases, the minimum point gets farther away from the origin.
69. (a) Loc and abs max $f(1) = \sqrt{2}$, no min (b) $\frac{1}{4}(3 - \sqrt{17})$
71. (b) CD on $(0, 0.85)$, $(1.57, 2.29)$; CU on $(0.85, 1.57)$, $(2.29, \pi)$; IPs $(0.85, 0.74)$, $(1.57, 0)$, $(2.29, -0.74)$
73. CU on $(-\infty, -0.6)$, $(0.0, \infty)$; CD on $(-0.6, 0.0)$
75. (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) $(8, 350)$
77. If $D(t)$ is the size of the deficit as a function of time, then at the time of the speech $D'(t) > 0$, but $D''(t) < 0$.
79. $K(3) - K(2)$; CD
81. 28.57 min, when the rate of increase of drug level in the bloodstream is greatest; 85.71 min, when rate of decrease is greatest

2000

0   250
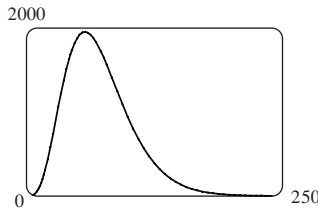
83. $f(x) = \frac{1}{9}(2x^3 + 3x^2 - 12x + 7)$

EXERCISES 4.4 ■ PAGE 316

1. (a) Indeterminate (b) 0 (c) 0
(d) ∞, $-\infty$, or does not exist (e) Indeterminate
3. (a) $-\infty$ (b) Indeterminate (c) ∞
5. $\frac{9}{4}$ **7.** 1 **9.** 6 **11.** $\frac{7}{3}$ **13.** $\sqrt{2}/2$ **15.** 2
17. $\frac{1}{4}$ **19.** 0 **21.** $-\infty$ **23.** $-\frac{1}{3}$ **25.** 3 **27.** 2
29. 1 **31.** 1 **33.** $1/\ln 3$ **35.** 0 **37.** 0
39. a/b **41.** $\frac{1}{24}$ **43.** π **45.** $\frac{5}{3}$ **47.** 0
49. $-2/\pi$ **51.** $\frac{1}{2}$ **53.** $\frac{1}{2}$ **55.** 0 **57.** 1 **59.** e^{-2}
61. $1/e$ **63.** 1 **65.** e^4 **67.** e^3 **69.** 0
71. e^2 **73.** $\frac{1}{4}$ **77.** 1
79. f has an absolute minimum for $c > 0$. As c increases, the minimum points get farther away from the origin.
83. (a) M; the population should approach its maximum size as time increases (b) $P_0 e^{kt}$; exponential
85. $\frac{16}{9}a$ **87.** $\frac{1}{2}$
89. (a) One possibility: $f(x) = 7/x^2$, $g(x) = 1/x^2$
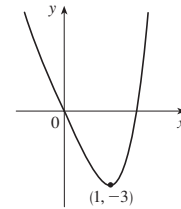(b) One possibility: $f(x) = 7 + (1/x^2)$, $g(x) = 1/x^2$
91. (a) 0

EXERCISES 4.5 ■ PAGE 327

*Abbreviations:* int, intercept; SA, slant asymptote
1. A. $\mathbb{R}$ B. y-int 0; x-int $-3, 0$
C. None D. None
E. Inc on $(-\infty, -2)$, $(0, \infty)$;
dec on $(-2, 0)$
F. Loc max $f(-2) = 4$;
loc min $f(0) = 0$
G. CU on $(-1, \infty)$; CD on $(-\infty, -1)$;
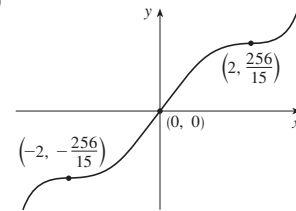IP $(-1, 2)$
H. See graph at right.

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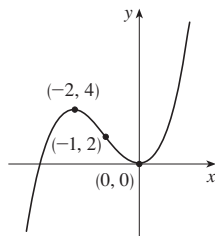
3. A. $\mathbb{R}$ B. y-int 0; x-int 0, $\sqrt[3]{4}$
C. None D. None
E. Inc on $(1, \infty)$; dec on $(-\infty, 1)$
F. Loc min $f(1) = -3$
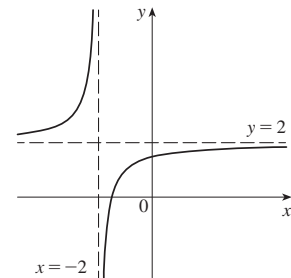G. CU on $(-\infty, \infty)$
H. See graph at right.

$(1, -3)$

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 $(2, 4)$;
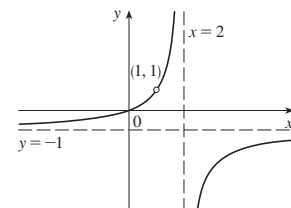IPs $(2, -16)$, $(4, 0)$
H. See graph at right.

$(4, 0)$
$(2, -16)$
$(1, -27)$
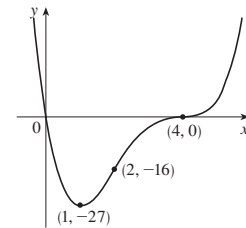
7. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About $(0, 0)$ D. None
E. Inc on $(-\infty, \infty)$
F. None
G. CU on $(-2, 0)$, $(2, \infty)$;
CD on $(-\infty, -2)$, $(0, 2)$;
IPs $\left(-2, -\frac{256}{15}\right)$, $(0, 0)$, $\left(2, \frac{256}{15}\right)$
H. See graph at right.

$\left(2, \frac{256}{15}\right)$
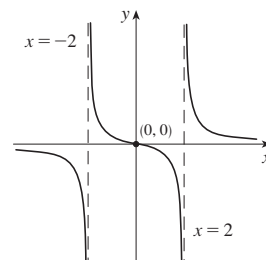$(0, 0)$
$\left(-2, -\frac{256}{15}\right)$

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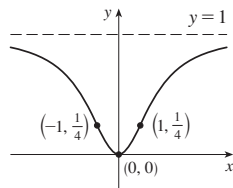CD on $(-2, \infty)$
H. See graph at right.

$y = 2$
$x = -2$

11. A. $(-\infty, 1) \cup (1, 2) \cup (2, \infty)$
B. y-int 0; x-int 0 C. None
D. VA $x = 2$; HA $y = -1$
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.

$x = 2$
$(1, 1)$
$y = -1$

13. A. $(-\infty, -2) \cup (-2, 2) \cup (2, \infty)$ B. y-int 0; x-int 0
C. About $(0, 0)$ D. VA $x = \pm 2$; HA $y = 0$
E. Dec on $(-\infty, -2)$, $(-2, 2)$, $(2, \infty)$
F. No local extrema
G. CU on $(-2, 0)$, $(2, \infty)$;
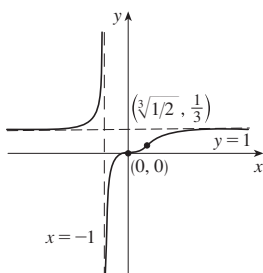CD on $(-\infty, -2)$, $(0, 2)$; IP $(0, 0)$
H. See graph at right.

$x = -2$
$(0, 0)$
$x = 2$

15. 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 $(-\infty, -1)$, $(1, \infty)$; IPs $\left(\pm 1, \frac{1}{4}\right)$
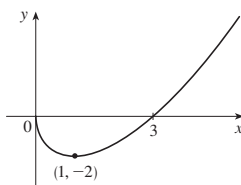H. See graph at right.

17. A. $(-\infty, 0) \cup (0, \infty)$ B. x-int 1
C. None   D. VA $x = 0$; HA $y = 0$
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 $\left(3, \frac{2}{9}\right)$
H. See graph at right.
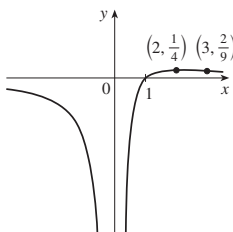
19. A. $(-\infty, -1) \cup (-1, \infty)$
B. y-int 0; x-int 0   C. None
D. VA $x = -1$; HA $y = 1$
E. Inc on $(-\infty, -1)$, $(-1, \infty)$;
F. None
G. CU on $(-\infty, -1)$, $\left(0, \sqrt[3]{\frac{1}{2}}\right)$;
CD on $(-1, 0)$, $\left(\sqrt[3]{\frac{1}{2}}, \infty\right)$;
IPs $(0, 0)$, $\left(\sqrt[3]{\frac{1}{2}}, \frac{1}{3}\right)$
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

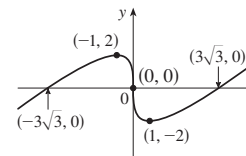G. CD on $(-\infty, -2)$, $(1, \infty)$

H. See graph at right.
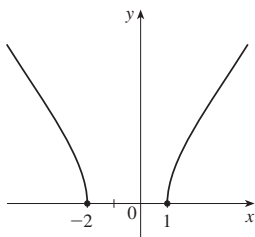
25. A. $\mathbb{R}$ B. y-int 0; x-int 0
C. About $(0, 0)$
D. HA $y = \pm 1$
E. Inc on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$;
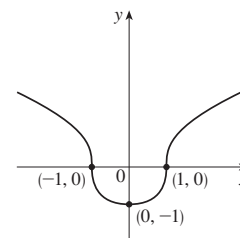CD on $(0, \infty)$; IP $(0, 0)$
H. See graph at right.
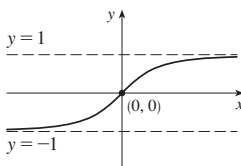
27. A. $[-1, 0) \cup (0, 1]$ B. x-int ± 1 C. About $(0, 0)$
D. VA $x = 0$
E. Dec on $(-1, 0)$, $(0, 1)$
F. None
G. CU on $\left(-1, -\sqrt{2/3}\right)$, $\left(0, \sqrt{2/3}\right)$;
CD on $\left(-\sqrt{2/3}, 0\right)$, $\left(\sqrt{2/3}, 1\right)$;
IPs $\left(\pm\sqrt{2/3}, \pm 1/\sqrt{2}\right)$
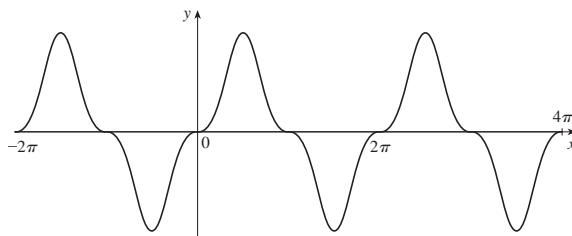H. See graph at right.
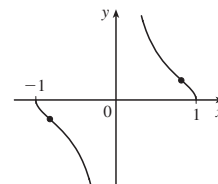
29. A. $\mathbb{R}$ B. y-int 0; x-int $\pm 3\sqrt{3}$, 0   C. About $(0, 0)$
D. None   E. Inc on $(-\infty, -1)$, $(1, \infty)$; dec on $(-1, 1)$
F. Loc max $f(-1) = 2$;
loc min $f(1) = -2$
G. CU on $(0, \infty)$;
CD on $(-\infty, 0)$; IP $(0, 0)$
H. See graph at right.

31. A. $\mathbb{R}$ B. y-int -1; x-int ± 1
C. About the 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 $(-\infty, -1)$, $(1, \infty)$; IPs $(\pm 1, 0)$
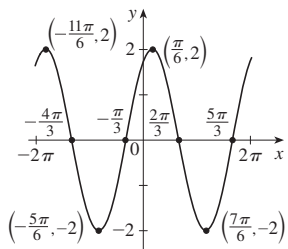H. See graph at right.

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 $0 \leqslant x \leqslant \pi$:
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 $(\alpha, \pi - \alpha)$; IPs 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 $(-\pi/2, \pi/2)$
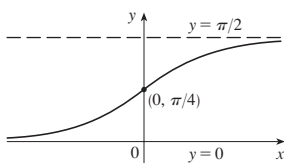H. See graph at right.
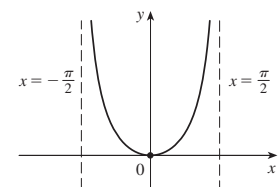
37. A. $[-2\pi, 2\pi]$
B. y-int $\sqrt{3}$; x-int $-4\pi/3, -\pi/3, 2\pi/3, 5\pi/3$
C. Period 2π D. None
E. Inc on $(-2\pi, -11\pi/6), (-5\pi/6, \pi/6), (7\pi/6, 2\pi)$;
dec on $(-11\pi/6, -5\pi/6), (\pi/6, 7\pi/6)$
F. Loc max $f(-11\pi/6) = f(\pi/6) = 2$;
loc min $f(-5\pi/6) = f(7\pi/6) = -2$
G. CU on $(-4\pi/3, -\pi/3)$,
$(2\pi/3, 5\pi/3)$;
CD on $(-2\pi, -4\pi/3)$,
$(-\pi/3, 2\pi/3), (5\pi/3, 2\pi)$;
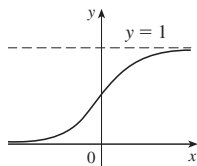IPs $(-4\pi/3, 0), (-\pi/3, 0)$,
$(2\pi/3, 0), (5\pi/3, 0)$
H. See graph at right.

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 $((2n - 1)\pi, 2n\pi)$; IPs $(2n\pi, 0)$
H.
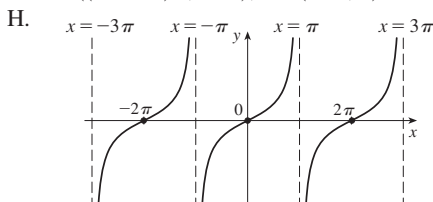
41. A. $\mathbb{R}$ B. y-int $\pi/4$
C. None
D. HA $y = 0, y = \pi/2$
E. Inc on $(-\infty, \infty)$ F. None
G. CU on $(-\infty, 0)$;
CD on $(0, \infty)$; IP $(0, \pi/4)$
H. See graph at right.

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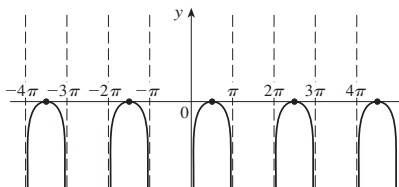H. See graph at right.

45. A. $(0, \infty)$ B. None
C. None   D. VA $x = 0$
E. Inc on $(1, \infty)$; dec on $(0, 1)$
F. Loc min $f(1) = 1$
G. CU on $(0, 2)$; CD on $(2, \infty)$;
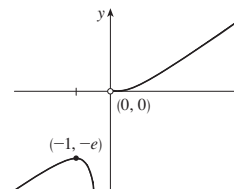IP $\left(2, \frac{1}{2} + \ln 2\right)$
H. See graph at right.
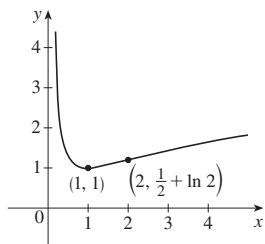
47. A. $\mathbb{R}$ B. y-int $\frac{1}{4}$
C. None
D. HA $y = 0, y = 1$
E. Dec on $\mathbb{R}$ F. None
G. CU on $\left(\ln \frac{1}{2}, \infty\right)$;
CD on $\left(-\infty, \ln \frac{1}{2}\right)$; IP $\left(\ln \frac{1}{2}, \frac{4}{9}\right)$
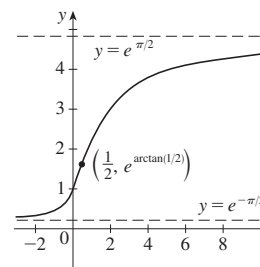H. See graph at right.
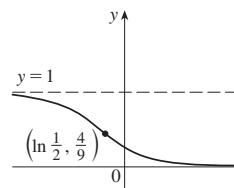
49. A. All x in $(2n\pi, (2n + 1)\pi)$ (n an integer)
B. x-int $\pi/2 + 2n\pi$ C. Period 2π D. VA $x = n\pi$
E. Inc on $(2n\pi, \pi/2 + 2n\pi)$; dec on $(\pi/2 + 2n\pi, (2n + 1)\pi)$
F. Loc max $f(\pi/2 + 2n\pi) = 0$ G. CD on $(2n\pi, (2n + 1)\pi)$
H.

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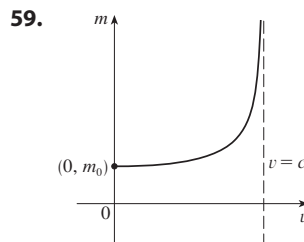H. See graph at right.

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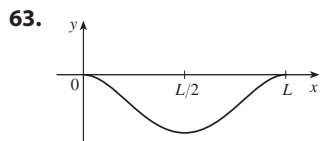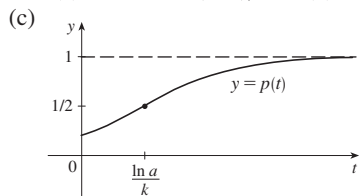H. See graph at right.

55. (a) $(-\infty, 7]$; $(-\infty, 3) \cup (3, 7)$ (b) 3, 5
(c) $-1/\sqrt{3} \approx -0.58$ (d) HA $y = \sqrt{2}$

57. (a) $\mathbb{R}$; $(-\infty, 3) \cup (3, 7) \cup (7, \infty)$ (b) 3, 5, 7, 9   (c) -2
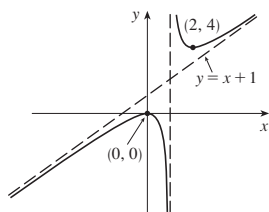(d) HA $y = 1, y = 2$

59.

61. (a) When $t = (\ln a)/k$ (b) When $t = (\ln a)/k$
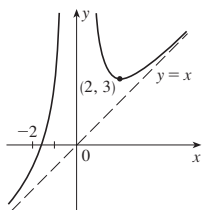
(c)

63.
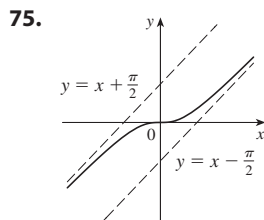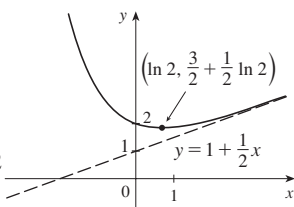

65. $y = x - 1$ **67.** $y = 2x - 3$

69. 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
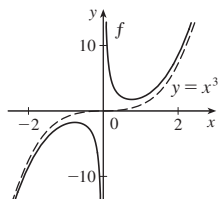$(-\infty, 1)$
H. See graph at right.

71. 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.

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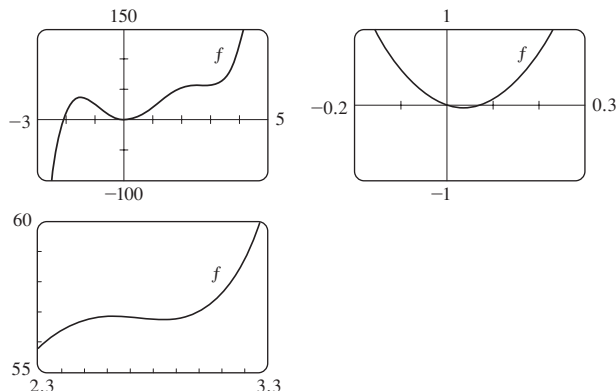G. CU on $(-\infty, \infty)$
H. See graph at right.

**75.**

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

1. Inc on $(-\infty, -1.50)$, $(0.04, 2.62)$, $(2.84, \infty)$; dec on
$(-1.50, 0.04)$, $(2.62, 2.84)$; loc max $f(-1.50) \approx 36.47$,
$f(2.62) \approx 56.83$; loc min $f(0.04) \approx -0.04$, $f(2.84) \approx 56.73$;
CU on $(-0.89, 1.15)$, $(2.74, \infty)$; CD on $(-\infty, -0.89)$, $(1.15, 2.74)$;
IPs $(-0.89, 20.90)$, $(1.15, 26.57)$, $(2.74, 56.78)$

3. Inc on $(-1.31, -0.84)$, $(1.06, 2.50)$, $(2.75, \infty)$;
dec on $(-\infty, -1.31)$, $(-0.84, 1.06)$, $(2.50, 2.75)$;
loc max $f(-0.84) \approx 23.71$, $f(2.50) \approx -11.02$; loc min
$f(-1.31) \approx 20.72$, $f(1.06) \approx -33.12$, $f(2.75) \approx -11.33$;
CU on $(-\infty, -1.10)$, $(0.08, 1.72)$, $(2.64, \infty)$;
CD on $(-1.10, 0.08)$, $(1.72, 2.64)$;
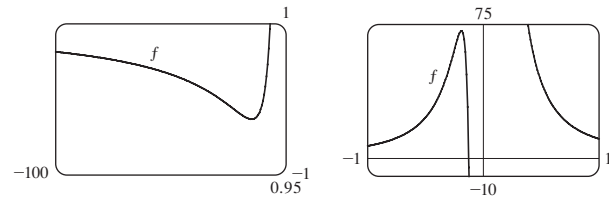IPs $(-1.10, 22.09)$, $(0.08, -3.88)$, $(1.72, -22.53)$, $(2.64, -11.18)$
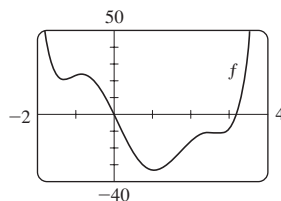
5. Inc on $(-\infty, -1.47)$, $(-1.47, 0.66)$; dec on $(0.66, \infty)$;
loc max $f(0.66) \approx 0.38$; CU on $(-\infty, -1.47)$, $(-0.49, 0)$,
$(1.10, \infty)$; CD on $(-1.47, -0.49)$, $(0, 1.10)$;
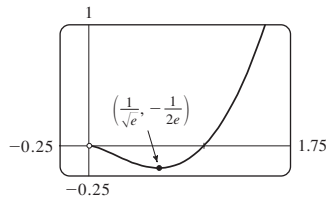IPs $(-0.49, -0.44)$, $(1.10, 0.31)$, $(0, 0)$
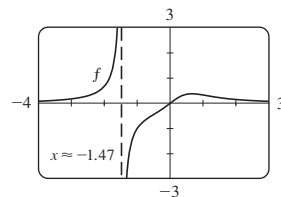
7. Inc on $(-1.40, -0.44)$, $(0.44, 1.40)$; dec on $(-\pi, -1.40)$, $(-0.44, 0)$, $(0, 0.44)$, $(1.40, \pi)$; loc max $f(-0.44) \approx -4.68$, $f(1.40) \approx 6.09$; loc min $f(-1.40) \approx -6.09$, $f(0.44) \approx 4.68$; CU on $(-\pi, -0.77)$, $(0, 0.77)$; CD on $(-0.77, 0)$, $(0.77, \pi)$; IPs $(-0.77, -5.22)$, $(0.77, 5.22)$
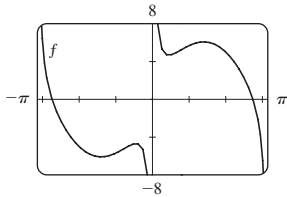
9. Inc on $\left(-8 - \sqrt{61}, -8 + \sqrt{61}\right)$; dec on $\left(-\infty, -8 - \sqrt{61}\right)$, $\left(-8 + \sqrt{61}, 0\right)$, $(0, \infty)$; CU on $\left(-12 - \sqrt{138}, -12 + \sqrt{138}\right)$, $(0, \infty)$; CD on $\left(-\infty, -12 - \sqrt{138}\right)$, $\left(-12 + \sqrt{138}, 0\right)$
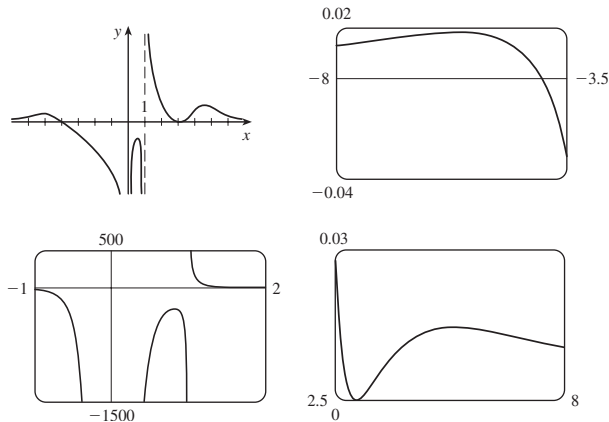

11. (a)

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

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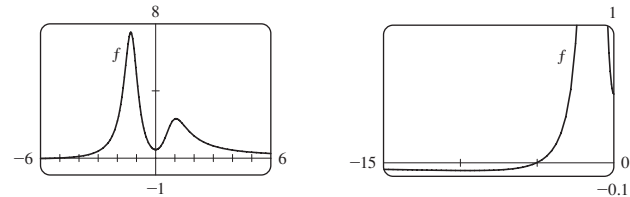

**15.** $f'(x) = -\dfrac{x(x+1)^2(x^3 + 18x^2 - 44x - 16)}{(x-2)^3(x-4)^5}$

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

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

17. 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 $(-\infty, -13.81)$, $(-1.55, -1.03)$, $(0.60, 1.48)$;
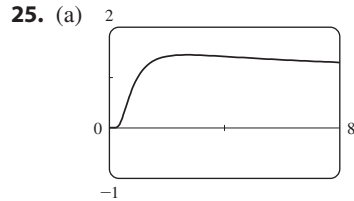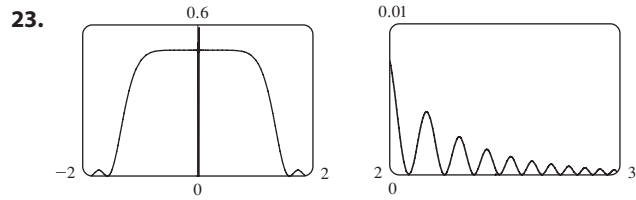IPs $(-13.81, -0.05)$, $(-1.55, 5.64)$, $(-1.03, 5.39)$, $(0.60, 1.52)$, $(1.48, 1.93)$

19. Inc on $(-4.91, -4.51)$, $(0, 1.77)$, $(4.91, 8.06)$, $(10.79, 14.34)$, $(17.08, 20)$;
dec on $(-4.51, -4.10)$, $(1.77, 4.10)$, $(8.06, 10.79)$, $(14.34, 17.08)$;
loc max $f(-4.51) \approx 0.62$, $f(1.77) \approx 2.58$, $f(8.06) \approx 3.60$, $f(14.34) \approx 4.39$;
loc min $f(10.79) \approx 2.43$, $f(17.08) \approx 3.49$;
CU on $(9.60, 12.25)$, $(15.81, 18.65)$;
CD on $(-4.91, -4.10)$, $(0, 4.10)$, $(4.91, 9.60)$, $(12.25, 15.81)$, $(18.65, 20)$;
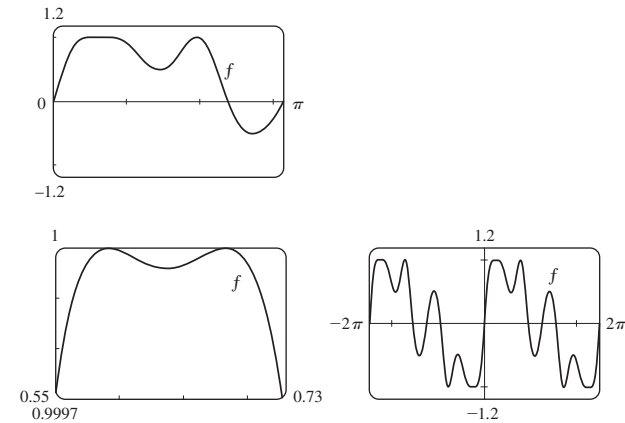IPs $(9.60, 2.95)$, $(12.25, 3.27)$, $(15.81, 3.91)$, $(18.65, 4.20)$
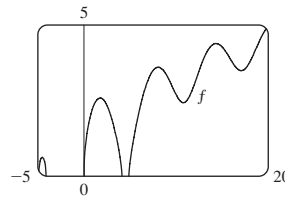
21. Inc on $(-\infty, 0)$, $(0, \infty)$;
CU on $(-\infty, -0.42)$, $(0, 0.42)$;
CD on $(-0.42, 0)$, $(0.42, \infty)$;
IPs $(\mp 0.42, \pm 0.83)$

23.

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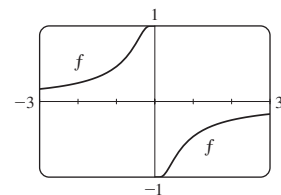
(b) $\lim_{x\to 0^+} x^{1/x} = 0$, $\lim_{x\to\infty} x^{1/x} = 1$
(c) Loc max $f(e) = e^{1/e}$ (d) IPs at $x \approx 0.58, 4.37$

27. On $[0, \pi]$: Max $f(0.59) \approx 1$, $f(0.68) \approx 1$, $f(1.96) \approx 1$;
min $f(0.64) \approx 0.99996$, $f(1.46) \approx 0.49$, $f(2.73) \approx -0.51$;
IPs $(0.61, 0.99998)$, $(0.66, 0.99998)$, $(1.17, 0.72)$,
$(1.75, 0.77)$, $(2.28, 0.34)$

29. For $c < 0$, there is a loc min that moves toward $(-3, -9)$ as
c increases. For $0 < c < 8$, there is a loc min that moves toward
$(-3, -9)$ and a loc max that moves toward the origin as c
decreases. For all $c > 0$, there is a first-quadrant loc min that
moves toward the origin as c decreases. $c = 0$ is a transitional
value that gives the graph of a parabola. For all nonzero c, the
y-axis is a VA and there is an IP that moves toward the origin
as $|c| \to 0$.

$c \leqslant 0$:


$c \geqslant 0$:
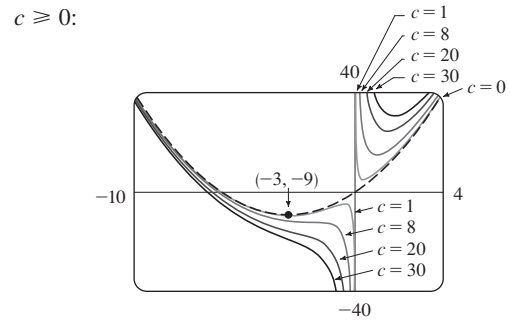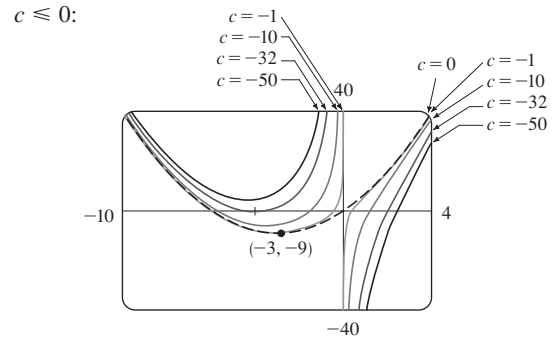
31. For $c < 0$, there is no extreme point and one IP, which
decreases along the x-axis. For $c > 0$, there is no IP, and one
minimum point.
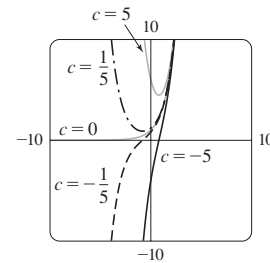
33. For $c > 0$, the maximum and minimum values are always
$\pm\frac{1}{2}$, but the extreme points and IPs move closer to the y-axis as c
increases. $c = 0$ is a transitional value: when c is replaced by $-c$,
the curve is reflected in the x-axis.
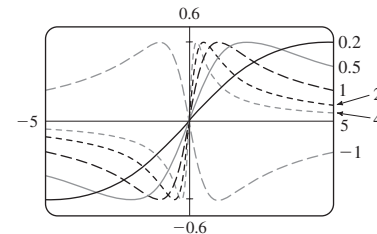
35. For $|c| < 1$, the graph has loc max and min values; for $|c| \geq 1$ it does not. The function increases for $c \geq 1$ and decreases for $c \leq -1$. As c changes, the IPs move vertically but not horizontally.
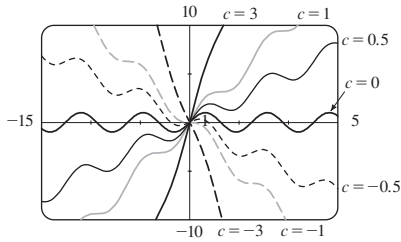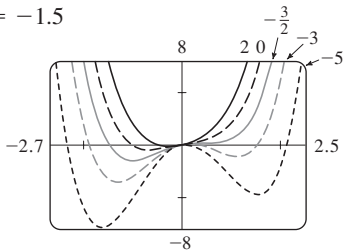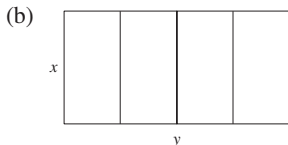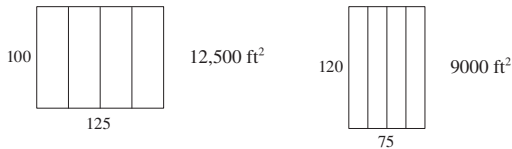

37.
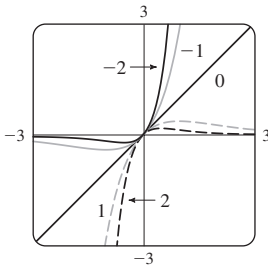
For $c > 0$, $\lim_{x\to\infty} f(x) = 0$ and $\lim_{x\to-\infty} f(x) = -\infty$.
For $c < 0$, $\lim_{x\to\infty} f(x) = \infty$ and $\lim_{x\to-\infty} f(x) = 0$.
As $|c|$ increases, the max and min points and the IPs get closer to the origin.

39. $c = 0$; $c = -1.5$

EXERCISES 4.7 ▪ PAGE 342

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 ft^2
13. 1000 ft by 1500 ft, middle fence parallel to short side
15. 125 ft by $\frac{250}{3}$ ft **19.** 4000 cm^3 **21.** $\approx$\$163.54
23. 18 in. by 18 in. by 36 in.
25. $\left(-\frac{6}{5}, \frac{3}{5}\right)$ **27.** $\left(-\frac{1}{3}, \pm\frac{4}{3}\sqrt{2}\right)$ **29.** Square, side $\sqrt{2}\,r$
31. $L/2$, $\sqrt{3}\,L/4$ **33.** Base $\sqrt{3}\,r$, height $3r/2$
37. $4\pi r^3/(3\sqrt{3})$ **39.** $\pi r^2(1 + \sqrt{5})$
41. 24 cm by 36 cm
43. (a) Use all of the wire for the square
(b) $40\sqrt{3}/(9 + 4\sqrt{3})$ m for the square
45. 16 in. **47.** $V = 2\pi R^3/(9\sqrt{3})$ **51.** $E^2/(4r)$
53. (a) $\frac{3}{2}s^2\csc\theta\,(\csc\theta - \sqrt{3}\cot\theta)$ (b) $\cos^{-1}(1/\sqrt{3}) \approx 55°$
(c) $6s\left[h + s/(2\sqrt{2})\right]$
55. Row directly to B **57.** $\approx$4.85 km east of the refinery
59. $10\sqrt[3]{3}/(1 + \sqrt[3]{3}) \approx 5.91$ ft from the stronger source
61. $(a^{2/3} + b^{2/3})^{3/2}$ **63.** $2\sqrt{6}$
65. (b) (i) \$342,491; \$342.49/unit; \$389.74/unit
(ii) 400 (iii) \$320/unit
67. (a) $p(x) = 19 - \frac{1}{3000}x$ (b) \$9.50
69. (a) $p(x) = 500 - \frac{1}{8}x$ (b) \$250 (c) \$310
75. 9.35 m **79.** $x = 6$ in. **81.** $\pi/6$
83. At a distance $5 - 2\sqrt{5} \approx 0.53$ from A **85.** $\frac{1}{2}(L + W)^2$
87. (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) $\approx$1.07; no such value (d) $\sqrt{41}/4 \approx 1.6$

EXERCISES 4.8 ▪ PAGE 354

1. (a) $x_2 \approx 7.3$, $x_3 \approx 6.8$ (b) Yes
3. $\frac{9}{2}$ **5.** a, b, c **7.** 1.5215 **9.** -1.25
11. 2.94283096 **13.** (b) 2.630020 **15.** -1.914021
17. 1.934563 **19.** -1.257691, 0.653483
21. -1.428293, 2.027975
23. -1.69312029, -0.74466668, 1.26587094
25. 0.76682579 **27.** -0.87828292, 0.79177077
29. (b) 31.622777
35. (a) -1.293227, -0.441731, 0.507854 (b) -2.0212
37. (1.519855, 2.306964) **39.** (0.410245, 0.347810)
41. 0.76286%

EXERCISES 4.9 ▪ PAGE 361

1. (a) $F(x) = 6x$ (b) $G(t) = t^3$
3. (a) $H(q) = \sin q$ (b) $F(x) = e^x$
5. $F(x) = 2x^2 + 7x + C$ **7.** $F(x) = \frac{1}{2}x^4 - \frac{2}{9}x^3 + \frac{5}{2}x^2 + C$
9. $F(x) = 4x^3 + 4x^2 + C$ **11.** $G(x) = 12x^{1/3} - \frac{3}{4}x^{8/3} + C$
13. $F(x) = 2x^{3/2} - \frac{3}{2}x^{4/3} + C$
15. $F(t) = \frac{4}{3}t^{3/2} - 8\sqrt{t} + 3t + C$
17. $F(x) = \dfrac{2}{5}\ln|x| + \dfrac{3}{x} + C$
19. $G(t) = 7e^t - e^3t + C$

21. $F(\theta) = -2\cos\theta - 3\sec\theta + C$
23. $F(r) = 4\tan^{-1}r - \frac{5}{9}r^{9/5} + C$
25. $F(x) = 2^x/\ln 2 + 4\cosh x + C$
27. $F(x) = 2e^x - 3x^2 - 1$
29. $f(x) = 4x^3 + Cx + D$
31. $f(x) = \frac{1}{5}x^5 + 4x^3 - \frac{1}{2}x^2 + Cx + D$
33. $f(x) = \frac{1}{3}x^3 + 3e^x + Cx + D$
35. $f(t) = 2t^3 + \cos t + Ct^2 + Dt + E$
37. $f(x) = 2x^4 + \ln x - 5$
39. $f(t) = 4\arctan t - \pi$
41. $f(x) = 3x^{5/3} - 75$
43. $f(t) = \tan t + \sec t - 2 - \sqrt{2}$
45. $f(x) = -x^2 + 2x^3 - x^4 + 12x + 4$
47. $f(\theta) = -\sin\theta - \cos\theta + 5\theta + 4$
49. $f(x) = 2x^2 + x^3 + 2x^4 + 2x + 3$
51. $f(x) = e^x + 2\sin x - \dfrac{2}{\pi}\left(e^{\pi/2} + 4\right)x + 2$
53. $f(x) = -\ln x + (\ln 2)x - \ln 2$
55. 8   **57.** b
59.

61.

63.
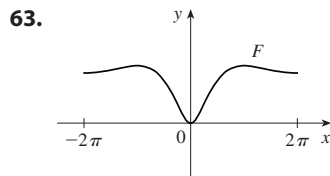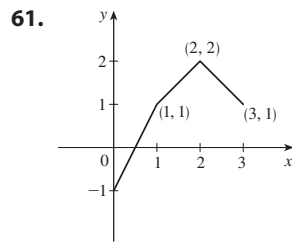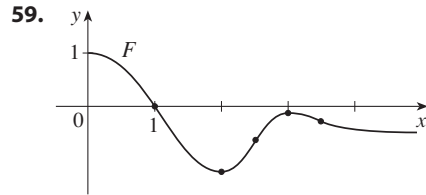
65. $s(t) = 2\sin t - 4\cos t + 7$
67. $s(t) = \frac{1}{3}t^3 + \frac{1}{2}t^2 - 2t + 3$
69. $s(t) = -\sin t + \cos t + \dfrac{8}{\pi}t - 1$
71. (a) $s(t) = 450 - 4.9t^2$ (b) $\sqrt{450/4.9} \approx 9.58$ s
(c) $-9.8\sqrt{450/4.9} \approx -93.9$ m/s   (d) About 9.09 s
75. 225 ft   **77.** \$742.08   **79.** $\frac{130}{11} \approx 11.8$ s
81. $\frac{88}{15} \approx 5.87$ ft/s²   **83.** 62,500 km/h² ≈ 4.82 m/s²
85. (a) 62.75 mi   (b) 54.5 mi   (c) 21 min 50 s
(d) 107 mi

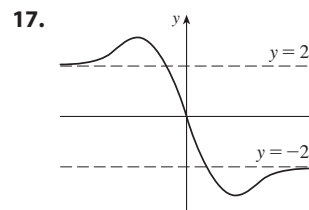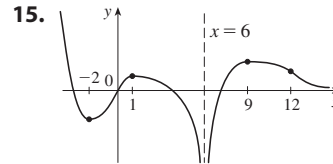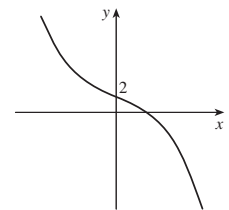**CHAPTER 4 REVIEW** ▪ **PAGE 364**

True-False Quiz
1. False   **3.** False   **5.** True   **7.** False   **9.** True
11. True   **13.** False   **15.** True   **17.** True
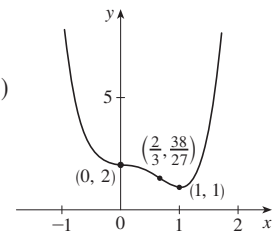**19.** True   **21.** False

Exercises
1. Abs max $f(2) = f(5) = 18$, abs min $f(0) = -2$,
loc max $f(2) = 18$, loc min $f(4) = 14$
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. 1   **9.** 4   **11.** 0   **13.** $\frac{1}{2}$
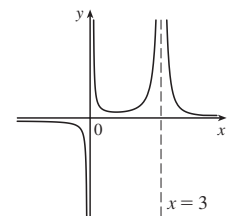**15.**

17.

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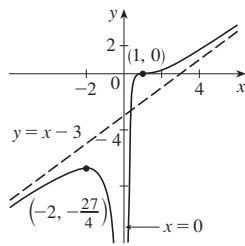CD on $(0, \infty)$; IP $(0, 2)$
H. See graph at right.

21. A. $\mathbb{R}$ B. y-int 2
C. None   D. None
E. Inc on $(1, \infty)$; dec on $(-\infty, 1)$
F. Loc min $f(1) = 1$
G. CU on $(-\infty, 0)$, $\left(\frac{2}{3}, \infty\right)$;
CD on $\left(0, \frac{2}{3}\right)$; IPs $(0, 2)$, $\left(\frac{2}{3}, \frac{38}{27}\right)$
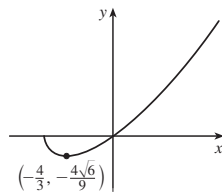H. See graph at right.

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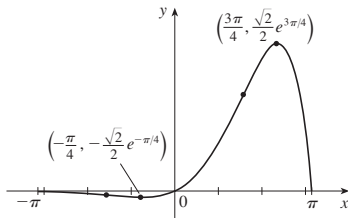CD on $(-\infty, 0)$
H. See graph at right.

25. A. $(-\infty, 0) \cup (0, \infty)$
B. x-int 1 C. None
D. VA $x = 0$; SA $y = x - 3$
E. Inc on $(-\infty, -2)$, $(0, \infty)$;
dec on $(-2, 0)$
F. Loc max $f(-2) = -\frac{27}{4}$
G. CU on $(1, \infty)$; CD on $(-\infty, 0)$,
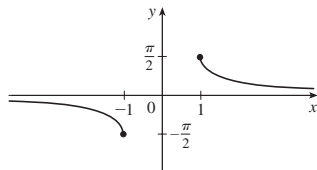$(0, 1)$; IP $(1, 0)$
H. See graph at right.

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

29. A. $[-\pi, \pi]$ B. y-int 0; x-int $-\pi, 0, \pi$
C. None D. None
E. Inc on $(-\pi/4, 3\pi/4)$; dec on $(-\pi, -\pi/4)$, $(3\pi/4, \pi)$
F. Loc max $f(3\pi/4) = \frac{1}{2}\sqrt{2}\,e^{3\pi/4}$,
loc min $f(-\pi/4) = -\frac{1}{2}\sqrt{2}\,e^{-\pi/4}$
G. CU on $(-\pi/2, \pi/2)$; CD on $(-\pi, -\pi/2)$, $(\pi/2, \pi)$;
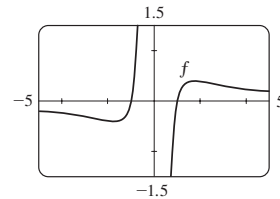IPs $(-\pi/2, -e^{-\pi/2})$, $(\pi/2, e^{\pi/2})$
H.

31. A. $(-\infty, -1] \cup [1, \infty)$
B. None C. About $(0, 0)$
D. HA $y = 0$
E. Dec on $(-\infty, -1)$, $(1, \infty)$
F. None
G. CU on $(1, \infty)$;
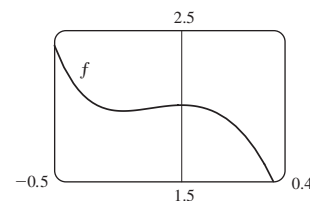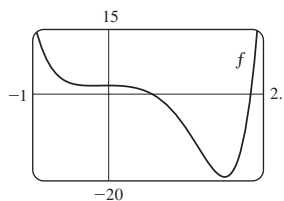CD on $(-\infty, -1)$
H. See graph at right.

33. A. $\mathbb{R}$
B. y-int -2; x-int 2
C. None D. HA $y = 0$
E. Inc on $(-\infty, 3)$; dec on $(3, \infty)$
F. Loc max $f(3) = e^{-3}$
G. CU on $(4, \infty)$;
CD on $(-\infty, 4)$;
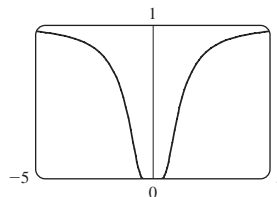IP $(4, 2e^{-4})$
H. See graph at right.
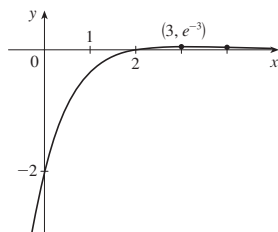
35. Inc on $\left(-\sqrt{3}, 0\right)$, $\left(0, \sqrt{3}\right)$;
dec on $\left(-\infty, -\sqrt{3}\right)$, $\left(\sqrt{3}, \infty\right)$;
loc max $f\left(\sqrt{3}\right) = \frac{2}{9}\sqrt{3}$,
loc min $f\left(-\sqrt{3}\right) = -\frac{2}{9}\sqrt{3}$;
CU on $\left(-\sqrt{6}, 0\right)$, $\left(\sqrt{6}, \infty\right)$;
CD on $\left(-\infty, -\sqrt{6}\right)$, $\left(0, \sqrt{6}\right)$;
IPs $\left(\sqrt{6}, \frac{5}{36}\sqrt{6}\right)$, $\left(-\sqrt{6}, -\frac{5}{36}\sqrt{6}\right)$

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

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

41. Loc max at $x \approx -2.96, -0.18, 3.01$;
loc min at $x \approx -1.57, 1.57$; IP at $x \approx -2.16, -0.75, 0.46, 2.21$
43. For $c > -1$, f is periodic with period 2π and has local
maxima at $2n\pi + \pi/2$, n an integer. For $c \le -1$, f has no graph.
For $-1 < c \le 1$, f has vertical asymptotes. For $c > 1$, f is
continuous on $\mathbb{R}$. As c increases, f moves upward and its
oscillations become less pronounced.
49. (a) 0 (b) CU on $\mathbb{R}$ **53.** $3\sqrt{3}\,r^2$
55. $4/\sqrt{3}$ cm from D **57.** $L = C$ **59.** \$11.50
61. 1.297383 **63.** 1.16718557
65. $F(x) = \frac{8}{3}x^{3/2} - 2x^3 + 3x + C$
67. $F(t) = -2\cos t - 3e^t + C$
69. $f(t) = t^2 + 3\cos t + 2$
71. $f(x) = \frac{1}{2}x^2 - x^3 + 4x^4 + 2x + 1$
73. $s(t) = t^2 - \tan^{-1}t + 1$
75. (b) $0.1e^x - \cos x + 0.9$
(c)
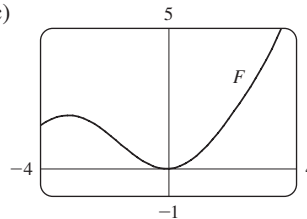
77. No
79. (b) About 8.5 in. by 2 in. (c) $20/\sqrt{3}$ in. by $20\sqrt{2/3}$ in.

85. $\tan^{-1}\left(-\dfrac{2}{\pi}\right) + 180° \approx 147.5°$

87. (a) $20\sqrt{2} \approx 28$ ft

(b) $\dfrac{dI}{dt} = \dfrac{-480k(h-4)}{[(h-4)^2 + 1600]^{5/2}}$, where k is the constant
of proportionality

PROBLEMS PLUS ■ **PAGE 369**

3. Abs max $f(-5) = e^{45}$, no abs min   **7.** 24
9. $(-2, 4)$, $(2, -4)$ **13.** $(1 + \sqrt{5})/2$ **15.** $(m/2, m^2/4)$
17. $a \leqslant e^{1/e}$
21. (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
25. $3/(\sqrt[3]{2} - 1) \approx 11\frac{1}{2}$ h

CHAPTER 5

EXERCISES 5.1 ■ PAGE 381

1. (a) Lower ≈ 12, upper ≈ 22
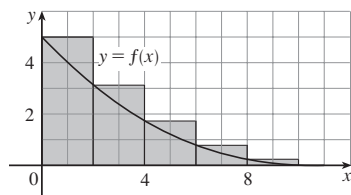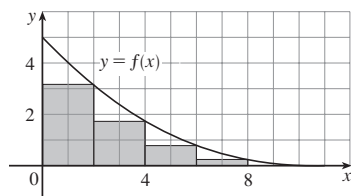
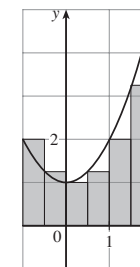(b) Lower ≈ 14.4, upper ≈ 19.4
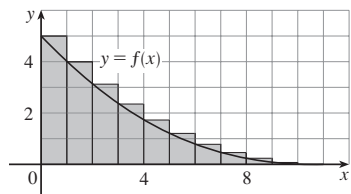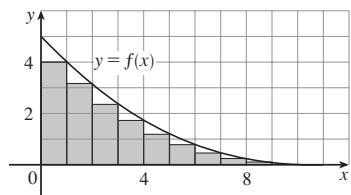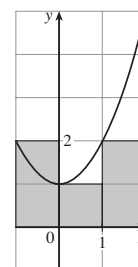

3. (a) 0.6345, underestimate   (b) 0.7595, overestimate
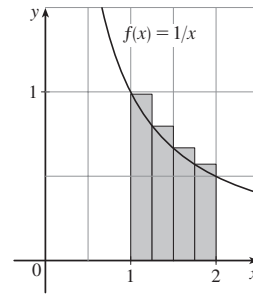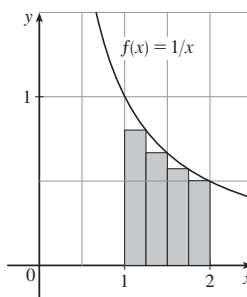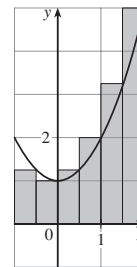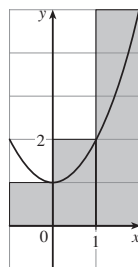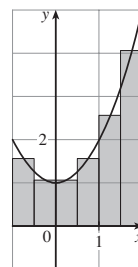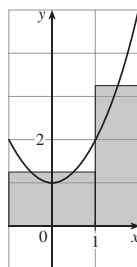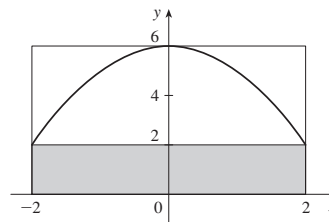

5. (a) 8, 6.875   (b) 5, 5.375

(c) 5.75, 5.9375

(d) M_6

7. $n = 2$: upper $= 24$, lower $= 8$

$n = 4$: upper $= 22$, lower $= 14$