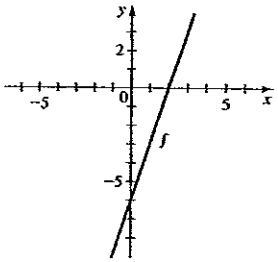
31. $(f \circ g)(x) = (x+1)^2, (-\infty, \infty)$;
$(g \circ f)(x) = x^2 + 1, (-\infty, \infty)$; $(f \circ f)(x) = x^4, (-\infty, \infty)$;
$(g \circ g)(x) = x + 2, (-\infty, \infty)$
32. $(f \circ g)(x) = x + 2, (-\infty, \infty)$;
$(g \circ f)(x) = \sqrt[3]{x^3 + 2}, (-\infty, \infty)$;
$(f \circ f)(x) = x^9 + 6x^6 + 12x^3 + 10, (-\infty, \infty)$;
$(g \circ g)(x) = x^{1/9}, (-\infty, \infty)$
33. $(f \circ g)(x) = \dfrac{1}{2x+4}, x \neq -2$; $(g \circ f)(x) = \dfrac{2}{x} + 4, x \neq 0$;
$(f \circ f)(x) = x, x \neq 0$, $(g \circ g)(x) = 4x + 12, (-\infty, \infty)$
34. $(f \circ g)(x) = x - 3, [3, \infty)$;
$(g \circ f)(x) = \sqrt{x^2 - 3}, (-\infty, -\sqrt{3}] \cup [\sqrt{3}, \infty)$;
$(f \circ f)(x) = x^4, (-\infty, \infty)$;
$(g \circ g)(x) = \sqrt{\sqrt{x-3} - 3}, [12, \infty)$
35. $(f \circ g)(x) = |2x + 3|, (-\infty, \infty)$;
$(g \circ f)(x) = 2|x| + 3, (-\infty, \infty)$; $(f \circ f)(x) = |x|, (-\infty, \infty)$;
$(g \circ g)(x) = 4x + 9, (-\infty, \infty)$
36. $(f \circ g)(x) = |x + 4| - 4, (-\infty, \infty)$;
$(g \circ f)(x) = |x|, (-\infty, \infty)$; $(f \circ f)(x) = x - 8, (-\infty, \infty)$;
$(g \circ g)(x) = |x + 4| + 4, (-\infty, \infty)$
37. $(f \circ g)(x) = \dfrac{2x - 1}{2x}, x \neq 0$;
$(g \circ f)(x) = \dfrac{2x}{x+1} - 1, x \neq -1$;
$(f \circ f)(x) = \dfrac{x}{2x+1}, x \neq -1, x \neq -\frac{1}{2}$;
$(g \circ g)(x) = 4x - 3, (-\infty, \infty)$
38. $(f \circ g)(x) = \dfrac{1}{\sqrt{x^2 - 4x}}, (-\infty, 0) \cup (4, \infty)$;
$(g \circ f)(x) = \dfrac{1}{x} - \dfrac{4}{\sqrt{x}}, (0, \infty)$; $(f \circ f)(x) = x^{1/4}, (0, \infty)$;
$(g \circ g)(x) = x^4 - 8x^3 + 12x^2 + 16x, (-\infty, \infty)$
39. $(f \circ g)(x) = \sqrt[12]{x}, [0, \infty)$; $(g \circ f)(x) = \sqrt[12]{x}, [0, \infty)$;
$(f \circ f)(x) = \sqrt[9]{x}, (-\infty, \infty)$; $(g \circ g)(x) = \sqrt[16]{x}, [0, \infty)$
40. $(f \circ g)(x) = \dfrac{2x + 4}{x}, x \neq -2, x \neq 0$;
$(g \circ f)(x) = \dfrac{1}{1 + x}, x \neq -1, x \neq 0$; $(f \circ f)(x) = x, x \neq 0$;
$(g \circ g)(x) = \dfrac{x}{3x + 4}, x \neq -2, x \neq -\frac{4}{3}$
41. $(f \circ g \circ h)(x) = \sqrt{x - 1} - 1$
42. $(f \circ g \circ h)(x) = \dfrac{1}{x^6 + 6x^4 + 12x^2 + 8}$
43. $(f \circ g \circ h)(x) = (\sqrt{x} - 5)^4 + 1$
44. $(f \circ g \circ h)(x) = \sqrt{\dfrac{\sqrt[3]{x}}{\sqrt[3]{x} - 1}}$ **45.** $g(x) = x - 9, f(x) = x^5$
46. $g(x) = \sqrt{x}, f(x) = x + 1$
47. $g(x) = x^2, f(x) = x/(x + 4)$
48. $g(x) = x + 3, f(x) = 1/x$ **49.** $g(x) = 1 - x^3, f(x) = |x|$
50. $g(x) = \sqrt{x}, f(x) = \sqrt{1 + x}$
51. $h(x) = x^2, g(x) = x + 1, f(x) = 1/x$
52. $h(x) = \sqrt{x}, g(x) = x - 1, f(x) = \sqrt[3]{x}$
53. $h(x) = \sqrt[3]{x}, g(x) = 4 + x, f(x) = x^9$
54. $h(x) = \sqrt{x}, g(x) = 3 + x, f(x) = 2/x^2$
55. $R(x) = 0.15x - 0.000002x^2$
56. $P(x) = 0.055x - 0.0000015x^2$ **57.** **(a)** $g(t) = 60t$
(b) $f(r) = \pi r^2$ **(c)** $(f \circ g)(t) = 3600\pi t^2$ **58.** **(a)** $f(t) = t$
(b) $g(r) = \frac{4}{3}\pi r^3$ **(c)** $(g \circ f)(t) = \frac{4}{3}\pi t^3$; the volume as a function of time **59.** $A(t) = 16\pi t^2$ **60.** **(a)** $f(x) = 0.80x$
(b) $g(x) = x - 50$ **(c)** $(f \circ g)(x) = 0.80x - 40$;
$(g \circ f)(x) = 0.80x - 50$; applying the 20% discount, then $50 coupon $(g \circ f)$ gives the lower price **61.** **(a)** $f(x) = 0.9x$
(b) $g(x) = x - 100$ **(c)** $f \circ g(x) = 0.9x - 90$,
$g \circ f(x) = 0.9x - 100$, $f \circ g$: first rebate, then discount,
$g \circ f$: first discount, then rebate, $g \circ f$ is the better deal
62. **(a)** $s = \sqrt{1 + d^2}$ **(b)** $d = 350t$
(c) $s(t) = \sqrt{1 + 122{,}500t^2}$

3.8

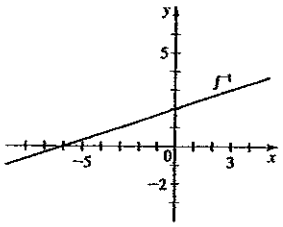
Section 3.8 ■ page [illegible]

1. No **2.** Yes **3.** Yes **4.** No **5.** No **6.** Yes **7.** Yes
8. Yes **9.** Yes **10.** No **11.** No **12.** Yes **13.** No
14. Yes **15.** No **16.** Yes **17.** **(a)** 2 **(b)** 3
18. **(a)** 5 **(b)** 4 **19.** 1 **20.** 1
31. $f^{-1}(x) = \frac{1}{2}(x - 1)$ **32.** $f^{-1}(x) = 6 - x$
33. $f^{-1}(x) = \frac{1}{4}(x - 7)$ **34.** $f^{-1}(x) = \frac{1}{5}(3 - x)$
35. $f^{-1}(x) = 2x$ **36.** $f^{-1}(x) = 1/\sqrt{x}, x > 0$
37. $f^{-1}(x) = (1/x) - 2$
38. $f^{-1}(x) = \dfrac{-2(x + 1)}{x - 1}$
39. $f^{-1}(x) = (5x - 1)/(2x + 3)$
40. $f^{-1}(x) = \sqrt[3]{\frac{1}{4}(5 - x)}$
41. $f^{-1}(x) = \frac{1}{5}(x^2 - 2), x \geq 0$
42. $f^{-1}(x) = \sqrt{x + \frac{1}{4}} - \frac{1}{2}, x \geq -\frac{1}{4}$
43. $f^{-1}(x) = \sqrt{4 - x}, x \leq 4$
44. $f^{-1}(x) = \frac{1}{2}(x^2 + 1), x \geq 0$
45. $f^{-1}(x) = (x - 4)^3$ **46.** $f^{-1}(x) = \sqrt[3]{2 - \sqrt[5]{x}}$
47. $f^{-1}(x) = x^2 - 2x, x \geq 1$
48. $f^{-1}(x) = \sqrt{9 - x^2}, 0 \leq x \leq 3$ **49.** $f^{-1}(x) = \sqrt[4]{x}$
50. $f^{-1}(x) = \sqrt[3]{1 - x}$

51. (a)

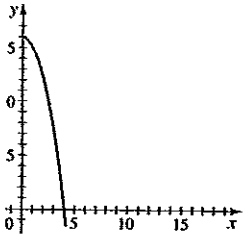


(b)

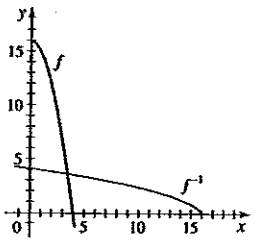


c) $f^{-1}(x) = \frac{1}{3}(x + 6)$

52. (a)

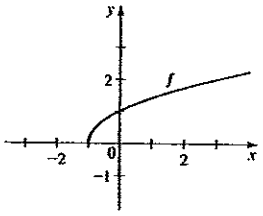


(b)

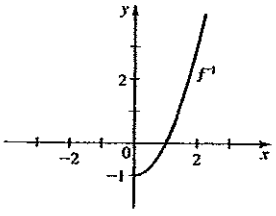


c) $f^{-1}(x) = \sqrt{16 - x}, x \leq 16$

53. (a)

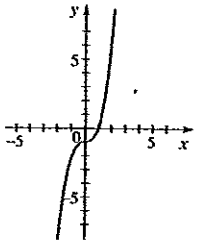


(b)

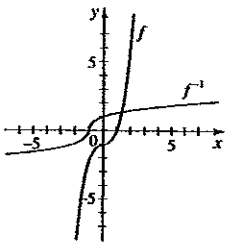


:) $f^{-1}(x) = x^2 - 1, x \geq 0$

54. (a)

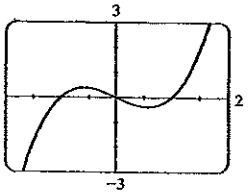


(b)

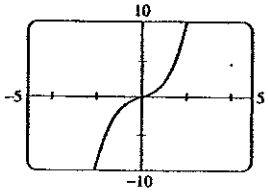


) $f^{-1}(x) = \sqrt[3]{x + 1}$

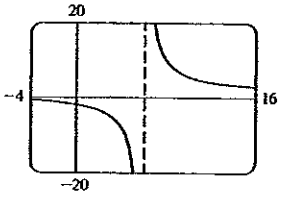
55. Not one-to-one



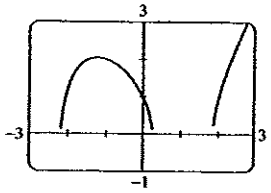
56. One-to-one



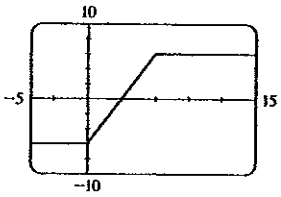
57. One-to-one



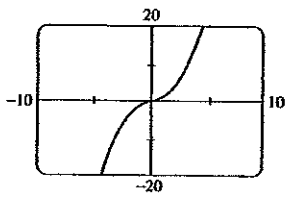
58. Not one-to-one



59. Not one-to-one

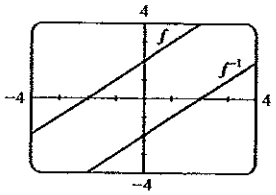


60. One-to-one

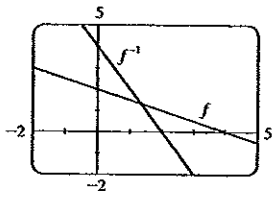


61. (a) $f^{-1}(x) = x - 2$

(b)

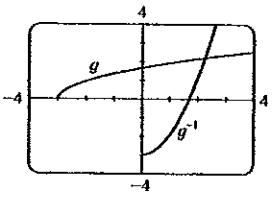


62. (a) $f^{-1}(x) = 4 - 2x$

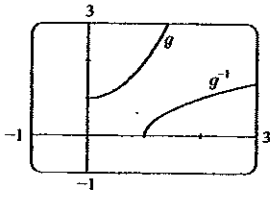


63. (a) $g^{-1}(x) = x^2 - 3, x \geq 0$

(b)



64. (a) $g^{-1}(x) = \sqrt{x - 1}$

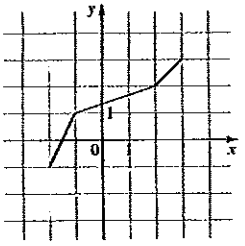


65. $x \geq 0, f^{-1}(x) = \sqrt{4 - x}$

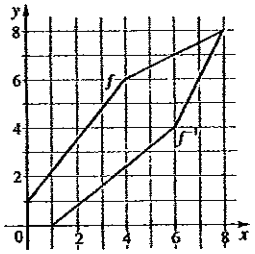
66. $x \geq 1, g^{-1}(x) = 1 + \sqrt{x}$

67. $x \geq -2, h^{-1}(x) = \sqrt{x} - 2$ **68.** $x \geq 3, k^{-1}(x) = 3 + x$

69.



70.



71. (a) $f(x) = 500 + 80x$ (b) $f^{-1}(x) = \frac{1}{80}(x - 500)$, the number of hours worked as a function of the fee (c) 9; if he charges \$1220, he worked 9 h **72.** (a) $V^{-1}(t) = 40 - 4\sqrt{t}$, time elapsed since the tank started to leak (b) 24.5 min; in 24.5 min the tank drained 15 gal of water

73. (a) $v^{-1}(t) = \sqrt{0.25 - \dfrac{t}{18{,}500}}$ (b) 0.498; at a distance 0.498 from the central axis, the velocity is 30

74. (a) $D^{-1}(p) = 50 - \frac{1}{3}p$, the price associated with the demand D (b) 40; when the demand is 30 units, the price is \$40 **75.** (a) $F^{-1}(x) = \frac{5}{9}(x - 32)$; the Celsius temperature when the Fahrenheit temperature is x (b) $F^{-1}(86) = 30$; when the temperature is 86°F, it is 30°C

76. (a) $f(x) = 0.8159x$ (b) $f^{-1}(x) = 1.2256x$, the exchange rate from U.S. dollars to Canadian dollars (c) \$15,014.09 in Canadian currency

77. (a) $f(x) = \begin{cases} 0.1x & \text{if } 0 \le x \le 20{,}000 \\ 2000 + 0.2(x - 20{,}000) & \text{if } x > 20{,}000 \end{cases}$

(b) $f^{-1}(x) = \begin{cases} 10x & \text{if } 0 \le x \le 2000 \\ 10{,}000 + 5x & \text{if } x > 2000 \end{cases}$

If you pay x euros in taxes, your income is $f^{-1}(x)$.

(c) $f^{-1}(10{,}000) = 60{,}000$ **78.** (a) $f(x) = 0.85x$

(b) $g(x) = x - 1000$ (c) $H = 0.85x - 850$

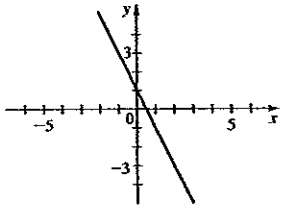
(d) $H^{-1}(x) = 1.176x + 1000$, the original sticker price for a given discounted price (e) \$16,288, the original price of the car when the discounted price (\$1000 rebate, then 15% off) is \$13,000 **79.** $f^{-1}(x) = \frac{1}{2}(x - 7)$. A pizza costing x dollars has $f^{-1}(x)$ toppings.

Chapter 3 Review ■ page 204

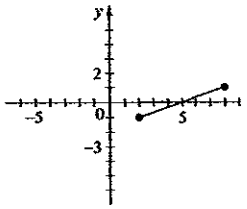
1. 6, 2, 18, $a^2 - 4a + 6$, $a^2 + 4a + 6$, $x^2 - 2x + 3$, $4x^2 - 8x + 6$, $2x^2 - 8x + 10$ **2.** $1, 4 - \sqrt{2t}, 4 - \sqrt{3a}, 4 - \sqrt{-3x - 6}, 4 - \sqrt{3x^2 - 6}, 3x - 8\sqrt{3x - 6} + 10$

3. (a) $-1, 2$ (b) $[-4, 5]$ (c) $[-4, 4]$ (d) Increasing on $[-4, -2]$ and $[-1, 4]$; decreasing on $[-2, -1]$ and $[4, 5]$ (e) No **4.** (a) Not a function (b) Function (c) Function, one-to-one (d) Not a function **5.** Domain $[-3, \infty)$, range $[0, \infty)$ **6.** Domain $(-\infty, \infty)$, range $[4, \infty)$ **7.** $(-\infty, \infty)$ **8.** $x \neq \frac{1}{2}$ **9.** $[-4, \infty)$ **10.** $(-1, \infty)$ **11.** $\{x \mid x \neq -2, -1, 0\}$ **12.** $x \neq -\frac{1}{2}, x \neq 3$ **13.** $(-\infty, -1] \cup [1, 4]$ **14.** $x \neq -4$

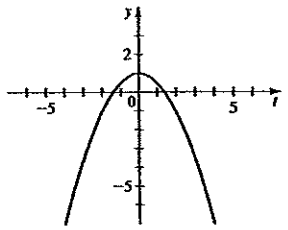
15.



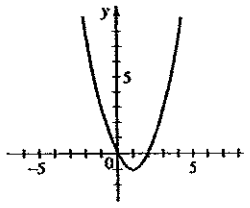
16.



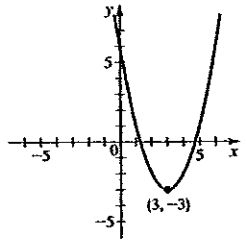
17.



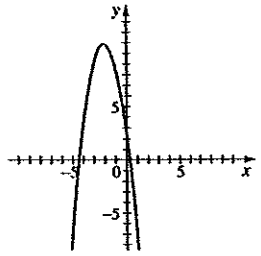
18.



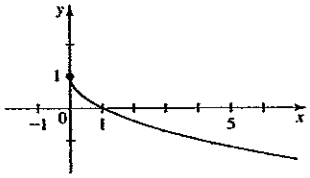
19.



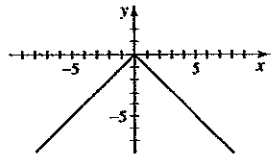
20.



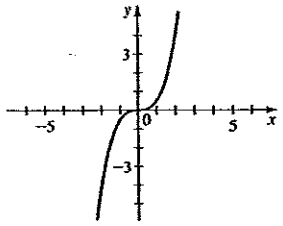
21.



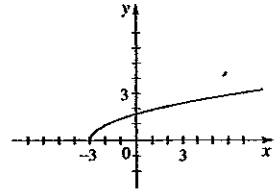
22.



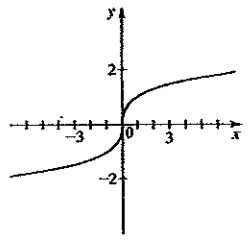
23.



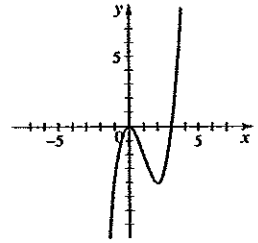
24.



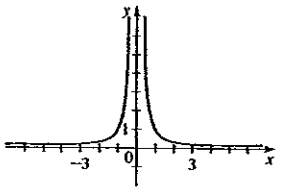
25.



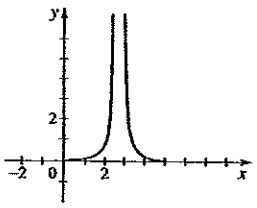
26.



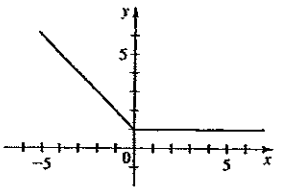
27.



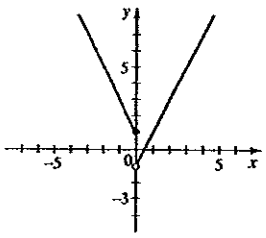
28.



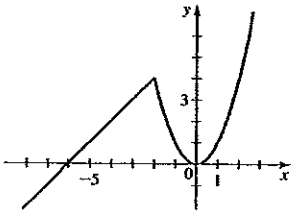
29.



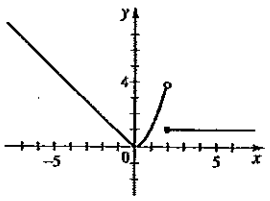
30.



31.



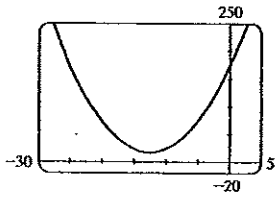
32.



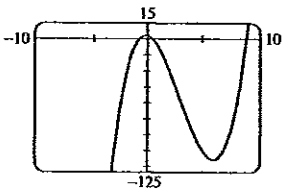
33. (iii)

34. (iii)

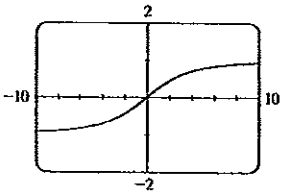
35.



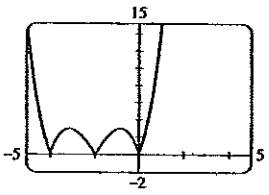
36.



37.



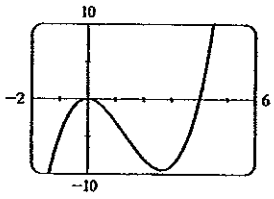
38.



39. $[-2.1, 0.2] \cup [1.9, \infty)$ **40.** $[-7.10, \infty)$ **41.** 5

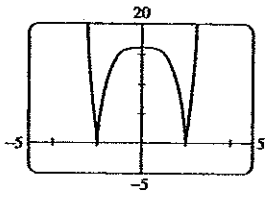
42. $-\frac{1}{12}$ **43.** $\frac{-1}{3(3+h)}$ **44.** $2a + h + 2$

45.



Increasing on $(-\infty, 0]$, $[2.67, \infty)$; decreasing on $[0, 2.67]$

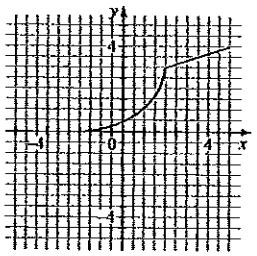
46.



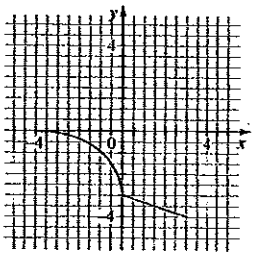
Increasing on $[-2, 0]$, $[2, \infty)$; decreasing on $(-\infty, -2]$, $[0, 2]$

47. (a) Shift upward 8 units (b) Shift left 8 units (c) Stretch vertically by a factor of 2, then shift upward 1 unit (d) Shift right 2 units and downward 2 units (e) Reflect in y-axis (f) Reflect in y-axis, then in x-axis (g) Reflect in x-axis (h) Reflect in line $y = x$

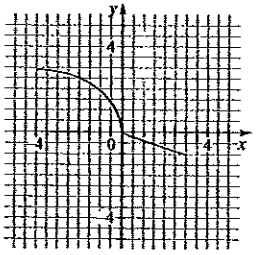
48. (a)



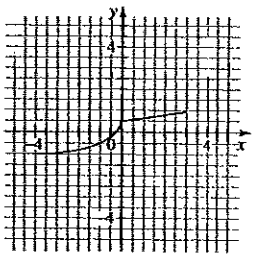
(b)



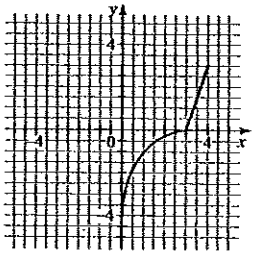
(c)



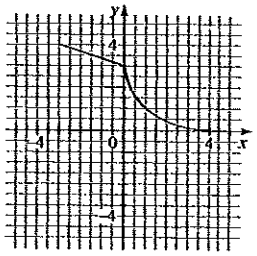
(d)



(e)



(f)

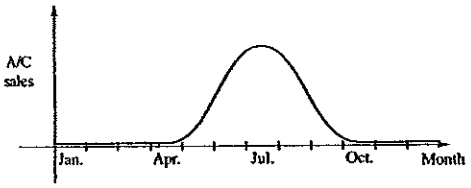


49. (a) Neither (b) Odd (c) Even (d) Neither

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

51. $f(x) = (x + 2)^2 - 3$ **52.** $f(x) = -2(x - 3)^2 + 30$

53. $g(-1) = -7$ **54.** $\frac{5}{4}$ **55.** 68 ft **56.** \$88,500, 15,000 units **57.** Local maximum ≈ 3.79 when $x \approx 0.46$; local minimum ≈ 2.81 when $x \approx -0.46$
58. Local maximum ≈ 3.175 when $x \approx 4.00$; local minimum $= 0$ when $x = 0$
59.

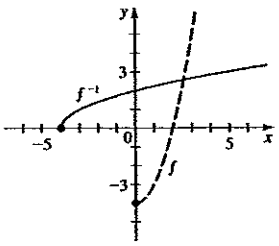


60. $A = b\sqrt{4 - b}$
61. (a) $A(x) = 5\sqrt{3}x - \frac{\sqrt{3}}{2}x^2$ (b) 5 cm by $\frac{5\sqrt{3}}{2}$ cm

62. (a) $A(x) = \frac{x^2}{16} + \frac{\sqrt{3}(10 - x)^2}{36}$, $0 \le x \le 10$
(b) 4.35 m **63.** (a) $(f + g)(x) = x^2 - 6x + 6$
(b) $(f - g)(x) = x^2 - 2$
(c) $(fg)(x) = -3x^3 + 13x^2 - 18x + 8$
(d) $(f/g)(x) = (x^2 - 3x + 2)/(4 - 3x)$
(e) $(f \circ g)(x) = 9x^2 - 15x + 6$
(f) $(g \circ f)(x) = -3x^2 + 9x - 2$ **64.** (a) $(f \circ g)(x) = x$
(b) $(g \circ f)(x) = |x|$ (c) 2 (d) 26
(e) $(f \circ g \circ f)(x) = 1 + x^2$ (f) $(g \circ f \circ g)(x) = \sqrt{x - 1}$
65. $(f \circ g)(x) = -3x^2 + 6x - 1, (-\infty, \infty)$;
$(g \circ f)(x) = -9x^2 + 12x - 3, (-\infty, \infty)$; $(f \circ f)(x) = 9x - 4$, $(-\infty, \infty)$; $(g \circ g)(x) = -x^4 + 4x^3 - 6x^2 + 4x, (-\infty, \infty)$

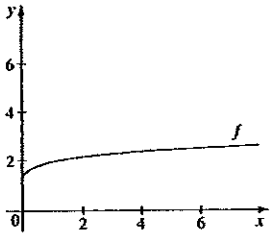
66. $(f \circ g)(x) = \sqrt{\frac{2}{x - 4}}, (4, \infty)$; $(g \circ f)(x) = \frac{2}{\sqrt{x} - 4}$, $[0, 16) \cup (16, \infty)$; $(f \circ f)(x) = x^{1/4}, [0, \infty)$;
$(g \circ g)(x) = \frac{x - 4}{9 - 2x}, x \ne 4, x \ne \frac{9}{2}$

67. $(f \circ g \circ h)(x) = 1 + \sqrt{x}$
68. $h(x) = \sqrt{x}, g(x) = 1 + x$, $f(x) = 1/\sqrt{x}$ **69.** Yes **70.** No **71.** No **72.** Yes **73.** No **74.** Yes **75.** $f^{-1}(x) = \frac{x + 2}{3}$ **76.** $f^{-1}(x) = \frac{1}{2}(3x - 1)$
77. $f^{-1}(x) = \sqrt[3]{x} - 1$ **78.** $f^{-1}(x) = 2 + (x - 1)^5$
79. (a), (b)

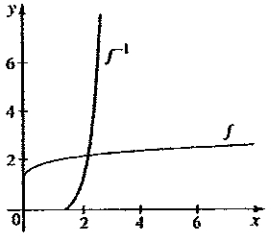


(c) $f^{-1}(x) = \sqrt{x + 4}$

80. (b)



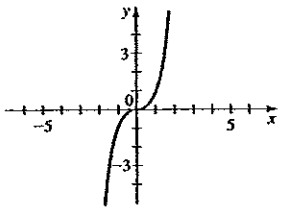
(c)



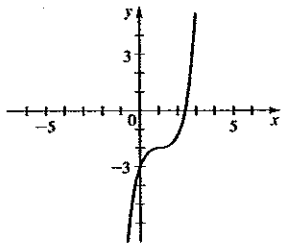
(d) $f^{-1}(x) = (x - 1)^4, x \ge 1$

Chapter 3 Test

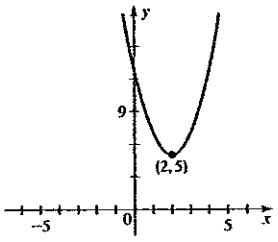
1. (a) and (b) are graphs of functions, (a) is one-to-one
2. (a) $2/3, \sqrt{6}/5, \sqrt{a}/(a - 1)$ (b) $[-1, 0) \cup (0, \infty)$
3. 5
4. (a)



(b)

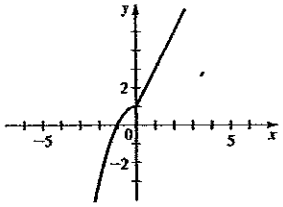


5. (a) Shift right 3 units, then shift upward 2 units
(b) Reflect in y-axis **6.** (a) $f(x) = 2(x - 2)^2 + 5$
(b)



(c) $f(2) = 5$

7. (a) $-3, 3$ (b)



8. (a) $A(x) = -3x^2 + 900x$ (b) 150 ft
9. (a) $(f \circ g)(x) = (x - 3)^2 + 1$ (b) $(g \circ f)(x) = x^2 - 2$
(c) 2 (d) 2 (e) $(g \circ g \circ g)(x) = x - 9$