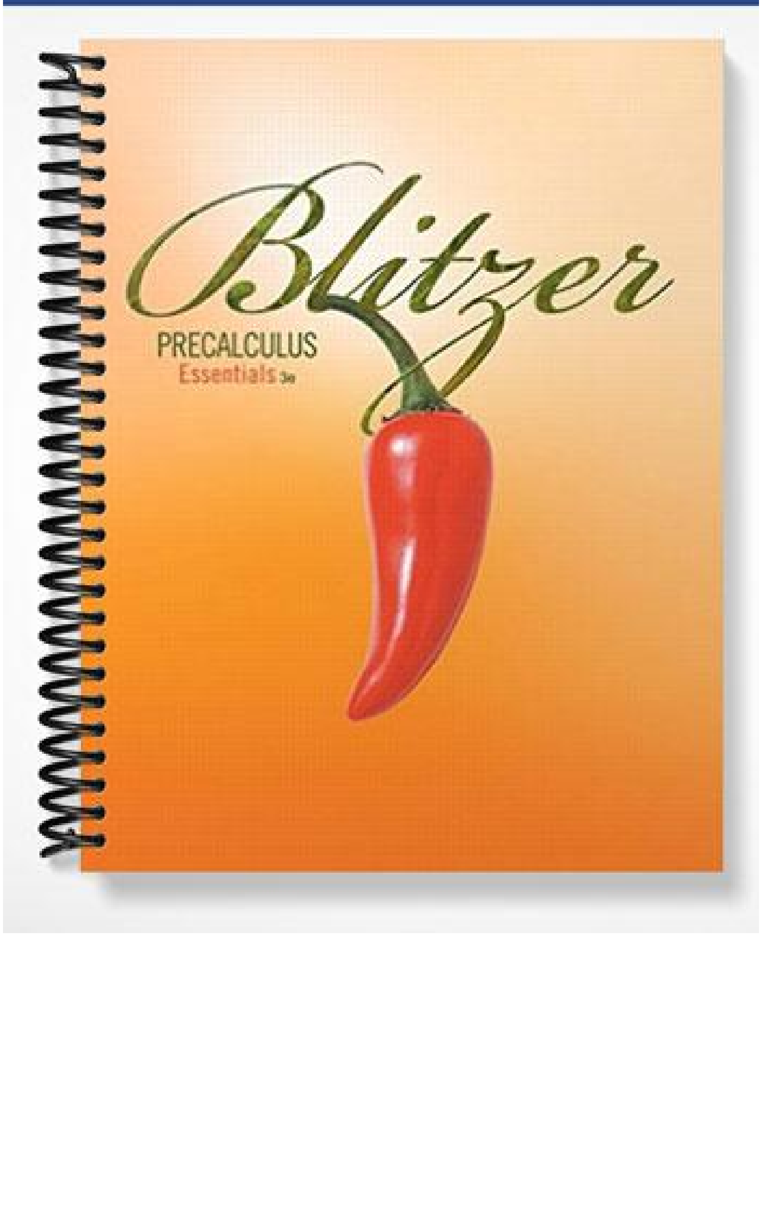
SOLUTIONS MANUAL

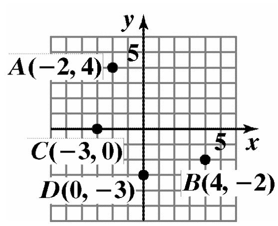


Chapter 1

Section 1.1

Check Point Exercises

1.



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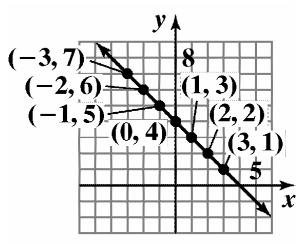


$y = 4 - x$

$x = -3,\ y = 7$

$x = -2,\ y = 6$

$x = -1,\ y = 5$

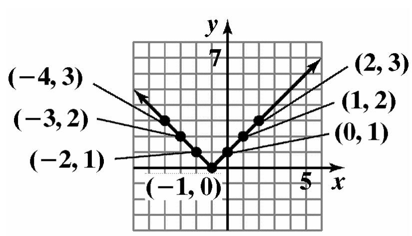
$x = 0,\ y = 4$

$x = 1,\ y = 3$

$x = 2,\ y = 2$

$x = 3,\ y = 1$

3.



$y = |x + 1|$

$x = -4,\ y = 3$

$x = -3,\ y = 2$

$x = -2,\ y = 1$

$x = -1,\ y = 0$

$x = 0,\ y = 1$

$x = 1,\ y = 2$

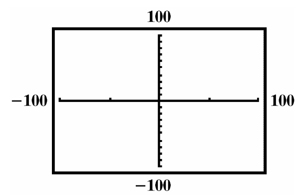
$x = 2,\ y = 3$

4. The meaning of a $[-100, 100, 50]$ by $[-100, 100, 10]$ viewing rectangle is as follows:

$$[\underbrace{-100}_{\text{minimum } x\text{-value}},\ \underbrace{100}_{\text{maximum } x\text{-value}},\ \underbrace{50}_{\text{distance between } x\text{-axis tick marks}}]$$

by

$$[\underbrace{-100}_{\text{minimum } y\text{-value}},\ \underbrace{100}_{\text{maximum } y\text{-value}},\ \underbrace{10}_{\text{distance between } y\text{-axis tick marks}}]$$



5. **a.** The graph crosses the *x*-axis at (–3, 0). Thus, the *x*-intercept is –3. The graph crosses the *y*-axis at (0, 5). Thus, the *y*-intercept is 5.

b. The graph does not cross the *x*-axis. Thus, there is no *x*-intercept. The graph crosses the *y*-axis at (0, 4). Thus, the *y*-intercept is 4.

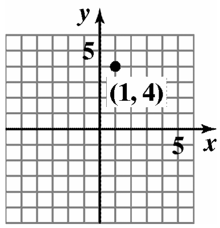
c. The graph crosses the *x*- and *y*-axes at the origin (0, 0). Thus, the *x*-intercept is 0 and the *y*-intercept is 0.

6. The number of federal prisoners sentenced for drug offenses in 2003 is about 57% of 159,275. This can be estimated by finding 60% of 160,000.

$$N \approx 60\% \text{ of } 160{,}000$$
$$= 0.60 \times 160{,}000$$
$$= 96{,}000$$

Exercise Set 1.1

1.



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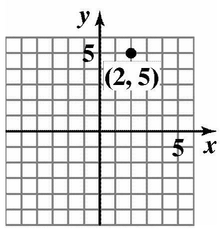
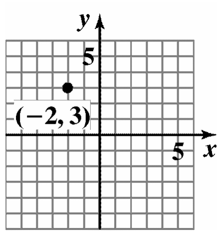


3.



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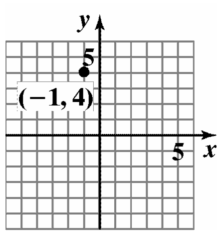
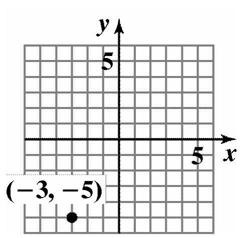


5.



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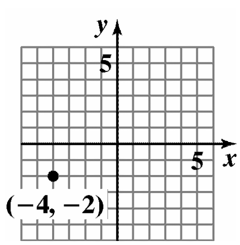

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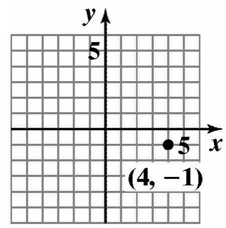

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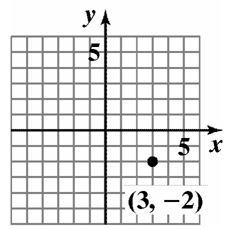

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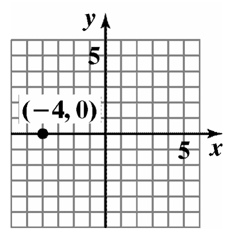

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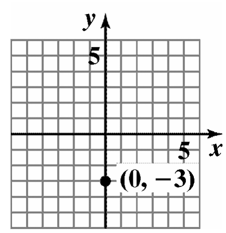
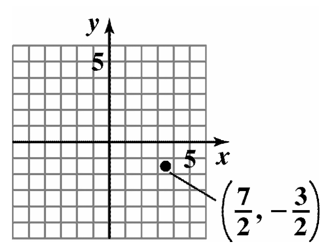
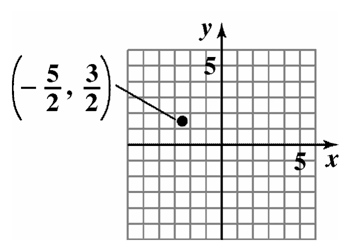


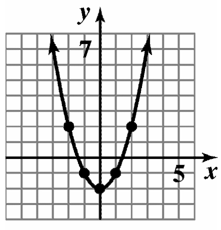
11.



12.



13.



$y = x^2 - 2$

$x = -3, y = 7$

$x = -2, y = 2$

$x = -1, y = -1$

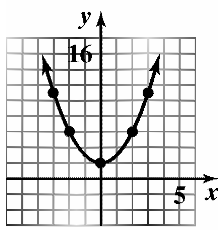
$x = 0, y = -2$

$x = 1, y = -1$

$x = 2, y = 2$

$x = 3, y = 7$

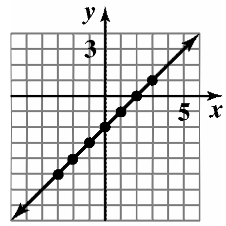
14.



$y = x^2 + 2$

$x = -3, y = 11$
$x = -2, y = 6$
$x = -1, y = 3$
$x = 0, y = 2$
$x = 1, y = 3$
$x = 2, y = 6$
$x = 3, y = 11$

15.



$y = x - 2$

$x = -3, y = -5$

$x = -2, y = -4$

$x = -1, y = -3$

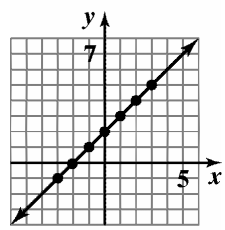
$x = 0, y = -2$

$x = 1, y = -1$

$x = 2, y = 0$

$x = 3, y = 1$

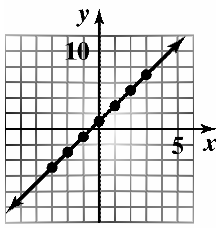
16.



$y = x + 2$

$x = -3, y = -1$
$x = -2, y = 0$
$x = -1, y = 1$
$x = 0, y = 2$
$x = 1, y = 3$
$x = 2, y = 4$
$x = 3, y = 5$

17.



$y = 2x + 1$

$x = -3, y = -5$

$x = -2, y = -3$

$x = -1, y = -1$

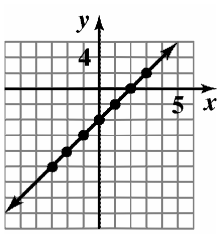
$x = 0, y = 1$

$x = 1, y = 3$

$x = 2, y = 5$

$x = 3, y = 7$

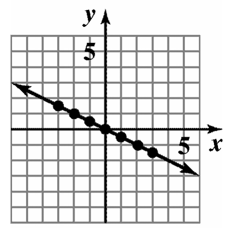
18.



$y = 2x - 4$

$x = -3, y = -10$
$x = -2, y = -8$
$x = -1, y = -6$
$x = 0, y = -4$
$x = 1, y = -2$
$x = 2, y = 0$
$x = 3, y = 2$

19.



$y = -\frac{1}{2}x$

$x = -3, y = \frac{3}{2}$

$x = -2, y = 1$

$x = -1, y = \frac{1}{2}$

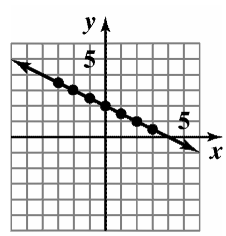
$x = 0, y = 0$

$x = 1, y = -\frac{1}{2}$

$x = 2, y = -1$

$x = 3, y = -\frac{3}{2}$

20.



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

$x = -3, y = \frac{7}{2}$

$x = -2, y = 3$

$x = -1, y = \frac{5}{2}$

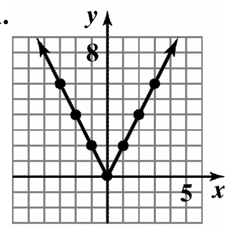
$x = 0, y = 2$

$x = 1, y = \frac{3}{2}$

$x = 2, y = 1$

$x = 3, y = \frac{1}{2}$

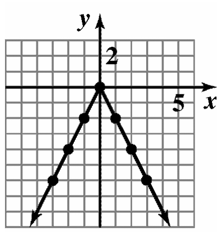
21.



$y = 2|x|$

$x = -3, y = 6$
$x = -2, y = 4$
$x = -1, y = 2$
$x = 0, y = 0$
$x = 1, y = 2$
$x = 2, y = 4$
$x = 3, y = 6$

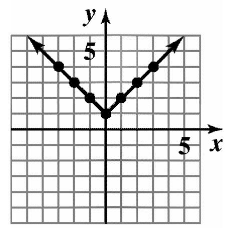
22.



$y = -2|x|$

$x = -3, y = -6$
$x = -2, y = -4$
$x = -1, y = -2$
$x = 0, y = 0$
$x = 1, y = -2$
$x = 2, y = -4$
$x = 3, y = -6$

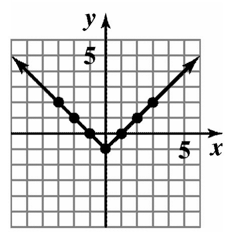
23.



$y = |x| + 1$

$x = -3, y = 4$
$x = -2, y = 3$
$x = -1, y = 2$
$x = 0, y = 1$
$x = 1, y = 2$
$x = 2, y = 3$
$x = 3, y = 4$

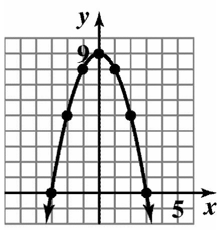
24.



$y = |x| - 1$

$x = -3, y = 2$
$x = -2, y = 1$
$x = -1, y = 0$
$x = 0, y = -1$
$x = 1, y = 0$
$x = 2, y = 1$
$x = 3, y = 2$

25.



$y = 9 - x^2$

$x = -3, y = 0$

$x = -2, y = 5$

$x = -1, y = 8$

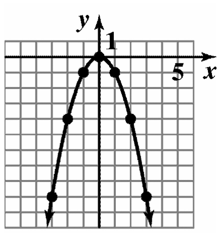
$x = 0, y = 9$

$x = 1, y = 8$

$x = 2, y = 5$

$x = 3, y = 0$

26.



$y = -x^2$

$x = -3, y = -9$

$x = -2, y = -4$

$x = -1, y = -1$

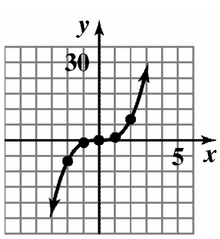
$x = 0, y = 0$

$x = 1, y = -1$

$x = 2, y = -4$

$x = 3, y = -9$

27.



$y = x^3$

$x = -3, y = -27$

$x = -2, y = -8$

$x = -1, y = 1$

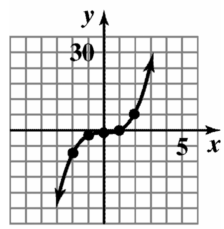
$x = 0, y = 0$

$x = 1, y = 1$

$x = 2, y = 8$

$x = 3, y = 27$

28.



$y = x^3 - 1$

$x = -3, y = -28$

$x = -2, y = -9$

$x = -1, y = -2$

$x = 0, y = -1$

$x = 1, y = 0$

$x = 2, y = 7$

$x = 3, y = 26$

29. (c) *x*-axis tick marks –5, –4, –3, –2, –1, 0, 1, 2, 3, 4, 5; *y*-axis tick marks are the same.

30. (d) *x*-axis tick marks –10, –8, –6, –4, –2, 0, 2, 4, 6, 8, 10; *y*-axis tick marks –4, –2, 0, 2, 4

31. (b); *x*-axis tick marks –20, –10, 0, 10, 20, 30, 40, 50, 60, 70, 80; *y*-axis tick marks –30, –20, –10, 0, 10, 20, 30, 40, 50, 60, 70

32. (a) *x*-axis tick marks –40, –20, 0, 20, 40; *y*-axis tick marks –1000, –900, –800, –700, . . . , 700, 800, 900, 1000

33. The equation that corresponds to Y_2 in the table is (c), $y_2 = 2 - x$. We can tell because all of the points $(-3,5)$, $(-2,4)$, $(-1,3)$, $(0,2)$, $(1,1)$, $(2,0)$, and $(3,-1)$ are on the line $y = 2 - x$, but all are not on any of the others.

34. The equation that corresponds to Y_1 in the table is (b), $y_1 = x^2$. We can tell because all of the points $(-3,9)$, $(-2,4)$, $(-1,1)$, $(0,0)$, $(1,1)$, $(2,4)$, and $(3,9)$ are on the graph $y = x^2$, but all are not on any of the others.

35. No. It passes through the point $(0,2)$.

36. Yes. It passes through the point $(0,0)$.

37. $(2,0)$

38. $(0, 2)$

39. The graphs of Y_1 and Y_2 intersect at the points $(-2, 4)$ and $(1, 1)$.

40. The values of Y_1 and Y_2 are the same when $x = -2$ and $x = 1$.

41. **a.** 2; The graph intersects the *x*-axis at (2, 0).

b. –4; The graph intersects the *y*-axis at (0,–4).

42. **a.** 1; The graph intersects the *x*-axis at (1, 0).

b. 2; The graph intersects the *y*-axis at (0, 2).

43. **a.** 1, –2; The graph intersects the *x*-axis at (1, 0) and (–2, 0).

b. 2; The graph intersects the *y*-axis at (0, 2).

44. **a.** 1, –1; The graph intersects the *x*-axis at (1, 0) and (–1, 0).

b. 1; The graph intersect the *y*-axis at (0, 1).

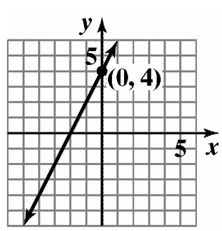
45. **a.** –1; The graph intersects the *x*-axis at (–1, 0).

b. none; The graph does not intersect the *y*-axis.

46. **a.** none; The graph does not intersect the *x*-axis.

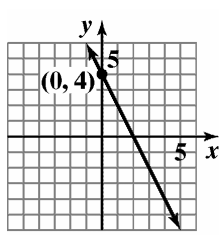
b. 2; The graph intersects the *y*-axis at (0, 2).

47.



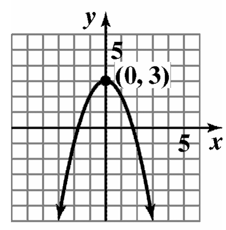
$y = 2x + 4$

48.



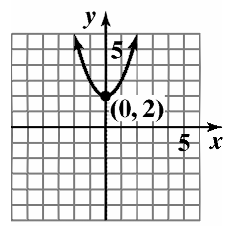
$y = 4 - 2x$

49.



$y = 3 - x^2$

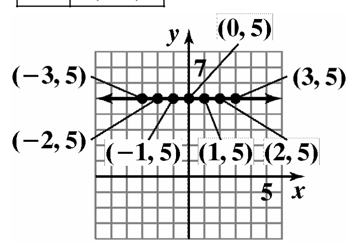
50.



$y = x^2 + 2$

51.

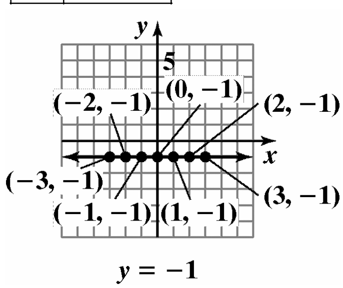
x	(x, y)
-3	$(-3, 5)$
-2	$(-2, 5)$
-1	$(-1, 5)$
0	$(0, 5)$
1	$(1, 5)$
2	$(2, 5)$
3	$(3, 5)$



$y = 5$

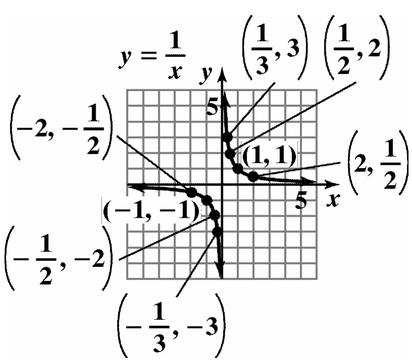
52.

x	(x, y)
-3	$(-3, -1)$
-2	$(-2, -1)$
-1	$(-1, -1)$
0	$(0, -1)$
1	$(1, -1)$
2	$(2, -1)$
3	$(3, -1)$



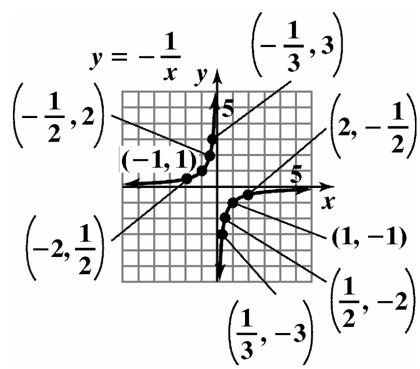
53.

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



54.

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



55. There were approximately 65 democracies in 1989.

56. There were 120 – 40 = 80 more democracies in 2002 than in 1973.

57. The number of democracies increased at the greatest rate between 1989 and 1993.

58. The number of democracies increased at the slowest rate between 1981 and 1985.

59. There were 49 democracies in 1977.

60. There were 110 democracies in 1997.

61. $R = 165 - 0.75A; \quad A = 40$

$R - 165 - 0.75A = 165 - 0.75(40)$

$= 165 - 30 = 135$

The desirable heart rate during exercise for a 40-year old man is 135 beats per minute. This corresponds to the point (40, 135) on the blue graph.

62. $R = 143 - 0.65A; \quad A = 40$

$R - 143 - 0.65A = 143 - 0.65(40)$

$= 143 - 26 = 117$

The desirable heart rate during exercise for a 40-year old woman is 117 beats per minute. This corresponds to the point (40, 117) on the red graph.

63. a. At birth we have $x = 0$.

$y = 2.9\sqrt{x} + 36$

$= 2.9\sqrt{0} + 36$

$= 2.9(0) + 36$

$= 36$

According to the model, the head circumference at birth is 36 cm.

b. At 9 months we have $x = 9$.

$y = 2.9\sqrt{x} + 36$

$= 2.9\sqrt{9} + 36$

$= 2.9(3) + 36$

$= 44.7$

According to the model, the head circumference at 9 months is 44.7 cm.

c. At 14 months we have $x = 14$.

$y = 2.9\sqrt{x} + 36$

$= 2.9\sqrt{14} + 36$

≈ 46.9

According to the model, the head circumference at 14 months is roughly 46.9 cm.

d. The model describes healthy children.

64. a. At birth we have $x = 0$.

$y = 4\sqrt{x} + 35$

$= 4\sqrt{0} + 35$

$= 4(0) + 35$

$= 35$

According to the model, the head circumference at birth is 35 cm.

b. At 9 months we have $x = 9$.

$y = 4\sqrt{x} + 35$

$= 4\sqrt{9} + 35$

$= 4(3) + 35$

$= 47$

According to the model, the head circumference at 9 months is 47 cm.

c. At 14 months we have $x = 14$.

$y = 4\sqrt{x} + 35$

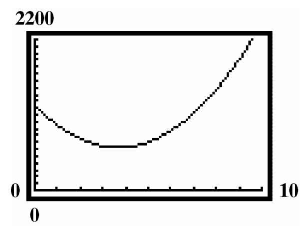
$= 4\sqrt{14} + 35$

≈ 50

According to the model, the head circumference at 14 months is roughly 50 cm.

d. The model describes severe autistic children.

71. $y = 45.48x^2 - 334.35x + 1237.9$



The discharges decreased from 1990 to 1994, but started to increase after 1994. The policy was not a success.

72. a. False; (x, y) can be in quadrant III.

b. False; when $x = 2$ and $y = 5$,
$3y - 2x = 3(5) - 2(2) = 11$.

c. False; if a point is on the x-axis, $y = 0$.

d. True; all of the above are false.
(d) is true.

73. (a)

74. (d)

75. (b)

76. (c)

77. (b)

78. (a)

Section 1.2

Check Point Exercises

1. The domain is the set of all first components: {5, 10, 15, 20, 25}. The range is the set of all second components: {12.8, 16.2, 18.9, 20.7, 21.8}.

2. **a.** The relation is not a function since the two ordered pairs (5, 6) and (5, 8) have the same first component but different second components.

b. The relation is a function since no two ordered pairs have the same first component and different second components.

3. **a.** $2x + y = 6$

$y = -2x + 6$

For each value of *x*, there is one and only one value for *y*, so the equation defines *y* as a function of *x*.

b. $x^2 + y^2 = 1$

$y^2 = 1 - x^2$

$y = \pm\sqrt{1-x^2}$

Since there are values of *x* (all values between –1 and 1 exclusive) that give more than one value for *y* (for example, if *x* = 0, then $y = \pm\sqrt{1-0^2} = \pm 1$), the equation does not define *y* as a function of *x*.

4. **a.** $f(-5) = (-5)^2 - 2(-5) + 7$

$= 25 - (-10) + 7$

$= 42$

b. $f(x+4) = (x+4)^2 - 2(x+4) + 7$

$= x^2 + 8x + 16 - 2x - 8 + 7$

$= x^2 + 6x + 15$

c. $f(-x) = (-x)^2 - 2(-x) + 7$

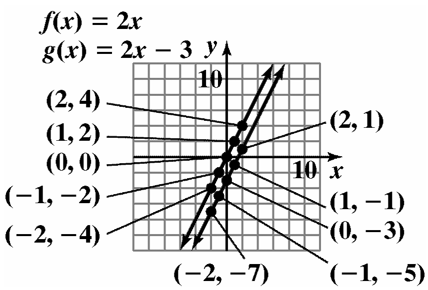
$= x^2 - (-2x) + 7$

$= x^2 + 2x + 7$

5.

x	$f(x) = 2x$	(x, y)
-2	–4	$(-2,-4)$
-1	–2	$(-1,-2)$
0	0	$(0,0)$
1	2	$(1,2)$
2	4	$(2,4)$

x	$g(x)=2x-3$	(x,y)
-2	$g(-2)=2(-2)-3=-7$	$(-2,-7)$
-1	$g(-1)=2(-1)-3=-5$	$(-1,-5)$
0	$g(0)=2(0)-3=-3$	$(0,-3)$
1	$g(1)=2(1)-3=-1$	$(1,-1)$
2	$g(2)=2(2)-3=1$	$(2,1)$



The graph of g is the graph of f shifted down 3 units.

6. The graph (c) fails the vertical line test and is therefore not a function. y is a function of x for the graphs in (a) and (b).

7. **a.** $f(10) \approx 16$ **b.** $x \approx 8$

8. **a.** Domain $=\{x|-2 \le x \le 1\}$ or $[-2,1]$.

Range $=\{y|0 \le y \le 3\}$ or $[0,3]$.

b. Domain $=\{x|-2 < x \le 1\}$ or $(-2,1]$.

Range $=\{y|-1 \le y < 2\}$ or $[-1,2)$.

c. Domain $=\{x|-3 \le x < 0\}$ or $[-3,0)$.

Range $=\{y|y=-3,-2,-1\}$.

Exercise Set 1.2

1. The relation is a function since no two ordered pairs have the same first component and different second components. The domain is {1, 3, 5} and the range is {2, 4, 5}.

2. The relation is a function because no two ordered pairs have the same first component and different second components The domain is {4, 6, 8} and the range is {5, 7, 8}.

3. The relation is not a function since the two ordered pairs (3, 4) and (3, 5) have the same first component but different second components (the same could be said for the ordered pairs (4, 4) and (4, 5)). The domain is {3, 4} and the range is {4, 5}.

4. The relation is not a function since the two ordered pairs (5, 6) and (5, 7) have the same first component but different second components (the same could be said for the ordered pairs (6, 6) and (6, 7)). The domain is {5, 6} and the range is {6, 7}.

5. The relation is a function because no two ordered pairs have the same first component and different second components The domain is
{3, 4, 5, 7} and the range is {–2, 1, 9}.

6. The relation is a function because no two ordered pairs have the same first component and different second components The domain is
{–2, –1, 5, 10} and the range is {1, 4, 6}.

7. The relation is a function since there are no same first components with different second components. The domain is {–3, –2, –1, 0} and the range is {–3, –2, –1, 0}.

8. The relation is a function since there are no ordered pairs that have the same first component but different second components. The domain is {–7, –5, –3, 0} and the range is {–7, –5, –3, 0}.

9. The relation is not a function since there are ordered pairs with the same first component and different second components. The domain is {1} and the range is {4, 5, 6}.

10. The relation is a function since there are no two ordered pairs that have the same first component and different second components. The domain is
{4, 5, 6} and the range is {1}.

11. $x + y = 16$

$y = 16 - x$

Since only one value of *y* can be obtained for each value of *x*, *y* is a function of *x*.

12. $x + y = 25$

$y = 25 - x$

Since only one value of *y* can be obtained for each value of *x, y* is a function of *x*.

13. $x^2 + y = 16$

$y = 16 - x^2$

Since only one value of *y* can be obtained for each value of *x*, *y* is a function of *x*.

14. $x^2 + y = 25$

$y = 25 - x^2$

Since only one value of *y* can be obtained for each value of *x, y* is a function of *x*.

15. $x^2 + y^2 = 16$

$y^2 = 16 - x^2$

$y = \pm\sqrt{16 - x^2}$

If $x = 0$, $y = \pm 4$.

Since two values, $y = 4$ and $y = -4$, can be obtained for one value of *x*, *y* is not a function of *x*.

16. $x^2 + y^2 = 25$

$y^2 = 25 - x^2$

$y = \pm\sqrt{25 - x^2}$

If $x = 0$, $y = \pm 5$.

Since two values, $y = 5$ and $y = -5$, can be obtained for one value of *x, y* is not a function of *x*.

17. $x = y^2$

$y = \pm\sqrt{x}$

If $x = 1,\ y = \pm 1.$

Since two values, $y = 1$ and $y = -1$, can be obtained for $x = 1$, y is not a function of x.

18. $4x = y2$

$y = \pm\sqrt{4x} = \pm 2\sqrt{x}$

If $x = 1,$ then $y = \pm 2.$

Since two values, $y = 2$ and $y = -2$, can be obtained for $x = 1$, y is not a function of x.

19. $y = \sqrt{x+4}$

Since only one value of y can be obtained for each value of x, y is a function of x.

20. $y = -\sqrt{x+4}$

Since only one value of y can be obtained for each value of x, y is a function of x.

21. $x + y^3 = 8$

$y^3 = 8 - x$

$y = \sqrt[3]{8-x}$

Since only one value of y can be obtained for each value of x, y is a function of x.

22. $x + y^3 = 27$

$y^3 = 27 - x$

$y = \sqrt[3]{27-x}$

Since only one value of y can be obtained for each value of x, y is a function of x.

23. $xy + 2y = 1$

$y(x+2) = 1$

$y = \dfrac{1}{x+2}$

Since only one value of y can be obtained for each value of x, y is a function of x.

24. $xy - 5y = 1$

$y(x-5) = 1$

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

Since only one value of y can be obtained for each value of x, y is a function of x.

25. $|x| - y = 2$

$-y = -|x| + 2$

$y = |x| - 2$

Since only one value of y can be obtained for each value of x, y is a function of x.

26. $|x| - y = 5$

$-y = -|x| + 5$

$y = |x| - 5$

Since only one value of *y* can be obtained for each value of *x*, *y* is a function of *x*.

27. **a.** $f(6) = 4(6) + 5 = 29$

b. $f(x + 1) = 4(x + 1) + 5 = 4x + 9$

c. $f(-x) = 4(-x) + 5 = -4x + 5$

28. **a.** $f(4) = 3(4) + 7 = 19$

b. $f(x + 1) = 3(x + 1) + 7 = 3x + 10$

c. $f(-x) = 3(-x) + 7 = -3x + 7$

29. **a.**
$$\begin{aligned} g(-1) &= (-1)^2 + 2(-1) + 3 \\ &= 1 - 2 + 3 \\ &= 2 \end{aligned}$$

b.
$$\begin{aligned} g(x+5) &= (x+5)^2 + 2(x+5) + 3 \\ &= x^2 + 10x + 25 + 2x + 10 + 3 \\ &= x^2 + 12x + 38 \end{aligned}$$

c.
$$\begin{aligned} g(-x) &= (-x)^2 + 2(-x) + 3 \\ &= x^2 - 2x + 3 \end{aligned}$$

30. **a.**
$$\begin{aligned} g(-1) &= (-1)^2 - 10(-1) - 3 \\ &= 1 + 10 - 3 \\ &= 8 \end{aligned}$$

b.
$$\begin{aligned} g(x+2) &= (x+2)^2 - 10(8+2) - 3 \\ &= x^2 + 4x + 4 - 10x - 20 - 3 \\ &= x^2 - 6x - 19 \end{aligned}$$

c.
$$\begin{aligned} g(-x) &= (-x)^2 - 10(-x) - 3 \\ &= x^2 + 10x - 3 \end{aligned}$$

31. **a.**
$$\begin{aligned} h(2) &= 2^4 - 2^2 + 1 \\ &= 16 - 4 + 1 \\ &= 13 \end{aligned}$$

b.
$$\begin{aligned} h(-1) &= (-1)^4 - (-1)^2 + 1 \\ &= 1 - 1 + 1 \\ &= 1 \end{aligned}$$

c. $h(-x) = (-x)^4 - (-x)^2 + 1 = x^4 - x^2 + 1$

d. $h(3a) = (3a)^4 - (3a)^2 + 1$
$= 81a^4 - 9a^2 + 1$

32. **a.** $h(3) = 3^3 - 3 + 1 = 25$

b. $h(-2) = (-2)^3 - (-2) + 1$
$= -8 + 2 + 1$
$= -5$

c. $h(-x) = (-x)^3 - (-x) + 1 = -x^3 + x + 1$

d. $h(3a) = (3a)^3 - (3a) + 1$
$= 27a^3 - 3a + 1$

33. **a.** $f(-6) = \sqrt{-6+6} + 3 = \sqrt{0} + 3 = 3$

b. $f(10) = \sqrt{10+6} + 3$
$= \sqrt{16} + 3$
$= 4 + 3$
$= 7$

c. $f(x-6) = \sqrt{x-6+6} + 3 = \sqrt{x} + 3$

34. **a.** $f(16) = \sqrt{25-16} - 6 = \sqrt{9} - 6 = 3 - 6 = -3$

b. $f(-24) = \sqrt{25-(-24)} - 6$
$= \sqrt{49} - 6$
$= 7 - 6 = 1$

c. $f(25-2x) = \sqrt{25-(25-2x)} - 6$
$= \sqrt{2x} - 6$

35. **a.** $f(2) = \dfrac{4(2)^2 - 1}{2^2} = \dfrac{15}{4}$

b. $f(-2) = \dfrac{4(-2)^2 - 1}{(-2)^2} = \dfrac{15}{4}$

c. $f(-x) = \dfrac{4(-x)^2 - 1}{(-x)^2} = \dfrac{4x^2 - 1}{x^2}$

36. **a.** $f(2) = \dfrac{4(2)^3 + 1}{2^3} = \dfrac{33}{8}$

b. $f(-2) = \dfrac{4(-2)^3 + 1}{(-2)^3} = \dfrac{-31}{-8} = \dfrac{31}{8}$

c. $f(-x) = \dfrac{4(-x)^3 + 1}{(-x)^3} = \dfrac{-4x^3 + 1}{-x^3}$

or $\dfrac{4x^3 - 1}{x^3}$

37. a. $f(6) = \dfrac{6}{|6|} = 1$

b. $f(-6) = \dfrac{-6}{|-6|} = \dfrac{-6}{6} = -1$

c. $f(r^2) = \dfrac{r^2}{|r^2|} = \dfrac{r^2}{r^2} = 1$

38. a. $f(5) = \dfrac{|5+3|}{5+3} = \dfrac{|8|}{8} = 1$

b. $f(-5) = \dfrac{|-5+3|}{-5+3} = \dfrac{|-2|}{-2} = \dfrac{2}{-2} = -1$

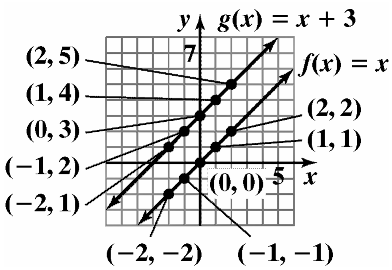
c. $f(-9-x) = \dfrac{|-9-x+3|}{-9-x+3}$

$= \dfrac{|-x-6|}{-x-6} = \begin{cases} 1, \text{ if } x < -6 \\ -1, \text{if } x > -6 \end{cases}$

39.

x	$f(x) = x$	(x, y)
-2	$f(-2) = -2$	$(-2, -2)$
-1	$f(-1) = -1$	$(-1, -1)$
0	$f(0) = 0$	$(0, 0)$
1	$f(1) = 1$	$(1, 1)$
2	$f(2) = 2$	$(2, 2)$

x	$g(x) = x + 3$	(x, y)
-2	$g(-2) = -2 + 3 = 1$	$(-2, 1)$
-1	$g(-1) = -1 + 3 = 2$	$(-1, 2)$
0	$g(0) = 0 + 3 = 3$	$(0, 3)$
1	$g(1) = 1 + 3 = 4$	$(1, 4)$
2	$g(2) = 2 + 3 = 5$	$(2, 5)$

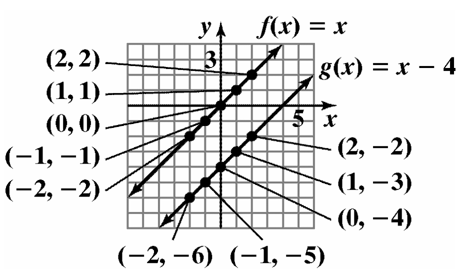


The graph of g is the graph of f shifted up 3 units.

40.

x	$f(x)=x$	(x,y)
–2	$f(-2)=-2$	$(-2,-2)$
–1	$f(-1)=-1$	$(-1,-1)$
0	$f(0)=0$	$(0,0)$
1	$f(1)=1$	$(1,1)$
2	$f(2)=2$	$(2,2)$

x	$g(x)=x-4$	(x,y)
–2	$g(-2)=-2-4=-6$	$(-2,-6)$
–1	$g(-1)=-1-4=-5$	$(-1,-5)$
0	$g(0)=0-4=-4$	$(0,-4)$
1	$g(1)=1-4=-3$	$(1,-3)$
2	$g(2)=2-4=-2$	$(2,-2)$

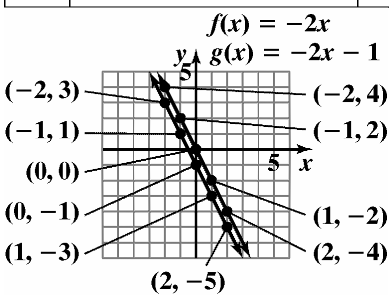


The graph of g is the graph of f shifted down 4 units.

41.

x	$f(x)=-2x$	(x,y)
–2	$f(-2)=-2(-2)=4$	$(-2,4)$
–1	$f(-1)=-2(-1)=2$	$(-1,2)$
0	$f(0)=-2(0)=0$	$(0,0)$
1	$f(1)=-2(1)=-2$	$(1,-2)$
2	$f(2)=-2(2)=-4$	$(2,-4)$

x	$g(x) = -2x - 1$	(x, y)
–2	$g(-2) = -2(-2) - 1 = 3$	$(-2, 3)$
–1	$g(-1) = -2(-1) - 1 = 1$	$(-1, 1)$
0	$g(0) = -2(0) - 1 = -1$	$(0, -1)$
1	$g(1) = -2(1) - 1 = -3$	$(1, -3)$
2	$g(2) = -2(2) - 1 = -5$	$(2, -5)$

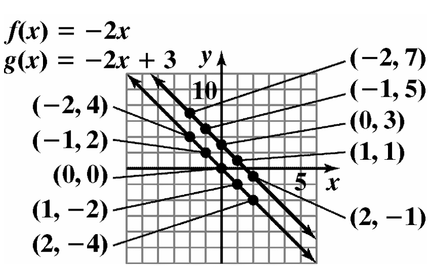


The graph of g is the graph of f shifted down 1 unit.

42.

x	$f(x) = -2x$	(x, y)
–2	$f(-2) = -2(-2) = 4$	$(-2, 4)$
–1	$f(-1) = -2(-1) = 2$	$(-1, 2)$
0	$f(0) = -2(0) = 0$	$(0, 0)$
1	$f(1) = -2(1) = -2$	$(1, -2)$
2	$f(2) = -2(2) = -4$	$(2, -4)$

x	$g(x) = -2x + 3$	(x, y)
–2	$g(-2) = -2(-2) + 3 = 7$	$(-2, 7)$
–1	$g(-1) = -2(-1) + 3 = 5$	$(-1, 5)$
0	$g(0) = -2(0) + 3 = 3$	$(0, 3)$
1	$g(1) = -2(1) + 3 = 1$	$(1, 1)$
2	$g(2) = -2(2) + 3 = -1$	$(2, -1)$

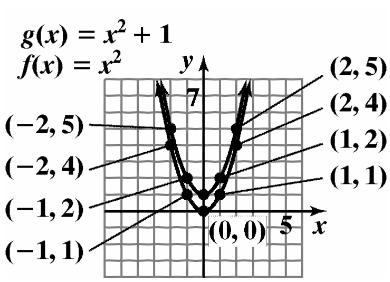


The graph of g is the graph of f shifted up 3 units.

43.

x	$f(x)=x^2$	(x,y)
–2	$f(-2)=(-2)^2=4$	$(-2,4)$
–1	$f(-1)=(-1)^2=1$	$(-1,1)$
0	$f(0)=(0)^2=0$	$(0,0)$
1	$f(1)=(1)^2=1$	$(1,1)$
2	$f(2)=(2)^2=4$	$(2,4)$

x	$g(x)=x^2+1$	(x,y)
–2	$g(-2)=(-2)^2+1=5$	$(-2,5)$
–1	$g(-1)=(-1)^2+1=2$	$(-1,2)$
0	$g(0)=(0)^2+1=1$	$(0,1)$
1	$g(1)=(1)^2+1=2$	$(1,2)$
2	$g(2)=(2)^2+1=5$	$(2,5)$

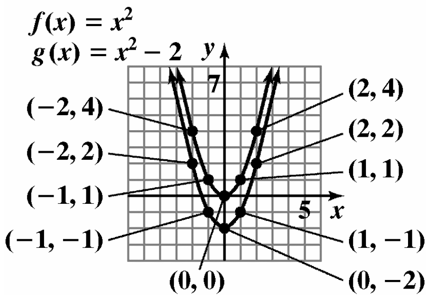


The graph of g is the graph of f shifted up 1 unit.

44.

x	$f(x)=x^2$	(x,y)
–2	$f(-2)=(-2)^2=4$	$(-2,4)$
–1	$f(-1)=(-1)^2=1$	$(-1,1)$
0	$f(0)=(0)^2=0$	$(0,0)$
1	$f(1)=(1)^2=1$	$(1,1)$
2	$f(2)=(2)^2=4$	$(2,4)$

x	$g(x)=x^2-2$	(x,y)
–2	$g(-2)=(-2)^2-2=2$	$(-2,2)$
–1	$g(-1)=(-1)^2-2=-1$	$(-1,-1)$
0	$g(0)=(0)^2-2=-2$	$(0,-2)$
1	$g(1)=(1)^2-2=-1$	$(1,-1)$
2	$g(2)=(2)^2-2=2$	$(2,2)$

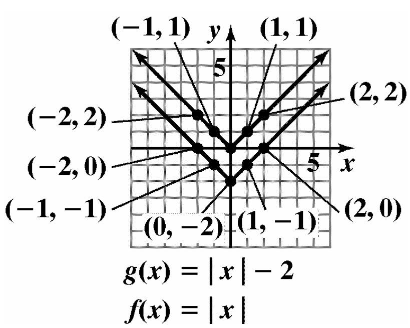


The graph of g is the graph of f shifted down 2 units.

45.

x	$f(x)=\|x\|$	(x,y)
–2	$f(-2)=\|-2\|=2$	$(-2,2)$
–1	$f(-1)=\|-1\|=1$	$(-1,1)$
0	$f(0)=\|0\|=0$	$(0,0)$
1	$f(1)=\|1\|=1$	$(1,1)$
2	$f(2)=\|2\|=2$	$(2,2)$

x	$g(x)=\|x\|-2$	(x,y)
–2	$g(-2)=\|-2\|-2=0$	$(-2,0)$
–1	$g(-1)=\|-1\|-2=-1$	$(-1,-1)$
0	$g(0)=\|0\|-2=-2$	$(0,-2)$
1	$g(1)=\|1\|-2=-1$	$(1,-1)$
2	$g(2)=\|2\|-2=0$	$(2,0)$

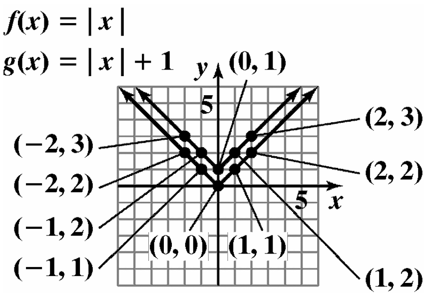


The graph of g is the graph of f shifted down 2 units.

46.

x	$f(x)=\|x\|$	(x,y)
–2	$f(-2)=\|-2\|=2$	$(-2,2)$
–1	$f(-1)=\|-1\|=1$	$(-1,1)$
0	$f(0)=\|0\|=0$	$(0,0)$
1	$f(1)=\|1\|=1$	$(1,1)$
2	$f(2)=\|2\|=2$	$(2,2)$

x	$g(x)=\|x\|+1$	(x,y)
-2	$g(-2)=\|-2\|+1=3$	$(-2,3)$
-1	$g(-1)=\|-1\|+1=2$	$(-1,2)$
0	$g(0)=\|0\|+1=1$	$(0,1)$
1	$g(1)=\|1\|+1=2$	$(1,2)$
2	$g(2)=\|2\|+1=3$	$(2,3)$

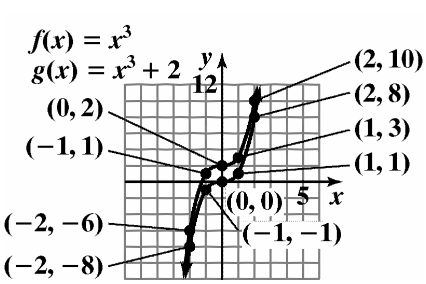


The graph of g is the graph of f shifted up 1 unit.

47.

x	$f(x)=x^3$	(x,y)
-2	$f(-2)=(-2)^3=-8$	$(-2,-8)$
-1	$f(-1)=(-1)^3=-1$	$(-1,-1)$
0	$f(0)=(0)^3=0$	$(0,0)$
1	$f(1)=(1)^3=1$	$(1,1)$
2	$f(2)=(2)^3=8$	$(2,8)$

x	$g(x)=x^3+2$	(x,y)
-2	$g(-2)=(-2)^3+2=-6$	$(-2,-6)$
-1	$g(-1)=(-1)^3+2=1$	$(-1,1)$
0	$g(0)=(0)^3+2=2$	$(0,2)$
1	$g(1)=(1)^3+2=3$	$(1,3)$
2	$g(2)=(2)^3+2=10$	$(2,10)$

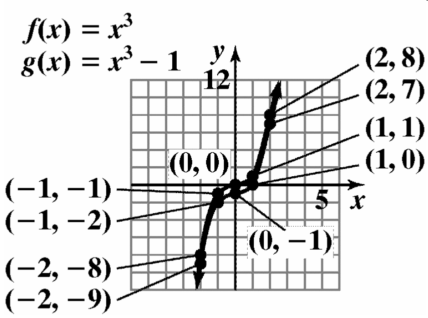


The graph of g is the graph of f shifted up 2 units.

48.

x	$f(x)=x^3$	(x,y)
–2	$f(-2)=(-2)^3=-8$	$(-2,-8)$
–1	$f(-1)=(-1)^3=-1$	$(-1,-1)$
0	$f(0)=(0)^3=0$	$(0,0)$
1	$f(1)=(1)^3=1$	$(1,1)$
2	$f(2)=(2)^3=8$	$(2,8)$

x	$g(x)=x^3-1$	(x,y)
–2	$g(-2)=(-2)^3-1=-9$	$(-2,-9)$
–1	$g(-1)=(-1)^3-1=-2$	$(-1,-2)$
0	$g(0)=(0)^3-1=-1$	$(0,-1)$
1	$g(1)=(1)^3-1=0$	$(1,0)$
2	$g(2)=(2)^3-1=7$	$(2,7)$

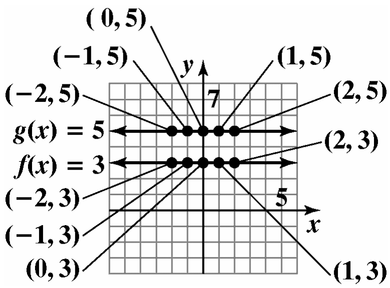


The graph of g is the graph of f shifted down 1 unit.

49.

x	$f(x)=3$	(x,y)
–2	$f(-2)=3$	$(-2,3)$
–1	$f(-1)=3$	$(-1,3)$
0	$f(0)=3$	$(0,3)$
1	$f(1)=3$	$(1,3)$
2	$f(2)=3$	$(2,3)$

x	$g(x)=5$	(x,y)
–2	$g(-2)=5$	$(-2,5)$
–1	$g(-1)=5$	$(-1,5)$
0	$g(0)=5$	$(0,5)$
1	$g(1)=5$	$(1,5)$
2	$g(2)=5$	$(2,5)$

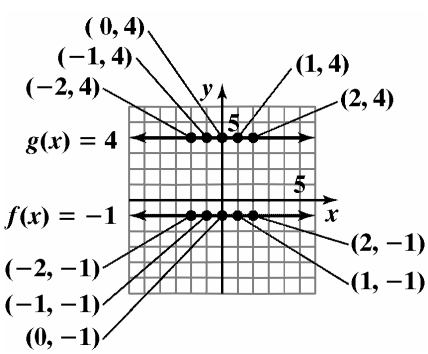


The graph of g is the graph of *f* shifted up 2 units.

50.

x	$f(x)=-1$	(x,y)
−2	$f(-2)=-1$	$(-2,-1)$
−1	$f(-1)=-1$	$(-1,-1)$
0	$f(0)=-1$	$(0,-1)$
1	$f(1)=-1$	$(1,-1)$
2	$f(2)=-1$	$(2,-1)$

x	$g(x)=4$	(x,y)
−2	$g(-2)=4$	$(-2,4)$
−1	$g(-1)=4$	$(-1,4)$
0	$g(0)=4$	$(0,4)$
1	$g(1)=4$	$(1,4)$
2	$g(2)=4$	$(2,4)$

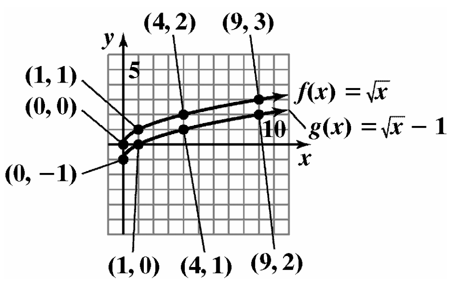


The graph of g is the graph of *f* shifted up 5 units.

51.

x	$f(x)=\sqrt{x}$	(x,y)
0	$f(0)=\sqrt{0}=0$	$(0,0)$
1	$f(1)=\sqrt{1}=1$	$(1,1)$
4	$f(4)=\sqrt{4}=2$	$(4,2)$
9	$f(9)=\sqrt{9}=3$	$(9,3)$

x	$g(x)=\sqrt{x}-1$	(x,y)
0	$g(0)=\sqrt{0}-1=-1$	$(0,-1)$
1	$g(1)=\sqrt{1}-1=0$	$(1,0)$
4	$g(4)=\sqrt{4}-1=1$	$(4,1)$
9	$g(9)=\sqrt{9}-1=2$	$(9,2)$

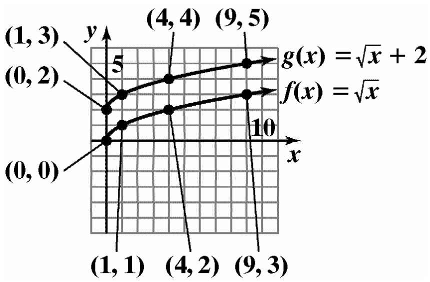


The graph of g is the graph of *f* shifted down 1 unit.

52.

x	$f(x)=\sqrt{x}$	(x,y)
0	$f(0)=\sqrt{0}=0$	$(0,0)$
1	$f(1)=\sqrt{1}=1$	$(1,1)$
4	$f(4)=\sqrt{4}=2$	$(4,2)$
9	$f(9)=\sqrt{9}=3$	$(9,3)$

x	$g(x)=\sqrt{x}+2$	(x,y)
0	$g(0)=\sqrt{0}+2=2$	$(0,2)$
1	$g(1)=\sqrt{1}+2=3$	$(1,3)$
4	$g(4)=\sqrt{4}+2=4$	$(4,4)$
9	$g(9)=\sqrt{9}+2=5$	$(9,5)$

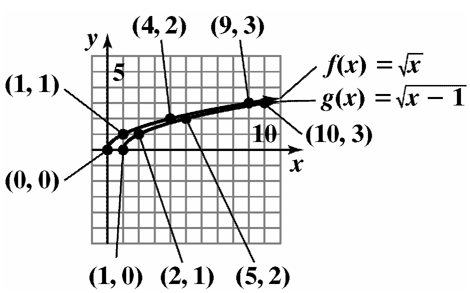


The graph of g is the graph of *f* shifted up 2 units.

53.

x	$f(x)=\sqrt{x}$	(x,y)
0	$f(0)=\sqrt{0}=0$	$(0,0)$
1	$f(1)=\sqrt{1}=1$	$(1,1)$
4	$f(4)=\sqrt{4}=2$	$(4,2)$
9	$f(9)=\sqrt{9}=3$	$(9,3)$

x	$g(x)=\sqrt{x-1}$	(x,y)
1	$g(1)=\sqrt{1-1}=0$	$(1,0)$
2	$g(2)=\sqrt{2-1}=1$	$(2,1)$
5	$g(5)=\sqrt{5-1}=2$	$(5,2)$
10	$g(10)=\sqrt{10-1}=3$	$(10,3)$

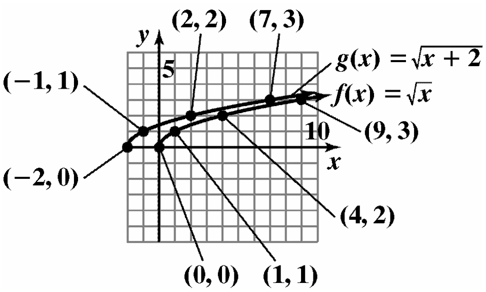


The graph of g is the graph of *f* shifted right 1 unit.

54.

x	$f(x)=\sqrt{x}$	(x,y)
0	$f(0)=\sqrt{0}=0$	$(0,0)$
1	$f(1)=\sqrt{1}=1$	$(1,1)$
4	$f(4)=\sqrt{4}=2$	$(4,2)$
9	$f(9)=\sqrt{9}=3$	$(9,3)$

x	$g(x)=\sqrt{x+2}$	(x,y)
–2	$g(-2)=\sqrt{-2+2}=0$	$(-2,0)$
–1	$g(-1)=\sqrt{-1+2}=1$	$(-1,1)$
2	$g(2)=\sqrt{2+2}=2$	$(2,2)$
7	$g(7)=\sqrt{7+2}=3$	$(7,3)$



The graph of g is the graph of *f* shifted left 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. $f(-2)=-4$

66. $f(2)=-4$

67. $f(4)=4$

68. $f(-4)=4$

69. $f(-3)=0$

70. $f(-1)=0$

71. $g(-4)=2$

72. $g(2)=-2$

73. $g(-10)=2$

74. $g(10)=-2$

75. When $x=-2$, $g(x)=1$.

76. When $x=1$, $g(x)=-1$.

77. **a.** domain: $(-\infty,\infty)$

b. range: $[-4,\infty)$

c. x-intercepts: –3 and 1

d. y-intercept: –3

e. $f(-2)=-3$ and $f(2)=5$

78. **a.** domain: $(-\infty, \infty)$

b. range: $(-\infty, 4]$

c. x-intercepts: –3 and 1

d. y-intercept: 3

e. $f(-2)=3$ and $f(2)=-5$

79. **a.** domain: $(-\infty, \infty)$

b. range: $[1, \infty)$

c. x-intercept: none

d. y-intercept: 1

e. $f(-1) = 2$ and $f(3) = 4$

80. **a.** domain: $(-\infty, \infty)$

b. range: $[0, \infty)$

c. x-intercept: -1

d. y-intercept: 1

e. $f(-4) = 3$ and $f(3) = 4$

81. **a.** domain: $[0, 5)$

b. range: $[-1, 5)$

c. x-intercept: 2

d. y-intercept: -1

e. $f(3) = 1$

82. **a.** domain: $(-6, 0]$

b. range: $[-3, 4)$

c. x-intercept: -3.75

d. y-intercept: -3

e. $f(-5) = 2$

83. **a.** domain: $[0, \infty)$

b. range: $[1, \infty)$

c. x-intercept: none

d. y-intercept: 1

e. $f(4) = 3$

84. **a.** domain: $[-1, \infty)$

b. range: $[0, \infty)$

c. x-intercept: -1

d. y-intercept: 1

e. $f(3) = 2$

85. **a.** domain: $[-2, 6]$

b. range: $[-2, 6]$

c. x-intercept: 4

d. y-intercept: 4

e. $f(-1) = 5$

86. **a.** Domain: $[-3, 2]$

b. Range: $[-5, 5]$

c. x-intercept: $-\frac{1}{2}$

d. y-intercept: 1

e. $f(-2) = -3$

87. **a.** domain: $(-\infty, \infty)$

b. range: $(-\infty, -2]$

c. x-intercept: none

d. y-intercept: -2

e. $f(-4) = -5$ and $f(4) = -2$

88. **a.** domain: $(-\infty, \infty)$

b. range: $[0, \infty)$

c. x-intercept: $\{x \mid x \le 0\}$

d. y-intercept: 0

e. $f(-2) = 0$ and $f(2) = 4$

89. **a.** domain: $(-\infty, \infty)$

b. range: $(0, \infty)$

c. x-intercept: none

d. y-intercept: 1.5

e. $f(4) = 6$

90. **a.** domain: $(-\infty,1)\cup(1,\infty)$

b. range: $(-\infty,0)\cup(0,\infty)$

c. x-intercept: none

d. y-intercept: -1

e. $f(2) = 1$

91. **a.** domain: {–5, –2, 0, 1, 3}

b. range: {2}

c. x-intercept: none

d. y-intercept: 2

e. $f(-5)+f(3)=2+2=4$

92. **a.** domain: {–5, –2, 0, 1, 4}

b. range: {–2}

c. x-intercept: none

d. y-intercept: –2

e. $f(-5)+f(4)=-2+(-2)=-4$

93.
$$g(1)=3(1)-5=3-5=-2$$
$$f(g(1))=f(-2)=(-2)^2-(-2)+4$$
$$=4+2+4=10$$

94.
$$g(-1)=3(-1)-5=-3-5=-8$$
$$f(g(-1))=f(-8)=(-8)^2-(-8)+4$$
$$=64+8+4=76$$

95.
$$\sqrt{3-(-1)}-(-6)^2+6\div(-6)\cdot 4$$
$$=\sqrt{3+1}-36+6\div(-6)\cdot 4$$
$$=\sqrt{4}-36+-1\cdot 4$$
$$=2-36+-4$$
$$=-34+-4$$
$$=-38$$

96.
$$|-4-(-1)|-(-3)^2+-3\div 3\cdot -6$$
$$=|-4+1|-9+-3\div 3\cdot -6$$
$$=|-3|-9+-1\cdot -6$$
$$=3-9+6=-6+6=0$$

97.
$$f(-x)-f(x)$$
$$=(-x)^3+(-x)-5-(x^3+x-5)$$
$$=-x^3-x-5-x^3-x+5=-2x^3-2x$$

98. $f(-x)-f(x)$
$=(-x)^2-3(-x)+7-(x^2-3x+7)$
$=x^2+3x+7-x^2+3x-7$
$=6x$

99. **a.** $\{$(U.S., 80%), (Japan, 64%),
(France, 64%), (Germany, 61%),
(England, 59%), (China, 47%)$\}$

b. Yes, the relation is a function. Each element in the domain corresponds to only one element in the range.

c. $\{$(80%, U.S.), (64%, Japan),
(64%, France), (61%, Germany),
(59%, England), (47%, China)$\}$

d. No, the relation is not a function. 64% in the domain corresponds to both Japan and France in the range.

100. **a.** {(EL,1%), (L,7%), (SL,11%),
(M,52%), (SC,13%), (C,13%),
(EC,3%)}

b. Yes, the relation in part (a) is a function because each ideology corresponds to exactly one percentage.

c. {(1%,EL),(7%,L),(11%,SL), (52%,M),(13%,SC),(13%,C), (3%,EC)}

d. No, the relation in is not a function because 13% in the domain corresponds to two ideologies, SC and C, in the range.

101. $W(16)=0.07(16)+4.1$
$=1.12+4.1=5.22$
In 2000 there were 5.22 million women enrolled in U.S. colleges.
(2000,5.22)

102. $M(16)=0.01(16)+3.9=0.16+3.9=4.06$
In 2000, there were 4.06 million men enrolled in U.S. colleges. This is represented by the point (2000, 4.06) on the graph.

103. $W(20)=0.07(20)+4.1$
$=1.4+4.1=5.5$
$M(20)=0.01(20)+3.9$
$=0.2+3.9=4.1$
$W(20)-M(20)=5.5-4.1=1.4$
In 2004, there will be 1.4 million more women than men enrolled in U.S. colleges.

104. $W(25) = 0.07(25) + 4.1 = 1.75 + 4.1 = 5.85$
$M(25) = 0.01(25) + 3.9 = 0.25 + 3.9 = 4.15$
$W(25) - M(25) = 5.85 - 4.15 = 1.7$
In 2009, there will be 1.7 million more women than men enrolled in U.S. colleges.

105. a. According to the graph, women's earnings were about 73% of men's in 2000.

b. $P(x) = 0.012x^2 - 0.16x + 60$
$P(40) = 0.012(40)^2 - 0.16(40) + 60 = 72.8$
According to the function, women's earnings were about 72.8% of men's in 2000.

c. $\frac{27,355}{37,339} \approx 0.733 = 73.3\%$
The answers in parts (a) and (b) model the actual data quite well.

106. a. According to the graph, women's earnings were about 76% of men's in 2003.

b. $P(x) = 0.012x^2 - 0.16x + 60$
$P(43) = 0.012(43)^2 - 0.16(43) + 60 = 75.3$
According to the function, women's earnings were about 75.3% of men's in 2003.

c. $\frac{30,724}{40,668} \approx 0.755 = 75.5\%$
The answers in parts (a) and (b) model the actual data quite well.

107. $C(x) = 100,000 + 100x$
$C(90) = 100,000 + 100(90) = \$109,000$
It will cost $109,000 to produce 90 bicycles.

108. $V(x) = 22,500 - 3200x$
$V(3) = 22,500 - 3200(3) = \$12,900$
After 3 years, the car will be worth $12,900.

109.
$$T(x) = \frac{40}{x} + \frac{40}{x+30}$$
$$T(30) = \frac{40}{30} + \frac{40}{30+30} = \frac{80}{60} + \frac{40}{60} = \frac{120}{60} = 2$$
If you travel 30 mph going and 60 mph returning, your total trip will take 2 hours.

110. $S(x) = 0.10x + 0.60(50 - x)$
$S(30) = 0.10(30) + 0.60(50 - 30) = 15$
When 30 mL of the 10% mixture is mixed with 20 mL of the 60% mixture, there will be 15 mL of sodium-iodine in the vaccine.

121. **a.** false; the domain of *f* is [–4, 4]

b. false; the range of *f* is [–2, 2)

c. true; $f(-1) - f(4) = 1 - (-1) = 2$

d. false; $f(0) < 1$ x

(c) is true.

122. $f(a+h) = 3(a+h)+7 = 3a+3h+7$

$f(a) = 3a+7$

$\frac{f(a+h)-f(a)}{h}$

$= \frac{(3a+3h+7)-(3a+7)}{h}$

$= \frac{3a+3h+7-3a-7}{h} = \frac{3h}{h} = 3$

123. Answers may vary.
An example is $\{(1,1),(2,1)\}$

124. It is given that $f(x+y) = f(x)+f(y)$ and $f(1) = 3$.
To find $f(2)$, rewrite 2 as 1 + 1.

$f(2) = f(1+1) = f(1)+f(1)$

$= 3+3 = 6$

Similarly:

$f(3) = f(2+1) = f(2)+f(1)$

$= 6+3 = 9$

$f(4) = f(3+1) = f(3)+f(1)$

$= 9+3 = 12$

While $f(x+y) = f(x)+f(y)$ is true for this function, it is not true for all functions. It is not true for $f(x) = x^2$, for example.

Section 1.3

Check Point Exercises

1. **a.** $f(x) = -2x^2 + x + 5$

$f(x+h) = -2(x+h)^2 + (x+h) + 5$

$= -2(x^2 + 2xh + h^2) + x + h + 5$

$= -2x^2 - 4xh - 2h^2 + x + h + 5$

b. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{-2x^2-4xh-2h^2+x+h+5-\left(-2x^2+x+5\right)}{h}$

$= \dfrac{-2x^2-4xh-2h^2+x+h+5+2x^2-x-5}{h}$

$= \dfrac{-4xh-2h^2+h}{h}$

$= \dfrac{h\left(-4x-2h+1\right)}{h}$

$= -4x-2h+1$

2. $C(t) = \begin{cases} 20 & \text{if } 0 \le t \le 60 \\ 20+0.40(t-60) & \text{if } t > 60 \end{cases}$

b. Since $0 \le 40 \le 60$, $C(40) = 20$
With 40 calling minutes, the cost is \$20.
This is represented by $(40, 20)$.

c. Since $80 > 60$, $C(80) = 20 + 0.40(80-60) = 28$
With 80 calling minutes, the cost is \$28.
This is represented by $(80, 28)$.

3. The function is increasing on the interval (–∞, –1), decreasing on the interval (–1, 1), and increasing on the interval (1, ∞).

4. **a.** $f(-x) = (-x)^2 + 6 = x^2 + 6 = f(x)$
The function is even.

b. $g(-x) = 7(-x)^3 - (-x) = -7x^3 + x = -f(x)$
The function is odd.

c. $h(-x) = (-x)^5 + 1 = -x^5 + 1$
The function is neither even nor odd.

Exercise Set 1.3

1. $\frac{f(x+h)-f(x)}{h}$
$=\frac{4(x+h)-4x}{h}$
$=\frac{4x+4h-4x}{h}$
$=\frac{4h}{h}$
$=4$

2. $\frac{f(x+h)-f(x)}{h}$
$=\frac{7(x+h)-7x}{h}$
$=\frac{7x+7h-7x}{h}$
$=\frac{7h}{h}$
$=7$

3. $\frac{f(x+h)-f(x)}{h}$
$=\frac{3(x+h)+7-(3x+7)}{h}$
$=\frac{3x+3h+7-3x-7}{h}$
$=\frac{3h}{h}$
$=3$

4. $\frac{f(x+h)-f(x)}{h}$
$=\frac{6(x+h)+1-(6x+1)}{h}$
$=\frac{6x+6h+1-6x-1}{h}$
$=\frac{6h}{h}$
$=6$

5. $\frac{f(x+h)-f(x)}{h}$
$=\frac{(x+h)^2-x^2}{h}$
$=\frac{x^2+2xh+h^2-x^2}{h}$
$=\frac{2xh+h^2}{h}$
$=\frac{h(2x+h)}{h}$
$=2x+h$

6. $\frac{f(x+h)-f(x)}{h}$
$=\frac{2(x+h)^2-2x^2}{h}$
$=\frac{2(x^2+2xh+h^2)-2x^2}{h}$
$=\frac{2x^2+4xh+2h^2-2x^2}{h}$
$=\frac{4xh+2h^2}{h}$
$=\frac{h(4x+2h)}{h}$
$=4x+2h$

7. $\frac{f(x+h)-f(x)}{h}$
$=\frac{(x+h)^2-4(x+h)+3-(x^2-4x+3)}{h}$
$=\frac{x^2+2xh+h^2-4x-4h+3-x^2+4x-3}{h}$
$=\frac{2xh+h^2-4h}{h}$
$=\frac{h(2x+h-4)}{h}$
$=2x+h-4$

8. $\frac{f(x+h)-f(x)}{h}$
$=\frac{(x+h)^2-5(x+h)+8-(x^2-5x+8)}{h}$
$=\frac{x^2+2xh+h^2-5x-5h+8-x^2+5x-8}{h}$
$=\frac{2xh+h^2-5h}{h}$
$=\frac{h(2x+h-5)}{h}$
$=2x+h-5$

9. $\frac{f(x+h)-f(x)}{h}$
$=\frac{2(x+h)^2+(x+h)-1-(2x^2+x-1)}{h}$
$=\frac{2x^2+4xh+2h^2+x+h-1-2x^2-x+1}{h}$
$=\frac{4xh+2h^2+h}{h}$
$=\frac{h(4x+2h+1)}{h}$
$=4x+2h+1$

10. $\frac{f(x+h)-f(x)}{h}$
$=\frac{3(x+h)^2+(x+h)+5-(3x^2+x+5)}{h}$
$=\frac{3x^2+6xh+3h^2+x+h+5-3x^2-x-5}{h}$
$=\frac{6xh+3h^2+h}{h}$
$=\frac{h(6x+3h+1)}{h}$
$=6x+3h+1$

11. $\frac{f(x+h)-f(x)}{h}$
$=\frac{-(x+h)^2+2(x+h)+4-(-x^2+2x+4)}{h}$
$=\frac{-x^2-2xh-h^2+2x+2h+4+x^2-2x-4}{h}$
$=\frac{-2xh-h^2+2h}{h}$
$=\frac{h(-2x-h+2)}{h}$
$=-2x-h+2$

12. $\frac{f(x+h)-f(x)}{h}$
$=\frac{-(x+h)^2-3(x+h)+1-(-x^2-3x+1)}{h}$
$=\frac{-x^2-2xh-h^2-3x-3h+1+x^2+3x-1}{h}$
$=\frac{-2xh-h^2-3h}{h}$
$=\frac{h(-2x-h-3)}{h}$
$=-2x-h-3$

13. $\frac{f(x+h)-f(x)}{h}$
$=\frac{-2(x+h)^2+5(x+h)+7-(-2x^2+5x+7)}{h}$
$=\frac{-2x^2-4xh-2h^2+5x+5h+7+2x^2-5x-7}{h}$
$=\frac{-4xh-2h^2+5h}{h}$
$=\frac{h(-4x-2h+5)}{h}$
$=-4x-2h+5$

14. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{-3(x+h)^2+2(x+h)-1-(-3x^2+2x-1)}{h}$

$= \dfrac{-3x^2-6xh-3h^2+2x+2h-1+3x^2-2x+1}{h}$

$= \dfrac{-6xh-3h^2+2h}{h}$

$= \dfrac{h(-6x-3h+2)}{h}$

$= -6x-3h+2$

15. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{-2(x+h)^2-(x+h)+3-(-2x^2-x+3)}{h}$

$= \dfrac{-2x^2-4xh-2h^2-x-h+3+2x^2+x-3}{h}$

$= \dfrac{-4xh-2h^2-h}{h}$

$= \dfrac{h(-4x-2h-1)}{h}$

$= -4x-2h-1$

16. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{-3(x+h)^2+(x+h)-1-(-3x^2+x-1)}{h}$

$= \dfrac{-3x^2-6xh-3h^2+x+h-1+3x^2-x+1}{h}$

$= \dfrac{-6xh-3h^2+h}{h}$

$= \dfrac{h(-6x-3h+1)}{h}$

$= -6x-3h+1$

17. $\dfrac{f(x+h)-f(x)}{h} = \dfrac{6-6}{h} = \dfrac{0}{h} = 0$

18. $\dfrac{f(x+h)-f(x)}{h} = \dfrac{7-7}{h} = \dfrac{0}{h} = 0$

19. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{\frac{1}{x+h}-\frac{1}{x}}{h}$

$= \dfrac{\frac{x}{x(x+h)}+\frac{-(x+h)}{x(x+h)}}{h}$

$= \dfrac{\frac{x-x-h}{x(x+h)}}{h}$

$= \dfrac{\frac{-h}{x(x+h)}}{h}$

$= \dfrac{-h}{x(x+h)}\cdot\dfrac{1}{h}$

$= \dfrac{-1}{x(x+h)}$

20. $\dfrac{f(x+h)-f(x)}{h}$

$= \dfrac{\frac{1}{2(x+h)}-\frac{1}{2x}}{h}$

$= \dfrac{\frac{x}{2x(x+h)}-\frac{x+h}{2x(x+h)}}{h}$

$= \dfrac{\frac{-h}{2x(x+h)}}{h}$

$= \dfrac{-h}{2x(x+h)}\cdot\dfrac{1}{h}$

$= \dfrac{-1}{2x(x+h)}$

21. $\dfrac{f(x+h)-f(x)}{h}$
$=\dfrac{\sqrt{x+h}-\sqrt{x}}{h}$
$=\dfrac{\sqrt{x+h}-\sqrt{x}}{h}\cdot\dfrac{\sqrt{x+h}+\sqrt{x}}{\sqrt{x+h}+\sqrt{x}}$
$=\dfrac{x+h-x}{h\left(\sqrt{x+h}+\sqrt{x}\right)}$
$=\dfrac{h}{h\left(\sqrt{x+h}+\sqrt{x}\right)}$
$=\dfrac{1}{\sqrt{x+h}+\sqrt{x}}$

22. $\dfrac{f(x+h)-f(x)}{h}$
$=\dfrac{\sqrt{x+h-1}-\sqrt{x-1}}{h}$
$=\dfrac{\sqrt{x+h-1}-\sqrt{x-1}}{h}\cdot\dfrac{\sqrt{x+h-1}+\sqrt{x-1}}{\sqrt{x+h-1}+\sqrt{x-1}}$
$=\dfrac{x+h-1-(x-1)}{h\left(\sqrt{x+h-1}+\sqrt{x-1}\right)}$
$=\dfrac{x+h-1-x+1}{h\left(\sqrt{x+h-1}+\sqrt{x-1}\right)}$
$=\dfrac{h}{h\left(\sqrt{x+h-1}+\sqrt{x-1}\right)}$
$=\dfrac{1}{\sqrt{x+h-1}+\sqrt{x-1}}$

23. **a.** $f(-2) = 3(-2) + 5 = -1$

b. $f(0) = 4(0) + 7 = 7$

c. $f(3) = 4(3) + 7 = 19$

24. **a.** $f(-3) = 6(-3) - 1 = -19$

b. $f(0) = 7(0) + 3 = 3$

c. $f(4) = 7(4) + 3 = 31$

25. **a.** $g(0) = 0 + 3 = 3$

b. $g(-6) = -(-6 + 3) = -(-3) = 3$

c. $g(-3) = -3 + 3 = 0$

26. **a.** $g(0) = 0 + 5 = 5$

b. $g(-6) = -(-6 + 5) = -(-1) = 1$

c. $g(-5) = -5 + 5 = 0$

27. **a.** $h(5)=\dfrac{5^2-9}{5-3}=\dfrac{25-9}{2}=\dfrac{16}{2}=8$

b. $h(0)=\dfrac{0^2-9}{0-3}=\dfrac{-9}{-3}=3$

c. $h(3) = 6$

28. **a.** $h(7)=\dfrac{7^2-25}{7-5}=\dfrac{49-25}{2}=\dfrac{24}{2}=12$

b. $h(0)=\dfrac{0^2-25}{0-5}=\dfrac{-25}{-5}=5$

c. $h(5) = 10$

29. **a.** increasing: $(-1,\infty)$

b. decreasing: $(-\infty,-1)$

c. constant: none

30. **a.** increasing: $(-\infty, -1)$

b. decreasing: $(-1, \infty)$

c. constant: none

31. **a.** increasing: $(0,\infty)$

b. decreasing: none

c. constant: none

32. **a.** increasing: $(-1, \infty)$

b. decreasing: none

c. constant: none

33. **a.** increasing: none

b. decreasing: $(-2, 6)$

c. constant: none

34. **a.** increasing: (–3, 2)

b. decreasing: none

c. constant: none

35. **a.** increasing: $(-\infty, -1)$

b. decreasing: none

c. constant: $(-1, \infty)$

36. **a.** increasing: $(0, \infty)$

b. decreasing: none

c. constant: $(-\infty, 0)$

37. **a.** increasing: $(-\infty, 0)$ or $(1.5, 3)$

b. decreasing: $(0, 1.5)$ or $(3, \infty)$

c. constant: none

38. **a.** increasing: $(-5, -4)$ or $(-2, 0)$ or $(2, 4)$

b. decreasing: $(-4, -2)$ or $(0, 2)$ or $(4, 5)$

c. constant: none

39. **a.** increasing: (–2, 4)

b. decreasing: none

c. constant: $(-\infty, -2)$ or $(4, \infty)$

40. **a.** increasing: none

b. decreasing: (–4, 2)

c. constant: $(-\infty, -4)$ or $(2, \infty)$

41. **a.** $x = 0$, relative maximum = 4

b. $x = -3, 3$, relative minimum = 0

42. **a.** $x = 0$, relative maximum = 2

b. $x = -3, 3$, relative minimum = –1

43. **a.** $x = -2$, relative maximum = 21

b. $x = 1$, relative minimum = −6

44. **a.** $x = 1$, relative maximum = 30

b. $x = 4$, relative minimum = 3

45. $f(x) = x^3 + x$
$f(-x) = (-x)^3 + (-x)$
$f(-x) = -x^3 - x = -(x^3 + x)$
$f(-x) = -f(x)$, odd function

46. $f(x) = x^3 - x$
$f(-x) = (-x)^3 - (-x)$
$f(-x) = -x^3 + x = -(x^3 - x)$
$f(-x) = -f(x)$, odd function

47. $g(x) = x^2 + x$
$g(-x) = (-x)^2 + (-x)$
$g(-x) = x^2 - x$, neither

48. $g(x) = x^2 - x$
$g(-x) = (-x)^2 - (-x)$
$g(-x) = x^2 + x$, neither

49. $h(x) = x^2 - x^4$
$h(-x) = (-x)^2 - (-x)^4$
$h(-x) = x^2 - x^4$
$h(-x) = h(x)$, even function

50. $h(x) = 2x^2 + x^4$
$h(-x) = 2(-x)^2 + (-x)^4$
$h(-x) = 2x^2 + x^4$
$h(-x) = h(x)$, even function

51. $f(x) = x^2 - x^4 + 1$
$f(-x) = (-x)^2 - (-x)^4 + 1$
$f(-x) = x^2 - x^4 + 1$
$f(-x) = f(x)$, even function

52. $f(x) = 2x^2 + x^4 + 1$
$f(-x) = 2(-x)^2 + (-x)^4 + 1$
$f(-x) = 2x^2 + x^4 + 1$
$f(-x) = f(x)$, even function

53. $f(x)=\frac{1}{5}x^6-3x^2$

$f(-x)=\frac{1}{5}(-x)^6-3(-x)^2$

$f(-x)=\frac{1}{5}x^6-3x^2$

$f(-x)=f(x)$, even function

54. $f(x)=2x^3-6x^5$

$f(-x)=2(-x)^3-6(-x)^5$

$f(-x)=-2x^3+6x^5$

$f(-x)=-(2x^3-6x^5)$

$f(-x)=-f(x),$ odd function

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

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

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

$=-\left(x\sqrt{1-x^2}\right)$

$f(-x)=-f(x)$, odd function

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

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

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

$f(-x)=f(x)$, even function

57. The graph is symmetric with respect to the *y*-axis. The function is even.

58. The graph is symmetric with respect to the origin. The function is odd.

59. The graph is symmetric with respect to the origin. The function is odd.

60. The graph is not symmetric with respect to the *y*-axis or the origin. The function is neither even nor odd.

61. **a.** Domain: $(-\infty,\infty)$

b. Range: $[-4,\infty)$

c. *x*-intercepts: 1, 7

d. *y*-intercept: 4

e. $(4,\infty)$

f. $(0,4)$

g. $(-\infty,0)$

h. $x=4$

i. $y=-4$

j. $f(-3)=4$

k. $f(2)=-2$ and $f(6)=-2$

l. neither ; $f(-x)\neq x$, $f(-x)\neq -x$

62. **a.** Domain: $(-\infty,\infty)$

b. Range: $(-\infty,4]$

c. *x*-intercepts: –4, 4

d. y-intercept: 1

e. $(-\infty,-2)$ or $(0,3)$

f. $(-2,0)$ or $(3,\infty)$

g. $(-\infty,-4]$ or $[4,\infty)$

h. $x=-2$ and $x=3$

i. $f(-2)=4$ and $f(3)=2$

j. $f(-2)=4$

k. $x=-4$ and $x=4$

l. neither ; $f(-x)\neq x$, $f(-x)\neq -x$

63. a. Domain: $(-\infty,3]$

b. Range: $(-\infty,4]$

c. x-intercepts: –3, 3

d. $f(0)=3$

e. $(-\infty,1)$

f. $(1,3)$

g. $(-\infty,-3]$

h. $f(1)=4$

i. $x=1$

j. positive; $f(-1)=+2$

64. a. Domain: $(-\infty,6]$

b. Range: $(-\infty,1]$

c. zeros of f: –3, 3

d. $f(0)=1$

e. $(-\infty,-2)$

f. $(2,6)$

g. $(-2, 2)$

h. $(-3, 3)$

i. $x = -5$ and $x = 5$

j. negative; $f(4) = -1$

k. neither

l. no; f(2) is not greater than the function values to the immediate left.

65. $f(1.06) = 1$

66. $f = (2.99) = 2$

67. $f\left(\frac{1}{3}\right) = 0$

68. $f(-1.5) = -2$

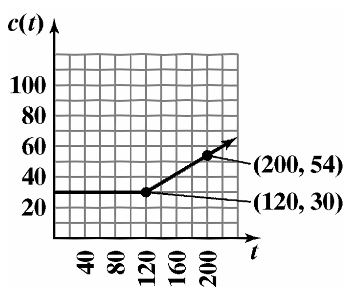
69. $f(-2.3) = -3$

70. $f(-99.001) = -100$

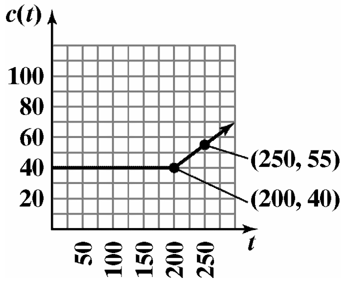
71. $\sqrt{f(-1.5) + f(-0.9)} - [f(\pi)]^2 + f(-3) \div f(1) \cdot f(-\pi)$
$= \sqrt{1+0} - [-4]^2 + 2 \div (-2) \cdot 3$
$= \sqrt{1} - 16 + (-1) \cdot 3$
$= 1 - 16 - 3$
$= -18$

72. $\sqrt{f(-2.5) - f(1.9)} - [f(-\pi)]^2 + f(-3) \div f(1) \cdot f(\pi)$
$\sqrt{f(-2.5) - f(1.9)} - [f(-\pi)]^2 + f(-3) \div f(1) \cdot f(\pi)$
$= \sqrt{2 - (-2)} - [3]^2 + 2 \div (-2) \cdot (-4)$
$= \sqrt{4} - 9 + (-1)(-4)$
$= 2 - 9 + 4$
$= -3$

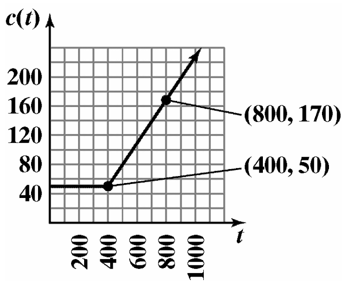
73. $30 + 0.30(t - 120) = 30 + 0.3t - 36 = 0.3t - 6$



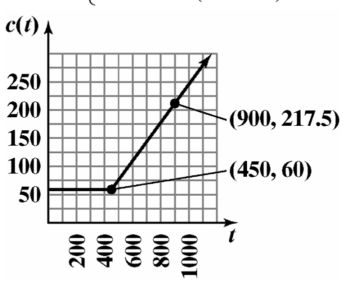
74. $40+0.30(t-200)=40+0.3t-60=0.3t-20$



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



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



77. $f(60)\approx 3.1$
In 1960, about 3.1% of the population were Jewish-Americans.

78 $f(100)\approx 2.2$
In 2002, about 2.2% of the population were Jewish-Americans.

79. $x\approx 19$ and $x\approx 64$
In 1919 and 1964, about 3% of the population were Jewish-Americans.

80. $x=14$ and $x\approx 90$, In 1914 and 1990, about 2.5% of the population were Jewish-Americans.

81. In 1940, the maximum of 3.7% of the population were Jewish-American.

82. In 1900, about 1.4% of the population were Jewish-American.

83. Each year corresponds to only 1 percentage.

84. The percentage of Jewish-Americans in the population increased until 1940 and decreased since then.

85. Increasing: (45, 74)
Decreasing: (16, 45)
The number of accidents occurring per 50 million miles driven increases with age starting at age 45, while it decreases with age starting at age 16.

86. $x = 45$ and $f(45) = 190$
The fewest number of accidents per 50 million miles driven occurs at age 45.

87. Answers may vary. An example is 16 and 74 year olds will have 526.4 accidents per 50 million miles.

88. $f(x) = 0.4x^2 - 36x + 1000$
$f(50) = 0.4(50)^2 - 36(50) + 1000 = 200$
50 year old drivers have 200 accidents per 50 million miles.
This is represented on the graph as the point $(50, 200)$.

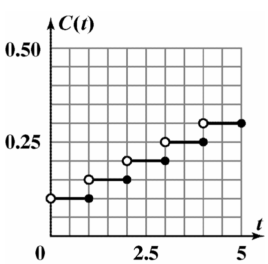
89. $f(30) = 61.9(30) + 132 = 1989$ cigarettes per adult
This describes the actual data quite well.

90. $f(80) = -2.2(80)^2 + 256(80) - 3503 = 2897$ cigarettes per adult
This describes the actual data quite well.

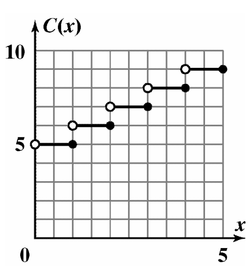
91. The maximum occurred in 1960. Graph estimates will vary near 4100.
$f(50) = -2.2(50)^2 + 256(50) - 3503 = 3797$ cigarettes per adult
The function does not describe the actual data reasonably well.

92. The minimum occurred in 1910. Graph estimates will vary near 100.
$f(0) = 61.9(0) + 132 = 132$ cigarettes per adult
The function describes the actual data reasonably well.

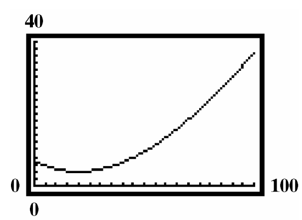
93.



94.

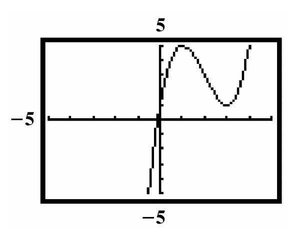


103.



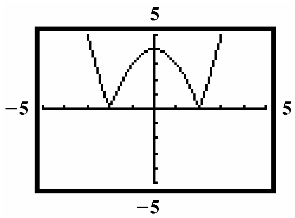
The number of doctor visits decreases during childhood and then increases as you get older. The minimum is (20.29, 3.99), which means that the minimum number of doctor visits, about 4, occurs at around age 20.

104



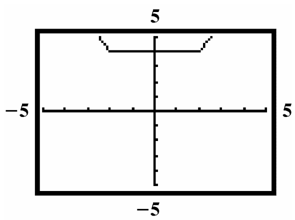
Increasing: $(-\infty, 1)$ or $(3, \infty)$
Decreasing: (1, 3)

105.



Increasing: (–2, 0) or (2, ∞)
Decreasing: (–∞, –2) or (0, 2)

106.

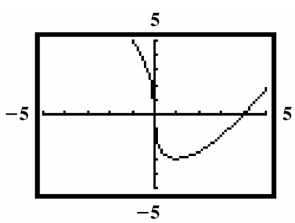


Increasing: $(2, \infty)$

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

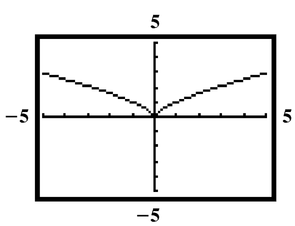
Constant: (–2, 2)

107.



Increasing: (1, ∞)
Decreasing: (–∞, 1)

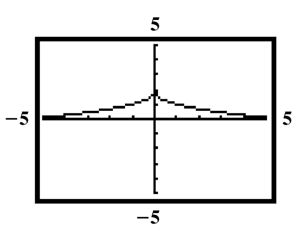
108.



Increasing: $(0, \infty)$

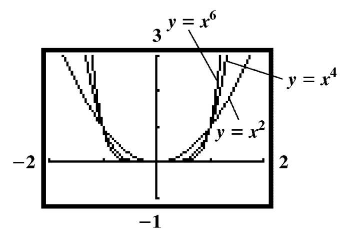
Decreasing: $(-\infty, 0)$

109.

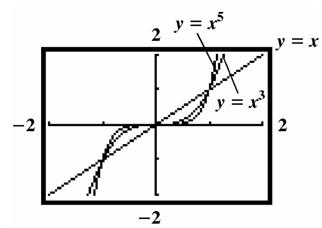


Increasing: (–∞, 0)
Decreasing: (0, ∞)

110. a.



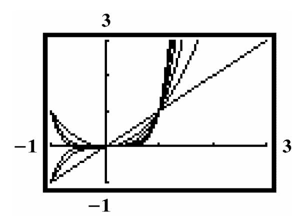
b.



c. Increasing: (0, ∞)
Decreasing: (–∞, 0)

d. $f(x) = x^n$ is increasing from (–∞, ∞) when n is odd.

e.



113. a. h is even if both f and g are even or if both f and g are odd.
f and g are both even:

$$h(-x) = \frac{f(-x)}{g(-x)} = \frac{f(x)}{g(x)} = h(x)$$

f and g are both odd:

$$h(-x) = \frac{f(-x)}{g(-x)} = \frac{-f(x)}{-g(x)} = \frac{f(x)}{g(x)} = h(x)$$

b. h is odd if f is odd and g is even or if f is even and g is odd.
f is odd and g is even:

$$h(-x) = \frac{f(-x)}{g(-x)} = \frac{-f(x)}{g(x)} = -\frac{f(x)}{g(x)} = -h(x)$$

f is even and g is odd:

$$h(-x) = \frac{f(-x)}{g(-x)} = \frac{f(x)}{-g(x)} = -\frac{f(x)}{g(x)} = -h(x)$$

114.

Weight at least	Cost
0 oz.	$0.37
1	0.60
2	0.83
3	1.06
4	1.29

Section 1.4

Check Point Exercises

1. **a.** $m = \frac{-2-4}{-4-(-3)} = \frac{-6}{-1} = 6$

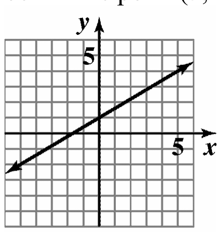
b. $m = \frac{5-(-2)}{-1-4} = \frac{7}{-5} = -\frac{7}{5}$

2.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-5) &= 6(x - 2) \\ y + 5 &= 6x - 12 \\ y &= 6x - 17 \end{aligned}$$

3. $m = \frac{-6-(-1)}{-1-(-2)} = \frac{-5}{1} = -5$,

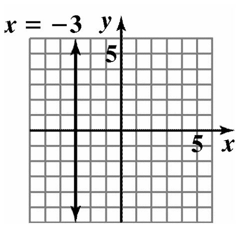
so the slope is –5. Using the point (–2, –1), we get the point slope equation:
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-1) &= -5[x - (-2)] \\ y + 1 &= -5(x + 2).\text{Solve the equation for } y: \\ y + 1 &= -5x - 10 \\ y &= -5x - 11. \end{aligned}$$

4. The slope m is $\frac{3}{5}$ and the y-intercept is 1, so one point on the line is (1, 0). We can find a second point on the line by using the slope $m = \frac{3}{5} = \frac{\text{Rise}}{\text{Run}}$: starting at the point (0, 1), move 3 units up and 5 units to the right, to obtain the point (5, 4).



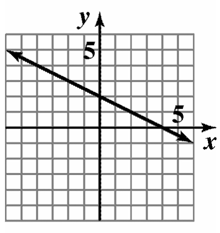
$f(x) = \frac{3}{5}x + 1$

5. All ordered pairs that are solutions of $x = -3$ have a value of x that is always –3. Any value can be used for y.



6. $3x + 6y - 12 = 0$

$$6y = -3x + 12$$
$$y = \frac{-3}{6}x + \frac{12}{6}$$
$$y = -\frac{1}{2}x + 2$$



3x + 6y − 12 = 0

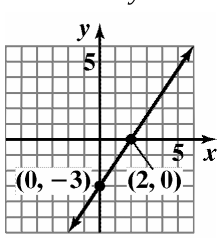
The slope is $-\frac{1}{2}$ and the y-intercept is 2.

7. Find the x-intercept:

$$3x - 2y - 6 = 0$$
$$3x - 2(0) - 6 = 0$$
$$3x - 6 = 0$$
$$3x = 6$$
$$x = 2$$

Find the y-intercept:

$$3x - 2y - 6 = 0$$
$$3(0) - 2y - 6 = 0$$
$$-2y - 6 = 0$$
$$-2y = 6$$
$$y = -3$$



3x − 2y = 6

8. $m = \frac{\text{Change in } y}{\text{Change in } x} = \frac{32.8 - 30.0}{20 - 10} = \frac{2.8}{10} = 0.28$

$$y - y_1 = m(x - x_1)$$
$$y - 30.0 = 0.28(x - 10)$$
$$y - 30.0 = 0.28x - 2.8$$
$$y = 0.28x + 27.2$$

2020 is 50 years after 1970.

$$y = 0.28x + 27.2$$
$$y = 0.28(50) + 27.2$$
$$y = 41.2$$

In 2020 the median age is expected to be 41.2.

Exercise Set 1.4

1. $m = \frac{10 - 7}{8 - 4} = \frac{3}{4}$; rises

2. $m = \frac{4 - 1}{3 - 2} = \frac{3}{1} = 3$; rises

3. $m = \frac{2 - 1}{2 - (-2)} = \frac{1}{4}$; rises

4. $m = \frac{4 - 3}{2 - (-1)} = \frac{1}{3}$; rises

5. $m = \frac{2 - (-2)}{3 - 4} = \frac{0}{-1} = 0$; horizontal

6. $m = \frac{-1 - (-1)}{3 - 4} = \frac{0}{-1} = 0$; horizontal

7. $m = \frac{-1 - 4}{-1 - (-2)} = \frac{-5}{1} = -5$; falls

8. $m = \frac{-2 - (-4)}{4 - 6} = \frac{2}{-2} = -1$; falls

9. $m = \frac{-2 - 3}{5 - 5} = \frac{-5}{0}$ undefined; vertical

10. $m = \frac{5 - (-4)}{3 - 3} = \frac{9}{0}$ undefined; vertical

11. $m = 2,\ x_1 = 3,\ y_1 = 5$;
point-slope form: $y - 5 = 2(x - 3)$;
slope-intercept form: $y - 5 = 2x - 6$
$$y = 2x - 1$$

12. point-slope form: $y - 3 = 4(x - 1)$;
$m = 4, x_1 = 1, y_1 = 3$;
slope-intercept form: $y = 4x - 1$

13. $m = 6,\ x_1 = -2,\ y_1 = 5$;
point-slope form: $y - 5 = 6(x + 2)$;
slope-intercept form: $y - 5 = 6x + 12$
$$y = 6x + 17$$

14. point-slope form: $y + 1 = 8(x - 4)$;
$m = 8, x_1 = 4, y_1 = -1$;
slope-intercept form: $y = 8x - 33$

15. $m = -3,\ x_1 = -2,\ y_1 = -3;$
point-slope form: $y + 3 = -3(x + 2);$
slope-intercept form: $y + 3 = -3x - 6$
$y = -3x - 9$

16. point-slope form: $y + 2 = -5(x + 4);$
$m = -5, x_1 = -4, y_1 = -2;$
slope-intercept form: $y = -5x - 22$

17. $m = -4,\ x_1 = -4,\ y_1 = 0;$
point-slope form: $y - 0 = -4(x + 4);$
slope-intercept form: $y = -4(x + 4)$
$y = -4x - 16$

18. point-slope form: $y + 3 = -2(x - 0)$
$m = -2, x_1 = 0, y_1 = -3;$
slope-intercept form: $y = -2x - 3$

19. $m = -1,\ x_1 = \frac{-1}{2},\ y_1 = -2;$
point-slope form: $y + 2 = -1\left(x + \frac{1}{2}\right);$
slope-intercept form: $y + 2 = -x - \frac{1}{2}$
$y = -x - \frac{5}{2}$

20. point-slope form: $y + \frac{1}{4} = -1(x + 4);$
$m = -1, x_1 = -4, y_1 = -\frac{1}{4};$
slope-intercept form: $y = -x - \frac{17}{4}$

21. $m = \frac{1}{2},\ x_1 = 0,\ y_1 = 0;$
point-slope form: $y - 0 = \frac{1}{2}(x - 0);$
slope-intercept form: $y = \frac{1}{2}x$

22. point-slope form: $y - 0 = \frac{1}{3}(x - 0);$
$m = \frac{1}{3}, x_1 = 0, y_1 = 0;$
slope-intercept form: $y = \frac{1}{3}x$

23. $m = -\frac{2}{3},\ x_1 = 6,\ y_1 = -2;$
point-slope form: $y + 2 = -\frac{2}{3}(x - 6);$
slope-intercept form: $y + 2 = -\frac{2}{3}x + 4$
$y = -\frac{2}{3}x + 2$

24. point-slope form: $y + 4 = -\frac{3}{5}(x - 10);$
$m = -\frac{3}{5}, x_1 = 10, y_1 = -4;$
slope-intercept form: $y = -\frac{3}{5}x + 2$

25. $m = \frac{10 - 2}{5 - 1} = \frac{8}{4} = 2;$
point-slope form: $y - 2 = 2(x - 1)$ using $(x_1,\ y_1) = (1,\ 2)$, or $y - 10 = 2(x - 5)$ using $(x_1,\ y_1) = (5,\ 10)$;
slope-intercept form: $y - 2 = 2x - 2$ or
$y - 10 = 2x - 10,$
$y = 2x$

26. $m = \frac{15 - 5}{8 - 3} = \frac{10}{5} = 2;$
point-slope form: $y - 5 = 2(x - 3)$ using $(x_1, y_1) = (3, 5)$, or $y - 15 = 2(x - 8)$ using $(x_1, y_1) = (8, 15)$;
slope-intercept form: $y = 2x - 1$

27. $m=\frac{3-0}{0-(-3)}=\frac{3}{3}=1$;

point-slope form: $y - 0 = 1(x + 3)$ using $(x_1,\ y_1)=(-3,\ 0)$, or $y - 3 = 1(x - 0)$ using $(x_1,\ y_1)=(0,\ 3)$; slope-intercept form: $y = x + 3$

28. $m=\frac{2-0}{0-(-2)}=\frac{2}{2}=1$;

point-slope form: $y - 0 = 1(x + 2)$ using $(x_1,y_1)=(-2,0)$, or $y - 2 = 1(x - 0)$ using $(x_1,y_1)=(0,2)$;
slope-intercept form: $y = x + 2$

29. $m=\frac{4-(-1)}{2-(-3)}=\frac{5}{5}=1$;

point-slope form: $y + 1 = 1(x + 3)$ using $(x_1,\ y_1)=(-3,\ -1)$, or $y - 4 = 1(x - 2)$ using $(x_1,\ y_1)=(2,\ 4)$; slope-intercept form: $y+1=x+3$ or

$$y-4=x-2$$
$$y=x+2$$

30. $m=\frac{-1-(-4)}{1-(-2)}=\frac{3}{3}=1$;

point-slope form: $y + 4 = 1(x + 2)$ using $(x_1,y_1)=(-2,-4)$, or $y + 1 = 1(x - 1)$ using $(x_1,y_1)=(1,-1)$
slope-intercept form: $y = x - 2$

31. $m=\frac{6-(-2)}{3-(-3)}=\frac{8}{6}=\frac{4}{3}$;

point-slope form: $y+2=\frac{4}{3}(x+3)$ using $(x_1,\ y_1)=(-3,\ -2)$, or $y-6=\frac{4}{3}(x-3)$ using $(x_1,\ y_1)=(3,\ 6)$;

slope-intercept form: $y+2=\frac{4}{3x}+4$ or

$$y-6=\frac{4}{3}x-4,$$
$$y=\frac{4}{3}x+2$$

32. $m=\frac{-2-6}{3-(-3)}=\frac{-8}{6}=-\frac{4}{3}$;

point-slope form: $y-6=-\frac{4}{3}(x+3)$ using $(x_1,y_1)=(-3,6)$, or $y+2=-\frac{4}{3}(x-3)$ using $(x_1,y_1)=(3,-2)$;

slope-intercept form: $y=-\frac{4}{3}x+2$

33. $m=\frac{-1-(-1)}{4-(-3)}=\frac{0}{7}=0$;

point-slope form: $y + 1 = 0(x + 3)$ using $(x_1,\ y_1)=(-3,\ -1)$, or $y + 1 = 0(x - 4)$ using $(x_1,\ y_1)=(4,\ -1)$;
slope-intercept form: $y+1=0,$ so

$$y=-1$$

34. $m = \frac{-5-(-5)}{6-(-2)} = \frac{0}{8} = 0$;

point-slope form: $y + 5 = 0(x + 2)$ using $(x_1, y_1) = (-2, -5)$, or $y + 5 = 0(x - 6)$ using $(x_1, y_1) = (6, -5)$;

slope-intercept form: $y + 5 = 0$, so

$y = -5$

35. $m = \frac{0-4}{-2-2} = \frac{-4}{-4} = 1$;

point-slope form: $y - 4 = 1(x - 2)$ using $(x_1,\ y_1) = (2,\ 4)$, or $y - 0 = 1(x + 2)$ using $(x_1,\ y_1) = (-2,\ 0)$;

slope-intercept form: $y - 9 = x - 2$, or

$y = x + 2$

36. $m = \frac{0-(-3)}{-1-1} = \frac{3}{-2} = -\frac{3}{2}$

point-slope form: $y + 3 = -\frac{3}{2}(x-1)$ using $(x_1, y_1) = (1, -3)$, or $y - 0 = -\frac{3}{2}(x+1)$ using $(x_1, y_1) = (-1, 0)$;

slope-intercept form: $y + 3 = -\frac{3}{2}x + \frac{3}{2}$, or

$y = -\frac{3}{2}x - \frac{3}{2}$

37. $m = \frac{4-0}{0-\left(-\frac{1}{2}\right)} = \frac{4}{\frac{1}{2}} = 8$;

point-slope form: $y - 4 = 8(x - 0)$ using $(x_1,\ y_1) = (0,\ 4)$, or $y - 0 = 8\left(x + \frac{1}{2}\right)$ using $(x_1,\ y_1) = \left(-\frac{1}{2},\ 0\right)$; or

$y - 0 = 8\left(x + \frac{1}{2}\right)$

slope-intercept form: $y = 8x + 4$

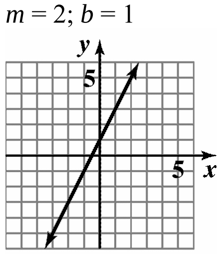
38. $m = \frac{-2-0}{0-4} = \frac{-2}{-4} = \frac{1}{2}$;

point-slope form: $y - 0 = \frac{1}{2}(x-4)$ using $(x_1, y_1) = (4, 0)$,

or $y + 2 = \frac{1}{2}(x-0)$ using $(x_1, y_1) = (0, -2)$;

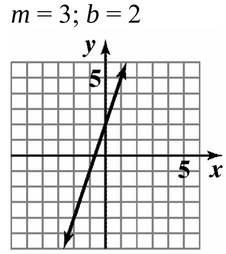
slope-intercept form: $y = \frac{1}{2}x - 2$

39. $m = 2$; $b = 1$



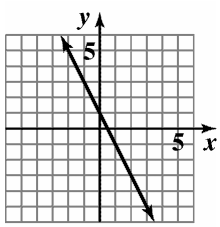
$y = 2x + 1$

40. $m = 3$; $b = 2$



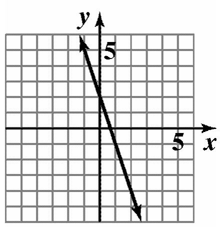
$y = 3x + 2$

41. $m = -2;\ b = 1$



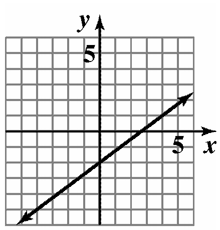
$f(x) = -2x + 1$

42. $m = -3;\ b = 2$



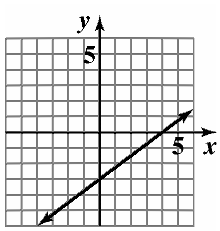
$f(x) = -3x + 2$

43. $m = \frac{3}{4};\ b = -2$



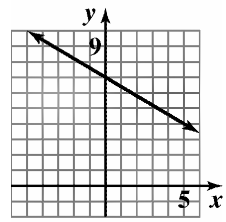
$f(x) = \frac{3}{4}x - 2$

44. $m = \frac{3}{4};\ b = -3$



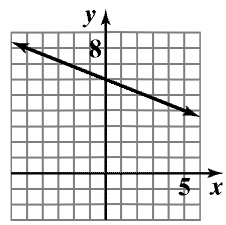
$f(x) = \frac{3}{4}x - 3$

45. $m = -\frac{3}{5};\ b = 7$



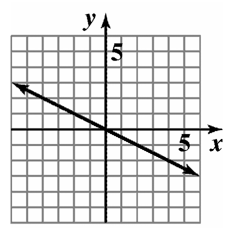
$y = -\frac{3}{5}x + 7$

46. $m = -\frac{2}{5};\ b = 6$



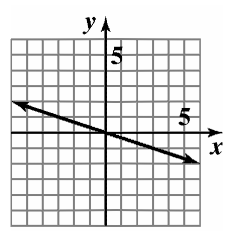
$y = -\frac{2}{5}x + 6$

47. $m = -\frac{1}{2};\ b = 0$



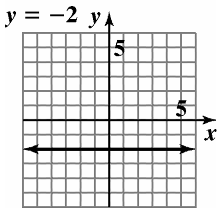
$g(x) = -\frac{1}{2}x$

48. $m = -\frac{1}{3};\ b = 0$

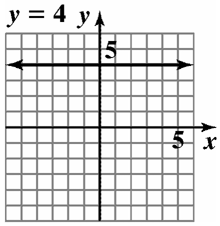


$g(x) = -\frac{1}{3}x$

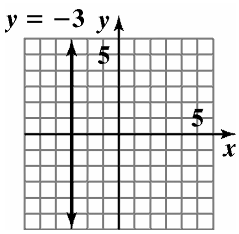
49.



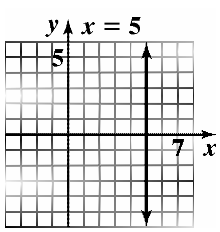
50.



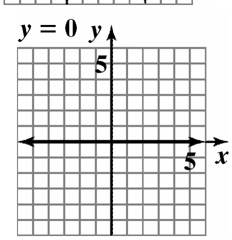
51.



52.



53.



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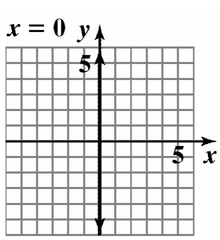
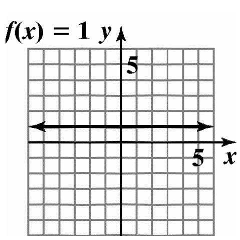
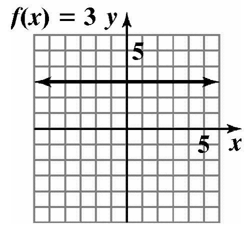


55.



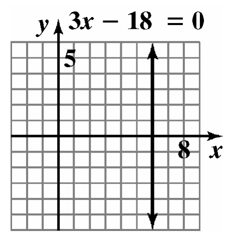
56.



57. $3x - 18 = 0$

$3x = 18$

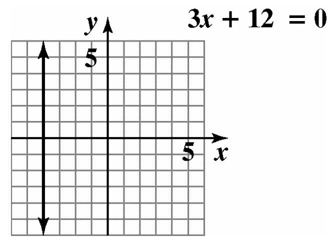
$x = 6$



58. $3x + 12 = 0$

$3x = -12$

$x = -4$



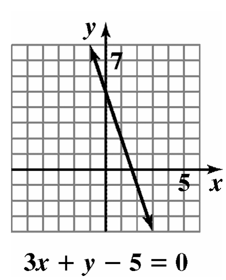
59. **a.** $3x + y - 5 = 0$

$y - 5 = -3x$

$y = -3x + 5$

b. $m = -3;\ b = 5$

c.



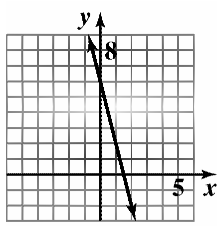
60. **a.** $4x + y - 6 = 0$

$y - 6 = -4x$

$y = -4x + 6$

b. $m = -4; b = 6$

c.

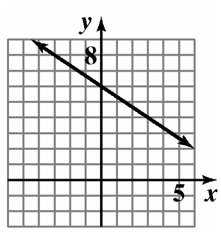


4x + y − 6 = 0

61. **a.**
$$2x+3y-18=0$$
$$2x-18=-3y$$
$$-3y=2x-18$$
$$y=\frac{2}{-3}x-\frac{18}{-3}$$
$$y=-\frac{2}{3}x+6$$

b. $m=-\frac{2}{3};\ b=6$

c.

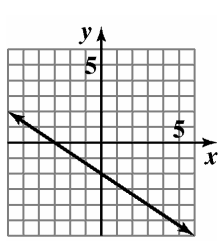


2x + 3y − 18 = 0

62. **a.**
$$4x+6y+12=0$$
$$4x+12=-6y$$
$$-6y=4x+12$$
$$y=\frac{4}{-6}x+\frac{12}{-6}$$
$$y=-\frac{2}{3}x-2$$

b. $m=-\frac{2}{3};\ b=-2$

c.

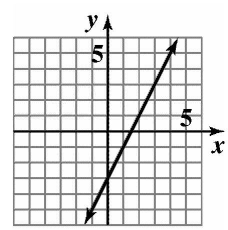


4x + 6y + 12 = 0

63. **a.**
$$8x-4y-12=0$$
$$8x-12=4y$$
$$4y=8x-12$$
$$y=\frac{8}{4}x-\frac{12}{4}$$
$$y=2x-3$$

b. $m=2;\ b=-3$

c.

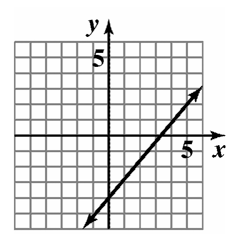


8x − 4y − 12 = 0

64. **a.**
$$6x-5y-20=0$$
$$6x-20=5y$$
$$5y=6x-20$$
$$y=\frac{6}{5}x-\frac{20}{5}$$
$$y=\frac{6}{5}x-4$$

b. $m=\frac{6}{5};b=-4$

c.

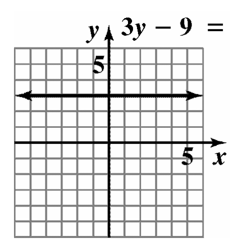


6x − 5y − 20 = 0

65. **a.**
$$3y-9=0$$
$$3y=9$$
$$y=3$$

b. $m=0;\ b=3$

c. **3y − 9 = 0**



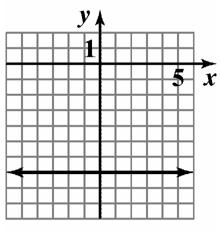
66. **a.** $4y + 28 = 0$

$4y = -28$

$y = -7$

b. $m = 0$; $b = -7$

c.



4y + 28 = 0

67. Find the *x*-intercept:

$6x - 2y - 12 = 0$

$6x - 2(0) - 12 = 0$

$6x - 12 = 0$

$6x = 12$

$x = 2$

Find the *y*-intercept:

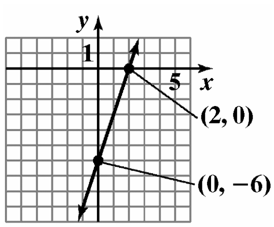
$6x - 2y - 12 = 0$

$6(0) - 2y - 12 = 0$

$-2y - 12 = 0$

$-2y = 12$

$y = -6$



6x − 2y − 12 = 0

68. Find the *x*-intercept:

$6x - 9y - 18 = 0$

$6x - 9(0) - 18 = 0$

$6x - 18 = 0$

$6x = 18$

$x = 3$

Find the *y*-intercept:

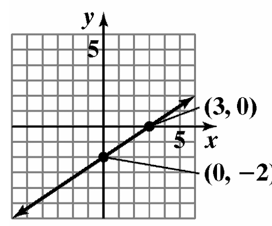
$6x - 9y - 18 = 0$

$6(0) - 9y - 18 = 0$

$-9y - 18 = 0$

$-9y = 18$

$y = -2$



6x − 9y − 18 = 0

69. Find the *x*-intercept:

$2x + 3y + 6 = 0$

$2x + 3(0) + 6 = 0$

$2x + 6 = 0$

$2x = -6$

$x = -3$

Find the *y*-intercept:

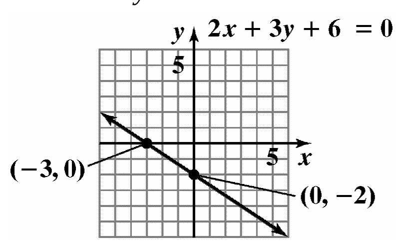
$2x + 3y + 6 = 0$

$2(0) + 3y + 6 = 0$

$3y + 6 = 0$

$3y = -6$

$y = -2$

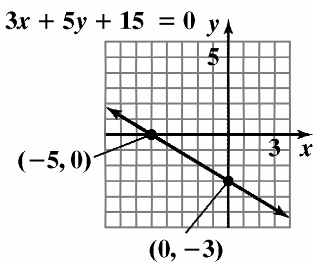


70. Find the x-intercept:

$$3x + 5y + 15 = 0$$
$$3x + 5(0) + 15 = 0$$
$$3x + 15 = 0$$
$$3x = -15$$
$$x = -5$$

Find the y-intercept:

$$3x + 5y + 15 = 0$$
$$3(0) + 5y + 15 = 0$$
$$5y + 15 = 0$$
$$5y = -15$$
$$y = -3$$

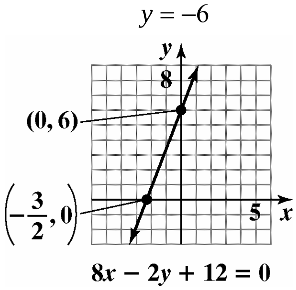


71. Find the x-intercept:

$$8x - 2y + 12 = 0$$
$$8x - 2(0) + 12 = 0$$
$$8x + 12 = 0$$
$$8x = -12$$
$$\frac{8x}{8} = \frac{-12}{8}$$
$$x = \frac{-3}{2}$$

Find the y-intercept:

$$8x - 2y + 12 = 0$$
$$8(0) - 2y + 12 = 0$$
$$-2y + 12 = 0$$
$$-2y = -12$$
$$y = -6$$

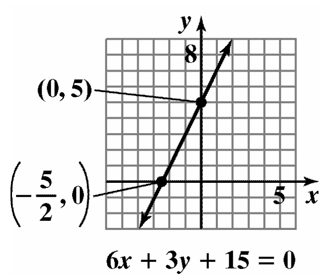


72. Find the x-intercept:

$$6x - 3y + 15 = 0$$
$$6x - 3(0) + 15 = 0$$
$$6x + 15 = 0$$
$$6x = -15$$
$$\frac{6x}{6} = \frac{-15}{6}$$
$$x = -\frac{5}{2}$$

Find the y-intercept:

$$6x - 3y + 15 = 0$$
$$6(0) - 3y + 15 = 0$$
$$-3y + 15 = 0$$
$$-3y = -15$$
$$y = 5$$



73. $m = \dfrac{0-a}{b-0} = \dfrac{-a}{b} = -\dfrac{a}{b}$

Since a and b are both positive, $-\dfrac{a}{b}$ is negative. Therefore, the line falls.

74. $m = \dfrac{-b-0}{0-(-a)} = \dfrac{-b}{a} = -\dfrac{b}{a}$

Since a and b are both positive, $-\dfrac{b}{a}$ is negative. Therefore, the line falls.

75. $m = \dfrac{(b+c)-b}{a-a} = \dfrac{c}{0}$

The slope is undefined.
The line is vertical.

76. $m = \dfrac{(a+c)-c}{a-(a-b)} = \dfrac{a}{b}$

Since a and b are both positive, $\dfrac{a}{b}$ is positive. Therefore, the line rises.

77. $Ax + By = C$

$By = -Ax + C$

$y = -\frac{A}{B}x + \frac{C}{B}$

The slope is $-\frac{A}{B}$ and the $y-$intercept is $\frac{C}{B}$.

78. $Ax = By - C$

$Ax + C = By$

$\frac{A}{B}x + \frac{C}{B} = y$

The slope is $\frac{A}{B}$ and the $y-$intercept is $\frac{C}{B}$.

79. $-3 = \frac{4-y}{1-3}$

$-3 = \frac{4-y}{-2}$

$6 = 4 - y$

$2 = -y$

$-2 = y$

80. $\frac{1}{3} = \frac{-4-y}{4-(-2)}$

$\frac{1}{3} = \frac{-4-y}{4+2}$

$\frac{1}{3} = \frac{-4-y}{6}$

$6 = 3(-4-y)$

$6 = -12 - 3y$

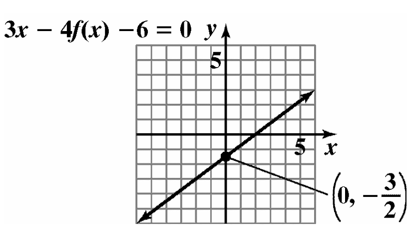
$18 = -3y$

$-6 = y$

81. $3x - 4f(x) = 6$

$-4f(x) = -3x + 6$

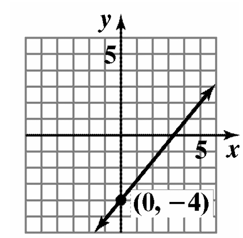
$f(x) = \frac{3}{4}x - \frac{3}{2}$



82. $6x - 5f(x) = 20$

$-5f(x) = -6x + 20$

$f(x) = \frac{6}{5}x - 4$



$6x - 5f(x) - 20 = 0$

83. Using the slope-intercept form for the equation of a line:

$-1 = -2(3) + b$

$-1 = -6 + b$

$5 = b$

84. $-6 = -\frac{3}{2}(2) + b$

$-6 = -3 + b$

$-3 = b$

85. m_1, m_3, m_2, m_4

86. b_2, b_1, b_4, b_3

87. **a.** First we must find the slope using $(10,16)$ and $(16,12.7)$.

$m = \frac{12.7-16}{16-10} = -\frac{3.3}{6} = -0.55$

Then use the slope and one of the points to write the equation in point-slope form.

$y - y_1 = m(x - x_1)$

$y - 16 = -0.55(x - 10)$

or

$y - 12.7 = -0.55(x - 16)$

b. $y - 16 = -0.55(x - 10)$

$y - 16 = -0.55x + 5.5$

$y = -0.55x + 21.5$

$f(x) = -0.55x + 21.5$

c. $f(20) = -0.55(20) + 21.5 = 10.5$

The linear function predicts 10.5% of adult women will be on weight-loss diets in 2007.

88. a. First, find the slope.

$m = \dfrac{7.1-8}{16-10} = \dfrac{-0.9}{6} = -0.15$

Use the slope and point to write the equation in point-slope form.

$y - 8 = -0.15(x - 10)$

b. Solve for y to obtain the slope-intercept form.

$y - 8 = -0.15(x - 10)$

$y - 8 = -0.15x + 1.5$

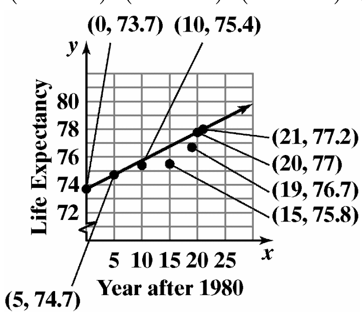
$y = -0.15x + 9.5$

$f(x) = -0.15x + 9.5$

c. $f(20) = -0.15(20) + 9.5 = 6.5\%$

89. a. points: $(0, 73.7), (5, 74.7), (10, 75.4)$

$(15, 75.8), (19, 76.7), (20, 77.0), (21, 77.2)$



b. $m = \dfrac{\text{Change in } y}{\text{Change in } x} = \dfrac{77.0 - 74.7}{20 - 5} \approx 0.15$

$y - y_1 = m(x - x_1)$

$y - 74.7 = 0.15(x - 5)$ [point-slope]

$y - 74.7 = 0.15x - 0.75$

$y = 0.15x + 73.95$ [slope-intercept]

c. $E(x) = 0.15x + 73.95$

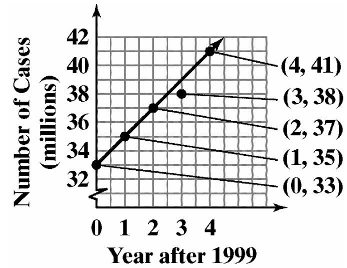
$E(40) = 0.15(40) + 73.95$

$= 79.95$

In 2020 the life expectancy is expected to be 79.95.

90. a. points: $(0, 33), (1, 35)$

$(2, 37), (3, 38), (4, 41)$



b. $m = \dfrac{\text{Change in } y}{\text{Change in } x} = \dfrac{41 - 35}{4 - 1} \approx 2$

$y - y_1 = m(x - x_1)$

$y - 35 = 2(x - 1)$ [point-slope]

$y - 35 = 2x - 2$

$y = 2x + 33$ [slope-intercept]

c. $A(x) = 2x + 33$

$A(11) = 2(11) + 33$

$= 55$

In 2010 there is expected to be 55 million cases.

91. (10, 230) (60, 110) Points may vary.

$m = \dfrac{110 - 230}{60 - 10} = -\dfrac{120}{50} = -2.4$

$y - 230 = -2.4(x - 10)$

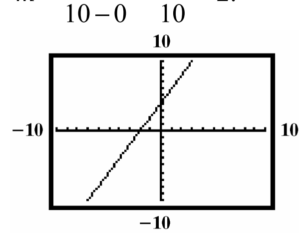
$y - 230 = -2.4x + 24$

$y = -2.4x + 254$

Answers may vary for predictions.

100. Two points are (0,4) and (10,24).

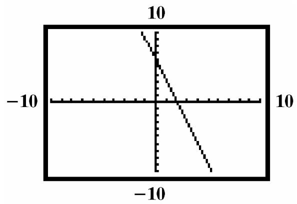
$m = \dfrac{24 - 4}{10 - 0} = \dfrac{20}{10} = 2.$



101. Two points are (0, 6) and (10, –24).

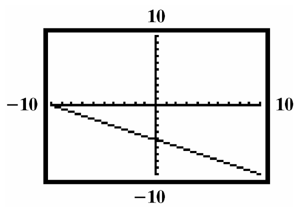
$m = \frac{-24-6}{10-0} = \frac{-30}{10} = -3.$

Check: $y = mx + b$: $y = -3x + 6$.



102. Two points are (0,–5) and (10,–10).

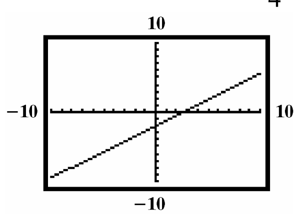
$m = \frac{-10-(-5)}{10-0} = \frac{-5}{10} = -\frac{1}{2}.$



103. Two points are (0, –2) and (10, 5.5).

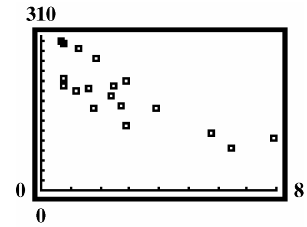
$m = \frac{5.5-(-2)}{10-0} = \frac{7.5}{10} = 0.75$ or $\frac{3}{4}.$

Check: $y = mx + b$: $y = \frac{3}{4}x - 2$.



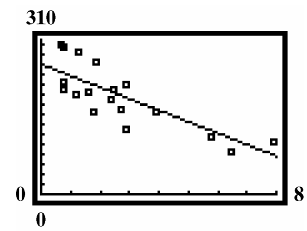
104. a. Enter data from table.

b.



c. $a = -22.96876741$
$b = 260.5633751$
$r = -0.8428126855$

d.



105. Statement **c.** is true.

Statement **a.** is false. One nonnegative slope is 0. A line with slope equal to zero does not rise from left to right.

Statement **b.** is false. Slope-intercept form is $y = mx + b$. Vertical lines have equations of the form $x = a$. Equations of this form have undefined slope and cannot be written in slope-intercept form.

Statement **d.** is false. The graph of $x = 7$ is a vertical line through the point (7, 0).

106. We are given that the $x-$intercept is -2 and the $y-$intercept is 4 . We can use the points $(-2,0)$ and $(0,4)$ to find the slope.

$m = \frac{4-0}{0-(-2)} = \frac{4}{0+2} = \frac{4}{2} = 2$

Using the slope and one of the intercepts, we can write the line in point-slope form.

$y - y_1 = m(x - x_1)$
$y - 0 = 2(x - (-2))$
$y = 2(x + 2)$
$y = 2x + 4$
$-2x + y = 4$

Find the *x*– and *y*–coefficients for the equation of the line with right-hand-side equal to 12. Multiply both sides of $-2x + y = 4$ by 3 to obtain 12 on the right-hand-side.

$-2x + y = 4$
$3(-2x + y) = 3(4)$
$-6x + 3y = 12$

Therefore, the coefficient of x is –6 and the coefficient of y is 3.

107. We are given that the $y-$intercept is -6 and the slope is $\frac{1}{2}$.

So the equation of the line is $y = \frac{1}{2}x - 6.$

We can put this equation in the form $ax + by = c$ to find the missing coefficients.

$y = \frac{1}{2}x - 6$
$y - \frac{1}{2}x = -6$
$2\left(y - \frac{1}{2}x\right) = 2(-6)$
$2y - x = -12$
$x - 2y = 12$

Therefore, the coefficient of x is 1 and the coefficient of y is -2.

109. Let (25, 40) and (125, 280) be ordered pairs (*M*, *E*) where *M* is degrees Madonna and *E* is degrees Elvis. Then $m = \frac{280-40}{125-25} = \frac{240}{100} = 2.4$. Using $(x_1, y_1) = (25, 40)$, point-slope form tells us that
E – 40 = 2.4 (*M* – 25) or *E* = 2.4 *M* – 20.

Section 1.5

Check Point Exercises

1. The slope of the line $y = 3x + 1$ is 3.

$y - y_1 = m(x - x_1)$
$y - 5 = 3(x - (-2))$
$y - 5 = 3(x + 2)$ point-slope
$y - 5 = 3x + 6$
$y = 3x + 11$ slope-intercept

2. **a.** Write the equation in slope-intercept form:

$$x + 3y - 12 = 0$$
$$3y = -x + 12$$
$$y = -\frac{1}{3}x + 4$$

The slope of this line is $-\frac{1}{3}$ thus the slope of any line perpendicular to this line is 3.

b. Use $m = 3$ and the point (–2, –6) to write the equation.

$$y - y_1 = m(x - x_1)$$
$$y - (-6) = 3\left(x - (-2)\right)$$
$$y + 6 = 3(x + 2)$$
$$y + 6 = 3x + 6$$
$$-3x + y = 0$$
$$3x - y = 0 \text{ general form}$$

3. $m = \frac{\text{Change in } y}{\text{Change in } x} = \frac{12 - 10}{2010 - 1995} = \frac{2}{15} \approx 0.13$

The slope indicates that the number of U.S. men living alone is projected to increase by 0.13 million each year.

4. **a.** $\frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{1^3 - 0^3}{1 - 0} = 1$

b. $\frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{2^3 - 1^3}{2 - 1} = \frac{8 - 1}{1} = 7$

c. $\frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{0^3 - (-2)^3}{0 - (-2)} = \frac{8}{2} = 4$

5. $\frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{f(3) - f(1)}{3 - 1} = \frac{0.05 - 0.03}{3 - 1} = 0.01$

6. **a.**

$$s(1) = 4(1)^2 = 4$$
$$s(2) = 4(2)^2 = 16$$
$$\frac{\Delta s}{\Delta t} = \frac{16 - 4}{2 - 1} = 12 \text{ feet per second}$$

b.

$$s(1) = 4(1)^2 = 4$$
$$s(1.5) = 4(1.5)^2 = 9$$
$$\frac{\Delta s}{\Delta t} = \frac{9 - 4}{1.5 - 1} = 10 \text{ feet per second}$$

c.

$$s(1) = 4(1)^2 = 4$$
$$s(1.01) = 4(1.01)^2 = 4.0804$$
$$\frac{\Delta s}{\Delta t} = \frac{4.0804 - 4}{1.01 - 1} = 8.04 \text{ feet per second}$$

Exercise Set 1.5

1. Since L is parallel to $y = 2x$, we know it will have slope $m = 2$. We are given that it passes through (4, 2). We use the slope and point to write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - 2 = 2(x - 4)$$

Solve for y to obtain slope-intercept form.

$$y - 2 = 2(x - 4)$$
$$y - 2 = 2x - 8$$
$$y = 2x - 6$$

In function notation, the equation of the line is $f(x) = 2x - 6$.

2. L will have slope $m = -2$. Using the point and the slope, we have $y - 4 = -2(x - 3)$. Solve for y to obtain slope-intercept form.

$$y - 4 = -2x + 6$$
$$y = -2x + 10$$
$$f(x) = -2x + 10$$

3. Since L is perpendicular to $y = 2x$, we know it will have slope $m = -\frac{1}{2}$. We are given that it passes through
(2, 4). We use the slope and point to write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - 4 = -\frac{1}{2}(x - 2)$$

Solve for y to obtain slope-intercept form.

$$y - 4 = -\frac{1}{2}(x - 2)$$
$$y - 4 = -\frac{1}{2}x + 1$$
$$y = -\frac{1}{2}x + 5$$

In function notation, the equation of the line is $f(x) = -\frac{1}{2}x + 5$.

4. L will have slope $m = \frac{1}{2}$. The line passes through (–1, 2). Use the slope and point to write the equation in point-slope form.

$$y - 2 = \frac{1}{2}(x - (-1))$$
$$y - 2 = \frac{1}{2}(x + 1)$$

Solve for y to obtain slope-intercept form.

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

$$y = \frac{1}{2}x + \frac{5}{2}$$
$$f(x) = \frac{1}{2}x + \frac{5}{2}$$

5. $m = -4$ since the line is parallel to $y = -4x + 3$; $x_1 = -8$, $y_1 = -10$;
point-slope form: $y + 10 = -4(x + 8)$
slope-intercept form: $y + 10 = -4x - 32$
$y = -4x - 42$

6. $m = -5$ since the line is parallel to $y = -5x + 4$; $x_1 = -2, y_1 = -7$;
point-slope form: $y + 7 = -5(x + 2)$
slope-intercept form: $y + 7 = -5x - 10$
$y = -5x - 17$

7. $m = -5$ since the line is perpendicular to $y = \frac{1}{5}x + 6$; $x_1 = 2$, $y_1 = -3$;
point-slope form: $y + 3 = -5(x - 2)$
slope-intercept form: $y + 3 = -5x + 10$
$y = -5x + 7$

8. $m = -3$ since the line is perpendicular to $y = \frac{1}{3}x + 7$; $x_1 = -4, y_1 = 2$;
point-slope form: $y - 2 = -3(x + 4)$
slope-intercept form: $y - 2 = -3x - 12$
$y = -3x - 10$

9. $2x - 3y - 7 = 0$
$-3y = -2x + 7$
$y = \frac{2}{3}x - \frac{7}{3}$
The slope of the given line is $\frac{2}{3}$, so $m = \frac{2}{3}$ since the lines are parallel.
point-slope form: $y - 2 = \frac{2}{3}(x + 2)$
general form: $2x - 3y + 10 = 0$

10. $3x - 2y - = 0$
$-2y = -3x + 5$
$y = \frac{3}{2}x - \frac{5}{2}$
The slope of the given line is $\frac{3}{2}$, so $m = \frac{3}{2}$ since the lines are parallel.
point-slope form: $y - 3 = \frac{3}{2}(x + 1)$
general form: $3x - 2y + 9 = 0$

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

$-2y=-x+3$

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

The slope of the given line is $\frac{1}{2}$, so $m = -2$ since the lines are perpendicular.

point-slope form: $y+7=-2(x-4)$

general form: $2x+y-1=0$

12. $x+7y-12=0$

$7y=-x+12$

$y=\frac{-1}{7}x+\frac{12}{7}$

The slope of the given line is $-\frac{1}{7}$, so $m = 7$ since the lines are perpendicular.

point-slope form: $y + 9 = 7(x - 5)$

general form: $7x-y-44=0$

13. $\frac{15-0}{5-0}=\frac{15}{5}=3$

14. $\frac{24-0}{4-0}=\frac{24}{4}=6$

15. $\frac{5^2+2\cdot5-(3^2+2\cdot3)}{5-3}$

$=\frac{25+10-(9+6)}{2}$

$=\frac{20}{2}$

$=10$

16. $\frac{6^2-2(6)-(3^2-2\cdot3)}{6-3}$

$=\frac{36-12-(9-6)}{3}=\frac{21}{3}=7$

17. $\frac{\sqrt{9}-\sqrt{4}}{9-4}=\frac{3-2}{5}=\frac{1}{5}$

18. $\frac{\sqrt{16}-\sqrt{9}}{16-9}=\frac{4-3}{7}=\frac{1}{7}$

19. **a.** $s(3) = 10(3)^2 = 90$

$s(4) = 10(4)^2 = 160$

$\frac{\Delta s}{\Delta t} = \frac{160 - 90}{4 - 3} = 70$ feet per second

b. $s(3) = 10(3)^2 = 90$

$s(3.5) = 10(3.5)^2 = 122.5$

$\frac{\Delta s}{\Delta t} = \frac{122.5 - 90}{3.5 - 3} = 65$ feet per second

c. $s(3) = 10(3)^2 = 90$

$s(3.01) = 10(3.01)^2 = 90.601$

$\frac{\Delta s}{\Delta t} = \frac{90.601 - 90}{3.01 - 3} = 60.1$ feet per second

d. $s(3) = 10(3)^2 = 90$

$s(3.001) = 10(3.001)^2 = 90.06$

$\frac{\Delta s}{\Delta t} = \frac{90.06 - 90}{3.001 - 3} = 60.01$ feet per second

20. **a.** $s(3) = 12(3)^2 = 108$

$s(4) = 12(4)^2 = 192$

$\frac{\Delta s}{\Delta t} = \frac{108 - 192}{4 - 3} = 84$ feet per second

b. $s(3) = 12(3)^2 = 108$

$s(3.5) = 12(3.5)^2 = 147$

$\frac{\Delta s}{\Delta t} = \frac{147 - 108}{3.5 - 2} = 78$ feet per second

c. $s(3) = 12(3)^2 = 108$

$s(3.01) = 12(3.01)^2 = 108.7212$

$\frac{\Delta s}{\Delta t} = \frac{108.7212 - 108}{3.01 - 3} = 72.12$ feet per second

d. $s(3) = 12(3)^2 = 108$

$s(3.001) = 12(3.001)^2 = 108.07201$

$\frac{\Delta s}{\Delta t} = \frac{108.07201 - 108}{3.001 - 3} = 72.01$ feet per second

21. Since the line is perpendicular to $x = 6$ which is a vertical line, we know the graph of f is a horizontal line with 0 slope. The graph of f passes through $(-1, 5)$, so the equation of f is $f(x) = 5$.

22. Since the line is perpendicular to $x = -4$ which is a vertical line, we know the graph of f is a horizontal line with 0 slope. The graph of f passes through $(-2, 6)$, so the equation of f is $f(x) = 6.$

23. First we need to find the equation of the line with $x-$intercept of 2 and $y-$intercept of -4. This line will pass through $(2, 0)$ and $(0, -4)$. We use these points to find the slope.

$$m = \frac{-4-0}{0-2} = \frac{-4}{-2} = 2$$

Since the graph of f is perpendicular to this line, it will have slope $m = -\frac{1}{2}$.

Use the point $(-6, 4)$ and the slope $-\frac{1}{2}$ to find the equation of the line.

$$y - y_1 = m(x - x_1)$$
$$y - 4 = -\frac{1}{2}(x - (-6))$$
$$y - 4 = -\frac{1}{2}(x + 6)$$
$$y - 4 = -\frac{1}{2}x - 3$$
$$y = -\frac{1}{2}x + 1$$
$$f(x) = -\frac{1}{2}x + 1$$

24. First we need to find the equation of the line with $x-$intercept of 3 and $y-$intercept of -9. This line will pass through $(3, 0)$ and $(0, -9)$. We use these points to find the slope.

$$m = \frac{-9-0}{0-3} = \frac{-9}{-3} = 3$$

Since the graph of f is perpendicular to this line, it will have slope $m = -\frac{1}{3}$.

Use the point $(-5, 6)$ and the slope $-\frac{1}{3}$ to find the equation of the line.

$$y - y_1 = m(x - x_1)$$
$$y - 6 = -\frac{1}{3}(x - (-5))$$
$$y - 6 = -\frac{1}{3}(x + 5)$$
$$y - 6 = -\frac{1}{3}x - \frac{5}{3}$$
$$y = -\frac{1}{3}x + \frac{13}{3}$$
$$f(x) = -\frac{1}{3}x + \frac{13}{3}$$

25. First put the equation $3x-2y-4=0$ in slope-intercept form.

$$3x-2y-4=0$$
$$-2y=-3x+4$$
$$y=\frac{3}{2}x-2$$

The equation of f will have slope $-\frac{2}{3}$ since it is perpendicular to the line above and the same $y-$intercept -2.

So the equation of f is $f(x)=-\frac{2}{3}x-2$.

26. First put the equation $4x-y-6=0$ in slope-intercept form.

$$4x-y-6=0$$
$$-y=-4x+6$$
$$y=4x-6$$

The equation of f will have slope $-\frac{1}{4}$ since it is perpendicular to the line above and the same $y-$intercept -6.

So the equation of f is $f(x)=-\frac{1}{4}x-6$.

27. The slope indicates that the global average temperature is projected to increase by 0.01 degrees Fahrenheit each year.

28. The slope indicates that drug industry spending on marketing to doctors increased by 2 billion dollars each year.

29. The slope indicates that the percentage of U.S. adults who smoked cigarettes decreased by 0.52% each year.

30. The slope indicates that the percentage of U.S. taxpayers who were audited by the IRS decreased by 0.28% each year.

31. $f(x)=13x+222$

32. $f(x)=18.50x+135$

33. $f(x)=-2.40x+52.40$

34. $f(x)=-2.80x+46.80$

35. $\frac{f(x_2)-f(x_1)}{x_2-x_1}=\frac{f(2003)-f(1997)}{2003-1997}=\frac{25.2-32.5}{2003-1997}\approx-1.22$

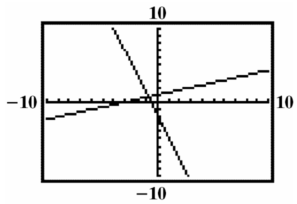
36. $\frac{f(x_2)-f(x_1)}{x_2-x_1}=\frac{f(2003)-f(1997)}{2003-1997}=\frac{13.3-10.1}{2003-1997}\approx 0.53$

43.

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

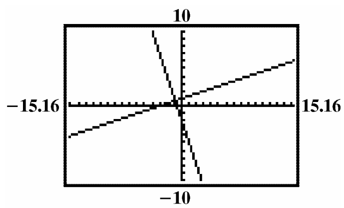
a. The lines are perpendicular because their slopes are negative reciprocals of each other. This is verified because product of their slopes is –1.

b.



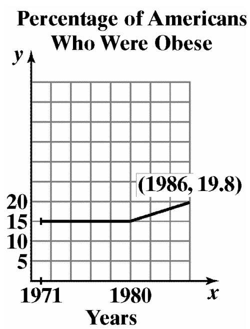
The lines do not appear to be perpendicular.

c.

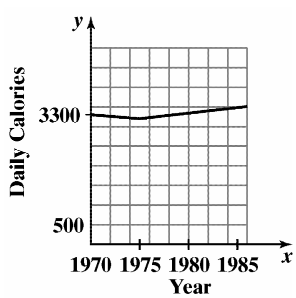


The lines appear to be perpendicular. The calculator screen is rectangular and does not have the same width and height. This causes the scale of the *x*–axis to differ from the scale on the *y*–axis despite using the same scale in the window settings. In part (b), this causes the lines not to appear perpendicular when indeed they are. The zoom square feature compensates for this and in part (c), the lines appear to be perpendicular.

44.



45.



46. Write $Ax + By + C = 0$ in slope-intercept form.

$$Ax + By + C = 0$$

$$By = -Ax - C$$

$$\frac{By}{B} = \frac{-Ax}{B} - \frac{C}{B}$$

$$y = -\frac{A}{B}x - \frac{C}{B}$$

The slope of the given line is $-\frac{A}{B}$.

The slope of any line perpendicular to $Ax + By + C = 0$ is $\frac{B}{A}$.

47. The slope of the line containing $(1,-3)$ and $(-2,4)$ has slope

$m=\frac{4-(-3)}{-2-1}=\frac{4+3}{-3}=\frac{7}{-3}=-\frac{7}{3}$.

Solve $Ax+y-2=0$ for y to obtain slope-intercept form.

$Ax+y-2=0$

$y=-Ax+2$

So the slope of this line is $-A$.

This line is perpendicular to the line above so its slope is $\frac{3}{7}$. Therefore, $-A=\frac{3}{7}$ so $A=-\frac{3}{7}$.

Mid-Chapter 1 Check Point

1. The relation is not a function.
The domain is $\{1,2\}$.
The range is $\{-6,4,6\}$.

2. The relation is a function.
The domain is $\{0,2,3\}$.
The range is $\{1,4\}$.

3. The relation is a function.
The domain is $\{x\,|\,-2\le x<2\}$.
The range is $\{y\,|\,0\le y\le 3\}$.

4. The relation is not a function.
The domain is $\{x\,|\,-3<x\le 4\}$.
The range is $\{y\,|\,-1\le y\le 2\}$.

5. The relation is not a function.
The domain is $\{-2,-1,0,1,2\}$.
The range is $\{-2,-1,1,3\}$.

6. The relation is a function.
The domain is $\{x\,|\,x\le 1\}$.
The range is $\{y\,|\,y\ge -1\}$.

7. $x^2+y=5$

$y=-x^2+5$

For each value of *x*, there is one and only one value for *y*, so the equation defines *y* as a function of *x*.

8. $x+y^2=5$

$y^2=5-x$

$y=\pm\sqrt{5-x}$

Since there are values of *x* that give more than one value for *y* (for example, if $x = 4$, then $y=\pm\sqrt{5-4}=\pm 1$), the equation does not define *y* as a function of *x*.

9. Each value of *x* corresponds to exactly one value of *y*.

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

11. Range: $(-\infty,4]$

12. *x*-intercepts: –6 and 2

13. *y*-intercept: 3

14. increasing: $(-\infty, -2)$

15. decreasing: $(-2, \infty)$

16. $x=-2$

17. $f(-2)=4$

18. $f(-4)=3$

19. $f(-7)=-2$ and $f(3)=-2$

20. $f(-6)=0$ and $f(2)=0$

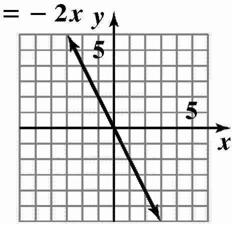
21. $(-6,2)$

22. $f(100)$ is negative.

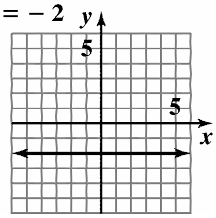
23. neither; $f(-x)\ne x$ and $f(-x)\ne -x$

24. $\dfrac{f(x_2)-f(x_1)}{x_2-x_1}=\dfrac{f(4)-f(-4)}{4-(-4)}=\dfrac{-5-3}{4+4}=-1$

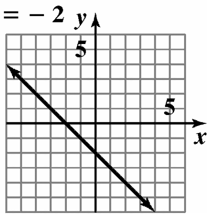
25. $y = -2x$



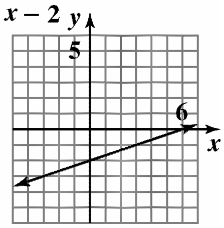
26. $y = -2$



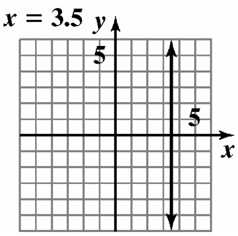
27. $x + y = -2$



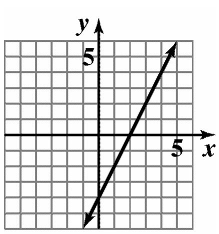
28. $y = \dfrac{1}{3}x - 2$



29. $x = 3.5$

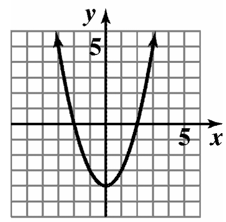


30.



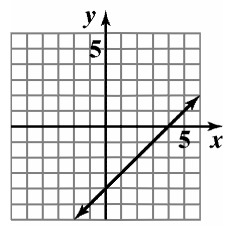
$4x - 2y = 8$

31.



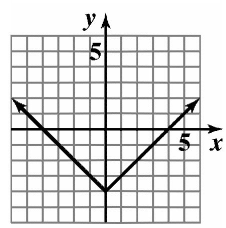
$f(x) = x^2 - 4$

32.



$f(x) = x - 4$

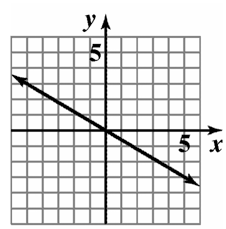
33.



$f(x) = |x| - 4$

34. $5y = -3x$

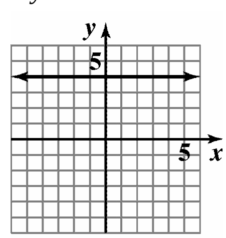
$y = -\dfrac{3}{5}x$



$5y = -3x$

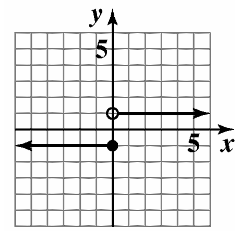
35. $5y = 20$

$y = 4$



$5y = 20$

36.



37. a. $f(-x) = -2(-x)^2 - x - 5 = -2x^2 - x - 5$

neither; $f(-x) \ne x$ and $f(-x) \ne -x$

b. $\frac{f(x+h) - f(x)}{h}$

$= \frac{-2(x+h)^2 + (x+h) - 5 - (-2x^2 + x - 5)}{h}$

$= \frac{-2x^2 - 4xh - 2h^2 + x + h - 5 + 2x^2 - x + 5}{h}$

$= \frac{-4xh - 2h^2 + h}{h}$

$= \frac{h(-4x - 2h + 1)}{h}$

$= -4x - 2h + 1$

38. $C(x) = \begin{cases} 30 & \text{if} \quad 0 \le t \le 200 \\ 30 + 0.40(t - 200) & \text{if} \quad t > 200 \end{cases}$

a. $C(150) = 30$

b. $C(250) = 30 + 0.40(250 - 200) = 50$

39. $y - y_1 = m(x - x_1)$

$y - 3 = -2(x - (-4))$

$y - 3 = -2(x + 4)$

$y - 3 = -2x - 8$

$y = -2x - 5$

$f(x) = -2x - 5$

40. $m = \frac{\text{Change in } y}{\text{Change in } x} = \frac{1 - (-5)}{2 - (-1)} = \frac{6}{3} = 2$

$y - y_1 = m(x - x_1)$

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

$y - 1 = 2x - 4$

$y = 2x - 3$

$f(x) = 2x - 3$

41. $3x - y - 5 = 0$

$-y = -3x + 5$

$y = 3x - 5$

The slope of the given line is 3, and the lines are parallel, so $m = 3$.

$y - y_1 = m(x - x_1)$

$y - (-4) = 3(x - 3)$

$y + 4 = 3x - 9$

$y = 3x - 13$

$f(x) = 3x - 13$

42. $2x - 5y - 10 = 0$

$-5y = -2x + 10$

$\frac{-5y}{-5} = \frac{-2x}{-5} + \frac{10}{-5}$

$y = \frac{2}{5}x - 2$

The slope of the given line is $\frac{2}{5}$, and the lines are perpendicular, so $m = -\frac{5}{2}$.

$y - y_1 = m(x - x_1)$

$y - (-3) = -\frac{5}{2}(x - (-4))$

$y + 3 = -\frac{5}{2}x - 10$

$y = -\frac{5}{2}x - 13$

$f(x) = -\frac{5}{2}x - 13$

43. $m_1 = \frac{\text{Change in } y}{\text{Change in } x} = \frac{0 - (-4)}{7 - 2} = \frac{4}{5}$

$m_2 = \frac{\text{Change in } y}{\text{Change in } x} = \frac{6 - 2}{1 - (-4)} = \frac{4}{5}$

The slope of the lines are equal thus the lines are parallel.

44. The slope indicates that the percentage of U.S. colleges offering distance learning is increasing by 7.8% each year.

45. $\frac{f(x_2) - f(x_1)}{x_2 - x_1} = \frac{f(2) - f(-1)}{2 - (-1)}$

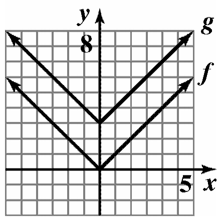
$= \frac{(3(2)^2 - 2) - (3(-1)^2 - (-1))}{2 + 1}$

$= 2$

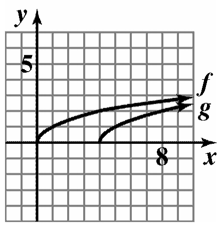
Section 1.6

Check Point Exercises

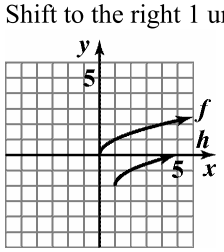
1. Shift up vertically 3 units.



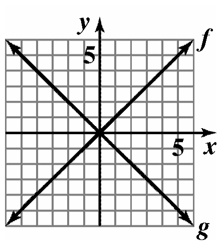
2. Shift to the right 4 units.



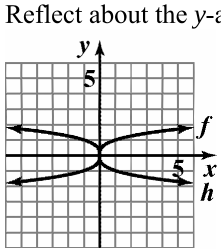
3. Shift to the right 1 unit and down 2 units.



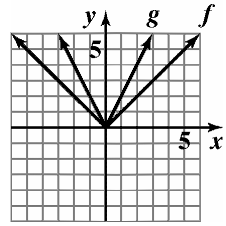
4. Reflect about the x-axis.



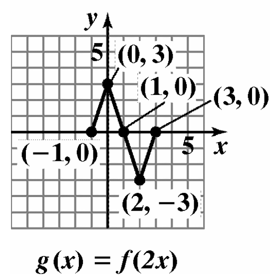
5. Reflect about the y-axis.



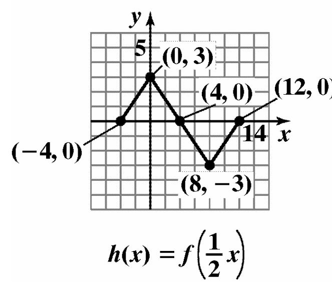
6. Vertically stretch the graph of $f(x) = |x|$.



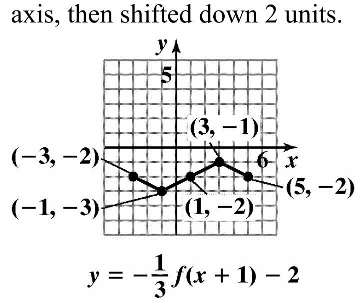
7. **a.** Horizontally shrink the graph of $y = f(x)$.



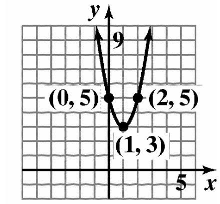
b. Horizontally stretch the graph of $y = f(x)$.



8. The graph of $y = f(x)$ is shifted 1 unit left, shrunk by a factor of $\frac{1}{3}$, reflected about the x-axis, then shifted down 2 units.



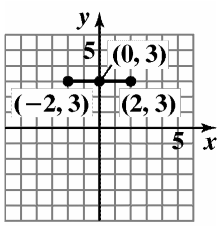
9. The graph of $f(x) = x^2$ is shifted 1 unit right, stretched by a factor of 2, then shifted up 3 units.



$g(x) = 2(x-1)^2 + 3$

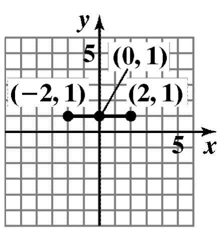
Exercise Set 1.6

1.



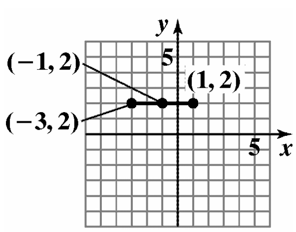
$g(x) = f(x) + 1$

2.



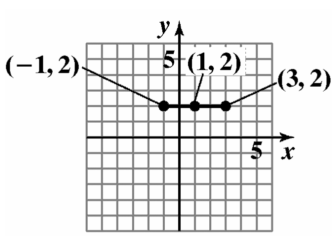
$g(x) = f(x) - 1$

3.



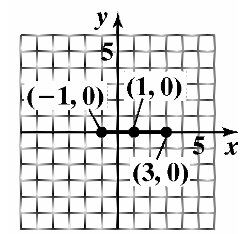
$g(x) = f(x + 1)$

4.



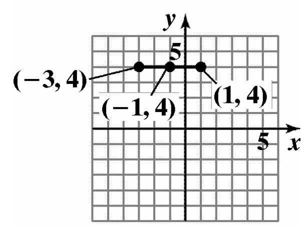
$g(x) = f(x - 1)$

5.



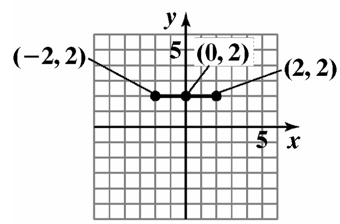
$g(x) = f(x - 1) - 2$

6.



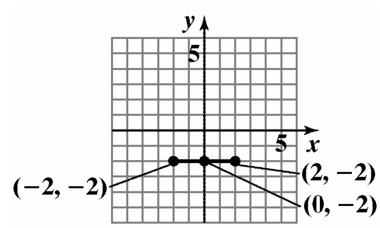
$g(x) = f(x + 1) + 2$

7.



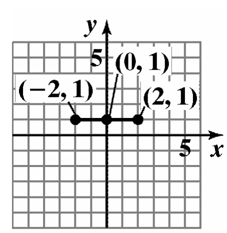
$g(x) = -f(x)$

8.



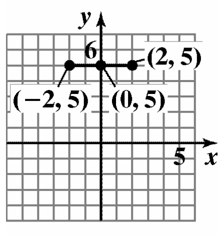
$g(x) = -f(x)$

9.



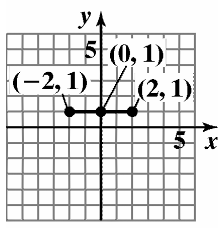
$g(x) = -f(x) + 3$

10.



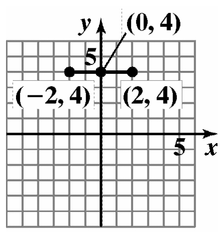
$g(x) = f(-x) + 3$

11.



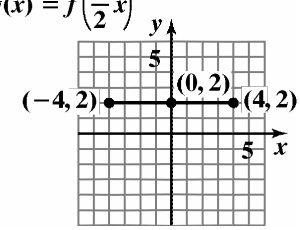
$g(x) = \frac{1}{2}f(x)$

12.

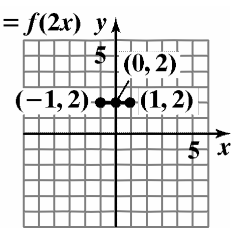


$g(x) = 2f(x)$

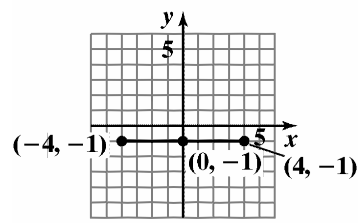
13. $g(x) = f\left(\frac{1}{2}x\right)$



14. $g(x) = f(2x)$

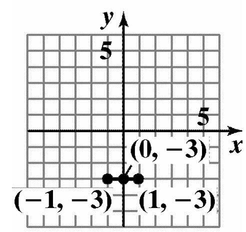


15.



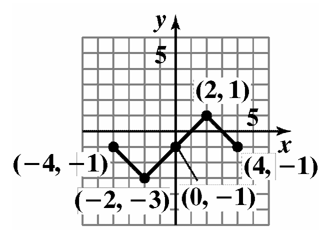
$g(x) = -f\left(\frac{1}{2}x\right) + 1$

16.



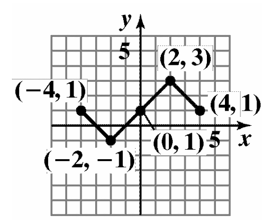
$g(x) = -f(2x) - 1$

17.



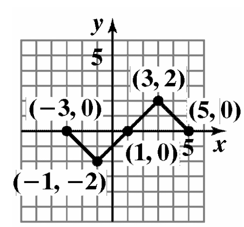
$g(x) = f(x) - 1$

18.



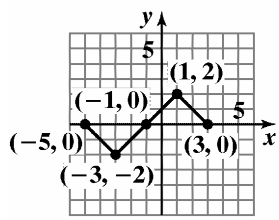
$g(x) = f(x) + 1$

19.



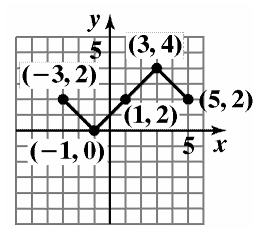
$g(x) = f(x - 1)$

20.



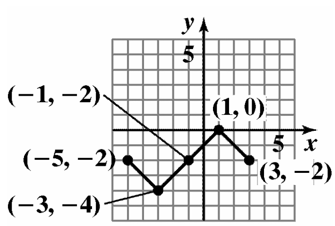
$g(x) = f(x + 1)$

21.



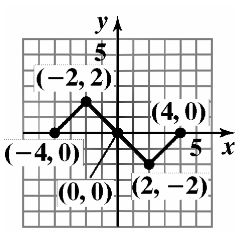
$g(x) = f(x - 1) + 2$

22.



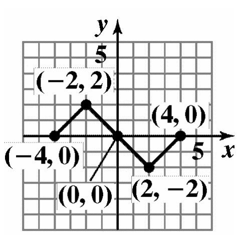
$g(x) = f(x + 1) - 2$

23.



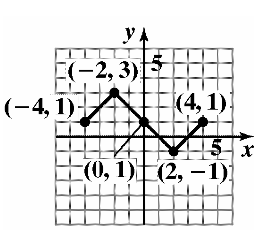
$g(x) = -f(x)$

24.



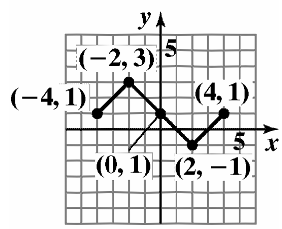
$g(x) = f(-x)$

25.



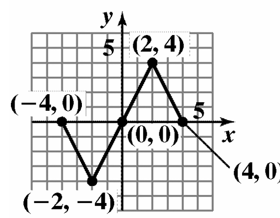
$g(x) = f(-x) + 1$

26.



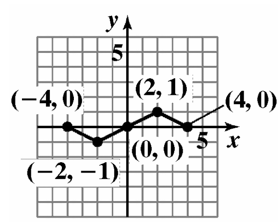
$g(x) = -f(x) + 1$

27.



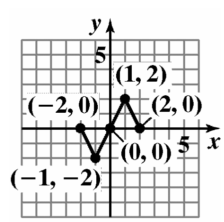
$g(x) = 2f(x)$

28.



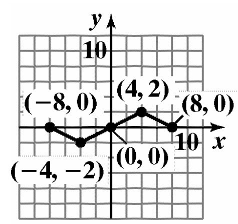
$g(x) = \frac{1}{2}f(x)$

29.



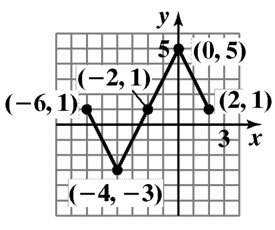
$g(x) = f(2x)$

30.



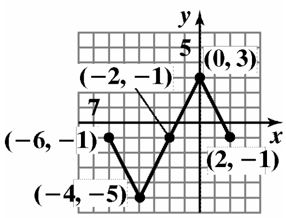
$g(x) = f\left(\frac{1}{2}x\right)$

31.



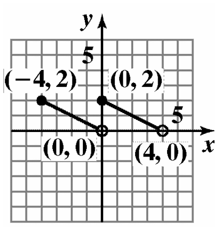
$g(x) = 2f(x+2) + 1$

32.



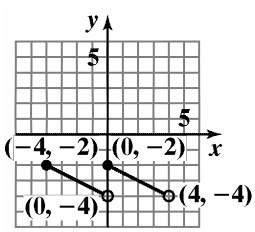
$g(x) = 2f(x+2) - 1$

33.



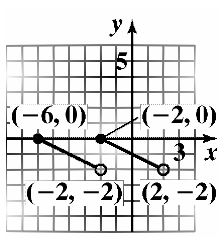
$g(x) = f(x) + 2$

34.



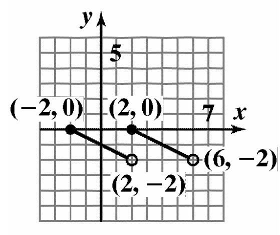
$g(x) = f(x) - 2$

35.



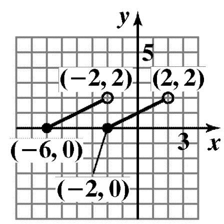
$g(x) = f(x+2)$

36.



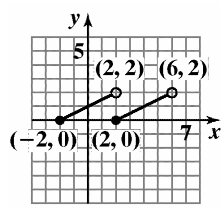
$g(x) = f(x-2)$

37.



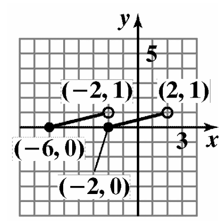
$g(x) = -f(x+2)$

38.



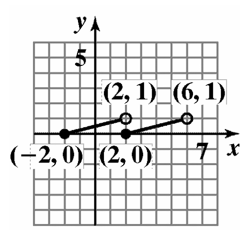
$g(x) = -f(x-2)$

39.



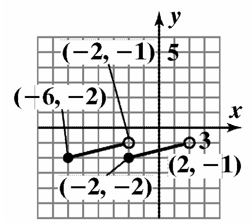
$g(x) = -\frac{1}{2}f(x+2)$

40.



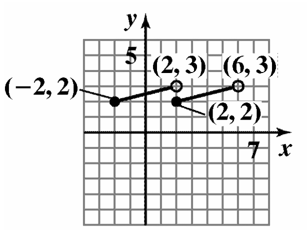
$g(x) = -\frac{1}{2}f(x-2)$

41.



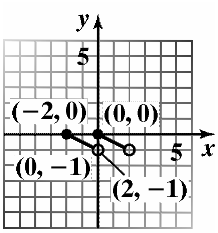
$g(x) = -\frac{1}{2}f(x+2) - 2$

42.



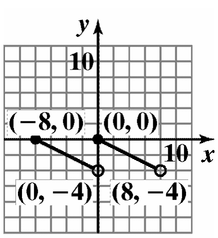
$g(x) = -\frac{1}{2}f(x-2) + 2$

43.



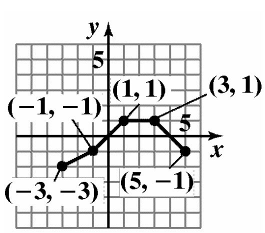
$g(x) = \frac{1}{2}f(2x)$

44.



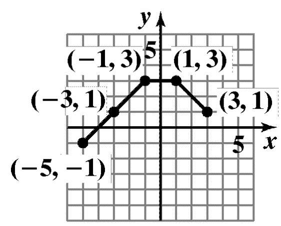
$g(x) = 2f\left(\frac{1}{2}x\right)$

45.



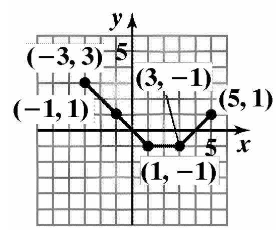
$g(x) = f(x-1) - 1$

46.



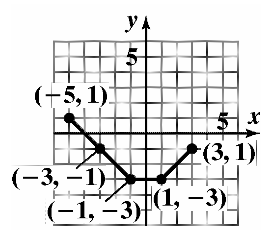
$g(x) = f(x+1) + 1$

47.



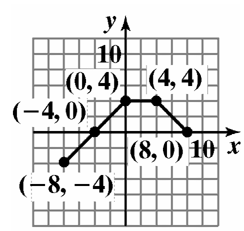
$g(x) = -f(x-1) + 1$

48.



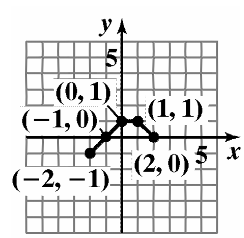
$g(x) = -f(x+1) - 1$

49.



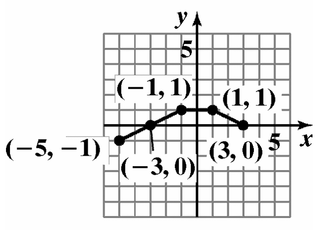
$g(x) = 2f\left(\frac{1}{2}x\right)$

50.



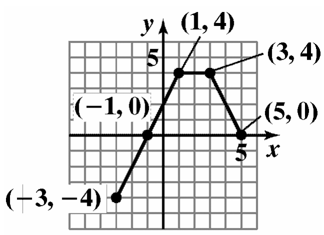
$g(x) = \frac{1}{2}f(2x)$

51.



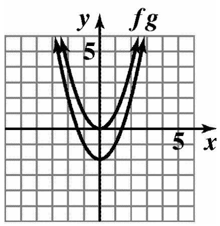
$g(x) = \frac{1}{2}f(x+1)$

52.



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

53.



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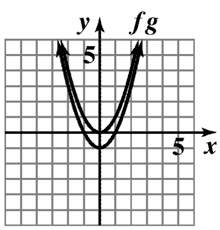

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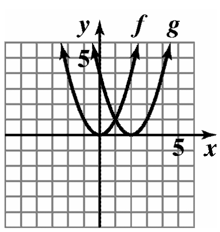

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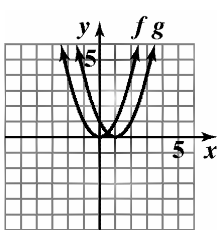

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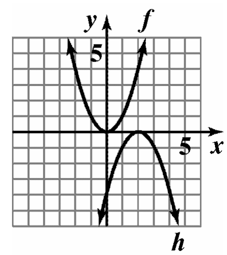

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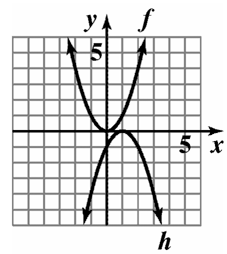

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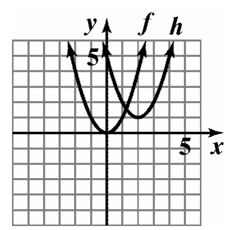

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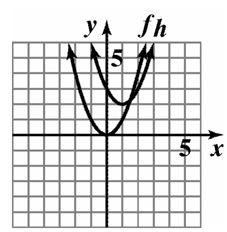

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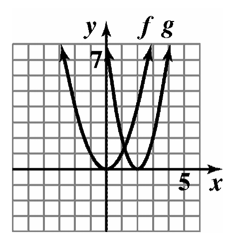

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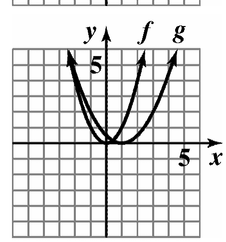

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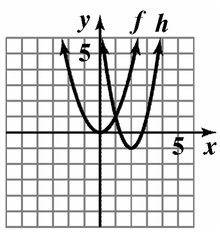

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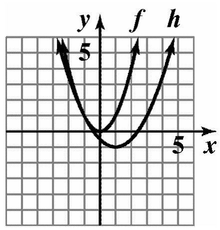

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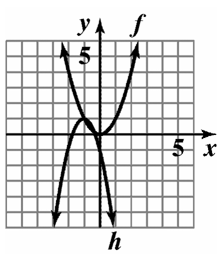

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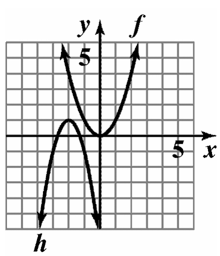

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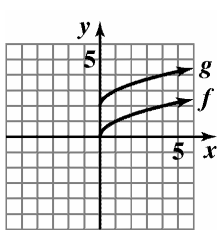

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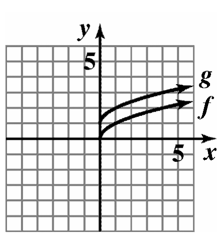

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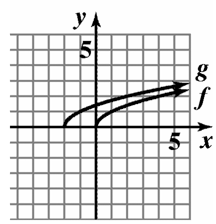

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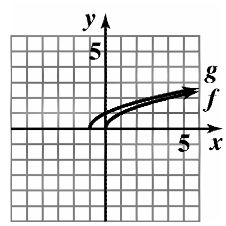

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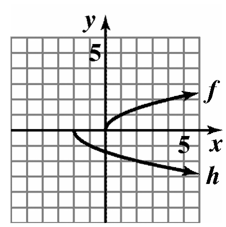

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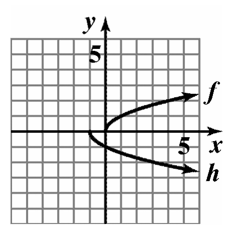

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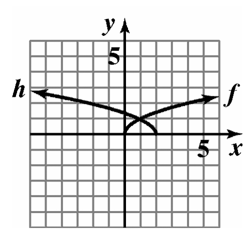

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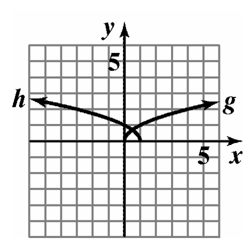

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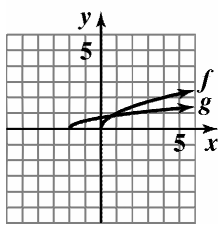

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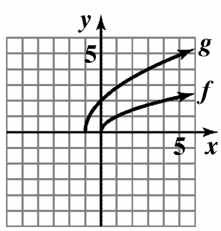

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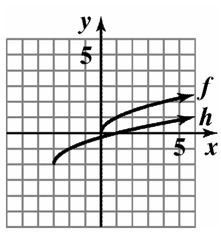

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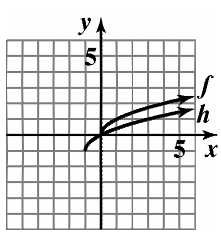

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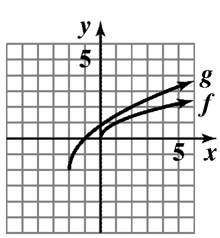

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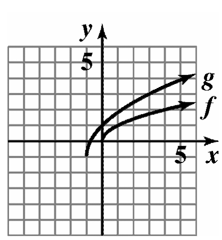

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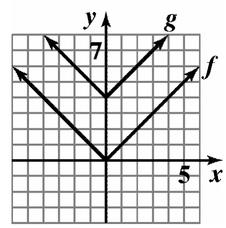

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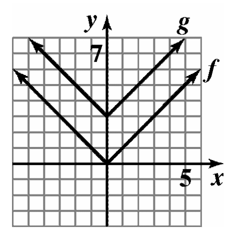

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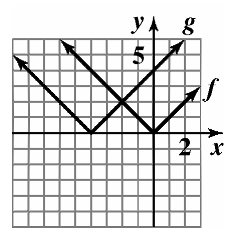

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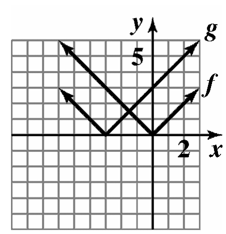

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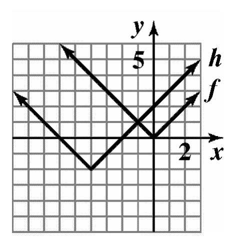

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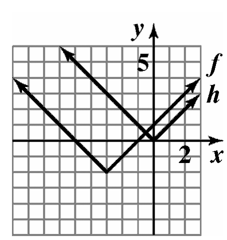

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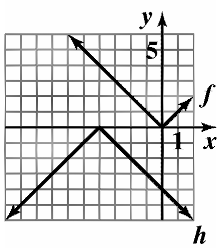

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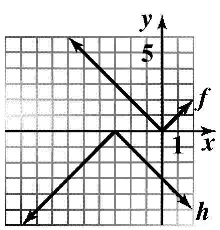

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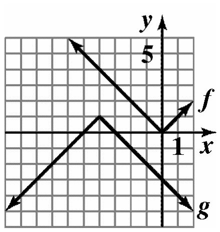

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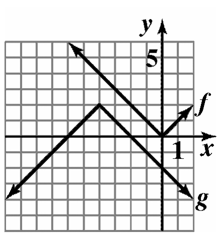

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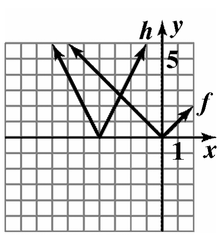

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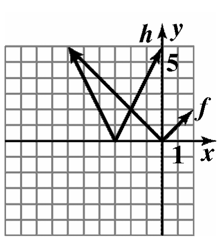

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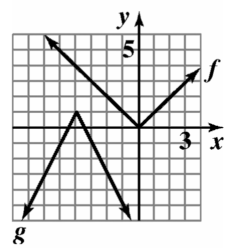

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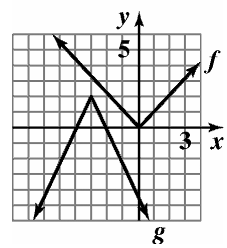

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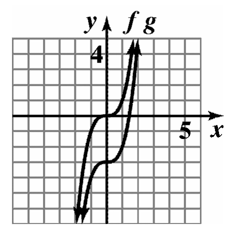

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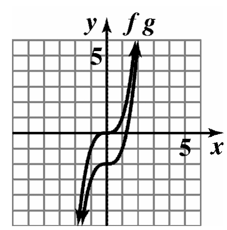

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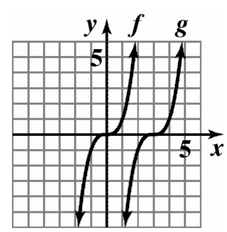

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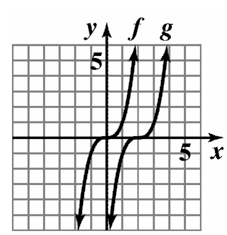

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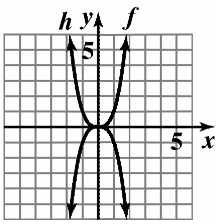

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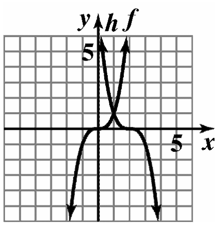

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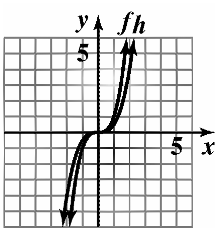

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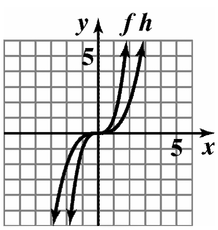

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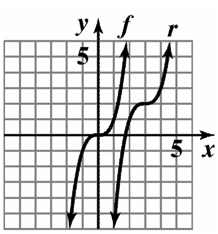

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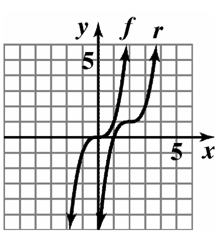

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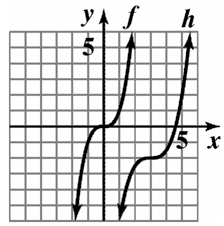

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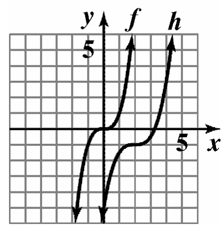

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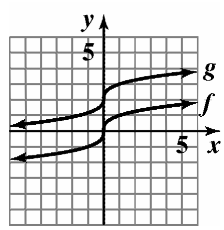

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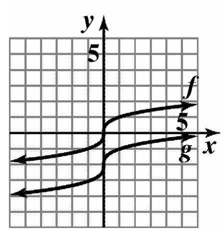

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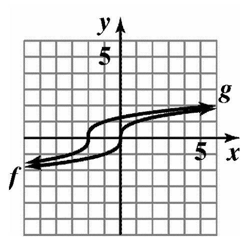

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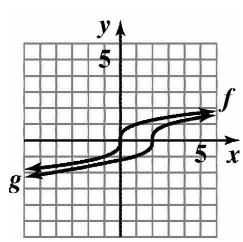

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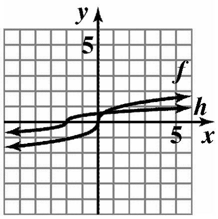

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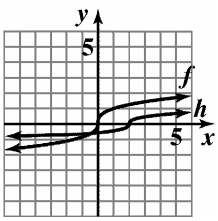

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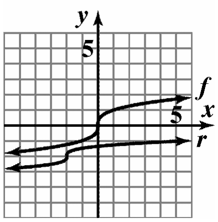

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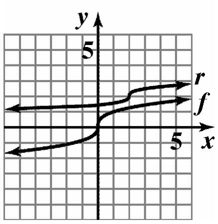

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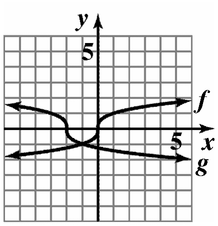

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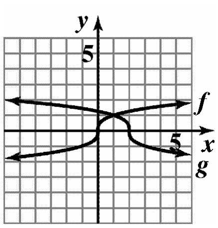

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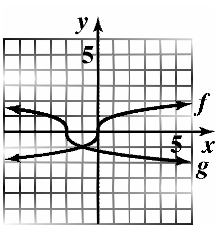

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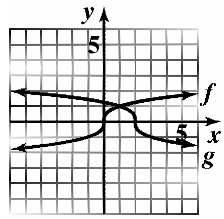

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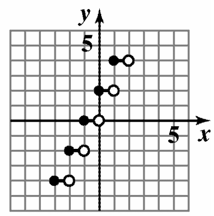
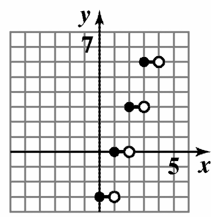


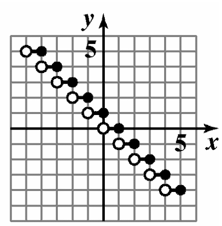
$g(x) = 2 \text{ int } (x + 1)$

120.



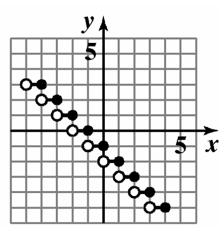
$g(x) = 3 \text{ int } (x - 1)$

121.



$h(x) = \text{int } (-x) + 1$

122.



$h(x) = \text{int } (-x) - 1$

123. $y = \sqrt{x-2}$

124. $y = -x^3 + 2$

125. $y = (x+1)^2 - 4$

126. $y = \sqrt{x-2} + 1$

127. a. First, vertically stretch the graph of $f(x)=\sqrt{x}$ by the factor 2.9; then shift the result up 20.1 units.

b. $f(x)=2.9\sqrt{x}+20.1$

$f(48)=2.9\sqrt{48}+20.1\approx 40.2$

The model describes the actual data very well.

c. $\frac{f(x_2)-f(x_1)}{x_2-x_1}$

$=\frac{f(10)-f(0)}{10-0}$

$=\frac{\left(2.9\sqrt{10}+20.1\right)-\left(2.9\sqrt{0}+20.1\right)}{10-0}$

$=\frac{29.27-20.1}{10}$

≈ 0.9

0.9 inches per month

d. $\frac{f(x_2)-f(x_1)}{x_2-x_1}$

$=\frac{f(60)-f(50)}{60-50}$

$=\frac{\left(2.9\sqrt{60}+20.1\right)-\left(2.9\sqrt{50}+20.1\right)}{60-50}$

$=\frac{42.5633-40.6061}{10}$

≈ 0.2

This rate of change is lower than the rate of change in part (c). The relative leveling off of the curve shows this difference.

128. a. First, vertically stretch the graph of $f(x)=\sqrt{x}$ by the factor 3.1; then shift the result up 19 units.

b. $f(x)=3.1\sqrt{x}+19$

$f(48)=3.1\sqrt{48}+19\approx 40.5$

The model describes the actual data very well.

c. $\frac{f(x_2)-f(x_1)}{x_2-x_1}$

$=\frac{f(10)-f(0)}{10-0}$

$=\frac{\left(3.1\sqrt{10}+19\right)-\left(3.1\sqrt{0}+19\right)}{10-0}$

$=\frac{28.8031-19}{10}$

≈ 1.0

1.0 inches per month

d. $\frac{f(x_2)-f(x_1)}{x_2-x_1}$

$= \frac{f(60)-f(50)}{60-50}$

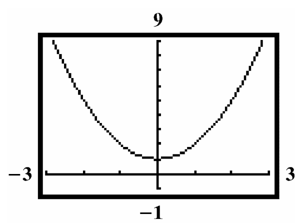
$= \frac{\left(3.1\sqrt{60}+19\right)-\left(3.1\sqrt{50}+19\right)}{60-50}$

$= \frac{43.0125-40.9203}{10}$

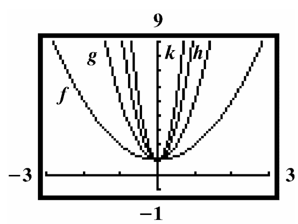
≈ 0.2

This rate of change is lower than the rate of change in part (c). The relative leveling off of the curve shows this difference.

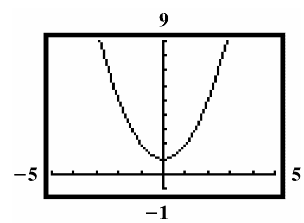
135. a.



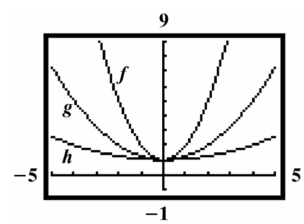
b.



136. a.



b.



137. a. False; the graph of *g* is a translation of three units upward and three units to the left of the graph of *f*.

b. False; the graph of *f* is a reflection of the graph of $y=\sqrt{x}$ in the *x*-axis, while the graph of *g* is a reflection of the graph of $y=\sqrt{x}$ in the *y*-axis.

c. False; $g(x)=5x^2-10$, so the graph of *g* can be obtained by stretching *f* five units followed by a downward shift of ten units.

d. True

(d) is true.

138. $g(x)=-(x+4)^2$

139. $g(x)=-|x-5|+1$

140. $g(x)=-\sqrt{x-2}+2$

141. $g(x)=-\frac{1}{4}\sqrt{16-x^2}-1$

142. $(-a, b)$

143. $(a, 2b)$

144. $(a+3, b)$

145. $(a, b-3)$

Section 1.7

Check Point Exercises

1. a. The function $f(x)=x^2+3x-17$ contains neither division nor an even root. The domain of *f* is the set of all real numbers or $(-\infty,\infty)$.

b. The denominator equals zero when $x = 7$ or $x = -7$. These values must be excluded from the domain. Domain of $g = (-\infty,-7)\cup(-7,7)\cup(7,\infty)$.

c. Since $h(x)=\sqrt{9x-27}$ contains an even root; the quantity under the radical must be greater than or equal to 0.

$$9x-27\geq 0$$
$$9x\geq 27$$
$$x\geq 3$$

Thus, the domain of *h* is $\{x|x\geq 3\}$, or the interval $[3,\infty)$.

2. a.
$$\begin{aligned}(f+g)(x) &= f(x)+g(x)\\ &= x-5+\left(x^2-1\right)\\ &= x-5+x^2-1\\ &= -x^2+x-6\end{aligned}$$

b.
$$\begin{aligned}(f-g)(x) &= f(x)-g(x)\\ &= x-5-\left(x^2-1\right)\\ &= x-5-x^2+1\\ &= -x^2+x-4\end{aligned}$$

c.
$$\begin{aligned}(fg)(x) &= (x-5)\left(x^2-1\right)\\ &= x\left(x^2-1\right)-5\left(x^2-1\right)\\ &= x^3-x-5x^2+5\\ &= x^3-5x^2-x+5\end{aligned}$$

d.
$$\begin{aligned}\left(\frac{f}{g}\right)(x) &= \frac{f(x)}{g(x)}\\ &= \frac{x-5}{x^2-1},\ x\neq\pm 1\end{aligned}$$

3. a.
$$\begin{aligned}(f+g)(x) &= f(x)+g(x)\\ &= \sqrt{x-3}+\sqrt{x+1}\end{aligned}$$

b. Domain of *f*: $x-3\geq 0$

$$x\geq 3$$
$$[3,\infty)$$

Domain of g: $x+1\geq 0$

$$x\geq -1$$
$$[-1,\infty)$$

The domain of $f+g$ is the set of all real numbers that are common to the domain of *f* and the domain of *g*. Thus, the domain of $f+g$ is $[3,\infty)$.

4. **a.** $(f \circ g)(x) = f(g(x))$
$= 5(2x^2 - x - 1) + 6$
$= 10x^2 - 5x - 5 + 6$
$= 10x^2 - 5x + 1$

b. $(g \circ f)(x) = g(f(x))$
$= 2(5x+6)^2 - (5x+6) - 1$
$= 2(25x^2 + 60x + 36) - 5x - 6 - 1$
$= 50x^2 + 120x + 72 - 5x - 6 - 1$
$= 50x^2 + 115x + 65$

5. **a.** $f \circ g(x) = \dfrac{4}{\frac{1}{x} + 2} = \dfrac{4x}{1+2x}$

b. $\left\{ x \middle| x \neq 0,\ x \neq -\frac{1}{2} \right\}$

6. $h(x) = f \circ g$ where $f(x) = \sqrt{x}$; $g(x) = x^2 + 5$

Exercise Set 1.7

1. The function contains neither division nor an even root. The domain $= (-\infty, \infty)$

2. The function contains neither division nor an even root. The domain $= (-\infty, \infty)$

3. The denominator equals zero when $x = 4$. This value must be excluded from the domain.
Domain: $(-\infty, 4) \cup (4, \infty)$.

4. The denominator equals zero when $x = -5$. This value must be excluded from the domain.
Domain: $(-\infty, -5) \cup (-5, \infty)$.

5. The function contains neither division nor an even root. The domain $= (-\infty, \infty)$

6. The function contains neither division nor an even root. The domain $= (-\infty, \infty)$

7. The values that make the denominator equal zero must be excluded from the domain.
Domain: $(-\infty, -3) \cup (-3, 5) \cup (5, \infty)$

8. The values that make the denominator equal zero must be excluded from the domain.
Domain: $(-\infty, -4) \cup (-4, 3) \cup (3, \infty)$

9. The values that make the denominators equal zero must be excluded from the domain.
Domain: $(-\infty, -7) \cup (-7, 9) \cup (9, \infty)$

10. The values that make the denominators equal zero must be excluded from the domain.
Domain: $(-\infty,-8)\cup(-8,10)\cup(10,\infty)$

11. The first denominator cannot equal zero. The values that make the second denominator equal zero must be excluded from the domain.
Domain: $(-\infty,-1)\cup(-1,1)\cup(1,\infty)$

12. The first denominator cannot equal zero. The values that make the second denominator equal zero must be excluded from the domain.
Domain: $(-\infty,-2)\cup(-2,2)\cup(2,\infty)$

13. Exclude *x* for $x=0$.
Exclude *x* for $\frac{3}{x}-1=0$.

$$\frac{3}{x}-1=0$$
$$x\left(\frac{3}{x}-1\right)=x(0)$$
$$3-x=0$$
$$-x=-3$$
$$x=3$$

Domain: $(-\infty,0)\cup(0,3)\cup(3,\infty)$

14. Exclude *x* for $x=0$.
Exclude *x* for $\frac{4}{x}-1=0$.

$$\frac{4}{x}-1=0$$
$$x\left(\frac{4}{x}-1\right)=x(0)$$
$$4-x=0$$
$$-x=-4$$
$$x=4$$

Domain: $(-\infty,0)\cup(0,4)\cup(4,\infty)$

15. Exclude *x* for $x-1=0$.

$$x-1=0$$
$$x=1$$

Exclude *x* for $\frac{4}{x-1}-2=0$.

$$\frac{4}{x-1}-2=0$$
$$(x-1)\left(\frac{4}{x-1}-2\right)=(x-1)(0)$$
$$4-2(x-1)=0$$
$$4-2x+2=0$$
$$-2x+6=0$$
$$-2x=-6$$
$$x=3$$

Domain: $(-\infty,1)\cup(1,3)\cup(3,\infty)$

16. Exclude *x* for $x-2=0$.

$$x-2=0$$
$$x=2$$

Exclude *x* for $\frac{4}{x-2}-3=0$.

$$\frac{4}{x-2}-3=0$$
$$(x-2)\left(\frac{4}{x-2}-3\right)=(x-2)(0)$$
$$4-3(x-2)=0$$
$$4-3x+6=0$$
$$-3x+10=0$$
$$-3x=-10$$
$$x=\frac{10}{3}$$

Domain: $(-\infty,2)\cup\left(2,\frac{10}{3}\right)\cup\left(\frac{10}{3},\infty\right)$

17. The expression under the radical must not be negative.
$x-3\geq 0$
$x\geq 3$
Domain: $[3,\infty)$

18. The expression under the radical must not be negative.
$x+2\geq 0$
$x\geq -2$
Domain: $[-2,\infty)$

19. The expression under the radical must be positive.
$x-3>0$
$x>3$
Domain: $(3,\infty)$

20. The expression under the radical must be positive.
$x+2>0$
$x>-2$
Domain: $(-2,\infty)$

21. The expression under the radical must not be negative.
$5x+35\geq 0$
$5x\geq -35$
$x\geq -7$
Domain: $[-7,\infty)$

22. The expression under the radical must not be negative.
$7x-70\geq 0$
$7x\geq 70$
$x\geq 10$
Domain: $[10,\infty)$

23. The expression under the radical must not be negative.
$24-2x\geq 0$
$-2x\geq -24$
$\frac{-2x}{-2}\leq\frac{-24}{-2}$
$x\leq 12$
Domain: $(-\infty,12]$

24. The expression under the radical must not be negative.
$84-6x\geq 0$
$-6x\geq -84$
$\frac{-6x}{-6}\leq\frac{-84}{-6}$
$x\leq 14$
Domain: $(-\infty,14]$

25. The expressions under the radicals must not be negative.

$x-2\geq 0$ and $x+3\geq 0$

$x\geq 2$ $\quad$ $x\geq -3$

To make both inequalities true, $x\geq 2$.

Domain: $[2,\infty)$

26. The expressions under the radicals must not be negative.

$x-3\geq 0$ and $x+4\geq 0$

$x\geq 3$ $\quad$ $x\geq -4$

To make both inequalities true, $x\geq 3$.

Domain: $[3,\infty)$

27. The expression under the radical must not be negative.

$x-2\geq 0$

$x\geq 2$

The denominator equals zero when $x=5$.

Domain: $[2,5)\cup(5,\infty)$.

28. The expression under the radical must not be negative.

$x-3\geq 0$

$x\geq 3$

The denominator equals zero when $x=6$.

Domain: $[3,6)\cup(6,\infty)$.

29. Find the values that make the denominator equal zero and must be excluded from the domain.

$x^3-5x^2-4x+20$

$=x^2(x-5)-4(x-5)$

$=(x-5)(x^2-4)$

$=(x-5)(x+2)(x-2)$

–2, 2, and 5 must be excluded.

Domain: $(-\infty,-2)\cup(-2,2)\cup(2,5)\cup(5,\infty)$

30. Find the values that make the denominator equal zero and must be excluded from the domain.

$x^3-2x^2-9x+18$

$=x^2(x-2)-9(x-2)$

$=(x-2)(x^2-9)$

$=(x-2)(x+3)(x-3)$

–3, 2, and 3 must be excluded.

Domain: $(-\infty,-3)\cup(-3,2)\cup(2,3)\cup(3,\infty)$

31. $(f+g)(x) = 3x + 2$
Domain: $(-\infty, \infty)$
$(f-g)(x) = f(x) - g(x)$
$= (2x + 3) - (x - 1)$
$= x + 4$
Domain: $(-\infty, \infty)$
$(fg)(x) = f(x) \cdot g(x)$
$= (2x+3) \cdot (x-1)$
$= 2x^2 + x - 3$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{f(x)}{g(x)} = \frac{2x+3}{x-1}$
Domain: $(-\infty, 1) \cup (1, \infty)$

32. $(f+g)(x) = 4x - 2$
Domain: $(-\infty, \infty)$
$(f-g)(x) = (3x - 4) - (x + 2) = 2x - 6$
Domain: $(-\infty, \infty)$
$(fg)(x) = (3x - 4)(x + 2) = 3x^2 + 2x - 8$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{3x-4}{x+2}$
Domain: $(-\infty, -2) \cup (-2, \infty)$

33. $(f+g)(x) = 3x^2 + x - 5$
Domain: $(-\infty, \infty)$
$(f-g)(x) = -3x^2 + x - 5$
Domain: $(-\infty, \infty)$
$(fg)(x) = (x-5)(3x^2) = 3x^3 - 15x^2$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{x-5}{3x^2}$
Domain: $(-\infty, 0) \cup (0, \infty)$

34. $(f+g)(x) = 5x^2 + x - 6$
Domain: $(-\infty, \infty)$
$(f-g)(x) = -5x^2 + x - 6$
Domain: $(-\infty, \infty)$
$(fg)(x) = (x-6)(5x^2) = 5x^3 - 30x^2$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{x-6}{5x^2}$
Domain: $(-\infty, 0) \cup (0, \infty)$

35. $(f+g)(x) = 2x^2 - 2$
Domain: $(-\infty, \infty)$
$(f-g)(x) = 2x^2 - 2x - 4$
Domain: $(-\infty, \infty)$
$(fg)(x) = (2x^2 - x - 3)(x+1)$
$= 2x^3 + x^2 - 4x - 3$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{2x^2 - x - 3}{x+1}$
$= \frac{(2x-3)(x+1)}{(x+1)} = 2x - 3$
Domain: $(-\infty, -1) \cup (-1, \infty)$

36. $(f+g)(x) = 6x^2 - 2$
Domain: $(-\infty, \infty)$
$(f-g)(x) = 6x^2 - 2x$
Domain: $(-\infty, \infty)$
$(fg)(x) = (6x^2 - x - 1)(x-1) = 6x^3 - 7x^2 + 1$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{6x^2 - x - 1}{x-1}$
Domain: $(-\infty, 1) \cup (1, \infty)$

37. $(f+g)(x) = (3 - x^2) + (x^2 + 2x - 15)$
$= 2x - 12$
Domain: $(-\infty, \infty)$
$(f-g)(x) = (3 - x^2) - (x^2 + 2x - 15)$
$= -2x^2 - 2x + 18$
Domain: $(-\infty, \infty)$
$(fg)(x) = (3 - x^2)(x^2 + 2x - 15)$
$= -x^4 - 2x^3 + 18x^2 + 6x - 45$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{3 - x^2}{x^2 + 2x - 15}$
Domain: $(-\infty, -5) \cup (-5, 3) \cup (3, \infty)$

38. $(f+g)(x) = (5 - x^2) + (x^2 + 4x - 12)$
$= 4x - 7$
Domain: $(-\infty, \infty)$
$(f-g)(x) = (5 - x^2) - (x^2 + 4x - 12)$
$= -2x^2 - 4x + 17$
Domain: $(-\infty, \infty)$
$(fg)(x) = (5 - x^2)(x^2 + 4x - 12)$
$= -x^4 - 4x^3 + 17x^2 + 20x - 60$
Domain: $(-\infty, \infty)$
$\left(\frac{f}{g}\right)(x) = \frac{5 - x^2}{x^2 + 4x - 12}$
Domain: $(-\infty, -6) \cup (-6, 2) \cup (2, \infty)$

39. $(f+g)(x)=\sqrt{x}+x-4$
Domain: $[0,\infty)$
$(f-g)(x)=\sqrt{x}-x+4$
Domain: $[0,\infty)$
$(fg)(x)=\sqrt{x}(x-4)$
Domain: $[0,\infty)$
$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x}}{x-4}$
Domain: $[0,4)\cup(4,\infty)$

40. $(f+g)(x)=\sqrt{x}+x-5$
Domain: $[0,\infty)$
$(f-g)(x)=\sqrt{x}-x+5$
Domain: $[0,\infty)$
$(fg)(x)=\sqrt{x}(x-5)$
Domain: $[0,\infty)$
$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x}}{x-5}$
Domain: $[0,5)\cup(5,\infty)$

41. $(f+g)(x)=2+\frac{1}{x}+\frac{1}{x}=2+\frac{2}{x}=\frac{2x+2}{x}$
Domain: $(-\infty,0)\cup(0,\infty)$
$(f-g)(x)=2+\frac{1}{x}-\frac{1}{x}=2$
Domain: $(-\infty,0)\cup(0,\infty)$
$(fg)(x)=\left(2+\frac{1}{x}\right)\cdot\frac{1}{x}=\frac{2}{x}+\frac{1}{x^2}=\frac{2x+1}{x^2}$
Domain: $(-\infty,0)\cup(0,\infty)$
$\left(\frac{f}{g}\right)(x)=\frac{2+\frac{1}{x}}{\frac{1}{x}}=\left(2+\frac{1}{x}\right)\cdot x=2x+1$
Domain: $(-\infty,0)\cup(0,\infty)$

42. $(f+g)(x)=6-\frac{1}{x}+\frac{1}{x}=6$
Domain: $(-\infty,0)\cup(0,\infty)$
$(f-g)(x)=6-\frac{1}{x}-\frac{1}{x}=6-\frac{2}{x}=\frac{6x-2}{x}$
Domain: $(-\infty,0)\cup(0,\infty)$
$(fg)(x)=\left(6-\frac{1}{x}\right)\cdot\frac{1}{x}=\frac{6}{x}-\frac{1}{x^2}=\frac{6x-1}{x^2}$
Domain: $(-\infty,0)\cup(0,\infty)$
$\left(\frac{f}{g}\right)(x)=\frac{6-\frac{1}{x}}{\frac{1}{x}}=\left(6-\frac{1}{x}\right)\cdot x=6x-1$
Domain: $(-\infty,0)\cup(0,\infty)$

43. $(f+g)(x)=f(x)+g(x)$
$=\frac{5x+1}{x^2-9}+\frac{4x-2}{x^2-9}$
$=\frac{9x-1}{x^2-9}$
Domain: $(-\infty,-3)\cup(-3,3)\cup(3,\infty)$
$(f-g)(x)=f(x)-g(x)$
$=\frac{5x+1}{x^2-9}-\frac{4x-2}{x^2-9}$
$=\frac{x+3}{x^2-9}$
$=\frac{1}{x-3}$
Domain: $(-\infty,-3)\cup(-3,3)\cup(3,\infty)$
$(fg)(x)=f(x)\cdot g(x)$
$=\frac{5x+1}{x^2-9}\cdot\frac{4x-2}{x^2-9}$
$=\frac{(5x+1)(4x-2)}{\left(x^2-9\right)^2}$
Domain: $(-\infty,-3)\cup(-3,3)\cup(3,\infty)$
$\left(\frac{f}{g}\right)(x)=\frac{\frac{5x+1}{x^2-9}}{\frac{4x-2}{x^2-9}}$
$=\frac{5x+1}{x^2-9}\cdot\frac{x^2-9}{4x-2}$
$=\frac{5x+1}{4x-2}$
The domain must exclude –3, 3, and any values that make $4x-2=0$.
$4x-2=0$
$4x=2$
$x=\frac{1}{2}$
Domain: $(-\infty,-3)\cup(-3,\frac{1}{2})\cup(\frac{1}{2},3)\cup(3,\infty)$

44. $(f+g)(x) = f(x)+g(x)$
$$= \frac{3x+1}{x^2-25}+\frac{2x-4}{x^2-25}$$
$$= \frac{5x-3}{x^2-25}$$
Domain: $(-\infty,-5)\cup(-5,5)\cup(5,\infty)$

$(f-g)(x) = f(x)-g(x)$
$$= \frac{3x+1}{x^2-25}-\frac{2x-4}{x^2-25}$$
$$= \frac{x+5}{x^2-25}$$
$$= \frac{1}{x-5}$$
Domain: $(-\infty,-5)\cup(-5,5)\cup(5,\infty)$

$(fg)(x) = f(x)\cdot g(x)$
$$= \frac{3x+1}{x^2-25}\cdot\frac{2x-4}{x^2-25}$$
$$= \frac{(3x+1)(2x-4)}{\left(x^2-25\right)^2}$$
Domain: $(-\infty,-5)\cup(-5,5)\cup(5,\infty)$

$$\left(\frac{f}{g}\right)(x) = \frac{\frac{3x+1}{x^2-25}}{\frac{2x-4}{x^2-25}}$$
$$= \frac{3x+1}{x^2-25}\cdot\frac{x^2-25}{2x-4}$$
$$= \frac{3x+1}{2x-4}$$
The domain must exclude –5, 5, and any values that make $2x-4=0$.
$$2x-4=0$$
$$2x=4$$
$$x=2$$
Domain: $(-\infty,-5)\cup(-5,2)\cup(2,5)\cup(5,\infty)$

45. $(f+g)(x)=\sqrt{x+4}+\sqrt{x-1}$
Domain: $[1,\infty)$
$(f-g)(x)=\sqrt{x+4}-\sqrt{x-1}$
Domain: $[1,\infty)$
$(fg)(x)=\sqrt{x+4}\cdot\sqrt{x-1}=\sqrt{x^2+3x-4}$
Domain: $[1,\infty)$
$$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x+4}}{\sqrt{x-1}}$$
Domain: $(1,\infty)$

46. $(f+g)(x)=\sqrt{x+6}+\sqrt{x-3}$
Domain: $[3,\infty)$
$(f-g)(x)=\sqrt{x+6}-\sqrt{x-3}$
Domain: $[3,\infty)$
$(fg)(x)=\sqrt{x+6}\cdot\sqrt{x-3}=\sqrt{x^2+3x-18}$
Domain: $[3,\infty)$
$$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x+6}}{\sqrt{x-3}}$$
Domain: $(3,\infty)$

47. $(f+g)(x)=\sqrt{x-2}+\sqrt{2-x}$
Domain: $\{2\}$
$(f-g)(x)=\sqrt{x-2}-\sqrt{2-x}$
Domain: $\{2\}$
$(fg)(x)=\sqrt{x-2}\cdot\sqrt{2-x}=\sqrt{-x^2+4x-4}$
Domain: $\{2\}$
$$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x-2}}{\sqrt{2-x}}$$
Domain: $\varnothing$

48. $(f+g)(x)=\sqrt{x-5}+\sqrt{5-x}$
Domain: $\{5\}$
$(f-g)(x)=\sqrt{x-5}-\sqrt{5-x}$
Domain: $\{5\}$
$(fg)(x)=\sqrt{x-5}\cdot\sqrt{5-x}=\sqrt{-x^2+10x-25}$
Domain: $\{5\}$
$$\left(\frac{f}{g}\right)(x)=\frac{\sqrt{x-5}}{\sqrt{5-x}}$$
Domain: $\varnothing$

49. $f(x) = 2x$; $g(x) = x + 7$

a. $(f\circ g)(x)=2(x+7)=2x+14$

b. $(g\circ f)(x)=2x+7$

c. $(f\circ g)(2)=2(2)+14=18$

50. $f(x) = 3x$; $g(x) = x - 5$

a. $(f\circ g)(x)=3(x-5)=3x-15$

b. $(g\circ f)(x)=3x-5$

c. $(f\circ g)(2)=3(2)-15=-9$

51. $f(x) = x + 4;\ g(x) = 2x + 1$

a. $(f \circ g)(x) = (2x+1)+4 = 2x+5$

b. $(g \circ f)(x) = 2(x+4)+1 = 2x+9$

c. $(f \circ g)(2) = 2(2)+5 = 9$

52. $f(x) = 5x + 2;\ g(x) = 3x - 4$

a. $(f \circ g)(x) = 5(3x-4)+2 = 15x-18$

b. $(g \circ f)(x) = 3(5x+2)-4 = 15x+2$

c. $(f \circ g)(2) = 15(2)-18 = 12$

53. $f(x) = 4x - 3;\ g(x) = 5x^2 - 2$

a. $(f \circ g)(x) = 4(5x^2-2)-3$
$= 20x^2 - 11$

b. $(g \circ f)(x) = 5(4x-3)^2 - 2$
$= 5(16x^2 - 24x + 9) - 2$
$= 80x^2 - 120x + 43$

c. $(f \circ g)(2) = 20(2)^2 - 11 = 69$

54. $f(x) = 7x+1;\ g(x) = 2x^2 - 9$

a. $(f \circ g)(x) = 7(2x^2-9)+1 = 14x^2 - 62$

b. $(g \circ f)(x) = 2(7x+1)^2 - 9$
$= 2(49x^2 + 14x + 1) - 9$
$= 98x^2 + 28x - 7$

c. $(f \circ g)(2) = 14(2)^2 - 62 = -6$

55. $f(x) = x^2 + 2;\ g(x) = x^2 - 2$

a. $(f \circ g)(x) = (x^2-2)^2 + 2$
$= x^4 - 4x^2 + 4 + 2$
$= x^4 - 4x^2 + 6$

b. $(g \circ f)(x) = (x^2+2)^2 - 2$
$= x^4 + 4x^2 + 4 - 2$
$= x^4 + 4x^2 + 2$

c. $(f \circ g)(2) = 2^4 - 4(2)^2 + 6 = 6$

56. $f(x) = x^2 + 1;\ g(x) = x^2 - 3$

a. $(f \circ g)(x) = (x^2-3)^2 + 1$
$= x^4 - 6x^2 + 9 + 1$
$= x^4 - 6x^2 + 10$

b. $(g \circ f)(x) = (x^2+1)^2 - 3$
$= x^4 + 2x^2 + 1 - 3$
$= x^4 + 2x^2 - 2$

c. $(f \circ g)(2) = 2^4 - 6(2)^2 + 10 = 2$

57. $f(x) = 4 - x;\quad g(x) = 2x^2 + x + 5$

a. $(f \circ g)(x) = 4 - \left(2x^2 + x + 5\right)$
$= 4 - 2x^2 - x - 5$
$= -2x^2 - x - 1$

b. $(g \circ f)(x) = 2\left(4-x\right)^2 + \left(4-x\right) + 5$
$= 2(16 - 8x + x^2) + 4 - x + 5$
$= 32 - 16x + 2x^2 + 4 - x + 5$
$= 2x^2 - 17x + 41$

c. $(f \circ g)(2) = -2(2)^2 - 2 - 1 = -11$

58. $f(x) = 5x - 2;\quad g(x) = -x^2 + 4x - 1$

a. $(f \circ g)(x) = 5\left(-x^2 + 4x - 1\right) - 2$
$= -5x^2 + 20x - 5 - 2$
$= -5x^2 + 20x - 7$

b. $(g \circ f)(x) = -\left(5x-2\right)^2 + 4\left(5x-2\right) - 1$
$= -(25x^2 - 20x + 4) + 20x - 8 - 1$
$= -25x^2 + 20x - 4 + 20x - 8 - 1$
$= -25x^2 + 40x - 13$

c. $(f \circ g)(2) = -5(2)^2 + 20(2) - 7 = 13$

59. $f(x)=\sqrt{x};\ g(x)=x-1$

a. $(f\circ g)(x)=\sqrt{x-1}$

b. $(g\circ f)(x)=\sqrt{x}-1$

c. $(f\circ g)(2)=\sqrt{2-1}=\sqrt{1}=1$

60. $f(x)=\sqrt{x};g(x)=x+2$

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

b. $(g\circ f)(x)=\sqrt{x}+2$

c. $(f\circ g)(2)=\sqrt{2+2}=\sqrt{4}=2$

61. $f(x)=2x-3;\ g(x)=\dfrac{x+3}{2}$

a. $(f\circ g)(x)=2\left(\dfrac{x+3}{2}\right)-3$
$=x+3-3$
$=x$

b. $(g\circ f)(x)=\dfrac{(2x-3)+3}{2}=\dfrac{2x}{2}=x$

c. $(f\circ g)(2)=2$

62. $f(x)=6x-3;g(x)=\dfrac{x+3}{6}$

a. $(f\circ g)(x)=6\left(\dfrac{x+3}{6}\right)-3=x+3-3=x$

b. $(g\circ f)(x)=\dfrac{6x-3+3}{6}=\dfrac{6x}{6}=x$

c. $(f\circ g)(2)=2$

63. $f(x)=\dfrac{1}{x};\quad g(x)=\dfrac{1}{x}$

a. $(f\circ g)(x)=\dfrac{1}{\frac{1}{x}}=x$

b. $(g\circ f)(x)=\dfrac{1}{\frac{1}{x}}=x$

c. $(f\circ g)(2)=2$

64. $f(x)=\dfrac{2}{x};\quad g(x)=\dfrac{2}{x}$

a. $(f\circ g)(x)=\dfrac{2}{\frac{2}{x}}=x$

b. $(g\circ f)(x)=\dfrac{2}{\frac{2}{x}}=x$

c. $(f\circ g)(2)=2$

65. a. $(f\circ g)(x)=f\left(\dfrac{1}{x}\right)=\dfrac{2}{\frac{1}{x}+3},x\neq 0$

$$=\frac{2(x)}{\left(\frac{1}{x}+3\right)(x)}$$

$$=\frac{2x}{1+3x}$$

b. We must exclude 0 because it is excluded from *g*.

We must exclude $-\dfrac{1}{3}$ because it causes the denominator of $f\circ g$ to be 0.

Domain: $\left(-\infty,-\dfrac{1}{3}\right)\cup\left(-\dfrac{1}{3},0\right)\cup(0,\infty)$.

66. **a.** $f \circ g(x) = f\left(\frac{1}{x}\right) = \frac{5}{\frac{1}{x}+4} = \frac{5x}{1+4x}$

b. We must exclude 0 because it is excluded from *g*.

We must exclude $-\frac{1}{4}$ because it causes the denominator of $f \circ g$ to be 0.

Domain: $\left(-\infty,-\frac{1}{4}\right)\cup\left(-\frac{1}{4},0\right)\cup(0,\infty)$.

67. **a.** $(f \circ g)(x) = f\left(\frac{4}{x}\right) = \frac{\frac{4}{x}}{\frac{4}{x}+1}$

$$= \frac{\left(\frac{4}{x}\right)(x)}{\left(\frac{4}{x}+1\right)(x)}$$

$$= \frac{4}{4+x}, x \neq -4$$

b. We must exclude 0 because it is excluded from *g*.
We must exclude -4 because it causes the denominator of $f \circ g$ to be 0.
Domain: $(-\infty,-4)\cup(-4,0)\cup(0,\infty)$.

68. **a.** $f \circ g(x) = f\left(\frac{6}{x}\right) = \frac{\frac{6}{x}}{\frac{6}{x}+5} = \frac{6}{6+5x}$

b. We must exclude 0 because it is excluded from *g*.

We must exclude $-\frac{6}{5}$ because it causes the denominator of $f \circ g$ to be 0.

Domain: $\left(-\infty,-\frac{6}{5}\right)\cup\left(-\frac{6}{5},0\right)\cup(0,\infty)$.

69. **a.** $f \circ g(x) = f(x-2) = \sqrt{x-2}$

b. The expression under the radical in $f \circ g$ must not be negative.

$x-2 \geq 0$

$x \geq 2$

Domain: $[2,\infty)$.

70. **a.** $f \circ g(x) = f(x-3) = \sqrt{x-3}$

b. The expression under the radical in $f \circ g$ must not be negative.

$x-3 \geq 0$

$x \geq 3$

Domain: $[3,\infty)$.

71. **a.** $(f \circ g)(x) = f(\sqrt{1-x})$
$= \left(\sqrt{1-x}\right)^2 + 4$
$= 1 - x + 4$
$= 5 - x$

b. The domain of $f \circ g$ must exclude any values that are excluded from g.
$1 - x \ge 0$
$-x \ge -1$
$x \le 1$
Domain: $(-\infty, 1]$.

72. **a.** $(f \circ g)(x) = f(\sqrt{2-x})$
$= \left(\sqrt{2-x}\right)^2 + 1$
$= 2 - x + 1$
$= 3 - x$

b. The domain of $f \circ g$ must exclude any values that are excluded from g.
$2 - x \ge 0$
$-x \ge -2$
$x \le 2$
Domain: $(-\infty, 2]$.

73. $f(x) = x^4 \quad g(x) = 3x - 1$

74. $f(x) = x^3; g(x) = 2x - 5$

75. $f(x) = \sqrt[3]{x} \quad g(x) = x^2 - 9$

76. $f(x) = \sqrt{x}; g(x) = 5x^2 + 3$

77. $f(x) = |x| \quad g(x) = 2x - 5$

78. $f(x) = |x|;\ g(x) = 3x - 4$

79. $f(x) = \dfrac{1}{x} \quad g(x) = 2x - 3$

80. $f(x) = \dfrac{1}{x}; g(x) = 4x + 5$

81. $(f + g)(-3) = f(-3) + g(-3) = 4 + 1 = 5$

82. $(g - f)(-2) = g(-2) - f(-2) = 2 - 3 = -1$

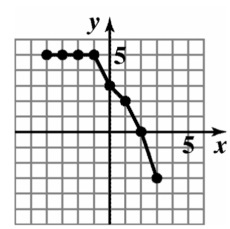
83. $(fg)(2) = f(2)g(2) = (-1)(1) = -1$

84. $\left(\dfrac{g}{f}\right)(3) = \dfrac{g(3)}{f(3)} = \dfrac{0}{-3} = 0$

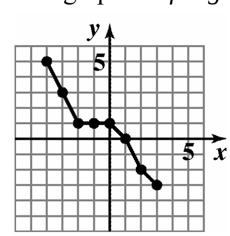
85. The domain of $f + g$ is $[-4, 3]$.

86. The domain of $\dfrac{f}{g}$ is $(-4, 3)$

87. The graph of $f + g$



88. The graph of $f - g$



89. $(f \circ g)(-1) = f(g(-1)) = f(-3) = 1$

90. $(f \circ g)(1) = f(g(1)) = f(-5) = 3$

91. $(g \circ f)(0) = g(f(0)) = g(2) = -6$

92. $(g \circ f)(-1) = g(f(-1)) = g(1) = -5$

93.
$$\begin{aligned} (f \circ g)(x) &= 7 \\ 2(x^2 - 3x + 8) - 5 &= 7 \\ 2x^2 - 6x + 16 - 5 &= 7 \\ 2x^2 - 6x + 11 &= 7 \\ 2x^2 - 6x + 4 &= 0 \\ x^2 - 3x + 2 &= 0 \\ (x-1)(x-2) &= 0 \end{aligned}$$
$x - 1 = 0$ or $x - 2 = 0$

$x = 1$ $\quad$ $x = 2$

94.
$$\begin{aligned} (f \circ g)(x) &= -5 \\ 1 - 2(3x^2 + x - 1) &= -5 \\ 1 - 6x^2 - 2x + 2 &= -5 \\ -6x^2 - 2x + 3 &= -5 \\ -6x^2 - 2x + 8 &= 0 \\ 3x^2 + x - 4 &= 0 \\ (3x+4)(x-1) &= 0 \end{aligned}$$
$3x + 4 = 0$ or $x - 1 = 0$

$3x = -4$ $\quad$ $x = 1$

$x = -\frac{4}{3}$

95. Domain: $\{0, 1, 2, 3, 4, 5, 6, 7, 8\}$

96. Domain: $\{0, 1, 2, 3, 4, 5, 6, 7, 8\}$

97. **a.**
$$\begin{aligned} (B-D)(x) &= (26{,}208x + 3{,}869{,}910) - (17{,}964x + 2{,}300{,}198) \\ &= 26{,}208x + 3{,}869{,}910 - 17{,}964x - 2{,}300{,}198 \\ &= 8244x + 1{,}569{,}712 \end{aligned}$$
This function represents the net change in population from births and deaths.

b. $(B-D)(x) = 8244x + 1{,}569{,}712$

$(B-D)(8) = 8244(8) + 1{,}569{,}712 = 1{,}635{,}664$

The U.S. population increased by 1,635,664 in 2003.

c. $4{,}093{,}000 - 2{,}423{,}000 = 1{,}670{,}000$

The difference of the functions modeled this value reasonably well.

98. **a.**
$$\begin{aligned} (B-D)(x) &= (26{,}208x + 3{,}869{,}910) - (17{,}964x + 2{,}300{,}198) \\ &= 26{,}208x + 3{,}869{,}910 - 17{,}964x - 2{,}300{,}198 \\ &= 8244x + 1{,}569{,}712 \end{aligned}$$
This function represents the net change in population from births and deaths.

b. $(B-D)(x) = 8244x + 1{,}569{,}712$

$(B-D)(6) = 8244(6) + 1{,}569{,}712 = 1{,}619{,}176$

The U.S. population increased by 1,619,176 in 2001.

c. $4{,}025{,}933 - 2{,}416{,}425 = 1{,}609{,}508$

The difference of the functions modeled this value well.

99. $f + g$ represents the total world population in year x.

100. $h - g$ represents the difference between the total world population and the population of the world's less-developed regions. This would be the population of the world's more-developed regions.

101. $(f + g)(2000) \approx 6$ billion people.

102. $(h-g)(2000) = f(2000) = 1.5$ The world's more-developed regions had a population of approximately 1.5 billion in 2000.

103. $(R-C)(20,000)$
$= 65(20,000) - (600,000 + 45(20,000))$
$= -200,000$
The company lost $200,000 since costs exceeded revenues.
$(R-C)(30,000)$
$= 65(30,000) - (600,000 + 45(30,000))$
$= 0$
The company broke even.

104. a. The slope for f is -0.44 This is the decrease in profits for the first store for each year after 1998.

b. The slope of g is 0.51 This is the increase in profits for the second store for each year after 1998.

c. $f + g = -.044x + 13.62 + 0.51x + 11.14$
$= 0.07x + 24.76$
The slope for $f + g$ is 0.07 This is the profit for the two stores combined for each year after 1998.

105. a. f gives the price of the computer after a \$400 discount. g gives the price of the computer after a 25% discount.

b. $(f \circ g)(x) = 0.75x - 400$
This models the price of a computer after first a 25% discount and then a \$400 discount.

c. $(g \circ f)(x) = 0.75(x - 400)$
This models the price of a computer after first a \$400 discount and then a 25% discount.

d. The function $f \circ g$ models the greater discount, since the 25% discount is taken on the regular price first.

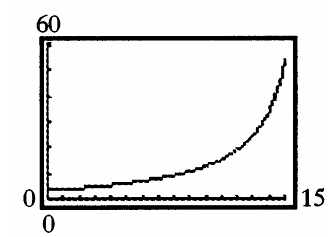
106. a. f gives the cost of a pair of jeans for which a \$5 rebate is offered.
g gives the cost of a pair of jeans that has been discounted 40%.

b. $(f \circ g)(x) = 0.6x - 5$
The cost of a pair of jeans is 60% of the regular price minus a \$5 rebate.

c. $(g \circ f)(x) = 0.6(x-5)$
$= 0.6x - 3$
The cost of a pair of jeans is 60% of the regular price minus a \$3 rebate.

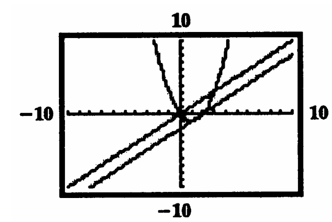
d. $f \circ g$ because of a \$5 rebate.

113.

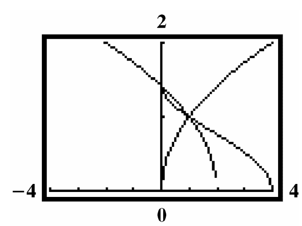


The per capita cost of Medicare is rising.

114. When your trace reaches $x = 0$, the y value disappears because the function is not defined at $x = 0$.



115.



$(f \circ g)(x) = \sqrt{2 - \sqrt{x}}$
The domain of g is $[0, \infty)$.
The expression under the radical in $f \circ g$ must not be negative.
$2 - \sqrt{x} \ge 0$
$-\sqrt{x} \ge -2$
$\sqrt{x} \le 2$
$x \le 4$
Domain: $[0, 4]$

116. a. false

$(f \circ g)(x) = f\left(\sqrt{x^2-4}\right)$

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

$= x^2 - 4 - 4$

$= x^2 - 8$

b. false

$f(x) = 2x; g(x) = 3x$

$(f \circ g)(x) = f(g(x)) = f(3x) = 2(3x) = 6x$

$(g \circ f)(x) = g(f(x)) = g(f(x)) = 3(2x) = 6x$

c. false

$(f \circ g)(4) = f(g(4)) = f(7) = 5$

d. true

$(f \circ g)(5) = f(g(5)) = f[2(5)-1] = f\left(\sqrt{9}\right) = 3$

$g(2) = 2(2) - 1 = 4 - 1 = 3$

$(f \circ g)(5) = g(2)$

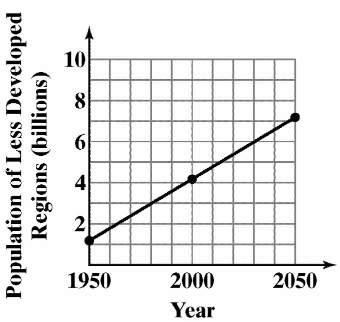
(d) is true.

117. $(f \circ g)(x) = (f \circ g)(-x)$

$f(g(x)) = f(g(-x))$ since g is even

$f(g(x)) = f(g(x))$ so $f \circ g$ is even

119.



Section 1.8

Check Point Exercises

1. $f\left(g(x)\right)=4\left(\frac{x+7}{4}\right)-7=x$

$g\left(f(x)\right)=\frac{(4x-7)+7}{4}=x$

$f\left(g(x)\right)=g\left(f(x)\right)=x$

2. $f(x)=2x+7$

Replace $f(x)$ with *y*:

$y=2x+7$

Interchange *x* and *y*:

$x=2y+7$

Solve for *y*:

$x=2y+7$

$x-7=2y$

$\frac{x-7}{2}=y$

Replace y with $f^{-1}(x)$:

$f^{-1}(x)=\frac{x-7}{2}$

3. $f(x)=4x^3-1$

Replace $f(x)$ with *y*:

$y=4x^3-1$

Interchange *x* and *y*:

$x=4y^3-1$

Solve for *y*:

$x=4y^3-1$

$x+1=4y^3$

$\frac{x+1}{4}=y^3$

$\sqrt[3]{\frac{x+1}{4}}=y$

Replace *y* with $f^{-1}(x)$:

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

Alternative form for answer:

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

$=\frac{\sqrt[3]{x+1}}{\sqrt[3]{4}}\cdot\frac{\sqrt[3]{2}}{\sqrt[3]{2}}=\frac{\sqrt[3]{2x+2}}{\sqrt[3]{8}}$

$=\frac{\sqrt[3]{2x+2}}{2}$

4. $f(x)=\frac{3}{x}-1$

Replace $f(x)$ with *y*:

$y=\frac{3}{x}-1$

Interchange *x* and *y*:

$x=\frac{3}{y}-1$

Solve for *y*:

$x=\frac{3}{y}-1$

$xy=3-y$

$xy+y=3$

$y(x+1)=3$

$y=\frac{3}{x+1}$

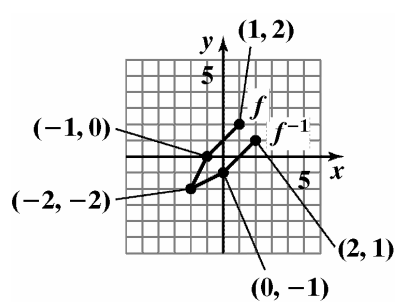
Replace y with $f^{-1}(x)$:

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

5. The graphs of (b) and (c) pass the horizontal line test and thus have an inverse.

6. Find points of f^{-1}.

$f(x)$	$f^{-1}(x)$
$(-2,-2)$	$(-2,-2)$
$(-1,0)$	$(0,-1)$
$(1,2)$	$(2,1)$



7. $f(x) = x^2 + 1$

Replace $f(x)$ with *y*:

$y = x^2 + 1$

Interchange *x* and *y*:

$x = y^2 + 1$

Solve for *y*:

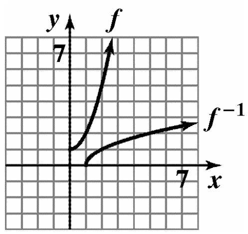
$x = y^2 + 1$

$x - 1 = y^2$

$\sqrt{x-1} = y$

Replace *y* with $f^{-1}(x)$:

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



Exercise Set 1.8

1. $f(x) = 4x;\ g(x) = \dfrac{x}{4}$

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

$g(f(x)) = \dfrac{4x}{4} = x$

f and *g* are inverses.

2. $f(x) = 6x;\ g(x) = \dfrac{x}{6}$

$f(g(x)) = 6\left(\dfrac{x}{6}\right) = x$

$g(f(x)) = \dfrac{6x}{6} = x$

f and *g* are inverses.

3. $f(x) = 3x + 8;\ g(x) = \dfrac{x-8}{3}$

$f(g(x)) = 3\left(\dfrac{x-8}{3}\right) + 8 = x - 8 + 8 = x$

$g(f(x)) = \dfrac{(3x+8)-8}{3} = \dfrac{3x}{3} = x$

f and *g* are inverses.

4. $f(x) = 4x + 9;\ g(x) = \dfrac{x-9}{4}$

$f(g(x)) = 4\left(\dfrac{x-9}{4}\right) + 9 = x - 9 + 9 = x$

$g(f(x)) = \dfrac{(4x+9)-9}{4} = \dfrac{4x}{4} = x$

f and *g* are inverses.

5. $f(x) = 5x - 9;\ g(x) = \dfrac{x+5}{9}$

$f(g(x)) = 5\left(\dfrac{x+5}{9}\right) - 9$

$= \dfrac{5x+25}{9} - 9$

$= \dfrac{5x-56}{9}$

$g(f(x)) = \dfrac{5x-9+5}{9} = \dfrac{5x-4}{9}$

f and *g* are not inverses.

6. $f(x) = 3x - 7;\ g(x) = \dfrac{x+3}{7}$

$f(g(x)) = 3\left(\dfrac{x+3}{7}\right) - 7 = \dfrac{3x+9}{7} - 7 = \dfrac{3x-40}{7}$

$g(f(x)) = \dfrac{3x-7+3}{7} = \dfrac{3x-4}{7}$

f and *g* are not inverses.

7. $f(x) = \dfrac{3}{x-4};\ g(x) = \dfrac{3}{x} + 4$

$f(g(x)) = \dfrac{3}{\frac{3}{x} + 4 - 4} = \dfrac{3}{\frac{3}{x}} = x$

$g(f(x)) = \dfrac{3}{\frac{3}{x-4}} + 4$

$= 3 \cdot \left(\dfrac{x-4}{3}\right) + 4$

$= x - 4 + 4$

$= x$

f and *g* are inverses.

8. $f(x) = \dfrac{2}{x-5};\ g(x) = \dfrac{2}{x} + 5$

$f(g(x)) = \dfrac{2}{\left(\frac{2}{x} + 5\right) - 5} = \dfrac{2x}{2} = x$

$g(f(x)) = \dfrac{2}{\frac{2}{x-5}} + 5 = 2\left(\dfrac{x-5}{2}\right) + 5 = x - 5 + 5 = x$

f and *g* are inverses.

9. $f(x) = -x; g(x) = -x$
$f(g(x)) = -(-x) = x$
$g(f(x)) = -(-x) = x$
f and g are inverses.

10. $f(x) = \sqrt[3]{x-4}; g(x) = x^3 + 4$
$f\left(g(x)\right) = \sqrt[3]{x^3 + 4 - 4} = \sqrt[3]{x^3} = x$
$g\left(f(x)\right) = \left(\sqrt[3]{x-4}\right)^3 + 4 = x - 4 + 4 = x$
f and g are inverses.

11. a.
$f(x) = x + 3$
$y = x + 3$
$x = y + 3$
$y = x - 3$
$f^{-1}(x) = x - 3$

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

12. a.
$f(x) = x + 5$
$y = x + 5$
$x = y + 5$
$y = x - 5$
$f^{-1}(x) = x - 5$

b. $f\left(f^{-1}(x)\right) = x - 5 + 5 = x$
$f^{-1}\left(f(x)\right) = x + 5 - 5 = x$

13. a.
$f(x) = 2x$
$y = 2x$
$x = 2y$
$y = \frac{x}{2}$
$f^{-1}(x) = \frac{x}{2}$

b. $f(f^{-1}(x)) = 2\left(\frac{x}{2}\right) = x$
$f^{-1}(f(x)) = \frac{2x}{2} = x$

14. a.
$f(x) = 4x$
$y = 4x$
$x = 4y$
$y = \frac{x}{4}$
$f^{-1}(x) = \frac{x}{4}$

b. $f\left(f^{-1}(x)\right) = 4\left(\frac{x}{4}\right) = x$
$f^{-1}\left(f(x)\right) = \frac{4x}{4} = x$

15. a.
$f(x) = 2x + 3$
$y = 2x + 3$
$x = 2y + 3$
$x - 3 = 2y$
$y = \frac{x-3}{2}$
$f^{-1}(x) = \frac{x-3}{2}$

b. $f(f^{-1}(x)) = 2\left(\frac{x-3}{2}\right) + 3$
$= x - 3 + 3$
$= x$
$f^{-1}(f(x)) = \frac{2x + 3 - 3}{2} = \frac{2x}{2} = x$

16. a.
$f(x) = 3x - 1$
$y = 3x - 1$
$x = 3y - 1$
$x + 1 = 3y$
$y = \frac{x+1}{3}$
$f^{-1}(x) = \frac{x+1}{3}$

b. $f\left(f^{-1}(x)\right) = 3\left(\frac{x+1}{3}\right) - 1 = x + 1 - 1 = x$
$f^{-1}\left(f(x)\right) = \frac{3x - 1 + 1}{3} = \frac{3x}{3} = x$

17. a.

$$f(x) = x^3 + 2$$
$$y = x^3 + 2$$
$$x = y^3 + 2$$
$$x - 2 = y^3$$
$$y = \sqrt[3]{x-2}$$
$$f^{-1}(x) = \sqrt[3]{x-2}$$

b.

$$f(f^{-1}(x)) = \left(\sqrt[3]{x-2}\right)^3 + 2$$
$$= x - 2 + 2$$
$$= x$$
$$f^{-1}(f(x)) = \sqrt[3]{x^3 + 2 - 2} = \sqrt[3]{x^3} = x$$

18. a.

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

b.

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

19. a.

$$f(x) = (x+2)^3$$
$$y = (x+2)^3$$
$$x = (y+2)^3$$
$$\sqrt[3]{x} = y + 2$$
$$y = \sqrt[3]{x} - 2$$
$$f^{-1}(x) = \sqrt[3]{x} - 2$$

b.

$$f(f^{-1}(x)) = \left(\sqrt[3]{x} - 2 + 2\right)^3 = \left(\sqrt[3]{x}\right)^3 = x$$
$$f^{-1}(f(x)) = \sqrt[3]{(x+2)^3} - 2$$
$$= x + 2 - 2$$
$$= x$$

20. a.

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

b.

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

21. a.

$$f(x) = \frac{1}{x}$$
$$y = \frac{1}{x}$$
$$x = \frac{1}{y}$$
$$xy = 1$$
$$y = \frac{1}{x}$$
$$f^{-1}(x) = \frac{1}{x}$$

b.

$$f(f^{-1}(x)) = \frac{1}{\frac{1}{x}} = x$$
$$f^{-1}(f(x)) = \frac{1}{\frac{1}{x}} = x$$

22. a.

$$f(x) = \frac{2}{x}$$
$$y = \frac{2}{x}$$
$$x = \frac{2}{y}$$
$$xy = 2$$
$$y = \frac{2}{x}$$
$$f^{-1}(x) = \frac{2}{x}$$

b.

$$f(f^{-1}(x)) = \frac{2}{\frac{2}{x}} = 2 \cdot \frac{x}{2} = x$$
$$f^{-1}(f(x)) = \frac{2}{\frac{2}{x}} = 2 \cdot \frac{x}{2} = x$$

23. a.

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

b.

$$f(f^{-1}(x)) = \sqrt{x^2} = |x| = x \text{ for } x \geq 0.$$
$$f^{-1}(f(x)) = (\sqrt{x})^2 = x$$

24. a.

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

b.

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

25. a.

$$f(x) = \frac{7}{x} - 3$$
$$y = \frac{7}{x} - 3$$
$$x = \frac{7}{y} - 3$$
$$xy = 7 - 3y$$
$$xy + 3y = 7$$
$$y(x+3) = 7$$
$$y = \frac{7}{x+3}$$
$$f^{-1}(x) = \frac{7}{x+3}$$

b.

$$f\left(f^{-1}(x)\right) = \frac{7}{\frac{7}{x+3}} - 3 = x$$
$$f^{-1}\left(f(x)\right) = \frac{7}{\frac{7}{x} - 3 + 3} = x$$

26. a.

$$f(x) = \frac{4}{x} + 9$$
$$y = \frac{4}{x} + 9$$
$$x = \frac{4}{y} + 9$$
$$xy = 4 + 9y$$
$$xy - 9y = 4$$
$$y(x-9) = 4$$
$$y = \frac{4}{x-9}$$
$$f^{-1}(x) = \frac{4}{x-9}$$

b.

$$f\left(f^{-1}(x)\right) = \frac{4}{\frac{4}{x-9}} + 9 = x$$
$$f^{-1}\left(f(x)\right) = \frac{4}{\frac{4}{x} + 9 - 9} = x$$

27. a.

$$f(x) = \frac{2x+1}{x-3}$$
$$y = \frac{2x+1}{x-3}$$
$$x = \frac{2y+1}{y-3}$$
$$x(y-3) = 2y + 1$$
$$xy - 3x = 2y + 1$$
$$xy - 2y = 3x + 1$$
$$y(x-2) = 3x + 1$$
$$y = \frac{3x+1}{x-2}$$
$$f^{-1}(x) = \frac{3x+1}{x-2}$$

b.

$$f(f^{-1}(x)) = \frac{2\left(\frac{3x+1}{x-2}\right)+1}{\frac{3x+1}{x-2} - 3}$$
$$= \frac{2(3x+1) + x - 2}{3x + 1 - 3(x-2)} = \frac{6x + 2 + x - 2}{3x + 1 - 3x + 6}$$
$$= \frac{7x}{7} = x$$

$$f^{-1}(f(x)) = \frac{3\left(\frac{2x+1}{x-3}\right)+1}{\frac{2x+1}{x-3}-2}$$
$$= \frac{3(2x+1)+x-3}{2x+1-2(x-3)}$$
$$= \frac{6x+3+x-3}{2x+1-2x+6} = \frac{7x}{7} = x$$

28. **a.** $f(x) = \frac{2x-3}{x+1}$

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

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

$xy + x = 2y - 3$

$y(x-2) = -x-3$

$y = \frac{-x-3}{x-2}$

$f^{-1}(x) = \frac{-x-3}{x-2}, \quad x \neq 2$

b. $f\left(f^{-1}(x)\right) = \frac{2\left(\frac{-x-3}{x-2}\right)-3}{\frac{-x-3}{x-2}+1}$

$= \frac{-2x-6-3x+6}{-x-3+x-2} = \frac{-5x}{-5} = x$

$f^{-1}(f(x)) = \frac{-\left(\frac{2x-3}{x+1}\right)-3}{\frac{2x-3}{x+1}-2}$

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

29. The function fails the horizontal line test, so it does not have an inverse function.

30. The function passes the horizontal line test, so it does have an inverse function.

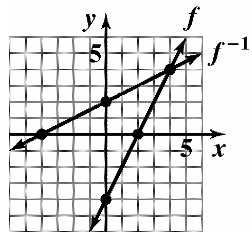
31. The function fails the horizontal line test, so it does not have an inverse function.

32. The function fails the horizontal line test, so it does not have an inverse function.

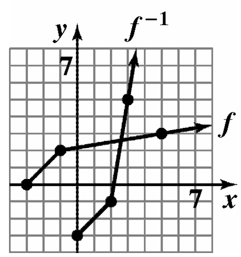
33. The function passes the horizontal line test, so it does have an inverse function.

34. The function passes the horizontal line test, so it does have an inverse function.

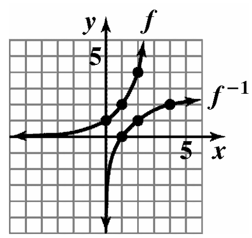
35.



36.



37.



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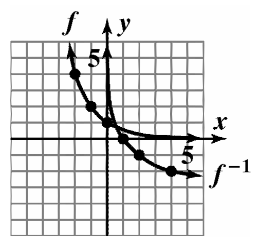


39. **a.** $f(x) = 2x-1$

$y = 2x-1$

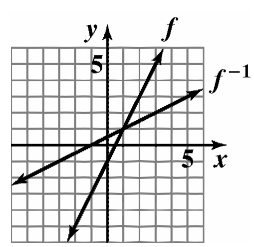
$x = 2y-1$

$x+1 = 2y$

$\frac{x+1}{2} = y$

$f^{-1}(x) = \frac{x+1}{2}$

b.



c. Domain of f: $(-\infty,\infty)$

Range of f: $(-\infty,\infty)$

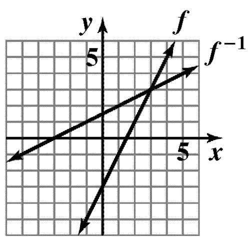
Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

40. a.

$$\begin{aligned} f(x) &= 2x-3 \\ y &= 2x-3 \\ x &= 2y-3 \\ x+3 &= 2y \\ \frac{x+3}{2} &= y \\ f^{-1}(x) &= \frac{x+3}{2} \end{aligned}$$

b.



c. Domain of f: $(-\infty,\infty)$

Range of f: $(-\infty,\infty)$

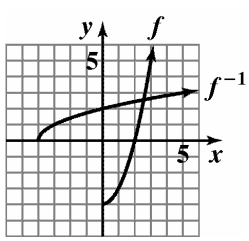
Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

41. a.

$$\begin{aligned} f(x) &= x^2-4 \\ y &= x^2-4 \\ x &= y^2-4 \\ x+4 &= y^2 \\ \sqrt{x+4} &= y \\ f^{-1}(x) &= \sqrt{x+4} \end{aligned}$$

b.



c. Domain of f: $[0,\infty)$

Range of f: $[-4,\infty)$

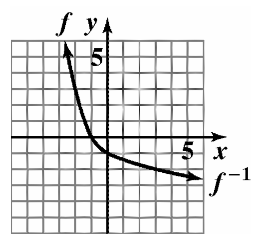
Domain of f^{-1}: $[-4,\infty)$

Range of f^{-1}: $[0,\infty)$

42. a.

$$\begin{aligned} f(x) &= x^2-1 \\ y &= x^2-1 \\ x &= y^2-1 \\ x+1 &= y^2 \\ -\sqrt{x+1} &= y \\ f^{-1}(x) &= -\sqrt{x+1} \end{aligned}$$

b.



c. Domain of f: $(-\infty,0]$

Range of f: $[-1,\infty)$

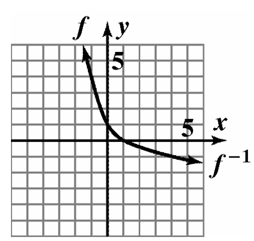
Domain of f^{-1}: $[-1,\infty)$

Range of f^{-1}: $(-\infty,0]$

43. a.

$$\begin{aligned} f(x) &= (x-1)^2 \\ y &= (x-1)^2 \\ x &= (y-1)^2 \\ -\sqrt{x} &= y-1 \\ -\sqrt{x}+1 &= y \\ f^{-1}(x) &= 1-\sqrt{x} \end{aligned}$$

b.



c. Domain of f: $(-\infty,1]$

Range of f: $[0,\infty)$

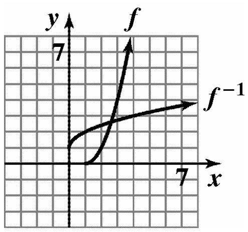
Domain of f^{-1}: $[0,\infty)$

Range of f^{-1}: $(-\infty,1]$

44. a.

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

b.



c. Domain of f : $[1,\infty)$

Range of f : $[0,\infty)$

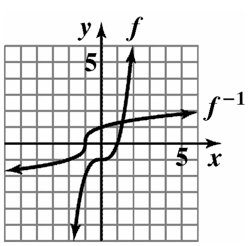
Domain of f^{-1}: $[0,\infty)$

Range of f^{-1}: $[1,\infty)$

45. a.

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

b.



c. Domain of f : $(-\infty,\infty)$

Range of f : $(-\infty,\infty)$

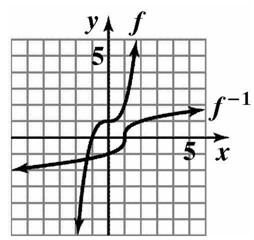
Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

46. a.

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

b.



c. Domain of f : $(-\infty,\infty)$

Range of f : $(-\infty,\infty)$

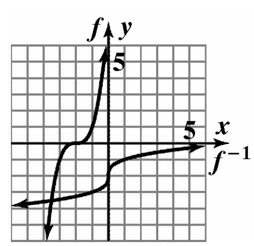
Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

47. a.

$$f(x) = (x+2)^3$$
$$y = (x+2)^3$$
$$x = (y+2)^3$$
$$\sqrt[3]{x} = y+2$$
$$\sqrt[3]{x}-2 = y$$
$$f^{-1}(x) = \sqrt[3]{x}-2$$

b.



c. Domain of f : $(-\infty,\infty)$

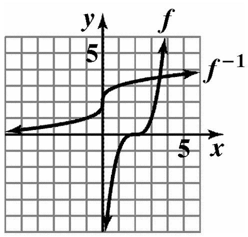
Range of f : $(-\infty,\infty)$

Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

48. **a.**
$$f(x) = (x-2)^3$$
$$y = (x-2)^3$$
$$x = (y-2)^3$$
$$\sqrt[3]{x} = y-2$$
$$\sqrt[3]{x}+2 = y$$
$$f^{-1}(x) = \sqrt[3]{x}+2$$

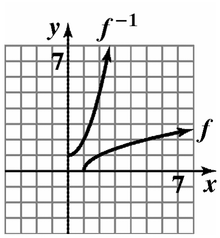
b.



c. Domain of f: $(-\infty,\infty)$
Range of f: $(-\infty,\infty)$
Domain of f^{-1}: $(-\infty,\infty)$
Range of f^{-1}: $(-\infty,\infty)$

49. **a.**
$$f(x) = \sqrt{x-1}$$
$$y = \sqrt{x-1}$$
$$x = \sqrt{y-1}$$
$$x^2 = y-1$$
$$x^2+1 = y$$
$$f^{-1}(x) = x^2+1$$

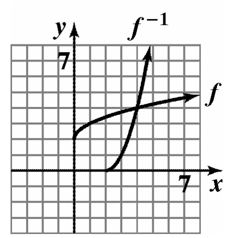
b.



c. Domain of f: $[1,\infty)$
Range of f: $[0,\infty)$
Domain of f^{-1}: $[0,\infty)$
Range of f^{-1}: $[1,\infty)$

50. **a.**
$$f(x) = \sqrt{x}+2$$
$$y = \sqrt{x}+2$$
$$x = \sqrt{y}+2$$
$$x-2 = \sqrt{y}$$
$$(x-2)^2 = y$$
$$f^{-1}(x) = (x-2)^2$$

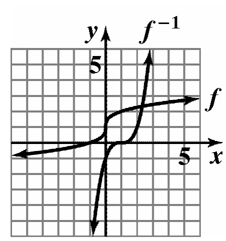
b.



c. Domain of f: $[0,\infty)$
Range of f: $[2,\infty)$
Domain of f^{-1}: $[2,\infty)$
Range of f^{-1}: $[0,\infty)$

51. **a.**
$$f(x) = \sqrt[3]{x}+1$$
$$y = \sqrt[3]{x}+1$$
$$x = \sqrt[3]{y}+1$$
$$x-1 = \sqrt[3]{y}$$
$$(x-1)^3 = y$$
$$f^{-1}(x) = (x-1)^3$$

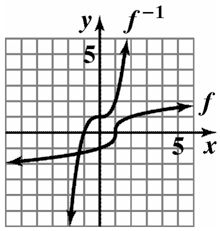
b.



c. Domain of f: $(-\infty,\infty)$
Range of f: $(-\infty,\infty)$
Domain of f^{-1}: $(-\infty,\infty)$
Range of f^{-1}: $(-\infty,\infty)$

52. **a.**
$$f(x)=\sqrt[3]{x-1}$$
$$y=\sqrt[3]{x-1}$$
$$x=\sqrt[3]{y-1}$$
$$x^3=y-1$$
$$x^3+1=y$$
$$f^{-1}(x)=x^3+1$$

b.



c. Domain of f: $(-\infty,\infty)$
Range of f: $(-\infty,\infty)$
Domain of f^{-1}: $(-\infty,\infty)$
Range of f^{-1}: $(-\infty,\infty)$

53. $f(g(1))=f(1)=5$

54. $f(g(4))=f(2)=-1$

55. $(g\circ f)(-1)=g(f(-1))=g(1)=1$

56. $(g\circ f)(0)=g(f(0))=g(4)=2$

57. $f^{-1}(g(10))=f^{-1}(-1)=2$, since $f(2)=-1$.

58. $f^{-1}(g(1))=f^{-1}(1)=-1$, since $f(-1)=1$.

59.
$$(f\circ g)(0)=f(g(0))$$
$$=f(4\cdot 0-1)$$
$$=f(-1)=2(-1)-5=-7$$

60.
$$(g\circ f)(0)=g(f(0))$$
$$=g(2\cdot 0-5)$$
$$=g(-5)=4(-5)-1=-21$$

61. Let $f^{-1}(1)=x$. Then
$$f(x)=1$$
$$2x-5=1$$
$$2x=6$$
$$x=3$$
Thus, $f^{-1}(1)=3$

62. Let $g^{-1}(7)=x$. Then
$$g(x)=7$$
$$4x-1=7$$
$$4x=8$$
$$x=2$$
Thus, $g^{-1}(7)=2$

63.
$$g(f[h(1)])=g(f[1^2+1+2])$$
$$=g(f(4))$$
$$=g(2\cdot 4-5)$$
$$=g(3)$$
$$=4\cdot 3-1=11$$

64.
$$f(g[h(1)])=f(g[1^2+1+2])$$
$$=f(g(4))$$
$$=f(4\cdot 4-1)$$
$$=f(15)$$
$$=2\cdot 15-5=25$$

65. **a.** {(Zambia, −7.3), (Colombia, −4.5), (Poland, −2.8), (Italy, −2.8), (United States, −1.9)}

b. {(−7.3, Zambia), (−4.5, Colombia), (−2.8, Poland), (−2.8, Italy), (−1.9, United States)} This relation is not a function because –2.8 corresponds to two elements in the range.

66. **a.** {(China, 251), (Japan, 243), (Korea, 220), (Israel, 215), (Germany, 210), (Russia, 210)}

b. {(251, China), (243, Japan), (220, Korea), (215, Israel), (210, Germany), (210, Russia)} No; 210 in the domain corresponds to two members of the range, Germany and Russia.

67. **a.** It passes the horizontal line test and is one-to-one.

b. $f^{-1}(0.25) = 15$ If there are 15 people in the room, the probability that 2 of them have the same birthday is 0.25.
$f^{-1}(0.5) = 21$ If there are 21 people in the room, the probability that 2 of them have the same birthday is 0.5.
$f^{-1}(0.7) = 30$ If there are 30 people in the room, the probability that 2 of them have the same birthday is 0.7.

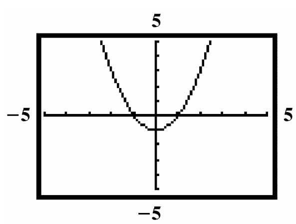
68. **a.** This function fails the horizontal line test. Thus, this function does not have an inverse.

b. The average happiness level is 3 at 12 noon and at 7 p.m. These values can be represented as $(12,3)$ and $(19,3)$.

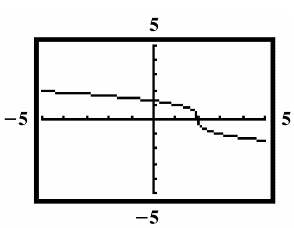
c. The graph does not represent a one-to-one function. $(12,3)$ and $(19,3)$ are an example of two *x*-values that correspond to the same *y*-value.

69.
$$\begin{aligned} f(g(x)) &= \frac{9}{5}\left[\frac{5}{9}(x-32)\right]+32 \\ &= x-32+32 \\ &= x \end{aligned}$$

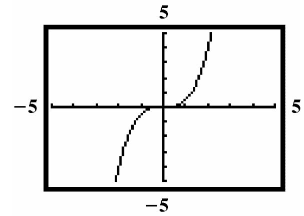
f and *g* are inverses.

76.


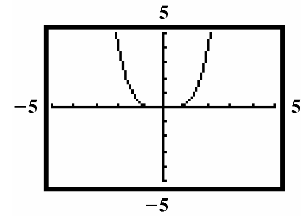
not one-to-one

77.


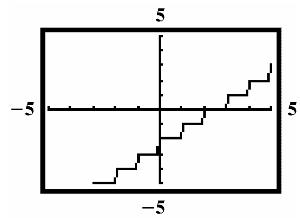
one-to-one

78.


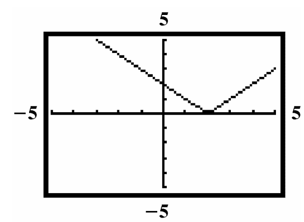
one-to-one

79.


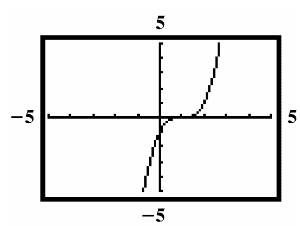
not one-to-one

80.


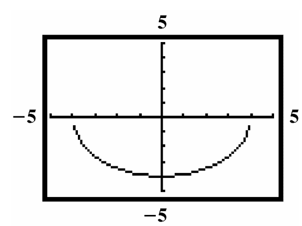
not one-to-one

81.


not one-to-one

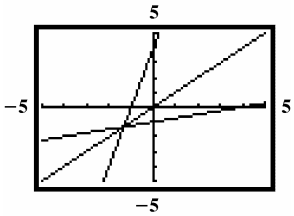
82.


one-to-one

83.


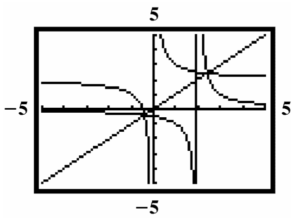
not one-to-one

84.



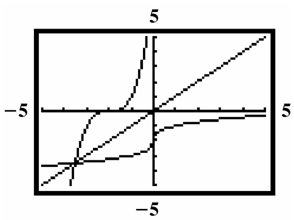
f and g are inverses

85.



f and g are inverses

86.



f and g are inverses

87. **a.** False. The inverse is $\{(4,1), (7,2)\}$.

b. False. $f(x) = 5$ is a horizontal line, so it does not pass the horizontal line test.

c. False. $f^{-1}(x) = \frac{x}{3}$.

d. True. The domain of f is the range of f^{-1} and the range of f is the domain of f^{-1}.

(d) is true.

88. $(f \circ g)(x) = 3(x+5) = 3x+15.$

$$y = 3x+15$$
$$x = 3y+15$$
$$y = \frac{x-15}{3}$$
$$\left(f \circ g\right)^{-1}(x) = \frac{x-15}{3}$$
$$g(x) = x+5$$
$$y = x+5$$
$$x = y+5$$
$$y = x-5$$
$$g^{-1}(x) = x-5$$
$$f(x) = 3x$$
$$y = 3x$$
$$x = 3y$$
$$y = \frac{x}{3}$$
$$f^{-1}(x) = \frac{x}{3}$$
$$\left(g^{-1} \circ f^{-1}\right)(x) = \frac{x}{3} - 5 = \frac{x-15}{3}$$

89.

$$f(x) = \frac{3x-2}{5x-3}$$
$$y = \frac{3x-2}{5x-3}$$
$$x = \frac{3y-2}{5y-3}$$
$$x(5y-3) = 3y-2$$
$$5xy-3x = 3y-2$$
$$5xy-3y = 3x-2$$
$$y(5x-3) = 3x-2$$
$$y = \frac{3x-2}{5x-3}$$
$$f^{-1}(x) = \frac{3x-2}{5x-3}$$

Note: An alternative approach is to show that $(f \circ f)(x) = x.$

90. No, there will be 2 times when the spacecraft is at the same height, when it is going up and when it is coming down.

91. $8 + f^{-1}(x-1) = 10$

$$f^{-1}(x-1) = 2$$
$$f(2) = x-1$$
$$6 = x-1$$
$$7 = x$$
$$x = 7$$

Section 1.9

Check Point Exercises

1. $d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$d=\sqrt{(1-(-4))^2+(-3-9)^2}$

$=\sqrt{(5)^2+(-12)^2}$

$=\sqrt{25+144}$

$=\sqrt{169}$

$=13$

2. $\left(\frac{1+7}{2},\frac{2+(-3)}{2}\right)=\left(\frac{8}{2},\frac{-1}{2}\right)=\left(4,-\frac{1}{2}\right)$

3. $h=0,\ k=0,\ r=4;$

$(x-0)^2+(y-0)^2=4^2$

$x^2+y^2=16$

4. $h=5,\ k=-6,\ r=10;$

$(x-5)^2+[y-(-6)]^2=10^2$

$(x-5)^2+(y+6)^2=100$

5. **a.** $(x+3)^2+(y-1)^2=4$

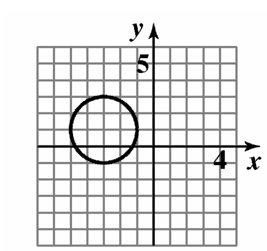
$[x-(-3)]^2+(y-1)^2=2^2$

So in the standard form of the circle's equation $(x-h)^2+(y-k)^2=r^2$, we have $h=-3,\ k=1,\ r=2.$

center: $(h,\ k)=(-3,\ 1)$

radius: $r=2$

b.



$(x+3)^2+(y-1)^2=4$

c. Domain: $[-5,-1]$

Range: $[-1,3]$

6. $x^2+y^2+4x-4y-1=0$

$x^2+y^2+4x-4y-1=0$

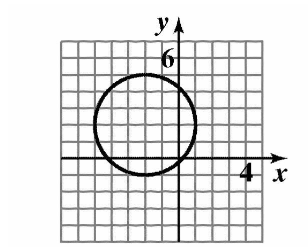
$(x^2+4x\quad)+(y^2-4y\quad)=0$

$(x^2+4x+4)+(y^2+4y+4)=1+4+4$

$(x+2)^2+(y-2)^2=9$

$[x-(-x)]^2+(y-2)^2=3^2$

So in the standard form of the circle's equation $(x-h)^2+(y-k)^2=r^2$, we have $h=-2,\ k=2,\ r=3$.



$x^2+y^2+4x-4y-1=0$

Exercise Set 1.9

1. $d=\sqrt{(14-2)^2+(8-3)^2}$

$=\sqrt{12^2+5^2}$

$=\sqrt{144+25}$

$=\sqrt{169}$

$=13$

2. $d=\sqrt{(8-5)^2+(5-1)^2}$

$=\sqrt{3^2+4^2}$

$=\sqrt{9+16}$

$=\sqrt{25}$

$=5$

3. $d=\sqrt{(-6-4)^2+(3-(-1))^2}$

$=\sqrt{(-10)^2+(4)^2}$

$=\sqrt{100+16}$

$=\sqrt{116}$

$=2\sqrt{29}$

≈ 10.77

4. $d=\sqrt{\left(-1-2\right)^2+\left(5-(-3)\right)^2}$
$=\sqrt{\left(-3\right)^2+\left(8\right)^2}$
$=\sqrt{9+64}$
$=\sqrt{73}$
≈ 8.54

5. $d=\sqrt{(-3-0)^2+(4-0)^2}$
$=\sqrt{3^2+4^2}$
$=\sqrt{9+16}$
$=\sqrt{25}$
$=5$

6. $d=\sqrt{(3-0)^2+\left(-4-0\right)^2}$
$=\sqrt{3^2+\left(-4\right)^2}$
$=\sqrt{9+16}$
$=\sqrt{25}$
$=5$

7. $d=\sqrt{[3-(-2)]^2+[-4-(-6)]^2}$
$=\sqrt{5^2+2^2}$
$=\sqrt{25+4}$
$=\sqrt{29}$
≈ 5.39

8. $d=\sqrt{[2-(-4)]^2+[-3-(-1)]^2}$
$=\sqrt{6^2+\left(-2\right)^2}$
$=\sqrt{36+4}$
$=\sqrt{40}$
$=2\sqrt{10}$
≈ 6.32

9. $d=\sqrt{(4-0)^2+[1-(-3)]^2}$
$=\sqrt{4^2+4^2}$
$=\sqrt{16+16}$
$=\sqrt{32}$
$=4\sqrt{2}$
≈ 5.66

10. $d=\sqrt{\left(4-0\right)^2+[3-\left(-2\right)]^2}$
$=\sqrt{4^2+[3+2]^2}$
$=\sqrt{16+5^2}$
$=\sqrt{16+25}$
$=\sqrt{41}$
≈ 6.40

11. $d=\sqrt{(-.5-3.5)^2+(6.2-8.2)^2}$
$=\sqrt{(-4)^2+(-2)^2}$
$=\sqrt{16+4}$
$=\sqrt{20}$
$=2\sqrt{5}$
≈ 4.47

12. $d=\sqrt{(1.6-2.6)^2+\left(-5.7-1.3\right)^2}$
$=\sqrt{\left(-1\right)^2+\left(-7\right)^2}$
$=\sqrt{1+49}$
$=\sqrt{50}$
$=5\sqrt{2}$
≈ 7.07

13. $d=\sqrt{(\sqrt{5}-0)^2+[0-(-\sqrt{3})]^2}$
$=\sqrt{(\sqrt{5})^2+(\sqrt{3})^2}$
$=\sqrt{5+3}$
$=\sqrt{8}$
$=2\sqrt{2}$
≈ 2.83

14. $d=\sqrt{\left(\sqrt{7}-0\right)^2+\left[0-\left(-\sqrt{2}\right)\right]^2}$
$=\sqrt{\left(\sqrt{7}\right)^2+\left[-\sqrt{2}\right]^2}$
$=\sqrt{7+2}$
$=\sqrt{9}$
$=3$

15. $d=\sqrt{(-\sqrt{3}-3\sqrt{3})^2+(4\sqrt{5}-\sqrt{5})^2}$
$=\sqrt{(-4\sqrt{3})^2+(3\sqrt{5})^2}$
$=\sqrt{16(3)+9(5)}$
$=\sqrt{48+45}$
$=\sqrt{93}$
≈ 9.64

16. $d=\sqrt{\left(-\sqrt{3}-2\sqrt{3}\right)^2+\left(5\sqrt{6}-\sqrt{6}\right)^2}$
$=\sqrt{\left(-3\sqrt{3}\right)^2+\left(4\sqrt{6}\right)^2}$
$=\sqrt{9\cdot 3+16\cdot 6}$
$=\sqrt{27+96}$
$=\sqrt{123}$
≈ 11.09

17. $d=\sqrt{\left(\frac{1}{3}-\frac{7}{3}\right)^2+\left(\frac{6}{5}-\frac{1}{5}\right)^2}$
$=\sqrt{(-2)^2+1^2}$
$=\sqrt{4+1}$
$=\sqrt{5}$
≈ 2.24

18. $d=\sqrt{\left[\frac{3}{4}-\left(-\frac{1}{4}\right)\right]^2+\left[\frac{6}{7}-\left(-\frac{1}{7}\right)\right]^2}$
$=\sqrt{\left(\frac{3}{4}+\frac{1}{4}\right)^2+\left[\frac{6}{7}+\frac{1}{7}\right]^2}$
$=\sqrt{1^2+1^2}$
$=\sqrt{2}$
≈ 1.41

19. $\left(\frac{6+2}{2},\frac{8+4}{2}\right)=\left(\frac{8}{2},\frac{12}{2}\right)=(4,6)$

20. $\left(\frac{10+2}{2},\frac{4+6}{2}\right)=\left(\frac{12}{2},\frac{10}{2}\right)=(6,5)$

21. $\left(\frac{-2+(-6)}{2},\frac{-8+(-2)}{2}\right)$
$=\left(\frac{-8}{2},\frac{-10}{2}\right)=(-4,-5)$

22. $\left(\frac{-4+(-1)}{2},\frac{-7+(-3)}{2}\right)=\left(\frac{-5}{2},\frac{-10}{2}\right)$
$=\left(\frac{-5}{2},-5\right)$

23. $\left(\frac{-3+6}{2},\frac{-4+(-8)}{2}\right)$
$=\left(\frac{3}{2},\frac{-12}{2}\right)=\left(\frac{3}{2},-6\right)$

24. $\left(\frac{-2+(-8)}{2}\frac{-1+6}{2}\right)=\left(\frac{-10}{2},\frac{5}{2}\right)=\left(-5,\frac{5}{2}\right)$

25. $\left(\frac{\frac{-7}{2}+\left(-\frac{5}{2}\right)}{2},\frac{\frac{3}{2}+\left(-\frac{11}{2}\right)}{2}\right)$
$=\left(\frac{\frac{-12}{2}}{2},\frac{\frac{-8}{2}}{2}\right)=\left(-\frac{6}{2},\frac{-4}{2}\right)=(-3,-2)$

26. $\left(\frac{-\frac{2}{5}+\left(-\frac{2}{5}\right)}{2},\frac{\frac{7}{15}+\left(-\frac{4}{15}\right)}{2}\right)=\left(\frac{-\frac{4}{5}}{2},\frac{\frac{3}{15}}{2}\right)$
$=\left(-\frac{4}{5}\cdot\frac{1}{2},\frac{3}{15}\cdot\frac{1}{2}\right)=\left(-\frac{2}{5},\frac{1}{10}\right)$

27. $\left(\frac{8+(-6)}{2},\frac{3\sqrt{5}+7\sqrt{5}}{2}\right)$
$=\left(\frac{2}{2},\frac{10\sqrt{5}}{2}\right)=\left(1,5\sqrt{5}\right)$

28. $\left(\frac{7\sqrt{3}+3\sqrt{3}}{2},\frac{-6+(-2)}{2}\right)=\left(\frac{10\sqrt{3}}{2},\frac{-8}{2}\right)$
$=\left(5\sqrt{3},-4\right)$

29. $\left(\frac{\sqrt{18}+\sqrt{2}}{2}, \frac{-4+4}{2}\right)$
$= \left(\frac{3\sqrt{2}+\sqrt{2}}{2}, \frac{0}{2}\right) = \left(\frac{4\sqrt{2}}{2}, 0\right) = (2\sqrt{2}, 0)$

30. $\left(\frac{\sqrt{50}+\sqrt{2}}{2}, \frac{-6+6}{2}\right) = \left(\frac{5\sqrt{2}+\sqrt{2}}{2}, \frac{0}{2}\right)$
$= \left(\frac{6\sqrt{2}}{2}, 0\right) = \left(3\sqrt{2}, 0\right)$

31. $(x-0)^2 + (y-0)^2 = 7^2$
$x^2 + y^2 = 49$

32. $(x-0)^2 + (y-0)^2 = 8^2$
$x^2 + y^2 = 64$

33. $(x-3)^2 + (y-2)^2 = 5^2$
$(x-3)^2 + (y-2)^2 = 25$

34. $(x-2)^2 + [y-(-1)]^2 = 4^2$
$(x-2)^2 + (y+1)^2 = 16$

35. $[x-(-1)]^2 + (y-4)^2 = 2^2$
$(x+1)^2 + (y-4)^2 = 4$

36. $[x-(-3)]^2 + (y-5)^2 = 3^2$
$(x+3)^2 + (y-5)^2 = 9$

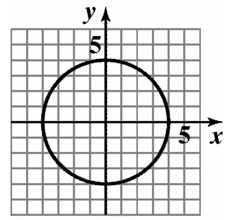
37. $[x-(-3)]^2 + [y-(-1)]^2 = \left(\sqrt{3}\right)^2$
$(x+3)^2 + (y+1)^2 = 3$

38. $[x-(-5)]^2 + [y-(-3)]^2 = \left(\sqrt{5}\right)^2$
$(x+5)^2 + (y+3)^2 = 5$

39. $[x-(-4)]^2 + (y-0)^2 = 10^2$
$(x+4)^2 + (y-0)^2 = 100$

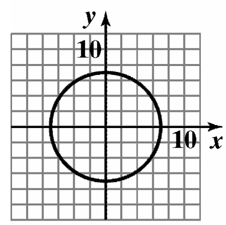
40. $[x-(-2)]^2 + (y-0)^2 = 6^2$
$(x+2)^2 + y^2 = 36$

41. $x^2 + y^2 = 16$
$(x-0)^2 + (y-0)^2 = y^2$
$h = 0,\ k = 0,\ r = 4;$
center = (0, 0); radius = 4



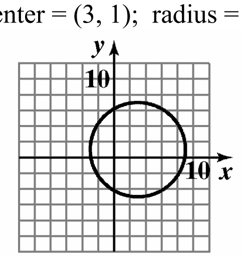
$x^2 + y^2 = 16$
Domain: $[-4, 4]$
Range: $[-4, 4]$

42. $x^2 + y^2 = 49$
$(x-0)^2 + (y-0)^2 = 7^2$
$h = 0, k = 0, r = 7;$
center = (0, 0); radius = 7



$x^2 + y^2 = 49$
Domain: $[-7, 7]$
Range: $[-7, 7]$

43. $(x-3)^2 + (y-1)^2 = 36$
$(x-3)^2 + (y-1)^2 = 6^2$
$h = 3,\ k = 1,\ r = 6;$
center = (3, 1); radius = 6



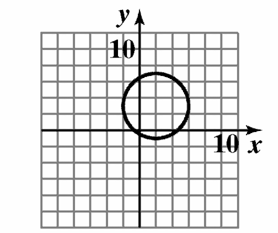
$(x - 3)^2 + (y - 1)^2 = 36$
Domain: $[-3, 9]$
Range: $[-5, 7]$

44. $(x-2)^2+(y-3)^2=16$

$(x-2)^2+(y-3)^2=4^2$

$h=2, k=3, r=4;$

center = (2, 3); radius = 4



$\mathbf{(x-2)^2+(y-3)^2=16}$

Domain: $[-2,6]$

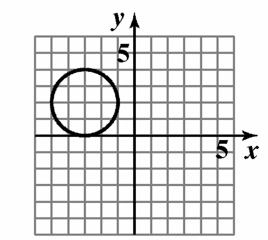
Range: $[-1,7]$

45. $(x+3)^2+(y-2)^2=4$

$[x-(-3)]^2+(y-2)^2=2^2$

$h=-3,\ k=2,\ r=2$

center = (–3, 2); radius = 2



$\mathbf{(x+3)^2+(y-2)^2=4}$

Domain: $[-5,-1]$

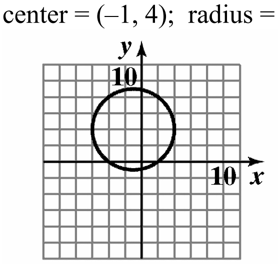
Range: $[0,4]$

46. $(x+1)^2+(y-4)^2=25$

$[x-(-1)]^2+(y-4)^2=5^2$

$h=-1, k=4, r=5;$

center = (–1, 4); radius = 5



$\mathbf{(x+1)^2+(y-4)^2=25}$

Domain: $[-6,4]$

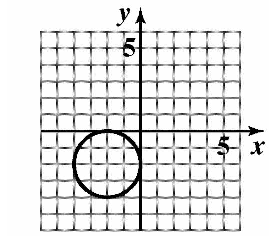
Range: $[-1,9]$

47. $(x+2)^2+(y+2)^2=4$

$[x-(-2)]^2+[y-(-2)]^2=2^2$

$h=-2,\ k=-2,\ r=2$

center = (–2, –2); radius = 2



$\mathbf{(x+2)^2+(y+2)^2=4}$

Domain: $[-4,0]$

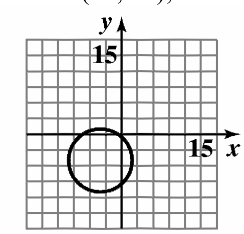
Range: $[-4,0]$

48. $(x+4)^2+(y+5)^2=36$

$[x-(-4)]^2+[y-(-5)]^2=6^2$

$h=-4, k-5, r=6;$

center = (–4, –5); radius = 6



$\mathbf{(x+4)^2+(y+5)^2=36}$

Domain: $[-10,2]$

Range: $[-11,1]$

49. $x^2+y^2+6x+2y+6=0$

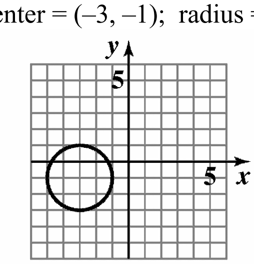
$(x^2+6x)+(y^2+2y)=-6$

$(x^2+6x+9)+(y^2+2y+1)=9+1-6$

$(x+3)^2+(y+1)^2=4$

$[x-(-3)]^2+[9-(-1)]^2=2^2$

center = (–3, –1); radius = 2

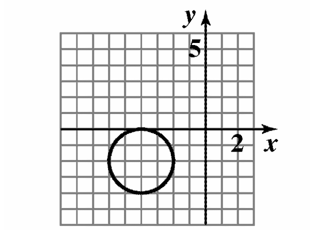


$\mathbf{x^2+y^2+6x+2y+6=0}$

50.

$$x^2+y^2+8x+4y+16=0$$
$$\left(x^2+8x\right)+\left(y^2+4y\right)=-16$$
$$\left(x^2+8x+16\right)+\left(y^2+4y+4\right)=20-16$$
$$\left(x+4\right)^2+\left(y+2\right)^2=4$$
$$\left[x-(-4)\right]^2+\left[y-(-2)\right]^2=2^2$$

center = (–4, –2); radius = 2

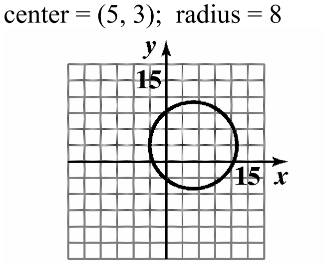


$\boldsymbol{x^2+y^2+8x+4y+16=0}$

51.

$$x^2+y^2-10x-6y-30=0$$
$$\left(x^2-10x\right)+\left(y^2-6y\right)=30$$
$$\left(x^2-10x+25\right)+\left(y^2-6y+9\right)=25+9+30$$
$$\left(x-5\right)^2+\left(y-3\right)^2=64$$
$$(x-5)^2+(y-3)^2=8^2$$

center = (5, 3); radius = 8

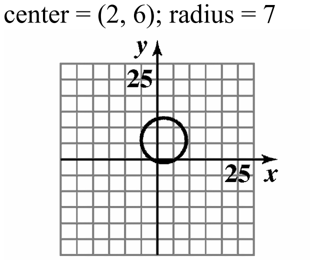


$\boldsymbol{x^2+y^2-10x-6y-30=0}$

52.

$$x^2+y^2-4x-12y-9=0$$
$$\left(x^2-4x\right)+\left(y^2-12y\right)=9$$
$$\left(x^2-4x+4\right)+\left(y^2-12y+36\right)=4+36+9$$
$$\left(x-2\right)^2+\left(y-6\right)^2=49$$
$$(x-2)^2+(y-6)^2=7^2$$

center = (2, 6); radius = 7

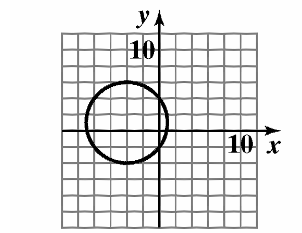


$\boldsymbol{x^2+y^2-4x-12y-9=0}$

53.

$$x^2+y^2+8x-2y-8=0$$
$$\left(x^2+8x\right)+\left(y^2-2y\right)=8$$
$$\left(x^2+8x+16\right)+\left(y^2-2y+1\right)=16+1+8$$
$$\left(x+4\right)^2+\left(y-1\right)^2=25$$
$$\left[x-(-4)\right]^2+(y-1)^2=5^2$$

center = (–4, 1); radius = 5

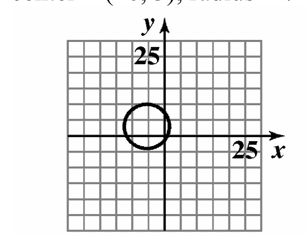


$\boldsymbol{x^2+y^2+8x-2y-8=0}$

54.

$$x^2+y^2+12x-6y-4=0$$
$$\left(x^2+12x\right)+\left(y^2-6y\right)=4$$
$$\left(x^2+12x+36\right)+\left(y^2-6y+9\right)=36+9+4$$
$$\left[x-(-6)\right]^2+\left(y-3\right)^2=7^2$$

center = (–6, 3); radius = 7

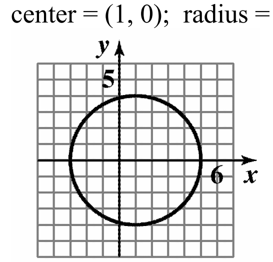


$\boldsymbol{x^2+y^2+12x-6y-4=0}$

55.

$$x^2-2x+y^2-15=0$$
$$\left(x^2-2x\right)+y^2=15$$
$$\left(x^2-2x+1\right)+\left(y-0\right)^2=1+0+15$$
$$\left(x-1\right)^2+\left(y-0\right)^2=16$$
$$\left(x-1\right)^2+\left(y-0\right)^2=4^2$$

center = (1, 0); radius = 4



$\boldsymbol{x^2-2x+y^2-15=0}$

56. $x^2 + y^2 - 6y - 7 = 0$

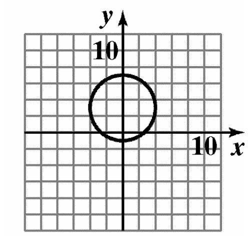
$x^2 + (y^2 - 6y) = 7$

$(x-0)^2 = (y^2 - 6y + 9) = 0 + 9 + 7$

$(x-0)^2 + (y-3)^2 = 16$

$(x-0)^2 + (y-3)^2 = 4^2$

center = (0, 3); radius = 4



$\mathbf{x^2 + y^2 - 6y - 7 = 0}$

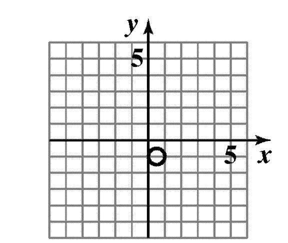
57. $x^2 + y^2 - x + 2y + 1 = 0$

$x^2 - x \quad + y^2 + 2y \quad = -1$

$x^2 - x + \frac{1}{4} + y^2 + 2y + 1 = -1 + \frac{1}{4} + 1$

$\left(x - \frac{1}{2}\right)^2 + (y+1)^2 = \frac{1}{4}$

center = $\left(\frac{1}{2}, -1\right)$; radius = $\frac{1}{2}$



$\mathbf{x^2 + y^2 - x + 2y + 1 = 0}$

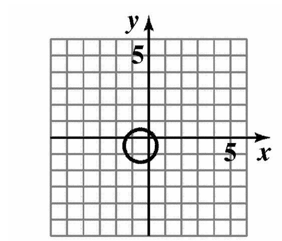
58. $x^2 + y^2 + x + y - \frac{1}{2} = 0$

$x^2 + x \quad + y^2 + y \quad = \frac{1}{2}$

$x^2 + x + \frac{1}{4} + y^2 + y + \frac{1}{4} = \frac{1}{2} + \frac{1}{4} + \frac{1}{4}$

$\left(x - \frac{1}{2}\right)^2 + \left(y - \frac{1}{2}\right)^2 = 1$

center = $\left(\frac{1}{2}, \frac{1}{2}\right)$; radius = 1



$\mathbf{x^2 + y^2 + x + y - \frac{1}{2} = 0}$

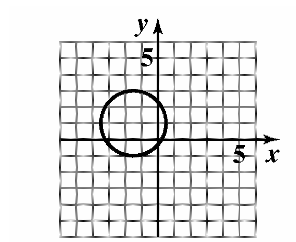
59. $x^2 + y^2 + 3x - 2y - 1 = 0$

$x^2 + 3x \quad + y^2 - 2y \quad = 1$

$x^2 + 3x + \frac{9}{4} + y^2 - 2y + 1 = 1 + \frac{9}{4} + 1$

$\left(x + \frac{3}{2}\right)^2 + (y-1)^2 = \frac{17}{4}$

center = $\left(-\frac{3}{2}, 1\right)$; radius = $\frac{\sqrt{17}}{2}$



$\mathbf{x^2 + y^2 + 3x - 2y - 1 = 0}$

60.

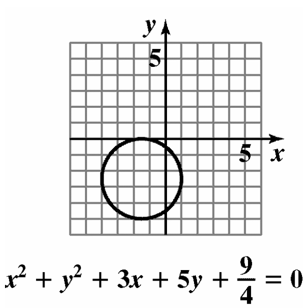
$$x^2 + y^2 + 3x + 5y + \frac{9}{4} = 0$$

$$x^2 + 3x \quad + y^2 + 5y \quad = -\frac{9}{4}$$

$$x^2 + 3x + \frac{9}{4} + y^2 + 5y + \frac{25}{4} = -\frac{9}{4} + \frac{9}{4} + \frac{25}{4}$$

$$\left(x + \frac{3}{2}\right)^2 + \left(y + \frac{5}{2}\right)^2 = \frac{25}{4}$$

center = $\left(-\frac{3}{2}, -\frac{5}{2}\right)$; radius = $\frac{5}{2}$



61. a. Since the line segment passes through the center, the center is the midpoint of the segment.

$$M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

$$= \left(\frac{3+7}{2}, \frac{9+11}{2}\right) = \left(\frac{10}{2}, \frac{20}{2}\right)$$

$$= (5, 10)$$

The center is $(5, 10)$.

b. The radius is the distance from the center to one of the points on the circle. Using the point $(3, 9)$, we get:

$$d = \sqrt{(5-3)^2 + (10-9)^2}$$

$$= \sqrt{2^2 + 1^2} = \sqrt{4+1}$$

$$= \sqrt{5}$$

The radius is $\sqrt{5}$ units.

c.

$$(x-5)^2 + (y-10)^2 = \left(\sqrt{5}\right)^2$$

$$(x-5)^2 + (y-10)^2 = 5$$

62. a. Since the line segment passes through the center, the center is the midpoint of the segment.

$$M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

$$= \left(\frac{3+5}{2}, \frac{6+4}{2}\right) = \left(\frac{8}{2}, \frac{10}{2}\right)$$

$$= (4, 5)$$

The center is $(4, 5)$.

b. The radius is the distance from the center to one of the points on the circle. Using the point $(3, 6)$, we get:

$$d = \sqrt{(4-3)^2 + (5-6)^2}$$

$$= \sqrt{1^2 + (-1)^2} = \sqrt{1+1}$$

$$= \sqrt{2}$$

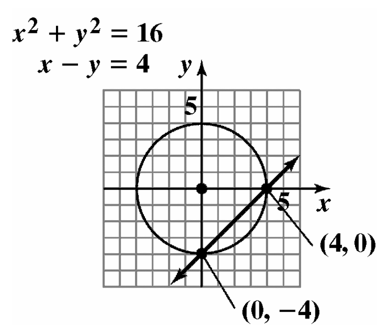
The radius is $\sqrt{2}$ units.

c.

$$(x-4)^2 + (y-5)^2 = \left(\sqrt{2}\right)^2$$

$$(x-4)^2 + (y-5)^2 = 2$$

63.



Intersection points: $(0, -4)$ and $(4, 0)$

Check $(0, -4)$:

$0^2 + (-4)^2 = 16$ $\quad$ $0 - (-4) = 4$

$16 = 16$ true $\quad$ $4 = 4$ true

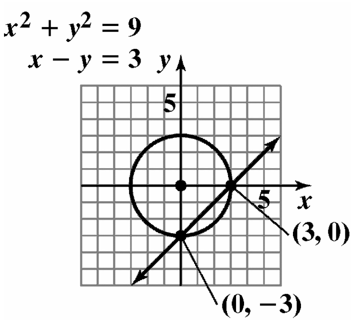
Check $(4, 0)$:

$4^2 + 0^2 = 16$ $\quad$ $4 - 0 = 4$

$16 = 16$ true $\quad$ $4 = 4$ true

The solution set is $\{(0, -4), (4, 0)\}$.

64.



Intersection points: $(0,-3)$ and $(3,0)$

Check $(0,-3)$:

$0^2+(-3)^2=9 \qquad 0-(-3)=3$

$9=9$ true $\qquad 3=3$ true

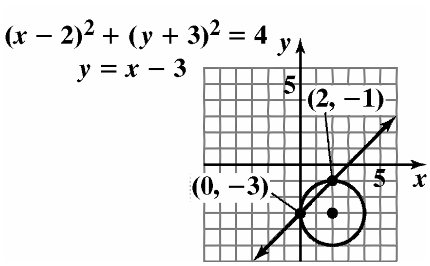
Check $(3,0)$:

$3^2+0^2=9 \qquad 3-0=3$

$9=9$ true $\qquad 3=3$ true

The solution set is $\{(0,-3),(3,0)\}$.

65.



Intersection points: $(0,-3)$ and $(2,-1)$

Check $(0,-3)$:

$(0-2)^2+(-3+3)^2=9 \qquad -3=0-3$

$(-2)^2+0^2=4 \qquad -3=-3$ true

$4=4$

true

Check $(2,-1)$:

$(2-2)^2+(-1+3)^2=4 \qquad -1=2-3$

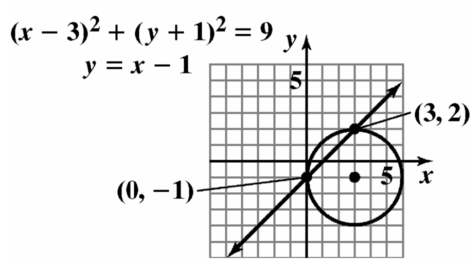
$0^2+2^2=4 \qquad -1=-1$ true

$4=4$

true

The solution set is $\{(0,-3),(2,-1)\}$.

66.



Intersection points: $(0,-1)$ and $(3,2)$

Check $(0,-1)$:

$(0-3)^2+(-1+1)^2=9 \qquad -1=0-1$

$(-3)^2+0^2=9 \qquad -1=-1$ true

$9=9$

true

Check $(3,2)$:

$(3-3)^2+(2+1)^2=9 \qquad 2=3-1$

$0^2+3^2=9 \qquad 2=2$ true

$9=9$

true

The solution set is $\{(0,-1),(3,2)\}$.

67.

$$d=\sqrt{[65-(-115)]^2+(70-170)^2}$$
$$d=\sqrt{(65+115)^2+(-100)^2}$$
$$d=\sqrt{180^2+10000}$$
$$d=\sqrt{32400+10000}$$
$$d=\sqrt{42400}$$
$$d=205.9 \text{ miles}$$
$$\frac{205.9 \text{ miles}}{400}=0.5 \text{ hours or 30 minutes}$$

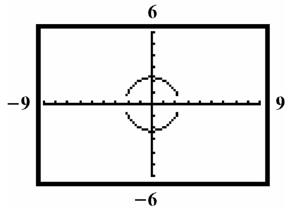
68. $C(0, 68+14)=(0, 82)$

$$(x-0)^2+(y-82)^2=68^2$$
$$x^2+(y-82)^2=4624$$

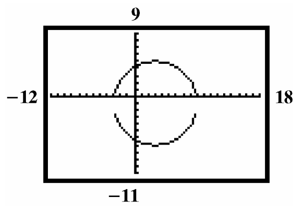
69. If we place L.A. at the origin, then we want the equation of a circle with center at $(-2.4,-2.7)$ and radius 30.

$$\left(x-(-2.4)\right)^2+\left(y-(-2.7)\right)^2=30^2$$
$$(x+2.4)^2+(y+2.7)^2=900$$

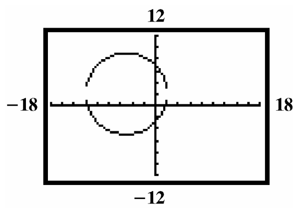
77.



78.



79.



80. **a.** False; the equation should be $x^2 + y^2 = 256$.

b. False; the center is at (3, –5).

c. False; this is not an equation for a circle.

d. True

(d) is true.

81. The distance for A to B:

$$\overline{AB} = \sqrt{(3-1)^2 + [3+d-(1+d)]^2}$$
$$= \sqrt{2^2 + 2^2}$$
$$= \sqrt{4+4}$$
$$= \sqrt{8}$$
$$= 2\sqrt{2}$$

The distance from B to C:

$$\overline{BC} = \sqrt{(6-3)^2 + [3+d-(6+d)]^2}$$
$$= \sqrt{3^2 + (-3)^2}$$
$$= \sqrt{9+9}$$
$$= \sqrt{18}$$
$$= 3\sqrt{2}$$

The distance for A to C:

$$\overline{AC} = \sqrt{(6-1)^2 + [6+d-(1+d)]^2}$$
$$= \sqrt{5^2 + 5^2}$$
$$= \sqrt{25+25}$$
$$= \sqrt{50}$$
$$= 5\sqrt{2}$$
$$\overline{AB} + \overline{BC} = \overline{AC}$$
$$2\sqrt{2} + 3\sqrt{2} = 5\sqrt{2}$$
$$5\sqrt{2} = 5\sqrt{2}$$

82. **a.** d_1 is distance from (x_1, x_2) to midpoint

$$d_1 = \sqrt{\left(\frac{x_1 + x_2}{2} - x_1\right)^2 + \left(\frac{y_1 + y_2}{2} - y_1\right)^2}$$
$$d_1 = \sqrt{\left(\frac{x_1 + x_2 - 2x_1}{2}\right)^2 + \left(\frac{y_1 + y_2 - 2y_1}{2}\right)^2}$$
$$d_1 = \sqrt{\left(\frac{x_2 - x_1}{2}\right)^2 + \left(\frac{y_2 - y_1}{2}\right)^2}$$
$$d_1 = \sqrt{\frac{x_2 - 2x_1x_2 + x_1^2}{4} + \frac{y_2^2 - 2y_2y_1 + y_1^2}{4}}$$
$$d_1 = \sqrt{\frac{1}{4}\left(x_2 - 2x_1x_2 + x_1 + y_2^2 - 2y_2y_1 + y_1^2\right)}$$
$$d_1 = \frac{1}{2}\sqrt{x_2 - 2x_1x_2 + x_1 + y_2^2 - 2y_2y_1 + y_1^2}$$

d_2 is distance from midpoint to (x_2, y_2)

$$d_2 = \sqrt{\left(\frac{x_1 + x_2}{2} - x_2\right)^2 + \left(\frac{y_1 + y_2}{2} - y_2\right)^2}$$

$$d_2 = \sqrt{\left(\frac{x_1 + x_2 - 2x_2}{2}\right)^2 + \left(\frac{y_1 + y_2 - 2y_2}{2}\right)^2}$$

$$d_2 = \sqrt{\left(\frac{x_1 - x_2}{2}\right)^2 + \left(\frac{y_1 - y_2}{2}\right)^2}$$

$$d_2 = \sqrt{\frac{x_1^2 - 2x_1x_2 + x_2^2}{4} + \frac{y_1^2 - 2y_2y_1 + y_2^2}{4}}$$

$$d_2 = \sqrt{\frac{1}{4}\left(x_1^2 - 2x_1x_2 + x_2^2 + y_1^2 - 2y_2y_1 + y_2^2\right)}$$

$$d_2 = \frac{1}{2}\sqrt{x_1^2 - 2x_1x_2 + x_2^2 + y_1^2 - 2y_2y_1 + y_2^2}$$

$$d_1 = d_2$$

b. d_3 is the distance from (x_1, y_1) to $(x_2 y_2)$

$$d_3 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$d_3 = \sqrt{x_2^2 - 2x_1x_2 + x_1^2 + y_2^2 - 2y_2y_1 + y_1^2}$$

$d_1 + d_2 = d_3$ because $\frac{1}{2}\sqrt{a} + \frac{1}{2}\sqrt{a} = \sqrt{a}$

83. Both circles have center (2, –3). The smaller circle has radius 5 and the larger circle has radius 6. The smaller circle is inside of the larger circle. The area between them is given by

$$\begin{aligned} \pi(6)^2 - \pi(5)^2 &= 36\pi - 25\pi \\ &= 11\pi \\ &\approx 34.56 \text{ square units.} \end{aligned}$$

84. The circle is centered at (0,0). The slope of the radius with endpoints (0,0) and (3,–4) is $m = -\frac{-4-0}{3-0} = -\frac{4}{3}$.

The line perpendicular to the radius has slope $\frac{3}{4}$. The tangent line has slope $\frac{3}{4}$ and passes through (3,–4), so its equation is:

$$y + 4 = \frac{3}{4}(x - 3).$$

Section 1.10

Check Point Exercises

1. **a.** $f(x) = 15 + 0.08x$

b. $g(x) = 3 + 0.12x$

c. $15 + 0.08x = 3 + 0.12x$
$12 = 0.04x$
$300 = x$
The plans cost the same for 300 minutes.

2. **a.** $N(x) = 8000 - 100(x - 100)$
$= 8000 - 100x + 10000$
$= 18{,}000 - 100x$

b. $R(x) = (18{,}000 - 100x)x$
$= -100x^2 + 18{,}000x$

3. $V(x) = (15 - 2x)(8 - 2x)x$
$= (120 - 46x + 4x^2)x$
$= 4x^3 - 46x^2 + 120x$
Since x represents the inches to be cut off, $x > 0$. The smallest side is 8, so must cut less than 4 off each side. The domain of V is $\{x | 0 < x < 4\}$ or, in interval notation, $(0, 4)$.

4. $2l + 2w = 200$
$2l = 200 - 2w$
$l = 100 - w$
Let x = width, then length = $100 - x$
$A(x) = x(100 - x)$
$= 100x - x^2$

5. $V = \pi r^2 h$
$1000 = \pi r^2 h$
$\frac{1000}{\pi r^2} = h$

$A = 2\pi r^2 + 2\pi r h$
$= 2\pi r^2 + 2\pi r\left(\frac{1000}{\pi r^2}\right)$
$= 2\pi r^2 + \frac{2000}{r}$

6. $I(x) = 0.07x + 0.09(25{,}000 - x)$

7. $d = \sqrt{(x-0)^2 + (y-0)^2}$
$= \sqrt{x^2 + y^2}$

$y = x^3$
$d = \sqrt{x^2 + \left(x^3\right)^2}$
$= \sqrt{x^2 + x^6}$

Exercise Set 1.10

1. **a.** $f(x) = 200 + 0.15x$

b. $320 = 200 + 0.15x$
$120 = 01.5x$
$800 = x$
800 miles

2. **a.** $f(x) = 180 + 0.25x$

b. $395 = 180 + 0.25x$
$215 = 0.25x$
$860 = x$
You drove 860 miles for \$395.

3. **a.** $M(x) = 239.4 - 0.3x$

b. $180 = 239.4 - 0.3x$
$0.3x = 59.4$
$x = 198$
198 years after 1954, in 2152, someone will run a 3 minute mile.

4. **a.** $P(x) = 28 + 0.6x$

b. $40 = 28 + 06x$
$12 = 0.6x$
$20 = x$
20 years after 1990, in 2010, 40% of babies born will be out of wedlock.

5. **a.** $f(x) = 1.25x$

b. $g(x) = 21 + 0.5x$

c. $1.25x = 21 + 0.5x$
$0.75x = 21$
$x = 28$
$f(28) = 1.25(28) = 35$
$g(28) = 21 + 0.5(28) = 35$
If a person crosses the bridge 28 times the cost will be \$35 for both options

6. **a.** $f(x) = 2.5x$

b. $g(x) = 21 + x$

c. $2.5x = 21 + x$
$1.5x = 21$
$x = 14$

$f(14) = 2.5(14) = 35$
$g(14) = 21 + 14 = 35$
To cross the bridge 14 times costs the same, $35, for either method.

7. **a.** $f(x) = 100 + 0.8x$

b. $g(x) = 40 + 0.9x$

c. $100 + 0.8x = 40 + 0.9x$
$60 = 0.1x$
$600 = x$
For $600 worth of merchandise, your cost is $580 for both plans

8. **a.** $f(x) = 300 + 0.7x$

b. $g(x) = 40 + 0.9x$

c. $300 + .7x = 40 + .9x$
$260 = .2x$
$1300 = x$
$f(1300) = 300 + 0.7(1300) = 1210$
$g(1300) = 40 + 0.9(1300) = 1210$
You would have to purchase $1300 in merchandise at a total cost of $1210.

9. **a.** $N(x) = 30,000 - 500(x - 20)$
$= 30,000 - 500x + 10000$
$= 40,000 - 500x$

b. $R(x) = (40,000 - 500x)x$
$= -500x^2 + 40,000$

10. **a.** $N(x) = 20,000 - 400(x - 15)$
$= 20,000 - 400x + 6000$
$= 26,000 - 400x$

b. $R(x) = (26,000 - 400x)x$
$= -400x^2 + 26,000x$

11. **a.** $N(x) = 9000 + 50(150 - x)$
$= 9000 - 50x + 7500$
$= 16500 - 50x$

b. $R(x) = (16500 - 50x)x$
$= -50x^2 + 16500x$

12. **a.** $N(x) = 7,000 + 60(90 - x)$
$= 7000 - 60x + 5400$
$= 12400 - 60x$

b. $R(x) = (12400 - 60x)x$
$= -60x^2 + 12400x$

13. **a.** $Y(x) = 320 - 4(x - 50)$
$= 320 - 4x + 200$
$= 520 - 4x$

b. $T(x) = (520 - 4x)x$
$= -4x^2 + 520x$

14. **a.** $Y(x) = 270 - 3(x - 30)$
$= 270 - 3x + 90$
$= 360 - 3x$

b. $T(x) = (360 - 3x)x$
$= -3x^2 + 360x$

15. **a.** $V(x) = (24 - 2x)(24 - 2x)x$
$= (576 - 96x + 4x^2)x$
$= 4x^3 - 96x^2 + 576x$

b. $V(2) = 4(2)^3 - 96(2)^2 + 576(2) = 800$ If 2-inch squares are cut off each corner, the volume will be 800 square inches.

$V(3) = 4(3)^3 - 96(3)^2 + 576(3) = 972$ If 3-inch squares are cut off each corner, the volume will be 972 square inches.

$V(4) = 4(4)^3 - 96(4)^2 + 576(4) = 1024$ If 4-inch squares are cut off each corner, the volume will be 1024 square inches.

$V(5) = 4(5)^3 - 96(5)^2 + 576(5) = 980$ If 5-inch squares are cut off each corner, the volume will be 980 square inches.

$V(6) = 4(6)^3 - 96(6)^2 + 576(6) = 864$ If 6-inch squares are cut off each corner, the volume will be 864 square inches.

c. If x is the inches to be cut off, $x > 0$. Since each side is 24, you must cut less than 12 inches off each end.
$0 < x < 12$

16. a.
$$V(x) = (30 - 2x)(30 - 2x)x = (900 - 120x + 4x^2)x = 4x^3 - 120x^2 + 900x$$

b. $V(3) = 4(3^3) - 120(3^2) + 900(3) = 1728$
If 3 inches are cut from each side, the volume will be 1728 square inches.

$V(4) = 4(4^3) - 120(4^2) + 900(4) = 1936$
If 4 inches are cut from each side, the volume will be 1936 square inches.

$V(5) = 4(5^3) - 120(5^2) + 900(5) = 2000$
If 5 inches are cut from each side, the volume will be 2000 square inches.

$V(6) = 4(6^3) - 120(6^2) + 900(6) = 1944$
If 6 inches are cut from each side, the volume will be 1944 square inches.

$V(7) = 4(7^3) - 120(7^2) + 900(7) = 1792$
If 7 inches are cut from each side, the volume will be 1792 square inches.

c. Since x is the number of inches to be cut from each side, $x > 0$. Since each side is 30 inches, you must cut less than 15 inches from each side.
$0 < x < 15$ or $(0, 15)$

17.
$$A(x) = x(20 - 2x) = -2x^2 + 20x$$

18.
$$A(x) = \left(\frac{x}{4}\right)^2 + \left(\frac{8-x}{4}\right)^2 = \frac{x^2}{16} + \frac{64 - 16x + x^2}{16} = \frac{2x^2 - 16x + 64}{16} = \frac{x^2 - 8x + 32}{8}$$

19.
$$P(x) = x(66 - x) = -x^2 + 66x$$

20.
$$P(x) = x(50 - x) = -x^2 + 50x$$

21.
$$A(x) = x(400 - x) = -x^2 + 400x$$

22.
$$A(x) = x(300 - x) = -x^2 + 300x$$

23.
$$2w + l = 800$$
$$l = 800 - 2w$$
Let $x = w$
$$A(x) = x(800 - 2x) = -2x^2 + 800x$$

24.
$$2w + l = 600$$
$$l = 600 - 2l$$
let $x =$ width, $600 - 2x =$ length

$$A(x) = (600 - 2x)x = -2x^2 + 600x$$

25.
$$2x + 3y = 1000$$
$$3y = 1000 - 2x$$
$$y = \frac{1000 - 2x}{3}$$
$$A(x) = x\left(\frac{1000 - 2x}{3}\right) = \frac{x(10000 - 2x)}{3}$$

26. $2x+4y=1200$

$4y=1200-2x$

$y=\dfrac{1200-2x}{4}$

$$A(x)=x\left(\frac{1200-2x}{4}\right)=\frac{x(1200-2x)}{4}=\frac{2x(600-x)}{4}=\frac{x(600-x)}{2}$$

27. $2x$ = distance around 2 straight sides

$\pi 2$r = distance around 2 curved sides

$2x+2\pi r=440$

$2x=440-2\pi r$

$x=220-\pi r$

$$A(x)=(220-\pi r)r+\pi r^2=220r-\pi r^2+\pi r^2=220r$$

28. $2x$ = distance around the 2 straight sides

$2\pi r$ = distance around the 2 curved sides

$2x+2\pi r=880$

$2x=880-2\pi r$

$x=440-\pi r$

$$A(x)=r(440-\pi r)+\pi r^2=440r-\pi r^2+\pi r^2=440r$$

29. $xy=4000$

$y=\dfrac{4000}{x}$

$$C(x)=\left[2x+2\left(\frac{4000}{x}\right)\right]175+125x=350x+\frac{1,400,000}{x}+125x=4750x+\frac{1,400,000}{x}$$

30. $125=lw$

$\dfrac{125}{l}=w$; let $x=l$

$$C(x)=20\left(2\left(\frac{125}{x}\right)+x\right)+9x=\frac{5000}{x}+20x+9x=\frac{5000}{x}+29x$$

31. $10=x^2y$

$\dfrac{10}{x^2}=y$

$$A(x)=x^2+4\left(x\cdot\frac{10}{x^2}\right)=x^2+\frac{40}{x}$$

32. $400=x^2y$

$\dfrac{400}{x^2}=y$

$$A=x^2+5\left(\frac{400}{x^2}\right)x=x^2+\frac{2000}{x}$$

33. $300=y+4x$

$300-4x=y$

$$A(x)=x^2(300-4x)=-4x^3+300x^2$$

34. $108=y+4x$

$108-4x=y$

$$A=x^2(108-4x)=-4x^3+108x^2$$

35. **a.** Let x = amount invested at 15%
$50000 - x$ = amount invested at 7%
$I(x) = 0.15x + 0.07(50000 - x)$

b.
$$6000 = 0.15x + 0.07x(50000 - x)$$
$$6000 = 0.15x + 3500 - 0.07x$$
$$2500 = 0.08x$$
$$31250 = x$$
$$50000 - 31250 = 18750$$
Invest $31,250 at 15% and $18,750 at 7%.

36. **a.** Let x = amount at 10%
$18,750 - x$ = amount at 12%
$I(x) = 0.10x + 0.12(18750 - x)$

b.
$$0.10x + 0.12(18750 - x) = 2117$$
$$0.1x + 2250 - 0.12x = 2117$$
$$-0.02x = -133$$
$$x = 6650$$
The amount of money to be invested should be $6650 at 10% and $12100 at 12%.

37. Let x = amount invested at 12%
$8000 - x$ = amount invested at 5% loss
$I(x) = 0.12x - 0.05(8000 - x)$

38. Let x = amount at 14%
$12000 - x$ = amount at 6%
$$I(x) = 0.14x + 0.06(12000 - x)$$
$$= 0.14x + 720 - 0.06x$$
$$= 0.08x + 720$$

39.
$$d = \sqrt{(x-0)^2 + (y-0)^2}$$
$$= \sqrt{x^2 + y^2}$$
$$= \sqrt{x^2 + \left(x^2 - 4\right)^2}$$
$$= \sqrt{x^2 + x^4 - 8x^2 + 16}$$
$$= \sqrt{x^4 - 7x^2 + 16}$$

40.
$$d = \sqrt{(x-0)^2 + (y-0)^2}$$
$$= \sqrt{x^2 + y^2}$$
$$= \sqrt{x^2 + \left(x^2 - 8\right)^2}$$
$$= \sqrt{x^2 + x^4 - 16x^2 + 64}$$
$$= \sqrt{x^4 - 15x^2 + 64}$$

41.
$$d = \sqrt{(x-1)^2 + y^2}$$
$$= \sqrt{x^2 - 2x + 1 + \left(\sqrt{x}\right)^2}$$
$$= \sqrt{x^2 - 2x + 1 + x}$$
$$= \sqrt{x^2 - x + 1}$$

42.
$$d = \sqrt{(x-2)^2 + y^2}$$
$$= \sqrt{x^2 - 4x + 4 + \left(\sqrt{x}\right)^2}$$
$$= \sqrt{x^2 - 3x + 4}$$

43. **a.**
$$A(x) = 2xy$$
$$= 2x\sqrt{4 - x^2}$$

b.
$$P(x) = 2(2x) + 2y$$
$$= 4x + 2\sqrt{4 - x^2}$$

44. **a.**
$$A(x) = 2xy$$
$$= 2x\sqrt{9 - x^2}$$

b.
$$P(x) = 2(2x) + 2y$$
$$= 4x + 2\sqrt{9 - x^2}$$

45. 6-foot pole
$$c^2 = 6^2 + x^2$$
$$x = \sqrt{36 + x^2}$$
8-foot pole
$$c^2 = 8^2 + (10 - x)^2$$
$$c = \sqrt{64 + 100 - 20x + x^2}$$
$$c = \sqrt{x^2 - 20x + 164}$$
total length
$$f(x) = \sqrt{36 + x^2} + \sqrt{x^2 - 20x + 164}$$

46. Road from Town A:

$$c^2 = 6^2 + x^2$$
$$c = \sqrt{36 + x^2}$$

Road from Town B:

$$c^2 = 3^2 + (12 - x)^2$$
$$c = \sqrt{9 + 144 - 24x + x^2}$$
$$c = \sqrt{x^2 - 24x + 153}$$

$$f(x) = \sqrt{36 + x^2} + \sqrt{x^2 - 24x + 153}$$

47. $$A(x) = \tfrac{1}{2}x(x-5) + \tfrac{1}{2}x(x+3) + (x+2)\left[(x-5)+(x+3)\right]$$
$$A(x) = \tfrac{1}{2}x^2 - \tfrac{5}{2}x + \tfrac{1}{2}x^2 + \tfrac{3}{2}x + (x+2)\left[2x-2\right]$$
$$A(x) = x^2 - x + 2x^2 + 2x - 4$$
$$A(x) = 3x^2 + x - 4$$

48. $$A(x) = \tfrac{1}{2}x(2x) + \tfrac{1}{2}(6x - 4x)(x+2) + (4x)(x+2) + 2x(8)$$
$$A(x) = x^2 + x(x+2) + 4x^2 + 8x + 16x$$
$$A(x) = x^2 + x^2 + 2x + 4x^2 + 8x + 16x$$
$$A(x) = 6x^2 + 26$$

49. $$V(x) = (x+5)(2x+1)(x+2) - (x+5)(3)(x)$$
$$V(x) = (x+5)(2x^2 + 5x + 2) - 3x(x+5)$$
$$V(x) = 2x^3 + 15x^2 + 27x + 10 - 3x^2 - 15x$$
$$V(x) = 2x^3 + 12x^2 + 12x + 10$$

50. $$V(x) = (x)(2x-1)(x+3) - (x)(x)\left[(2x-1)-(x+1)\right]$$
$$V(x) = (x)(2x^2 + 5x - 3) - x^2(x-2)$$
$$V(x) = 2x^3 + 5x^2 - 3x - x^3 + 2x^2$$
$$V(x) = x^3 + 7x^2 - 3x$$

63. Distance and time rowed:

$$d^2 = 2^2 + x^2$$
$$d = \sqrt{4 + x^2}$$
$$rt = d$$
$$2t = \sqrt{4 + x^2}$$
$$t = \frac{\sqrt{4 + x^2}}{2}$$

Distance and time walked:

$$d = 6 - x$$
$$rt = d$$
$$5t = 6 - x$$
$$t = \frac{6 - x}{5}$$

Total time:

$$T(x) = \frac{\sqrt{4 + x^2}}{2} + \frac{6 - x}{5}$$

64. $$A(x) = (20 + 2x)(10 + 2x) - 10(20)$$
$$= 4x^2 + 60x + 200 - 200$$
$$= 4x^2 + 60x$$

65. $$P = 2h + 2r + \frac{1}{2}(\pi 2r)$$
$$12 = 2h + 2r + \pi r$$
$$12 - 2r - \pi r = 2h$$
$$\frac{12 - 2r - \pi r}{2} = h$$

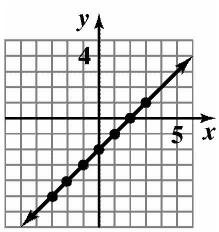
$$A = \left(\frac{12 - 2r - \pi r}{2}\right)2r + \frac{1}{2}\left(\pi r^2\right)$$
$$= 12r - 2r^2 - \pi r^2 + \frac{1}{2}\pi r^2$$
$$= 12r - 2r^2 - \frac{1}{2}\pi r^2$$

66. $$r = \frac{1}{2}h$$

$$V(h) = \frac{1}{3}\pi r^2 h$$
$$= \frac{1}{3}\pi\left(\frac{1}{2}h\right)^2 h$$
$$= \frac{1}{3}\pi\frac{1}{4}h^2 h$$
$$= \frac{\pi}{12}h^3$$

Chapter 1 Review Exercises

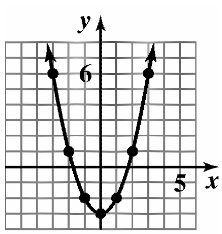
1.



$y = 2x - 2$

$x = -3, y = -8$
$x = -2, y = -6$
$x = -1, y = -4$
$x = 0, y = -2$
$x = 1, y = 0$
$x = 2, y = 2$
$x = 3, y = 4$

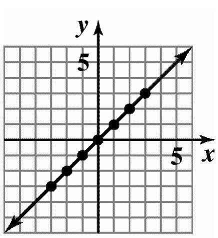
2.



$y = x^2 - 3$

$x = -3, y = 6$
$x = -2, y = 1$
$x = -1, y = -2$
$x = 0, y = -3$
$x = 1, y = -2$
$x = 2, y = 1$
$x = 3, y = 6$

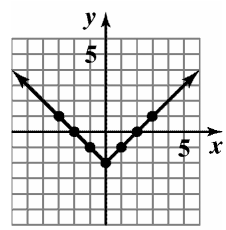
3.



$y = x$

$x = -3, y = -3$
$x = -2, y = -2$
$x = -1, y = -1$
$x = 0, y = 0$
$x = 1, y = 1$
$x = 2, y = 2$
$x = 3, y = 3$

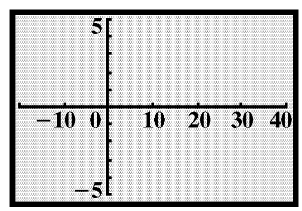
4.



$y = |x| - 2$

$x = -3, y = 1$
$x = -2, y = 0$
$x = -1, y = -1$
$x = 0, y = -2$
$x = 1, y = -1$
$x = 2, y = 0$
$x = 3, y = 1$

5. A portion of Cartesian coordinate plane with minimum x-value equal to –20, maximum x-value equal to 40, x-scale equal to 10 and with minimum y-value equal to –5, maximum y-value equal to 5, and y-scale equal to 1.



6. x-intercept: –2; The graph intersects the x-axis at (–2, 0).
y-intercept: 2; The graph intersects the y-axis at (0, 2).

7. x-intercepts: 2, –2; The graph intersects the x-axis at (–2, 0) and (2, 0).
y-intercept: –4; The graph intercepts the y-axis at (0, –4).

8. x-intercept: 5; The graph intersects the x-axis at (5, 0).
y-intercept: None; The graph does not intersect the y-axis.

9. Point A is (91, 125). This means that in 1991, 125,000 acres were used for cultivation

10. Opium cultivation was 150,000 acres in 1997.

11. Opium cultivation was at a minimum in 2001 when approximately 25,000 acres were used.

12. Opium cultivation was at a maximum in 2004 when approximately 300,000 acres were used.

13. Opium cultivation did not change between 1991 and 1992.

14. Opium cultivation increased at the greatest rate between 2001 and 2002. The increase in acres used for opium cultivation in this time period was approximately 180,000 – 25,000 = 155,000 acres.

15. function
domain: {2, 3, 5}
range: {7}

16. function
domain: {1, 2, 13}
range: {10, 500, π}

17. not a function
domain: {12, 14}
range: {13, 15, 19}

18. $2x + y = 8$
$y = -2x + 8$
Since only one value of *y* can be obtained for each value of *x*, *y* is a function of *x*.

19. $3x^2 + y = 14$
$y = -3x^2 + 14$
Since only one value of *y* can be obtained for each value of *x*, *y* is a function of *x*.

20. $2x + y^2 = 6$
$y^2 = -2x + 6$
$y = \pm\sqrt{-2x+6}$
Since more than one value of *y* can be obtained from some values of *x*, *y* is not a function of *x*.

21. $f(x) = 5 - 7x$

a. $f(4) = 5 - 7(4) = -23$

b. $f(x+3) = 5 - 7(x+3)$
$= 5 - 7x - 21$
$= -7x - 16$

c. $f(-x) = 5 - 7(-x) = 5 + 7x$

22. $g(x) = 3x^2 - 5x + 2$

a. $g(0) = 3(0)^2 - 5(0) + 2 = 2$

b. $g(-2) = 3(-2)^2 - 5(-2) + 2$
$= 12 + 10 + 2$
$= 24$

c. $g(x-1) = 3(x-1)^2 - 5(x-1) + 2$
$= 3(x^2 - 2x + 1) - 5x + 5 + 2$
$= 3x^2 - 11x + 10$

d. $g(-x) = 3(-x)^2 - 5(-x) + 2$
$= 3x^2 + 5x + 2$

23. **a.** $g(13) = \sqrt{13-4} = \sqrt{9} = 3$

b. $g(0) = 4 - 0 = 4$

c. $g(-3) = 4 - (-3) = 7$

24. **a.** $f(-2) = \dfrac{(-2)^2 - 1}{-2-1} = \dfrac{3}{-3} = -1$

b. $f(1) = 12$

c. $f(2) = \dfrac{2^2 - 1}{2-1} = \dfrac{3}{1} = 3$

25. The vertical line test shows that this is not the graph of a function.

26. The vertical line test shows that this is the graph of a function.

27. The vertical line test shows that this is the graph of a function.

28. The vertical line test shows that this is not the graph of a function.

29. The vertical line test shows that this is not the graph of a function.

30. The vertical line test shows that this is the graph of a function.

31. $\dfrac{8(x+h) - 11 - (8x - 11)}{h}$
$= \dfrac{8x + 8h - 11 - 8x + 11}{h}$
$= \dfrac{8h}{8}$
$= 8$

32. $\frac{-2(x+h)^2+(x+h)+10-\left(-2x^2+x+10\right)}{h}$

$= \frac{-2\left(x^2+2xh+h^2\right)+x+h+10+2x^2-x-10}{h}$

$= \frac{-2x^2-4xh-2h^2+x+h+10+2x^2-x-10}{h}$

$= \frac{-4xh-2h^2+h}{h}$

$= \frac{h\left(-4x-2h+1\right)}{h}$

$-4x-2h+1$

33. **a.** domain: [–3, 5)

b. range: [–5, 0]

c. *x*-intercept: –3

d. *y*-intercept: –2

e. increasing: $(-2, 0)$ or $(3, 5)$
decreasing: $(-3, -2)$ or $(0, 3)$

f. *f*(–2) = –3 and *f*(3) = –5

34. **a.** domain: $(-\infty, \infty)$

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

c. *x*-intercepts: –2 and 3

d. *y*-intercept: 3

e. increasing: (–5, 0)
decreasing: $(-\infty, -5)$ or $(0, \infty)$

f. *f*(–2) = 0 and *f*(6) = –3

35. **a.** domain: $(-\infty, \infty)$

b. range: [–2, 2]

c. *x*-intercept: 0

d. *y*-intercept: 0

e. increasing: (–2, 2)
constant: $(-\infty, -2)$ or $(2, \infty)$

f. *f*(–9) = –2 and *f*(14) = 2

36. **a.** 0, relative maximum −2

b. −2, 3, relative minimum −3, –5

37. **a.** 0, relative maximum 3

b. −5, relative minimum −6

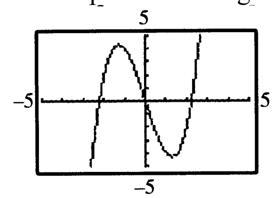
38. $f(x) = x^3 - 5x$

$f(-x) = (-x)^3 - 5(-x)$

$= -x^3 + 5x$

$= -f(x)$

The function is odd. The function is symmetric with respect to the origin.



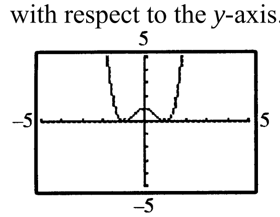
39. $f(x) = x^4 - 2x^2 + 1$

$f(-x) = (-x)^4 - 2(-x)^2 + 1$

$= x^4 - 2x^2 + 1$

$= f(x)$

The function is even. The function is symmetric with respect to the *y*-axis.



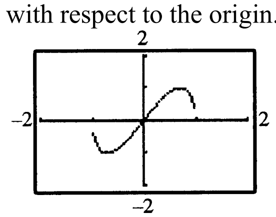
40. $f(x) = 2x\sqrt{1-x^2}$

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

$= -2x\sqrt{1-x^2}$

$= -f(x)$

The function is odd. The function is symmetric with respect to the origin.



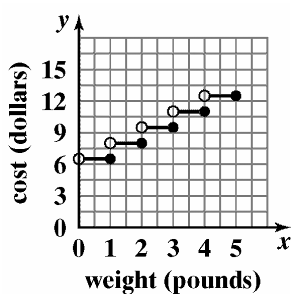
41. a. Yes, the eagle's height is a function of time since the graph passes the vertical line test.

b. Decreasing: (3, 12)
The eagle descended.

c. Constant: (0, 3) or (12, 17)
The eagle's height held steady during the first 3 seconds and the eagle was on the ground for 5 seconds.

d. Increasing: (17, 30)
The eagle was ascending.

42.



43. $m = \frac{1-2}{5-3} = \frac{-1}{2} = -\frac{1}{2}$; falls

44. $m = \frac{-4-(-2)}{-3-(-1)} = \frac{-2}{-2} = 1$; rises

45. $m = \frac{\frac{1}{4}-\frac{1}{4}}{6-(-3)} = \frac{0}{9} = 0$; horizontal

46. $m = \frac{10-5}{-2-(-2)} = \frac{5}{0}$ undefined; vertical

47. point-slope form: $y - 2 = -6(x + 3)$
slope-intercept form: $y = -6x - 16$

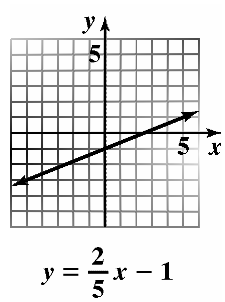
48. $m = \frac{2-6}{-1-1} = \frac{-4}{-2} = 2$
point-slope form: $y - 6 = 2(x - 1)$
or $y - 2 = 2(x + 1)$
slope-intercept form: $y = 2x + 4$

49. $3x + y - 9 = 0$
$y = -3x + 9$
$m = -3$
point-slope form:
$y + 7 = -3(x - 4)$
slope-intercept form:
$y = -3x + 12 - 7$
$y = -3x + 5$

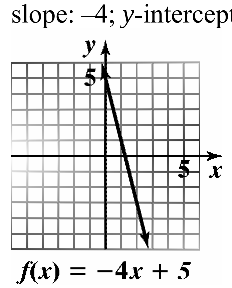
50. perpendicular to $y = \frac{1}{3}x + 4$
$m = -3$
point-slope form:
$y - 6 = -3(x + 3)$
slope-intercept form:
$y = -3x - 9 + 6$
$y = -3x - 3$

51. Write $6x - y - 4 = 0$ in slope intercept form.
$6x - y - 4 = 0$
$-y = -6x + 4$
$y = 6x - 4$
The slope of the perpendicular line is 6, thus the slope of the desired line is $m = -\frac{1}{6}$.
$y - y_1 = m(x - x_1)$
$y - (-1) = -\frac{1}{6}\left(x - (-12)\right)$
$y + 1 = -\frac{1}{6}(x + 12)$
$y + 1 = -\frac{1}{6}x - 2$
$6y + 6 = -x - 12$
$x + 6y + 18 = 0$

52. slope: $\frac{2}{5}$; y-intercept: –1



53. slope: –4; y-intercept: 5

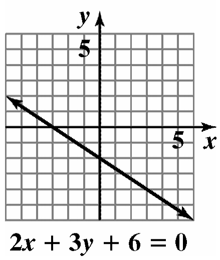


54. $2x+3y+6=0$

$3y=-2x-6$

$y=-\frac{2}{3}x-2$

slope: $-\frac{2}{3}$; y-intercept: –2

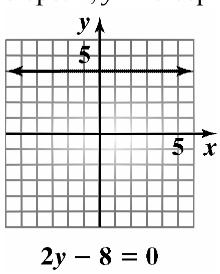


55. $2y-8=0$

$2y=8$

$y=4$

slope: 0; y-intercept: 4



56. $2x-5y-10=0$

Find x-intercept:

$2x-5(0)-10=0$

$2x-10=0$

$2x=10$

$x=5$

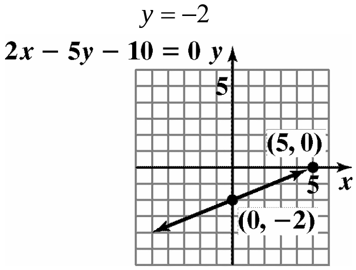
Find y-intercept:

$2(0)-5y-10=0$

$-5y-10=0$

$-5y=10$

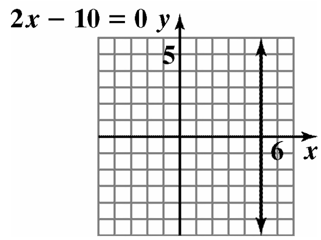
$y=-2$



57. $2x-10=0$

$2x=10$

$x=5$



58. **a.** First, find the slope. $(1,1.5)$ and $(3,3.4)$.

$m=\frac{3.4-1.5}{3-1}=\frac{1.9}{2}=0.95$

Next, use the slope and one of the points to write the point-slope equation of the line.

$y-1.5=0.95(x-1)$ or $y-3.4=0.95(x-3)$

b. $y-1.5=0.95(x-1)$

$y-1.5=0.95x-0.95$

$y=0.95x-0.55$

c. Since 2009 is 2009-1999 = 10, let x = 10.

$y=0.95(10)+0.55$

$=9.5+0.55=10.05$

\$10.05 billion in revenue was earned from online gambling in 2009.

59. **a.** $(1999,41315)$ and $(2001,41227)$

$m=\frac{41227-41315}{2001-1999}=\frac{-88}{2}=-44$

The number of new AIDS diagnoses decreased at a rate of 44 each year from 1999 to 2001.

b. $(2001,41227)$ and $(2003,43045)$

$m=\frac{43045-41227}{2003-2001}=\frac{1818}{2}=909$

The number of new AIDS diagnoses increased at a rate of 909 each year from 2001 to 2003.

c. $(1999,41315)$ and $(2003,43045)$

$m=\frac{43045-41315}{2003-1999}=\frac{1730}{4}=432.5$

$\frac{-44+909}{2}=\frac{865}{2}=432.5$

Yes, the slope equals the average of the two values.

60. $\dfrac{9^2-4(9)-[4^2-4\cdot 5]}{9-5}=\dfrac{40}{4}=10$

61. **a.** $S(0)=-16(0)^2+64(0)+80=80$

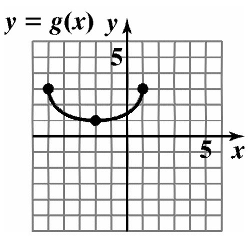
$S(2)=-16(2)^2+64(2)+80=144$

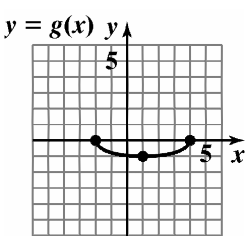
$\dfrac{144-80}{2-0}=32$

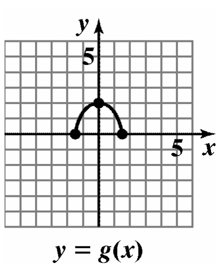
b. $S(4)=-16(4)^2+64(4)+80=80$

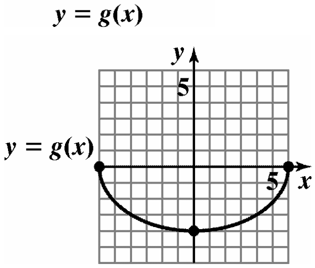
$\dfrac{80-144}{4-2}=-32$

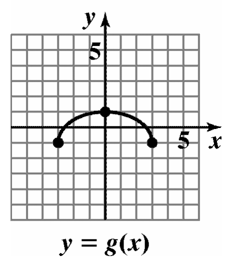
c. The ball is traveling up until 2 seconds, then it starts to come down.

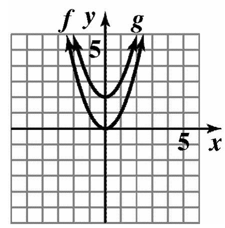
62. 

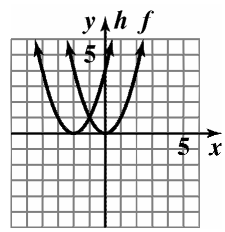
63. 

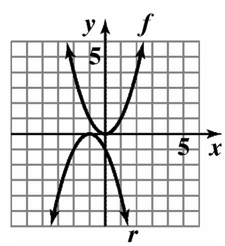
64. 

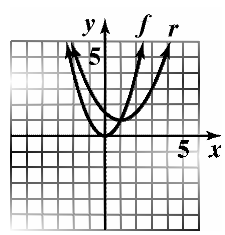
65. 

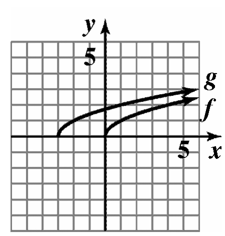
66. 

67. 

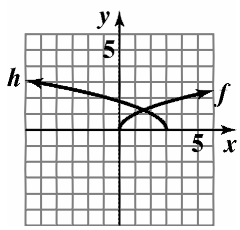
68. 

69. 

70. 

71. 

72.



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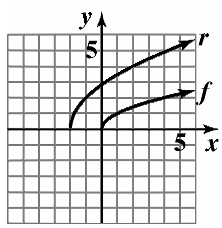

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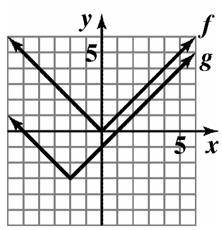

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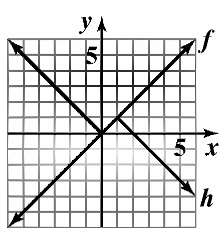
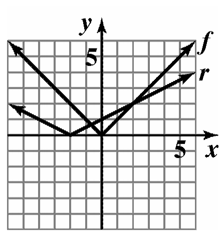
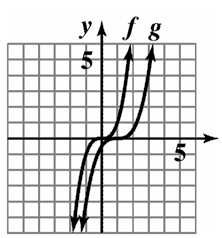


76.



77.



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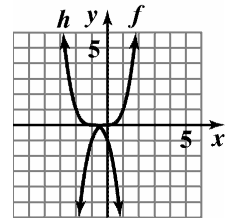

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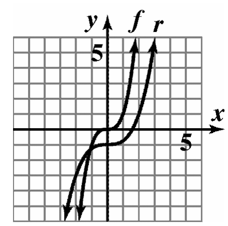
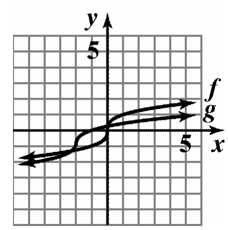
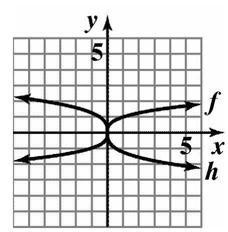


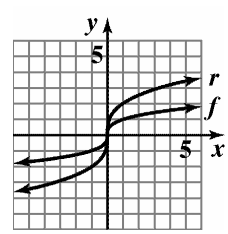
80.



81.



82.



83. domain: $(-\infty, \infty)$

84. The denominator is zero when $x = 7$. The domain is $(-\infty, 7)\cup(7, \infty)$.

85. The expressions under each radical must not be negative.
$8 - 2x \geq 0$
$-2x \geq -8$
$x \leq 4$
Domain: $(-\infty, 4]$.

86. The denominator is zero when $x = -7$ or $x = 3$.
Domain: $(-\infty,-7)\cup(-7,3)\cup(3,\infty)$

87. The expressions under each radical must not be negative. The denominator is zero when $x = 5$.
$x - 2 \ge 0$
$x \ge 2$
Domain: $[2,5)\cup(5,\infty)$

88. The expressions under each radical must not be negative.
$x-1\ge 0$ and $x+5\ge 0$
$x\ge 1$ $x\ge -5$
Domain: $[1,\infty)$

89. $f(x) = 3x - 1$; $g(x) = x - 5$
$(f + g)(x) = 4x - 6$
Domain: $(-\infty,\infty)$
$(f - g)(x) = (3x - 1) - (x - 5) = 2x + 4$
Domain: $(-\infty,\infty)$
$(fg)(x) = (3x-1)(x-5) = 3x^2 - 16x + 5$
Domain: $(-\infty,\infty)$
$\left(\frac{f}{g}\right)(x) = \frac{3x-1}{x-5}$
Domain: $(-\infty,5)\cup(5,\infty)$

90. $f(x) = x^2 + x + 1$; $g(x) = x^2 - 1$
$(f+g)(x) = 2x^2 + x$
Domain: $(-\infty,\infty)$
$(f-g)(x) = (x^2+x+1)-(x^2-1) = x+2$
Domain: $(-\infty,\infty)$
$(fg)(x) = (x^2+x+1)(x^2-1)$
$= x^4 + x^3 - x - 1$
$\left(\frac{f}{g}\right)(x) = \frac{x^2+x+1}{x^2-1}$
Domain: $(-\infty,-1)\cup(-1,1)\cup(1,\infty)$

91. $f(x) = \sqrt{x+7}$; $g(x) = \sqrt{x-2}$
$(f+g)(x) = \sqrt{x+7} + \sqrt{x-2}$
Domain: $[2,\infty)$
$(f-g)(x) = \sqrt{x+7} - \sqrt{x-2}$
Domain: $[2,\infty)$
$(fg)(x) = \sqrt{x+7}\cdot\sqrt{x-2}$
$= \sqrt{x^2+5x-14}$
Domain: $[2,\infty)$
$\left(\frac{f}{g}\right)(x) = \frac{\sqrt{x+7}}{\sqrt{x-2}}$
Domain: $(2,\infty)$

92. $f(x) = x^2 + 3$; $g(x) = 4x - 1$

a. $(f\circ g)(x) = (4x-1)^2 + 3$
$= 16x^2 - 8x + 4$

b. $(g\circ f)(x) = 4(x^2+3) - 1$
$= 4x^2 + 11$

c. $(f\circ g)(3) = 16(3)^2 - 8(3) + 4 = 124$

93. $f(x) = \sqrt{x}$; $g(x) = x + 1$

a. $(f\circ g)(x) = \sqrt{x+1}$

b. $(g\circ f)(x) = \sqrt{x} + 1$

c. $(f\circ g)(3) = \sqrt{3+1} = \sqrt{4} = 2$

94. **a.** $(f\circ g)(x) = f\left(\frac{1}{x}\right)$
$$= \frac{\frac{1}{x}+1}{\frac{1}{x}-2} = \frac{\left(\frac{1}{x}+1\right)x}{\left(\frac{1}{x}-2\right)x} = \frac{1+x}{1-2x}$$

b. $x \ne 0$ $1-2x \ne 0$
$x \ne \frac{1}{2}$
$(-\infty,0)\cup\left(0,\frac{1}{2}\right)\cup\left(\frac{1}{2},\infty\right)$

95. **a.** $(f\circ g)(x) = f(x+3) = \sqrt{x+3-1} = \sqrt{x+2}$

b. $x+2\ge 0$
$x \ge -2$
$[-2,\infty)$

96. $f(x) = x^4$ $g(x) = x^2 + 2x - 1$

97. $f(x)=\sqrt[3]{x} \quad g(x)=7x+4$

98. $f(x)=\frac{3}{5}x+\frac{1}{2};\ g(x)=\frac{5}{3}x-2$

$$f(g(x))=\frac{3}{5}\left(\frac{5}{3}x-2\right)+\frac{1}{2}$$
$$=x-\frac{6}{5}+\frac{1}{2}$$
$$=x-\frac{7}{10}$$
$$g(f(x))=\frac{5}{3}\left(\frac{3}{5}x+\frac{1}{2}\right)-2$$
$$=x+\frac{5}{6}-2$$
$$=x-\frac{7}{6}$$

f and *g* are not inverses of each other.

99. $f(x)=2-5x;\ g(x)=\frac{2-x}{5}$

$$f(g(x))=2-5\left(\frac{2-x}{5}\right)$$
$$=2-(2-x)$$
$$=x$$
$$g(f(x))=\frac{2-(2-5x)}{5}=\frac{5x}{5}=x$$

f and *g* are inverses of each other.

100. a.
$$f(x)=4x-3$$
$$y=4x-3$$
$$x=4y-3$$
$$y=\frac{x+3}{4}$$
$$f^{-1}(x)=\frac{x+3}{4}$$

b.
$$f(f^{-1}(x))=4\left(\frac{x+3}{4}\right)-3$$
$$=x+3-3$$
$$=x$$
$$f^{-1}(f(x))=\frac{(4x-3)+3}{4}=\frac{4x}{4}=x$$

101. a.
$$f(x)=8x^3+1$$
$$y=8x^3+1$$
$$x=8y^3+1$$
$$x-1=8y^3$$
$$\frac{x-1}{8}=y^3$$
$$\sqrt[3]{\frac{x-1}{8}}=y$$
$$\frac{\sqrt[3]{x-1}}{2}=y$$
$$f^{-1}(x)=\frac{\sqrt[3]{x-1}}{2}$$

b.
$$f\left(f^{-1}(x)\right)=8\left(\frac{\sqrt[3]{x-1}}{2}\right)^3+1$$
$$=8\left(\frac{x-1}{8}\right)+1$$
$$=x-1+1$$
$$=x$$
$$f^{-1}\left(f(x)\right)=\frac{\sqrt[3]{\left(8x^3+1\right)-1}}{2}$$
$$=\frac{\sqrt[3]{8x^3}}{2}$$
$$=\frac{2x}{2}$$
$$=x$$

102. a.
$$f(x)=\frac{2}{x}+5$$
$$y=\frac{2}{x}+5$$
$$x=\frac{2}{y}+5$$
$$xy=2+5y$$
$$xy-5y=2$$
$$y(x-5)=2$$
$$y=\frac{2}{x-5}$$
$$f^{-1}(x)=\frac{2}{x-5}$$

b. $f\left(f^{-1}(x)\right) = \dfrac{2}{\frac{2}{x-5}} + 5$

$= \dfrac{2(x-5)}{2} + 5$

$= x - 5 + 5$

$= x$

$f^{-1}\left(f(x)\right) = \dfrac{2}{\frac{2}{x} + 5 - 5}$

$= \dfrac{2}{\frac{2}{x}}$

$= \dfrac{2x}{2}$

$= x$

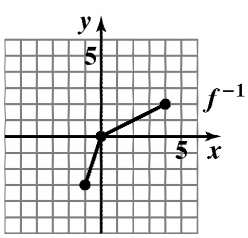
103. The inverse function exists.

104. The inverse function does not exist since it does not pass the horizontal line test.

105. The inverse function exists.

106. The inverse function does not exist since it does not pass the horizontal line test.

107.



108. $f(x) = 1 - x^2$

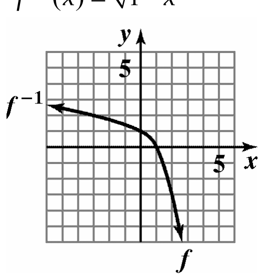
$y = 1 - x^2$

$x = 1 - y^2$

$y^2 = 1 - x$

$y = \sqrt{1-x}$

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



109. $f(x) = \sqrt{x} + 1$

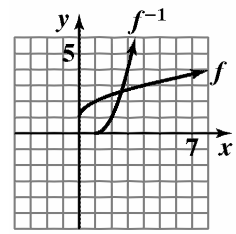
$y = \sqrt{x} + 1$

$x = \sqrt{y} + 1$

$x - 1 = \sqrt{y}$

$(x-1)^2 = y$

$f^{-1}(x) = (x-1)^2, \quad x \ge 1$



$\boldsymbol{f(x) = \sqrt{x} + 1}$

$\boldsymbol{g(x) = (x-1)^2, x \ge 1}$

110. $d = \sqrt{[3-(-2)]^2 + [9-(-3)]^2}$

$= \sqrt{5^2 + 12^2}$

$= \sqrt{25 + 144}$

$= \sqrt{169}$

$= 13$

111. $d = \sqrt{[-2-(-4)]^2 + (5-3)^2}$

$= \sqrt{2^2 + 2^2}$

$= \sqrt{4+4}$

$= \sqrt{8}$

$= 2\sqrt{2}$

≈ 2.83

112. $\left(\dfrac{2+(-12)}{2}, \dfrac{6+4}{2}\right) = \left(\dfrac{-10}{2}, \dfrac{10}{2}\right) = (-5, 5)$

113. $\left(\dfrac{4+(-15)}{2}, \dfrac{-6+2}{2}\right) = \left(\dfrac{-11}{2}, \dfrac{-4}{2}\right) = \left(\dfrac{-11}{2}, -2\right)$

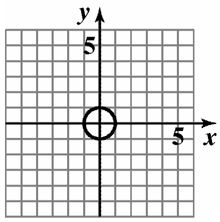
114. $x^2 + y^2 = 3^2$

$x^2 + y^2 = 9$

115. $(x-(-2))^2 + (y-4)^2 = 6^2$

$(x+2)^2 + (y-4)^2 = 36$

116. center: (0, 0); radius: 1

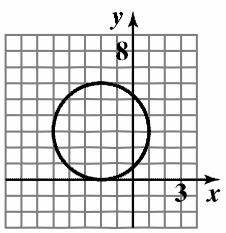


$x^2 + y^2 = 1$

Domain: $[-1,1]$

Range: $[-1,1]$

117. center: (–2, 3); radius: 3



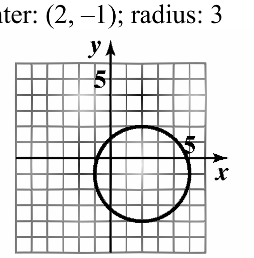
$(x+2)^2 + (y-3)^2 = 9$

Domain: $[-5,1]$

Range: $[0,6]$

118.
$$x^2 + y^2 - 4x + 2y - 4 = 0$$
$$x^2 - 4x \quad + y^2 + 2y \quad = 4$$
$$x^2 - 4x + 4 + y^2 + 2y + 1 = 4 + 4 + 1$$
$$(x-2)^2 + (y+1)^2 = 9$$

center: (2, –1); radius: 3



$x^2 + y^2 - 4x + 2y - 4 = 0$

Domain: $[-1,5]$

Range: $[-4,2]$

119. a. $W(x) = 567 + 15x$

b.
$$702 = 567 + 15x$$
$$135 = 15x$$
$$9 = x$$

9 years after 2000, in 2009, the average weekly sales will be \$702.

120. a. $f(x) = 15 + 0.05x$

b. $g(x) = 5 + 0.07x$

c.
$$15 + 0.05x = 5 + 0.07x$$
$$10 = 0.02x$$
$$500 = x$$

For 500 minutes, the two plans cost the same.

121. a.
$$N(x) = 400 - 2(x - 120)$$
$$= 400 - 2x + 240$$
$$= 640 - 2x$$

b.
$$R(x) = x(640 - 2x)$$
$$= -2x^2 + 640x$$

122. a. $w = 16 - 2x \quad l = 24 - 2x$
$$V(x) = (16 - 2x)(24 - 2x)x$$

b. $0 < x < 8$

123.
$$2l + 3w = 400$$
$$2l = 400 - 3w$$
$$l = \frac{400 - 3w}{2}$$

Let x = width

$$A(x) = x\left(\frac{400 - 3w}{2}\right)$$
$$= \frac{x(400 - 3w)}{2}$$

124.
$$V = lwh$$
$$8 = x \cdot x \cdot h$$
$$\frac{8}{x^2} = h$$

$$A(x) = 2x \cdot x + 4hx$$
$$= 2x^2 + 4\left(\frac{8}{x^2}\right)x$$
$$= 2x^2 + \frac{32}{x}$$

125. $I = 0.08x + 0.12(10{,}000 - x)$

Chapter 1 Test

1. (b), (c), and (d) are not functions.

2. **a.** $f(4) - f(-3) = 3 - (-2) = 5$

b. domain: $(-5, 6]$

c. range: $[-4, 5]$

d. increasing: $(-1, 2)$

e. decreasing: $(-5, -1)$ or $(2, 6)$

f. 2, $f(2) = 5$

g. $(-1, -4)$

h. x-intercepts: -4, 1, and 5.

i. y-intercept: -3

3. **a.** $-2, 2$

b. $-1, 1$

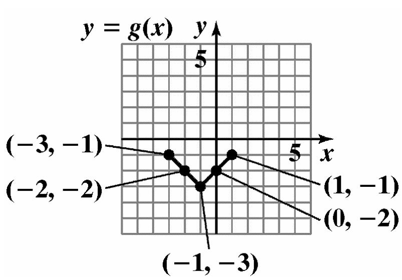
c. 0

d. even; $f(-x) = f(x)$

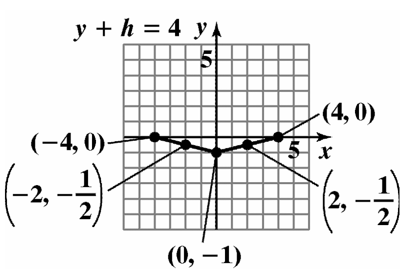
e. no; f fails the horizontal line test

f. $f(0)$ is a relative minimum.

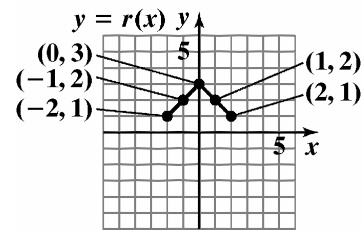
g.



h.

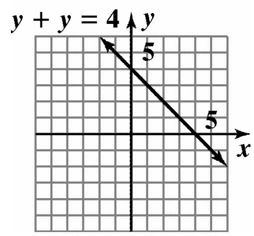


i.



j. $\dfrac{f(x_2) - f(x_1)}{x_2 - x_1} = \dfrac{-1-0}{1-(-2)} = -\dfrac{1}{3}$

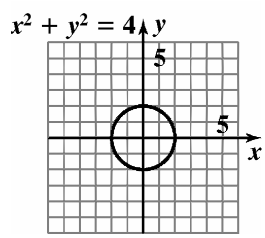
4.



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

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

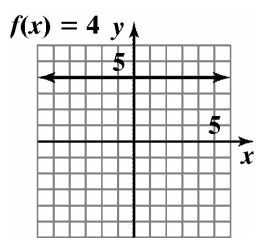
5.



Domain: $[-2, 2]$

Range: $[-2, 2]$

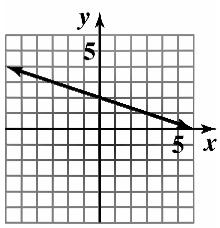
6.



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

Range: $\{4\}$

7.

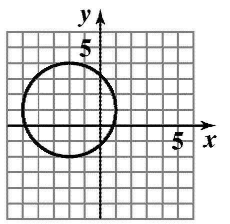


$f(x) = -\frac{1}{3}x + 2$

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

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

8.

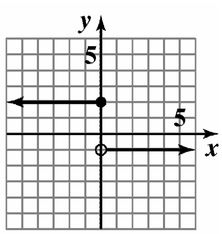


$(x + 2)^2 + (y - 1)^2 = 9$

Domain: $[-5, 1]$

Range: $[-2, 4]$

9.

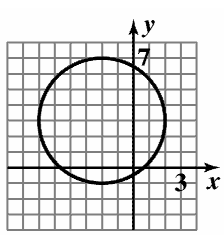


$f(x) = \begin{cases} 2 \text{ if } x \le 0 \\ -1 \text{ if } x > 0 \end{cases}$

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

Range: $\{-1, 2\}$

10.

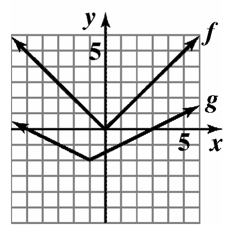


$x^2 + y^2 + 4x + 6y - 3 = 0$

Domain: $[-6, 2]$

Range: $[-1, 7]$

11.



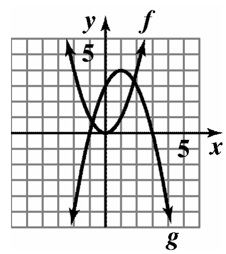
Domain of f: $(-\infty, \infty)$

Range of f: $[0, \infty)$

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

Range of g: $[-2, \infty)$

12.



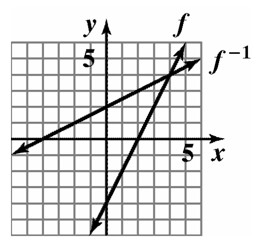
Domain of f: $(-\infty, \infty)$

Range of f: $[0, \infty)$

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

Range of g: $(-\infty, 4]$

13.



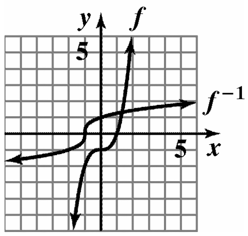
Domain of f: $(-\infty, \infty)$

Range of f: $(-\infty, \infty)$

Domain of f^{-1}: $(-\infty, \infty)$

Range of f^{-1}: $(-\infty, \infty)$

14.



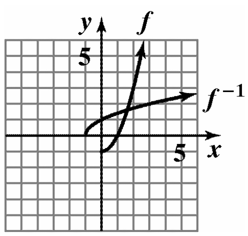
Domain of *f*: $(-\infty,\infty)$

Range of *f*: $(-\infty,\infty)$

Domain of f^{-1}: $(-\infty,\infty)$

Range of f^{-1}: $(-\infty,\infty)$

15.



Domain of *f*: $[0,\infty)$

Range of *f*: $[-1,\infty)$

Domain of f^{-1}: $[-1,\infty)$

Range of f^{-1}: $[0,\infty)$

16. $$\begin{aligned} f(x) &= x^2 - x - 4 \\ f(x-1) &= (x-1)^2 - (x-1) - 4 \\ &= x^2 - 2x + 1 - x + 1 - 4 \\ &= x^2 - 3x - 2 \end{aligned}$$

17. $$\begin{aligned} &\frac{f(x+h) - f(x)}{h} \\ &= \frac{(x+h)^2 - (x+h) - 4 - \left(x^2 - x - 4\right)}{h} \\ &= \frac{x^2 + 2xh + h^2 - x - h - 4 - x^2 + x + 4}{h} \\ &= \frac{2xh + h^2 - h}{h} \\ &= \frac{h\left(2x + h - 1\right)}{h} \\ &= 2x + h - 1 \end{aligned}$$

18. $$\begin{aligned} (g - f)(x) &= 2x - 6 - \left(x^2 - x - 4\right) \\ &= 2x - 6 - x^2 + x + 4 \\ &= -x^2 + 3x - 2 \end{aligned}$$

19. $$\left(\frac{f}{g}\right)(x) = \frac{x^2 - x - 4}{2x - 6}$$

Domain: $(-\infty,3)\cup(3,\infty)$

20. $$\begin{aligned} (f \circ g)(x) &= f\left(g(x)\right) \\ &= (2x-6)^2 - (2x-6) - 4 \\ &= 4x^2 - 24x + 36 - 2x + 6 - 4 \\ &= 4x^2 - 26x + 38 \end{aligned}$$

21. $$\begin{aligned} (g \circ f)(x) &= g\left(f(x)\right) \\ &= 2\left(x^2 - x - 4\right) - 6 \\ &= 2x^2 - 2x - 8 - 6 \\ &= 2x^2 - 2x - 14 \end{aligned}$$

22. $$\begin{aligned} g\left(f(-1)\right) &= 2\left((-1)^2 - (-1) - 4\right) - 6 \\ &= 2\left(1 + 1 - 4\right) - 6 \\ &= 2\left(-2\right) - 6 \\ &= -4 - 6 \\ &= -10 \end{aligned}$$

23. $$\begin{aligned} f(x) &= x^2 - x - 4 \\ f(-x) &= (-x)^2 - (-x) - 4 \\ &= x^2 + x - 4 \end{aligned}$$

f is neither even nor odd.

24. $$m = \frac{-8-1}{-1-2} = \frac{-9}{-3} = 3$$

point-slope form: $y - 1 = 3(x - 2)$
or $y + 8 = 3(x + 1)$
slope-intercept form: $y = 3x - 5$

25. $y = -\frac{1}{4}x + 5$ so $m = 4$

point-slope form: $y - 6 = 4(x + 4)$
slope-intercept form: $y = 4x + 22$

26. Write $4x+2y-5=0$ in slope intercept form.

$$4x+2y-5=0$$
$$2y=-4x+5$$
$$y=-2x+\frac{5}{2}$$

The slope of the parallel line is –2, thus the slope of the desired line is $m=-2$.

$$y-y_1=m(x-x_1)$$
$$y-(-10)=-2\left(x-(-7)\right)$$
$$y+10=-2(x+7)$$
$$y+10=-2x-14$$
$$2x+y+24=0$$

27. a. $(2,4.85)$ and $(5,4.49)$

First, find the slope using the points $(2,4.85)$ and $(5,4.49)$

$$m=\frac{4.49-4.85}{5-2}=\frac{-0.36}{3}=-0.12$$

Then use the slope and one of the points to write the equation in point-slope form.

$$y-y_1=m\left(x-x_1\right)$$
$$y-4.85=-0.12\left(x-2\right)$$

or

$$y-4.49=-0.12\left(x-5\right)$$

b. Solve for *y* to obtain slope-intercept form.

$$y-4.85=-0.12\left(x-2\right)$$
$$y-4.85=-0.12x+0.24$$
$$y=-0.12x+5.09$$
$$f(x)=-0.12x+5.09$$

c. To predict the minimum hourly inflation-adjusted wages in 2007, let $x = 2007 - 1997 = 10$.

$$f(10)=-0.12\left(10\right)+5.09=3.89$$

The linear function predicts the minimum hourly inflation-adjusted wage in 2007 to \$3.89.

28.
$$\frac{\left[3(10)^2-5\right]-[3(6)^2-5]}{10-6}$$
$$=\frac{205-103}{4}$$
$$=\frac{192}{4}$$
$$=48$$

29. $g(-1) = 3 - (-1) = 4$

$$g(7)=\sqrt{7-3}=\sqrt{4}=2$$

30. The denominator is zero when $x = 1$ or $x = -5$.

Domain: $\left(-\infty,-5\right)\cup\left(-5,1\right)\cup\left(1,\infty\right)$

31. The expressions under each radical must not be negative.

$x+5\ge 0$ and $x-1\ge 0$

$x\ge -5$ $\quad$ $x\ge 1$

Domain: $\left[1,\infty\right)$

32.
$$(f\circ g)(x)=\frac{7}{\frac{2}{x}-4}=\frac{7x}{2-4x}$$

$x\ne 0,\quad 2-4x\ne 0$

$$x\ne\frac{1}{2}$$

Domain: $\left(-\infty,0\right)\cup\left(0,\frac{1}{2}\right)\cup\left(\frac{1}{2},\infty\right)$

33. $f\left(x\right)=x^7 \qquad g\left(x\right)=2x+3$

34.
$$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$
$$d=\sqrt{(x_2-x_1)^2+\left(y_2-y_1\right)^2}$$
$$=\sqrt{(5-2)^2+\left(2-(-2)\right)^2}$$
$$=\sqrt{3^2+4^2}$$
$$=\sqrt{9+16}$$
$$=\sqrt{25}$$
$$=5$$

$$\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)=\left(\frac{2+5}{2},\frac{-2+2}{2}\right)$$
$$=\left(\frac{7}{2},0\right)$$

The length is 5 and the midpoint is $\left(\frac{7}{2},0\right)$.

35. a. $T(x)=41.78-0.19x$

b.
$$37.22=41.78-0.19x$$
$$-4.56=-0.19x$$
$$24=x$$

24 years after 1908, in 2004, the winning time will be 37.22 seconds.

36. **a.**
$$\begin{aligned}Y(x) &= 50-1.5(x-30)\\ &= 50-1.5x+45\\ &= 95-1.5x\end{aligned}$$

b.
$$\begin{aligned}T(x) &= x(95-1.5x)\\ &= -1.5x^2+95x\end{aligned}$$

37.
$$\begin{aligned}2l+2w &= 600\\ 2l &= 600-2w\\ l &= 300-w\end{aligned}$$
Let $x = w$

$$\begin{aligned}A(x) &= x(300-x)\\ &= -x^2+300x\end{aligned}$$

38.
$$\begin{aligned}V &= lwh\\ 8000 &= x\cdot x\cdot h\\ \frac{8000}{x^2} &= h\end{aligned}$$

$$\begin{aligned}A(x) &= 2x^2+4x\left(\frac{8000}{x^2}\right)\\ &= 2x^2+\frac{3200}{x}\end{aligned}$$