37. Tangent line: $3x - y + 7 = 0$
Normal line: $x + 3y - 1 = 0$

39. Tangent line: $x + 2y - 10 = 0$
Normal line: $2x - y = 0$

41. Tangent line: $2x - 3y - 3 = 0$
Normal line: $3x + 2y - 11 = 0$

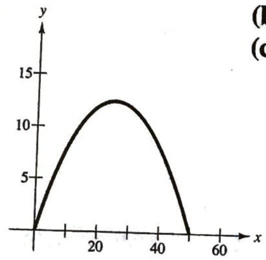
43. **(a)** $(0, -1), \left(-2, \frac{7}{3}\right)$ **(b)** $(-3, 2), \left(1, -\frac{2}{3}\right)$
(c) $\left(-1 + \sqrt{2}, \frac{2[1 - 2\sqrt{2}]}{3}\right), \left(-1 - \sqrt{2}, \frac{2[1 + 2\sqrt{2}]}{3}\right)$

45. $f'(x) = -\dfrac{2}{x^3}$ **47.** $f'(x) = \dfrac{1}{2\sqrt{x + 2}}$

49. $v(t) = 1 - \dfrac{1}{(t + 1)^2}$, $a(t) = \dfrac{2}{(t + 1)^3}$

51. **(a)** -18.667 **(b)** -7.284 **(c)** -3.240
(d) -0.747 **53.** 56 ft/sec

55. **(a)**



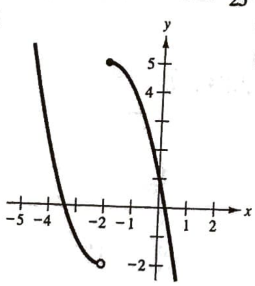
(b) 50
(c) $x = 25$
(d) $y' = 1 - 0.04x$

x	0	10	25	30	50
y'	1	0.6	0	-0.2	-1

(e) $y'(25) = 0$

59. **(a)** $2\sqrt{2}$ units/sec **(b)** 4 units/sec
(c) 8 units/sec **61.** $\frac{2}{25}$ ft/min

65. **(a)**



(b) No
(c) No

Chapter 4

Section 4.1

1. $f'(0) = 0$ **3.** $f'(4) = 0$

5. $f'(-2)$ is undefined

7. Minimum: $(2, 2)$
Maximum: $(-1, 8)$

9. Minima: $(0, 0)$ and $(3, 0)$
Maximum: $\left(\frac{3}{2}, \frac{9}{4}\right)$

11. Minima: $(-1, -4)$ and $(2, -4)$
Maxima: $(0, 0)$ and $(3, 0)$

13. Minimum: $(0, 0)$
Maximum: $(-1, 5)$

15. Minimum: $(1, 1)$
Maximum: $(4, 4)$

17. Minimum: $(1, -1)$
Maximum: $\left(0, -\frac{1}{2}\right)$

19. f is bounded on $[1, 2]$ but not bounded on $(0, 2]$.

21. **(a)** Yes **(b)** No

23. **(a)** No **(b)** Yes

25. **(a)** Minimum: $(0, -3)$
Maximum: $(2, 1)$
(b) Minimum: $(0, -3)$
(c) Maximum: $(2, 1)$
(d) No extrema

27. Maximum: $|f''(0)| = 2$

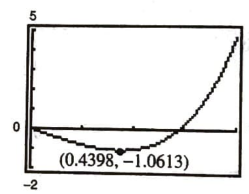
29. Maximum: $\left|f''\left(\sqrt[3]{-10 + \sqrt{108}}\right)\right| \approx 1.47$

31. Maximum: $\left|f^{(4)}\left(\frac{1}{2}\right)\right| = 360$

33. Maximum: $\left|f^{(4)}(0)\right| = \frac{56}{81}$

35. Maximum: $P(12) = 72$

37. 0.4398



Section 4.2

1. $f(0) = f(2) = 0$
f is not differentiable on $(0, 2)$

3. $f'(1) = 0$ **5.** $f'\left(\dfrac{6 - \sqrt{3}}{3}\right) = 0$
$f'\left(\dfrac{6 + \sqrt{3}}{3}\right) = 0$

7. Not differentiable at $x = 0$

9. Not differentiable at $x = 0$

11. $f'(-2 + \sqrt{5}) = 0$ **13.** $f'\left(-\frac{1}{2}\right) = -1$

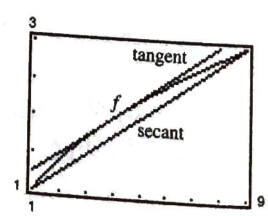
15. $f'\left(\dfrac{8}{27}\right) = 1$ **17.** $f'\left(\dfrac{-2 + \sqrt{6}}{2}\right) = \dfrac{2}{3}$

19. $f'\left(\dfrac{\sqrt{3}}{3}\right) = 1$ **21.** **(a)** $f(1) = f(2) = 64$
(b) Velocity $= 0$ for some t in $[1, 2]$

23. **(a)** -48 ft/sec **(b)** $t = \frac{3}{2}$ sec

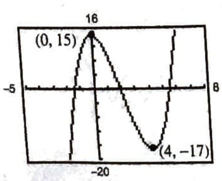
25. $f(x)$ is not continuous on $[2, 6]$

33. **(a)** $x - 4y + 3 = 0$ **(b)** $c = 4$, $x - 4y + 4 = 0$

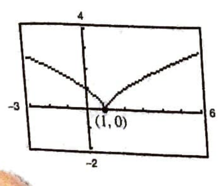


Section 4.3

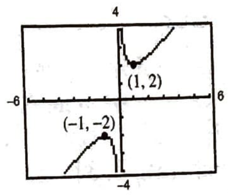
1. Increasing on $(3, \infty)$
Decreasing on $(-\infty, 3)$
3. Increasing on $(-\infty, -2)$ and $(2, \infty)$
Decreasing on $(-2, 2)$
5. Increasing on $(-\infty, 0)$
Decreasing on $(0, \infty)$
7. Critical number: $x = 1$
Increasing on $(-\infty, 1)$
Decreasing on $(1, \infty)$
Relative maximum: $(1, 5)$
9. Critical number: $x = 3$
Increasing on $(3, \infty)$
Decreasing on $(-\infty, 3)$
Relative minimum: $(3, -9)$
11. Critical numbers: $x = -2, 1$
Increasing on $(-\infty, -2)$ and $(1, \infty)$
Decreasing on $(-2, 1)$
Relative maximum: $(-2, 20)$
Relative minimum: $(1, -7)$
13. Critical number: $x = 0$
Increasing on $(-\infty, \infty)$
No relative extrema
15. Critical number: $x = 0$
Discontinuities: $x = -3, 3$
Increasing on $(-\infty, -3)$ and $(-3, 0)$
Decreasing on $(0, 3)$ and $(3, \infty)$
Relative maximum: $(0, 0)$
17. Critical numbers: $x = -1, 1$
Increasing on $(-\infty, -1)$ and $(1, \infty)$
Decreasing on $(-1, 1)$
Relative maximum: $\left(-1, \frac{4}{5}\right)$
Relative minimum: $\left(1, -\frac{4}{5}\right)$
19. Critical numbers: $x = 0, 4$
Increasing on $(-\infty, 0)$ and $(4, \infty)$
Decreasing on $(0, 4)$
Relative maximum: $(0, 15)$
Relative minimum: $(4, -17)$



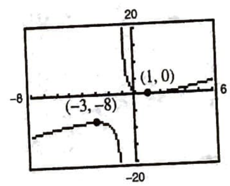
21. Critical number: $x = 1$
Increasing on $(1, \infty)$
Decreasing on $(-\infty, 1)$
Relative minimum: $(1, 0)$



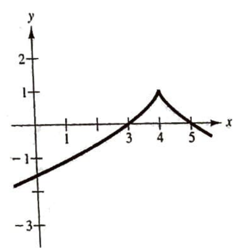
23. Critical numbers: $x = -1, 1$
Discontinuity: $x = 0$
Increasing on $(-\infty, -1)$ and $(1, \infty)$
Decreasing on $(-1, 0)$ and $(0, 1)$
Relative maximum: $(-1, -2)$
Relative minimum: $(1, 2)$



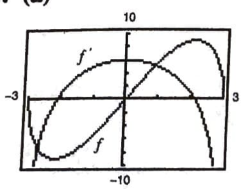
25. Critical numbers: $x = -3, 1$
Discontinuity: $x = -1$
Increasing on $(-\infty, -3)$ and $(1, \infty)$
Decreasing on $(-3, -1)$ and $(-1, 1)$
Relative maximum: $(-3, -8)$
Relative minimum: $(1, 0)$



27. (a) Not monotonic
(b) Strictly monotonic
(c) Strictly monotonic
29. Moving upward when $0 < t < 3$
Moving downward when $3 < t < 6$
Maximum height: $s(3) = 144$ ft
31. $r = \dfrac{2R}{3}$
33. Increasing when $0 < t < 84.3388$ minutes
Decreasing when $84.3388 < t < 120$ minutes
35. Increasing when $6.02 < t < 14$ days
Decreasing when $0 < t < 6.02$ days
37. $T = 10°$ 39. $f(x) = -\frac{1}{2}x^3 + \frac{3}{2}x^2$
41. $g'(0) < 0$ 43. $g'(-6) < 0$ 45. $g'(0) > 0$
47.



49. (a)



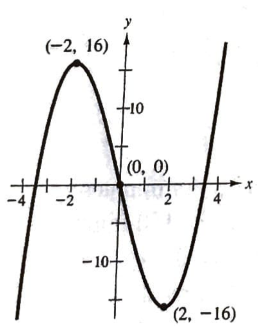
(b) Critical numbers: $x = \pm\dfrac{3\sqrt{2}}{2}$

(c) $f' > (0)$ on $\left(-\dfrac{3\sqrt{2}}{2}, \dfrac{3\sqrt{2}}{2}\right)$

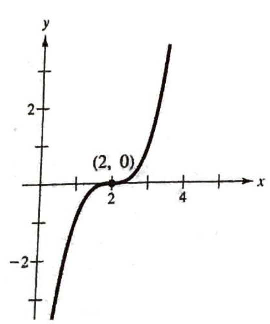
$f' < (0)$ on $\left(-3, -\dfrac{3\sqrt{2}}{2}\right), \left(\dfrac{3\sqrt{2}}{2}, 3\right)$

Section 4.4

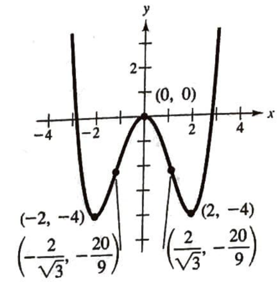
1. Concave upward: $(-\infty, \infty)$
3. Concave upward: $(-\infty, 1)$
   Concave downward: $(1, \infty)$
5. Concave upward: $(-\infty, -1)$, $(1, \infty)$
   Concave downward: $(-1, 1)$
7. Relative maximum: $(3, 9)$
9. Relative minimum: $(5, 0)$
11. Relative maximum: $(0, 3)$
    Relative minimum: $(2, -1)$
13. Relative minimum: $(3, -25)$
15. Relative minimum: $(0, -3)$
17. Relative maximum: $(-2, -4)$
    Relative minimum: $(2, 4)$
19. Relative maximum: $(-2, 16)$
    Relative minimum: $(2, -16)$
    Point of inflection: $(0, 0)$



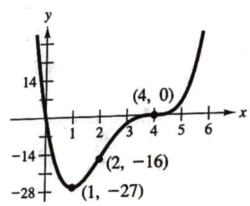
21. Point of inflection: $(2, 0)$



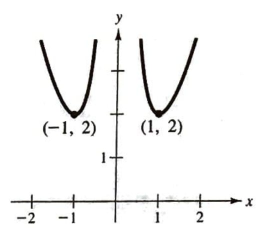
23. Relative minima: $(\pm 2, -4)$
    Relative maximum: $(0, 0)$
    Points of inflection: $\left(\pm\dfrac{2}{\sqrt{3}}, -\dfrac{20}{9}\right)$



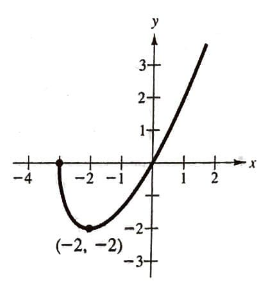
25. Relative minimum: $(1, -27)$
    Points of inflection: $(2, -16)$, $(4, 0)$



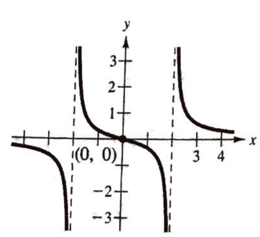
27. Relative minima: $(-1, 2)$, $(1, 2)$



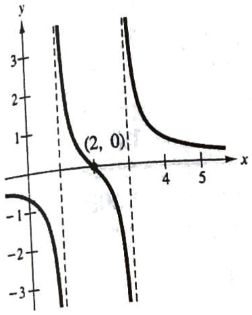
29. Relative minimum: $(-2, -2)$



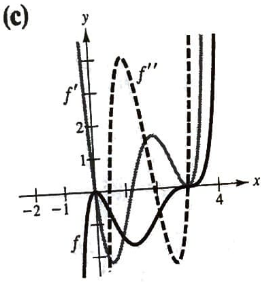
31. Point of inflection: $(0, 0)$



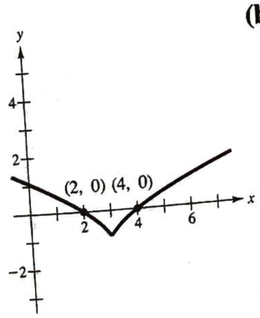
33. Point of inflection: $(2, 0)$



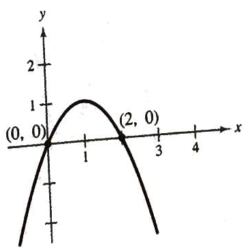
35. (a) $f'(x) = 0.2x(x - 3)^2(5x - 6)$
$f''(x) = 0.4(x - 3)(10x^2 - 24x + 9)$
(b) Relative maximum: $(0, 0)$
Relative minimum: $(1.2, -1.6796)$
Points of inflection: $(0.4652, -0.7049)$, $(1.9348, -0.9049$, $(3, 0)$
(c)



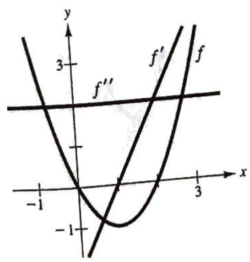
37. (a)



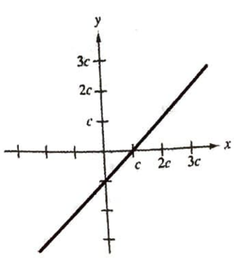
(b)

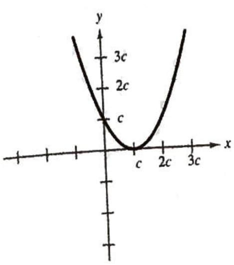


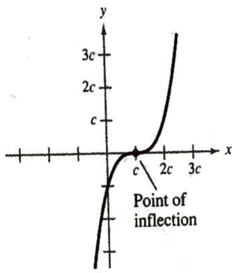
39.

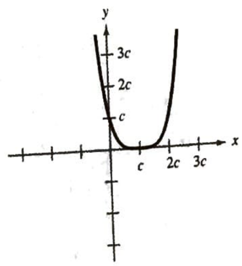


41. $f(x) = (x - c)^n$ has a point of inflection at $(c, 0)$ if n is odd and $n \geq 3$.





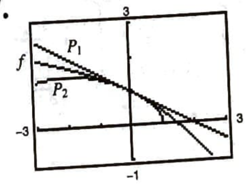




43. Relative extrema: $(2, 32)$, $(6, 0)$
Point of inflection: $(4, 16)$

45. (a) $f(x) = \frac{1}{32}x^3 + \frac{3}{16}x^2$
(b) Two miles from touchdown

47.



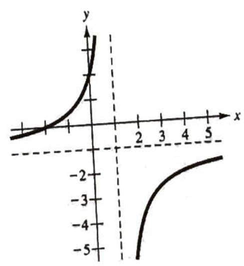
The values of f, P_1, and P_2, and their first derivatives, are equal at $x = 0$.

49. (a) $S'' > 0$
(b) $S'' < 0$
(c) $S' = C$, $S'' = 0$
(d) $S' = 0$, $S'' = 0$
(e) $S' < 0$, $S'' > 0$
(f) $S' > 0$

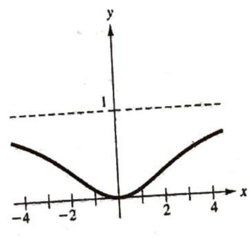
Section 4.5

1. h **2.** c **3.** e **4.** a **5.** d **6.** g
7. b **8.** f **9.** $\frac{2}{3}$ **11.** 0
13. Limit does not exist.
15. Limit does not exist. **17.** 5 **19.** -1
21. 2 **23.** 1 **25.** 0 **27.** $-\frac{1}{2}$

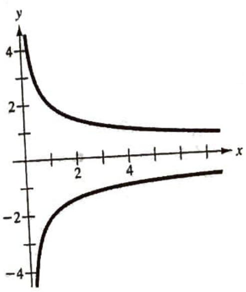
29.



31.



33.



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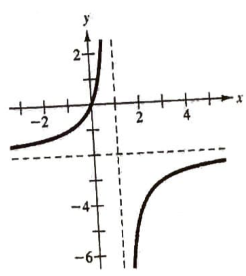

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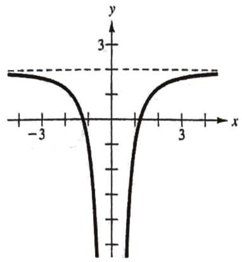

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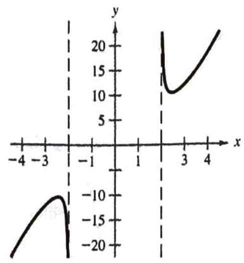

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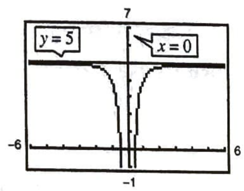

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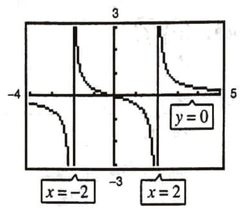
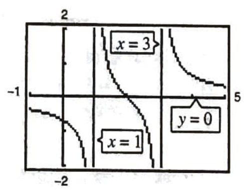
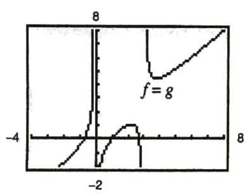


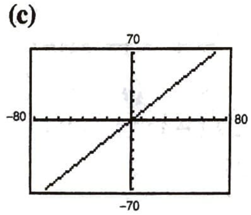
45.



47. (a)



(c)



The slant asymptote $y = x$

49.

x	1	10	10^2	10^3
$f(x)$	2.000	0.348	0.101	0.032

x	10^4	10^5	10^6
$f(x)$	0.010	0.0032	0.001

$$\lim_{x\to\infty} \frac{x+1}{x\sqrt{x}} = 0$$

51.

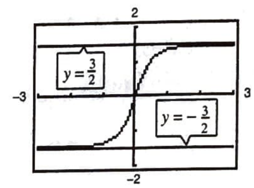
x	1	10	10^2	10^3
$f(x)$	−0.236	−0.025	−0.003	−0.000

x	10^4	10^5	10^6
$f(x)$	−0.000	−0.000	−0.000

$$\lim_{x\to\infty} (2x - \sqrt{4x^2+1}) = 0$$

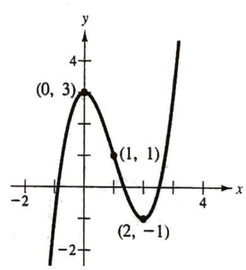
53. 0.5 **55.** 100%

57. Horizontal asymptotes: $y = \pm\frac{3}{2}$

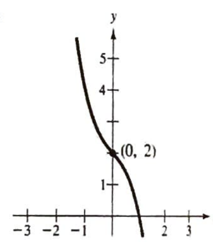


Section 4.6

1.



3.



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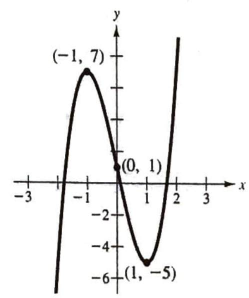
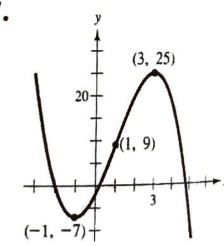
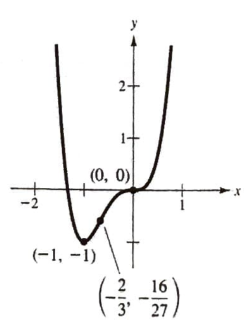


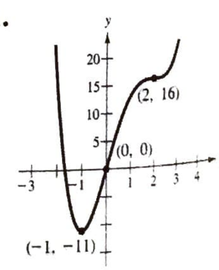
7.



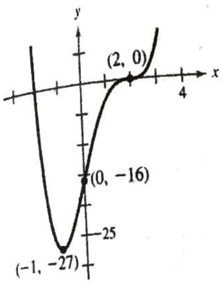
9.



11.



13.



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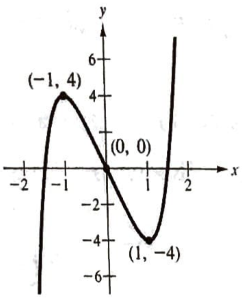

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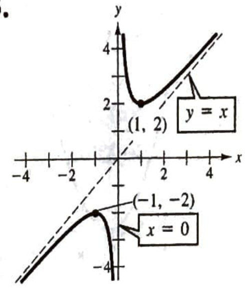

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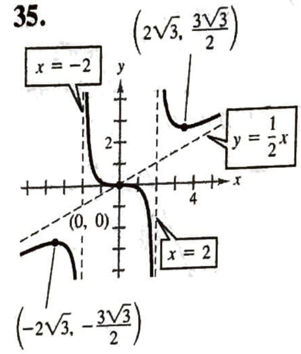

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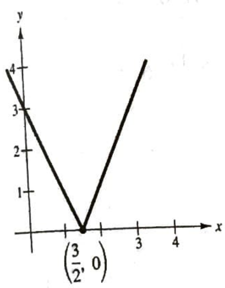

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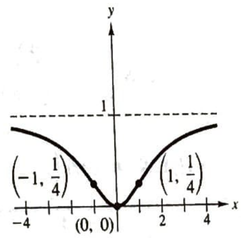

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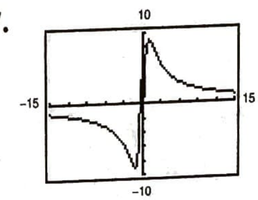

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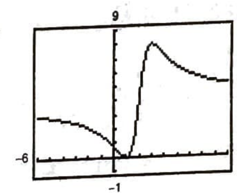
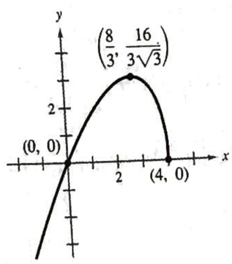


The graph crosses the horizontal asymptote $y = 4$. The graph of f does not cross its vertical asymptote $x = c$ because $f(c)$ does not exist.

21.



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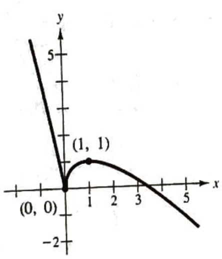

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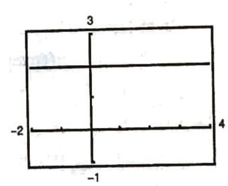
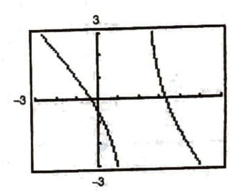


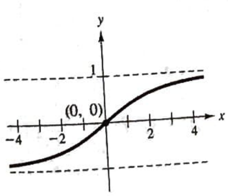
The rational function is not reduced to lowest terms.

43.



The graph appears to approach the line $y = -x + 1$, which is the slant asymptote.

25.



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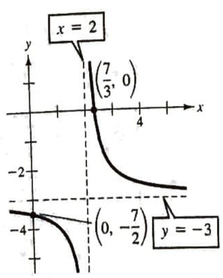
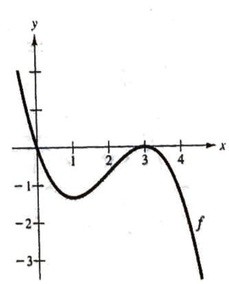


45. $y = \dfrac{1}{x - 5}$

47. $y = \dfrac{3x^2 - 13x - 9}{x - 5}$

49.



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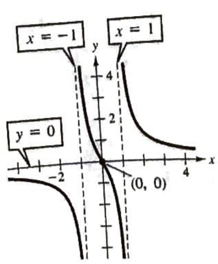

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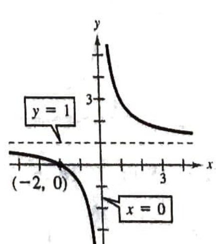

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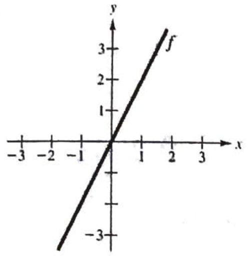

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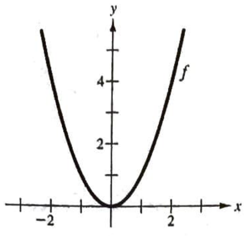


Section 4.7

1. (a)

First number, x	Second number	Product, P
10	$110 - 10$	$10(110 - 10) = 1000$
20	$110 - 20$	$20(110 - 20) = 1800$
30	$110 - 30$	$30(110 - 30) = 2400$
40	$110 - 40$	$40(110 - 40) = 2800$
50	$110 - 50$	$50(110 - 50) = 3000$
60	$110 - 60$	$60(110 - 60) = 3000$

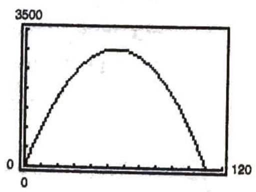
(b) $P = x(110 - x)$

(c) 55 and 55

(d)

First number, x	Second number	Product, P
10	$110 - 10$	$10(110 - 10) = 1000$
20	$110 - 20$	$20(110 - 20) = 1800$
30	$110 - 30$	$30(110 - 30) = 2400$
40	$110 - 40$	$40(110 - 40) = 2800$
50	$110 - 50$	$50(110 - 50) = 3000$
60	$110 - 60$	$60(110 - 60) = 3000$
70	$110 - 70$	$70(110 - 70) = 2800$
80	$110 - 80$	$80(110 - 80) = 2400$
90	$110 - 90$	$90(110 - 90) = 1800$
100	$110 - 100$	$100(110 - 100) = 1000$

(e)



3. $\sqrt{192}$ and $\sqrt{192}$ **5.** 1 and 1

7. $l = w = 25$ ft **9.** $l = w = 8$ ft

11. $\left(\frac{7}{2}, \sqrt{\frac{7}{2}}\right)$ **13.** $600m \times 300m$

15. $V = 128$ when $x = 2$

17. $\frac{5 - \sqrt{7}}{6}$ ft $\times \frac{1 + \sqrt{7}}{3}$ ft $\times \frac{4 + \sqrt{7}}{3}$ ft

19. Rectangular portion: $\frac{16}{\pi + 4}$ ft $\times \frac{32}{\pi + 4}$ ft

21. $(0, 0)$, $(4, 0)$, $(0, 6)$

23. Length: $\frac{5\sqrt{2}}{2}$; width: $5\sqrt{2}$

25. Bases: r and $2r$; altitude: $\frac{\sqrt{3}r}{2}$

27. (a)

Radius, r	Height	Surface area, S
0.2	$\frac{22}{\pi(0.2)^2}$	$2\pi(0.2)\left[0.2 + \frac{22}{\pi(0.2)^2}\right] \approx 220.3$
0.4	$\frac{22}{\pi(0.4)^2}$	$2\pi(0.4)\left[0.4 + \frac{22}{\pi(0.4)^2}\right] \approx 111.0$
0.6	$\frac{22}{\pi(0.6)^2}$	$2\pi(0.6)\left[0.6 + \frac{22}{\pi(0.6)^2}\right] \approx 75.6$
0.8	$\frac{22}{\pi(0.8)^2}$	$2\pi(0.8)\left[0.8 + \frac{22}{\pi(0.8)^2}\right] \approx 59.0$

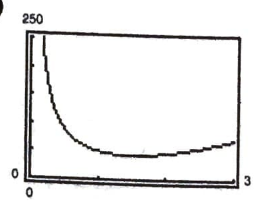
(b) $S = 2\pi r\left(r + \frac{22}{\pi r^2}\right)$

(c) $r = \sqrt[3]{\frac{11}{\pi}}$, $h = 2r$

(d)

Radius, r	Height	Surface area, S
0.2	$\frac{22}{\pi(0.2)^2}$	$2\pi(0.2)\left[0.2 + \frac{22}{\pi(0.2)^2}\right] \approx 220.3$
0.4	$\frac{22}{\pi(0.4)^2}$	$2\pi(0.4)\left[0.4 + \frac{22}{\pi(0.4)^2}\right] \approx 111.0$
0.6	$\frac{22}{\pi(0.6)^2}$	$2\pi(0.6)\left[0.6 + \frac{22}{\pi(0.6)^2}\right] \approx 75.6$
0.8	$\frac{22}{\pi(0.8)^2}$	$2\pi(0.8)\left[0.8 + \frac{22}{\pi(0.8)^2}\right] \approx 59.0$
1.0	$\frac{22}{\pi(1.0)^2}$	$2\pi(1.0)\left[1.0 + \frac{22}{\pi(1.0)^2}\right] \approx 50.3$
1.2	$\frac{22}{\pi(1.2)^2}$	$2\pi(1.2)\left[1.2 + \frac{22}{\pi(1.2)^2}\right] \approx 45.7$
1.4	$\frac{22}{\pi(1.4)^2}$	$2\pi(1.4)\left[1.4 + \frac{22}{\pi(1.4)^2}\right] \approx 43.7$
1.6	$\frac{22}{\pi(1.6)^2}$	$2\pi(1.6)\left[1.6 + \frac{22}{\pi(1.6)^2}\right] \approx 43.6$
1.8	$\frac{22}{\pi(1.8)^2}$	$2\pi(1.8)\left[1.8 + \frac{22}{\pi(1.8)^2}\right] \approx 44.8$
2.0	$\frac{22}{\pi(2.0)^2}$	$2\pi(2.0)\left[2.0 + \frac{22}{\pi(2.0)^2}\right] \approx 47.1$

(e)

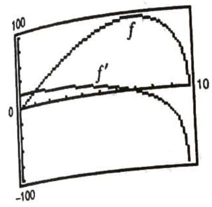


29. 18 in. $\times$ 18 in. $\times$ 36 in. **31.** $\frac{32\pi r^3}{81}$

33. $r = \sqrt[3]{\frac{9}{\pi}} \approx 1.42$ in.

35. Side of square: $\frac{10\sqrt{3}}{9 + 4\sqrt{3}}$; side of triangle: $\frac{30}{9 + 4\sqrt{3}}$

37. (a) $\dfrac{10\pi}{\pi + 3 + 2\sqrt{2}} \approx 3.5$ ft (b) 10 ft
39. $w = 8\sqrt{3}$, $h = 8\sqrt{6}$
41. 1 mile from the nearest point on the coast
43. 14.1421×7.071



(e) If the initial estimate $x = x_1$ is not sufficiently close to the desired zero of a function, the x-intercept of the corresponding tangent line to the function may approximate a second zero of the function.

Section 4.8

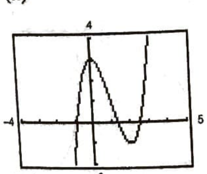
1.

n	x_n	$f(x_n)$	$f'(x_n)$	$\dfrac{f(x_n)}{f'(x_n)}$	$x_n - \dfrac{f(x_n)}{f'(x_n)}$
1	1.700	−0.110	3.400	−0.032	1.732

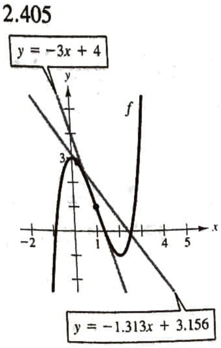
3.

n	x_n	$f(x_n)$	$f'(x_n)$	$\dfrac{f(x_n)}{f'(x_n)}$	$x_n - \dfrac{f(x_n)}{f'(x_n)}$
1	1	1.000	9.000	0.111	0.889

5. 0.682 7. 1.146 9. 3.317 11. 0.569
13. $f'(x_1) = 0$ 15. $1 = x_1 = x_3 = \cdots$
$0 = x_2 = x_4 = \cdots$
17. $x_{i+1} = \dfrac{x_i^2 + a}{2x_i}$ 19. 2.646 21. 1.565
25. (1.939, 0.240) 27. $x \approx 1.563$ mi
29. (a)



(b) 1.333
(c) 2.405
(d)



Section 4.9

1. $6x\,dx$ 3. $12x^2\,dx$ 5. $-\dfrac{3}{(2x-1)^2}\,dx$

7. $\dfrac{1}{2\sqrt{x}}\,dx$ 9. $\dfrac{1-2x^2}{\sqrt{1-x^2}}\,dx$

11.

$dx = \Delta x$	dy	Δy	$\Delta y - dy$	$\dfrac{dy}{\Delta y}$
1.000	1.000	1.000	0.000	1.000
0.500	0.500	0.500	0.000	1.000
0.100	0.100	0.100	0.000	1.000
0.010	0.010	0.010	0.000	1.000
0.001	0.001	0.001	0.000	1.000

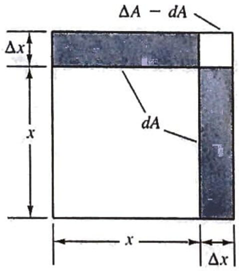
13.

$dx = \Delta x$	dy	Δy	$\Delta y - dy$	$\dfrac{dy}{\Delta y}$
1.000	4.000	5.000	1.000	0.800
0.500	2.000	2.250	0.250	0.889
0.100	0.400	0.410	0.010	0.976
0.010	0.040	0.040	0.000	1.000
0.001	0.004	0.004	0.000	1.000

15.

$dx = \Delta x$	dy	Δy	$\Delta y - dy$	$\dfrac{dy}{\Delta y}$
1.000	80.000	211.000	131.000	0.379
0.500	40.000	65.656	25.656	0.609
0.100	8.000	8.841	0.841	0.905
0.010	0.800	0.808	0.008	0.990
0.001	0.080	0.080	0.000	1.000

17. **(a)** $dA = 2x\Delta x$, $\Delta A = 2x\Delta x + (\Delta x)^2$
(b)



(c) $\Delta A - dA = (\Delta x)^2$

19. $\pm 7\pi$ in.^{2} **21.** **(a)** $\frac{2}{3}\%$ **(b)** 1.25%

23. **(a)** $\pm 2.88\pi$ in.^{3} **(b)** $\pm 0.96\pi$ in.^{2}
(c) 1%, $\frac{2}{3}\%$

25. **(a)** $\frac{1}{4}\%$ **(b)** 216 sec = 3.6 min

Section 4.10

1. 4500 **3.** 300 **5.** 200 **7.** 200

9. $x = 30$, $p = 60$ **11.** $x = 1500$, $p = 35$ **13.** 20 **15.** 200

17. Line should run from power station to point across the river $3/(2\sqrt{7})$ mile downstream.

19. 8% **21.** $x = 3$

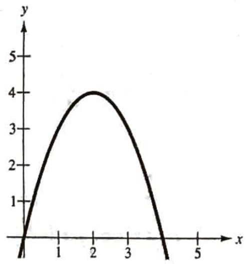
23. **(a)** $p = \$68$ **(b)** $\overline{C} \approx \$50.88$

25. $x \approx 40$ units **27.** \$30,000

29. $y = \frac{64}{141}x$, 6.1

Review Exercises for Chapter 4

1.



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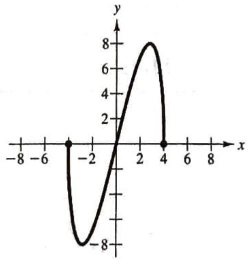

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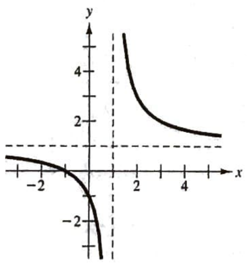

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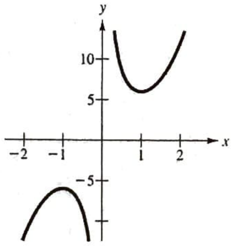

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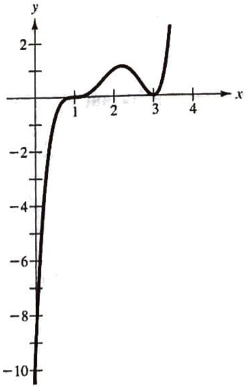

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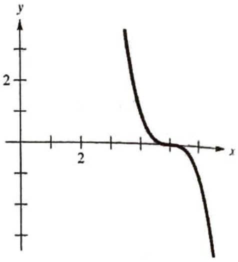

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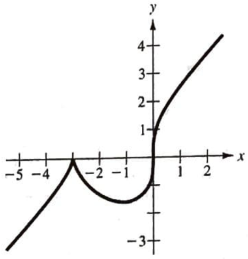

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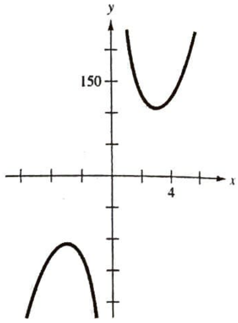

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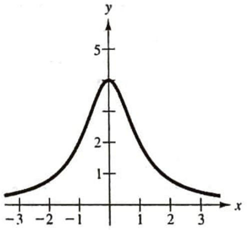
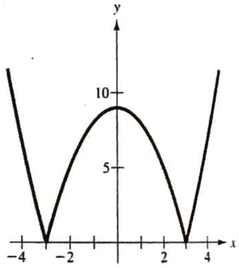


19.



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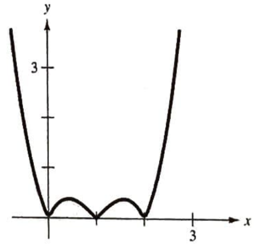
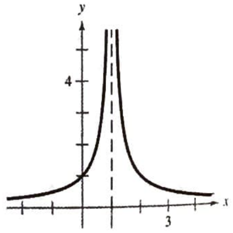


23.



25. Maximum: (1, 3)
Minimum: (1, 1)

27. $f'\left(\frac{-2 + \sqrt{85}}{3}\right) = -\frac{1}{17}$

29. $f'\left(\frac{2744}{729}\right) = \frac{3}{7}$ **31.** $f'(2) = \frac{5}{4}$

33. No, f is discontinuous at $x = 0$

35. $c = \dfrac{x_1 + x_2}{2}$ **37.** $t \approx 4.92 \approx$ 4:55 P.M.
$d \approx 64$ mi

39. \$48 **41.** (0, 0), (5, 0), (0, 10) **43.** 120

47. 14.05 ft **49.** $x = \sqrt{\dfrac{2Qs}{r}}$ **51.** −0.347

53. −0.453 **55.** **(a)** 2% **(b)** 3%