14. $x^3 - 6x^2 + 12x - 8$ **15.** $x^2 + 2xy + y^2 - z^2$

16. $x^2(2x + 1)(x - 2)$ **17.** $(x - 2)(x + 2)^2$

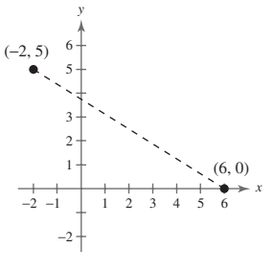
18. $(2x - 3)(4x^2 + 6x + 9)$

19. (a) $\dfrac{\sqrt[3]{16^5}}{16} = 4\sqrt[3]{4}$ (b) $-3 - 3\sqrt{3}$

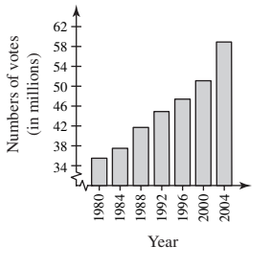
(c) $\dfrac{\sqrt{x+2} + \sqrt{2}}{x}$

20. $\frac{5}{6}\sqrt{3}x^2$

21.



22.



Midpoint: $\left(2, \frac{5}{2}\right)$; Distance: $\sqrt{89}$

Chapter 1

Section 1.1 (page 84)

Vocabulary Check (page 84)

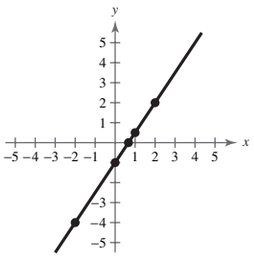
1. solution point **2.** graph **3.** intercepts

1. (a) Yes (b) Yes **3.** (a) No (b) Yes

5. (a) No (b) Yes

7.

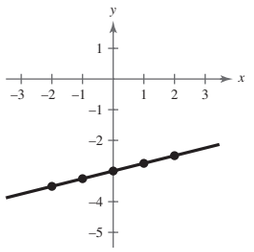
x	-2	0	$\frac{2}{3}$	1	2
y	-4	-1	0	$\frac{1}{2}$	2
Solution point	$(-2, -4)$	$(0, -1)$	$\left(\frac{2}{3}, 0\right)$	$\left(1, \frac{1}{2}\right)$	$(2, 2)$



9. (a)

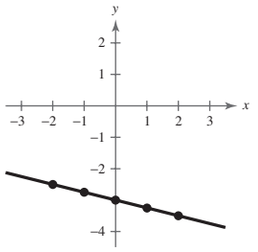
x	-2	-1	0	1	2
y	$-\frac{7}{2}$	$-\frac{13}{4}$	-3	$-\frac{11}{4}$	$-\frac{5}{2}$

(b)



(c)

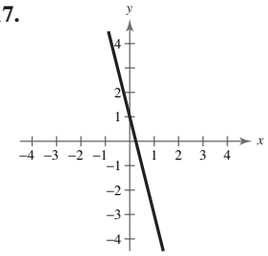
x	-2	-1	0	1	2
y	$-\frac{5}{2}$	$-\frac{11}{4}$	-3	$-\frac{13}{4}$	$-\frac{7}{2}$



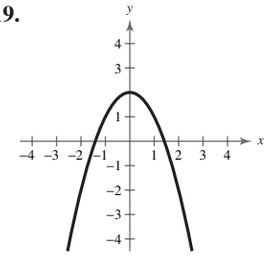
The lines have opposite slopes but the same y-intercept.

11. e **12.** f **13.** b **14.** d **15.** c **16.** a

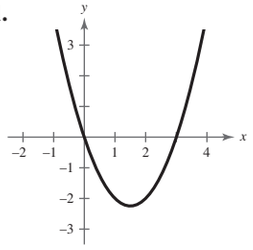
17.



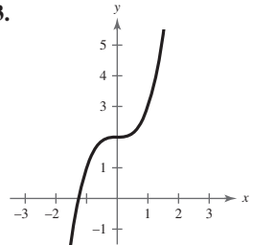
19.



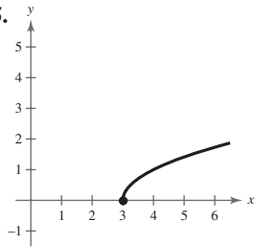
21.



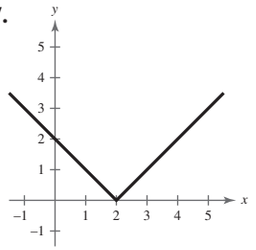
23.



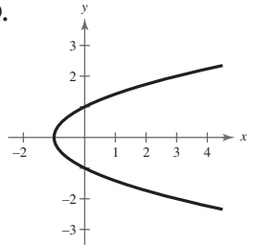
25.



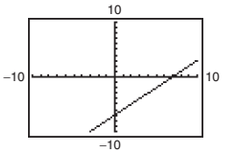
27.



29.

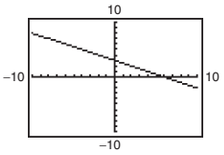


31.



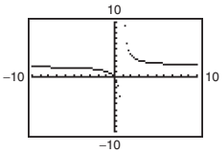
Intercepts: $(7, 0), (0, -7)$

33.



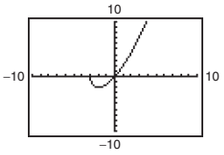
Intercepts: $(6, 0), (0, 3)$

35.



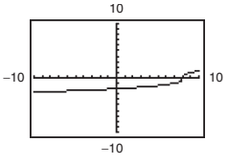
Intercept: $(0, 0)$

37.



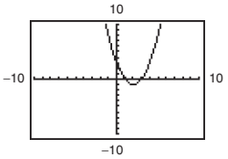
Intercepts: $(-3, 0), (0, 0)$

39.



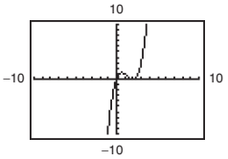
Intercept: $(0, -2), (8, 0)$

41.



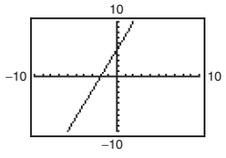
Intercepts: $(0, 3), (1, 0), (3, 0)$

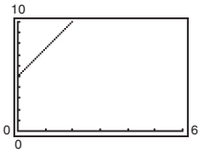
43.



Intercepts: $(0, 0), (2, 0)$

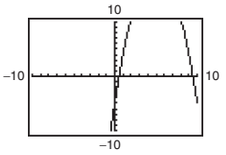
45.

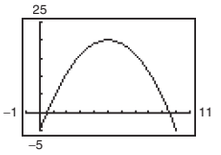




The standard setting gives a more complete graph.

47.





The specified setting gives a more complete graph.

49.

```
Xmin = -10
Xmax = 10
Xscl = 2
Ymin = -50
Ymax = 100
Yscl = 25
```

51.

```
Xmin = -5
Xmax = 1
Xscl = 1
Ymin = -3
Ymax = 1
Yscl = 1
```

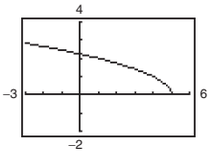
53.

```
Xmin = -30
Xmax = 30
Xscl = 5
Ymin = -10
Ymax = 50
Yscl = 5
```

55. The graphs are identical. Distributive Property

57. The graphs are identical. Associative Property of Multiplication

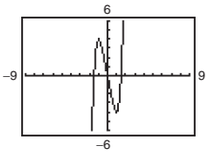
59.



(a) $(2, 1.73)$

(b) $(-4, 3)$

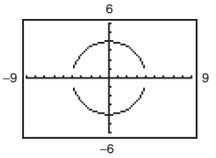
61.



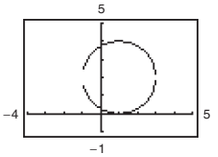
(a) $(-0.5, 2.47)$

(b) $(1, -4), (-1.65, -4)$

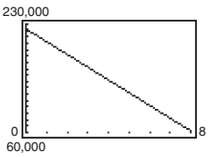
63. $y_1 = \sqrt{16 - x^2},\ y_2 = -\sqrt{16 - x^2}$



65. $y_1 = \sqrt{4 - (x - 1)^2} + 2,\ y_2 = -\sqrt{4 - (x - 1)^2} + 2$



67. a **69.** b, c, d

71. (a) 

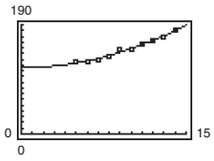
(b) \$109,000 (c) \$178,000

73. (a)

Year	1995	1996	1997	1998	1999
Median sales price (in thousands of dollars)	123.4	127.1	131.5	136.5	142.3

Year	2000	2001	2002	2003	2004
Median sales price (in thousands of dollars)	148.6	155.5	163.0	171.1	179.6

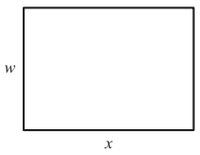
The model fits the data fairly well.

(b) 

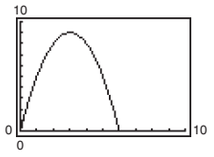
Answers will vary. Sample answer: Because the graphs overlap and have little divergence from one another, the model fits the data well.

(c) 2008: \$218,155; 2010: \$239,700; Answers will vary.

(d) 2000

75. (a) 

(b) Answers will vary.

(c) 

(d) $A \approx 5.4$

(e) $x = 3, w = 3$

77. False. $y = x^2 - 1$ has two x-intercepts.

79. Answers will vary. Sample answer: Use the zoom fit and zoom out features as needed.

81. Answers will vary. Sample answer: $y = 250x + 1000$ could represent the amount of money in someone's checking account after time x if they deposited an initial \$1000 and added \$250 every x time increment (x could potentially stand for a month, for example).

83. $27\sqrt{2}$ **85.** 823,543 **87.** $2x^2 + 8x + 11$

Section 1.2 (page 96)

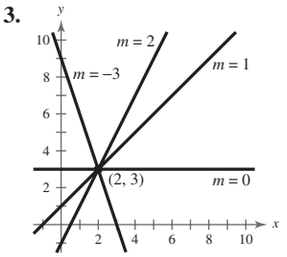
Vocabulary Check (page 96)

1. (a) iii (b) i (c) v (d) ii (e) iv

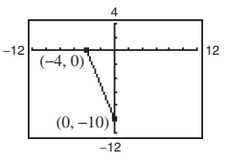
2. slope **3.** parallel **4.** perpendicular

5. linear extrapolation

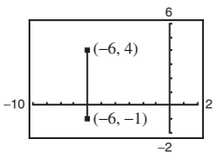
1. (a) L_2 (b) L_3 (c) L_1

3. 

5. $\frac{3}{2}$

7. 

$m = -\frac{5}{2}$

9. 

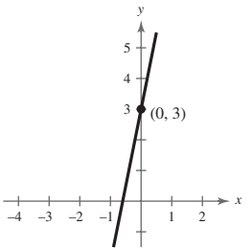
m is undefined.

11. (0, 1), (3, 1), (−1, 1) **13.** (1, 4), (1, 6), (1, 9)

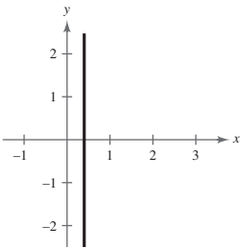
15. (−1, −7), (−2, −5), (−5, 1)

17. (3, −4), (5, −3), (9, −1)

19. (a) $m = 5$; y-intercept: (0, 3)

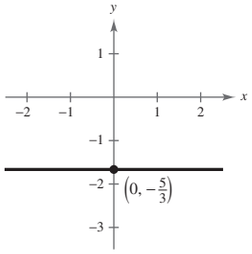
(b) 

21. (a) Slope is undefined; there is no y-intercept.

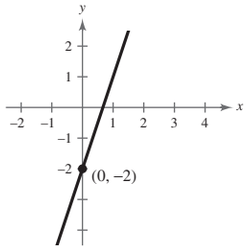
(b) 

23. (a) $m = 0$; y-intercept: $\left(0, -\frac{5}{3}\right)$

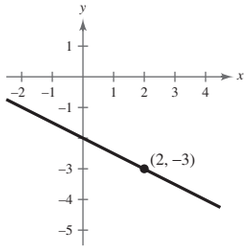
(b)



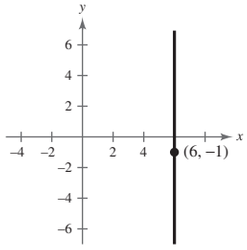
25. $3x - y - 2 = 0$



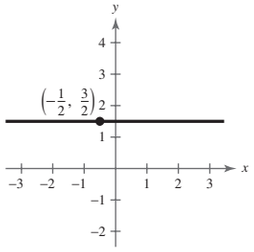
27. $y + \frac{1}{2}x + 2 = 0$



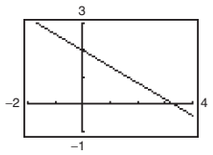
29. $x - 6 = 0$



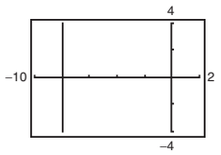
31. $y - \frac{3}{2} = 0$



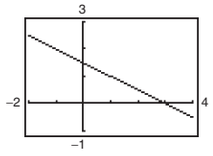
33. $y = -\frac{3}{5}x + 2$



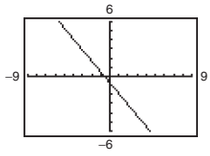
35. $x + 8 = 0$



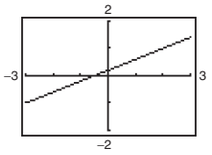
37. $y = -\frac{1}{2}x + \frac{3}{2}$



39. $y = -\frac{6}{5}x - \frac{18}{25}$



41. $y = \frac{2}{5}x + \frac{1}{5}$



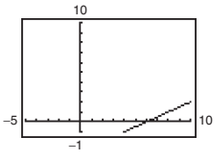
43. $y = 2x - 5$

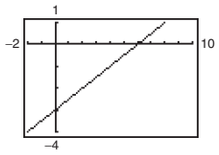
45. \$37,300

47. $m = \frac{1}{2}$; y-intercept: $(0, -2)$; a line that rises from left to right

49. Slope is undefined; no y-intercept; a vertical line at $x = -6$

51.





The second setting gives a more complete graph, with a view of both intercepts.

53. Perpendicular **55.** Parallel

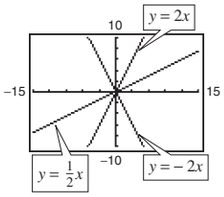
57. (a) $y = 2x - 3$ (b) $y = -\frac{1}{2}x + 2$

59. (a) $y = -\frac{3}{4}x + \frac{3}{8}$ (b) $y = \frac{4}{3}x + \frac{127}{72}$

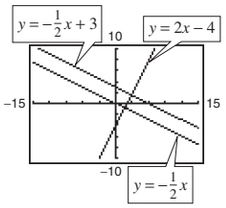
61. (a) $x = 3$ (b) $y = -2$

63. $y = 2x + 1$ **65.** $y = -\frac{1}{2}x + 1$

67. The lines $y = \frac{1}{2}x$ and $y = -2x$ are perpendicular.



69. The lines $y = -\frac{1}{2}x$ and $y = -\frac{1}{2}x + 3$ are parallel. Both are perpendicular to $y = 2x - 4$.



71. (a) The greatest increase $(+0.86)$ was from 1998 to 1999 and the greatest decrease (-0.78) was from 1999 to 2000.

(b) $y = -0.067t + 1.24$, $t = 5$ corresponds to 1995.

(c) There is a decrease of about \$0.067 per year.

(d) -0.1, Answers will vary.

73. 12 feet **75.** $V = 125t + 1790$

77. $V = -2000t + 32{,}400$

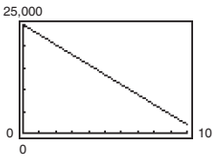
79. b; slope $= -10$; the amount owed decreases by \$10 per week.

80. c; slope = 1.5; 1.50; the hourly wage increases by \$1.50 per unit produced.

81. a; slope = 0.35; expenses increase by \$0.35 per mile.

82. d; slope $= -100$; the value depreciates \$100 per year.

83. (a) $V = 25{,}000 - 2300t$

(b) 

t	0	1	2	3	4
V	25,000	22,700	20,400	18,100	15,800

t	5	6	7	8	9	10
V	13,500	11,200	8900	6600	4300	2000

85. (a) $C = 16.75t + 36{,}500$ (b) $R = 27t$

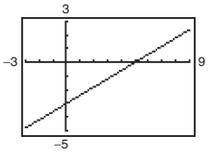
(c) $P = 10.25t - 36{,}500$ (d) $t \approx 3561$ hours

87. (a) Increase of about 341 students per year

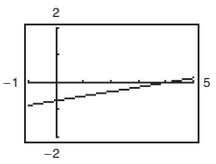
(b) 72,962; 77,395; 78,418

(c) $y = 341x + 75{,}008$, where $x = 1$ corresponds to 1991; $m = 341$; the slope determines the average increase in enrollment.

89. False. The slopes $\left(\frac{2}{7}$ and $-\frac{11}{7}\right)$ are not equal.

91. 

a and b represent the x- and y-intercepts.

93. 

a and b represent the x- and y-intercepts.

95. $3x + 2y - 6 = 0$ **97.** $12x + 3y + 2 = 0$

99. a **101.** c

103. No. Answers will vary. Sample answer: The line, $y = 2$, does not have an x-intercept.

105. Yes. Once a parallel line is established to the given line, there are an infinite number of distances away from that line, creating an infinite number of parallel lines.

107. Yes. $x + 20$ **109.** No **111.** No

113. $(x - 9)(x + 3)$ **115.** $(2x - 5)(x + 8)$

117. Answers will vary.

Section 1.3 (page 109)

Vocabulary Check (page 109)

1. domain, range, function

2. independent, dependent **3.** piecewise-defined

4. implied domain **5.** difference quotient

1. Yes. Each element of the domain is assigned to exactly one element of the range.

3. No. The National League, an element in the domain, is assigned to three items in the range, the Cubs, the Pirates, and the Dodgers; the American League, an element in the domain, is also assigned to three items in the range, the Orioles, the Yankees, and the Twins.

5. Yes. Each input value is matched with one output value.

7. No. The inputs 7 and 10 are both matched with two different outputs.

9. (a) Function

(b) Not a function because the element 1 in A corresponds to two elements, -2 and 1, in B.

(c) Function

(d) Not a function because the element 2 in A corresponds to no element in B.

11. Each is a function of the year. To each year there corresponds one and only one circulation.

13. Not a function **15.** Function **17.** Function

19. Not a function **21.** Function **23.** Not a function

25. (a) $\frac{1}{5}$ (b) 1 (c) $\frac{1}{4t + 1}$ (d) $\frac{1}{x + c + 1}$

27. (a) 7 (b) -11 (c) $3t + 7$

29. (a) 0 (b) -0.75 (c) $x^2 + 2x$

31. (a) 1 (b) 2.5 (c) $3 - 2|x|$

33. (a) $-\frac{1}{9}$ (b) Undefined (c) $\frac{1}{y^2 + 6y}$

35. (a) 1 (b) -1 (c) $\frac{|t|}{t}$

37. (a) -1 (b) 2 (c) 6

39. (a) 6 (b) 3 (c) 10

41. (a) 0 (b) 4 (c) 17

43.

t	-5	-4	-3	-2	-1
$h(t)$	1	$\frac{1}{2}$	0	$\frac{1}{2}$	1

45.

x	-2	-1	0	1	2
$f(x)$	5	$\frac{9}{2}$	4	1	0

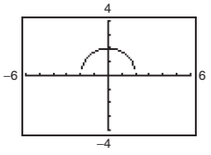
47. 5 **49.** $\frac{4}{3}$ **51.** $2, -1$ **53.** All real numbers x

55. All real numbers t except $t = 0$ **57.** All real numbers x

59. All real numbers x except $x = 0, -2$

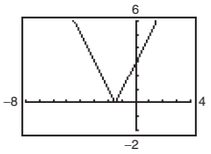
61. All real numbers y such that $y > 10$

63.



Domain: $[-2, 2]$; range: $[0, 2]$

65.



Domain: $(-\infty, \infty)$; range: $[0, \infty)$

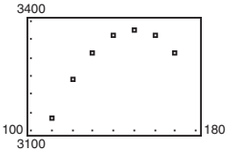
67. $\{(-2, 4), (-1, 1), (0, 0), (1, 1), (2, 4)\}$

69. $\{(-2, 4), (-1, 3), (0, 2), (1, 3), (2, 4)\}$

71. $A = \dfrac{C^2}{4\pi}$

73. (a) \$3375

(b)



Yes, it is a function.

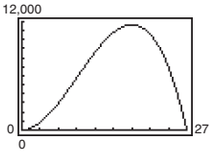
(c) $P(x) = \begin{cases} 30x, & x \le 100 \\ 45x - 0.15x^2, & x > 100 \end{cases}$

75. $A = \dfrac{x^2}{2(x-2)}$, $x > 2$

77. (a) $V = 108x^2 - 4x^3$

Domain: all real numbers x such that $0 < x < 27$

(b)



$x = 18$ inches, $y = 36$ inches

79. $7 \le x \le 12$, $1 \le x \le 6$; Answers will vary.

81. 4.63; \$4630 in monthly revenue in November

83.

t	0	1	2	3	4	5	6
$n(t)$	577	647	704	749	782	803	811

t	7	8	9	10	11	12	13
$n(t)$	846	871	896	921	946	971	996

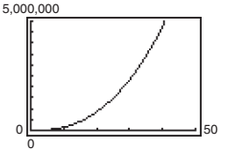
85. (a)

y	5	10	20
$F(y)$	26,474	149,760	847,170

y	30	40
$F(y)$	2,334,527	4,792,320

Each time the depth is doubled, the force increases by more than 5.7 times.

(b)



Xmin = 0
Xmax = 50
Xscl = 10
Ymin = 0
Ymax = 5,000,000
Yscl = 500,000

(c) Depth $\approx$ 21.37 feet
Use the *trace* and *zoom* features on a graphing utility.

87. $2, c \neq 0$ **89.** $3 + h, h \neq 0$ **91.** $-\dfrac{1}{t}, t \neq 1$

93. False. The range is $[-1, \infty)$.

95. $f(x) = \begin{cases} x + 4, & x \le 0 \\ 4 - x^2, & x > 0 \end{cases}$

97. $f(x) = \begin{cases} 2 - x, & x \le -2 \\ 4, & -2 < x < 3 \\ x + 1, & x \ge 3 \end{cases}$

99. The domain is the set of input values of a function. The range is the set of output values.

101. $\dfrac{12x + 20}{x + 2}$ **103.** $\dfrac{(x + 6)(x + 10)}{5(x + 3)}, x \neq 0, \dfrac{1}{2}$

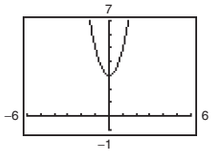
Section 1.4 (page 123)

Vocabulary Check (page 123)

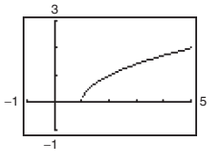
1. ordered pairs **2.** Vertical Line Test
3. decreasing **4.** minimum
5. greatest integer **6.** even

1. Domain: $(-\infty, \infty)$; range: $(-\infty, 1]$; $f(0) = 1$

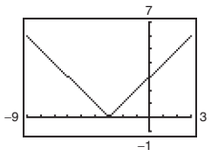
3. Domain: $[-4, 4]$; range: $[0, 4]$; $f(0) = 4$

5. 

Domain: $(-\infty, \infty)$
Range: $[3, \infty)$

7. 

Domain: $[1, \infty)$
Range: $[0, \infty)$

9. 

Domain: $(-\infty, \infty)$
Range: $[0, \infty)$

11. (a) $(-\infty, \infty)$ (b) $-2, 3$ (c) x-intercepts
(d) -6 (e) y-intercept (f) -6; $(1, -6)$
(g) -4; $(-1, -4)$ (h) 6

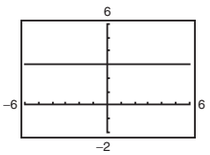
13. (a) $(-\infty, \infty)$ (b) $-1, 3$ (c) x-intercepts
(d) -1 (e) y-intercept (f) -2; $(1, -2)$
(g) 0; $(-1, 0)$ (h) 2

15. Function. Graph the given function over the window shown in the figure.

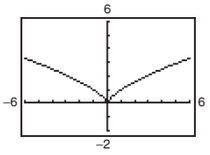
17. Not a function. Solve for y and graph the two resulting functions.

19. Increasing on $(-\infty, \infty)$

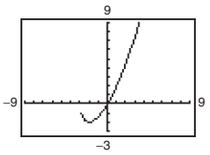
21. Increasing on $(-\infty, 0), (2, \infty)$
Decreasing on $(0, 2)$

23. (a) 

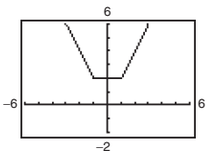
(b) Constant: $(-\infty, \infty)$

25. (a) 

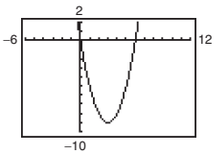
(b) Decreasing on $(-\infty, 0)$
Increasing on $(0, \infty)$

27. (a) 

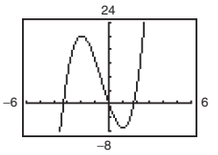
(b) Increasing on $(-2, \infty)$
Decreasing on $(-3, -2)$

29. (a) 

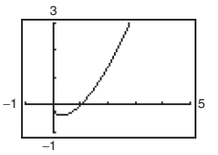
(b) Decreasing on $(-\infty, -1)$
Constant on $(-1, 1)$
Increasing on $(1, \infty)$

31. 

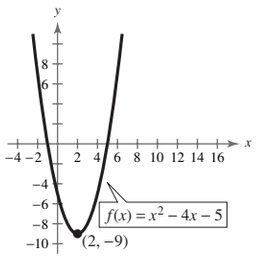
Relative minimum: $(3, -9)$

33. 

Relative minimum: $(1, -7)$
Relative maximum: $(-2, 20)$

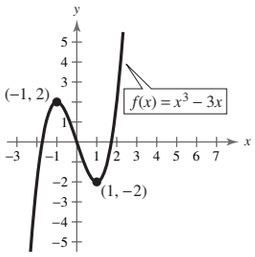
35. 

Minimum: $(0.33, -0.38)$

37. (a) 

(b) Relative minimum at $(2, -9)$
(c) Answers are the same.

39. (a)

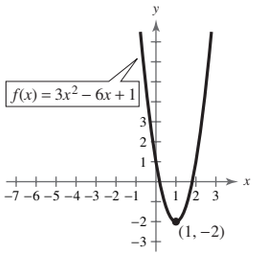


(b) Relative minimum at $(1, -2)$

Relative maximum at $(-1, 2)$

(c) Answers are the same.

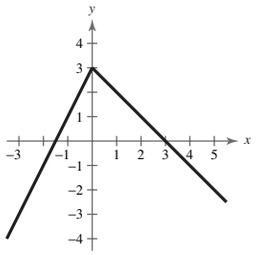
41. (a)



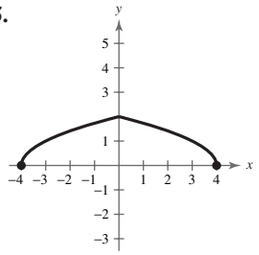
(b) Relative minimum at $(1, -2)$

(c) Answers are the same.

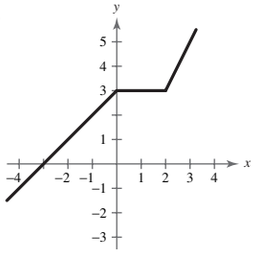
43.



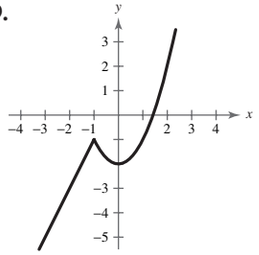
45.



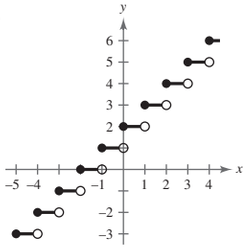
47.



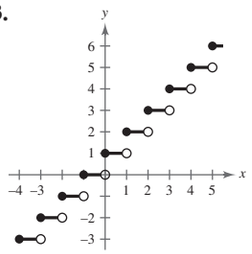
49.



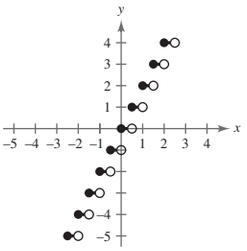
51.



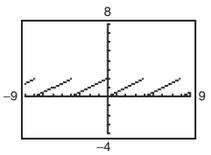
53.



55.



57.



Domain: $(-\infty, \infty)$

Range: $[0, 2)$

Sawtooth pattern

59. Neither even nor odd **61.** Odd function

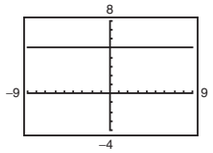
63. Odd function **65.** Even function

67. (a) $\left(\frac{3}{2}, 4\right)$ (b) $\left(\frac{3}{2}, -4\right)$

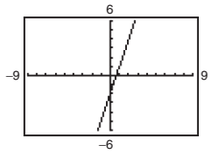
69. (a) $(-4, 9)$ (b) $(-4, -9)$

71. (a) $(-x, -y)$ (b) $(-x, y)$

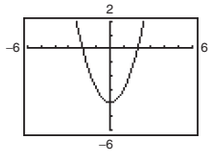
73. Even function



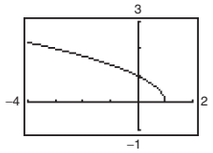
75. Neither even nor odd



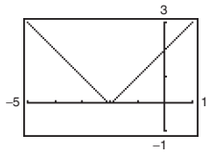
77. Even function



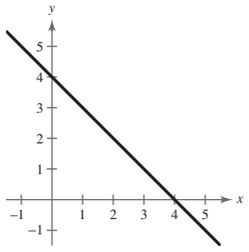
79. Neither even nor odd



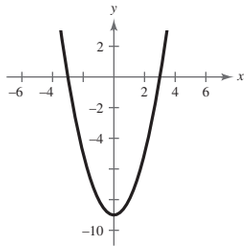
81. Neither even nor odd



83. $(-\infty, 4]$

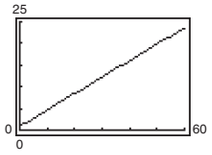


85. $(-\infty, -3], [3, \infty)$



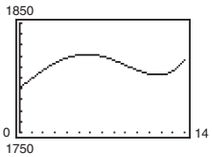
CHAPTER 1

87. (a) C_2 is the appropriate model. The cost of the first minute is \$1.05 and the cost increases \$0.38 when the next minute begins, and so on.

(b) 

\$7.89

89. $h = -x^2 + 4x - 3,\ 1 \le x \le 3$

91. (a) 

(b) Increasing from 1990 to 1995 and from 2001 to 2004; decreasing from 1995 to 2001

(c) About 1,821,00.

93. False. Counterexample: $f(x) = \sqrt{1 + x^2}$

95. c **96.** d **97.** b **98.** e

99. a **100.** f

101. Proof

103. (a) Even. g is a reflection in the x-axis.

(b) Even. g is a reflection in the y-axis.

(c) Even. g is a vertical shift downward.

(d) Neither even nor odd. g is shifted to the right and reflected in the x-axis.

105. No. x is not a function of y because horizontal lines can be drawn to intersect the graph twice. Therefore, each y-value corresponds to two distinct x-values when $-5 < y < 5$.

107. Terms: $-2x^2, 8x$; coefficients: $-2, 8$

109. Terms: $\frac{x}{3}, -5x^2, x^3$; coefficients: $\frac{1}{3}, -5, 1$

111. (a) $d = 4\sqrt{5}$ (b) Midpoint: $(2, 5)$

113. (a) $d = \sqrt{41}$ (b) Midpoint: $\left(\frac{1}{2}, \frac{3}{2}\right)$

115. (a) 29 (b) -6 (c) $5x - 16$

117. (a) 0 (b) 36 (c) $6\sqrt{3}$

119. $h + 4, h \neq 0$

Section 1.5 (page 133)

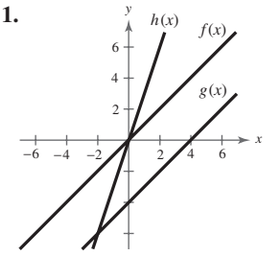
Vocabulary Check (page 133)

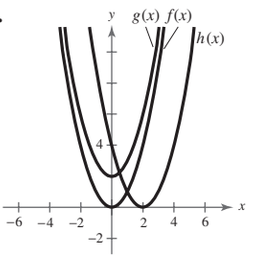
1. quadratic function **2.** absolute value function

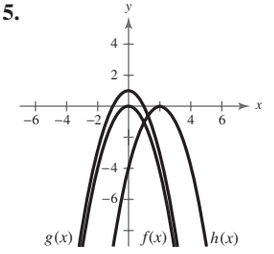
3. rigid transformations **4.** $-f(x), f(-x)$

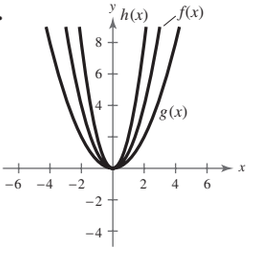
5. $c > 1, 0 < c < 1$

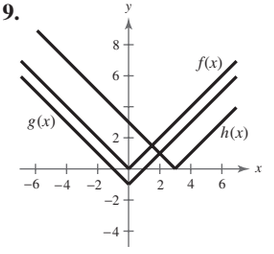
6. (a) ii (b) iv (c) iii (d) i

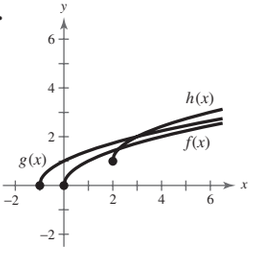
1. 

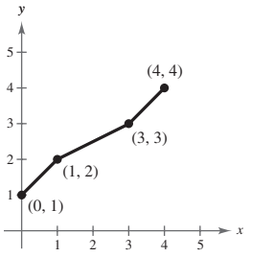
3. 

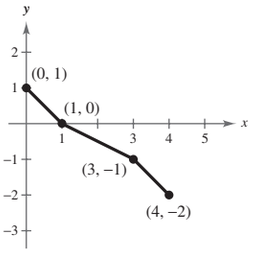
5. 

7. 

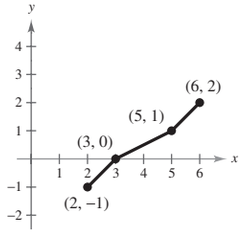
9. 

11. 

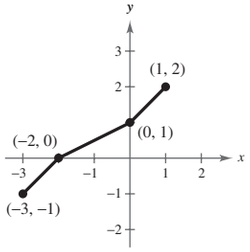
13. (a) 

(b) 

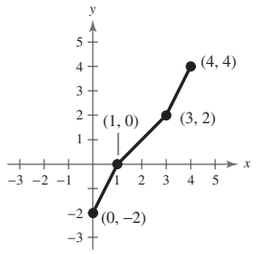
(c)



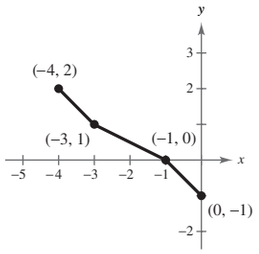
(d)



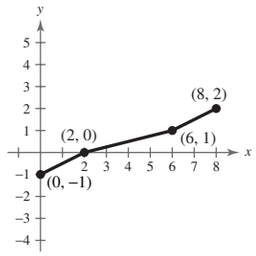
(e)



(f)



(g)



15. Vertical shift of $y = x$; $y = x + 3$

17. Vertical shift of $y = x^2$; $y = x^2 - 1$

19. Reflection in the x-axis and a vertical shift one unit upward of $y = \sqrt{x}$; $y = 1 - \sqrt{x}$

21. Reflection in the x-axis and vertical shift one unit downward

23. Horizontal shift two units to the right

25. Vertical stretch

27. Horizontal shift five units to the left

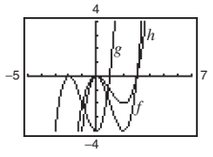
29. Reflection in the x-axis **31.** Vertical stretch

33. Reflection in the x-axis and vertical shift four units upward

35. Horizontal shift two units to the left and vertical shrink

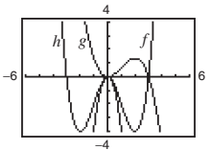
37. Horizontal stretch and vertical shift two units upward

39.



g is a horizontal shift and h is a vertical shrink.

41.

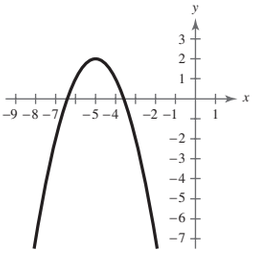


g is a vertical shrink and a reflection in the x-axis and h is a reflection in the y-axis.

43. (a) $f(x) = x^2$

(b) Horizontal shift five units to the left, reflection in the x-axis, and vertical shift two units upward

(c)

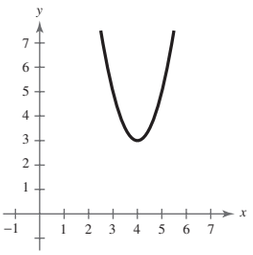


(d) $g(x) = 2 - f(x + 5)$

45. (a) $f(x) = x^2$

(b) Horizontal shift four units to the right, vertical stretch, and vertical shift three units upward

(c)

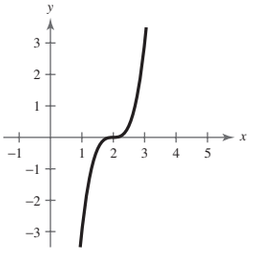


(d) $g(x) = 3 + 2f(x - 4)$

47. (a) $f(x) = x^3$

(b) Horizontal shift two units to the right and vertical stretch

(c)

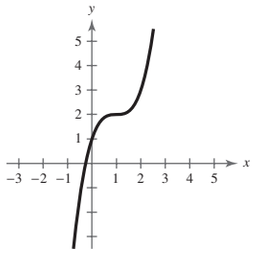


(d) $g(x) = 3f(x - 2)$

49. (a) $f(x) = x^3$

(b) Horizontal shift one unit to the right and vertical shift two units upward

(c)

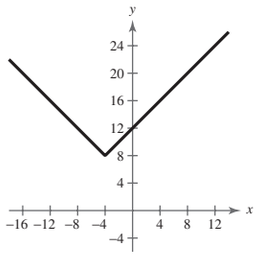


(d) $g(x) = f(x - 1) + 2$

51. (a) $f(x) = |x|$

(b) Horizontal shift four units to the left and vertical shift eight units upward

(c)

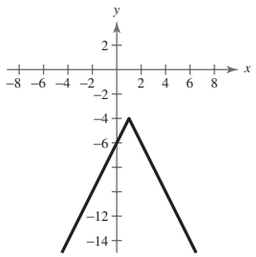


(d) $g(x) = f(x + 4) + 8$

53. (a) $f(x) = |x|$

(b) Horizontal shift one unit to the right, reflection in the x-axis, vertical stretch, and vertical shift four units downward

(c)

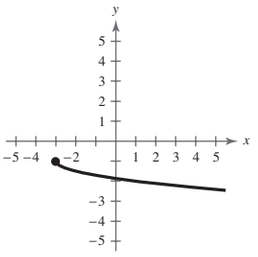


(d) $g(x) = -2f(x - 1) - 4$

55. (a) $f(x) = \sqrt{x}$

(b) Horizontal shift three units to the left, reflection in the x-axis, vertical shrink, and vertical shift one unit downward

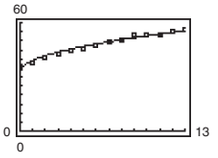
(c)



(d) $g(x) = -\frac{1}{2}f(x + 3) - 1$

57. (a) Vertical stretch and vertical shift

(b)



(c) $G(t) = 33.0 + 6.2\sqrt{t + 13}$, where $t = 0$ corresponds to 2003. Answers will vary.

59. False. When $f(x) = x^2$, $f(-x) = (-x)^2 = x^2$. Because $f(x) = f(-x)$ in this case, $y = f(-x)$ is not a reflection of $y = f(x)$ across the x-axis in all cases.

61. (a) $x = -2$ and $x = 3$

(b) $x = -3$ and $x = 2$

(c) $x = -3$ and $x = 2$

(d) Cannot be determined

(e) $x = 0$ and $x = 5$

63. (a) Increasing on the interval $(-\infty, -2)$ and decreasing on the interval $(-2, \infty)$

(b) Increasing on the interval $(2, \infty)$ and decreasing on the interval $(-\infty, 2)$

(c) Increasing on the interval $(-\infty, 2)$ and decreasing on the interval $(2, \infty)$

(d) Increasing on the interval $(-\infty, 2)$ and decreasing on the interval $(2, \infty)$

(e) Increasing on the interval $(-\infty, 1)$ and decreasing on the interval $(1, \infty)$

65. c **67.** c **69.** Neither

71. All real numbers x except $x = 9$

73. All real numbers x such that $-10 \leq x \leq 10$

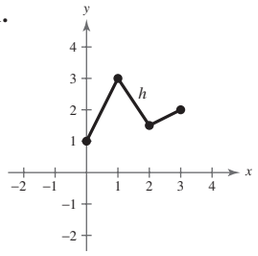
Section 1.6 (page 143)

Vocabulary Check (page 143)

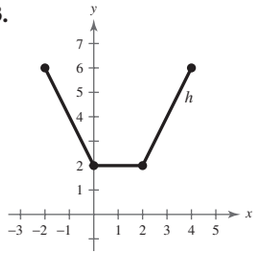
1. addition, subtraction, multiplication, division

2. composition **3.** $g(x)$ **4.** inner, outer

1.



3.



5. (a) $2x$ (b) 6 (c) $x^2 - 9$

(d) $\dfrac{x+3}{x-3}$, All real numbers x except $x = 3$

7. (a) $x^2 - x + 1$ (b) $x^2 + x - 1$ (c) $x^2 - x^3$

(d) $\dfrac{x^2}{1-x}$, All real numbers x except $x = 1$

9. (a) $x^2 + 5 + \sqrt{1-x}$ (b) $x^2 + 5 - \sqrt{1-x}$

(c) $(x^2 + 5)\sqrt{1-x}$ (d) $\dfrac{x^2+5}{\sqrt{1-x}}$, $x < 1$

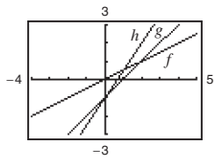
11. (a) $\dfrac{x+1}{x^2}$ (b) $\dfrac{x-1}{x^2}$ (c) $\dfrac{1}{x^3}$ (d) x, $x \neq 0$

13. 9 **15.** 1 **17.** 30 **19.** $-\frac{24}{7}$

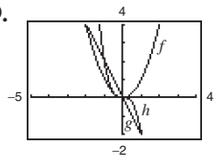
21. $4t^2 - 2t + 1$ **23.** $-125t^3 - 50t^2 + 5t + 2$

25. $\dfrac{t^2-1}{-t-2}$

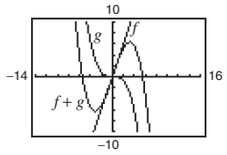
27.



29.

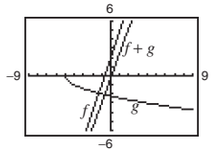


31.



$f(x), 0 \le x \le 2$;
$g(x), x > 6$

33.



$f(x), 0 \le x \le 2$;
$f(x), x > 6$

35. (a) $(x-1)^2$ (b) $x^2 - 1$ (c) 1

37. (a) $20 - 3x$ (b) $-3x$ (c) 20

39. (a) All real numbers x such that $x \ge -4$

(b) All real numbers x (c) All real numbers x

41. (a) All real numbers x

(b) All real numbers x such that $x \ge 0$

(c) All real numbers x such that $x \ge 0$

43. (a) All real numbers x except $x = 0$

(b) All real numbers x

(c) All real numbers x except $x = -3$

45. (a) All real numbers x (b) All real numbers x

(c) All real numbers x

47. (a) All real numbers x

(b) All real numbers x except $x = \pm 2$

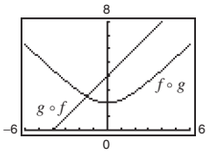
(c) All real numbers x except $x = \pm 2$

49. (a) $(f \circ g)(x) = \sqrt{x^2 + 4}$

$(g \circ f)(x) = x + 4,\ x \ge -4$;

Domain of $f \circ g$: all real numbers x

(b)

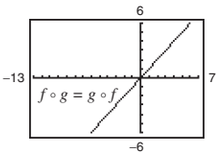


$f \circ g \neq g \circ f$

51. (a) $(f \circ g)(x) = x$; $(g \circ f)(x) = x$;

Domain of $f \circ g$: all real numbers x

(b)

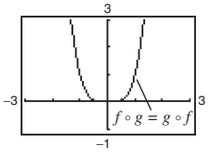


$f \circ g = g \circ f$

53. (a) $(f \circ g)(x) = x^4$; $(g \circ f)(x) = x^4$;

Domain of $f \circ g$: all real numbers x

(b)



$f \circ g = g \circ f$

55. (a) $(f \circ g)(x) = 24 - 5x; (g \circ f)(x) = -5x$

(b) $24 - 5x \neq -5x$

(c)

x	0	1	2	3
$g(x)$	4	3	2	1
$(f \circ g)(x)$	24	19	14	9

x	0	1	2	3
$f(x)$	4	9	14	19
$(g \circ f)(x)$	0	-5	-10	-15

57. (a) $(f \circ g)(x) = \sqrt{x^2 + 1}; (g \circ f)(x) = x + 1,\ x \geq -6$

(b) $x + 1 \neq \sqrt{x^2 + 1}$

(c)

x	0	1	2	3
$g(x)$	-5	-4	-1	4
$(f \circ g)(x)$	1	$\sqrt{2}$	$\sqrt{5}$	$\sqrt{10}$

x	0	1	2	3
$f(x)$	$\sqrt{6}$	$\sqrt{7}$	$\sqrt{8}$	3
$(g \circ f)(x)$	1	2	3	4

59. (a) $(f \circ g)(x) = |2x + 2|; (g \circ f)(x) = 2|x + 3| - 1$

(b) $(f \circ g)(x) = \begin{cases} 2x + 2, & x \geq -1 \\ -2x - 2, & x < -1 \end{cases}$

$(g \circ f)(x) = \begin{cases} 2x + 5, & x \geq -3 \\ -2x - 7, & x < -3 \end{cases}$

$(f \circ g)(x) \neq (g \circ f)(x)$

(c)

x	-2	-1	0	1	2
$g(x)$	-16	-2	0	2	16
$(f \circ g)(x)$	-16	2	0	2	16

x	-2	-1	0	1	2
$f(x)$	2	1	0	1	2
$(g \circ f)(x)$	-16	2	0	2	16

61. (a) 3 (b) 0 **63.** (a) 0 (b) 4

65. $f(x) = x^2,\ g(x) = 2x + 1$

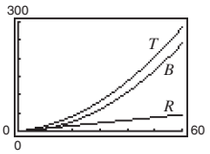
67. $f(x) = \sqrt[3]{x},\ g(x) = x^2 - 4$

69. $f(x) = \dfrac{1}{x},\ g(x) = x + 2$

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

73. (a) $T = \frac{3}{4}x + \frac{1}{15}x^2$

(b)



(c) B. For example, $B(60) = 240$, whereas $R(60)$ is only 45.

75.

Year	1995	1996	1997	1998
y_1	140	151.4	162.8	174.2
y_2	325.8	342.8	364.4	390.6
y_3	458.8	475.3	497.9	526.5

Year	1999	2000	2001	2002
y_1	185.6	197	208.4	219.8
y_2	421.5	457	497.1	541.8
y_3	561.2	602	648.8	701.7

Year	2003	2004	2005
y_1	231.2	242.6	254
y_2	591.2	645.2	703.8
y_3	760.7	825.7	896.8

Answers will vary.

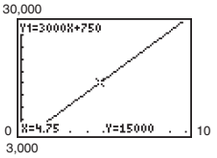
77. $(A \circ r)(t) = 0.36\pi t^2$

$(A \circ r)(t)$ represents the area of the circle at time t.

79. (a) $C(x(t)) = 3000t + 750$; $C(x(t))$ represents the production cost after t production hours.

(b) 200 units

(c)



$t = 4.75$, or 4 hours 45 minutes

81. (a) $N(T(t))$ or $(N \circ T)(t) = 40t^2 + 590$; $N(T(t))$ or $(N \circ T)(t)$ represents the number of bacteria after t hours outside the refrigerator.

(b) $(N \circ T)(6) = 2030$; There are 2030 bacteria in a refrigerated food product after 6 hours outside the refrigerator.

(c) About 2.3 hours

83. $g(f(x))$ represents 3% of an amount over \$500,000.

85. False. $(f \circ g)(x) = 6x + 1 \neq 6x + 6 = (g \circ f)(x)$

87. (a) $O(M(Y)) = 2\left(6 + \frac{1}{2}Y\right) = 12 + Y$

(b) Middle child is 8 years old, youngest child is 4 years old.

89. Proof **91.** Proof

93. $(0, -5), (1, -5), (2, -7)$

95. $\left(0, 2\sqrt{6}\right), \left(1, \sqrt{23}\right), \left(2, 2\sqrt{5}\right)$

97. $10x - y + 38 = 0$ **99.** $30x + 11y - 34 = 0$

Section 1.7 (page 154)

Vocabulary Check (page 154)

1. inverse, f^{-1} **2.** range, domain **3.** $y = x$

4. one-to-one **5.** Horizontal

1. $f^{-1}(x) = \frac{x}{6}$ **3.** $f^{-1}(x) = x - 7$

5. $f^{-1}(x) = \frac{1}{2}(x - 1)$ **7.** $f^{-1}(x) = x^3$

9. (a) $f(g(x)) = f\left(-\frac{2x + 6}{7}\right)$

$$= -\frac{7}{2}\left(-\frac{2x + 6}{7}\right) - 3 = x$$

$$g(f(x)) = g\left(-\frac{7}{2}x - 3\right)$$

$$= -\frac{2\left(-\frac{7}{2}x - 3\right) + 6}{7} = x$$

(b)

x	0	2	-2	6
$f(x)$	-3	-10	4	-24

x	-3	-10	4	-24
$g(x)$	0	2	-2	6

11. (a) $f(g(x)) = f\left(\sqrt[3]{x - 5}\right) = \left(\sqrt[3]{x - 5}\right)^3 + 5 = x$

$g(f(x)) = g(x^3 + 5) = \sqrt[3]{(x^3 + 5) - 5} = x$

(b)

x	0	1	-1	-2	4
$f(x)$	5	6	4	-3	69

x	5	6	4	-3	69
$g(x)$	0	1	-1	-2	4

13. (a) $f(g(x)) = f(8 + x^2)$

$$= -\sqrt{(8 + x^2) - 8}$$

$$= -\sqrt{x^2} = -(-x) = x, \ x \leq 0$$

$g(f(x)) = g\left(-\sqrt{x - 8}\right)$

$$= 8 + \left(-\sqrt{x - 8}\right)^2$$

$$= 8 + (x - 8) = x, \ x \geq 8$$

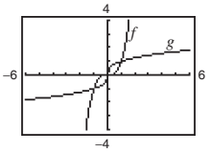
(b)

x	8	9	12	15
$f(x)$	0	-1	-2	$-\sqrt{7}$

x	0	-1	-2	$-\sqrt{7}$
$g(x)$	8	9	12	15

15. $f(g(x)) = f\left(\sqrt[3]{x}\right) = \left(\sqrt[3]{x}\right)^3 = x$

$g(f(x)) = g(x^3) = \sqrt[3]{x^3} = x$



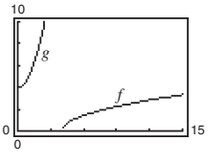
Reflections in the line $y = x$

17. $f(g(x)) = f(x^2 + 4), \quad x \geq 0$

$$= \sqrt{(x^2 + 4) - 4} = x$$

$g(f(x)) = g\left(\sqrt{x - 4}\right)$

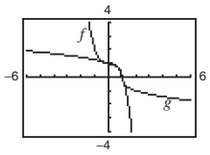
$$= \left(\sqrt{x - 4}\right)^2 + 4 = x$$



Reflections in the line $y = x$

19. $f(g(x)) = f\left(\sqrt[3]{1-x}\right) = 1 - \left(\sqrt[3]{1-x}\right)^3 = x$

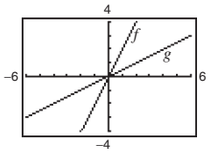
$g(f(x)) = g(1-x^3) = \sqrt[3]{1-(1-x^3)} = x$



Reflections in the line $y = x$

21. c **22.** b **23.** a **24.** d

25. (a)

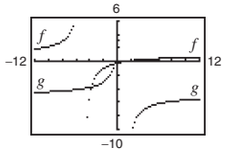


(b)

x	-4	-2	0	2	4
$f(x)$	-8	-4	0	4	8

x	-8	-4	0	4	8
$g(x)$	-4	-2	0	2	4

27. (a)



(b)

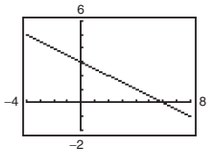
x	-3	-2	-1	0	2	3	4
$f(x)$	-2	-1	$-\frac{1}{2}$	$-\frac{1}{5}$	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{1}{3}$

x	-2	-1	$-\frac{1}{2}$	$-\frac{1}{5}$	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{1}{3}$
$g(x)$	-3	-2	-1	0	2	3	4

29. Not a function **31.** Function; one-to-one

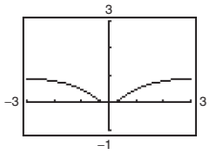
33. Function; one-to-one

35.



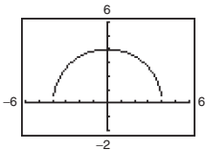
One-to-one

37.



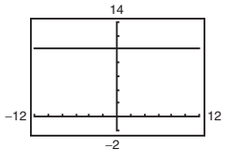
Not one-to-one

39.



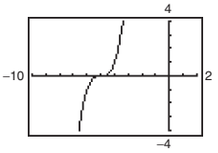
Not one-to-one

41.



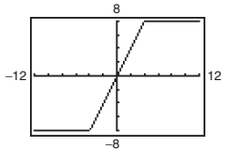
Not one-to-one

43.



One-to-one

45.



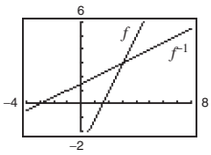
Not one-to-one

47. Not one-to-one **49.** $f^{-1}(x) = \dfrac{5x-4}{3}$

51. Not one-to-one **53.** $f^{-1}(x) = \sqrt{x} - 3, x \geq 0$

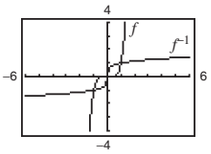
55. $f^{-1}(x) = \dfrac{x^2-3}{2}, x \geq 0$ **57.** $f^{-1}(x) = 2 - x, x \geq 0$

59. $f^{-1}(x) = \dfrac{x+3}{2}$



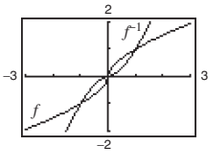
Reflections in the line $y = x$

61. $f^{-1}(x) = \sqrt[5]{x}$



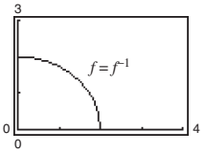
Reflections in the line $y = x$

63. $f^{-1}(x) = x^{5/3}$



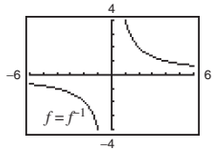
Reflections in the line $y = x$

65. $f^{-1}(x) = \sqrt{4-x^2}, 0 \leq x \leq 2$



The graphs are the same.

67. $f^{-1}(x) = \dfrac{4}{x}$



The graphs are the same.

69. $f^{-1}(x) = \sqrt{x} + 2$

Domain of f: all real numbers x such that $x \geq 2$
Range of f: all real numbers y such that $y \geq 0$
Domain of f^{-1}: all real numbers x such that $x \geq 0$
Range of f^{-1}: all real numbers y such that $y \geq 2$

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

Domain of f: all real numbers x such that $x \geq -2$
Range of f: all real numbers y such that $y \geq 0$
Domain of f^{-1}: all real numbers x such that $x \geq 0$
Range of f^{-1}: all real numbers y such that $y \geq -2$

73. $f^{-1}(x) = \sqrt{x} - 3$

Domain of f: all real numbers x such that $x \geq -3$
Range of f: all real numbers y such that $y \geq 0$
Domain of f^{-1}: all real numbers x such that $x \geq 0$
Range of f^{-1}: all real numbers y such that $y \geq -3$

75. $f^{-1}(x) = \dfrac{\sqrt{-2(x-5)}}{2}$

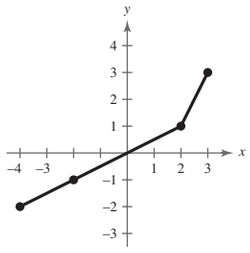
Domain of f: all real numbers x such that $x \geq 0$
Range of f: all real numbers y such that $y \leq 5$
Domain of f^{-1}: all real numbers x such that $x \leq 5$
Range of f^{-1}: all real numbers y such that $y \geq 0$

77. $f^{-1}(x) = x + 3$

Domain of f: all real numbers x such that $x \geq 4$
Range of f: all real numbers y such that $y \geq 1$
Domain of f^{-1}: all real numbers x such that $x \geq 1$
Range of f^{-1}: all real numbers y such that $y \geq 4$

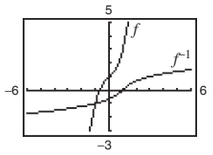
79.

x	-4	-2	2	3
$f^{-1}(x)$	-2	-1	1	3



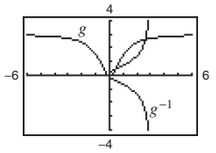
81. $\frac{1}{2}$ **83.** -2 **85.** 0 **87.** 2

89. (a) and (b)



(c) Inverse function because it satisfies the Vertical Line Test

91. (a) and (b)



(c) Not an inverse function because it does not satisfy the Vertical Line Test

93. 32 **95.** 600 **97.** $2\sqrt[3]{x+3}$

99. $\dfrac{x+1}{2}$ **101.** $\dfrac{x+1}{2}$

103. (a) f is one-to-one because no two elements in the domain (men's U.S. shoe sizes) correspond to the same element in the range (men's European shoe sizes).

(b) 45 (c) 10 (d) 41 (e) 13

105. (a) Yes

(b) $f^{-1}(t)$ represents the year new car sales totaled $\$t$ billion.

(c) 10 or 2000

(d) No. The inverse would not be a function because f would not be one-to-one.

107. False. For example, $y = x^2$ is even, but does not have an inverse.

109. Proof

111. f and g are not inverses of each other because one is not the graph of the other when reflected through the line $y = x$.

113. f and g are inverses of each other because one is the graph of the other when reflected through the line $y = x$.

115. This situation could be represented by a one-to-one function. The inverse function would represent the number of miles completed in terms of time in hours.

117. This function could not be represented by a one-to-one function because it oscillates.

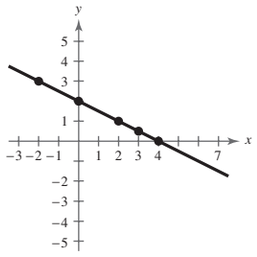
119. $9x,\ x \neq 0$ **121.** $-(x+6),\ x \neq 6$

123. Function **125.** Not a function **127.** Function

Review Exercises (page 159)

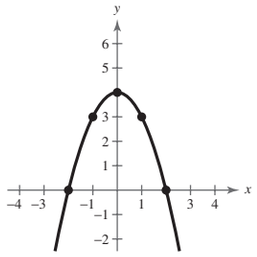
1.

x	-2	0	2	3	4
y	3	2	1	$\frac{1}{2}$	0
Solution point	$(-2, 3)$	$(0, 2)$	$(2, 1)$	$\left(3, \frac{1}{2}\right)$	$(4, 0)$

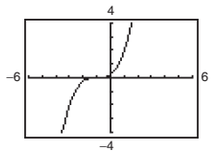


3.

x	-2	-1	0	1	2
y	0	3	4	3	0
Solution point	$(-2, 0)$	$(-1, 3)$	$(0, 4)$	$(1, 3)$	$(2, 0)$

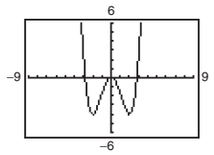


5.



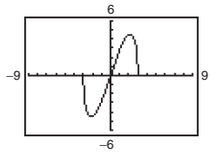
Intercepts: $(-1, 0), \left(0, \frac{1}{4}\right)$

7.



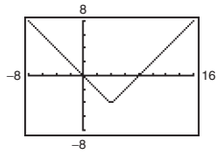
Intercepts: $(0, 0), \left(\pm 2\sqrt{2}, 0\right)$

9.



Intercepts: $(0, 0), (\pm 3, 0)$

11.



Intercepts: $(0, 0), (8, 0)$

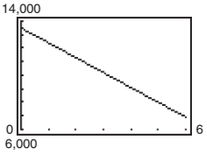
13.

```
Xmin = -20
Xmax = 50
Xscl = 10
Ymin = -2
Ymax = 1
Yscl = 0.5
```

15. (a)

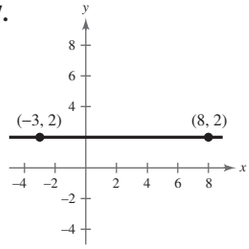
```
Xmin = 0
Xmax = 6
Xscl = 1
Ymin = 6000
Ymax = 14,000
Yscl = 1000
```

(b)



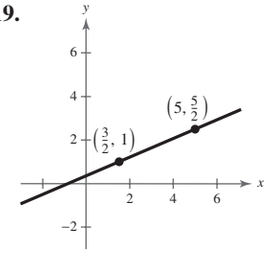
(c) 4

17.



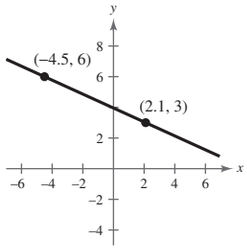
$m = 0$

19.



$m = \frac{3}{7}$

21.



$m = -\frac{5}{11}$

23. $x - 4y - 6 = 0$; $(6, 0), (10, 1), (-2, -2)$

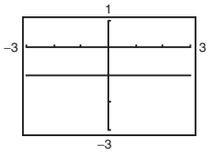
25. $3x - 2y - 10 = 0$; $(4, 1), (2, -2), (-2, -8)$

27. $5x + 5y + 24 = 0$; $\left(-5, \frac{1}{5}\right), \left(-4, -\frac{4}{5}\right), \left(-6, \frac{6}{5}\right)$

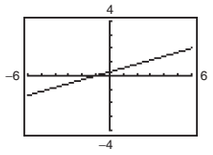
29. $y = 6$; $(0, 6), (1, 6), (-1, 6)$

31. $x = 10$; $(10, 1), (10, 3), (10, -2)$

33. $y = -1$



35. $y = \frac{2}{7}x + \frac{2}{7}$



37. $V = 850t + 5700$ **39.** \$210,000

41. (a) $5x - 4y - 23 = 0$ **43.** (a) $x = -6$

(b) $4x + 5y - 2 = 0$ (b) $y = 2$

45. (a) Not a function because element 20 in A corresponds to two elements, 4 and 6, in B.

(b) Function

(c) Function

(d) Not a function because 30 in A corresponds to no element in B.

47. Not a function **49.** Function

51. (a) 2 (b) 10 (c) $b^6 + 1$ (d) $x^2 - 2x + 2$

53. (a) -3 (b) -1 (c) 2 (d) 6

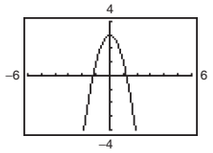
55. All real numbers x except $x = -2$ **57.** $[-5, 5]$

59. All real numbers s except $s = 3$

61. (a) $C = 5.35x + 16{,}000$ (b) $P = 2.85x - 16{,}000$

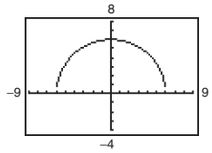
63. $2h + 4x + 3,\ h \neq 0$

65.



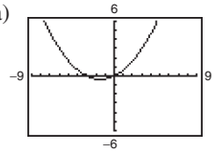
Domain: $(-\infty, \infty)$
Range: $(-\infty, 3]$

67.



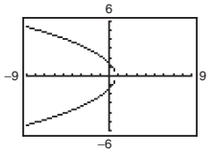
Domain: $[-6, 6]$
Range: $[0, 6]$

69. (a)



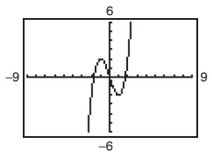
(b) Function

71. (a)



(b) Not a function

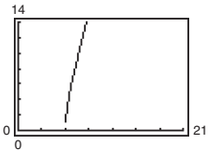
73. (a)



(b) Increasing on $(-\infty, -1), (1, \infty)$

Decreasing on $(-1, 1)$

75. (a)



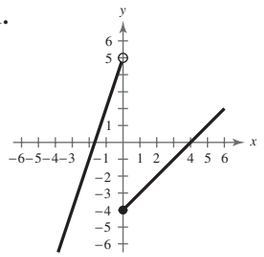
(b) Increasing on $(6, \infty)$

77. Relative maximum: $(0, 16)$

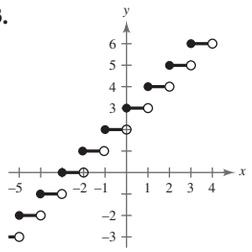
Relative minima: $(-2, 0), (2, 0)$

79. Relative maximum: $(3, 27)$

81.



83.

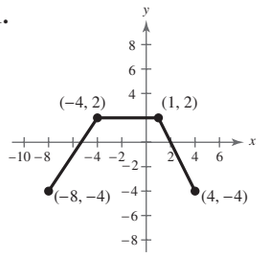


85. Even

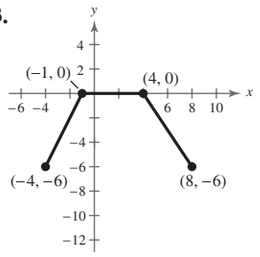
87. Constant function $f(x) = C$; vertical shift two units downward; $g(x) = -2$

89. Cubic function $f(x) = x^3$; reflection in the x-axis and vertical shift two units downward; $g(x) = -x^3 - 2$

91.



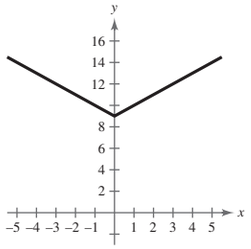
93.



95. (a) Absolute value function

(b) Vertical shift nine units upward

(c)

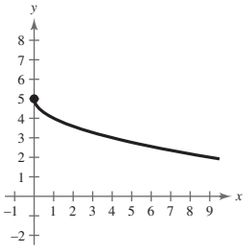


(d) $h(x) = f(x) + 9$

97. (a) Square root function

(b) Reflection in the x-axis and a vertical shift five units upward

(c)

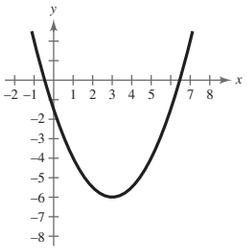


(d) $h(x) = -f(x) + 5$

99. (a) Quadratic function

(b) Horizontal shift three units to the right, vertical shrink, and a vertical shift six units downward

(c)



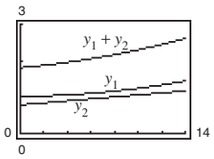
(d) $h(x) = \frac{1}{2}f(x - 3) - 6$

101. $f(x) = x^2, g(x) = x + 3$

103. $f(x) = \sqrt{x}, g(x) = 4x + 2$

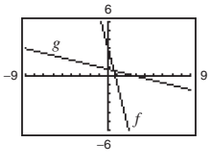
105. $f(x) = \dfrac{4}{x}, g(x) = x + 2$

107.



109. $f^{-1}(x) = 2x - 6$

111. (a)

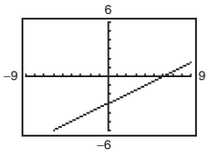


(b)

x	-2	-1	0	1	2
$f(x)$	11	7	3	-1	-5

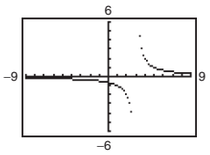
x	11	7	3	-1	-5
$g(x)$	-2	-1	0	1	2

113.



One-to-one

115.



One-to-one

117. $f^{-1}(x) = 2x + 10$

119. $f^{-1}(x) = \sqrt[3]{\dfrac{x + 3}{4}}$

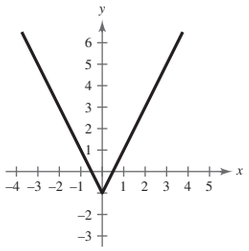
121. $f^{-1}(x) = x^2 - 10, \ x \geq 0$

123. False. The point $(-1, 28)$ does not lie on the graph of the function $g(x) = -(x - 6)^2 - 3$.

125. False. For example, $f(x) = 4 - x = f^{-1}(x)$.

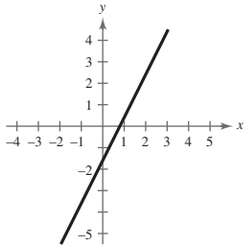
Chapter Test (page 163)

1.



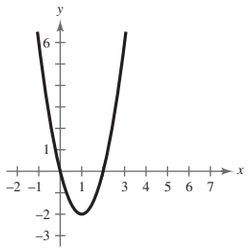
Intercepts: $(0, -1), \left(-\frac{1}{2}, 0\right), \left(\frac{1}{2}, 0\right)$

2.



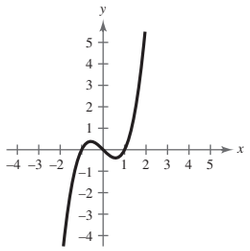
Intercepts: $\left(0, -\frac{8}{5}\right), \left(\frac{4}{5}, 0\right)$

3.



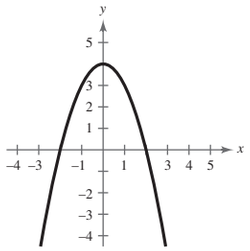
Intercepts: $(0, 0), (2, 0)$

4.



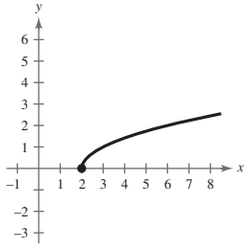
Intercepts: $(-1, 0), (0, 0), (1, 0)$

5.



Intercepts: $(-2, 0), (0, 4), (2, 0)$

6.



Intercept: $(2, 0)$

7. (a) $5x + 2y - 8 = 0$ (b) $2x - 5y + 20 = 0$

8. $y = -x + 1$

9. No. For some values of x there corresponds more than one value of y.

10. (a) -9 (b) 1 (c) $|t - 4| - 15$

11. $(-\infty, 3]$

12. $C = 5.60x + 24{,}000$

$P = 93.9x - 24{,}000$

13. Odd

14. Even

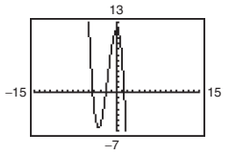
15. Increasing: $(-2, 0), (2, \infty)$

Decreasing: $(-\infty, -2), (0, 2)$

16. Increasing: $(-2, 2)$

Constant: $(-\infty, -2), (2, \infty)$

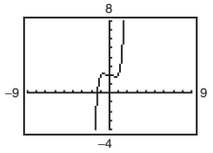
17.



Relative maximum: $(0, 12)$

Relative minimum: $(-3.33, -6.52)$

18.



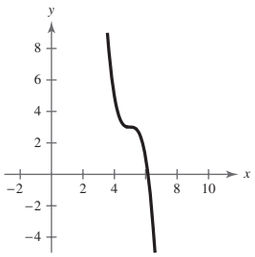
Relative minimum: $(0.77, 1.81)$

Relative maximum: $(-0.77, 2.19)$

19. (a) $f(x) = x^3$

(b) Horizontal shift five units to the right, reflection in the x-axis, vertical stretch, and a vertical shift three units upward

(c)



20. (a) $f(x) = \sqrt{x}$

(b) Reflection in the y-axis and a horizontal shift seven units to the left

(c)