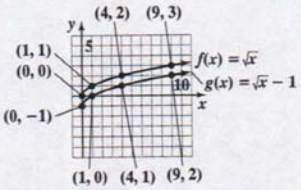
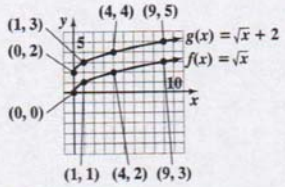
51.



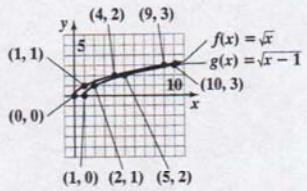
The graph of g is the graph of f shifted down by 1 unit.

52.



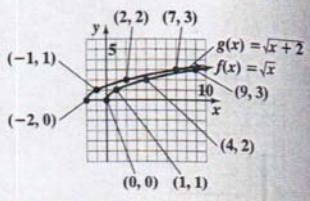
The graph of g is the graph of f shifted up by 2 units.

53.



The graph of g is the graph of f shifted to the right by 1 unit.

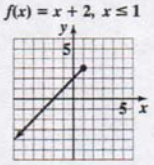
54.



The graph of g is the graph of f shifted to the left by 2 units.

55. function **56.** function **57.** function **58.** not a function **59.** not a function **60.** not a function **61.** function **62.** not a function **63.** function **64.** function **65.** -4 **66.** -4 **67.** 4 **68.** 4 **69.** 0 **70.** 0 **71.** 2 **72.** -2 **73.** 2 **74.** -2 **75.** -2 **76.** 1 **77. a.** $(-\infty, \infty)$ **b.** $[-4, \infty)$ **c.** -3 and 1 **d.** -3 **e.** $f(-2) = -3$ and $f(2) = 5$ **78. a.** $(-\infty, \infty)$ **b.** $(-\infty, 4]$ **c.** -3 and 1 **d.** 3 **e.** $f(-2) = 3$ and $f(2) = -5$ **79. a.** $(-\infty, \infty)$ **b.** $[1, \infty)$ **c.** none **d.** 1 **e.** $f(-1) = 2$ and $f(3) = 4$ **80. a.** $(-\infty, \infty)$ **b.** $[0, \infty)$ **c.** -1 **d.** 1 **e.** $f(-4) = 3$ and $f(3) = 4$ **81. a.** $[0, 5)$ **b.** $[-1, 5)$ **c.** 2 **d.** -1 **e.** $f(3) = 1$ **82. a.** $(-6, 0]$ **b.** $[-3, 4)$ **c.** -3.75 **d.** -3 **e.** $f(-5) = 2$ **83. a.** $[0, \infty)$ **b.** $[1, \infty)$ **c.** none **d.** 1 **e.** $f(4) = 3$ **84. a.** $[-1, \infty)$ **b.** $[0, \infty)$ **c.** -1 **d.** 1 **e.** $f(3) = 2$ **85. a.** $[-2, 6]$ **b.** $[-2, 6]$ **c.** 4 **d.** 4 **e.** $f(-1) = 5$ **86. a.** $[-3, 2]$ **b.** $[-5, 5]$ **c.** $-\frac{1}{2}$ **d.** 1 **e.** $f(-2) = -3$ **87. a.** $(-\infty, \infty)$ **b.** $(-\infty, -2]$ **c.** none **d.** -2 **e.** $f(-4) = -5$ and $f(4) = -2$ **88. a.** $(-\infty, \infty)$ **b.** $[0, \infty)$ **c.** $\{x \mid x \le 0\}$ **d.** 0 **e.** $f(-2) = 0$ and $f(2) = 4$ **89. a.** $(-\infty, \infty)$ **b.** $(0, \infty)$ **c.** none **d.** 1.5 **e.** $f(4) = 6$ **90. a.** $(-\infty, 1)$ or $(1, \infty)$ **b.** $(-\infty, 0)$ or $(0, \infty)$ **c.** none **d.** -1 **e.** $f(2) = 1$ **91. a.** $\{-5, -2, 0, 1, 3\}$ **b.** $\{2\}$ **c.** none **d.** 2 **e.** $f(-5) + f(3) = 4$ **92. a.** $\{-5, -2, 0, 1, 4\}$ **b.** $\{-2\}$ **c.** none **d.** -2 **e.** $f(-5) + f(4) = -4$ **93.** -2; 10 **94.** -8; 76 **95.** -38 **96.** 0 **97.** $-2x^3 - 2x$ **98.** $6x$ **99. a.** {(Iceland, 9.7), (Finland, 9.6), (New Zealand, 9.6), (Denmark, 9.5)} **b.** Yes, each country is paired with only one corruption rating. **c.** {(9.7, Iceland), (9.6, Finland), (9.6, New Zealand), (9.5, Denmark)} **d.** No, the corruption rating 9.6 is paired with two different countries, Finland and New Zealand. **100. a.** {(Bangladesh, 1.7), (Chad, 1.7), (Haiti, 1.8), (Myanmar, 1.8)} **b.** Yes, each country is paired with only one corruption rating. **c.** {(1.7, Bangladesh), (1.7, Chad), (1.8, Haiti), (1.8, Myanmar)} **d.** No, the corruption rating 1.7 is paired with two different countries, Bangladesh and Chad. **101. a.** 83; The chance that a 60-year-old will survive to age 70 is 83%. **b.** 76; The chance that a 60-year-old will survive to age 70 is 76%. **c.** f **102. a.** 25; The chance that a 60-year-old will survive to age 90 is 25%. **b.** 10; The chance that a 60-year-old will survive to age 90 is 10%. **c.** f **103. a.** 127; In 2004, Americans ordered an average of 127 takeout meals per person.; by the point (20, 127) **b.** 94; In 1984, Americans ordered an average of 94 meals in restaurants per person.; by the point (0, 94) **c.** 1988; 91 takeout meals and 91.6 meals in restaurants **104. a.** 126; In 2002, Americans ordered an average of 126 takeout meals per person.; by the point (18, 126) **b.** 82; In 2004, Americans ordered an average of 82 meals in restaurants per person.; by the point (20, 82) **105.** $C = 100{,}000 + 100x$, where x is the number of bicycles produced; $C(90) = 109{,}000$; It costs \$109,000 to produce 90 bicycles. **106.** $V = 22{,}500 - 3200x$; $V(3) = 12{,}900$; The value of the car after 3 years is \$12,900. **107.** $T = \frac{40}{x} + \frac{40}{x + 30}$, where x is the rate on the outgoing trip; $T(30) = 2$; It takes 2 hours, traveling 30 mph outgoing and 60 mph returning. **108.** $S = 0.1x + 0.6(50 - x)$, where x is the number of milliliters of the 10% solution; $S(30) = 15$; There are 15 milliliters of sodium iodine in the mixture when 30 milliliters of the 10% solution are used. **118.** makes sense **119.** does not make sense **120.** does not make sense **121.** does not make sense **122.** false **123.** false **124.** true **125.** false **126.** 3 **127.** Answers will vary; an example is $\{(1, 1), (2, 1)\}$. **128.** $f(2) = 6$; $f(3) = 9$; $f(4) = 12$; no **129.** 36; For 100 calling minutes, the monthly cost is \$36.

130. $f(x) = x + 2,\ x \le 1$



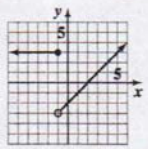
131. $4xh + 2h^2 + 3h$

Section 2.2

Check Point Exercises

1. increasing on $(-\infty, -1)$, decreasing on $(-1, 1)$, increasing on $(1, \infty)$ **2. a.** even **b.** odd **c.** neither **3. a.** 20; With 40 calling minutes, the cost is \$20.; (40, 20) **b.** 28; With 80 calling minutes, the cost is \$28.; (80, 28)

4.



$f(x) = \begin{cases} 3 & \text{if } x \le -1 \\ x - 2 & \text{if } x > -1 \end{cases}$

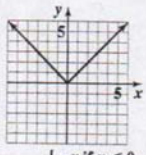
5. a. $-2x^2 - 4xh - 2h^2 + x + h + 5$ **b.** $-4x - 2h + 1,\ h \ne 0$

Exercise Set 2.2

1. a. $(-1, \infty)$ **b.** $(-\infty, -1)$ **c.** none **2. a.** $(-\infty, -1)$ **b.** $(-1, \infty)$ **c.** none **3. a.** $(0, \infty)$ **b.** none **c.** none **4. a.** $(-1, \infty)$ **b.** none **c.** none **5. a.** none **b.** $(-2, 6)$ **c.** none **6. a.** $(-3, 2)$ **b.** none **c.** none **7. a.** $(-\infty, -1)$ **b.** none **c.** $(-1, \infty)$ **8. a.** $(0, \infty)$ **b.** none **c.** $(-\infty, 0)$ **9. a.** $(-\infty, 0)$ or $(1.5, 3)$ **b.** $(0, 1.5)$ or $(3, \infty)$ **c.** none **10. a.** $(-5, -4)$ or $(-2, 0)$ or $(2, 4)$ **b.** $(-4, -2)$ or $(0, 2)$ or $(4, 5)$ **c.** none **11. a.** $(-2, 4)$ **b.** none **c.** $(-\infty, -2)$ or $(4, \infty)$ **12. a.** none **b.** $(-4, 2)$ **c.** $(-\infty, -4)$ or $(2, \infty)$ **13. a.** 0; $f(0) = 4$ **b.** $-3, 3$; $f(-3) = f(3) = 0$ **14. a.** 0; $f(0) = 2$ **b.** $-3, 3$; $f(-3) = f(3) = -1$ **15. a.** -2; $f(-2) = 21$ **b.** 1; $f(1) = -6$ **16. a.** 1; $f(1) = 30$ **b.** 4; $f(4) = 3$ **17.** odd **18.** odd **19.** neither **20.** neither **21.** even **22.** even **23.** even **24.** even

25. even **26.** odd **27.** odd **28.** even **29.** even **30.** odd **31.** odd **32.** neither **33. a.** $(-\infty, \infty)$ **b.** $[-4, \infty)$ **c.** 1 and 7 **d.** 4 **e.** $(4, \infty)$ **f.** $(0, 4)$ **g.** $(-\infty, 0)$ **h.** 4 **i.** -4 **j.** 4 **k.** 2 and 6 **l.** neither **34. a.** $(-\infty, \infty)$ **b.** $(-\infty, 4]$ **c.** -4 and 4 **d.** 1 **e.** $(-\infty, -2)$ or $(0, 3)$ **f.** $(-2, 0)$ or $(3, \infty)$ **g.** $(-\infty, -4]$ or $[4, \infty)$ **h.** -2 and 3 **i.** 2 and 4 **j.** 4 **k.** -4 and 4 **l.** neither **35. a.** $(-\infty, 3]$ **b.** $(-\infty, 4]$ **c.** -3 and 3 **d.** 3 **e.** $(-\infty, 1)$ **f.** $(1, 3)$ **g.** $(-\infty, -3]$ **h.** A relative maximum of 4 occurs at 1. **i.** 1 **j.** positive **36. a.** $(-\infty, 6]$ **b.** $(-\infty, 1]$ **c.** -3 and 3 **d.** 1 **e.** $(-\infty, -2)$ **f.** $(2, 6)$ **g.** $(-2, 2)$ **h.** $(-3, 3)$ **i.** -5 and 5 **j.** negative **k.** neither **l.** no **37. a.** -1 **b.** 7 **c.** 19 **38. a.** -19 **b.** 3 **c.** 31 **39. a.** 3 **b.** 3 **c.** 0 **40. a.** 5 **b.** 1 **c.** 0 **41. a.** 8 **b.** 3 **c.** 6 **42. a.** 12 **b.** 5 **c.** 10

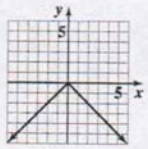
43. a.



$f(x) = \begin{cases} -x & \text{if } x < 0 \\ x & \text{if } x \geq 0 \end{cases}$

b. $[0, \infty)$

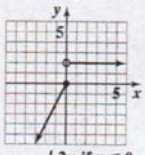
44. a.



$f(x) = \begin{cases} x & \text{if } x < 0 \\ -x & \text{if } x \geq 0 \end{cases}$

b. $(-\infty, 0]$

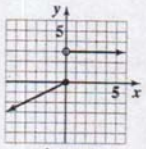
45. a.



$f(x) = \begin{cases} 2x & \text{if } x \leq 0 \\ 2 & \text{if } x > 0 \end{cases}$

b. $(-\infty, 0] \cup \{2\}$

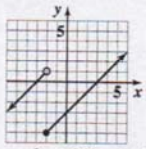
46. a.



$f(x) = \begin{cases} \frac{1}{2}x & \text{if } x \leq 0 \\ 3 & \text{if } x > 0 \end{cases}$

b. $(-\infty, 0] \cup \{3\}$

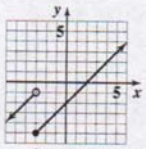
47. a.



$f(x) = \begin{cases} x + 3 & \text{if } x < -2 \\ x - 3 & \text{if } x \geq -2 \end{cases}$

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

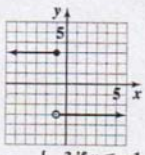
48. a.



$f(x) = \begin{cases} x + 2 & \text{if } x < -3 \\ x - 2 & \text{if } x \geq -3 \end{cases}$

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

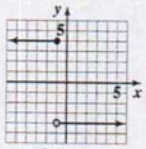
49. a.



$f(x) = \begin{cases} 3 & \text{if } x \leq -1 \\ -3 & \text{if } x > -1 \end{cases}$

b. $\{-3, 3\}$

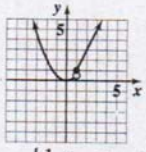
50. a.



$f(x) = \begin{cases} 4 & \text{if } x \leq -1 \\ -4 & \text{if } x > -1 \end{cases}$

b. $\{-4, 4\}$

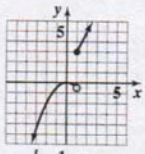
51. a.



$f(x) = \begin{cases} \frac{1}{2}x^2 & \text{if } x < 1 \\ 2x - 1 & \text{if } x \geq 1 \end{cases}$

b. $[0, \infty)$

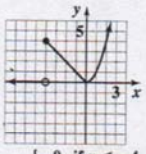
52. a.



$f(x) = \begin{cases} -\frac{1}{2}x^2 & \text{if } x < 1 \\ 2x + 1 & \text{if } x \geq 1 \end{cases}$

b. $(-\infty, 0] \cup [3, \infty)$

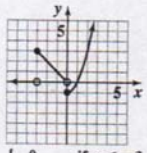
53. a.



$f(x) = \begin{cases} 0 & \text{if } x < -4 \\ -x & \text{if } -4 \leq x < 0 \\ x^2 & \text{if } x \geq 0 \end{cases}$

b. $[0, \infty)$

54. a.



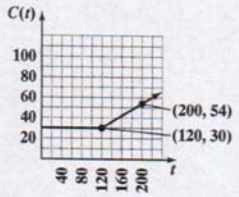
$f(x) = \begin{cases} 0 & \text{if } x < -3 \\ -x & \text{if } -3 \leq x < 0 \\ x^2 - 1 & \text{if } x \geq 0 \end{cases}$

b. $[-1, \infty)$

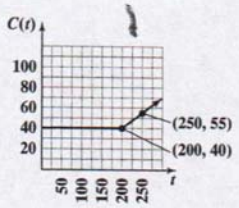
55. $4, h \neq 0$ **56.** $7, h \neq 0$ **57.** $3, h \neq 0$ **58.** $6, h \neq 0$ **59.** $2x + h, h \neq 0$ **60.** $4x + 2h, h \neq 0$ **61.** $2x + h - 4, h \neq 0$ **62.** $2x + h - 5, h \neq 0$ **63.** $4x + 2h + 1, h \neq 0$ **64.** $6x + 3h + 1, h \neq 0$ **65.** $-2x - h + 2, h \neq 0$ **66.** $-2x - h - 3, h \neq 0$ **67.** $-4x - 2h + 5, h \neq 0$ **68.** $-6x - 3h + 2, h \neq 0$ **69.** $-4x - 2h - 1, h \neq 0$ **70.** $-6x - 3h + 1, h \neq 0$ **71.** $0, h \neq 0$ **72.** $0, h \neq 0$

73. $-\dfrac{1}{x(x+h)}, h \neq 0$ **74.** $-\dfrac{1}{2x(x+h)}, h \neq 0$ **75.** $\dfrac{1}{\sqrt{x+h} + \sqrt{x}}, h \neq 0$ **76.** $\dfrac{1}{\sqrt{x+h-1} + \sqrt{x-1}}, h \neq 0$ **77.** -18 **78.** -3

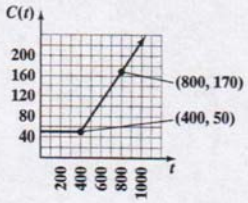
79. $0.30t - 6$



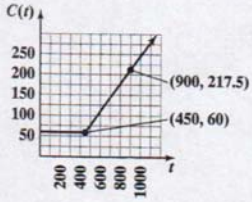
80. $0.30t - 20$



81. $C(t) = \begin{cases} 50 & \text{if } 0 \leq t \leq 400 \\ 50 + 0.30(t - 400) & \text{if } t > 400 \end{cases}$



82. $C(t) = \begin{cases} 60 & \text{if } 0 \leq t \leq 450 \\ 60 + 0.35(t - 450) & \text{if } t > 450 \end{cases}$



83. increasing: $(25, 55)$; decreasing: $(55, 75)$ **84.** increasing: $(25, 65)$; decreasing: $(65, 75)$

85. 55 years old; 38% **86.** 65 years old; 26% **87.** domain: $[25, 75]$; range: $[34, 38]$

88. domain: $[25, 75]$; range: $[23, 26]$ **89.** men **90.** women

91. 2608.75; A single taxpayer with taxable income of \$20,000 owes \$2608.75.

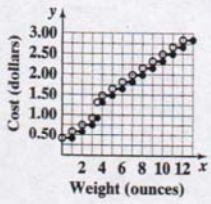
92. 8923.75; A single taxpayer with taxable income of \$50,000 owes \$8923.75.

93. $39{,}148.75 + 0.33(x - 160{,}850)$ **94.** $101{,}469.25 + 0.35(x - 349{,}700)$

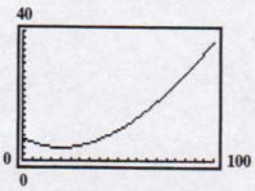
95. 0.76; It costs \$0.76 to mail a 3-ounce first-class letter.

96. 0.93; It costs \$0.93 to mail a 3.5-ounce first-class letter. **97.** \$0.59 **98.** \$0.59

99.

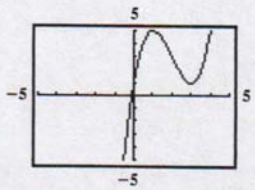


106.



The number of doctor visits decreases during childhood and then increases as you get older. The minimum is $(20.29, 3.99)$, which means that the minimum number of annual doctor visits, about 4, occurs at around age 20.

107.



increasing: $(-\infty, 1)$ or $(3, \infty)$
decreasing: $(1, 3)$