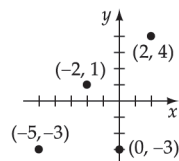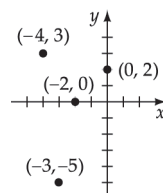## Chapter 2 Functions and Graphs

Section 2.1 Exercises

1. Plot the points:

2. Plot the points:

3. a. Find the decrease: The average debt decreased between 2006 and 2007, and 2008 and 2009.

b. Find the average debt in 2011:

Increase between 2009 to 2010: $22.0 - 20.1 = 1.9$
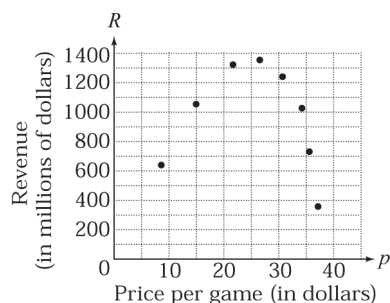
Then the increase from 2010 to 2011:

$22.0 + 1.9 = 23.9$, or \$23,900.

4. a. When the cost of a game is \$22, 60 million games can be sold.

b. The projected numbers of sales decreases as the price of this game increases.

c. .Create a table and scatter diagram:

p	$R = p \cdot N$
8	$8 \cdot 80 = 640$
15	$15 \cdot 70 = 1050$
22	$22 \cdot 60 = 1320$
27	$27 \cdot 50 = 1350$
31	$31 \cdot 40 = 1240$
34	$34 \cdot 30 = 1020$
36	$36 \cdot 20 = 720$
37	$37 \cdot 10 = 370$

d. The revenue increases to a certain point and then decreases as the price of the game increases.

5. Determine whether the ordered pair is a solution

$$2x + 5y = 16$$
$$2(-2) + 5(4) \overset{?}{=} 16$$
$$-4 + 20 \overset{?}{=} 16$$
$$16 = 16 \quad \text{True}$$

(–2, 4) is a solution.

6. Determine whether the ordered pair is a solution

$$2x^2 - 3y = 4$$
$$2(1)^2 - 3(-1) \overset{?}{=} 4$$
$$2 + 3 \overset{?}{=} 4$$
$$5 = 4 \quad \text{False}$$

(1,–1) is not a solution.

7. Determine whether the ordered pair is a solution

$$y = 3x^2 - 4x + 2$$
$$17 \overset{?}{=} 3(-3)^2 - 4(-3) + 2$$
$$17 \overset{?}{=} 27 + 12 + 2$$
$$17 = 41 \quad \text{False}$$

(–3, 17) is not a solution.

8. Determine whether the ordered pair is a solution

$$x^2 + y^2 = 169$$
$$(-2)^2 + (12)^2 \overset{?}{=} 169$$
$$4 + 144 \overset{?}{=} 169$$
$$148 = 169 \quad \text{False}$$

(–2, 12) is not a solution.

9. Find the distance: (6, 4), (–8, 11)

$$d = \sqrt{(-8-6)^2 + (11-4)^2}$$
$$= \sqrt{(-14)^2 + (7)^2}$$
$$= \sqrt{196 + 49}$$
$$= \sqrt{245}$$
$$= 7\sqrt{5}$$

10. Find the distance: (–5, 8), (–10, 14)

$$d = \sqrt{(-10-(-5))^2 + (14-8)^2}$$
$$= \sqrt{(-5)^2 + (6)^2}$$
$$= \sqrt{25+36}$$
$$= \sqrt{61}$$

11. Find the distance: (–4, –20), (–10, 15)

$$d = \sqrt{(-10-(-4))^2 + (15-(-20))^2}$$
$$= \sqrt{(-6)^2 + (35)^2}$$
$$= \sqrt{36+1225}$$
$$= \sqrt{1261}$$

12. Find the distance: (40, 32), (36, 20)

$$d = \sqrt{(36-40)^2 + (20-32)^2}$$
$$= \sqrt{(-4)^2 + (-12)^2}$$
$$= \sqrt{16+144}$$
$$= \sqrt{160}$$
$$= 4\sqrt{10}$$

13. Find the distance: (5, –8), (0, 0)

$$d = \sqrt{(0-5)^2 + (0-(-8))^2}$$
$$= \sqrt{(-5)^2 + (8)^2}$$
$$= \sqrt{25+64}$$
$$= \sqrt{89}$$

14. Find the distance: (0, 0), (5, 13)

$$d = \sqrt{(5-0)^2 + (13-0)^2}$$
$$= \sqrt{5^2 + 13^2}$$
$$= \sqrt{25+169}$$
$$= \sqrt{194}$$

15. Find the distance: $\left(\sqrt{3}, \sqrt{8}\right), \left(\sqrt{12}, \sqrt{27}\right)$

$$d = \sqrt{(\sqrt{12}-\sqrt{3})^2 + (\sqrt{27}-\sqrt{8})^2}$$
$$= \sqrt{(2\sqrt{3}-\sqrt{3})^2 + (3\sqrt{3}-2\sqrt{2})^2}$$
$$= \sqrt{(\sqrt{3})^2 + (3\sqrt{3}-2\sqrt{2})^2}$$
$$= \sqrt{3+(27-12\sqrt{6}+8)}$$
$$= \sqrt{3+27-12\sqrt{6}+8}$$
$$= \sqrt{38-12\sqrt{6}}$$

16. Find the distance: $\left(\sqrt{125}, \sqrt{20}\right), \left(6, 2\sqrt{5}\right)$

$$d = \sqrt{(6-\sqrt{125})^2 + (2\sqrt{5}-\sqrt{20})^2}$$
$$= \sqrt{(6-5\sqrt{5})^2 + (2\sqrt{5}-2\sqrt{5})^2}$$
$$= \sqrt{(6-5\sqrt{5})^2 + 0^2}$$
$$= \sqrt{(6-5\sqrt{5})^2} = \left|6-5\sqrt{5}\right| = 5\sqrt{5}-6$$

Note: for another form of the solution,

$$d = \sqrt{(6-5\sqrt{5})^2}$$
$$= \sqrt{36-60\sqrt{5}+125} = \sqrt{161-60\sqrt{5}}$$

17. Find the distance: (a, b), (–a, –b)

$$d = \sqrt{(-a-a)^2 + (-b-b)^2}$$
$$= \sqrt{(-2a)^2 + (-2b)^2}$$
$$= \sqrt{4a^2 + 4b^2}$$
$$= \sqrt{4(a^2 + b^2)}$$
$$= 2\sqrt{a^2 + b^2}$$

18. Find the distance: (a – b, b), (a, a + b)

$$d = \sqrt{(a-(a-b))^2 + (a+b-b)^2}$$
$$= \sqrt{(a-a+b)^2 + (a)^2}$$
$$= \sqrt{b^2 + a^2}$$
$$= \sqrt{a^2 + b^2}$$

19. Find the distance: (x, 4x), (–2x, 3x)

$$d = \sqrt{(-2x-x)^2 + (3x-4x)^2} \text{ with } x < 0$$
$$= \sqrt{(-3x)^2 + (-x)^2}$$
$$= \sqrt{9x^2 + x^2}$$
$$= \sqrt{10x^2}$$
$$= -x\sqrt{10} \quad \text{(Note: since } x < 0, \sqrt{x^2} = -x\text{)}$$

20. Find the distance: (x, 4x), (–2x, 3x)

$$d = \sqrt{(-2x-x)^2 + (3x-4x)^2} \text{ with } x > 0$$
$$= \sqrt{(-3x)^2 + (-x)^2}$$
$$= \sqrt{9x^2 + x^2}$$
$$= \sqrt{10x^2}$$
$$= x\sqrt{10} \quad \text{(since } x > 0, \sqrt{x^2} = x\text{)}$$

21. Find the midpoint: $(1, -1)$, $(5, 5)$

$$M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

$$= \left(\frac{1+5}{2}, \frac{-1+5}{2}\right)$$

$$= \left(\frac{6}{2}, \frac{4}{2}\right)$$

$$= (3, 2)$$

22. Find the midpoint: $(-5, -2)$, $(6, 10)$

$$M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

$$= \left(\frac{-5+6}{2}, \frac{-2+10}{2}\right)$$

$$= \left(\frac{1}{2}, \frac{8}{2}\right)$$

$$= \left(\frac{1}{2}, 4\right)$$

23. Find the midpoint: $(6, -3)$, $(6, 11)$

$$M = \left(\frac{6+6}{2}, \frac{-3+11}{2}\right)$$

$$= \left(\frac{12}{2}, \frac{8}{2}\right)$$

$$= (6, 4)$$

24. Find the midpoint: $(4, 7)$, $(-10, 7)$

$$M = \left(\frac{4+(-10)}{2}, \frac{7+7}{2}\right)$$

$$= \left(\frac{-6}{2}, \frac{14}{2}\right)$$

$$= (-3, 7)$$

25. Find the midpoint: $(1.75, 2.25)$, $(-3.5, 5.57)$

$$M = \left(\frac{1.75+(-3.5)}{2}, \frac{2.25+5.57}{2}\right)$$

$$= \left(-\frac{1.75}{2}, \frac{7.82}{2}\right)$$

$$= (-0.875, 3.91)$$

26. Find the midpoint: $(-8.2, 10.1)$, $(-2.4, -5.7)$

$$\left(\frac{-8.2+(-2.4)}{2}, \frac{10.1+(-5.7)}{2}\right)$$

$$= \left(-\frac{10.6}{2}, \frac{4.4}{2}\right)$$

$$= (-5.3, 2.2)$$

27. Find other endpoint: endpoint $(5, 1)$, midpoint $(9, 3)$

$$\left(\frac{x+5}{2}, \frac{y+1}{2}\right) = (9, 3)$$

therefore $\dfrac{x+5}{2} = 9$ and $\dfrac{y+1}{2} = 3$

$ x+5 = 18 \qquad\qquad y+1 = 6$

$ x = 13 \qquad\qquad\quad y = 5$

Thus $(13, 5)$ is the other endpoint.

28. Find other endpoint: endpoint $(4, -6)$,

midpoint $(-2, 11)$

$$\left(\frac{x+4}{2}, \frac{y+(-6)}{2}\right) = (-2, 11)$$

therefore $\dfrac{x+4}{2} = -2$ and $\dfrac{y+(-6)}{2} = 11$

$ x+4 = -4 \qquad\qquad y-6 = 22$

$ x = -8 \qquad\qquad\quad y = 28$

Thus $(-8, 28)$ is the other endpoint.

29. Find other endpoint: endpoint $(-3, -8)$,

midpoint $(2, -7)$

$$\left(\frac{x+(-3)}{2}, \frac{y+(-8)}{2}\right) = (2, -7)$$

therefore $\dfrac{x-3}{2} = 2$ and $\dfrac{y-8}{2} = -7$

$ x-3 = 4 \qquad\quad y-8 = -14$

$ x = 7 \qquad\qquad y = -6$

Thus $(7, -6)$ is the other endpoint.

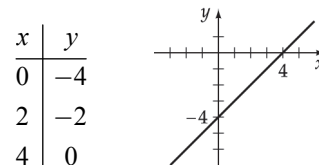**30.** Find other endpoint: endpoint $(5, -4)$, midpoint $(0, 0)$

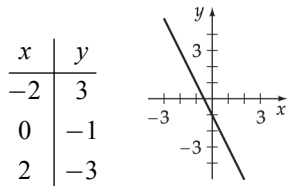$$\left(\frac{x+5}{2}, \frac{y+(-4)}{2}\right) = (0, 0)$$

therefore $\dfrac{x+5}{2} = 0$ and $\dfrac{y-4}{2} = 0$

$ x+5 = 0 \qquad\qquad y-4 = 0$

$ x = -5 \qquad\qquad\quad y = 4$

Thus $(-5, 4)$ is the other endpoint.

31. Graph the equation: $x - y = 4$

x	y
0	-4
2	-2
4	0

32. Graph the equation: $2x + y = -1$

x	y
−2	3
0	−1
2	−3

33. Graph the equation: $y = 0.25x^2$

x	y
−4	4
−2	1
0	0
2	1
4	4
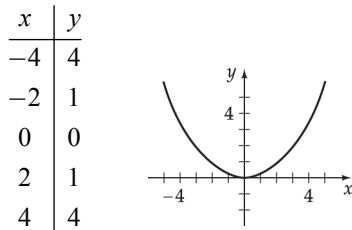
34. Graph the equation: $3x^2 + 2y = -4$

x	y
−2	−8
−1	−3.5
0	−2
1	−3.5
2	−8

35. Graph the equation: $y = -2|x - 3|$
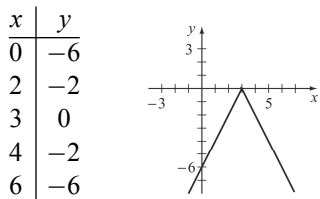
x	y
0	−6
2	−2
3	0
4	−2
6	−6

36. Graph the equation: $y = |x + 3| - 2$

x	y
−6	1
−5	0
−3	−2
−1	0
0	1

37. Graph the equation: $y = x^2 - 3$

x	y
−2	1
−1	−2
0	−3
1	−2
2	1

38. Graph the equation: $y = x^2 + 1$

x	y
−2	5
−1	2
0	1
1	2
2	5
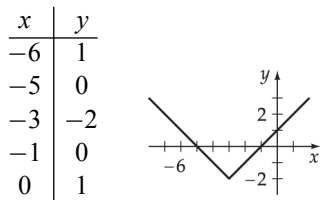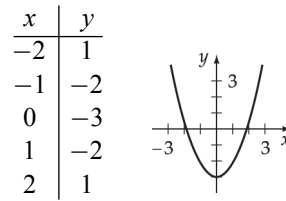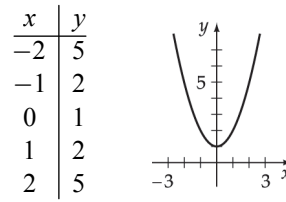
39. Graph the equation: $y = \frac{1}{2}(x - 1)^2$
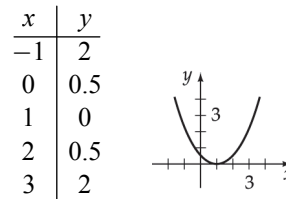
x	y
−1	2
0	0.5
1	0
2	0.5
3	2

40. Graph the equation: $y = 2(x + 2)^2$
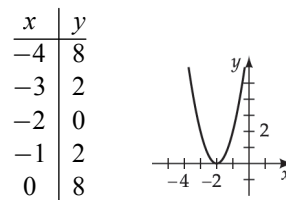
x	y
−4	8
−3	2
−2	0
−1	2
0	8

41. Graph the equation: $y = x^2 + 2x - 8$

x	y
−4	0
−2	−8
−1	−9
0	−8
2	0

42. Graph the equation: $y = x^2 - 2x - 8$

x	y
-2	0
0	-8
1	-9
2	-8
4	0
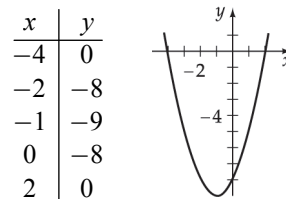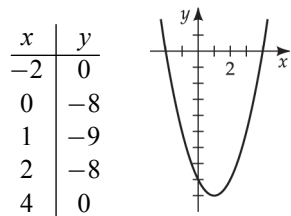
43. Graph the equation: $y = -x^2 + 2$

x	y
-2	-2
-1	1
0	2
1	1
2	-2
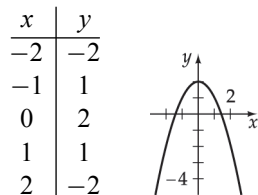
44. Graph the equation: $y = -x^2 - 1$

x	y
-2	-5
-1	-2
0	-1
1	-2
2	-5
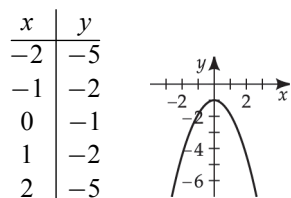
45. Find the x- and y-intercepts and graph: $2x + 5y = 12$

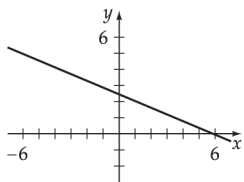For the y-intercept, let $x = 0$ and solve for y.

$$2(0) + 5y = 12$$
$$y = \frac{12}{5}, \ y\text{-intercept: } \left(0, \ \frac{12}{5}\right)$$

For the x-intercept, let $y = 0$ and solve for x.

$$2x + 5(0) = 12$$
$$x = 6, \ x\text{-intercept: } (6, 0)$$

46. Find the x- and y-intercepts and graph: $3x - 4y = 15$
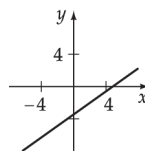
For the y-intercept, let $x = 0$ and solve for y.

$$3(0) - 4y = 15$$
$$y = -\frac{15}{4}, \ y\text{-intercept: } \left(0, \ -\frac{15}{4}\right)$$

For the x-intercept, let $y = 0$ and solve for x.

$$3x - 4(0) = 15$$
$$x = 5, \ x\text{-intercept: } (5, 0)$$

47. Find the x- and y-intercepts and graph: $x = -y^2 + 5$
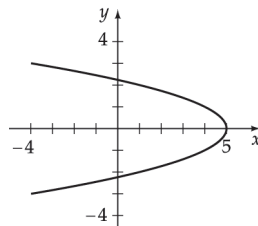
For the y-intercept, let $x = 0$ and solve for y.

$$0 = -y^2 + 5$$
$$y = \pm\sqrt{5}, \ y\text{-intercepts: } \left(0, -\sqrt{5}\right), \left(0, \ \sqrt{5}\right)$$

For the x-intercept, let $y = 0$ and solve for x.

$$x = -(0)^2 + 5$$
$$x = 5, \ x\text{-intercept: } (5, 0)$$

48. Find the x- and y-intercepts and graph: $x = y^2 - 6$
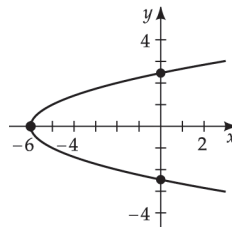
For the y-intercept, let $x = 0$ and solve for y.

$$0 = y^2 - 6$$
$$y = \pm\sqrt{6}, \ y\text{-intercepts: } \left(0, -\sqrt{6}\right), \left(0, \ \sqrt{6}\right)$$

For the x-intercept, let $y = 0$ and solve for x.

$$x = (0)^2 - 6$$
$$x = -6, \ x\text{-intercept: } (-6, 0)$$

49. Find the x- and y-intercepts and graph: $x = |y| - 4$

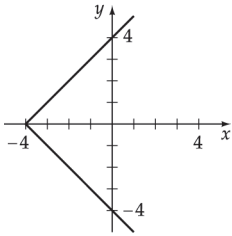For the y-intercept, let $x = 0$ and solve for y.

$$0 = |y| - 4$$
$$y = \pm 4, \ y\text{-intercepts: } (0, -4), (0, \ 4)$$

For the x-intercept, let $y = 0$ and solve for x.

$x = |0| - 4$

$x = -4$, x-intercept: $(-4, 0)$

50. Find the x- and y-intercepts and graph: $x = y^3 - 2$

For the y-intercept, let $x = 0$ and solve for y.

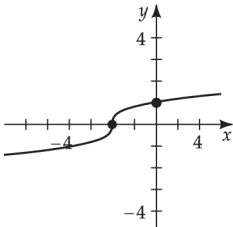$0 = y^3 - 2$

$y = \sqrt[3]{2}$, y-intercept: $\left(0, \sqrt[3]{2}\right)$

For the x-intercept, let $y = 0$ and solve for x.

$x = (0)^3 - 2$

$x = -2$, x-intercept: $(-2, 0)$

51. Find the x- and y-intercepts and graph: $x^2 + y^2 = 4$

For the y-intercept, let $x = 0$ and solve for y.

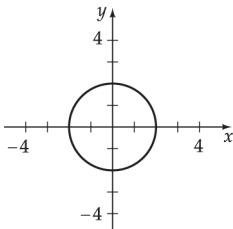$(0)^2 + y^2 = 4$

$y = \pm 2$, y-intercepts: $(0, -2), (0, 2)$

For the x-intercept, let $y = 0$ and solve for x.

$x^2 + (0)^2 = 4$

$x = \pm 2$, x-intercepts: $(-2, 0), (2, 0)$

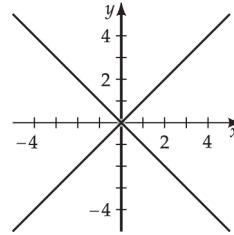**52.** Find the x- and y-intercepts and graph: $x^2 = y^2$

For the y-intercept, let $x = 0$ and solve for y.

For the x-intercept, let $y = 0$ and solve for x.

Intercept: $(0, 0)$

53. Find center and radius: $x^2 + y^2 = 36$

center $(0, 0)$, radius 6

54. Find center and radius: $x^2 + y^2 = 49$

center $(0, 0)$, radius 7

55. Find center and radius: $(x-1)^2 + (y-3)^2 = 49$

center $(1, 3)$, radius 7

56. Find center and radius: $(x-2)^2 + (y-4)^2 = 25$

center $(2, 4)$, radius 5

57. Find center and radius: $(x+2)^2 + (y+5)^2 = 25$

center $(-2, -5)$, radius 5

58. Find center and radius: $(x+3)^2 + (y+5)^2 = 121$

center $(-3, -5)$, radius 11

59. Find center and radius: $(x-8)^2 + y^2 = \dfrac{1}{4}$

center $(8, 0)$, radius $\dfrac{1}{2}$

60. Find center and radius: $x^2 + (y-12)^2 = 1$

center $(0, 12)$, radius 1

61. Find circle equation: center $(4, 1)$, radius 2

$(x-4)^2 + (y-1)^2 = 2^2$

$(x-4)^2 + (y-1)^2 = 4$

62. Find circle equation: center $(5, -3)$, radius 4

$(x-5)^2 + (y+3)^2 = 4^2$

$(x-5)^2 + (y+3)^2 = 16$

63. Find circle equation: center $\left(\frac{1}{2}, \frac{1}{4}\right)$, radius $\sqrt{5}$

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

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

64. Find circle equation: center $\left(0, \frac{2}{3}\right)$, radius $\sqrt{11}$

$$(x-0)^2 + \left(y-\frac{2}{3}\right)^2 = \left(\sqrt{11}\right)^2$$

$$(x-0)^2 + \left(y-\frac{2}{3}\right)^2 = 11$$

65. Find circle equation: center (0, 0), through (–3, 4)

$$(x-0)^2 + (y-0)^2 = r^2$$
$$(-3-0)^2 + (4-0)^2 = r^2$$
$$(-3)^2 + 4^2 = r^2$$
$$9+16 = r^2$$
$$25 = 5^2 = r^2$$
$$(x-0)^2 + (y-0)^2 = 25$$

66. Find circle equation: center (0, 0), through (5, 12)

$$(x-0)^2 + (y-0)^2 = r^2$$
$$(5-0)^2 + (12-0)^2 = r^2$$
$$5^2 + 12^2 = r^2$$
$$25+144 = r^2$$
$$169 = 13^2 = r^2$$
$$(x-0)^2 + (y-0)^2 = 169$$

67. Find circle equation: center (1, 3), through (4, –1)

$$(x+2)^2 + (y-5)^2 = r^2$$
$$(x-1)^2 + (y-3)^2 = r^2$$
$$(4-1)^2 + (-1-3)^2 = r^2$$
$$3^2 + (-4)^2 = r^2$$
$$9+16 = r^2$$
$$25 = 5^2 = r^2$$
$$(x-1)^2 + (y-3)^2 = 25$$

68. Find circle equation: center (–2, 5), through (1, 7)

$$(1+2)^2 + (7-5)^2 = r^2$$
$$3^2 + 2^2 = r^2$$
$$9+4 = r^2$$
$$13 = \left(\sqrt{13}\right)^2 = r^2$$
$$(x+2)^2 + (y-5)^2 = 13$$

69. Find circle equation: center $(-2, 5)$, diameter 10

diameter 10 means the radius is $5 \Rightarrow r^2 = 25$.

$$(x+2)^2 + (y-5)^2 = 25$$

70. Find circle equation: center $(0, -1)$, diameter 8

diameter 8 means the radius is $4 \Rightarrow r^2 = 16$.

$$(x-0)^2 + (y+1)^2 = 16$$

71. Find circle equation: endpoints (2, 3) and (–4, 11)

$$d = \sqrt{(-4-2)^2 + (11-3)^2}$$
$$= \sqrt{36+64} = \sqrt{100}$$
$$= 10$$

Since the diameter is 10, the radius is 5.

The center is the midpoint of the line segment from (2, 3) to (–4, 11).

$$\left(\frac{2+(-4)}{2}, \frac{3+11}{2}\right) = (-1, 7) \text{ center}$$
$$(x+1)^2 + (y-7)^2 = 25$$

72. Find circle equation: endpoints (7, –2) and (–3, 5)

$$d = \sqrt{(-3-7)^2 + (5-(-2))^2} = \sqrt{100+49} = \sqrt{149}$$

Since the diameter is $\sqrt{149}$, the radius is $\frac{\sqrt{149}}{2}$.

Center is $\left(\frac{7+(-3)}{2}, \frac{(-2)+5}{2}\right) = \left(2, \frac{3}{2}\right)$

$$(x-2)^2 + \left(y-\frac{3}{2}\right)^2 = \left(\frac{\sqrt{149}}{2}\right)^2$$
$$(x-2)^2 + \left(y-\frac{3}{2}\right)^2 = \frac{149}{4}$$

73. Find circle equation: endpoints (5,–3) and (–1,–5)

$$d = \sqrt{(-5-(-3))^2 + (-1-5)^2} = \sqrt{4+36} = \sqrt{40}$$

Since the diameter is $\sqrt{40}$, the radius is $\dfrac{\sqrt{40}}{2} = \sqrt{10}$.

Center is $\left(\dfrac{5+(-1)}{2}, \dfrac{(-3)+(-5)}{2}\right) = (2,-4)$

$$(x-2)^2 + (y+4)^2 = \left(\sqrt{10}\right)^2$$
$$(x-2)^2 + (y+4)^2 = 10$$

74. Find circle equation: endpoints (4,–6) and (0,–2)

$$d = \sqrt{(-2-(-6))^2 + (0-4)^2} = \sqrt{16+16} = \sqrt{32}$$

Since the diameter is $\sqrt{32}$, the radius is $\dfrac{\sqrt{32}}{2} = 2\sqrt{2}$.

Center is $\left(\dfrac{4+0}{2}, \dfrac{(-6)+(-2)}{2}\right) = (2,-4)$

$$(x-2)^2 + (y+4)^2 = \left(2\sqrt{2}\right)^2$$
$$(x-2)^2 + (y+4)^2 = 8$$

75. Find circle equation: center (7, 11), tangent to *x*-axis

Since it is tangent to the *x*-axis, its radius is 11.

$$(x-7)^2 + (y-11)^2 = 11^2$$

76. Find circle equation: center (–2, 3), tangent to *y*-axis

Since it is tangent to the *y*-axis, its radius is 2.

$$(x+2)^2 + (y-3)^2 = 2^2$$

77. Find center and radius: $x^2 + y^2 - 6x + 5 = 0$

$$x^2 - 6x \quad + y^2 = -5$$
$$x^2 - 6x + 9 + y^2 = -5 + 9$$
$$(x-3)^2 + y^2 = 2^2$$

center (3, 0), radius 2

78. Find center and radius: $x^2 + y^2 - 6x - 4y + 12 = 0$

$$x^2 - 6x \quad + y^2 - 4y \quad = -12$$
$$x^2 - 6x + 9 + y^2 - 4y + 4 = -12 + 9 + 4$$
$$(x-3)^2 + (y-2)^2 = 1^2$$

center (3, 2), radius 1

79. Find center and radius: $x^2 + y^2 - 14x + 8y + 53 = 0$

$$x^2 - 14x \quad + y^2 + 8y \quad = -53$$
$$x^2 - 14x + 49 + y^2 + 8y + 16 = -53 + 49 + 16$$
$$(x-7)^2 + (y+4)^2 = 12$$

center (7, –4), radius $\sqrt{12} = 2\sqrt{3}$

80. Find center and radius: $x^2 + y^2 - 10x + 2y + 18 = 0$

$$x^2 - 10x \quad + y^2 + 2y \quad = -18$$
$$x^2 - 10x + 25 + y^2 + 2y + 1 = -18 + 25 + 1$$
$$(x-5)^2 + (y+1)^2 = 8$$

center (5, –1), radius $\sqrt{8} = 2\sqrt{2}$

81. Find center and radius: $x^2 + y^2 - x + 3y - \dfrac{15}{4} = 0$

$$x^2 - x \quad + y^2 + 3y \quad = \dfrac{15}{4}$$
$$x^2 - x + \dfrac{1}{4} + y^2 + 3y + \dfrac{9}{4} = \dfrac{15}{4} + \dfrac{1}{4} + \dfrac{9}{4}$$
$$\left(x - \dfrac{1}{2}\right)^2 + \left(y + \dfrac{3}{2}\right)^2 = \left(\dfrac{5}{2}\right)^2$$

center $\left(\dfrac{1}{2}, -\dfrac{3}{2}\right)$, radius $\dfrac{5}{2}$

82. Find center and radius: $x^2 + y^2 + 3x - 5y + \dfrac{25}{4} = 0$

$$x^2 + 3x \quad + y^2 - 5y \quad = -\dfrac{25}{4}$$
$$x^2 + 3x + \dfrac{9}{4} + y^2 - 5y + \dfrac{25}{4} = -\dfrac{25}{4} + \dfrac{9}{4} + \dfrac{25}{4}$$
$$\left(x + \dfrac{3}{2}\right)^2 + \left(y - \dfrac{5}{2}\right)^2 = \left(\dfrac{3}{2}\right)^2$$

center $\left(-\dfrac{3}{2}, \dfrac{5}{2}\right)$, radius $\dfrac{3}{2}$

83. Find center and radius: $x^2 + y^2 + 3x - 6y + 2 = 0$

$$x^2 + 3x \quad + y^2 - 6y \quad = -2$$
$$x^2 + 3x + \dfrac{9}{4} + y^2 - 6y + 9 = -2 + \dfrac{9}{4} + 9$$
$$\left(x + \dfrac{3}{2}\right)^2 + (y - 3)^2 = \left(\dfrac{\sqrt{37}}{2}\right)^2$$

center $\left(-\dfrac{3}{2}, 3\right)$, radius $\dfrac{\sqrt{37}}{2}$

84. Find center and radius: $x^2 + y^2 - 5x - y - 4 = 0$

$$x^2 - 5x \qquad + y^2 - y \qquad = 4$$

$$x^2 - 5x + \frac{25}{4} \quad + y^2 - y + \frac{1}{4} \quad = 4 + \frac{25}{4} + \frac{1}{4}$$

$$\left(x - \frac{5}{2}\right)^2 + \left(y - \frac{1}{2}\right)^2 = \left(\frac{\sqrt{42}}{2}\right)^2$$

center $\left(\frac{5}{2}, \frac{1}{2}\right)$, radius $\frac{\sqrt{42}}{2}$

85. Find the points:

$$\sqrt{(4-x)^2 + (6-0)^2} = 10$$

$$\left(\sqrt{(4-x)^2 + (6-0)^2}\right)^2 = 10^2$$

$$16 - 8x + x^2 + 36 = 100$$

$$x^2 - 8x - 48 = 0$$

$$(x - 12)(x + 4) = 0$$

$$x = 12 \quad \text{or} \quad x = -4$$

The points are $(12, 0)$, $(-4, 0)$.

86. Find the points:

$$\sqrt{(5-0)^2 + (y - (-3))^2} = 12$$

$$\left(\sqrt{(5)^2 + (y + 3)^2}\right)^2 = 12^2$$

$$25 + y^2 + 6y + 9 = 144$$

$$y^2 + 6y - 110 = 0$$

$$y = \frac{-6 \pm \sqrt{6^2 - 4(1)(-110)}}{2(1)}$$

$$y = \frac{-6 \pm \sqrt{36 + 440}}{2}$$

$$y = \frac{-6 \pm \sqrt{476}}{2}$$

$$y = \frac{-6 \pm 2\sqrt{119}}{2}$$

$$y = -3 \pm \sqrt{119}$$

The points are $(0, -3 + \sqrt{119})$, $(0, -3 - \sqrt{119})$.

87. Find the x- and y-intercepts and graph: $|x| + |y| = 4$
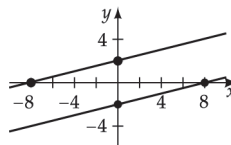
Intercepts: $(0, \pm 4)$, $(\pm 4, 0)$
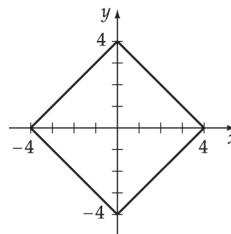
88. Find the x- and y-intercepts and graph: $|x - 4y| = 8$

For the y-intercept, let $x = 0$ and solve for y.

$$|0 - 4y| = 8$$

$$4y = \pm 8$$

$$y = \pm 2, \quad y\text{-intercepts: } (0, -2), (0, 2)$$

For the x-intercept, let $y = 0$ and solve for x.

$$|x - 4(0)| = 8$$

$$x = \pm 8, \quad x\text{-intercepts: } (-8, 0), (8, 0)$$

89. Find the formula:

$$\sqrt{(3-x)^2 + (4-y)^2} = 5$$

$$(3-x)^2 + (4-y)^2 = 5^2$$

$$9 - 6x + x^2 + 16 - 8y + y^2 = 25$$

$$x^2 - 6x + y^2 - 8y = 0$$

90. Find the formula:

$$\sqrt{(-5-x)^2 + (12-y)^2} = 13$$

$$(-5-x)^2 + (12-y)^2 = 13^2$$

$$25 + 10x + x^2 + 144 - 24y + y^2 = 169$$

$$x^2 + 10x + y^2 - 24y = 0$$

Prepare for Section 2.2

P1. $x^2 + 3x - 4$

$$(-3)^2 + 3(-3) - 4 = 9 - 9 - 4 = -4$$

P2. $D = \{-3, -2, -1, 0, 2\}$

$R = \{1, 2, 4, 5\}$

P3. $d = \sqrt{(3-(-4))^2 + (-2-1)^2} = \sqrt{49+9} = \sqrt{58}$

P4. $2x - 6 \geq 0$

$\qquad 2x \geq 6$

$\qquad x \geq 3$

P5. $\qquad x^2 - x - 6 = 0$

$\qquad (x+2)(x-3) = 0$

$\qquad x + 2 = 0 \qquad x - 3 = 0$

$\qquad\quad x = -2 \qquad\quad x = 3$

$\quad$ –2, 3

P6. $a = 3x + 4, \quad a = 6x - 5$

$\qquad 3x + 4 = 6x - 5$

$\qquad\quad 9 = 3x$

$\qquad\quad 3 = x$

$\qquad a = 3(3) + 4 = 13$

Section 2.2 Exercises

1. Write the domain and range. State whether a relation.

Domain: {–4, 2, 5, 7}; range: {1, 3, 11}

Yes. The set of ordered pairs defines y as a function of x since each x is paired with exactly one y.

2. Write the domain and range. State whether a relation.

Domain: {3, 4, 5}; range: {–2, 7, 8, 10}

No. The set of ordered pair does not define y as a function of x since 5 is paired with 10 and 8.

3. Write the domain and range. State whether a relation.

Domain: {4, 5, 6}; range: {–3, 1, 4, 5}

No. The set of ordered pair does not define y as a function of x since 4 is paired with 4 and 5.

4. Write the domain and range. State whether a relation.

Domain: {1, 2, 3}; range {0}

Yes. The set of ordered pairs defines y as a function of x since each x is paired with exactly one y.

5. Determine if the value is in the domain.

$f(0) = \dfrac{3(0)}{0+4} = 0$

Yes, 0 is in the domain of the function.

6. Determine if the value is in the domain.

$g(-1) = 1 - (-1)^2 = 0$

Yes, –1 is in the domain of the function.

7. Determine if the value is in the domain.

$F(0) = \dfrac{-1-1}{-1+1} = \dfrac{-2}{0}$ undefined

No, –1 is not in the domain of the function.

8. Determine if the value is in the domain.

$y(2) = \sqrt{2(2)-8} = \sqrt{-4}$

No, 2 is not in the domain of the function.

9. Determine if the value is in the domain.

$g(-1) = \dfrac{5(-1)-1}{(-1)^2+1} = \dfrac{-6}{2} = -3$

Yes, –1 is in the domain of the function.

10. Determine if the value is in the domain.

$F(-2) = \dfrac{1}{(-2)^3+8} = \dfrac{1}{0}$

No, 0 is not in the domain of the function.

11. Is y a function of x?

$2x + 3y = 7$

$\qquad 3y = -2x + 7$

$\qquad\quad y = -\dfrac{2}{3}x + \dfrac{7}{3}, \;\; y$ is a function of x.

12. Is y a function of x?

$5x + y = 8$

$\qquad\quad y = -5x + 8, \;\; y$ is a function of x.

13. Is y a function of x?

$-x + y^2 = 2$

$\qquad\quad y^2 = x + 2$

$\qquad\quad y = \pm\sqrt{x+2}, \;\; y$ is a not function of x.

14. Is y a function of x?

$x^2 - 2y = 2$

$\qquad -2y = -x^2 + 2$

$\qquad\quad y = \dfrac{1}{2}x^2 - 1, \;\; y$ is a function of x.

15. Is y a function of x?

$$x^2 + y^2 = 9$$
$$y^2 = 9 - x^2$$
$$y = \pm\sqrt{9 - x^2}, \ y \text{ is a not function of } x.$$

16. Is y a function of x?

$$y = \sqrt[3]{x}, \ y \text{ is a function of } x.$$

17. Is y a function of x?

$$y = |x| + 5, \ y \text{ is a function of } x.$$

18. Is y a function of x?

$$y = \sqrt{x^2 + 4}, \ y \text{ is a function of } x.$$

19. Determine if the value is a zero.

$$f(-2) = 3(-2) + 6 = 0$$

Yes, –2 is a zero.

20. Determine if the value is a zero.

$$f(0) = 2(0)^3 - 4(0)^2 + 5(0) = 0$$

Yes, 0 is a zero.

21. Determine if the value is a zero.

$$G\left(-\frac{1}{3}\right) = 3\left(-\frac{1}{3}\right)^2 + 2\left(-\frac{1}{3}\right) - 1 = -\frac{4}{3}$$

No, $-\frac{1}{3}$ is not a zero.

22. Determine if the value is a zero.

$$s(-1) = \frac{2(-1) + 6}{-1 + 1} = \frac{4}{0} \text{ undefined}$$

No, –1 is not a zero.

23. Determine if the value is a zero.

$$y(1) = 5(1)^2 - 2(1) - 2 = 1$$

No, 1 is not a zero.

24. Determine if the value is a zero.

$$g(-3) = \frac{3(-3) + 9}{(-3)^2 - 4} = \frac{0}{5} = 0$$

Yes, –3 is a zero.

25. Evaluate the function $f(x) = 3x - 1$,

a. $f(2) = 3(2) - 1$
$$= 6 - 1$$
$$= 5$$

b. $f(-1) = 3(-1) - 1$
$$= -3 - 1$$
$$= -4$$

c. $f(0) = 3(0) - 1$
$$= 0 - 1$$
$$= -1$$

d. $f\left(\frac{2}{3}\right) = 3\left(\frac{2}{3}\right) - 1$
$$= 2 - 1$$
$$= 1$$

e. $f(k) = 3(k) - 1$
$$= 3k - 1$$

f. $f(k + 2) = 3(k + 2) - 1$
$$= 3k + 6 - 1$$
$$= 3k + 5$$

26. Evaluate the function $g(x) = 2x^2 + 3$,

a. $g(3) = 2(3)^2 + 3 = 18 + 3 = 21$

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

c. $g(0) = 2(0)^2 + 3 = 0 + 3 = 3$

d. $g\left(\frac{1}{2}\right) = 2\left(\frac{1}{2}\right)^2 + 3 = \frac{1}{2} + 3 = \frac{7}{2}$

e. $g(c) = 2(c)^2 + 3 = 2c^2 + 3$

f. $g(c + 5) = 2(c + 5)^2 + 3$
$$= 2c^2 + 20c + 50 + 3$$
$$= 2c^2 + 20c + 53$$

27. Evaluate the function $A(w) = \sqrt{w^2 + 5}$,

a. $A(0) = \sqrt{(0)^2 + 5} = \sqrt{5}$

b. $A(2) = \sqrt{(2)^2 + 5} = \sqrt{9} = 3$

c. $A(-2) = \sqrt{(-2)^2 + 5} = \sqrt{9} = 3$

d. $A(4) = \sqrt{4^2 + 5} = \sqrt{21}$

e. $A(r+1) = \sqrt{(r+1)^2 + 5}$

$$= \sqrt{r^2 + 2r + 1 + 5}$$

$$= \sqrt{r^2 + 2r + 6}$$

f. $A(-c) = \sqrt{(-c)^2 + 5} = \sqrt{c^2 + 5}$

28. Evaluate the function $J(t) = 3t^2 - t$,

a. $J(-4) = 3(-4)^2 - (-4) = 48 + 4 = 52$

b. $J(0) = 3(0)^2 - (0) = 0 - 0 = 0$

c. $J\left(\dfrac{1}{3}\right) = 3\left(\dfrac{1}{3}\right)^2 - \dfrac{1}{3} = \dfrac{1}{3} - \dfrac{1}{3} = 0$

d. $J(-c) = 3(-c)^2 - (-c) = 3c^2 + c$

e. $J(x+1) = 3(x+1)^2 - (x+1)$

$$= 3x^2 + 6x + 3 - x - 1$$

$$= 3x^2 + 5x + 2$$

f. $J(x+h) = 3(x+h)^2 - (x+h)$

$$= 3x^2 + 6xh + 3h^2 - x - h$$

29. Evaluate the function $f(x) = \dfrac{1}{|x|}$,

a. $f(2) = \dfrac{1}{|2|} = \dfrac{1}{2}$

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

c. $f\left(-\dfrac{3}{5}\right) = \dfrac{1}{\left|-\dfrac{3}{5}\right|}$

$$= \dfrac{1}{\frac{3}{5}}$$

$$= 1 \div \dfrac{3}{5} = 1 \cdot \dfrac{5}{3}$$

$$= \dfrac{5}{3}$$

d. $f(2) + f(-2) = \dfrac{1}{2} + \dfrac{1}{2} = 1$

e. $f(c^2 + 4) = \dfrac{1}{|c^2 + 4|} = \dfrac{1}{c^2 + 4}$

f. $f(2+h) = \dfrac{1}{|2+h|}$

30. Evaluate the function $T(x) = 5$,

a. $T(-3) = 5$

b. $T(0) = 5$

c. $T\left(\dfrac{2}{7}\right) = 5$

d. $T(3) + T(1) = 5 + 5 = 10$

e. $T(x+h) = 5$

f. $T(3k+5) = 5$

31. Evaluate the function $s(x) = \dfrac{x}{|x|}$,

a. $s(4) = \dfrac{4}{|4|} = \dfrac{4}{4} = 1$

b. $s(5) = \dfrac{5}{|5|} = \dfrac{5}{5} = 1$

c. $s(-2) = \dfrac{-2}{|-2|} = \dfrac{-2}{2} = -1$

d. $s(-3) = \dfrac{-3}{|-3|} = \dfrac{-3}{3} = -1$

e. Since $t > 0$, $|t| = t$.

$$s(t) = \dfrac{t}{|t|} = \dfrac{t}{t} = 1$$

f. Since $t < 0$, $|t| = -t$.

$$s(t) = \dfrac{t}{|t|} = \dfrac{t}{-t} = -1$$

32. Evaluate the function $r(x) = \dfrac{x}{x+4}$,

a. $r(0) = \dfrac{0}{0+4} = \dfrac{0}{4} = 0$

b. $r(-1) = \dfrac{-1}{-1+4} = \dfrac{-1}{3} = -\dfrac{1}{3}$

c. $r(-3) = \dfrac{-3}{-3+4} = \dfrac{-3}{1} = -3$

d. $r\left(\dfrac{1}{2}\right) = \dfrac{\dfrac{1}{2}}{\dfrac{1}{2}+4} = \dfrac{\left(\dfrac{1}{2}\right)}{\left(\dfrac{9}{2}\right)}$

$$= \dfrac{1}{2} \div \dfrac{9}{2} = \dfrac{1}{2} \cdot \dfrac{2}{9} = \dfrac{1}{9}$$

e. $r(0.1) = \dfrac{0.1}{0.1+4} = \dfrac{0.1}{4.1} = \dfrac{1}{41}$

f. $r(10,000) = \dfrac{10,000}{10,000+4} = \dfrac{10,000}{10,004} = \dfrac{2500}{2501}$

33. a. Since $x = -4 < 2$, use $P(x) = 3x+1$.

$P(-4) = 3(-4)+1 = -12+1 = -11$

b. Since $x = \sqrt{5} \geq 2$, use $P(x) = -x^2 +11$.

$P\left(\sqrt{5}\right) = -\left(\sqrt{5}\right)^2 +11 = -5+11 = 6$

c. Since $x = c < 2$, use $P(x) = 3x+1$.

$P(c) = 3c+1$

d. Since $k \geq 1$, then $x = k+1 \geq 2$,

so use $P(x) = -x^2 +11$.

$P(k+1) = -(k+1)^2 +11 = -(k^2 +2k+1)+11$

$\qquad\qquad = -k^2 -2k-1+11$

$\qquad\qquad = -k^2 -2k+10$

34. a. Since $t = 0$ and $0 \leq t \leq 5$, use $Q(t) = 4$.

$Q(0) = 4$

b. Since $t = e$ and $6 < e < 7$, then $5 < t \leq 8$,

so use $Q(t) = -t+9$.

$Q(e) = -e+9$

c. Since $t = n$ and $1 < n < 2$, then $0 \leq t \leq 5$,

so use $Q(t) = 4$

$Q(0) = 4$

d. Since $t = m^2 +7$ and $1 < m \leq 2$,

then $1^2 < m^2 \leq 2^2$

$1^2 +7 < m^2 +7 \leq 2^2 +7$

$1+7 < m^2 +7 \leq 4+7$

$8 < m^2 +7 \leq 11$

thus $8 < \quad t \quad \leq 11$,

so use $Q(t) = \sqrt{t-7}$

$Q(m^2 +7) = \sqrt{\left(m^2 +7\right)-7}$

$\qquad\qquad = \sqrt{m^2} = |m| = m$ since $m > 0$

35. For $f(x) = 3x-4$, the domain is the set of all real numbers.

36. For $f(x) = -2x+1$, the domain is the set of all real numbers.

37. For $f(x) = x^2 +2$, the domain is the set of all real numbers.

38. For $f(x) = 3x^2 +1$, the domain is the set of all real numbers.

39. For $f(x) = \dfrac{4}{x+2}$, the domain is $\{x | x \neq -2\}$.

40. For $f(x) = \dfrac{6}{x-5}$, the domain is $\{x | x \neq 5\}$.

41. For $f(x) = \sqrt{7+x}$, the domain is $\{x | x \geq -7\}$.

42. For $f(x) = \sqrt{4-x}$, the domain is $\{x | x \leq 4\}$.

43. For $f(x) = \sqrt{4-x^2}$, the domain is $\{x | -2 \leq x \leq 2\}$.

44. For $f(x) = \sqrt{12-x^2}$, the domain is

$\left\{x | -2\sqrt{3} \leq x \leq 2\sqrt{3}\right\}$.

45. For $f(x) = \dfrac{1}{\sqrt{x+4}}$, the domain is $\{x | x > -4\}$.

46. For $f(x) = \dfrac{1}{\sqrt{5-x}}$, the domain is $\{x | x < 5\}$.

47. To graph $f(x) = 3x-4$, plot points and draw a smooth graph.

x	-1	0	1	2
$y = f(x) = 3x-4$	-7	-4	-1	2
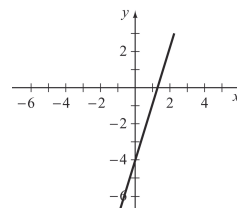
48. To graph $f(x)=2-\dfrac{1}{2}x$, plot points and draw a smooth graph.

x	-4	-2	0	4
$y=f(x)=2-\dfrac{1}{2}x$	4	3	2	0
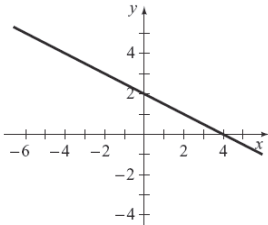
49. To graph $g(x)=x^2-1$, plot points and draw a smooth graph.

x	-2	-1	0	1	2
$y=g(x)=x^2-1$	3	0	-1	0	3
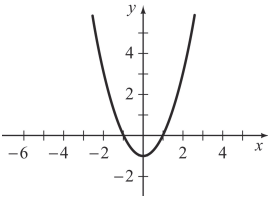
50. To graph $g(x)=3-x^2$, plot points and draw a smooth graph.

x	-3	-1	0	1	3
$y=g(x)=3-x^2$	-6	2	3	2	-6
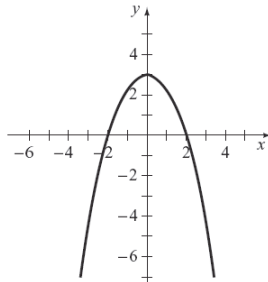
51. To graph $f(x)=\sqrt{x+4}$, plot points and draw a smooth graph.

x	-4	-2	0	2	5
$y=f(x)=\sqrt{x+4}$	0	$\sqrt{2}$	2	$\sqrt{6}$	3
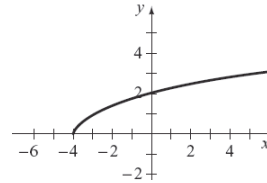
52. To graph $h(x)=\sqrt{5-x}$, plot points and draw a smooth graph.

x	-4	0	1	3	5
$y=h(x)=\sqrt{5-x}$	3	$\sqrt{5}$	2	$\sqrt{2}$	0
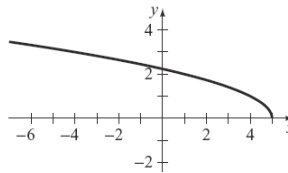
53. To graph $f(x)=|x-2|$, plot points and draw a smooth graph.

x	-3	0	2	4	6
$y=f(x)=|x-2|$	5	2	0	2	4
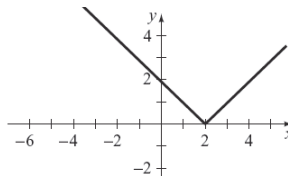
54. To graph $h(x)=3-|x|$, plot points and draw a smooth graph.

x	-3	-1	0	1	3
$y=h(x)=3-|x|$	0	2	3	2	0
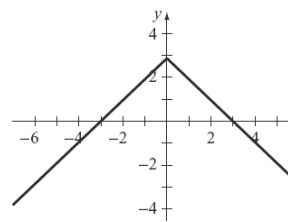
55. To graph $L(x) = \left[\!\left[\frac{1}{3}x\right]\!\right]$ for $-6 \le x \le 6$, plot points

and draw a smooth graph.

x	-6	-4	-3	-1	0	4	6
$y = L(x) = \left[\!\left[\frac{1}{3}x\right]\!\right]$	-2	-2	-1	-1	0	1	2
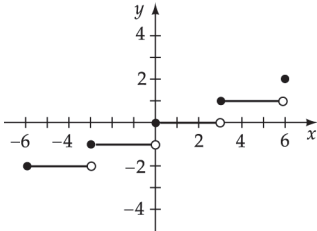
56. To graph $L(x) = [\![x]\!] + 2$ for $0 \le x \le 4$, plot points

and draw a smooth graph.

x	0	1	2	3	4
$y = L(x) = [\![x]\!] + 2$	2	3	4	5	6
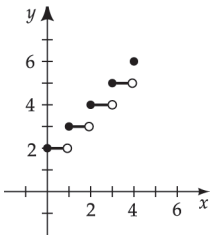
57. To graph $N(x) = \text{int}(-x)$ for $-3 \le x \le 3$, plot points

and draw a smooth graph.
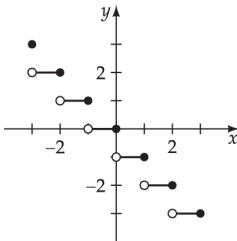
58. To graph $N(x) = \text{int}(x) + x$ for $0 \le x \le 4$, plot points

and draw a smooth graph.
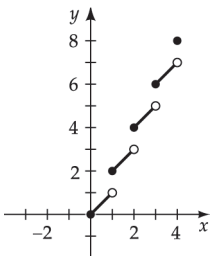
59. Graph $f(x) = \begin{cases} 1-x, & x < 2 \\ 2x, & x \ge 2 \end{cases}$.

Graph $y = 1-x$ for $x < 2$ and graph $y = 2x$ for

$x \ge 2$.
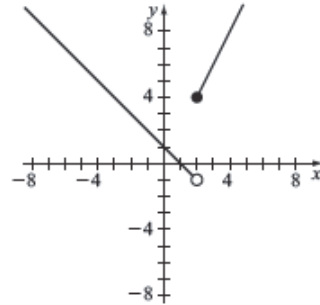
60. Graph $f(x) = \begin{cases} 2x, & x \le -1 \\ \dfrac{x}{2}, & x > -1 \end{cases}$.

Graph $y = 2x$ for $x \le -1$ and graph $y = \dfrac{x}{2}$ for

$x > -1$.
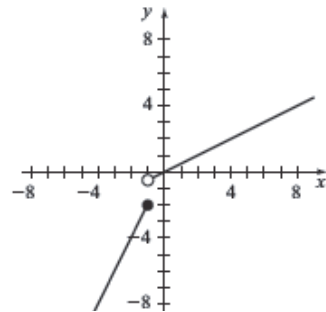
61. Graph $r(x) = \begin{cases} -x^2 + 4, & x < -1 \\ -x + 2, & -1 \le x \le 1 \\ 3x - 2, & x > 1 \end{cases}$.

Graph $y = -x^2 + 4$ for $x < -1$, graph $y = -x + 2$ for

$-1 \le x \le 1$, and graph $y = 3x - 2$ for $x > 1$.
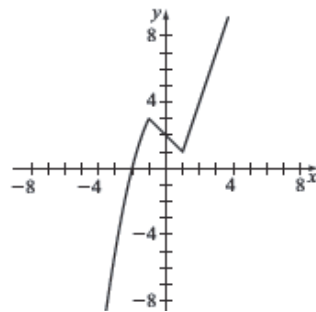
62. Graph $A(x) = \begin{cases} |\,x\,|, & x < 1 \\ x^2, & 1 \le x < 3 \\ -x+2, & x \ge 3 \end{cases}$.

Graph $y = |\,x\,|$ for $x < 1$, graph $y = x^2$ for $1 \le x < 3$,

and graph $y = -x + 2$ for $x \ge 3$.
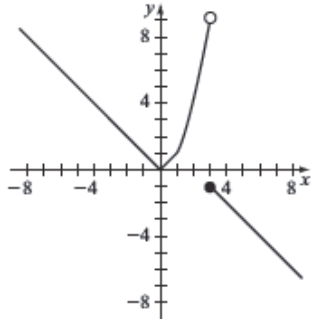
63. Find the value of a in the domain of $f(x) = 3x - 2$ for

which $f(a) = 10$.

$3a - 2 = 10$ Replace $f(a)$ with $3a - 2$

$3a = 12$

$a = 4$

64. Find the value of a in the domain of $f(x) = 2 - 5x$ for

which $f(a) = 7$.

$2 - 5a = 7$ Replace $f(a)$ with $2 - 5a$

$-5a = 5$

$a = -1$

65. Find the values of a in the domain of

$f(x) = x^2 + 2x - 2$ for which $f(a) = 1$.

$a^2 + 2a - 2 = 1$ Replace $f(a)$ with $a^2 + 2a - 2$

$a^2 + 2a - 3 = 0$

$(a + 3)(a - 1) = 0$

$a + 3 = 0 \quad\quad a - 1 = 0$

$\quad a = -3 \quad\quad\quad a = 1$

66. Find the values of a in the domain of

$f(x) = x^2 - 5x - 16$ for which $f(a) = -2$.

$a^2 - 5a - 16 = -2$ Replace $f(a)$ with $a^2 - 5a - 16$

$a^2 - 5a - 14 = 0$

$(a + 2)(a - 7) = 0$

$a + 2 = 0 \quad\quad a - 7 = 0$

$\quad a = -2 \quad\quad\quad a = 7$

67. Find the values of a in the domain of $f(x) = |x|$ for

which $f(a) = 4$.

$|a| = 4$ Replace $f(a)$ with $|a|$

$a = -4 \quad a = 4$

68. Find the values of a in the domain of $f(x) = |x + 2|$

for which $f(a) = 6$.

$|a + 2| = 6$ Replace $f(a)$ with $|a + 2|$

$a + 2 = -6 \quad a + 2 = 6$

$\quad a = -8 \quad\quad\quad a = 4$

69. Find the values of a in the domain of $f(x) = x^2 + 2$

for which $f(a) = 1$.

$a^2 + 2 = 1$ Replace $f(a)$ with $a^2 + 2$

$a^2 = -1$

There are no real values of a.

70. Find the values of a in the domain of $f(x) = |x| - 2$

for which $f(a) = -3$.

$|a| - 2 = -3$ Replace $f(a)$ with $|a| - 2$

$|a| = -1$

There are no real values of a.

71. Find the zeros of f for $f(x) = 3x - 6$.

$f(x) = 0$

$3x - 6 = 0$

$3x = 6$

$x = 2$

72. Find the zeros of f for $f(x) = 6 + 2x$.

$f(x) = 0$

$6 + 2x = 0$

$2x = -6$

$x = -3$

73. Find the zeros of *f* for $f(x) = 5x + 2$.

$$f(x) = 0$$
$$5x + 2 = 0$$
$$5x = -2$$
$$x = -\frac{2}{5}$$

74. Find the zeros of *f* for $f(x) = 8 - 6x$.

$$f(x) = 0$$
$$8 - 6x = 0$$
$$-6x = -8$$
$$x = \frac{4}{3}$$

75. Find the zeros of *f* for $f(x) = x^2 - 4$.

$$f(x) = 0$$
$$x^2 - 4 = 0$$
$$(x + 2)(x - 2) = 0$$
$$x + 2 = 0 \quad x - 2 = 0$$
$$x = -2 \quad x = 2$$

76. Find the zeros of *f* for $f(x) = x^2 + 4x - 21$.

$$f(x) = 0$$
$$x^2 + 4x - 21 = 0$$
$$(x + 7)(x - 3) = 0$$
$$x + 7 = 0 \quad x - 3 = 0$$
$$x = -7 \quad x = 3$$

77. Find the zeros of *f* for $f(x) = x^2 - 5x - 24$.

$$f(x) = 0$$
$$x^2 - 5x - 24 = 0$$
$$(x + 3)(x - 8) = 0$$
$$x + 3 = 0 \quad x - 8 = 0$$
$$x = -3 \quad x = 8$$

78. Find the zeros of *f* for $f(x) = 2x^2 + 3x - 5$.

$$f(x) = 0$$
$$2x^2 + 3x - 5 = 0$$
$$(2x + 5)(x - 1) = 0$$
$$2x + 5 = 0 \quad x - 1 = 0$$
$$x = -\frac{5}{2} \quad x = 1$$

79. Determine which graphs are functions.

   a. Yes; every vertical line intersects the graph in one point.

   b. Yes; every vertical line intersects the graph in one point.

   c. No; some vertical lines intersect the graph at more than one point.

   d. Yes; every vertical line intersects the graph in one point.

80. a. Yes; every vertical line intersects the graph in one point.

   b. No; some vertical lines intersect the graph at more than one point.

   c. No; a vertical line intersects the graph at more than one point.

   d. Yes; every vertical line intersects the graph in one point.

81. Determine where the graph is increasing, constant, or decreasing. Decreasing on $(-\infty, 0]$; increasing on $[0, \infty)$

82. Determine where the graph is increasing, constant, or decreasing. Decreasing on $(-\infty, \infty)$

83. Determine where the graph is increasing, constant, or decreasing. Increasing on $(-\infty, \infty)$

84. Determine where the graph is increasing, constant, or decreasing. Increasing on $(-\infty, 2]$; decreasing on $[2, \infty)$

85. Determine where the graph is increasing, constant, or decreasing. Decreasing on $(-\infty, -3]$; increasing on $[-3, 0]$; decreasing on $[0, 3]$; increasing on $[3, \infty)$

86. Determine where the graph is increasing, constant, or decreasing. Increasing on $(-\infty, \infty)$

87. Determine where the graph is increasing, constant, or decreasing. Constant on $(-\infty, 0]$; increasing on $[0, \infty)$

88. Determine where the graph is increasing, constant, or decreasing. Constant on $(-\infty, \infty)$

89. Determine where the graph is increasing, constant, or decreasing. Decreasing on $(-\infty, 0]$;

constant on $[0, 1]$; increasing on $[1, \infty)$

90. Determine where the graph is increasing, constant, or decreasing. Constant on $(-\infty, 0]$;

decreasing on $[0, 3]$; constant on $[3, \infty)$

91. Determine which functions from 77-81 are one-to-one.

g and F are one-to-one since every horizontal line intersects the graph at one point.

f, V, and p are not one-to-one since some horizontal lines intersect the graph at more than one point.

92. Determine which functions from 82-86 are one-to-one.

s is one-to-one since every horizontal line intersects the graph at one point.

t, m, r and k are not one-to-one since some horizontal lines intersect the graph at more than one point.

93. a. $C(2.8) = 0.90 - 0.20\text{int}(1 - 2.8)$
$$= 0.90 - 0.20\text{int}(-1.8)$$
$$= 0.90 - 0.20(-2)$$
$$= 0.90 + 0.4$$
$$= \$1.30$$

b. Graph $C(w)$.
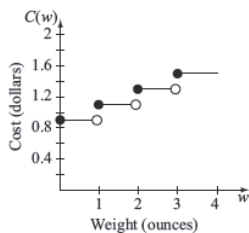
94. a. Domain: $[0, \infty)$

b. $T(50,020) = 0.25(50,020 - 35,350) + 4867.50$
$$= 0.25(14,670) + 4867.50$$
$$= 3667.50 + 4867.50$$
$$= \$8535$$

c. $T(123,500) = 0.28(123,500 - 85,650) + 17,442.50$
$$= 0.28(37,850) + 17,442.50$$
$$= 10,598 + 17,442.50$$
$$= \$28,040.50$$

95. a. Write the width.
$$2l + 2w = 50$$
$$2w = 50 - 2l$$
$$w = 25 - l$$

b. Write the area.
$$A = lw$$
$$A = l(25 - l)$$
$$A = 25l - l^2$$

96. a. Write the length.
$$\frac{4}{l} = \frac{12}{d + l}$$
$$4(d + l) = 12l$$
$$4d + 4l = 12l$$
$$4d = 8l$$
$$\frac{1}{2}d = l$$
$$l(d) = \frac{1}{2}d$$

b. Find the domain. Domain: $[0, \infty)$

c. Find the length. $l(8) = \frac{1}{2}(8) = 4$ ft

97. Write the function.
$$v(t) = 80,000 - 6500t, \quad 0 \le t \le 10$$

98. Write the function.
$$v(t) = 44,000 - 4200t, \quad 0 \le t \le 8$$

99. a. Write the total cost function.
$$C(x) = 5(400) + 22.80x$$
$$= 2000 + 22.80x$$

b. Write the revenue function. $R(x) = 37.00x$

c. Write the profit function.
$$P(x) = 37.00x - C(x)$$
$$= 37.00 - [2000 + 22.80x]$$
$$= 37.00x - 2000 - 22.80x$$
$$= 14.20x - 2000$$

Note x is a natural number.

100.a. Write the volume function.

$V = lwh$

$V = (30 - 2x)(30 - 2x)(x)$

$V = (900 - 120x + 4x^2)(x)$

$V = 900x - 120x^2 + 4x^3$

b. State the domain.

$V = lwh \Rightarrow$ the domain of V is dependent on the

domains of l, w, and h. Length, width and height must

be positive values $\Rightarrow 30 - 2x > 0 \quad$ and $x > 0$.

$\qquad\qquad\qquad -2x > -30$

$\qquad\qquad\qquad x < 15$

Thus, the domain of V is $\{x \mid 0 < x < 15\}$.

101. Write the function.

$\dfrac{15}{3} = \dfrac{15 - h}{r}$

$5 = \dfrac{15 - h}{r}$

$5r = 15 - h$

$h = 15 - 5r$

$h(r) = 15 - 5r$

102.a. Write the function.

$\dfrac{r}{h} = \dfrac{2}{4}$

$r = \dfrac{2}{4}h$

$r = \dfrac{1}{2}h$

b. Write the function.

$V = \dfrac{1}{3}\pi r^2 h$

$V = \dfrac{1}{3}\pi \left(\dfrac{1}{2}h\right)^2 h = \dfrac{1}{3}\pi \left(\dfrac{1}{4}h^2\right)h$

$V = \dfrac{1}{12}\pi h^3$

103. Write the function.

$d = \sqrt{(3t)^2 + (50)^2}$

$d = \sqrt{9t^2 + 2500}$ meters, $0 \le t \le 60$

104. Write the function.

$t = \dfrac{d}{r}$

$t = \dfrac{\sqrt{1 + x^2}}{2} + \dfrac{3 - x}{8}$ hours

105. Write the function.

$d = \sqrt{(45 - 8t)^2 + (6t)^2}$ miles

where t is the number of hours after 12:00 noon

106. Write the function.

$d = \sqrt{(60 - 7t)^2 + (10t)^2}$ miles

where t is the number of hours after 12:00 noon

107.a. Write the function.

Left side triangle   Right side triangle

$c^2 = 20^2 + (40 - x)^2 \qquad\quad c^2 = 30^2 + x^2$

$c = \sqrt{400 + (40 - x)^2} \qquad c = \sqrt{900 + x^2}$

Total length $= \sqrt{900 + x^2} + \sqrt{400 + (40 - x)^2}$

b. Complete the table.

x	0	10	20	30	40
Total Length	74.72	67.68	64.34	64.79	70

c. Find the domain. Domain: [0, 40].

108. Complete the table.

p	40	50	60	75	90
$f(p)$	4900	4300	3800	3200	2800

Answers accurate to nearest 100 feet.

109. Complete the table.

x	5	10	12.5	15	20
$Y(x)$	275	375	385	390	394

Answers accurate to the nearest apple.

110. Complete the table.

x	100	200	500	750	1000
$C(x)$	57,121	59,927	65,692	69,348	72,507

Answers accurate to the nearest dollar.

111. Find c.

$f(c) = c^2 - c - 5 = 1$

$\qquad c^2 - c - 6 = 0$

$\qquad (c - 3)(c + 2) = 0$

$c - 3 = 0 \quad$ or $\quad c + 2 = 0$

$\quad c = 3 \qquad\qquad\quad c = -2$

112. Find c.

$$g(c) = -2c^2 + 4c - 1 = -4$$
$$= -2c^2 + 4c + 3 = 0$$

$$c = \frac{-4 \pm \sqrt{4^2 - 4(-2)(3)}}{2(-2)}$$

$$c = \frac{-4 \pm \sqrt{16 + 24}}{-4} = \frac{-4 \pm \sqrt{40}}{-4}$$

$$c = \frac{-4 \pm 2\sqrt{10}}{-4}$$

$$c = \frac{2 \pm \sqrt{10}}{2}$$

113. Determine if 1 is in the range.

1 is not in the range of $f(x)$, since

$1 = \frac{x-1}{x+1}$ only if $x + 1 = x - 1$ or $1 = -1$.

114. Determine if 0 is in the range.

0 is not in the range of $g(x)$, since

$0 = \frac{1}{x-3}$ only if $(x-3)(0) = 1$ or $0 = 1$.

115. Graph functions. Explain how the graphs are related.
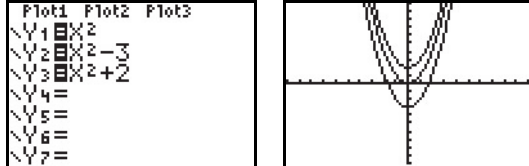
The graph of $g(x) = x^2 - 3$ is the graph of $f(x) = x^2$

shifted down 3 units. The graph of $h(x) = x^2 + 2$ is

the graph of $f(x) = x^2$ shifted up 2 units.

116. Graph functions. Explain how the graphs are related.
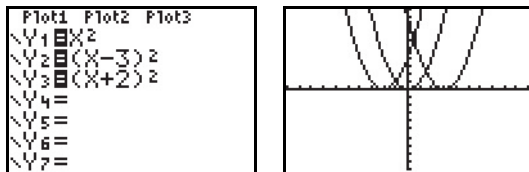
The graph of $g(x) = (x-3)^2$ is the graph of

$f(x) = x^2$ shifted 3 units to the right. The graph of

$h(x) = (x+2)^2$ is the graph of $f(x) = x^2$ shifted 2

units to the left.

117. Find all fixed points.

$$a^2 + 3a - 3 = a$$
$$a^2 + 2a - 3 = 0$$
$$(a-1)(a+3) = 0$$
$$a = 1 \quad \text{or} \quad a = -3$$

118. Find all fixed points.

$$\frac{a}{a+5} = a$$
$$a = a(a+5)$$
$$a = a^2 + 5a$$
$$0 = a^2 + 4a$$
$$0 = a(a+4)$$
$$a = 0 \quad \text{or} \quad a = -4$$

119.a. Write the function.

$$A = xy$$
$$A(x) = x\left(-\frac{1}{2}x + 4\right)$$
$$A(x) = -\frac{1}{2}x^2 + 4x$$

b. Complete the table.

x	1	2	4	6	7
Area	3.5	6	8	6	3.5

c. Find the domain. Domain: [0, 8].

120.a. Write the function.

$$m_{PB} = \frac{0-2}{x-2} = \frac{-2}{x-2}$$
$$m_{AB} = \frac{0-y}{x-0} = \frac{-y}{x}$$
$$m_{PB} = m_{AB}$$
$$\frac{-2}{x-2} = \frac{-y}{x}$$
$$\frac{2x}{x-2} = y$$

$$\text{Area} = \frac{1}{2}bh = \frac{1}{2}xy$$
$$= \frac{1}{2}x\frac{2x}{x-2}$$
$$= \frac{x^2}{x-2}$$

b. Find the domain. Domain: $(2, \infty)$

121.a. Write the function.

Circle	Square
$C = 2\pi r$	$C = 4s$
$x = 2\pi r$	$20 - x = 4s$
$r = \dfrac{x}{2\pi}$	$s = 5 - \dfrac{x}{4}$
$\text{Area} = \pi r^2 = \pi\left(\dfrac{x}{2\pi}\right)^2$	$\text{Area} = s^2 = \left(5 - \dfrac{x}{4}\right)^2$
$= \dfrac{x^2}{4\pi}$	$= 25 - \dfrac{5}{2}x + \dfrac{x^2}{16}$

$$\text{Total Area} = \frac{x^2}{4\pi} + 25 - \frac{5}{2}x + \frac{x^2}{16}$$

$$= \left(\frac{1}{4\pi} + \frac{1}{16}\right)x^2 - \frac{5}{2}x + 25$$

b. Complete the table.

x	0	4	8	12	16	20
Total Area	25	17.27	14.09	15.46	21.37	31.83

c. Find the domain. Domain: [0, 20].

122.a. Let $m = 10, d = 7, c = 19,$ and $y = 41.$ Then

$$z = \left[\!\left[\frac{13m-1}{5}\right]\!\right] + \left[\!\left[\frac{y}{4}\right]\!\right] + \left[\!\left[\frac{c}{4}\right]\!\right] + d + y - 2c$$

$$= \left[\!\left[\frac{13\cdot10-1}{5}\right]\!\right] + \left[\!\left[\frac{41}{4}\right]\!\right] + \left[\!\left[\frac{19}{4}\right]\!\right] + 7 + 41 - 2\cdot19$$

$$= 25 + 10 + 4 + 7 + 41 - 38$$

$$= 49$$

The remainder of 49 divided by 7 is 0.

Thus December 7, 1941, was a Sunday.

b. This one is tricky. Because we are finding a date in the month of January, we must use 11 for the month and we must use the previous year, which is 2019.

Thus we let $m = 11, \ d = 1, \ c = 20,$ and $y = 19.$

Then

$$z = \left[\!\left[\frac{13m-1}{5}\right]\!\right] + \left[\!\left[\frac{y}{4}\right]\!\right] + \left[\!\left[\frac{c}{4}\right]\!\right] + d + y - 2c$$

$$= \left[\!\left[\frac{13\cdot11-1}{5}\right]\!\right] + \left[\!\left[\frac{19}{4}\right]\!\right] + \left[\!\left[\frac{20}{4}\right]\!\right] + 1 + 19 - 2\cdot20$$

$$= 28 + 4 + 5 + 1 + 19 - 40$$

$$= 17$$

The remainder of 17 divided by 7 is 3.

Thus January 1, 2020, will be a Wednesday.

c. Let $m = 5, \ d = 4, \ c = 17,$ and $y = 76.$ Then

$$z = \left[\!\left[\frac{13m-1}{5}\right]\!\right] + \left[\!\left[\frac{y}{4}\right]\!\right] + \left[\!\left[\frac{c}{4}\right]\!\right] + d + y - 2c$$

$$= \left[\!\left[\frac{13\cdot5-1}{5}\right]\!\right] + \left[\!\left[\frac{76}{4}\right]\!\right] + \left[\!\left[\frac{17}{4}\right]\!\right] + 4 + 76 - 2\cdot17$$

$$= 12 + 19 + 4 + 4 + 76 - 34$$

$$= 81$$

The remainder of 81 divided by 7 is 4.

Thus July 4, 1776 was a Thursday.

d. Answers will vary.

Prepare for Section 2.3

P1. $d = 5 - (-2) = 7$

P2. The product of any number and its negative reciprocal is -1. For example,

$$-7 \cdot \frac{1}{7} = -1$$

P3. $\dfrac{-4-4}{2-(-3)} = \dfrac{-8}{5}$

P4. $y - 3 = -2(x - 3)$
$y - 3 = -2x + 6$
$y = -2x + 9$

P5. $3x - 5y = 15$
$-5y = -3x + 15$
$y = \dfrac{3}{5}x - 3$

P6. $y = 3x - 2(5 - x)$
$0 = 3x - 2(5 - x)$
$0 = 3x - 10 + 2x$
$10 = 5x$
$2 = x$

Section 2.3 Exercises

1. If a line has a negative slope, then as the value of y increases, the value of x <u>decreases</u>.

2. If a line has a positive slope, then as the value of y decreases, the value of x <u>decreases</u>.

3. The graph of a line with zero slope is <u>horizontal</u>.

4. The graph of a line whose slope is undefined is <u>vertical</u>.

5. Determine the slope and y-intercept.

$y = 4x - 5$: $m = 4$, y-intercept: $(0,-5)$

6. Determine the slope and y-intercept.

$y = 3 - 2x$: $m = -2$, y-intercept: $(0, 3)$

7. Determine the slope and y-intercept.

$f(x) = \dfrac{2x}{3}$: $m = \dfrac{2}{3}$, y-intercept: $(0, 0)$

8. Determine the slope and y-intercept.

$f(x) = -1$: $m = 0$, y-intercept: $(0, -1)$

9. Determine whether the graphs are parallel, perpendicular, or neither.

$y = 3x - 4$: $m = 3$,
$y = -3x + 2$: $m = -3$

The graphs are neither parallel nor perpendicular

10. Determine whether the graphs are parallel, perpendicular, or neither.

$y = -\dfrac{2}{3}x + 1$: $m = -\dfrac{2}{3}$,
$y = 2 - \dfrac{2x}{3}$: $m = -\dfrac{2}{3}$

The graphs are parallel.

11. Determine whether the graphs are parallel, perpendicular, or neither.

$f(x) = 3x - 1$: $m = 3$,
$y = -\dfrac{x}{3} - 1$: $m = -\dfrac{1}{3}$
$3\left(-\dfrac{1}{3}\right) = -1$

The graphs are perpendicular.

12. Determine whether the graphs are parallel, perpendicular, or neither.

$f(x) = \dfrac{4x}{3} + 2$: $m = \dfrac{4}{3}$,
$f(x) = 2 - \dfrac{3}{4}x$: $m = -\dfrac{3}{4}$
$\dfrac{4}{3}\left(-\dfrac{3}{4}\right) = -1$

The graphs are perpendicular.

13. Find the slope.

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7 - 4}{1 - 3} = \dfrac{3}{-2} = -\dfrac{3}{2}$

14. Find the slope.

$m = \dfrac{1 - 4}{5 - (-2)} = \dfrac{-3}{7} = -\dfrac{3}{7}$

15. Find the slope.

$m = \dfrac{2 - 0}{0 - 4} = -\dfrac{1}{2}$

16. Find the slope.

$m = \dfrac{4 - 4}{2 - (-3)} = \dfrac{0}{5} = 0$

17. Find the slope.

$m = \dfrac{-7 - 2}{3 - 3} = \dfrac{-9}{0}$ undefined

18. Find the slope.

$m = \dfrac{0 - 0}{3 - 0} = \dfrac{0}{3} = 0$

19. Find the slope.

$m = \dfrac{-2 - 4}{-4 - (-3)} = \dfrac{-6}{-1} = 6$

20. Find the slope.

$m = \dfrac{4 - (-1)}{-3 - (-5)} = \dfrac{5}{2}$

21. Find the slope.

$m = \dfrac{\dfrac{7}{2} - \dfrac{1}{2}}{\dfrac{7}{3} - (-4)} = \dfrac{\dfrac{6}{2}}{\dfrac{19}{3}} = 3 \cdot \dfrac{3}{19} = \dfrac{9}{19}$

22. Find the slope.

$m = \dfrac{2 - 4}{\dfrac{7}{4} - \dfrac{1}{2}} = \dfrac{-2}{\dfrac{5}{4}} = -\dfrac{8}{5}$

23. Find the slope, y-intercept, and graph. $y = 2x - 4$

$m = 2$, y-intercept $(0, -4)$
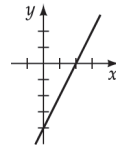
24. Find the slope, y-intercept, and graph. $y = -x + 1$

$m = -1$, y-intercept $(0, 1)$
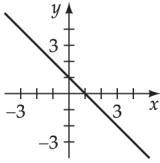
25. Find the slope, y-intercept, and graph. $y = \frac{3}{4}x + 1$

$m = \frac{3}{4}$, y-intercept $(0, 1)$
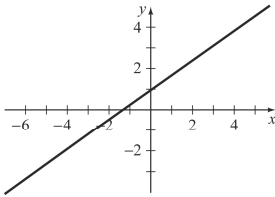
26. Find the slope, y-intercept, and graph. $y = -\frac{3}{2}x + 4$

$m = -\frac{3}{2}$, y-intercept $(0, 4)$
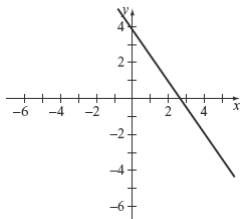
27. Find the slope, y-intercept, and graph. $y = -2x + 3$

$m = -2$, y-intercept $(0, 3)$
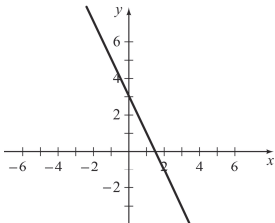
28. Find the slope, y-intercept, and graph. $y = 3x - 1$

$m = 3$, y-intercept $(0, -1)$
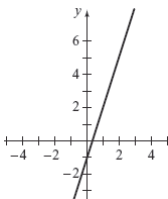
29. Find the slope, y-intercept, and graph. $y = 3$

$m = 0$, y-intercept $(0, 3)$
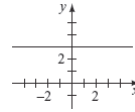
30. Find the slope, y-intercept, and graph. $y = -2$

$m = 0$, y-intercept $(0, -2)$
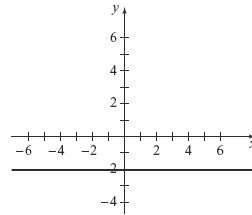
31. Find the slope, y-intercept, and graph. $y = 2x$

$m = 2$, y-intercept $(0, 0)$
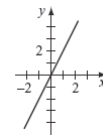
32. Find the slope, y-intercept, and graph. $y = -3x$

$m = -3$, y-intercept $(0, 0)$
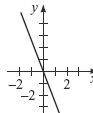
33. Find the slope, y-intercept, and graph. $y = x$
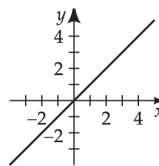
$m = 1$, y-intercept $(0, 0)$

34. Find the slope, y-intercept, and graph. $y = -x$
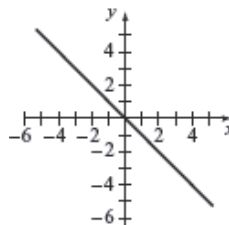
$m = -1$, y-intercept $(0, 0)$

35. Write slope-intercept form, find intercepts, and graph.

$2x + y = 5$

$y = -2x + 5$

x-intercept $\left(\dfrac{5}{2},\ 0\right)$, y-intercept $(0, 5)$
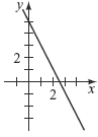
36. Write slope-intercept form, find intercepts, and graph.

$x - y = 4$

$y = x - 4$

x-intercept $(4, 0)$, y-intercept $(0, -4)$
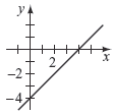
37. Write slope-intercept form, find intercepts, and graph.

$4x + 3y - 12 = 0$

$3y = -4x + 12$

$y = -\dfrac{4}{3}x + 4$

x-intercept $(3, 0)$, y-intercept $(0, 4)$
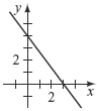
38. Write slope-intercept form, find intercepts, and graph.

$2x + 3y + 6 = 0$

$3y = -2x - 6$

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

x-intercept $(-3, 0)$, y-intercept $(0, -2)$
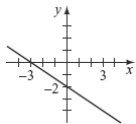
39. Write slope-intercept form, find intercepts, and graph.

$2x - 5y = -15$

$-5y = -2x - 15$

$y = \dfrac{2}{5}x + 3$

x-intercept $\left(-\dfrac{15}{2},\ 0\right)$, y-intercept $(0, 3)$
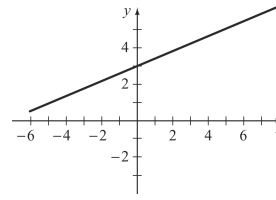
40. Write slope-intercept form, find intercepts, and graph.

$3x - 4y = 8$

$-4y = -3x + 8$

$y = \dfrac{3}{4}x - 2$

x-intercept $\left(\dfrac{8}{3},\ 0\right)$, y-intercept $(0, -2)$
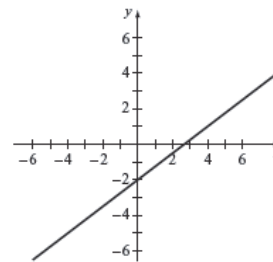
41. Write slope-intercept form, find intercepts, and graph.

$x + 2y = 6$

$y = -\dfrac{1}{2}x + 3$

x-intercept $(6, 0)$, y-intercept $(0, 3)$
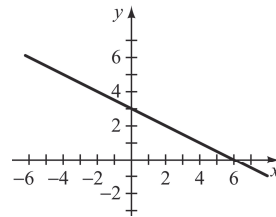
42. Write slope-intercept form, find intercepts, and graph.

$x - 3y = 9$

$y = \dfrac{1}{3}x - 3$

x-intercept $(9, 0)$, y-intercept $(0, -3)$
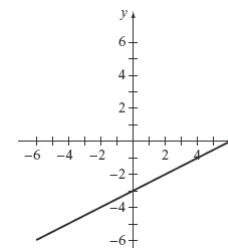
43. Find the equation.

Use $y = mx + b$ with $m = 1$, $b = 3$.

$y = x + 3$

44. Find the equation.

Use $y = mx + b$ with $m = -2$, $b = 5$.

$y = -2x + 5$

45. Find the equation.

Use $y = mx + b$ with $m = \frac{3}{4}$, $b = \frac{1}{2}$.

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

46. Find the equation.

Use $y = mx + b$ with $m = -\frac{2}{3}$, $b = \frac{3}{4}$.

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

47. Find the equation.

Use $y = mx + b$ with $m = 0$, $b = 4$.

$y = 4$

48. Find the equation.

Use $y = mx + b$ with $m = \frac{1}{2}$, $b = -1$.

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

49. Find the equation.

$y - 2 = -4(x - (-3))$

$y - 2 = -4x - 12$

$y = -4x - 10$

50. Find the equation.

$y + 1 = -3(x + 5)$

$y = -3x - 15 - 1$

$y = -3x - 16$

51. Find the equation.

$m = \dfrac{4 - 1}{-1 - 3} = \dfrac{3}{-4} = -\dfrac{3}{4}$

$y - 1 = -\frac{3}{4}(x - 3)$

$y = -\frac{3}{4}x + \frac{9}{4} + \frac{4}{4}$

$y = -\frac{3}{4}x + \frac{13}{4}$

52. Find the equation.

$m = \dfrac{-8 - (-6)}{2 - 5} = \dfrac{-2}{-3} = \dfrac{2}{3}$

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

$y + 6 = \frac{2}{3}x - \frac{10}{3}$

$y = \frac{2}{3}x - \frac{10}{3} - 6$

$y = \frac{2}{3}x - \frac{28}{3}$

53. Find the equation.

$m = \dfrac{-1 - 11}{2 - 7} = \dfrac{-12}{-5} = \dfrac{12}{5}$

$y - 11 = \frac{12}{5}(x - 7)$

$y - 11 = \frac{12}{5}x - \frac{84}{5}$

$y = \frac{12}{5}x - \frac{84}{5} + \frac{55}{5}$

$= \frac{12}{5}x - \frac{29}{5}$

54. Find the equation.

$m = \dfrac{-4 - 6}{-3 - (-5)} = \dfrac{-10}{2} = -5$

$y - 6 = -5(x + 5)$

$y - 6 = -5x - 25$

$y = -5x - 25 + 6$

$y = -5x - 19$

55. Find the equation.

$y = 2x + 3$ has slope $m = 2$.

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

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

$y + 4 = 2x - 4$

$y = 2x - 8$

56. Find the equation.

$y = -x + 1$ has slope $m = -1$.

$y - y_1 = -1(x - x_1)$

$y - 4 = -1(x + 2)$

$y - 4 = -x - 2$

$y = -x + 2$

57. Find the equation.

$y = -\frac{3}{4}x + 3$ has slope $m = -\frac{3}{4}$.

$y - y_1 = -\frac{3}{4}(x - x_1)$

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

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

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

58. Find the equation.

$y = \frac{2}{3}x - 1$ has slope $m = \frac{2}{3}$.

$y - y_1 = \frac{2}{3}(x - x_1)$

$y + 5 = \frac{2}{3}(x + 3)$

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

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

59. Find the equation.

$2x - 5y = 2$

$-5y = -2x + 2$

$y = \frac{2}{5}x - \frac{2}{5}$ has slope $m = \frac{2}{5}$.

$y - y_1 = \frac{2}{5}(x - x_1)$

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

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

$y = \frac{2}{5}x$

60. Find the equation.

$x + 3y = 4$

$3y = -x + 4$

$y = -\frac{1}{3}x + \frac{4}{3}$ has slope $m = -\frac{1}{3}$.

$y - y_1 = -\frac{1}{3}(x - x_1)$

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

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

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

61. Find the equation.

$y = 2x - 5$ has perpendicular slope $m = -\frac{1}{2}$.

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

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

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

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

62. Find the equation.

$y = -x + 3$ has perpendicular slope $m = 1$.

$y - y_1 = 1(x - x_1)$

$y - 2 = 1(x + 5)$

$y - 2 = x + 5$

$y = x + 7$

63. Find the equation.

$y = -\frac{3}{4}x + 1$ has perpendicular slope $m = \frac{4}{3}$.

$y - y_1 = \frac{4}{3}(x - x_1)$

$y - 0 = \frac{4}{3}(x + 6)$

$y = \frac{4}{3}x + 8$

64. Find the equation.

$3x - 2y = 5$

$-2y = -3x + 5$

$y = \frac{3}{2}x - \frac{5}{2}$ has perpendicular slope $m = -\frac{2}{3}$.

$y - y_1 = -\frac{2}{3}(x - x_1)$

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

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

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

65. Find the equation.

$$-x-4y=6$$
$$-4y=x+6$$
$$y=-\frac{1}{4}x-\frac{3}{2} \text{ has perpendicular slope } m=4 .$$

$$y-y_1=4(x-x_1)$$
$$y-2=4(x-5)$$
$$y-2=4x-20$$
$$y=4x-18$$

66. Find the equation.

$$5x-y=2$$
$$-y=-5x+2$$
$$y=5x-2 \quad \text{has perpendicular slope } m=-\frac{1}{5} .$$

$$y-y_1=-\frac{1}{5}(x-x_1)$$
$$y+2=-\frac{1}{5}(x-10)$$
$$y+2=-\frac{1}{5}x+2$$
$$y=-\frac{1}{5}x$$

67. Find the zero of f.

$$f(x)=3x-12$$
$$3x-12=0$$
$$3x=12$$
$$x=4$$

The x-intercept of the graph of $f(x)$ is (4, 0).

Xmin = – 4, Xmax = 6, Xscl=2,
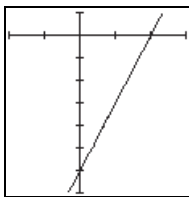
Ymin = –12.2, Ymax = 2, Yscl = 2

68. Find the zero of f.

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

The x-intercept of the graph of $f(x)$ is (–2, 0).

Xmin = – 4, Xmax = 6, Xscl=2,
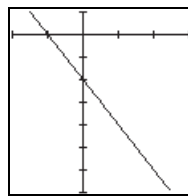
Ymin = –12.2, Ymax = 2, Yscl = 2

69. Find the zero of f.

$$f(x)=\frac{1}{4}x+5$$
$$\frac{1}{4}x+5=0$$
$$\frac{1}{4}x=-5$$
$$x=-20$$

The x-intercept of the graph of $f(x)$ is $(-20,0)$.

Xmin $=-30$, Xmax = 30, Xscl = 10,
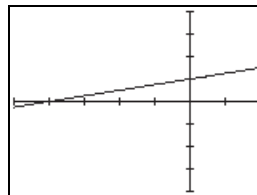
Ymin $=-10$, Ymax = 10, Yscl = 1

70. Find the zero of f.

$$f(x)=-\frac{1}{3}x+2$$
$$-\frac{1}{3}x+2=0$$
$$-\frac{1}{3}x=-2$$
$$x=6$$

The x-intercept of the graph of $f(x)$ is $(6,0)$.

Xmin = –2, Xmax = 8, Xscl = 2,
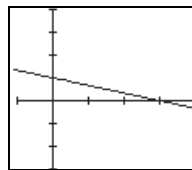
Ymin = –6, Ymax = 8, Yscl = 2

71. Find the slope and explain the meaning.

$$m=\frac{1505-1482}{28-20}=2.875$$

The value of the slope indicates that the speed of sound

in water increases 2.875 m/s for a one-degree Celsius increase in temperature.

72. Find the slope and explain the meaning.

$$m = \frac{40-10}{100-25} = 0.4$$

The value of the slope indicates that the file is being downloaded at 0.4 megabytes per second.

73. a. $m = \frac{31-20}{23-12} = 1$

$$H(c)-20 = 1(c-12)$$
$$H(c) = c+8$$

b. $H(19) = (19)+8 = 27$ mpg

74. a. $m = \frac{864.9-1008.1}{2011-2007} = -35.8$

$$C(t)-864.9 = -35.8(t-2011)$$
$$C(t) = -35.8t+72{,}858.7$$

b. $750 = -35.8t+72{,}858.7$
$$-72{,}108.7 = -35.8t$$
$$2014.2 \approx t$$

The debt will fall below $750 billion in 2014.

75. a. $m = \frac{316{,}500-279{,}200}{2020-2010} = 3730$

$$N(t)-279{,}200 = 3730(t-2010)$$
$$N(t) = 3730t-7{,}218{,}100$$

b. $300{,}000 = 3730t-7{,}218{,}100$
$$7{,}518{,}100 = 3730t$$
$$2015.6 \approx t$$

The number of jobs will exceed 300,000 in 2015.

76. a. $m = \frac{2200-2150}{15-20} = -10$

$$T(t)-2200 = -10(t-15)$$
$$T(t) = -10t+2350$$

b. The value of the slope means that the temperature is decreasing at a rate of 10°F per minute.

c. $T(180) = -10(180)+2350 = 550°\,\text{F}$

After 3 hours, the temperature will be 550°F.

77. a. $m = \frac{240-180}{18-16} = 30$

$$B(d)-180 = 30(d-16)$$
$$B(d) = 30d-300$$

b. The value of the slope means that a 1-inch increase in the diameter of a log 32 ft long results in an increase of 30 board-feet of lumber that can be obtained from the log.

c. $B(19) = 30(19)-300 = 270$ board feet

78. a. $m = \frac{1640-800}{60-40} = 42$

$$E(T)-800 = 42(T-40)$$
$$E(T) = 42T-880$$

b. The value of the slope means that an additional 42 acre-feet of water evaporate for a one°F increase in temperature.

c. $E(75) = 42(75)-880 = 2270$ acre-feet

79. Line A represents Michelle.

Line B represents Amanda.

Line C represents the distance between Michelle and Amanda.

80. a. $m_{AB} = \frac{1-9}{8-6} = -4°\,\text{F}$

b. $m_{AB} = \frac{1-9}{8-6} = -4°\,\text{F}$

$$m_{DE} = \frac{-4-5}{5-6} = 9°\,\text{F}$$

The temperature changed most rapidly between points D and E.

c. The temperature remained constant (zero slope) between points C and D.

81. a. $m = \frac{80.5-19.9}{0-65} \approx -0.9323$

$$y-80.5 = -0.9323(x-0)$$
$$y = -0.9323x+80.5$$

b. $y = -0.9323(25)+80.5 = 57.19 \approx 57$ years

82. a. $m = \dfrac{75.5 - 17.2}{0 - 65} \approx -0.8969$

$y - 75.5 = -0.8969(x - 0)$

$\quad\quad y = -0.8969x + 75.5$

b. $y = -0.8969(25) + 75.5 = 53.08 \approx 53$ years

83. Determine the profit function and break-even point.

$P(x) = 92.50x - (52x + 1782)$

$P(x) = 92.50x - 52x - 1782$

$P(x) = 40.50x - 1782$

$40.50x - 1782 = 0$

$\quad 40.50x = 1782$

$\quad\quad\quad x = \dfrac{1782}{40.50}$

$\quad\quad\quad x = 44$, the break-even point

84. Determine the profit function and break-even point.

$P(x) = 124x - (78.5x + 5005)$

$P(x) = 124x - 78.5x - 5005$

$P(x) = 45.5x - 5005$

$45.5x - 5005 = 0$

$\quad 45.5x = 5005$

$\quad\quad\quad x = \dfrac{5005}{45.5}$

$\quad\quad\quad x = 110$, the break-even point

85. Determine the profit function and break-even point.

$P(x) = 259x - (180x + 10,270)$

$P(x) = 259x - 180x - 10,270$

$P(x) = 79x - 10,270$

$79x - 10,270 = 0$

$\quad 79x = 10,270$

$\quad\quad x = \dfrac{10,270}{79}$

$\quad\quad x = 130$, the break-even point

86. Determine the profit function and break-even point.

$P(x) = 14,220x - (8010x + 1,602,180)$

$P(x) = 14,220x - 8010x - 1,602,180$

$P(x) = 6210x - 1,602,180$

$6210x - 1,602,180 = 0$

$\quad 6210x = 1,602,180$

$\quad\quad x = \dfrac{1,602,180}{6210}$

$\quad\quad x = 258$, the break-even point

87. a. $C(0) = 8(0) + 275 = 0 + 275 = \$275$

b. $C(1) = 8(1) + 275 = 8 + 275 = \$283$

c. $C(10) = 8(10) + 275 = 80 + 275 = \$355$

d. The marginal cost is the slope of $C(x) = 8x + 275$, which is \$8 per unit.

88. a. $R(0) = 210(0) = \$0$

b. $R(1) = 210(1) = \$210$

c. $R(10) = 210(10) = \$2100$

d. The marginal revenue is the slope of $R(x) = 210x$, which is \$210 per unit.

89. a. $C(t) = 19,500.00 + 6.75t$

b. $R(t) = 55.00t$

c. $P(t) = R(t) - C(t)$

$P(t) = 55.00t - (19,500.00 + 6.75t)$

$P(t) = 55.00t - 19,500.00 - 6.75t$

$P(t) = 48.25t - 19,500.00$

d. $48.25t = 19,500.00$

$\quad\quad t = \dfrac{19,500.00}{48.25}$

$\quad\quad t = 404.1451$ days ≈ 405 days

90. $m = \dfrac{117,500 - 98,000}{35,000 - 32,000} = \dfrac{19,500}{3000} = 6.5$

a. $P(s) - 98,000 = 6.5(s - 32,000)$

$P(s) = 6.5s - 208,000 + 98,000$

$P(s) = 6.5s - 110,000$

b. $P(50,000) = 6.5(50,000) - 110,000$

$= 325,000 - 110,000$

$= \$215,000$

c. Let $6.5s - 110,000 = 0$. Then

$6.5s = 110,000$

$\quad s = \dfrac{110,000}{6.5} \approx 16,924$ subscribers

91. The equation of the line through (0,0) and $P(3,4)$ has

slope $\dfrac{4}{3}$.

The path of the rock is on the line through $P(3,4)$ with

slope $-\frac{3}{4}$, so $y-4=-\frac{3}{4}(x-3)$.

$$y-4=-\frac{3}{4}x+\frac{9}{4}$$

$$y=-\frac{3}{4}x+\frac{9}{4}+4$$

$$y=-\frac{3}{4}x+\frac{25}{4}$$

The point where the rock hits the wall at $y=10$ is the

point of intersection of $y=-\frac{3}{4}x+\frac{25}{4}$ and $y=10$.

$$-\frac{3}{4}x+\frac{25}{4}=10$$

$$-3x+25=40$$

$$-3x=15$$

$$x=-5 \text{ feet}$$

Therefore the rock hits the wall at $(-5, 10)$.

The x-coordinate is –5.
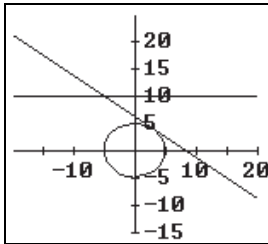
92. The equation of the line through (0,0) and

$P(\sqrt{15}, 1)$ has slope $\frac{1}{\sqrt{15}}$.

The path of the rock is on the line through

$P(\sqrt{15}, 1)$ with slope $-\sqrt{15}$ so

$$y-1=-\sqrt{15}(x-\sqrt{15})$$

$$y-1=-\sqrt{15}x+15$$

$$y=-\sqrt{15}x+15+1$$

$$y=-\sqrt{15}x+16$$

The point of impact with the wall at $y=14$ is the point

of intersection of $y=-\sqrt{15}x+16$ and $y=14$

intersect.

$$-\sqrt{15}x+16=14$$

$$-\sqrt{15}x=-2$$

$$x=\frac{2}{\sqrt{15}}\approx 0.52 \text{ feet}$$

Therefore, the rock hits the wall at $\left(\frac{2}{\sqrt{15}}, 14\right)$.

The x-coordinate is $\frac{2}{\sqrt{15}}$ or approximately 0.52.
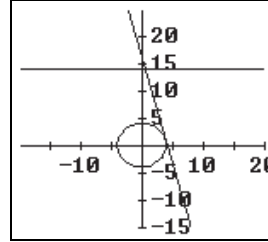
93. Find a.

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

$$2a=-4$$

$$a=-2$$

94. Find a.

$$f(a)=4-3a=7$$

$$-3a=3$$

$$a=-1$$

95. Find a.

$$f(a)=1-4a=3$$

$$-4a=2$$

$$a=-\frac{1}{2}$$

96. Find a.

$$f(a)=\frac{2a}{3}+2=4$$

$$\frac{2a}{3}=2$$

$$a=2\left(\frac{3}{2}\right)$$

$$a=3$$

97. a. $h=1$ so

$$Q(1+h, [1+h]^2 +1)=Q(2, 2^2+1)=Q(2, 5)$$

$$m=\frac{5-2}{2-1}=\frac{3}{1}=3$$

b. $h=0.1$ so

$$Q(1+h, [1+h]^2 +1)=Q(1.1, 1.1^2+1)=Q(1.1, 2.21)$$

$$m=\frac{2.21-2}{1.1-1}=\frac{0.21}{0.1}=2.1$$

c. $h = 0.01$ so

$$Q(1+h, [1+h]^2 + 1) = Q(1.01, 1.01^2 + 1)$$
$$= Q(1.01, 2.0201)$$

$$m = \frac{2.0201 - 2}{1.01 - 1} = \frac{0.0201}{0.01} = 2.01$$

d. As h approaches 0, the slope of PQ seems to be approaching 2.

e. $x_1 = 1, \ y_1 = 2, \ x_2 = 1 + h, \ y_2 = [1+h]^2 + 1$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{[1+h]^2 + 1 - 2}{(1+h) - 1} = \frac{(1 + 2h + h^2) + 1 - 2}{h}$$

$$= \frac{2h + h^2}{h} = 2 + h$$

98. a. $h = 1$, so

$$Q(-2+h, 9 - [-2+h]^2) = Q(-2+1, 9 - [-2+1]^2)$$
$$= Q(-1, 8)$$

$$m = \frac{8 - 5}{-1 - (-2)} = \frac{3}{1} = 3$$

b. $h = 0.1$ so

$$Q(-2+h, 9 - [-2+h]^2) = Q(-2+0.1, 9 - [-2+0.1]^2)$$
$$= Q(-1.9, 5.39)$$

$$m = \frac{5.39 - 5}{-1.9 - (-2)} = \frac{0.39}{0.1} = 3.9$$

c. $h = 0.01$ so

$$Q(-2+h, 9 - [-2+h]^2) = Q(-2+0.01, 9 - [-2+0.01]^2)$$
$$= Q(-1.99, 5.0399)$$

$$m = \frac{5.0399 - 5}{-1.99 - (-2)} = \frac{0.0399}{0.01} = 3.99$$

d. As h approaches 0, the slope of PQ seems to be approaching 4.

e. $x_1 = -2, \ y_1 = 5, \ x_2 = -2 + h, \ y_2 = 9 - [-2+h]^2$

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9 - [-2+h]^2 - 5}{(-2+h) - (-2)}$$

$$= \frac{9 - (4 - 4h + h^2) - 5}{h}$$

$$= \frac{4h - h^2}{h} = 4 - h$$

99. The slope of the line through $(3, 9)$ and (x, y)

is $\frac{15}{2}$, so $\frac{y - 9}{x - 3} = \frac{15}{2}$.

Therefore

$$2(y - 9) = 15(x - 3)$$
$$2y - 18 = 15x - 45$$
$$2y - 15x + 27 = 0$$
$$2x^2 - 15x + 27 = 0 \quad \text{Substituting } y = x^2$$
$$(2x - 9)(x - 3) = 0$$
$$x = \frac{9}{2} \quad \text{or} \quad x = 3$$

If $x = \frac{9}{2}, \ y = x^2 = \left(\frac{9}{2}\right)^2 = \frac{81}{4} \Rightarrow \left(\frac{9}{2}, \ \frac{81}{4}\right)$.

If $x = 3, \ y = x^2 = (3)^2 = 9 \Rightarrow (3, \ 9)$, but this is the

point itself. The point $\left(\frac{9}{2}, \ \frac{81}{4}\right)$ is on the graph of

$y = x^2$, and the slope of the line containing $(3, 9)$ and

$\left(\frac{9}{2}, \ \frac{81}{4}\right)$ is $\frac{15}{2}$.

100. The slope of the line through $(3, 2)$ and (x, y) is

$\frac{3}{8}$, so $\frac{y - 2}{x - 3} = \frac{3}{8}$.

Therefore

$$8(y - 2) = 3(x - 3).$$
$$8y - 16 = 3x - 9$$
$$8y = 3x + 7$$
$$8\sqrt{x+1} = 3x + 7 \quad \text{Substituting } y = \sqrt{x+1}$$
$$\left(8\sqrt{x+1}\right)^2 = (3x + 7)^2$$
$$64(x + 1) = 9x^2 + 42x + 49$$
$$64x + 64 = 9x^2 + 42x + 49$$
$$0 = 9x^2 - 22x - 15$$
$$0 = (9x + 5)(x - 3)$$
$$x = -\frac{5}{9} \quad \text{or} \quad x = 3$$

If $x = -\frac{5}{9}$,

$$y = \sqrt{x+1} = \sqrt{-\frac{5}{9} + \frac{9}{9}} = \sqrt{\frac{4}{9}} = \frac{2}{3} \Rightarrow \left(-\frac{5}{9}, \ \frac{2}{3}\right).$$

If $x = 3, \ y = \sqrt{x+1} = \sqrt{3+1} = \sqrt{4} = 2 \Rightarrow (3, \ 2)$, but

this is the point itself.

The point $\left(-\dfrac{5}{9},\ \dfrac{2}{3}\right)$ is on the graph of $y = \sqrt{x+1}$, and

the slope of the line containing (3, 2) and

$\left(-\dfrac{5}{9},\ \dfrac{2}{3}\right)$ is $\dfrac{3}{8}$.

Mid-Chapter 2 Quiz

1. Find the midpoint and length.

$$M = \left(\dfrac{-3+1}{2},\ \dfrac{4-2}{2}\right) = \left(\dfrac{-2}{2},\ \dfrac{2}{2}\right) = (-1,\ 1)$$

$$d = \sqrt{(1-(-3))^2 + (-2-4)^2} = \sqrt{(4)^2 + (-6)^2}$$
$$= \sqrt{16+36} = \sqrt{52}$$
$$= 2\sqrt{13}$$

2. Find the center and radius.

$$x^2 + y^2 - 6x + 4y - 2 = 0$$
$$x^2 - 6x \quad + y^2 + 4y \quad = 2$$
$$x^2 - 6x + 9 + y^2 + 4y + 4 = 2 + 9 + 4$$
$$(x-3)^2 + (y+2)^2 = 15$$

center (3, –2), radius $\sqrt{15}$

3. Evaluate.

$$f(x) = x^2 - 6x + 1$$
$$f(-3) = (-3)^2 - 6(-3) + 1 = 9 + 18 + 1 = 28$$

4. Find the domain.

For $f(x) = \sqrt{2-x}$, the domain is $(-\infty,\ 2]$.

5. Find the zeros of f for $f(x) = x^2 - x - 12$.

$$f(x) = 0$$
$$x^2 - x - 12 = 0$$
$$(x+3)(x-4) = 0$$

$$x+3 = 0 \quad x-4 = 0$$
$$x = -3 \qquad x = 4$$

6. Find the slope.

$$m = \dfrac{3-(-2)}{-2-8} = \dfrac{5}{-10} = -\dfrac{1}{2}$$

7. Find the equation.

$$2x + 3y = 5$$
$$3y = -2x + 5$$
$$y = -\dfrac{2}{3}x + \dfrac{5}{3} \text{ has slope } m = -\dfrac{2}{3}.$$

$$y - y_1 = -\dfrac{2}{3}(x - x_1)$$
$$y - (-1) = -\dfrac{2}{3}(x - 3)$$
$$y + 1 = -\dfrac{2}{3}x + 2$$
$$y = -\dfrac{2}{3}x + 1$$

8. $f(x) = -\dfrac{2}{3}x + 1$ has y-intercept (0, 1).
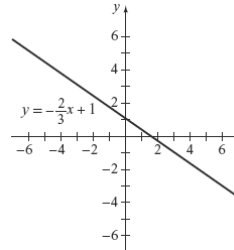
Prepare for Section 2.4

P1. $3x^2 + 10x - 8 = (3x - 2)(x + 4)$

P2. $x^2 - 8x = x^2 - 8x + 16 = (x - 4)^2$

P3. $f(-3) = 2(-3)^2 - 5(-3) - 7$
$$= 18 + 15 - 7$$
$$= 26$$

P4. $\qquad 2x^2 - x = 1$
$$2x^2 - x - 1 = 0$$
$$(2x + 1)(x - 1) = 0$$
$$2x + 1 = 0 \qquad x - 1 = 0$$
$$x = -\dfrac{1}{2} \qquad x = 1$$

P5. $x^2 + 3x - 2 = 0$

$$x = \dfrac{-3 \pm \sqrt{(3)^2 - 4(1)(-2)}}{2(1)}$$
$$= \dfrac{-3 \pm \sqrt{17}}{2}$$

P6. $53 = -16t^2 + 64t + 5$

$16t^2 - 64t + 48 = 0$

$t^2 - 4t + 3 = 0$

$(t-1)(t-3) = 0$

$t = 1, 3$

Section 2.4 Exercises

1. d

2. f

3. b

4. h

5. g

6. e

7. c

8. a

9. Write in standard form, find the vertex, the axis of symmetry and graph.

$f(x) = (x^2 + 4x) + 1$

$\quad\quad = (x^2 + 4x + 4) + 1 - 4$

$\quad\quad = (x+2)^2 - 3 \quad$ standard form,

vertex $(-2, -3)$, axis of symmetry $x = -2$
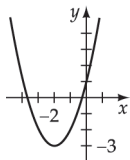
10. Write in standard form, find the vertex, the axis of symmetry and graph.

$f(x) = (x^2 + 6x) - 1$

$\quad\quad = (x^2 + 6x + 9) - 1 - 9$

$\quad\quad = (x+3)^2 - 10 \quad$ standard form,

vertex $(-3, -10)$, axis of symmetry $x = -3$
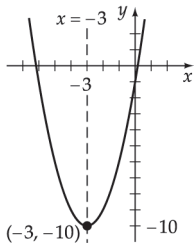
11. Write in standard form, find the vertex, the axis of symmetry and graph.

$f(x) = (x^2 - 8x) + 5$

$\quad\quad = (x^2 - 8x + 16) + 5 - 16$

$\quad\quad = (x-4)^2 - 11 \quad$ standard form,

vertex $(4, -11)$, axis of symmetry $x = 4$
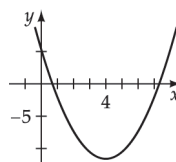
12. Write in standard form, find the vertex, the axis of symmetry and graph.

$f(x) = (x^2 - 10x) + 3$

$\quad\quad = (x^2 - 10x + 25) + 3 - 25$

$\quad\quad = (x-5)^2 - 22 \quad$ standard form,

vertex $(5, -22)$, axis of symmetry $x = 5$
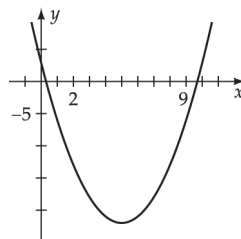
13. Write in standard form, find the vertex, the axis of symmetry and graph.

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

$\quad\quad = \left(x^2 + 3x + \dfrac{9}{4}\right) + 1 - \dfrac{9}{4}$

$\quad\quad = \left(x + \dfrac{3}{2}\right)^2 + \dfrac{4}{4} - \dfrac{9}{4}$

$\quad\quad = \left(x + \dfrac{3}{2}\right)^2 - \dfrac{5}{4} \quad$ standard form,

vertex $\left(-\dfrac{3}{2},\ -\dfrac{5}{4}\right)$, axis of symmetry $x = -\dfrac{3}{2}$
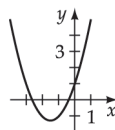
14. Write in standard form, find the vertex, the axis of symmetry and graph.

$$f(x) = (x^2 + 7x) + 2$$
$$= \left(x^2 + 7x + \frac{49}{4}\right) + 2 - \frac{49}{4}$$
$$= \left(x + \frac{7}{2}\right)^2 + \frac{8}{4} - \frac{49}{4}$$
$$= \left(x + \frac{7}{2}\right)^2 - \frac{41}{4} \quad \text{standard form,}$$

vertex $\left(-\frac{7}{2}, \ -\frac{41}{4}\right)$, axis of symmetry $x = -\frac{7}{2}$
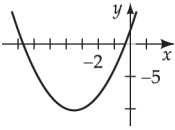
15. Write in standard form, find the vertex, the axis of symmetry and graph.

$$f(x) = -x^2 + 4x + 2$$
$$= -(x^2 - 4x) + 2$$
$$= -(x^2 - 4x + 4) + 2 + 4$$
$$= -(x - 2)^2 + 6 \quad \text{standard form,}$$

vertex (2, 6), axis of symmetry $x = 2$
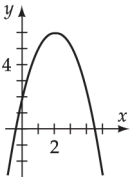
16. Write in standard form, find the vertex, the axis of symmetry and graph.

$$f(x) = -x^2 - 2x + 5$$
$$= -(x^2 + 2x) + 5$$
$$= -(x^2 + 2x + 1) + 5 + 1$$
$$= -(x + 1)^2 + 6 \quad \text{standard form,}$$

vertex (−1, 6), axis of symmetry $x = -1$
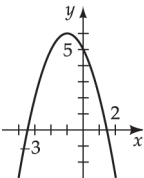
17. Write in standard form, find the vertex, the axis of symmetry and graph.

$$f(x) = -3x^2 + 3x + 7$$
$$= -3(x^2 - 1x) + 7$$
$$= -3\left(x^2 - 1x + \frac{1}{4}\right) + 7 + \frac{3}{4}$$
$$= -3\left(x - \frac{1}{2}\right)^2 + \frac{28}{4} + \frac{3}{4}$$
$$= -3\left(x - \frac{1}{2}\right)^2 + \frac{31}{4} \quad \text{standard form,}$$

vertex $\left(\frac{1}{2}, \ \frac{31}{4}\right)$, axis of symmetry $x = \frac{1}{2}$
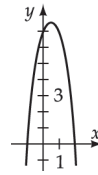
18. Write in standard form, find the vertex, the axis of symmetry and graph.

$$f(x) = -2x^2 - 4x + 5$$
$$= -2(x^2 + 2x) + 5$$
$$= -2(x^2 + 2x + 1) + 5 + 2$$
$$= -2(x + 1)^2 + 7 \quad \text{standard form,}$$

vertex (−1, 7), axis of symmetry $x = -1$
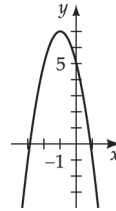
19. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{10}{2(1)} = 5$$

$$y = f(5) = (5)^2 - 10(5)$$
$$= 25 - 50 = -25$$

vertex (5, − 25)

$$f(x) = (x - 5)^2 - 25$$

20. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{6}{2(1)} = 3$$

$$y = f(3) = (3)^2 - 6(3)$$
$$= 9 - 18 = -9$$

vertex $(3, -9)$

$$f(x) = (x-3)^2 - 9$$

21. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{0}{2(1)} = 0$$

$$y = f(0) = (0)^2 - 10 = -10$$

vertex $(0, -10)$

$$f(x) = x^2 - 10$$

22. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{0}{2(1)} = 0$$

$$y = f(0) = (0)^2 - 4 = -4$$

vertex $(0, -4)$

$$f(x) = x^2 - 4$$

23. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{-6}{2(-1)} = \frac{-6}{-2} = 3$$

$$y = f(3) = -(3)^2 + 6(3) + 1$$
$$= -9 + 18 + 1$$
$$= 10$$

vertex $(3, 10)$

$$f(x) = -(x-3)^2 + 10$$

24. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{-4}{2(-1)} = \frac{-4}{-2} = 2$$

$$y = f(2) = -(2)^2 + 4(2) + 1$$
$$= -4 + 8 + 1$$
$$= 5$$

vertex $(2, 5)$

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

25. Find the vertex, write the function in standard form.

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

$$y = f\left(\frac{3}{4}\right) = 2\left(\frac{3}{4}\right)^2 - 3\left(\frac{3}{4}\right) + 7$$
$$= 2\left(\frac{9}{16}\right) - \frac{9}{4} + 7$$
$$= \frac{9}{8} - \frac{9}{4} + 7 = \frac{9}{8} - \frac{18}{8} + \frac{56}{8}$$
$$= \frac{47}{8}$$

vertex $\left(\frac{3}{4}, \frac{47}{8}\right)$

$$f(x) = 2\left(x - \frac{3}{4}\right)^2 + \frac{47}{8}$$

26. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{10}{2(3)} = \frac{10}{6} = \frac{5}{3}$$

$$y = f\left(\frac{5}{3}\right) = 3\left(\frac{5}{3}\right)^2 - 10\left(\frac{5}{3}\right) + 2$$
$$= 3\left(\frac{25}{9}\right) - \frac{50}{3} + 2$$
$$= \frac{25}{3} - \frac{50}{3} + 2 = \frac{25}{3} - \frac{50}{3} + \frac{6}{3}$$
$$= -\frac{19}{3}$$

vertex $\left(\frac{5}{3}, -\frac{19}{3}\right)$

$$f(x) = 3\left(x - \frac{5}{3}\right)^2 - \frac{19}{3}$$

27. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{-1}{2(-4)} = \frac{1}{8}$$

$$y = f\left(\frac{1}{8}\right) = -4\left(\frac{1}{8}\right)^2 + \left(\frac{1}{8}\right) + 1$$
$$= -4\left(\frac{1}{64}\right) + \frac{1}{8} + 1$$
$$= -\frac{1}{16} + \frac{1}{8} + 1 = -\frac{1}{16} + \frac{2}{16} + \frac{16}{16}$$
$$= \frac{17}{16}$$

vertex $\left(\frac{1}{8}, \frac{17}{16}\right)$

$$f(x) = -4\left(x - \frac{1}{8}\right)^2 + \frac{17}{16}$$

28. Find the vertex, write the function in standard form.

$$x = \frac{-b}{2a} = \frac{6}{2(-5)} = \frac{6}{-10} = -\frac{3}{5}$$

$$y = f\left(-\frac{3}{5}\right) = -5\left(-\frac{3}{5}\right)^2 - 6\left(-\frac{3}{5}\right) + 3$$

$$= -5\left(\frac{9}{25}\right) + \frac{18}{5} + 3$$

$$= -\frac{9}{5} + \frac{18}{5} + 3 = -\frac{9}{5} + \frac{18}{5} + \frac{15}{5}$$

$$= \frac{24}{5}$$

vertex $\left(-\frac{3}{5}, \frac{24}{5}\right)$

$$f(x) = -5\left(x + \frac{3}{5}\right)^2 + \frac{24}{5}$$

29. Find the range, find x.

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

$$= (x^2 - 2x) - 1$$

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

$$= (x - 1)^2 - 2$$

vertex $(1, -2)$

The y-value of the vertex is -2.

The parabola opens up since $a = 1 > 0$.

Thus the range is $\{y | y \geq -2\}$.

30. Find the range, find x.

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

$$= -(x^2 + 6x) - 2$$

$$= -(x^2 + 6x + 9) - 2 + 9$$

$$= -(x + 3)^2 + 7$$

vertex $(-3, 7)$

The y-value of the vertex is 7.

The parabola opens down since $a = -1 < 0$.

Thus the range is $\{y | y \leq 7\}$.

31. Find the range, find x.

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

$$= -2\left(x^2 - \frac{5}{2}x\right) - 1$$

$$= -2\left(x^2 - \frac{5}{2}x + \frac{25}{16}\right) - 1 + 2\left(\frac{25}{16}\right)$$

$$= -2\left(x - \frac{5}{4}\right)^2 - \frac{8}{8} + \frac{25}{8}$$

$$= -2\left(x - \frac{5}{4}\right)^2 + \frac{17}{8}$$

vertex $\left(\frac{5}{4}, \frac{17}{8}\right)$

The y-value of the vertex is $\frac{17}{8}$.

The parabola opens down since $a = -2 < 0$.

Thus the range is $\left\{y \middle| y \leq \frac{17}{8}\right\}$.

32. Find the range, find x.

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

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

$$= 2\left(x^2 + 3x + \frac{9}{4}\right) - 5 - 2\left(\frac{9}{4}\right)$$

$$= 2\left(x + \frac{3}{2}\right)^2 - \frac{10}{2} - \frac{9}{2}$$

$$= 2\left(x + \frac{3}{2}\right)^2 - \frac{19}{2}$$

vertex $\left(-\frac{3}{2}, -\frac{19}{2}\right)$

The y-value of the vertex is $-\frac{19}{2}$.

The parabola opens up since $a = 2 > 0$.

Thus the range is $\left\{y \middle| y \geq -\frac{19}{2}\right\}$.

33. Find the real zeros and x-intercepts.

$$f(x) = x^2 + 2x - 24$$

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

$$x + 6 = 0 \qquad x - 4 = 0$$

$$x = -6 \qquad x = 4$$

$$(-6, 0) \qquad (4, 0)$$

34. Find the real zeros and x-intercepts.

$$f(x) = -x^2 + 6x + 7$$
$$= -(x^2 - 6x - 7)$$
$$= -(x + 1)(x - 7)$$

$$x + 1 = 0 \qquad x - 7 = 0$$
$$x = -1 \qquad x = 7$$
$$(-1,\ 0) \qquad (7,\ 0)$$

35. Find the real zeros and x-intercepts.

$$f(x) = 2x^2 + 11x + 12$$
$$= (x + 4)(2x + 3)$$

$$x + 4 = 0 \qquad 2x + 3 = 0$$
$$x = -4 \qquad x = -\frac{3}{2}$$
$$(-4,\ 0) \qquad \left(-\frac{3}{2},\ 0\right)$$

36. Find the real zeros and x-intercepts.

$$f(x) = 2x^2 - 9x + 10$$
$$= (x - 2)(2x - 5)$$

$$x - 2 = 0 \qquad 2x - 5 = 0$$
$$x = 2 \qquad x = \frac{5}{2}$$
$$(2,\ 0) \qquad \left(\frac{5}{2},\ 0\right)$$

37. Find the minimum or maximum.

$$f(x) = x^2 + 8x$$
$$= (x^2 + 8x + 16) - 16$$
$$= (x + 4)^2 - 16$$

minimum value of –16 when $x = -4$

38. Find the minimum or maximum.

$$f(x) = -x^2 - 6x$$
$$= -(x^2 + 6x)$$
$$= -(x^2 + 6x + 9) + 9$$
$$= -(x + 3)^2 + 9$$

maximum value of 9 when $x = -3$

39. Find the minimum or maximum.

$$f(x) = -x^2 + 6x + 2$$
$$= -(x^2 - 6x) + 2$$
$$= -(x^2 - 6x + 9) + 2 + 9$$
$$= -(x - 3)^2 + 11$$

maximum value of 11 when $x = 3$

40. Find the minimum or maximum.

$$f(x) = -x^2 + 10x - 3$$
$$= -(x^2 - 10x) - 3$$
$$= -(x^2 - 10x + 25) - 3 + 25$$
$$= -(x - 5)^2 + 22$$

maximum value of 22 when $x = 5$

41. Find the minimum or maximum.

$$f(x) = 2x^2 + 3x + 1$$
$$= 2\left(x^2 + \frac{3}{2}x\right) + 1$$
$$= 2\left(x^2 + \frac{3}{2}x + \frac{9}{16}\right) + 1 - 2\left(\frac{9}{16}\right)$$
$$= 2\left(x + \frac{3}{4}\right)^2 + \frac{8}{8} - \frac{9}{8}$$
$$= 2\left(x + \frac{3}{4}\right)^2 - \frac{1}{8}$$

minimum value of $-\frac{1}{8}$ when $x = -\frac{3}{4}$

42. Find the minimum or maximum.

$$f(x) = 3x^2 + x - 1$$
$$= 3\left(x^2 + \frac{1}{3}x\right) - 1$$
$$= 3\left(x^2 + \frac{1}{3}x + \frac{1}{36}\right) - 1 - 3\left(\frac{1}{36}\right)$$
$$= 3\left(x + \frac{1}{6}\right)^2 - \frac{12}{12} - \frac{1}{12}$$
$$= 3\left(x + \frac{1}{6}\right)^2 - \frac{13}{12}$$

minimum value of $-\frac{13}{12}$ when $x = -\frac{1}{6}$

43. Find the minimum or maximum.

$f(x) = 5x^2 - 11$

$\quad = 5(x^2) - 11$

$\quad = 5(x-0)^2 - 11$

minimum value of -11 when $x = 0$

44. Find the minimum or maximum.

$f(x) = 3x^2 - 41$

$\quad = 3(x^2) - 41$

$\quad = 3(x-0)^2 - 41$

minimum value of -41 when $x = 0$

45. Find the minimum or maximum.

$f(x) = -\dfrac{1}{2}x^2 + 6x + 17$

$\quad = -\dfrac{1}{2}(x^2 - 12x) + 17$

$\quad = -\dfrac{1}{2}(x^2 - 12x + 36) + 17 + 18$

$\quad = -\dfrac{1}{2}(x-6)^2 + 35$

maximum value of 35 when $x = 6$

46. Find the minimum or maximum.

$f(x) = -\dfrac{3}{4}x^2 - \dfrac{2}{5}x + 7$

$\quad = -\dfrac{3}{4}\left(x^2 + \dfrac{8}{15}x\right) + 7$

$\quad = -\dfrac{3}{4}\left(x^2 + \dfrac{8}{15}x + \dfrac{16}{225}\right) + 7 + \dfrac{4}{75}$

$\quad = -\dfrac{3}{4}\left(x + \dfrac{4}{15}\right)^2 + \dfrac{529}{75}$

maximum value of $\dfrac{529}{75} = 7\dfrac{4}{75}$ when $x = -\dfrac{4}{15}$

47. $A(t) = -4.9t^2 + 90t + 9000$

Microgravity begins and ends at a height of 9000 m.

$9000 = -4.9t^2 + 90t + 9000$

$4.9t^2 - 90t = 0$

$t(4.9t - 90) = 0$

$t = 0 \quad 4.9t - 90 = 0$

$t = 0 \qquad\quad t = \dfrac{90}{4.9} \approx 18.4$

The time of microgravity is 18.4 seconds.

48. $h(t) = -4.9t^2 + 12.8t$

$0 = -4.9t^2 + 12.8t$

$0 = t(-4.9t + 12.8)$

$t = 0 \quad -4.9t + 12.8 = 0$

$t = 0 \qquad\quad t = \dfrac{12.8}{4.9} \approx 2.6$

The ball is in the air 2.6 seconds.

49. $h(x) = -\dfrac{3}{64}x^2 + 27 = -\dfrac{3}{64}(x-0)^2 + 27$

a. The maximum height of the arch is 27 feet.

b. $h(10) = -\dfrac{3}{64}(10)^2 + 27$

$\quad = -\dfrac{3}{64}(100) + 27$

$\quad = -\dfrac{75}{16} + 27$

$\quad = -\dfrac{75}{16} + \dfrac{432}{16}$

$\quad = \dfrac{357}{16} = 22\dfrac{5}{16}$ feet

c. $h(x) = 8 = -\dfrac{3}{64}x^2 + 27$

$8 - 27 = -\dfrac{3}{64}x^2$

$-19 = -\dfrac{3}{64}x^2$

$64(-19) = -3x^2$

$\dfrac{64(-19)}{-3} = x^2$

$\sqrt{\dfrac{64(-19)}{-3}} = x$

$8\sqrt{\dfrac{19}{3}} = x$

$\dfrac{8\sqrt{19}\sqrt{3}}{3} = x$

$\dfrac{8\sqrt{57}}{3} = x$

$20.1 \approx x$

$h(x) = 8$ when $x \approx 20.1$ feet

50. $l + w = 240$

a. $w = 240 - l$

b. $A = l(240 - l)$

$A = 240l - l^2$

c. $A = -l^2 + 240l$

$A = -(l^2 - 240l)$

$A = -(l^2 - 240l + 120^2) + 120^2$

$A = -(l - 120)^2 + 120^2$

Thus $l = 120$ and $w = 120$ produce the greatest area.

51. a. $3w + 2l = 600$

$3w = 600 - 2l$

$w = \dfrac{600 - 2l}{3}$

b. $A = w \cdot l$

$A = \left(\dfrac{600 - 2l}{3}\right) l$

$= 200l - \dfrac{2}{3}l^2$

c. $A = -\dfrac{2}{3}(l^2 - 300l)$

$A = -\dfrac{2}{3}(l^2 - 300l + 150^2) + 15{,}000$

In standard form,

$A = -\dfrac{2}{3}(l - 150)^2 + 15{,}000$

The maximum area of 15,000 ft^2 is produced when

$l = 150$ ft and the width $w = \dfrac{600 - 2(150)}{3} = 100$ ft .

52. a. Find the temperature for maximum surviving larvae.

$N(t) = -0.6t^2 + 32.1t - 350$

$= -0.6\left(t^2 - \dfrac{32.1}{0.6}t\right) - 350$

$= -0.6(t^2 - 53.5t) - 350$

$= -0.6\,[t^2 - 53.5t + (26.75)^2] - 350 + 0.6(26.75)^2$

$= -0.6(t - 26.75)^2 + 79.3375$

$\approx -0.6(t - 27)^2 + 79$

The maximum number of larvae will survive at 27°C.

b. A maximum of 79 larvae will survive.

c. $N(t) = 0 = -0.6t^2 + 32.1t - 350$

$t = \dfrac{-32.1 \pm \sqrt{(-32.1)^2 - 4(-0.6)(-350)}}{2(-0.6)}$.

$t = \dfrac{-32.1 \pm \sqrt{1030.41 - 840}}{-1.2}$

$t = \dfrac{-32.1 \pm \sqrt{190.41}}{-1.2} \approx \dfrac{-32.1 \pm 13.8}{-1.2}$

$t = \dfrac{-32.1 + 13.8}{-1.2}$ or $t = \dfrac{-32.1 - 13.8}{-1.2}$

$= 15.25 \approx 15$ $= 38.25 \approx 38$

Thus the x-intercepts to the nearest whole number for $N(t)$ are (15, 0) and (38, 0).

d. When the temperature is less than 15°C or greater than 38°C, none of the larvae survive.

53. a. $T(t) = -0.7t^2 + 9.4t + 59.3$

$= -0.7\left(t^2 - \dfrac{9.4}{0.7}t\right) + 59.3$

$= -0.7\left(t^2 - \dfrac{94}{7}t\right) + 59.3$

$= -0.7\left(t^2 - \dfrac{94}{7}t + \left[\dfrac{47}{7}\right]^2\right) + 59.3 + 0.7\left[\dfrac{47}{7}\right]^2$

$\approx -0.7\left(t - \dfrac{47}{7}\right)^2 + 90.857$

$\approx -0.7\left(t - 6\dfrac{5}{7}\right)^2 + 91$

The temperature is a maximum when $t = \dfrac{47}{7} = 6\dfrac{5}{7}$

hours after 6:00 A.M. Note $\dfrac{5}{7}(60 \text{ min}) \approx 43$ min.

Thus the temperature is a maximum at 12:43 P.M.

b. The maximum temperature is approximately 91°F.

54. $h(t) = -9.8t^2 + 100t$

$h(t) = -9.8(t^2 - 10.2t)$

$h(t) = -9.8(t - 5.1)^2 + 254.9$

The maximum height is 255 m.

55. $t = -\dfrac{b}{2a} = -\dfrac{82.86}{2(-279.67)} = 0.14814$

$E(0.14814) = -279.67(0.14814)^2 + 82.86(0.14814)$

≈ 6.1

The maximum energy is 6.1 joules.

56. $h(x) = -0.0009x^2 + 6$

$h(60.5) = -0.0009(60.5)^2 + 6 \approx 2.7$

Since 2.7 is less than 5.4 and greater than 2.5, yes, the pitch is a strike.

57. a. $E(v) = -0.018v^2 + 1.476v + 3.4$

$= -0.018\left(v^2 - \dfrac{1.476}{0.018}v\right) + 3.4$

$= -0.018(v^2 - 82v) + 3.4$

$= -0.018\left(v^2 - 82v + 41^2\right) + 3.4 + 0.018(41)^2$

$= -0.018(v - 41)^2 + 33.658$

The maximum fuel efficiency is obtained at a speed of 41 mph.

b. The maximum fuel efficiency for this car, to the nearest mile per gallon, is 34 mpg.

58. $h(x) = -0.0002348x^2 + 0.0375x$

$= -0.0002348\left(x^2 - \frac{0.0375}{0.0002348}x\right)$

$= -0.0002348\left(x^2 - \frac{0.0375}{0.0002348}x + \left[\frac{1}{2} \cdot \frac{0.0375}{0.0002348}\right]^2\right)$

$+ 0.0002348\left[\frac{1}{2} \cdot \frac{0.0375}{0.0002348}\right]^2$

$\approx -0.0002348\left(x^2 - \frac{0.0375}{0.0002348}x + \left[\frac{1}{2} \cdot \frac{0.0375}{0.0002348}\right]^2\right) + 1.5$

The maximum height of the field, to the nearest tenth of a foot, is 1.5 feet.

59. $-\dfrac{b}{2a} = -\dfrac{296}{2(-0.2)} = 740$

$R(740) = 296(740) - 0.2(740)^2 = 109,520$

Thus, 740 units yield a maximum revenue of $109,520.

60. $-\dfrac{b}{2a} = -\dfrac{810}{2(-0.6)} = 675$

$R(675) = 810(675) - 0.6(675)^2 = 273,375$

Thus, 675 units yield a maximum revenue of $273,375.

61. $-\dfrac{b}{2a} = -\dfrac{1.7}{2(-0.01)} = 85$

$P(85) = -0.01(85)^2 + 1.7(85) - 48 = 24.25$

Thus, 85 units yield a maximum profit of $24.25.

62. $-\dfrac{b}{2a} = -\dfrac{1.68}{2\left(-\dfrac{1}{14,000}\right)} = 11,760$

$P(11,760) = -\dfrac{(11,760)^2}{14,000} + 1.68(11,760) - 4000$

$= 5878.40$

Thus, 11,760 units yield a maximum profit of $5878.40.

63. $P(x) = R(x) - C(x)$

$= x(102.50 - 0.1x) - (52.50x + 1840)$

$= -0.1x^2 + 50x - 1840$

The break-even points occur when $R(x) = C(x)$ or $P(x) = 0$.

Thus, $0 = -0.1x^2 + 50x - 1840$

$x = \dfrac{-50 \pm \sqrt{50^2 - 4(-0.1)(-1840)}}{2(-0.1)}$

$= \dfrac{-50 \pm \sqrt{1764}}{-0.2}$

$= \dfrac{-50 \pm 42}{-0.2}$

$x = 40$ or $x = 460$

The break-even points occur when $x = 40$ or $x = 460$.

64. $P(x) = R(x) - C(x)$

$= x(210 - 0.25x) - (78x + 6399)$

$= -0.25x^2 + 132x - 6399$

$-\dfrac{b}{2a} = -\dfrac{132}{2(-0.25)} = 264$

$P(264) = -0.25(264)^2 + 132(264) - 6399$

$= \$11,025$, the maximum profit

The break-even points occur when $P(x) = 0$.

Thus, $0 = -0.25x^2 + 132x - 6399$

$x = \dfrac{-132 \pm \sqrt{132^2 - 4(-0.25)(-6399)}}{2(-0.25)}$

$= \dfrac{-132 \pm \sqrt{11025}}{-0.5}$

$= \dfrac{-132 \pm 105}{-0.5} \Rightarrow x = 54$ or $x = 474$

The break-even points occur when $x = 54$ or $x = 474$.

65. Let x = the number of people that take the tour.

  a. $R(x) = x(15.00 + 0.25(60 - x))$
  $$= x(15.00 + 15 - 0.25x)$$
  $$= -0.25x^2 + 30.00x$$

  b. $P(x) = R(x) - C(x)$
  $$= (-0.25x^2 + 30.00x) - (180 + 2.50x)$$
  $$= -0.25x^2 + 27.50x - 180$$

  c. $-\dfrac{b}{2a} = -\dfrac{27.50}{2(-0.25)} = 55$

  $P(55) = -0.25(55)^2 + 27.50(55) - 180 = \$576.25$

  d. The maximum profit occurs when x = 55 tickets.

66. Let x = the number of parcels.

  a. $R(x) = xp = x(22 - 0.01x) = -0.01x^2 + 22x$

  b. $P(x) = R(x) - C(x)$
  $$= (-0.01x^2 + 22x) - (2025 + 7x)$$
  $$= -0.01x^2 + 15x - 2025$$

  c. $-\dfrac{b}{2a} = -\dfrac{15}{2(-0.01)} = 750$

  $P(750) = -0.01(750)^2 + 15(750) - 2025 = \$3600$

  d. $p(750) = 22 - 0.01(750) = \$14.50$

  e. The break-even points occur when $R(x) = C(x)$.

  $$-0.01x^2 + 22x = 2025 + 7x$$
  $$-0.01x^2 + 15x - 2025 = 0$$

  $$x = \dfrac{-(15) \pm \sqrt{15^2 - 4(-0.01)(-2025)}}{2(-0.01)}$$

  x = 150 or x = 1350 are the break-even points.

  Thus the minimum number of parcels the air freight

  company must ship to break even is 150 parcels.

67. Let x = the number of $0.05 price reductions.

  Then the price per gallon is

  $$p(x) = 3.95 - 0.05x$$

  The number of gallons sold each day is

  $$q(x) = 10,000 + 500x$$

  Then the revenue is

$$R(x) = (3.95 - 0.05x)(10,000 + 500x)$$
$$= -25x^2 + 1475x + 39,500$$

The cost is

$$C(x) = 2.75(10,000 + 500x) = 27,500 + 1375x$$

The profit equals revenue minus cost.

$$P(x) = R(x) - C(x)$$
$$= -25x^2 + 1475x + 39,500 - (27,500 + 1375x)$$
$$= -25x^2 + 100x + 12,000$$

The maximum profit occurs when

$$x = -\frac{b}{2a} = -\frac{100}{2(-25)} = 2$$

The price per gallon that maximizes profit is

$$p(2) = 3.95 - 0.05(2) = \$3.85$$

68. Let x = the number of $10 price reductions.

Then the price per ticket is

$$p(x) = 390 - 10x$$

The number of tickets sold each day is

$$q(x) = 350 + 25x$$

Then the revenue is

$$R(x) = (390 - 10x)(350 + 25x)$$
$$= -250x^2 + 6250x + 136,500$$

The cost is

$$C(x) = 150(350 + 25x) = 52,500 + 3750x$$

The profit equals revenue minus cost.

$$P(x) = R(x) - C(x)$$
$$= -250x^2 + 6250x + 136,500 - (52,500 + 3750x)$$
$$= -250x^2 + 2500x + 84,000$$

The maximum profit occurs when

$$x = -\frac{b}{2a} = -\frac{2500}{2(-250)} = 5$$

The price per ticket that maximizes profit is

$$p(5) = 390 - 10(5) = \$340$$

69. $h(t) = -16t^2 + 128t$

   a. $-\dfrac{b}{2a} = -\dfrac{128}{2(-16)} = 4$ seconds

   b. $h(4) = -16(4)^2 + 128(4) = 256$ feet

   c. $0 = -16t^2 + 128t$

         $0 = -16t(t - 8)$

      $-16t = 0$ or $t - 8 = 0$

        $t = 0$ $t = 8$

   The projectile hits the ground at $t = 8$ seconds.

70. $h(t) = -16t^2 + 64t + 80$

   a. $-\dfrac{b}{2a} = -\dfrac{64}{2(-16)} = 2$

    $h(2) = -16(2)^2 + 64(2) + 80$

        $= 144$ feet

   b. $-\dfrac{b}{2a} = -\dfrac{64}{2(-16)}$

         $= 2$ seconds

   c. $0 = -16t^2 + 64t + 80$

        $0 = -16(t^2 - 4t - 5)$

        $0 = -16(t - 5)(t + 1)$

      $t - 5 = 0$ or $t + 1 = 0$

        $t = 5$ $t = -1$ No

   The projectile has height 0 feet at $t = 5$ seconds.

71. $y(x) = -0.014x^2 + 1.19x + 5$

    $-\dfrac{b}{2a} = -\dfrac{1.19}{2(-0.014)}$

        $= 42.5$

    $y(42.5) = -0.014(42.5)^2 + 1.19(42.5) + 5$

        $= 30.2875$

        ≈ 30 feet

72. $h(t) = -6.6t^2 + 430t + 28,000$

    $-\dfrac{b}{2a} = -\dfrac{430}{2(-6.6)}$

        $= 32.6$

    $h(32.6) = -6.6(32.6)^2 + 430(32.6) + 28,000$

        $= 35,0003.784$

        $\approx 35,000$ feet

73. $h(x) = -0.002x^2 - 0.03x + 8$

    $h(39) = -0.002(39)^2 - 0.03(39) + 8 = 3.788 > 3$

   Solve for x using quadratic formula.

    $-0.002x^2 - 0.03x + 8 = 0$

    $x^2 + 15x - 4000 = 0$

    $x = \dfrac{-15 \pm \sqrt{(15)^2 - 4(1)(-4000)}}{2(1)}$

     $= \dfrac{-15 \pm \sqrt{16,225}}{2}$, use positive value of x

    $x \approx 56.2$

   Yes, the conditions are satisfied.

74. $4w + 2l = 1200$

          $2l = 1200 - 4w$

           $l = \dfrac{1200 - 4w}{2}$

           $l = 600 - 2w$

          $A = w(600 - 2w)$

          $A = 600w - 2w^2$

          $A = -2w^2 + 600w$

          $A = -2(w^2 - 300w)$

          $A = -2(w^2 - 300w + 150^2) + 2 \cdot 150^2$

          $A = -2(w - 150)^2 + 45,000$

   Thus when $w = 150$, the length $l = \dfrac{1200 - 4(150)}{2} = 300.$

   Thus the dimensions that yield the greatest enclosed area are $w = 150$ ft and $l = 300$ ft.

75. Find height and radius.
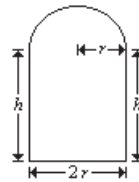
   The perimeter is $48 = \pi r + h + 2r + h$.

   Solve for h.

      $48 - \pi r - 2r = 2h$

      $\dfrac{1}{2}(48 - \pi r - 2r) = h$

Area = semicircle + rectangle

$$A = \frac{1}{2}\pi r^2 + 2rh$$

$$= \frac{1}{2}\pi r^2 + 2r\left(\frac{1}{2}\right)(48 - \pi r - 2r)$$

$$= \frac{1}{2}\pi r^2 + r(48 - \pi r - 2r)$$

$$= \frac{1}{2}\pi r^2 + 48r - \pi r^2 - 2r^2$$

$$= \left(\frac{1}{2}\pi - \pi - 2\right) r^2 + 48r$$

$$= \left(-\frac{1}{2}\pi - 2\right) r^2 + 48r$$

Graph the function A to find that its maximum occurs when $r \approx 6.72$ feet.
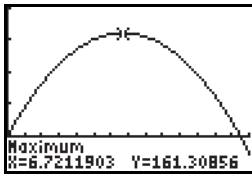
Xmin = 0, Xmax = 14, Xscl = 1

Ymin = –50, Ymax = 200, Yscl = 50

$$h = \frac{1}{2}(48 - \pi r - 2r)$$

$$\approx \frac{1}{2}(48 - \pi(6.72) - 2(6.72))$$

$$\approx 6.72 \text{ feet}$$

Hence the optimal window has its semicircular radius equal to its height.

Note: Using calculus it can be shown that the exact value of $r = h = \dfrac{48}{\pi + 4}$.

76. $y = a(x - h)^2 + k$

$y = a(x - 0)^2 + 6$

$y = ax^2 + 6$

$$500 = a(2100)^2 + 6$$

$$494 = a(2100)^2$$

$$\frac{494}{2100^2} = a$$

$$0.000112018 \approx a$$

$$y = 0.000112018x^2 + 6$$

Prepare for Section 2.5

P1. $f(x) = x^2 + 4x - 6$

$$-\frac{b}{2a} = -\frac{4}{2(1)} = -2$$

$$x = -2$$

P2. $f(3) = \dfrac{3(3)^4}{(3)^2 + 1} = \dfrac{243}{10} = 24.3$

$$f(-3) = \dfrac{3(-3)^4}{(-3)^2 + 1} = \dfrac{243}{10} = 24.3$$

$$f(3) = f(-3)$$

P3. $f(-2) = 2(-2)^3 - 5(-2) = -16 + 10 = -6$

$$-f(2) = -[2(2)^3 - 5(2)] = -[16 - 10] = -6$$

$$f(-2) = -f(2)$$

P4. $f(-2) - g(-2) = (-2)^2 - [-2 + 3] = 4 - 1 = 3$

$$f(-1) - g(-1) = (-1)^2 - [-1 + 3] = 1 - 2 = -1$$

$$f(0) - g(0) = (0)^2 - [0 + 3] = 0 - 3 = -3$$

$$f(1) - g(1) = (1)^2 - [1 + 3] = 1 - 4 = -3$$

$$f(2) - g(2) = (2)^2 - [2 + 3] = 4 - 5 = -1$$

P5. $\dfrac{-a + a}{2} = 0, \quad \dfrac{b + b}{2} = b$

midpoint is $(0, b)$

P6. $\dfrac{-a + a}{2} = 0, \quad \dfrac{-b + b}{2} = 0$

midpoint is $(0, 0)$

Section 2.5 Exercises

1. Plot the points.
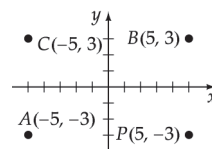
2. Plot the points.

3. Plot the points.

R(-2, 3)   A(2, 3)

B(-2, -3)   C(2, -3)

4. Plot the points.

S(-5, 3)   A(5, 3)

B(-5, -3)   C(5, -3)

5. Plot the points.

B(-4, 5)   C(4, 5)

T(-4, -5)   A(4, -5)

6. Plot the points.

A(-5, 1)   U(5, 1)

C(-5, -1)   B(5, -1)
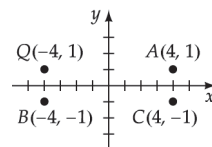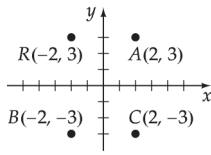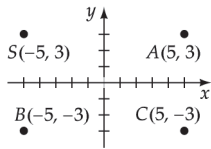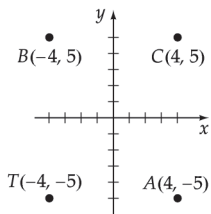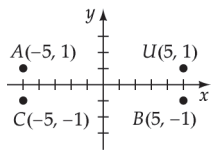
7. Determine how the graph is symmetric.

The graph is symmetric with respect to the origin.

8. Determine how the graph is symmetric.

The graph is symmetric with respect to the y-axis.

9. Determine how the graph is symmetric.

The graph is symmetric with respect to the x-axis, the y-axis, and the origin.

10. Determine how the graph is symmetric.

The graph is symmetric with respect to the x-axis.

11. Sketch the graph symmetric to the x-axis.
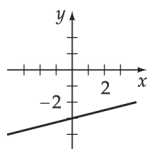
12. Sketch the graph symmetric to the x-axis.
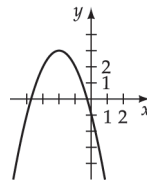
13. Sketch the graph symmetric to the y-axis.
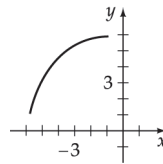
14. Sketch the graph symmetric to the y-axis.
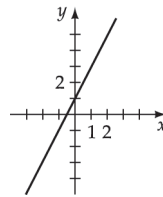
15. Sketch the graph symmetric to the origin.
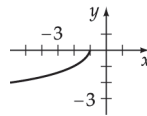
16. Sketch the graph symmetric to the origin.
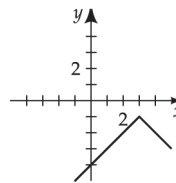
17. Determine if the graph is symmetric.

  a. No

  b. Yes

18. Determine if the graph is symmetric.

  a. Yes

  b. No

19. Determine if the graph is symmetric.

  a. No

  b. No

20. Determine if the graph is symmetric.

  a. No

  b. No

21. Determine if the graph is symmetric.

　　a. Yes

　　b. Yes

22. Determine if the graph is symmetric.

　　a. Yes

　　b. Yes

23. Determine if the graph is symmetric.

　　a. Yes

　　b. Yes

24. Determine if the graph is symmetric.

　　a. No

　　b. No

25. Determine if the graph is symmetric.

　　a. Yes

　　b. Yes

26. Determine if the graph is symmetric to the origin.
Not symmetric with respect to the origin since
$(-y) = (-x) + 1$ does not simplify to the original
equation $y = x + 1$.

27. Determine if the graph is symmetric to the origin.
No, since $(-y) = 3(-x) - 2$ simplifies to
$(-y) = -3x - 2$, which is not equivalent to the original
equation $y = 3x - 2$.

28. Determine if the graph is symmetric to the origin.
Yes, since $(-y) = (-x)^3 - (-x)$ simplifies to
$-y = -x^3 + x$, which is equivalent to the original
equation $y = x^3 - x$.

29. Determine if the graph is symmetric to the origin.
Yes, since $(-y) = -(-x)^3$ implies
$-y = x^3$ or $y = -x^3$, which is the original equation.

30. Determine if the graph is symmetric to the origin.
Yes, since $(-y) = \dfrac{9}{(-x)}$ is equivalent to the original
equation $y = \dfrac{9}{x}$.

31. Determine if the graph is symmetric to the origin.
Yes, since $(-x)^2 + (-y)^2 = 10$ simplifies to the
original equation.

32. Determine if the graph is symmetric to the origin.
Yes, since $(-x)^2 - (-y)^2 = 4$ simplifies to the original
equation.

33. Determine if the graph is symmetric to the origin.
Yes, since $-y = \dfrac{-x}{|-x|}$ simplifies to the original
equation.

34. Determine if the graph is symmetric to the origin.
Yes, since $|-y| = |-x|$ simplifies to the original
equation.

35. Determine if the function is odd, even or neither.
Even since $g(-x) = (-x)^2 - 7 = x^2 - 7 = g(x)$.

36. Determine if the function is odd, even or neither.
Even, since $h(-x) = (-x)^2 + 1 = x^2 + 1 = h(x)$.

37. Determine if the function is odd, even or neither.
Odd, since $F(-x) = (-x)^5 + (-x)^3$
$$= -x^5 - x^3$$
$$= -F(x).$$

38. Determine if the function is odd, even or neither.
Neither, since $G(-x) \neq G(x)$ and $G(-x) \neq -G(x)$.

39. Determine if the function is odd, even or neither.
Even

40. Determine if the function is odd, even or neither.
Even

41. Determine if the function is odd, even or neither.
Even

42. Determine if the function is odd, even or neither.
Neither

43. Determine if the function is odd, even or neither.
Even

44. Determine if the function is odd, even or neither.
Even

45. Determine if the function is odd, even or neither.

Even

46. Determine if the function is odd, even or neither.

Neither

47. Determine if the function is odd, even or neither.

Neither

48. Determine if the function is odd, even or neither.

Odd

49. Sketch the graphs.
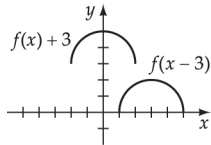
50. Sketch the graphs.
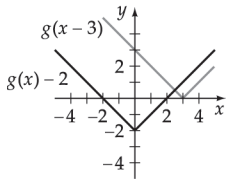
51. Sketch the graphs.

a. $f(x+2)$
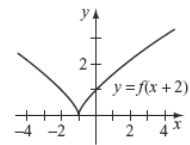
b. $f(x)+2$
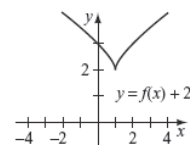
52. Sketch the graphs.

a. $g(x-1)$
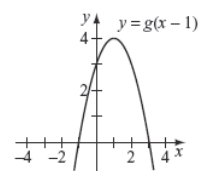
b. $g(x)-1$
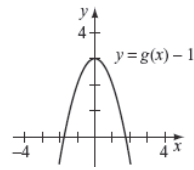
53. Sketch the graphs.

a. $y=f(x-2)+1$
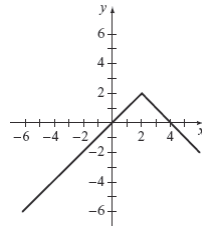
b. $y=f(x+3)-2$
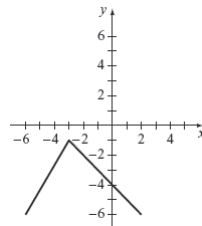
54. Sketch the graphs.

a. $y=f(x+3)+2$
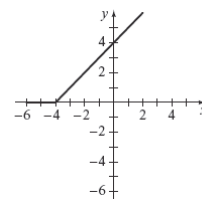
b. $y=f(x-2)-1$
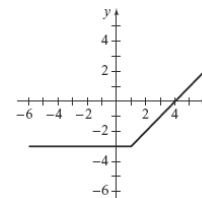
55. a. Give three points on the graph.

$f(x+3)$

$(-2-3,5)=(-5,5)$

$(0-3,-2)=(-3,-2)$

$(1-3,0)=(-2,0)$

b. Give three points on the graph.

$f(x)+1$

$(-2, 5+1)=(-2, 6)$

$(0, -2+1)=(0, -1)$

$(1, 0+1)=(1, 1)$

56. a. Give three points on the graph.

$g(x-2)$

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

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

$(4+2, 2)=(6, 2)$

b. Give three points on the graph.

$g(x)-2$

$(-3, -1-2)=(-3, -3)$

$(1, -3-2)=(1, -5)$

$(4, 2-2)=(4, 0)$

57. a. Give two points on the graph.

$f(-x)$

$(--1, 3)=(1, 3)$

$(-2, -4)$

b. Give two points on the graph.

$-f(x)$

$(-1, -3)$

$(2, --4)=(2, 4)$

58. a. Give two points on the graph.

$-g(x)$

$(4, --5)=(4, 5)$

$(-3, -2)$

b. Give two points on the graph.

$g(-x)$

$(-4, -5)$

$(--3, 2)=(3, 2)$

59. Sketch the graphs.

a. $f(-x)$
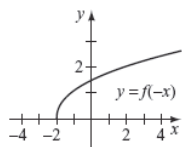
b. $-f(x)$
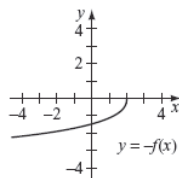
60. Sketch the graphs.

a. $-g(x)$
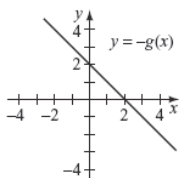
b. $g(-x)$
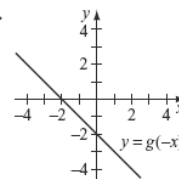
61. Sketch the graphs.
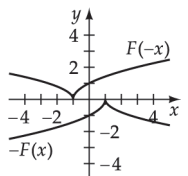
62. Sketch the graphs.
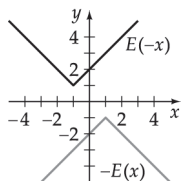
63. Sketch the graphs.

a. $2g(x)$
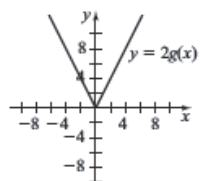
b. $\frac{1}{2}g(x)$
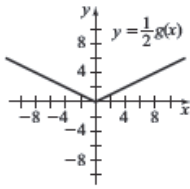
64. Sketch the graphs.

a. $2f(x)$
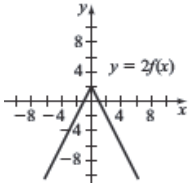
b. $\frac{1}{2}f(x)$
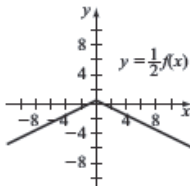
65. Sketch the graphs.

a. $3h(x)$
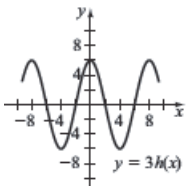
b. $\frac{1}{2}h(x)$
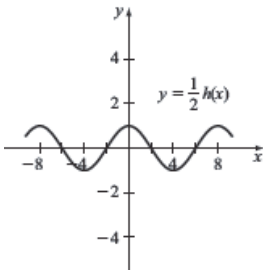
66. Sketch the graphs.

a. $4f(x)$
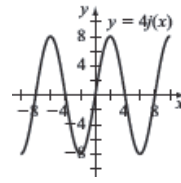
b. $\frac{1}{4}f(x)$
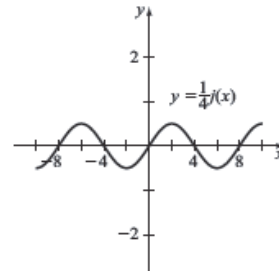
67. Sketch the graphs.

a. $f(2x)$
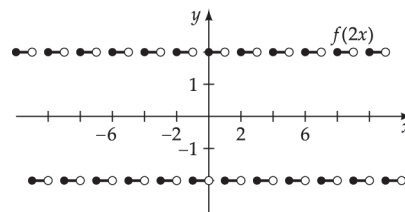
b. $f\left(\frac{1}{3}x\right)$
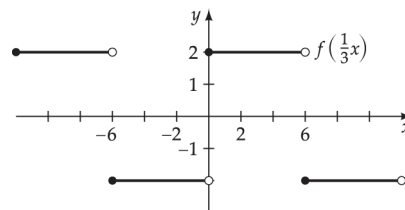
68. Sketch the graphs.

a. $g(2x)$
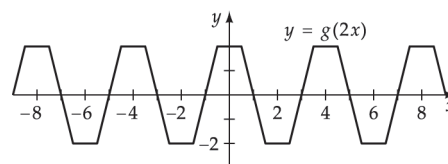
b. $g\left(\dfrac{1}{2}x\right)$

$y = g\left(\dfrac{1}{2}x\right)$
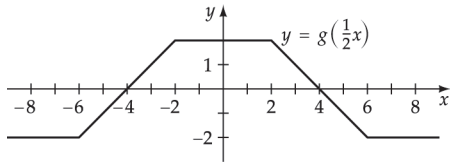
69. Sketch the graphs.

a. $h(2x)$
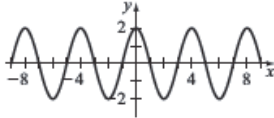
b. $h\left(\dfrac{1}{2}x\right)$
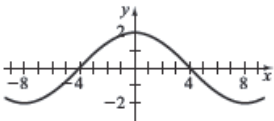
70. Sketch the graphs.

a. $j(2x)$

b. $j\left(\dfrac{1}{3}x\right)$
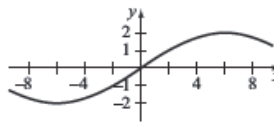
71. Sketch the graph.
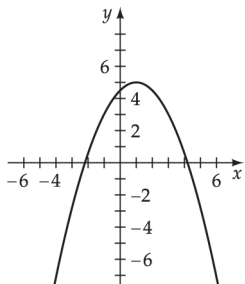
72. Sketch the graph.
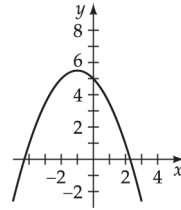
73. Sketch the graphs.

a. $y = -\dfrac{1}{2}j(x)+1$
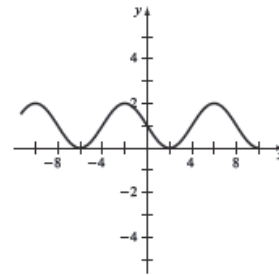
b. $y = 2j(x)-1$
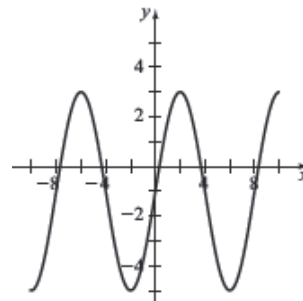
74. Sketch the graphs.

a. $y = \dfrac{1}{2}h(x)-1$
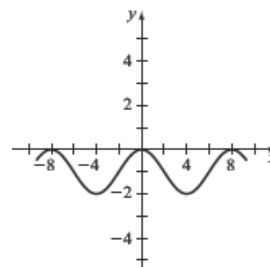
b. $y = -2h(x) + 1$
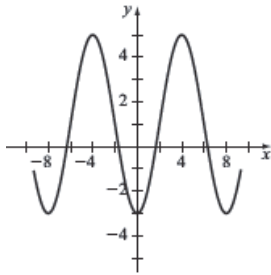
75. Graph using a graphing utility.
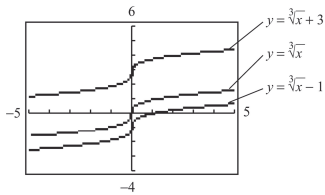
76. Graph using a graphing utility.
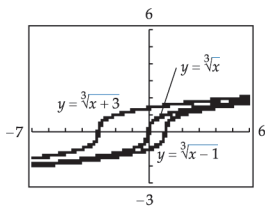
77. Graph using a graphing utility.
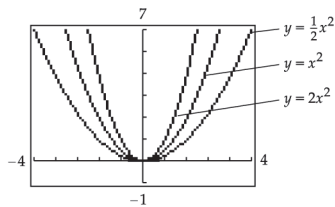
78. Graph using a graphing utility.
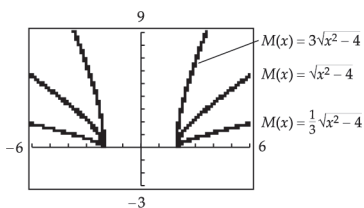
79. Reflect the graph about the y-axis and then about the origin.
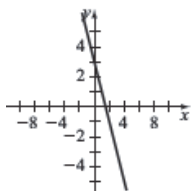
80. Reflect the graph about the origin and then about the y-axis.
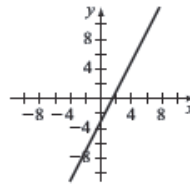
81. Reflect the graph about the y-axis and then about the x-axis.
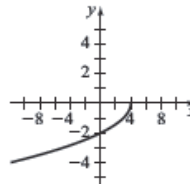
82. Reflect the graph about the x-axis and then about the origin.
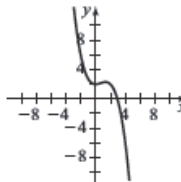
Prepare for Section 2.6

P1. $(2x^2 + 3x - 4) - (x^2 + 3x - 5) = x^2 + 1$

P2. $(3x^2 - x + 2)(2x - 3) = 6x^3 - 2x^2 + 4x - 9x^2 + 3x - 6$
$$= 6x^3 - 11x^2 + 7x - 6$$

P3. $f(3a) = 2(3a)^2 - 5(3a) + 2$
$$= 18a^2 - 15a + 2$$

P4. $f(2 + h) = 2(2 + h)^2 - 5(2 + h) + 2$
$$= 2h^2 + 8h + 8 - 5h - 10 + 2$$
$$= 2h^2 + 3h$$

P5. Domain: all real numbers except $x = 1$

P6. $2x - 8 = 0$
$$x = 4$$

Domain: $x \geq 4$ or $[4, \infty)$

Section 2.6 Exercises

1. Evaluate.

$$(f+g)(-2) = f(-2)+g(-2)$$
$$= 3+(-6)$$
$$= -3$$

2. Evaluate.

$$(f-g)(-2) = f(-2)-g(-2)$$
$$= 3-(-6)$$
$$= 9$$

3. Evaluate.

$$(f \cdot g)(-2) = f(-2) \cdot g(-2)$$
$$= 3(-6)$$
$$= -18$$

4. Evaluate.

$$\frac{f}{g}(-2) = \frac{f(-2)}{g(-2)}$$
$$= \frac{3}{-6}$$
$$= -\frac{1}{2}$$

5. Evaluate.

$$g[f(-5)] = g[7] = -2$$

6. Evaluate.

$$f(4) = f[g(0)] = 3$$

7. Simplify.

$$f(2+h) = 3(2+h)-4$$
$$= 6+3h-4$$
$$= 2+3h$$

8. Simplify.

$$f(2+h) = (2+h)^2 +1$$
$$= 4+4h+h^2 +1$$
$$= 5+4h+h^2$$

9. Perform the operations and find the domain.

$$f(x)+g(x) = (x^2 -2x-15)+(x+3)$$
$$= x^2 -x-12 \text{ Domain all real numbers}$$

$$f(x)-g(x) = (x^2 -2x-15)-(x+3)$$
$$= x^2 -3x-18 \text{ Domain all real numbers}$$

$$f(x)g(x) = (x^2 -2x-15)(x+3)$$
$$= x^3 +x^2 -21x-45$$
$$\text{Domain all real numbers}$$

$$f(x)/g(x) = (x^2 -2x-15)/(x+3)$$
$$= x-5 \text{ Domain } \{x \mid x \neq -3\}$$

10. Perform the operations and find the domain.

$$f(x)+g(x) = (x^2 -25)+(x-5)$$
$$= x^2 +x-30 \text{ Domain all real numbers}$$

$$f(x)-g(x) = (x^2 -25)-(x-5)$$
$$= x^2 -x-20 \text{ Domain all real numbers}$$

$$f(x)g(x) = (x^2 -25)(x-5)$$
$$= x^3 -5x^2 -25x+125$$
$$\text{Domain all real numbers}$$

$$f(x)/g(x) = (x^2 -25)/(x-5)$$
$$= x+5 \text{ Domain } \{x \mid x \neq 5\}$$

11. Perform the operations and find the domain.

$$f(x)+g(x) = (2x+8)+(x+4)$$
$$= 3x+12 \text{ Domain all real numbers}$$

$$f(x)-g(x) = (2x+8)-(x+4)$$
$$= x+4 \text{ Domain all real numbers}$$

$$f(x)g(x) = (2x+8)(x+4)$$
$$= 2x^2 +16x+32 \text{ Domain all real numbers}$$

$$f(x)/g(x) = (2x+8)/(x+4)$$
$$= [2(x+4)]/(x+4)$$
$$= 2 \text{ Domain } \{x \mid x \neq -4\}$$

12. Perform the operations and find the domain.

$$f(x)+g(x) = (5x-15)+(x-3)$$
$$= 6x-18 \text{ Domain all real numbers}$$

$$f(x)-g(x) = (5x-15)-(x-3)$$
$$= 4x-12 \text{ Domain all real numbers}$$

$$f(x)g(x) = (5x-15)(x-3)$$
$$= 5x^2 -30x+45 \text{ Domain all real numbers}$$

$$f(x)/g(x) = (5x-15)/(x-3)$$
$$= [5(x-3)]/(x-3)$$
$$= 5 \text{ Domain } \{x \mid x \neq 3\}$$

13. Perform the operations and find the domain.

$$f(x)+g(x)=(x^3-2x^2+7x)+x$$
$$=x^3-2x^2+8x \text{ Domain all real numbers}$$

$$f(x)-g(x)=(x^3-2x^2+7x)-x$$
$$=x^3-2x^2+6x \text{ Domain all real numbers}$$

$$f(x)g(x)=(x^3-2x^2+7x)x$$
$$=x^4-2x^3+7x^2 \text{ Domain all real numbers}$$

$$f(x)/g(x)=(x^3-2x^2+7x)/x$$
$$=x^2-2x+7 \text{ Domain } \{x\,|\,x\neq0\}$$

14. Perform the operations and find the domain.

$$f(x)+g(x)=(x^2-5x-8)+(-x)$$
$$=x^2-6x-8 \text{ Domain all real numbers}$$

$$f(x)-g(x)=(x^2-5x-8)-(-x)$$
$$=x^2-4x-8 \text{ Domain all real numbers}$$

$$f(x)g(x)=(x^2-5x-8)(-x)$$
$$=-x^3+5x^2+8x \text{ Domain all real numbers}$$

$$f(x)/g(x)=(x^2-5x-8x)/(-x)$$
$$=-x+5+\frac{8}{x} \text{ Domain } \{x\,|\,x\neq0\}$$

15. Perform the operations and find the domain.

$$f(x)+g(x)=(4x-7)+(2x^2+3x-5)$$
$$=2x^2+7x-12 \text{ Domain all real numbers}$$

$$f(x)-g(x)=(4x-7)-(2x^2+3x-5)$$
$$=-2x^2+x-2 \text{ Domain all real numbers}$$

$$f(x)g(x)=(4x-7)(2x^2+3x-5)$$
$$=8x^3-14x^2+12x^2-20x-21x+35$$
$$=8x^3-2x^2-41x+35$$
Domain all real numbers

$$f(x)/g(x)=(4x-7)/(2x^2+3x-5)$$
$$=\frac{4x-7}{2x^2+3x-5}$$
$$\text{Domain } \left\{x\,|\,x\neq1, x\neq-\frac{5}{2}\right\}$$

16. Perform the operations and find the domain.

$$f(x)+g(x)=(6x+10)+(3x^2+x-10)$$
$$=3x^2+7x \text{ Domain all real numbers}$$

$$f(x)-g(x)=(6x+10)-(3x^2+x-10)$$
$$=-3x^2+5x+20$$
Domain all real numbers

$$f(x)g(x)=(6x+10)(3x^2+x-10)$$
$$=18x^3+6x^2-60x+30x^2+10x-100$$
$$=18x^3+36x^2-50x-100$$
Domain all real numbers

$$f(x)/g(x)=(6x+10)/(3x^2+x-10)$$
$$=\frac{6x+10}{3x^2+x-10}$$
$$\text{Domain } \left\{x\,|\,x\neq-2, x\neq\frac{5}{3}\right\}$$

17. Perform the operations and find the domain.

$$f(x)+g(x)=\sqrt{x-3}+x \qquad \text{Domain } \{x\,|\,x\geq3\}$$

$$f(x)-g(x)=\sqrt{x-3}-x \qquad \text{Domain } \{x\,|\,x\geq3\}$$

$$f(x)g(x)=x\sqrt{x-3} \qquad \text{Domain } \{x\,|\,x\geq3\}$$

$$f(x)/g(x)=\frac{\sqrt{x-3}}{x} \qquad \text{Domain } \{x\,|\,x\geq3\}$$

18. Perform the operations and find the domain.

$$f(x)+g(x)=\sqrt{x-4}-x \text{ Domain } \{x\,|\,x\geq4\}$$

$$f(x)-g(x)=\sqrt{x-4}+x \text{ Domain } \{x\,|\,x\geq4\}$$

$$f(x)g(x)=-x\sqrt{x-4} \qquad \text{Domain } \{x\,|\,x\geq4\}$$

$$f(x)/g(x)=-\frac{\sqrt{x-4}}{x} \qquad \text{Domain } \{x\,|\,x\geq4\}$$

19. Perform the operations and find the domain.

$$f(x)+g(x)=\sqrt{4-x^2}+2+x$$
$$\text{Domain } \{x\,|-2\leq x\leq2\}$$

$$f(x)-g(x)=\sqrt{4-x^2}-2-x$$
$$\text{Domain } \{x\,|-2\leq x\leq2\}$$

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

Domain $\{x \mid -2 \le x \le 2\}$

$f(x)/g(x) = \dfrac{\sqrt{4-x^2}}{2+x}$ Domain $\{x \mid -2 < x \le 2\}$

20. Perform the operations and find the domain.

$f(x) + g(x) = \sqrt{x^2 - 9} + x - 3$

Domain $\{x \mid x \le -3 \text{ or } x \ge 3\}$

$f(x) - g(x) = \sqrt{x^2 - 9} - x + 3$

Domain $\{x \mid x \le -3 \text{ or } x \ge 3\}$

$f(x)g(x) = \left(\sqrt{x^2 - 9}\right)(x - 3)$

Domain $\{x \mid x \le -3 \text{ or } x \ge 3\}$

$f(x)/g(x) = \dfrac{\sqrt{x^2 - 9}}{x - 3}$ Domain $\{x \mid x \le -3 \text{ or } x > 3\}$

21. Evaluate the function.

$(f + g)(x) = x^2 - x - 2$

$(f + g)(5) = (5)^2 - (5) - 2$
$\quad = 25 - 5 - 2$
$\quad = 18$

22. Evaluate the function.

$(f + g)(x) = x^2 - x - 2$
$(f + g)(-7) = (-7)^2 - (-7) - 2$
$\quad = 49 + 7 - 2$
$\quad = 54$

23. Evaluate the function.

$(f + g)(x) = x^2 - x - 2$

$(f + g)\left(\dfrac{1}{2}\right) = \left(\dfrac{1}{2}\right)^2 - \left(\dfrac{1}{2}\right) - 2$

$\quad = \dfrac{1}{4} - \dfrac{1}{2} - 2$

$\quad = -\dfrac{9}{4}$

24. Evaluate the function.

$(f + g)(x) = x^2 - x - 2$

$(f + g)\left(\dfrac{2}{3}\right) = \left(\dfrac{2}{3}\right)^2 - \left(\dfrac{2}{3}\right) - 2$

$\quad = \dfrac{4}{9} - \dfrac{2}{3} - 2$

$\quad = -\dfrac{20}{9}$

25. Evaluate the function.

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

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

$\quad = 9 + 15 + 6$

$\quad = 30$

26. Evaluate the function.

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

$(f - g)(24) = (24)^2 - 5(24) + 6$

$\quad = 576 - 120 + 6$

$\quad = 462$

27. Evaluate the function.

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

$(f - g)(-1) = (-1)^2 - 5(-1) + 6$

$\quad = 1 + 5 + 6$

$\quad = 12$

28. Evaluate the function.

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

$(f - g)(0) = (0)^2 - 5(0) + 6$

$\quad = 6$

29. Evaluate the function.

$(fg)(x) = \left(x^2 - 3x + 2\right)(2x - 4)$

$\quad = 2x^3 - 6x^2 + 4x - 4x^2 + 12x - 8$

$\quad = 2x^3 - 10x^2 + 16x - 8$

$(fg)(7) = 2(7)^3 - 10(7)^2 + 16(7) - 8$

$\quad = 686 - 490 + 112 - 8$

$\quad = 300$

30. Evaluate the function.

$$(fg)(x) = 2x^3 - 10x^2 + 16x - 8$$
$$(fg)(-3) = 2(-3)^3 - 10(-3)^2 + 16(-3) - 8$$
$$= -54 - 90 - 48 - 8$$
$$= -200$$

31. Evaluate the function.

$$(fg)(x) = 2x^3 - 10x^2 + 16x - 8$$
$$(fg)\left(\frac{2}{5}\right) = 2\left(\frac{2}{5}\right)^3 - 10\left(\frac{2}{5}\right)^2 + 16\left(\frac{2}{5}\right) - 8$$
$$= \frac{16}{125} - \frac{40}{25} + \frac{32}{5} - 8$$
$$= \frac{-384}{125} = -3.072$$

32. Evaluate the function.

$$(fg)(x) = 2x^3 - 10x^2 + 16x - 8$$
$$(fg)(-100) = 2(-100)^3 - 10(-100)^2 + 16(-100) - 8$$
$$= -2,000,000 - 100,000 - 1600 - 8$$
$$= -2,101,608$$

33. Evaluate the function.

$$\left(\frac{f}{g}\right)(x) = \frac{x^2 - 3x + 2}{2x - 4}$$
$$\left(\frac{f}{g}\right)(x) = \frac{1}{2}x - \frac{1}{2}$$
$$\left(\frac{f}{g}\right)(-4) = \frac{1}{2}(-4) - \frac{1}{2}$$
$$= -2 - \frac{1}{2}$$
$$= -2\frac{1}{2} \text{ or } -\frac{5}{2}$$

34. Evaluate the function.

$$\left(\frac{f}{g}\right)(x) = \frac{1}{2}x - \frac{1}{2}$$
$$\left(\frac{f}{g}\right)(11) = \frac{1}{2}(11) - \frac{1}{2}$$
$$= \frac{11}{2} - \frac{1}{2}$$
$$= \frac{10}{2} = 5$$

35. Evaluate the function.

$$\left(\frac{f}{g}\right)(x) = \frac{1}{2}x - \frac{1}{2}$$
$$\left(\frac{f}{g}\right)\left(\frac{1}{2}\right) = \frac{1}{2}\left(\frac{1}{2}\right) - \frac{1}{2}$$
$$= \frac{1}{4} - \frac{1}{2}$$
$$= -\frac{1}{4}$$

36. Evaluate the function.

$$\left(\frac{f}{g}\right)(x) = \frac{1}{2}x - \frac{1}{2}$$
$$\left(\frac{f}{g}\right)\left(\frac{1}{4}\right) = \frac{1}{2}\left(\frac{1}{4}\right) - \frac{1}{2}$$
$$= \frac{1}{8} - \frac{1}{2}$$
$$= -\frac{3}{8}$$

37. Find the difference quotient.

$$\frac{f(x+h) - f(x)}{h} = \frac{[2(x+h)+4] - (2x+4)}{h}$$
$$= \frac{2x + 2(h) + 4 - 2x - 4}{h}$$
$$= \frac{2h}{h}$$
$$= 2$$

38. Find the difference quotient.

$$\frac{f(x+h) - f(x)}{h} = \frac{[4(x+h)-5] - (4x-5)}{h}$$
$$= \frac{4x + 4(h) - 5 - 4x + 5}{h}$$
$$= \frac{4(h)}{h}$$
$$= 4$$

39. Find the difference quotient.

$$\frac{f(x+h) - f(x)}{h} = \frac{[(x+h)^2 - 6] - (x^2 - 6)}{h}$$
$$= \frac{x^2 + 2x(h) + (h)^2 - 6 - x^2 + 6}{h}$$
$$= \frac{2x(h) + h^2}{h}$$
$$= 2x + h$$

40. Find the difference quotient.

$$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2+11\right]-(x^2+11)}{h}$$

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

$$= \frac{2xh+h^2}{h}$$

$$= 2x+h$$

41. Find the difference quotient.

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

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

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

$$= \frac{4xh+2h^2+4h}{h}$$

$$= 4x+2h+4$$

42. Find the difference quotient.

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

$$= \frac{2(x+h)^2-5(x+h)+7-(2x^2-5x+7)}{h}$$

$$= \frac{2x^2+4xh+2h^2-5x-5h+7-2x^2+5x-7}{h}$$

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

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

43. Find the difference quotient.

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

$$= \frac{-4x^2-8xh-4h^2+6+4x^2-6}{h}$$

$$= \frac{-8xh-4h^2}{h}$$

$$= -8x-4h$$

44. Find the difference quotient.

$$f(x) = -5x^2-4x$$

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

$$= \frac{-5(x+h)^2-4(x+h)-(-5x^2-4x)}{h}$$

$$= \frac{-5x^2-10x(h)-5h^2-4x-4h+5x^2+4x}{h}$$

$$= \frac{-10x(h)-5h^2-4h}{h}$$

$$= -10x-5h-4$$

45. a. On $[0,\ 1]$, $a = 0$

$$\Delta t = 1-0 = 1$$

$$C(a+\Delta t) = C(1) = 99.8 \text{ (mg/L)/h}$$

$$C(a) = C(0) = 0$$

Average rate of change $= \dfrac{C(1)-C(0)}{1} = 99.8-0 = 99.8$

This is identical to the slope of the line through

$(0,\ C(0))$ and $(1,\ C(1))$ since

$$m = \frac{C(1)-C(0)}{1-0} = C(1)-C(0)$$

b. On $[0,\ 0.5]$, $a = 0$, $\Delta t = 0.5$

Average rate of change

$$= \frac{C(0.5)-C(0)}{0.5} = \frac{78.1-0}{0.5} = 156.2 \text{ (mg/L)/h}$$

c. On $[1,\ 2]$, $a = 1$, $\Delta t = 2-1 = 1$

Average rate of change

$$= \frac{C(2)-C(1)}{1} = \frac{50.1-99.8}{1} = -49.7 \text{ (mg/L)/h}$$

d. On $[1,\ 1.5]$, $a = 1$, $\Delta t = 1.5-1 = 0.5$

Average rate of change

$$= \frac{C(1.5)-C(1)}{0.5} = \frac{84.4-99.8}{0.5} = \frac{-15.4}{0.5} = -30.8 \text{ (mg/L)/h}$$

e. On $[1,\ 1.25]$, $a = 1$, $\Delta t = 1.25-1 = 0.25$

Average rate of change

$$= \frac{C(1.25)-C(1)}{0.25} = \frac{95.7-99.8}{0.25} = \frac{-4.1}{0.25} = -16.4 \text{ (mg/L)/h}$$

f. On $[1, 1+\Delta t]$,

$Con(1+\Delta t)$

$= 25(1+\Delta t)^3 - 150(1+\Delta t)^2 + 225(1+\Delta t)$

$= 25(1+3\Delta t + 3(\Delta t)^2 + 1(\Delta t)^3) - 150(1+2(\Delta t)+(\Delta t)^2)$
$\quad + 225(1+\Delta t)$

$= 25 + 75(\Delta t) + 75(\Delta t)^2 + 25(\Delta t)^3$

$\quad -150 - 300(\Delta t) - 150(\Delta t)^2 + 225 + 225(\Delta t)$

$= 100 - 75(\Delta t)^2 + 25(\Delta t)^3$

$Con(1) = 100$

Average rate of change

$= \dfrac{Con(1+\Delta t) - Con(1)}{\Delta t}$

$= \dfrac{100 - 75(\Delta t)^2 + 25(\Delta t)^3 - 100}{\Delta t}$

$= \dfrac{-75(\Delta t)^2 + 25(\Delta t)^3}{\Delta t}$

$= -75(\Delta t) + 25(\Delta t)^2$

As Δt approaches 0, the average rate of change over

$[1, 1+\Delta t]$ seems to approach 0 (mg/L)/h.

46. a. On $[2, 3]$, $a = 2$

$\Delta t = 3 - 2 = 1$

$s(a+\Delta t) = s(3) = 6 \cdot 3^2 = 54$

$s(a) = s(2) = 6 \cdot 2^2 = 24$

Average velocity $= \dfrac{s(a+\Delta t) - s(a)}{\Delta t} = \dfrac{s(3) - s(2)}{1}$

$\qquad\qquad = 54 - 24 = 30$ feet per second

This is identical to the slope of the line through

$(2, s(2))$ and $(3, s(3))$ since

$m = \dfrac{s(3) - s(2)}{3 - 2} = s(3) - s(2).$

b. On $[2, 2.5]$, $a = 2$,

$\Delta t = 2.5 - 2 = 0.5$

$s(a+\Delta t) = s(2.5) = 6(2.5)^2 = 37.5$

Average velocity $= \dfrac{s(2.5) - s(2)}{0.5} = \dfrac{37.5 - 24}{0.5}$

$\qquad\qquad = \dfrac{13.5}{0.5} = 27$ feet per second

c. On $[2, 2.1]$, $a = 2$

$\Delta t = 2.1 - 2 = 0.1$

$s(a+\Delta t) = s(2.1) = 6(2.1)^2 = 26.46$

Average velocity $= \dfrac{s(2.1) - s(2)}{0.1} = \dfrac{26.46 - 24}{0.1}$

$\qquad\qquad = \dfrac{2.46}{0.1} = 24.6$ feet per second

d. On $[2, 2.01]$, $a = 2$

$\Delta t = 2.01 - 2 = 0.01$

$s(a+\Delta t) = s(2.01) = 6(2.01)^2 = 24.2406$

Average velocity $= \dfrac{s(2.01) - s(2)}{0.01} = \dfrac{24.2406 - 24}{0.01}$

$\qquad\qquad = \dfrac{0.2406}{0.01} = 24.06$ feet per second

e. On $[2, 2.001]$, $a = 2$

$\Delta t = 2.001 - 2 = 0.001$

$s(a+\Delta t) = s(2.001) = 6(2.001)^2 = 24.024006$

Average velocity $= \dfrac{s(2.001) - s(2)}{0.001} = \dfrac{24.024006 - 24}{0.001}$

$\qquad\qquad = \dfrac{0.024006}{0.001} = 24.006$ feet per second

f. On $[2, 2+\Delta t]$,

$Con \dfrac{s(2+\Delta t) - s(2)}{\Delta t} = \dfrac{6(2+\Delta t)^2 - 24}{\Delta t}$

$\qquad\qquad = \dfrac{6(4 + 4(\Delta t) + (\Delta t)^2) - 24}{\Delta t}$

$\qquad\qquad = \dfrac{24 + 24(\Delta t) + 6(\Delta t)^2 - 24}{(\Delta t)}$

$\qquad\qquad = \dfrac{24\Delta t + 6(\Delta t)^2}{\Delta t} = 24 + 6(\Delta t)$

As Δt approaches 0, the average velocity seems to

approach 24 feet per second.

47. Find the composite functions.

$\begin{aligned}
(g \circ f)(x) &= g[f(x)] & (f \circ g)(x) &= f[g(x)] \\
&= g[3x+5] & &= f[2x-7] \\
&= 2[3x+5]-7 & &= 3[2x-7]+5 \\
&= 6x+10-7 & &= 6x-21+5 \\
&= 6x+3 & &= 6x-16
\end{aligned}$

48. Find the composite functions.

$$(g \circ f)(x) = g[f(x)] \qquad (f \circ g)(x) = f[g(x)]$$
$$= g[2x-7] \qquad\qquad = f[3x+2]$$
$$= 3[2x-7]+2 \qquad\quad = 2[3x+2]-7$$
$$= 6x-21+2 \qquad\quad = 6x+4-7$$
$$= 6x-19 \qquad\qquad\quad = 6x-3$$

49. Find the composite functions.

$$(g \circ f)(x) = g\left[x^2+4x-1\right]$$
$$= \left[x^2+4x-1\right]+2$$
$$= x^2+4x+1$$

$$(f \circ g)(x) = f[x+2]$$
$$= [x+2]^2+4[x+2]-1$$
$$= x^2+4x+4+4x+8-1$$
$$= x^2+8x+11$$

50. Find the composite functions.

$$(g \circ f)(x) = g\left[x^2-11x\right]$$
$$= 2\left[x^2-11x\right]+3$$
$$= 2x^2-22x+3$$

$$(f \circ g)(x) = f[2x+3]$$
$$= [2x+3]^2-11[2x+3]$$
$$= 4x^2+12x+9-22x-33$$
$$= 4x^2-10x-24$$

51. Find the composite functions.

$$(g \circ f)(x) = g[f(x)]$$
$$= g\left[x^3+2x\right]$$
$$= -5\left[x^3+2x\right]$$
$$= -5x^3-10x$$

$$(f \circ g)(x) = f[g(x)]$$
$$= f[-5x]$$
$$= [-5x]^3+2[-5x]$$
$$= -125x^3-10x$$

52. Find the composite functions.

$$(g \circ f)(x) = g[f(x)]$$
$$= g\left[-x^3-7\right]$$
$$= \left[-x^3-7\right]+1$$
$$= -x^3-6$$

$$(f \circ g)(x) = f[g(x)]$$
$$= f[x+1]$$
$$= -[x+1]^3-7$$
$$= -x^3-3x^2-3x-1-7$$
$$= -x^3-3x^2-3x-8$$

53. Find the composite functions.

$$(g \circ f)(x) = g[f(x)]$$
$$= g\left[\frac{2}{x+1}\right]$$
$$= 3\left[\frac{2}{x+1}\right]-5 = \frac{6}{x+1}-\frac{5(x+1)}{x+1}$$
$$= \frac{6-5x-5}{x+1}$$
$$= \frac{1-5x}{x+1}$$

$$(f \circ g)(x) = f[g(x)]$$
$$= f[3x-5]$$
$$= \frac{2}{[3x-5]+1}$$
$$= \frac{2}{3x-4}$$

54. Find the composite functions.

$$(g \circ f)(x) = g[f(x)] \qquad (f \circ g)(x) = f[g(x)]$$
$$= g\left[\sqrt{x+4}\right] \qquad\qquad = f\left(\frac{1}{x}\right)$$
$$= \frac{1}{\sqrt{x+4}} \qquad\qquad\quad = \sqrt{\frac{1}{x}+4}$$
$$= \frac{\sqrt{x+4}}{x+4} \qquad\qquad\quad = \sqrt{\frac{1+4x}{x}}$$
$$\qquad\qquad\qquad\qquad\quad = \frac{\sqrt{1+4x}}{\sqrt{x}}$$
$$\qquad\qquad\qquad\qquad\quad = \frac{\sqrt{x}\sqrt{1+4x}}{x}$$
$$\qquad\qquad\qquad\qquad\quad = \frac{\sqrt{x+4x^2}}{x}$$

55. Find the composite functions.

$$(g \circ f)(x) = g[f(x)] = g\left[\frac{1}{x^2}\right]$$

$$= \sqrt{\left[\frac{1}{x^2}\right] - 1}$$

$$= \sqrt{\frac{1-x^2}{x^2}}$$

$$= \frac{\sqrt{1-x^2}}{|x|}$$

$$(f \circ g)(x) = f[g(x)]$$

$$= f\left[\sqrt{x-1}\right]$$

$$= \frac{1}{\left[\sqrt{x-1}\right]^2}$$

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

$$(f \circ g)(x) = f\left[-\frac{2}{x}\right]$$

$$= \frac{3}{\left|5 - \left[-\frac{2}{x}\right]\right|}$$

$$= \frac{3}{\left|5 + \frac{2}{x}\right|}$$

$$= \frac{3}{\frac{|5x+2|}{|x|}}$$

$$= \frac{3|x|}{|5x+2|}$$

56. Find the composite functions.

$$(g \circ f)(x) = g[f(x)]$$

$$= g\left[\frac{6}{x-2}\right]$$

$$= \frac{3}{5\left[\frac{6}{x-2}\right]} = \frac{3}{\left(\frac{30}{x-2}\right)}$$

$$= 3 \cdot \frac{x-2}{30}$$

$$= \frac{x-2}{10}$$

$$(f \circ g)(x) = f[g(x)]$$

$$= f\left[\frac{3}{5x}\right]$$

$$= \frac{6}{\left[\frac{3}{5x}\right] - 2}$$

$$= \frac{6}{\left(\frac{3-10x}{5x}\right)}$$

$$= \frac{30x}{3-10x}$$

58. Find the composite functions.

$$(g \circ f)(x) = g[|2x+1|]$$

$$= 3[|2x+1|]^2 - 1$$

$$= 3(2x+1)^2 - 1$$

$$= 3(4x^2 + 4x + 1) - 1$$

$$= 12x^2 + 12x + 3 - 1$$

$$= 12x^2 + 12x + 2$$

$$(f \circ g)(x) = f[g(x)]$$

$$= f\left[3x^2 - 1\right]$$

$$= \left|2\left[3x^2 - 1\right] + 1\right|$$

$$= \left|6x^2 - 2 + 1\right|$$

$$= \left|6x^2 - 1\right|$$

59. Evaluate the composite function.

$$(g \circ f)(x) = 4x^2 + 2x - 6$$

$$(g \circ f)(4) = 4(4)^2 + 2(4) - 6$$

$$= 64 + 8 - 6$$

$$= 66$$

60. Evaluate the composite function.

$$(f \circ g)(x) = 2x^2 - 10x + 3$$

$$(f \circ g)(4) = 2(4)^2 - 10(4) + 3$$

$$= 32 - 40 + 3$$

$$= -5$$

57. Find the composite functions.

$$(g \circ f)(x) = g\left[\frac{3}{|5-x|}\right]$$

$$= -\frac{2}{\frac{3}{|5-x|}}$$

$$= \frac{-2|5-x|}{3}$$

61. Evaluate the composite function.

$$(f \circ g)(x) = 2x^2 - 10x + 3$$
$$(f \circ g)(-3) = 2(-3)^2 - 10(-3) + 3$$
$$= 18 + 30 + 3$$
$$= 51$$

62. Evaluate the composite function.

$$(g \circ f)(x) = 4x^2 + 2x - 6$$
$$(g \circ f)(-1) = 4(-1)^2 + 2(-1) - 6$$
$$= 4 - 2 - 6$$
$$= -4$$

63. Evaluate the composite function.

$$(g \circ h)(x) = 9x^4 - 9x^2 - 4$$
$$(g \circ h)(0) = 9(0)^4 - 9(0)^2 - 4$$
$$= -4$$

64. Evaluate the composite function.

$$(h \circ g)(x) = -3x^4 + 30x^3 - 75x^2 + 4$$
$$(h \circ g)(0) = -3(0)^4 + 30(0)^3 - 75(0)^2 + 4$$
$$= 4$$

65. Evaluate the composite function.

$$(f \circ f)(x) = 4x + 9$$
$$(f \circ f)(8) = 4(8) + 9$$
$$= 41$$

66. Evaluate the composite function.

$$(f \circ f)(x) = 4x + 9$$
$$(f \circ f)(-8) = 4(-8) + 9$$
$$= -23$$

67. Evaluate the composite function.

$$(h \circ g)(x) = -3x^4 + 30x^3 - 75x^2 + 4$$
$$(h \circ g)\left(\frac{2}{5}\right) = -3\left(\frac{2}{5}\right)^4 + 30\left(\frac{2}{5}\right)^3 - 75\left(\frac{2}{5}\right)^2 + 4$$
$$= -\frac{48}{625} + \frac{240}{125} - \frac{300}{25} + 4$$
$$= \frac{-48 + 1200 - 7500 + 2500}{625}$$
$$= -\frac{3848}{625}$$

68. Evaluate the composite function.

$$(g \circ h)(x) = 9x^4 - 9x^2 - 4$$
$$(g \circ h)\left(-\frac{1}{3}\right) = 9\left(-\frac{1}{3}\right)^4 - 9\left(-\frac{1}{3}\right)^2 - 4$$
$$= \frac{9}{81} - \frac{9}{9} - 4$$
$$= \frac{1}{9} - 1 - 4$$
$$= -4\frac{8}{9} \quad \text{or} \quad -\frac{44}{9}$$

69. Evaluate the composite function.

$$(g \circ f)(x) = 4x^2 + 2x - 6$$
$$(g \circ f)(\sqrt{3}) = 4(\sqrt{3})^2 + 2(\sqrt{3}) - 6$$
$$= 12 + 2\sqrt{3} - 6$$
$$= 6 + 2\sqrt{3}$$

70. Evaluate the composite function.

$$(f \circ g)(x) = 2x^2 - 10x + 3$$
$$(f \circ g)(\sqrt{2}) = 2(\sqrt{2})^2 - 10(\sqrt{2}) + 3$$
$$= 4 - 10\sqrt{2} + 3$$
$$= 7 - 10\sqrt{2}$$

71. Evaluate the composite function.

$$(g \circ f)(x) = 4x^2 + 2x - 6$$
$$(g \circ f)(2c) = 4(2c)^2 + 2(2c) - 6$$
$$= 16c^2 + 4c - 6$$

72. Evaluate the composite function.

$$(f \circ g)(x) = 2x^2 - 10x + 3$$
$$(f \circ g)(3k) = 2(3k)^2 - 10(3k) + 3$$
$$= 18k^2 - 30k + 3$$

73. Evaluate the composite function.

$$(g \circ h)(x) = 9x^4 - 9x^2 - 4$$
$$(g \circ h)(k+1)$$
$$= 9(k+1)^4 - 9(k+1)^2 - 4$$
$$= 9(k^4 + 4k^3 + 6k^2 + 4k + 1) - 9k^2 - 18k - 9 - 4$$
$$= 9k^4 + 36k^3 + 54k^2 + 36k + 9 - 9k^2 - 18k - 13$$
$$= 9k^4 + 36k^3 + 45k^2 + 18k - 4$$

74. Evaluate the composite function.

$(h \circ g)(x) = -3x^4 + 30x^3 - 75x^2 + 4$

$(h \circ g)(k-1)$

$= -3(k-1)^4 + 30(k-1)^3 - 75(k-1)^2 + 4$

$= -3k^4 + 12k^3 - 18k^2 + 12k - 3$

$\quad + 30k^3 - 90k^2 + 90k - 30 - 75k^2 + 150k - 75 + 4$

$= -3k^4 + 42k^3 - 183k^2 + 252k - 104$

75. Show $(g \circ f)(x) = (f \circ g)(x)$.

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

$= g[f(x)]$ 　　　　　　$= f[g(x)]$

$= g[2x+3]$ 　　　　　$= f[5x+12]$

$= 5(2x+3)+12$ 　　　$= 2(5x+12)+3$

$= 10x+15+12$ 　　　$= 10x+24+3$

$= 10x+27$ 　　　　　$= 10x+27$

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

76. Show $(g \circ f)(x) = (f \circ g)(x)$.

$(g \circ f)(x) = g[f(x)]$ 　　$(f \circ g)(x) = f[g(x)]$

$\quad = g[4x-2]$ 　　　　$\quad = f[7x-4]$

$\quad = 7(4x-2)-4$ 　　$\quad = 4(7x-4)-2$

$\quad = 28x-14-4$ 　　$\quad = 28x-16-2$

$\quad = 28x-18$ 　　　$\quad = 28x-18$

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

77. Show $(g \circ f)(x) = (f \circ g)(x)$.

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

$= g[f(x)]$ 　　　　　　$= f[g(x)]$

$= g\left[\dfrac{6x}{x-1}\right]$ 　　　　$= f\left[\dfrac{5x}{x-2}\right]$

$= \dfrac{5\left(\frac{6x}{x-1}\right)}{\frac{6x}{x-1}-2}$ 　　　　$= \dfrac{6\left(\frac{5x}{x-2}\right)}{\frac{5x}{x-2}-1}$

$= \dfrac{\frac{30x}{x-1}}{\frac{6x-2x+2}{x-1}} = \dfrac{\frac{30x}{x-1}}{\frac{4x+2}{x-1}}$ 　　$= \dfrac{\frac{30x}{x-2}}{\frac{5x-x+2}{x-2}} = \dfrac{\frac{30x}{x-2}}{\frac{4x+2}{x-2}}$

$= \dfrac{30x}{x-1} \cdot \dfrac{x-1}{2(2x+1)}$ 　　$= \dfrac{30x}{x-2} \cdot \dfrac{x-2}{2(2x+1)}$

$= \dfrac{15x}{2x+1}$ 　　　　$= \dfrac{15x}{2x+1}$

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

78. Show $(g \circ f)(x) = (f \circ g)(x)$.

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

$= g[f(x)]$ 　　　　　　$= f[g(x)]$

$= g\left[\dfrac{5x}{x+3}\right]$ 　　　　$= f\left[-\dfrac{2x}{x-4}\right]$

$= -\dfrac{2\left(\frac{5x}{x+3}\right)}{\frac{5x}{x+3}-4}$ 　　　$= \dfrac{5\left(-\frac{2x}{x-4}\right)}{-\frac{2x}{x-4}+3}$

$= -\dfrac{\frac{10x}{x+3}}{\frac{5x-4x-12}{x+3}} = -\dfrac{\frac{10x}{x+3}}{\frac{x-12}{x+3}}$ 　　$= \dfrac{\frac{-10x}{x-4}}{\frac{-2x+3x-12}{x-4}} = \dfrac{\frac{-10x}{x-4}}{\frac{x-12}{x-4}}$

$= -\dfrac{10x}{x+3} \cdot \dfrac{x+3}{x-12}$ 　　$= \dfrac{-10x}{x-4} \cdot \dfrac{x-4}{x-12}$

$= -\dfrac{10x}{x-12}$ 　　　$= -\dfrac{10x}{x-12}$

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

79. Show $(g \circ f)(x) = x$ and $(f \circ g)(x) = x$.

$(g \circ f)(x) = g[f(x)]$ 　　$(f \circ g)(x) = f[g(x)]$

$\quad = g[2x+3]$ 　　　　$\quad = f\left[\dfrac{x-3}{2}\right]$

$\quad = \dfrac{[2x+3]-3}{2}$ 　　$\quad = 2\left[\dfrac{x-3}{2}\right]+3$

$\quad = \dfrac{2x}{2}$ 　　　　$\quad = x-3+3$

$\quad = x$ 　　　　　　$\quad = x$

80. Show $(g \circ f)(x) = x$ and $(f \circ g)(x) = x$.

$(g \circ f)(x) = g[f(x)]$ 　　$(f \circ g)(x) = f[g(x)]$

$\quad = g[4x-5]$ 　　　　$\quad = f\left[\dfrac{x+5}{4}\right]$

$\quad = \dfrac{[4x-5]+5}{4}$ 　　$\quad = 4\left[\dfrac{x+5}{4}\right]-5$

$\quad = \dfrac{4x}{4}$ 　　　　$\quad = x+5-5$

$\quad = x$ 　　　　　　$\quad = x$

81. Show $(g \circ f)(x) = x$ and $(f \circ g)(x) = x$.

$$(g \circ f)(x) = g[f(x)] \qquad (f \circ g)(x) = f[g(x)]$$

$$= g\left[\frac{4}{x+1}\right] \qquad = f\left[\frac{4-x}{x}\right]$$

$$= \frac{4 - \left[\frac{4}{x+1}\right]}{\left[\frac{4}{x+1}\right]} \qquad = \frac{4}{\left[\frac{4-x}{x}\right]+1}$$

$$= \frac{\frac{4x+4-4}{x+1}}{\frac{4}{x+1}} \qquad = \frac{4}{\frac{4-x+x}{x}}$$

$$= \frac{4x}{x+1} \cdot \frac{x+1}{4} \qquad = \frac{4}{\frac{4}{x}}$$

$$= x \qquad = 4 \cdot \frac{x}{4}$$

$$\qquad = x$$

82. Show $(g \circ f)(x) = x$ and $(f \circ g)(x) = x$.

$$(g \circ f)(x) = g[f(x)] \qquad (f \circ g)(x) = f[g(x)]$$

$$= g\left[\frac{2}{1-x}\right] \qquad = f\left[\frac{x-2}{x}\right]$$

$$= \frac{\left[\frac{2}{1-x}\right]-2}{\left[\frac{2}{1-x}\right]} \qquad = \frac{2}{1-\left[\frac{x-2}{x}\right]}$$

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

$$= \frac{2x}{1-x} \cdot \frac{1-x}{2} \qquad = \frac{2}{1} \cdot \frac{x}{x-x+2}$$

$$= x \qquad = \frac{2}{1} \cdot \frac{x}{2}$$

$$\qquad = x$$

83. $(Y \circ F)(x) = Y(F(x))$ converts x inches to yards. F takes x inches to feet, and then Y takes feet to yards.

84. $(I \circ F)(x) = I(F(x))$ converts x yards to inches. F takes x yards to feet, and then I takes feet to inches.

85. a. $r = 1.5t$ and $A = \pi r^2$

so $A(t) = \pi[r(t)]^2$

$$= \pi(1.5t)^2$$

$$A(2) = 2.25\pi(2)^2$$

$$= 9\pi \text{ square feet}$$

$$\approx 28.27 \text{ square feet}$$

b. $r = 1.5t$

$h = 2r = 2(1.5t) = 3t$ and

$V = \frac{1}{3}\pi r^2 h$ so

$$V(t) = \frac{1}{3}\pi(1.5t)^2[3t]$$

$$= 2.25\pi t^3$$

Note: $V = \frac{1}{3}\pi r^2 h = \frac{1}{3}(\pi r^2 h) = \frac{1}{3}hA$

$$= \frac{1}{3}(3t)(2.25\pi t^2) = 2.25\pi t^3$$

$$V(3) = 2.25\pi(3)^3$$

$$= 60.75\pi \text{ cubic feet}$$

$$\approx 190.85 \text{ cubic feet}$$

86. a. $l = 3 - 0.5t$ for $0 \le t \le 6$

$$= -3 + 0.5t \text{ for } 6 \le t \le 14$$

or $l = |3 - 0.5t|$

$$w = 2 - 0.2t \text{ for } 0 \le t \le 10$$

$$= -2 + 0.2t \text{ for } 10 \le t \le 14$$

or $w = |2 - 0.2t|$

b. $l = lw = |3 - 0.5t| \; |2 - 0.2t|$

$$= |(3 - 0.5t)(2 - 0.2t)|$$

c. A is increasing on $[6, \; 8]$ and on $[10, \; 14]$; and A is decreasing on $[0, \; 6]$ and on $[8, \; 10]$.

d. The highest point on the graph of A occurs when $t = 0$ seconds.
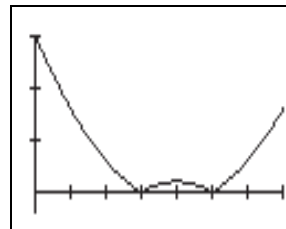
Xmin = 0, Xmax = 14, Xscl = 2,

Ymin = -1, Ymax = 6, Yscl = 2

87. a. Since

$$d^2 + 4^2 = s^2,$$

$$d^2 = s^2 - 16$$

$$d = \sqrt{s^2 - 16}$$

$$d = \sqrt{(48-t)^2 - 16} \quad \text{Substitute } 48-t \text{ for } s$$

$$= \sqrt{2304 - 96t + t^2 - 16}$$

$$= \sqrt{t^2 - 96t + 2288}$$

b. $s(35) = 48 - 35 = 13$ ft

$$d(35) = \sqrt{35^2 - 96(35) + 2288}$$

$$= \sqrt{153} \approx 12.37 \text{ ft}$$

88. The sides of the triangles are proportional, so we have

$$\frac{x}{22} = \frac{12}{16t^2}.$$

Solving for x

$$x = \frac{12(22)}{16t^2}, \text{ or } \frac{33}{2t^2}$$

Prepare for Section 2.7

P1. Slope: $-\dfrac{1}{3}$; y-intercept: $(0, 4)$

P2. $3x - 4y = 12$

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

Slope: $\dfrac{3}{4}$; y-intercept: $(0, -3)$

P3. $y = -0.45x + 2.3$

P4. $y + 4 = -\dfrac{2}{3}(x - 3)$

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

P5. $f(2) = 3(2)^2 + 4(2) - 1 = 12 + 8 - 1 = 19$

P6. $\left| f(x_1) - y_1 \right| + \left| f(x_2) - y_2 \right|$

$$= \left| (2)^2 - 3 - (-1) \right| + \left| (4)^2 - 3 - 14 \right|$$

$$= \left| 4 - 3 + 1 \right| + \left| 16 - 3 - 14 \right|$$

$$= 2 + 1$$

$$= 3$$

Section 2.7 Exercises

1. The scatter diagram suggests no relationship between x and y.

2. The scatter diagram suggest a nonlinear relationship between x and y.

3. The scatter diagram suggests a linear relationship between x and y.

4. The scatter diagram suggests a linear relationship between x and y.

5. Figure A better approximates a graph that can be modeled by an equation than does Figure B. Thus Figure A has a coefficient of determination closer to 1.

6. Figure A better approximates a graph that can be modeled by an equation than does Figure B. Thus Figure A has a coefficient of determination closer to 1.

7. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = 2.00862069x + 0.5603448276$

8. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = -1.918918919x + 0.4594594595$

9. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = -0.7231182796x + 9.233870968$

10. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.
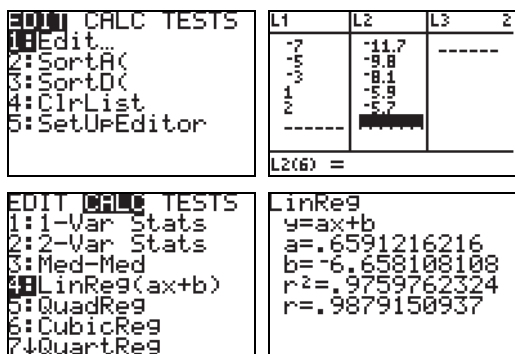
$y = 0.6591216216x - 6.658108108$

11. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.
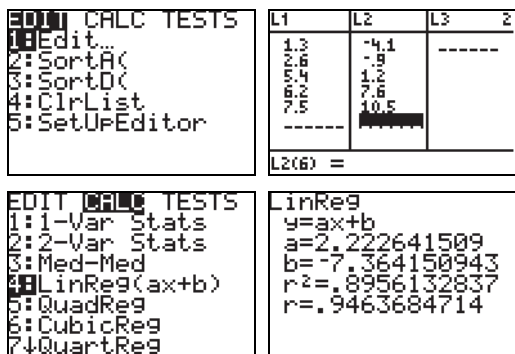
$y = 2.222641509x - 7.364150943$

12. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.
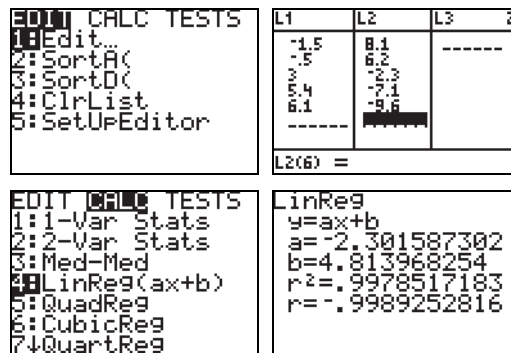
$y = -2.301587302x + 4.813968254$

13. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.
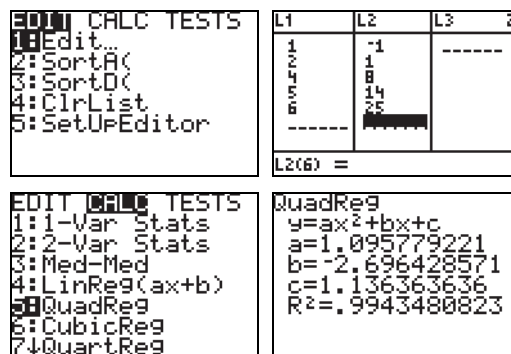
$y = 1.095779221x^2 - 2.696428571x + 1.136363636$

14. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = -0.5714285714x^2 + 2.2x + 1.942857143$

15. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    2
1:Edit…               1.5   -2.2  ------
2:SortA(              2.2   -4.8
3:SortD(              3.4   -11.2
4:ClrList             5.1   -20.6
5:SetUpEditor
                     L2(5) =
```

```
EDIT CALC TESTS      QuadReg
1:1-Var Stats        y=ax²+bx+c
2:2-Var Stats        a=-.2654221158
3:Med-Med            b=-3.416277638
4:LinReg(ax+b)       c=3.68308472
5:QuadReg            R²=.9991631359
6:CubicReg
7↓QuartReg
```

$y = -0.2987274717x^2 - 3.20998141x + 3.416463667$

16. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    2
1:Edit…               -2    -1    ------
2:SortA(              -1    -3.1
3:SortD(              0     -2.9
4:ClrList             1     .8
5:SetUpEditor         2     6.8
                      3     15.9
                     L2(7) =
```

```
EDIT CALC TESTS      QuadReg
1:1-Var Stats        y=ax²+bx+c
2:2-Var Stats        a=1.414285714
3:Med-Med            b=1.954285714
4:LinReg(ax+b)       c=-2.705714286
5:QuadReg            R²=.9996947754
6:CubicReg
7↓QuartReg
```

$y = 1.414285714x^2 + 1.954285714x - 2.705714286$

17. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               24    600   ------
2:SortA(              32    750
3:SortD(              25    430
4:ClrList             17    370
5:SetUpEditor         13    270
                      4.4   68
                      13.2  53
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=23.55706665
3:Med-Med            b=-24.4271215
4:LinReg(ax+b)       r²=.9763673085
5:QuadReg            r=.9881130039
6:CubicReg
7↓QuartReg
```

a. $y = 23.55706665x - 24.4271215$

b. $y = 23.55706665(54) - 24.4271215 \approx 1248$ cm

18. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               40    200   ------
2:SortA(              45    213
3:SortD(              50    242
4:ClrList             60    275
5:SetUpEditor         70    297
                      75    326
                      80    335
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=3.410344828
3:Med-Med            b=65.09359606
4:LinReg(ax+b)       r²=.9892492056
5:QuadReg            r=.9946100772
6:CubicReg
7↓QuartReg
```

a. $y = 3.410344828x + 65.09359606$

b. $y = 3.410344828(58) + 65.09359606 \approx 263$ ft

19. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               30    4.1   ------
2:SortA(              31    4.2
3:SortD(              33    4.4
4:ClrList             34    4.5
5:SetUpEditor         36    4.7
                      39    5.1
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=.1094224924
3:Med-Med            b=.7978723404
4:LinReg(ax+b)       r²=.9947499309
5:QuadReg            r=.997371511
6:CubicReg
7↓QuartReg
```

a. $y = 0.1094224924x + 0.7978723404$

b. $y = 0.1094224924(32) + 0.7978723404 \approx 4.3$ m/s

20. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               4     116   ------
2:SortA(              5     120
3:SortD(              6     131
4:ClrList             7     136
5:SetUpEditor         8     141
                      9     151
                      10    148
                     L3 =
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=6.357142857
3:Med-Med            b=90.57142857
4:LinReg(ax+b)       r²=.9624934181
5:QuadReg            r=.9810674891
6:CubicReg
7↓QuartReg
```

a. $y = 6.357142857x + 90.57142857$

b. $y = 6.357142857(7.5) + 90.57142857 = 138.25$ or 138,000 bacteria

21. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               110   17    -------
2:SortA(              120   19
3:SortD(              125   20
4:ClrList             135   21
5:SetUpEditor         140   22
                      145   23
                      150   24
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=.1628623408
3:Med-Med            b=-.6875682232
4:LinReg(ax+b)       r²=.9976804345
5:QuadReg            r=.9988395439
6:CubicReg
7↓QuartReg
```

a. $y = 0.1628623408x - 0.6875682232$

b. $y = 0.1628623408(158) - 0.6875682232 \approx 25$

22. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               60    29    -------
2:SortA(              62    27
3:SortD(              64    25
4:ClrList             66    24
5:SetUpEditor         67    23
                      68    23
                      70    21
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=-.6800298805
3:Med-Med            b=69.05129482
4:LinReg(ax+b)       r²=.9857545667
5:QuadReg            r=-.9928517345
6:CubicReg
7↓QuartReg
```

a. $y = -0.6800298805x + 69.05129482$

b. 5 feet 8 inches = 68 inches;

$y = -0.6800298805(68) + 69.05129482 \approx 23$

23. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    3
1:Edit…               7.3   9.4   -------
2:SortA(              11.9  2.8
3:SortD(              5.6   5.6
4:ClrList             14.2  4.9
5:SetUpEditor         7.9   7
                      8.5   8.6
                      7.9   4.3
                     L3(1)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=7.9539822ᴇ-4
3:Med-Med            b=6.501958524
4:LinReg(ax+b)       r²=1.08788ᴇ-6
5:QuadReg            r=.001043015
6:CubicReg
7↓QuartReg
```

The value of r is close to 0. Therefore, no, there is not

a strong linear relationship between the current and the torque.

24. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    1
1:Edit…               0     75.5  -------
2:SortA(              15    61.3
3:SortD(              35    42.6
4:ClrList             65    17.2
5:SetUpEditor         75    10.6
                      ----  ----
                     L1(1)=0
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=-.870122549
3:Med-Med            b=74.50465686
4:LinReg(ax+b)       r²=.9982194598
5:QuadReg            r=-.9991093332
6:CubicReg
7↓QuartReg
```

Yes, because the linear correlation coefficient is close to –1.

25. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    1
1:Edit…               0     80.5  -------
2:SortA(              15    66.1
3:SortD(              35    46.7
4:ClrList             65    19.9
5:SetUpEditor         75    12.5
                      ----  ----
                     L1(1)=0
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=-.9116666667
3:Med-Med            b=79.78333333
4:LinReg(ax+b)       r²=.9989757978
5:QuadReg            r=-.9994877677
6:CubicReg
7↓QuartReg
```

a. Yes, there is a strong linear correlation.

b. $y = -0.911\overline{6}x + 79.78\overline{3}$

c. $y = -0.911\overline{6}(25) + 79.78\overline{3} \approx 57$ years
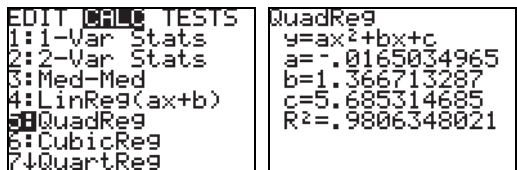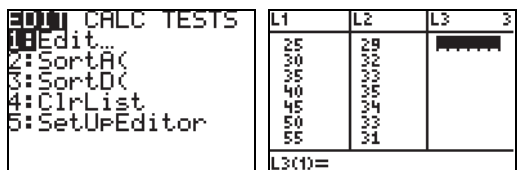
26. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

```
EDIT CALC TESTS      L1    L2    L3    2
1:Edit…               1.3   6.6   -------
2:SortA(              8.1   11.2
3:SortD(              8.5   10
4:ClrList             11    12
5:SetUpEditor         56    22.8
                      ----
                     L2(6)=
```

```
EDIT CALC TESTS      LinReg
1:1-Var Stats        y=ax+b
2:2-Var Stats        a=.2711847067
3:Med-Med            b=7.91528368
4:LinReg(ax+b)       r²=.9643238532
5:QuadReg            r=.9819999253
6:CubicReg
7↓QuartReg
```

$y = 0.2711847067x + 7.91528368$

$y = 0.2711847067(41) + 7.91528368$

≈ 19 meters per second

27. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = 113.3111246x + 21.83605895$

a. Positively

b. $y = 113.3111246(9.5) + 21.83605895$

≈ 1098 calories

28. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

a. $y = -0.0074642857x^2 + 1.148214286x$
$+ 4.807142857$

b. $y = -0.0074642857(65)^2 + 1.148214286(65)$
$+ 4.807142857$
≈ 47.9 ft

29. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = -0.6328671329x^2 + 33.61608329x - 379.4405594$

30. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = -0.75x^2 + 10.66x - 17.91$

For August 2011, $x = 8$,

$y = -0.75(8)^2 + 10.66(8) - 17.91$
$\approx 19.4°$

31. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

$y = 198.2272727x^2 + 10{,}708.60909x + 52{,}885.98182$

For 2006, $x = 1$,

$y = 198.2272727(1)^2 + 10{,}708.60909(1) + 52{,}885.98182$
$\approx 63{,}793$ thousand gallons

32. Enter the data on your calculator. The technique for a

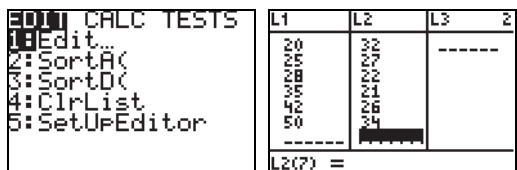TI-83 calculator is illustrated here. Press STAT.
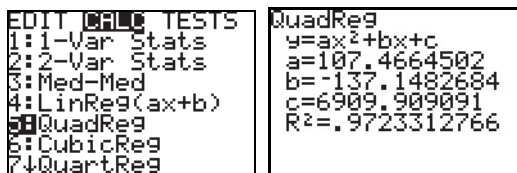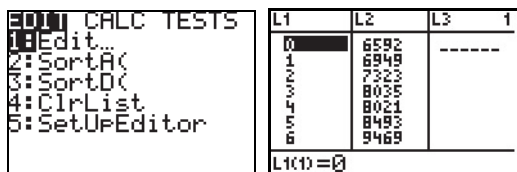
$$y = 107.4664502x^2 - 137.1482684x + 6909.909091$$

33. Enter the data on your calculator. The technique for a
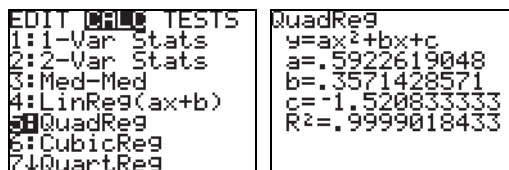
TI-83 calculator is illustrated here. Press STAT.

a. $y = -0.0165034965x^2 + 1.366713287x$

$+ 5.685314685$

b. $y = -0.0165034965(50)^2 + 1.366713287(50)$

$+ 5.685314685$

≈ 32.8 mpg

34. Enter the data on your calculator. The technique for a

TI-83 calculator is illustrated here. Press STAT.
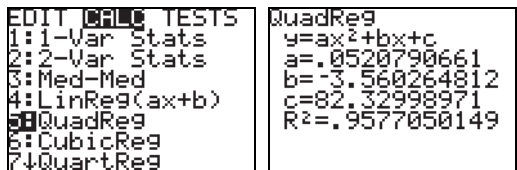
a. $y = 0.05208x^2 - 3.56026x + 82.32999$

b. $-\dfrac{b}{2a} = -\dfrac{-3.56026}{2(0.05208)} \approx 34$ kilometers per hour

35. a. Enter the data on your calculator. The technique for

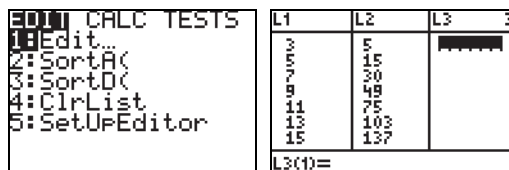a TI-83 calculator is illustrated here. Press STAT.
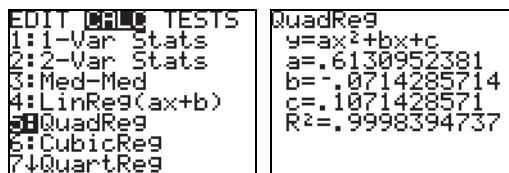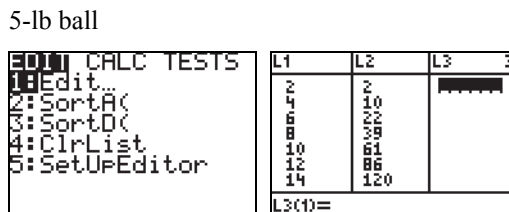
5-lb ball

$$y = 0.6130952381t^2 - 0.0714285714t + 0.1071428571$$

10-lb ball
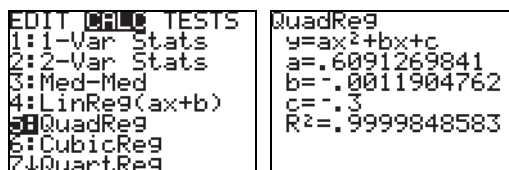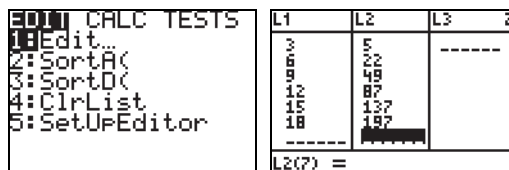
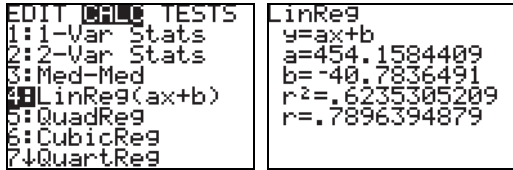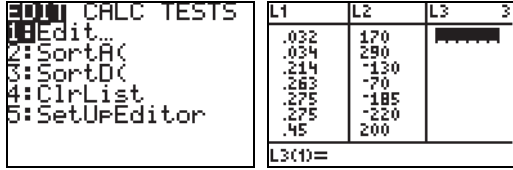
$$y = 0.6091269841t^2 - 0.0011904762t - 0.3$$

15-lb ball

$$y = 0.5922619048t^2 + 0.3571428571t - 1.520833333$$

b. All the regression equations are approximately the same. Therefore, there is one equation of motion.

36. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT.

a. $y = 454.1584409x - 40.78364910$

b. $y = 454.1584409(1.5) - 40.78364910$

≈ 640 kilometers per second

Chapter 2 Review Exercises

1. Finding the distance. [2.1]

$d = \sqrt{(7-(-3))^2 + (11-2)^2}$

$= \sqrt{10^2 + 9^2} = \sqrt{100+81} = \sqrt{181}$

2. Finding the distance. [2.1]

$d = \sqrt{(5-(-3))^2 + (-4-(-8))^2}$

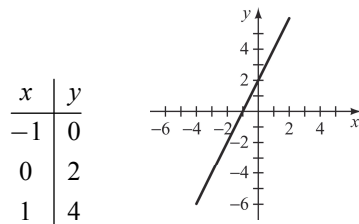$= \sqrt{8^2 + 4^2} = \sqrt{64+16} = \sqrt{80} = 4\sqrt{5}$

3. Finding the midpoint: (2, 8), (–3, 12). [2.1]

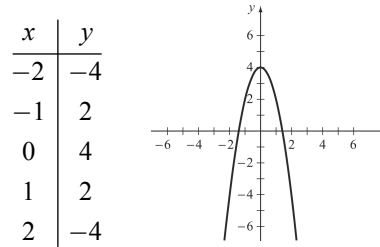$M = \left(\dfrac{2+(-3)}{2}, \dfrac{8+12}{2}\right) = \left(-\dfrac{1}{2}, 10\right)$

4. Finding the midpoint: (–4, 7), (8, –11). [2.1]

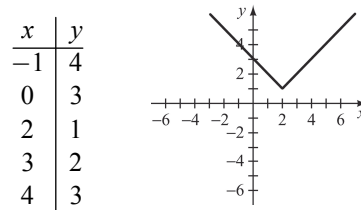$M = \left(\dfrac{-4+8}{2}, \dfrac{7+(-11)}{2}\right) = (2,-2)$
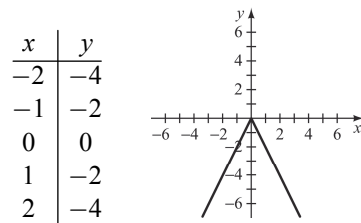
5. Graph the equation: $2x - y = -2$. [2.1]

x	y
−1	0
0	2
1	4

6. Graph the equation: $2x^2 + y = 4$. [2.1]

x	y
−2	−4
−1	2
0	4
1	2
2	−4

7. Graph the equation: $y = |x-2| + 1$. [2.1]

x	y
−1	4
0	3
2	1
3	2
4	3

8. Graph the equation: $y = -|2x|$. [2.1]

x	y
−2	−4
−1	−2
0	0
1	−2
2	−4

9. Finding x- and y-intercepts and graph: $x = y^2 - 1$ [2.1]
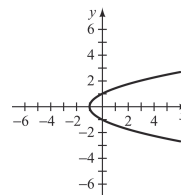
For the y-intercept, let x = 0 and solve for y.

$0 = y^2 - 1$

$y = \pm 1, \quad y\text{-intercepts: } (0,-1),(0,\,1)$

For the x-intercept, let y = 0 and solve for x.

$x = (0)^2 - 1$

$x = -1, \quad x\text{-intercept: } (-1,\,0)$

10. Finding x- and y-intercepts and graph: $|x - y| = 4$ [2.1]
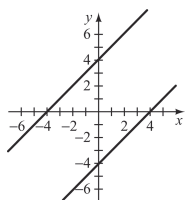
For the y-intercept, let x = 0 and solve for y.

$|0 - y| = 4$

$y = \pm 4, \quad y\text{-intercepts: } (0,-4),(0,\,4)$

For the x-intercept, let y = 0 and solve for x.

$$|x - (0)| = 4$$

$$x = \pm 4, \ \ x\text{-intercepts: } (-4, \ 0), (4, \ 0)$$

11. Finding x- and y-intercepts and graph: [2.1]

$$3x + 4y = 12$$
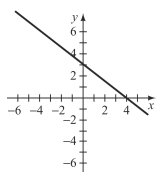
For the y-intercept, let $x = 0$ and solve for y.

$$3(0) + 4y = 12$$

$$y = 3, \ \ y\text{-intercept: } (0, \ 3)$$

For the x-intercept, let $y = 0$ and solve for x.

$$3x + 4(0) = 12$$

$$x = 4, \ \ x\text{-intercept: } (4, 0)$$

12. Finding x- and y-intercepts and graph:

$$x = |y - 1| + 1 \ \ [2.1]$$

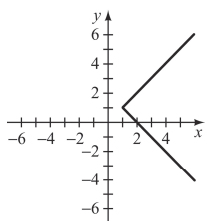For the y-intercept, let $x = 0$ and solve for y.

$$0 = |y - 1| + 1$$

$$-1 = |y - 1|, \ \ \text{since this statement is false,}$$

$$\text{there is no } y\text{-intercept.}$$

For the x-intercept, let $y = 0$ and solve for x.

$$x = |0 - 1| + 1$$

$$x = 2, \ \ x\text{-intercept: } (2, \ 0)$$

13. Finding the center and radius. [2.1]

$$(x - 3)^2 + (y + 4)^2 = 81$$

center (3, –4), radius 9

14. Finding the center and radius. [2.1]

$$x^2 + 10x + y^2 + 4y = -20$$

$$x^2 + 10x + 25 + y^2 + 4y + 4 = -20 + 25 + 4$$

$$(x + 5)^2 + (y + 2)^2 = 9$$

center (–5, –2), radius 3

15. Finding the equation. [2.1]

Center: (2, –3), radius 5

$$(x - 2)^2 + (y + 3)^2 = 5^2$$

16. Finding the equation. [2.1]

Center: (–5, 1), passing through (3, 1)

$$(x + 5)^2 + (y - 1)^2 = r^2$$

$$(3 + 5)^2 + (1 - 1)^2 = r^2$$

$$8^2 + 0^2 = r^2$$

$$8^2 = r^2$$

$$(x + 5)^2 + (y - 1)^2 = 8^2$$

17. Is y a function of x? [2.2]

$$x - y = 4$$

$$y = x - 4, \ \ y \text{ is a function of } x.$$

18. Is y a function of x? [2.2]

$$x + y^2 = 4$$

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

$$y = \pm\sqrt{-x + 4}, \ \ y \text{ is a not function of } x.$$

19. Is y a function of x? [2.2]

$$|x| + |y| = 4$$

$$|y| = -|x| + 4$$

$$y = \pm(-|x| + 4), \ \ y \text{ is a not function of } x.$$

20. Is y a function of x? [2.2]

$$|x| + y = 4$$

$$y = -|x| + 4, \ \ y \text{ is a function of } x.$$

21. Evaluate the function $f(x) = 3x^2 + 4x - 5$, [2.2]

   a. $f(1) = 3(1)^2 + 4(1) - 5$

$$= 3(1) + 4 - 5$$

$$= 3 + 4 - 5$$

$$= 2$$

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

$= 3(9) - 12 - 5$

$= 27 - 12 - 5$

$= 10$

c. $f(t) = 3t^2 + 4t - 5$

d. $f(x+h) = 3(x+h)^2 + 4(x+h) - 5$

$= 3(x^2 + 2xh + h^2) + 4x + 4h - 5$

$= 3x^2 + 6xh + 3h^2 + 4x + 4h - 5$

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

$= 9t^2 + 12t - 15$

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

$= 3(9t^2) + 12t - 5$

$= 27t^2 + 12t - 5$

22. Evaluate the function $g(x) = \sqrt{64 - x^2}$, [2.2]

a. $g(3) = \sqrt{64 - 3^2}$

$= \sqrt{64 - 9}$

$= \sqrt{55}$

b. $g(-5) = \sqrt{64 - (-5)^2}$

$= \sqrt{64 - 25}$

$= \sqrt{39}$

c. $g(8) = \sqrt{64 - (8)^2}$

$= \sqrt{64 - 64}$

$= \sqrt{0}$

$= 0$

d. $g(-x) = \sqrt{64 - (-x)^2}$

$= \sqrt{64 - x^2}$

e. $2g(t) = 2\sqrt{64 - t^2}$

f. $g(2t) = \sqrt{64 - (2t)^2}$

$= \sqrt{64 - 4t^2}$

$= \sqrt{4(16 - t^2)}$

$= 2\sqrt{16 - t^2}$

23. Evaluate the function. [2.2]

a. Since $x = 3 \geq 0$, use $f(x) = x^2 - 3$.

$f(3) = (3)^2 - 3 = 9 - 3 = 6$

b. Since $x = -2 < 0$, use $f(x) = 3x + 2$.

$f(-2) = 3(-2) + 2 = -6 + 2 = -4$

c. Since $x = 0 \geq 0$, use $f(x) = x^2 - 3$.

$f(0) = (0)^2 - 3 = 0 - 3 = -3$

24. Evaluate the function. [2.2]

a. Since $x = 0$ and $-3 \leq x < 5$, use $f(x) = x^2 + 1$.

$f(0) = (0)^2 + 1 = 1$

b. Since $x = -3$ and $-3 \leq x < 5$, use $f(x) = x^2 + 1$.

$f(-3) = (-3)^2 + 1 = 9 + 1 = 10$

c. Since $x = 5 \geq 5$, use $f(x) = x - 7$.

$f(5) = 5 - 7 = -2$

25. Find the domain of $f(x) = -2x^2 + 3$. [2.2]

Domain $\{x | x$ is a real number$\}$

26. Find the domain of $f(x) = \sqrt{6 - x}$. [2.2]

Domain $\{x | x \leq 6\}$

27. Find the domain of $f(x) = \sqrt{25 - x^2}$. [2.2]

Domain $\{x | -5 \leq x \leq 5\}$

28. Find the domain of $f(x) = \dfrac{3}{x^2 - 2x - 15}$. [2.2]

Domain $\{x | x \neq -3, \ x \neq 5\}$

29. Find the values of a in the domain of

$f(x) = x^2 + 2x - 4$ for which $f(a) = -1$. [2.2]

$a^2 + 2a - 4 = -1$ Replace $f(a)$ with $a^2 + 2a - 4$

$a^2 + 2a - 3 = 0$

$(a + 3)(a - 1) = 0$

$a + 3 = 0 \qquad a - 1 = 0$

$a = -3 \qquad a = 1$

30. Find the values of a in the domain of $f(x) = \dfrac{4}{x+1}$ for

which $f(a) = 2$. [2.2]

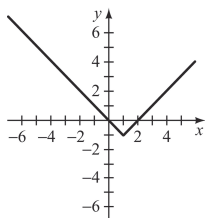$\dfrac{4}{a+1} = 2$ Replace $f(a)$ with $\dfrac{4}{a+1}$

$\quad 4 = 2(a+1)$

$\quad 4 = 2a+2$

$\quad 2 = 2a$

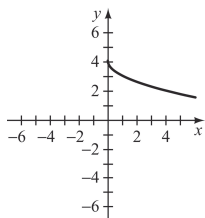$\quad 1 = a$

31. Graph $f(x) = |x-1| - 1$ [2.2]

32. Graph $f(x) = 4 - \sqrt{x}$ [2.2]

33. Find the zeros of f for $f(x) = 2x+6$. [2.2]

$\quad f(x) = 0$

$2x + 6 = 0$

$\quad 2x = -6$

$\quad\; x = -3$

34. Find the zeros of f for $f(x) = x^2 - 4x - 12$. [2.2]

$\qquad f(x) = 0$

$x^2 - 4x - 12 = 0$

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

$x+2 = 0 \quad x-6 = 0$

$\quad x = -2 \qquad x = 6$

35. Evaluate the function $g(x) = [\![2x]\!]$. [2.2]

a. $g(\pi) = [\![2\pi]\!] \approx [\![6.283185307]\!] = 6$

b. $g\left(-\dfrac{2}{3}\right) = \left[\!\!\left[2\left(-\dfrac{2}{3}\right)\right]\!\!\right] = \left[\!\!\left[-\dfrac{4}{3}\right]\!\!\right] \approx [\![-1.333333]\!] = -2$

c. $g(-2) = [\![2(-2)]\!] = -4$

36. Evaluate the function $f(x) = [\![1-x]\!]$. [2.2]

a. $f(\sqrt{2}) = [\![1-\sqrt{2}]\!] \approx [\![-0.4142]\!] = -1$

b. $f(0.5) = [\![1-0.5]\!] = [\![0.5]\!] = 0$

c. $f(-\pi) = [\![1+\pi]\!] \approx [\![4.14159265]\!] = 4$

37. Find the slope. [2.3]

$m = \dfrac{-1-6}{4+3} = \dfrac{-7}{7} = -1$

38. Find the slope. [2.3]

$m = \dfrac{4-2}{-5+5} = \dfrac{2}{0}$ Undefined
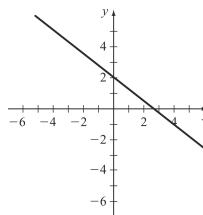
39. Find the slope. [2.3]

$m = \dfrac{-2+2}{-3-4} = \dfrac{0}{-7} = 0$

40. Find the slope. [2.3]

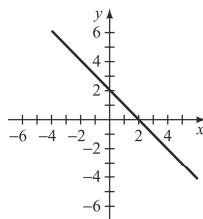$m = \dfrac{-1+3}{-4-6} = \dfrac{2}{-10} = -\dfrac{1}{5}$

41. Graph $f(x) = -\dfrac{3}{4}x + 2$. [2.3]

$m = -\dfrac{3}{4}$, y-intercept $(0, 2)$

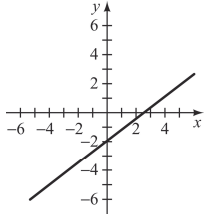**42.** Graph $f(x) = 2 - x$. [2.3]

$m = -1$, y-intercept $(0, 2)$

43. Graph $3x - 4y = 8$. [2.3]

$$-4y = -3x + 8$$

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

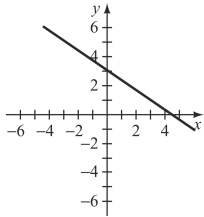x-intercept $\left(\frac{8}{3}, 0\right)$, y-intercept $(0, -2)$

44. Graph $2x + 3y = 9$. [2.3]

$$3y = -2x + 9$$

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

x-intercept $\left(\frac{9}{2}, 0\right)$, y-intercept $(0, 3)$

45. Find the equation. [2.3]

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

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

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

46. Find the equation. [2.3]

$$y + 4 = -2(x - 1)$$
$$y + 4 = -2x + 2$$
$$y = -2x - 2$$

47. Find the equation. [2.3]

$$m = \frac{6 - 3}{1 + 2} = \frac{3}{3} = 1$$

$$y - 6 = 1(x - 1)$$
$$y - 6 = x - 1$$
$$y = x + 5$$

48. Find the equation. [2.3]

$$m = \frac{15 + 6}{8 + 4} = \frac{21}{12} = \frac{7}{4}$$

$$y - 15 = \frac{7}{4}(x - 8)$$

$$y - 15 = \frac{7}{4}x - 14$$

$$y = \frac{7}{4}x + 1$$

49. Find the equation. [2.3]

$$y = \frac{2}{3}x - 1 \text{ has slope } m = \frac{2}{3}.$$

$$y - y_1 = \frac{2}{3}(x - x_1)$$

$$y - (-5) = \frac{2}{3}(x - 3)$$

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

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

50. Find the equation. [2.3]

$$2x - 5y = 2$$
$$-5y = -2x - 2$$
$$y = \frac{2}{5}x + \frac{2}{5} \text{ has slope } m = \frac{2}{5}.$$

$$y - y_1 = \frac{2}{5}(x - x_1)$$

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

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

$$y = \frac{2}{5}x - \frac{23}{5}$$

51. Find the equation. [2.3]

$$y = -\frac{3}{2}x - 2 \text{ has perpendicular slope } m = \frac{2}{3}.$$

$$y - y_1 = \frac{2}{3}(x - x_1)$$

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

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

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

52. Find the equation. [2.3]

$$2x - 5y = 10$$
$$-5y = -2x + 10$$
$$y = \frac{2}{5}x - 2 \quad \text{has perpendicular slope } m = -\frac{5}{2}.$$

$$y - y_1 = -\frac{5}{2}(x - x_1)$$
$$y - 6 = -\frac{5}{2}(x - 2)$$
$$y - 6 = -\frac{5}{2}x + 5$$
$$y = -\frac{5}{2}x + 11$$

53. Find the function. [2.3]

$$m = \frac{175 - 155}{118 - 106} = \frac{20}{12} = \frac{5}{3}$$

$$f(x) - 175 = \frac{5}{3}(x - 118)$$
$$f(x) - 175 = \frac{5}{3}x - \frac{590}{3}$$
$$f(x) = \frac{5}{3}x - \frac{65}{3}$$

54. Find the function. [2.3]

$$m = \frac{350 - 122}{10 - 2} = \frac{228}{8} = 28.5$$

$$f(t) - 350 = 28.5(t - 10)$$
$$f(t) - 350 = 28.5t - 285$$
$$f(t) = 28.5t + 65$$

55. Write the quadratic equation in standard form. [2.4]

$$f(x) = (x^2 + 6x) + 10$$
$$f(x) = (x^2 + 6x + 9) + 10 - 9$$
$$f(x) = (x + 3)^2 + 1$$

56. Write the quadratic equation in standard form. [2.4]

$$f(x) = (2x^2 + 4x) + 5$$
$$f(x) = 2(x^2 + 2x) + 5$$
$$f(x) = 2(x^2 + 2x + 1) + 5 - 2$$
$$f(x) = 2(x + 1)^2 + 3$$

57. Write the quadratic equation in standard form. [2.4]

$$f(x) = -x^2 - 8x + 3$$
$$f(x) = -(x^2 + 8x) + 3$$
$$f(x) = -(x^2 + 8x + 16) + 3 + 16$$
$$f(x) = -(x + 4)^2 + 19$$

58. Write the quadratic equation in standard form. [2.4]

$$f(x) = (4x^2 - 6x) + 1$$
$$f(x) = 4\left(x^2 - \frac{3}{2}x\right) + 1$$
$$f(x) = 4\left(x^2 - \frac{3}{2}x + \frac{9}{16}\right) + 1 - \frac{9}{4}$$
$$f(x) = 4\left(x - \frac{3}{4}\right)^2 + \frac{4}{4} - \frac{9}{4}$$
$$f(x) = 4\left(x - \frac{3}{4}\right)^2 - \frac{5}{4}$$

59. Write the quadratic equation in standard form. [2.4]

$$f(x) = -3x^2 + 4x - 5$$
$$f(x) = -3\left(x^2 - \frac{4}{3}x\right) - 5$$
$$f(x) = -3\left(x^2 - \frac{4}{3}x + \frac{4}{9}\right) - 5 + \frac{4}{3}$$
$$f(x) = -3\left(x - \frac{2}{3}\right)^2 - \frac{11}{3}$$

60. Write the quadratic equation in standard form. [2.4]

$$f(x) = x^2 - 6x + 9$$
$$f(x) = (x^2 - 6x) + 9$$
$$f(x) = (x^2 - 6x + 9) + 9 - 9$$
$$f(x) = (x - 3)^2 + 0$$

61. Find the vertex. [2.4]

$$\frac{-b}{2a} = \frac{-(-6)}{2(3)} = \frac{6}{6} = 1$$

$$f(1) = 3(1)^2 - 6(1) + 11$$
$$= 3(1) - 6 + 11$$
$$= 3 - 6 + 11$$
$$= 8$$

Thus the vertex is (1, 8).

62. Find the vertex. [2.4]

$$\frac{-b}{2a} = \frac{0}{2(4)} = 0$$

$$f(0) = 4(0)^2 - 10$$
$$= 0 - 101$$
$$= -10$$

Thus the vertex is (0, −10).

63. Find the vertex. [2.4]

$$\frac{-b}{2a} = \frac{-(60)}{2(-6)} = \frac{-60}{-12} = 5$$

$$\begin{aligned}
f(5) &= -6(5)^2 + 60(5) + 11 \\
&= -6(25) + 300 + 11 \\
&= -150 + 300 + 11 \\
&= 161
\end{aligned}$$

Thus the vertex is (5, 161).

64. Find the vertex. [2.4]

$$\frac{-b}{2a} = \frac{-(-8)}{2(-1)} = \frac{8}{-2} = -4$$

$$\begin{aligned}
f(-4) &= 14 - 8(-4) - (-4)^2 \\
&= 14 + 32 - 16 \\
&= 30
\end{aligned}$$

Thus the vertex is (–4, 30).

65. Find the value. [2.4]

$$\begin{aligned}
f(x) &= -x^2 + 6x - 3 \\
&= -(x^2 - 6x) - 3 \\
&= -(x^2 - 6x + 9) - 3 + 9 \\
&= -(x - 3)^2 + 6
\end{aligned}$$

maximum value of 6

66. Find the value. [2.4]

$$\begin{aligned}
f(x) &= 2x^2 + 3x - 4 \\
&= 2\left(x^2 - \frac{3}{2}x\right) - 4 \\
&= 2\left(x^2 - \frac{3}{2}x + \frac{9}{16}\right) - 4 - \frac{9}{8} \\
&= 2\left(x - \frac{3}{4}\right)^2 - 5.125
\end{aligned}$$

minimum value of –5.125

67. Find the maximum height. [2.4]

$$h(t) = -16t^2 + 50t + 4$$

$$-\frac{b}{2a} = -\frac{50}{2(-16)} = \frac{25}{16}$$

$$h\left(\frac{25}{16}\right) = -16\left(\frac{25}{16}\right)^2 + 50\left(\frac{25}{16}\right) + 4 = 43.0625$$

The ball reaches a maximum height of 43.0625 ft.

68. a. Revenue $= 13x$ [2.5]

b. Profit = Revenue – Cost

$$\begin{aligned}
P &= 13x - (0.5x + 1050) \\
P &= 13x - 0.5x - 1050 \\
P &= 12.5x - 1050
\end{aligned}$$

c. Break even $\Rightarrow$ Revenue $=$ Cost

$$\begin{aligned}
13x &= 0.5x + 1050 \\
12.5x &= 1050 \\
x &= 84
\end{aligned}$$

The company must ship 84 parcels.

69. Find the maximum area. [2.4]

Let x be the width. Using the formula for perimeter for three sides, $P = 2w + l \Rightarrow 700 = 2x + l$

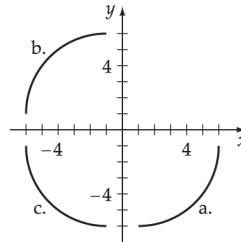$$l = 700 - 2x$$

Using the formula for area, $A = lw$. Then
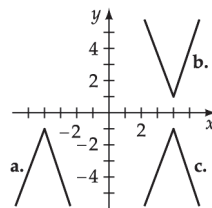
$$A(x) = x(700 - 2x)$$

$$A(x) = -2x^2 + 700x$$

$$-\frac{b}{2a} = -\frac{700}{2(-2)} = 175$$

$$A(175) = -2(175)^2 + 700(175) = 61,250 \text{ ft}^2$$

70. Sketch a graph with different kinds of symmetry. [2.5]

71. Sketch a graph with different kinds of symmetry. [2.5]

72. The graph of $y = x^2 - 7$ is symmetric with respect to the y-axis. [2.5]

73. The graph of $x = y^2 + 3$ is symmetric with respect to the x-axis. [2.5]

74. The graph of $y = x^3 - 4x$ is symmetric with respect to the origin. [2.5]

75. The graph of $y^2 = x^2 + 4$ is symmetric with respect to the x-axis, y-axis, and the origin. [2.5]
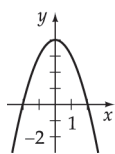
76. The graph of $\dfrac{x^2}{3^2} + \dfrac{y^2}{4^2} = 1$ is symmetric with respect to the x-axis, y-axis, and the origin. [2.5]

77. The graph of $xy = 8$ is symmetric with respect to the origin. [2.5]

78. The graph of $|y| = |x|$ is symmetric with respect to the x-axis, y-axis, and the origin. [2.5]

79. The graph of $|x + y| = 4$ is symmetric with respect to the origin. [2.5]

80. Sketch the graph $g(x) = -x^2 + 4$. [2.5]

a. Domain all real numbers
Range $\{y | y \leq 4\}$

b. g is an even function

81. Sketch the graph $g(x) = -2x - 4$. [2.5]
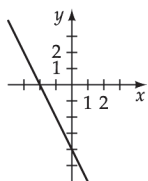
a. Domain all real numbers
Range all real numbers

b. g is neither even nor odd

82. Sketch the graph $g(x) = |x - 2| + |x + 2|$. [2.5]
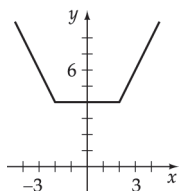
a. Domain all real numbers
Range $\{y | y \geq 4\}$

b. g is an even function

83. Sketch the graph $g(x) = \sqrt{16 - x^2}$. [2.5]
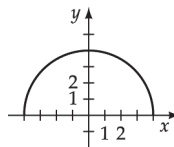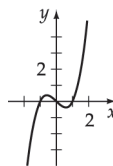

a. Domain $\{x | -4 \leq x \leq 4\}$

Range $\{y | 0 \leq y \leq 4\}$

b. g is an even function

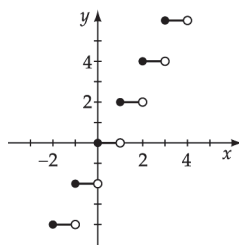**84.** Sketch the graph $g(x) = x^3 - x$. [2.5]

a. Domain all real numbers
Range all real numbers

b. g is an odd function

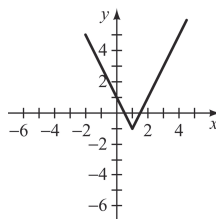**85.** Sketch the graph $g(x) = 2[\![x]\!]$. [2.5]

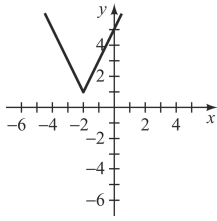
a. Domain all real numbers

Range $\{y | y \text{ is an even integer}\}$

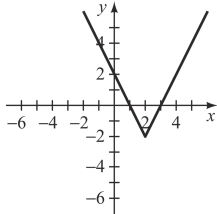**b.** g is neither even nor odd

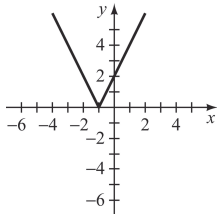**86.** $g(x) = f(x) - 2$ [2.5]

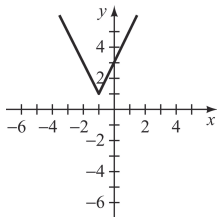**87.** $g(x) = f(x+3)$ [2.5]

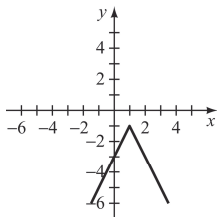

88. $g(x) = f(x-1)-3$ [2.5]

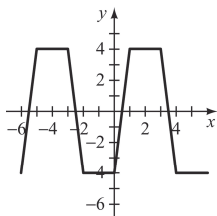**89.** $g(x) = f(x+2)-1$ [2.5]

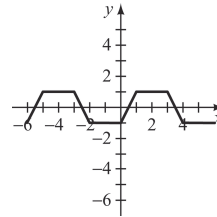**90.** $g(x) = f(-x)$ [2.5]

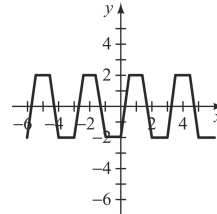**91.** $g(x) = -f(x)$ [2.5]

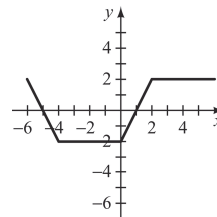
92. $g(x) = 2f(x)$ [2.5]

93. $g(x) = \frac{1}{2}f(x)$ [2.5]

94. $g(x) = f(2x)$ [2.5]

95. $g(x) = f\left(\frac{1}{2}x\right)$ [2.5]

96. Perform the operations. [2.6]

   a. $(f+g)(2) = \left[2^2 + 2 - 2\right] + \left[3(2)+1\right]$
$$= 4 + 7 = 11$$

   b. $\left(\dfrac{f}{g}\right)(-1) = \dfrac{(-1)^2 + (-1) - 2}{3(-1)+1} = \dfrac{-2}{-2} = 1$

   c. $(f-g)(x) = \left(x^2 + x - 2\right) - (3x+1) = x^2 - 2x - 3$

   d. $(f \cdot g)(x) = \left(x^2 + x - 2\right)(3x+1)$
$$= 3x^2 + 4x^2 - 5x - 2$$

97. Find the difference quotient. [2.6]

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

$$= \frac{4(x+h)^2 - 3(x+h) - 1 - (4x^2 - 3x - 1)}{h}$$

$$= \frac{4x^2 + 8xh + 4h^2 - 3x - 3h - 1 - 4x^2 + 3x + 1}{h}$$

$$= \frac{8xh + 4h^2 - 3h}{h}$$

$$= 8x + 4h - 3$$

98. Find the difference quotient. [2.6]

$$\frac{g(x+h)-g(x)}{h}$$

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

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

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

$$=3x^2+3xh+h^2-1$$

99. $s(t)=3t^2$ [2.4]

a. Average velocity $=\dfrac{3(4)^2-3(2)^2}{4-2}$

$$=\frac{3(16)-3(4)}{2}$$

$$=\frac{48-12}{2}$$

$$=\frac{36}{2}=18 \text{ ft/sec}$$

b. Average velocity $=\dfrac{3(3)^2-3(2)^2}{3-2}$

$$=\frac{3(9)-3(4)}{1}$$

$$=\frac{27-12}{1}=15 \text{ ft/sec}$$

c. Average velocity $=\dfrac{3(2.5)^2-3(2)^2}{2.5-2}$

$$=\frac{3(6.25)-3(4)}{0.5}$$

$$=\frac{18.75-12}{0.5}$$

$$=\frac{6.75}{0.5}=13.5 \text{ ft/sec}$$

d. Average velocity $=\dfrac{3(2.01)^2-3(2)^2}{2.01-2}$

$$=\frac{3(4.0401)-3(4)}{0.01}$$

$$=\frac{12.1203-12}{0.01}$$

$$=\frac{0.1203}{0.01}=12.03 \text{ ft/sec}$$

e. It appears that the average velocity of the ball approaches 12 ft/sec.

100. Evaluate the composite functions. [2.6]

a. $(f \circ g)(3)=f\big(g(3)\big)=f(3-8)$

$$=f(-5)=(-5)^2+4(-5)$$

$$=25-20=5$$

b. $(g \circ f)(-3)=g\big(f(-3)\big)=g\big((-3)^2+4(-3)\big)$

$$=g(-3)=-3-8$$

$$=-11$$

c. $(f \circ g)(x)=f\big(g(x)\big)$

$$=(x-8)^2+4(x-8)$$

$$=x^2-16x+64+4x-32$$

$$=x^2-12x+32$$

d. $(g \circ f)(x)=g\big(f(x)\big)$

$$=\big(x^2+4x\big)-8$$

$$=x^2+4x-8$$

101. Evaluate the composite functions. [2.6]

a. $(f \circ g)(-5)=f\big(g(-5)\big)=f\big(|-5-1|\big)=f\big(|-6|\big)$

$$=f(6)=2(6)^2+7$$

$$=72+7=79$$

b. $(g \circ f)(-5)=g\big(f(-5)\big)=g\big(2(-5)^2+7\big)$

$$=g(57)=|57-1|$$

$$=56$$

c. $(f \circ g)(x)=f\big(g(x)\big)$

$$=2|x-1|^2+7$$

$$=2x^2-4x+2+7$$

$$=2x^2-4x+9$$

d. $(g \circ f)(x)=g\big(f(x)\big)$

$$=\big|2x^2+7-1\big|$$

$$=\big|2x^2+6\big|$$

$$=2x^2+6$$

102. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT. [2.7]
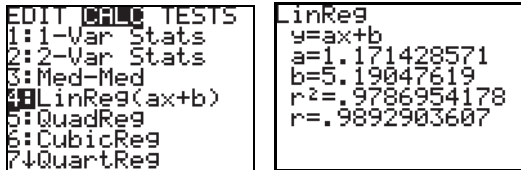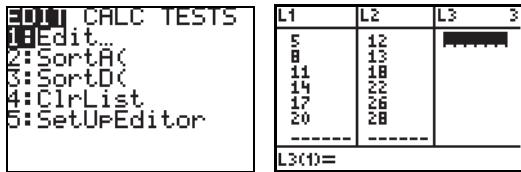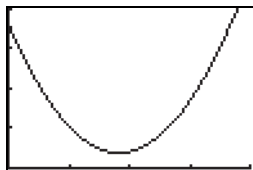

a. $y = 1.171428571x + 5.19047619$

b. $y = 1.171428571(12) + 5.19047619 \approx 19$ m/s

103.a. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT. [2.7]
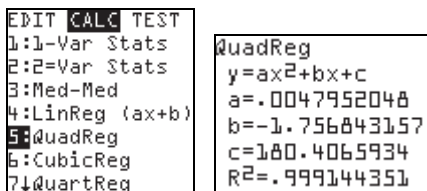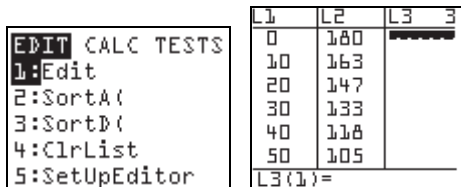
$h = 0.0047952048t^2 - 1.756843157t + 180.4065934$

b. Empty $\Rightarrow y = 0 \Rightarrow$ the graph intersects the x-axis.

Graph the equation, and notice that it never intersects the x-axis.

Xmin = 0, Xmax = 400, Xscl = 100

Ymin = 0, Ymax = 200, Xscl = 50

Thus, no, on the basis of this model, the can never empties.

c. The regression line is a model of the data and is not based on physical principles.

Chapter 2 Test

1. Finding the midpoint and length. [2.1]

$$\text{midpoint} = \left(\frac{x_1 + x_2}{2}, \ \frac{y_1 + y_2}{2} \right)$$

$$= \left(\frac{-2 + 4}{2}, \ \frac{3 + (-1)}{2} \right)$$

$$= \left(\frac{2}{2}, \ \frac{2}{2} \right) = (1, \ 1)$$

$$\text{length} = d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

$$= \sqrt{(-2 - 4)^2 + (3 - (-1))^2}$$

$$= \sqrt{(-6)^2 + 4^2} = \sqrt{36 + 16} = \sqrt{52}$$

$$= 2\sqrt{13}$$

2. Finding the x- and y-intercepts and graphing. [2.1]

$$x = 2y^2 - 4$$
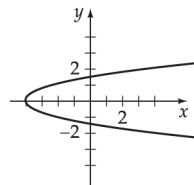
$$y = 0 \Rightarrow x = 2(0)^2 - 4 = -4$$

Thus the x-intercept is $(-4, 0)$.

$$x = 0 \Rightarrow 0 = 2y^2 - 4$$

$$4 = 2y^2$$

$$2 = y^2$$

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

Thus the y-intercepts are $(0, -\sqrt{2})$ and $(0, \ \sqrt{2})$.

3. Graphing $y = |x + 2| + 1$. [2.1]

x	y
-4	3
-3	2
-2	1
-1	2
0	3
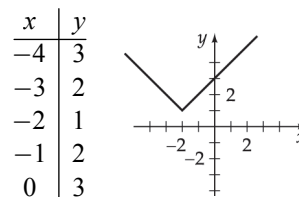
4. Finding the center and radius. [2.1]

$$x^2 - 4x + y^2 + 2y - 4 = 0$$
$$(x^2 - 4x) + (y^2 + 2y) = 4$$
$$(x^2 - 4x + 4) + (y^2 + 2y + 1) = 4 + 4 + 1$$
$$(x - 2)^2 + (y + 1)^2 = 9$$

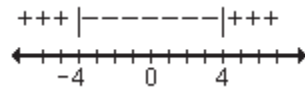center $(2, -1)$, radius 3

5. Determining the domain of the function. [2.2]

$$x^2 - 16 \geq 0$$
$$(x - 4)(x + 4) \geq 0$$

The product is positive or zero.

The critical values are 4 and -4.

```
+++ |--------|+++
<---+++++++++++++++++-->
     -4    0    4
```

The domain is $\{x | x \geq 4 \text{ or } x \leq -4\}$.

6. Find the values of a in the domain of

$f(x) = x^2 + 6x - 17$ for which $f(a) = -1$. [2.2]

$$a^2 + 6a - 17 = -1 \quad \text{Replace } f(a) \text{ with } a^2 + 6a - 17$$
$$a^2 + 6a - 16 = 0$$
$$(a + 8)(a - 2) = 0$$

$$a + 8 = 0 \qquad a - 2 = 0$$
$$a = -8 \qquad a = 2$$

7. Find the slope. [2.3]

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

8. Find the equation. [2.3]

$$y - (-3) = -2(x - 5)$$
$$y + 3 = -2x + 10$$
$$y = -2x + 7$$

9. Finding the equation in slope-intercept form. [2.3]

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

Slope of perpendicular line is $-\frac{2}{3}$.

$$y - y_1 = m(x - x_1)$$
$$y + 2 = -\frac{2}{3}(x - 4)$$
$$y + 2 = -\frac{2}{3}x + \frac{8}{3}$$
$$y = -\frac{2}{3}x + \frac{8}{3} - \frac{6}{3}$$
$$y = -\frac{2}{3}x + \frac{2}{3}$$

10. Write in standard form, find the vertex and the axis of symmetry. [2.4]

$$f(x) = x^2 + 6x - 2$$
$$= (x^2 + 6x + 9) - 2 - 9$$
$$= (x + 3)^2 - 11 \quad \text{standard form,}$$

vertex $(-3, -11)$, axis of symmetry $x = -3$

11. Finding the maximum or minimum value. [2.4]

$$-\frac{b}{2a} = -\frac{-4}{2(1)} = 2$$

$$f(2) = 2^2 - 4(2) - 8$$
$$= 4 - 8 - 8$$
$$= -12$$

The minimum value of the function is -12.

12. Classifying the functions as even, odd or neither. [2.5]

a. $f(x) = x^4 - x^2$

$f(-x) = (-x)^4 - (-x)^2 = x^4 - x^2 = f(x)$

$f(x)$ is an even function.

b. $f(x) = x^3 - x$

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

$f(x)$ is an odd function.

c. $f(x) = x - 1$

$f(-x) = -x - 1 \neq f(x)$ not an even function

$f(-x) = -x - 1 \neq -f(x)$ not an odd function

neither

13. Identify the type of symmetry. [2.5]

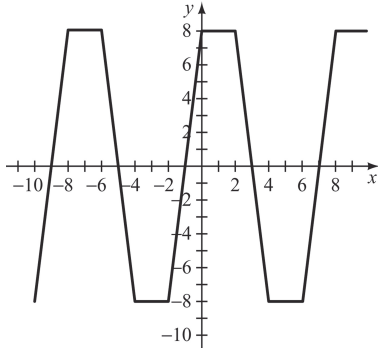**a.** $(-y)^2 = x + 1$

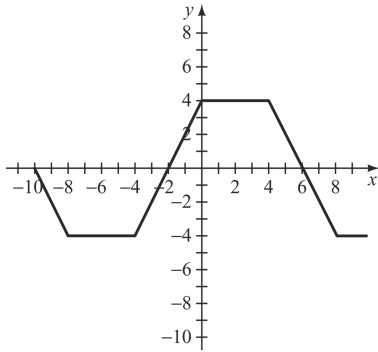$y^2 = x + 1$ symmetric with respect to x-axis

b. $-y = 2(-x)^3 + 3(-x)$

$y = 2x^3 + 3x$ symmetric with respect to origin

c. $y = 3(-x)^2 - 2$
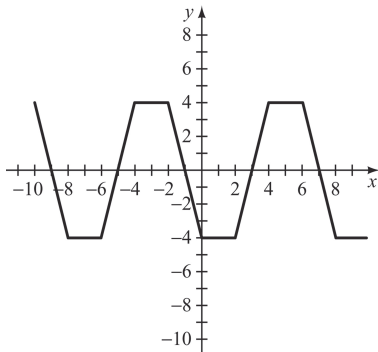
$y = 3x^2 - 2$ symmetric with respect to y-axis

14. $g(x) = 2f(x)$ [2.5]

15. $g(x) = f\left(\frac{1}{2}x\right)$ [2.5]

16. $g(x) = -f(x)$ [2.5]

17. $g(x) = f(x-1) + 3$ [2.5]
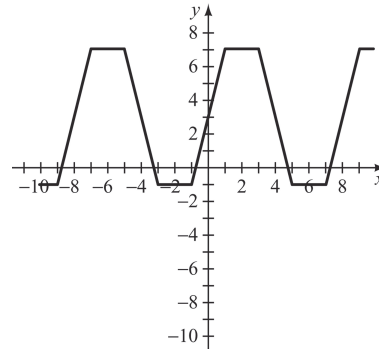
18. $g(x) = f(-x)$ [2.5]
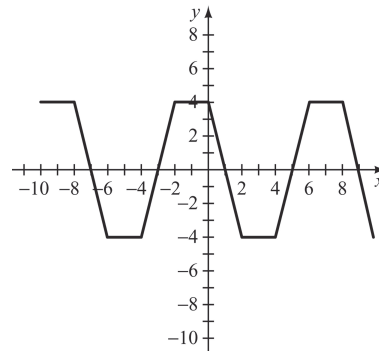
19. Perform the operations. [2.6]

a. $(f-g)(x) = (x^2 - x + 2) - (2x - 1) = x^2 - 3x + 3$

b. $(f \cdot g)(-2) = \left((-2)^2 - (-2) + 2\right)(2(-2) - 1)$
$= (8)(-5) = -40$

c. $(f \circ g)(3) = f(g(3)) = f(2(3) - 1)$
$= f(5) = 5^2 - 5 + 2$
$= 22$

d. $(g \circ f)(x) = g(f(x)) = 2(x^2 - x + 2) - 1$
$= 2x^2 - 2x + 3$

20. Finding the difference quotient of the function. [2.6]

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

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

$$= \frac{x^2 + 2xh + h^2 + 1 - x^2 - 1}{h}$$

$$= \frac{2xh + h^2}{h} = \frac{h(2x+h)}{h}$$

$$= 2x + h$$

21. Find the maximum area. [2.4]

Using the formula for perimeter for three sides,

$$P = 2w + l \Rightarrow 80 = 2x + y$$
$$y = 80 - 2x$$

Using the formula for area, $A = xy$. Then

$$A(x) = x(80 - 2x)$$
$$A(x) = -2x^2 + 80x$$

$$-\frac{b}{2a} = -\frac{80}{2(-2)} = 20$$

$$y = 80 - 2(20) = 40$$

$x = 20$ ft and $y = 40$ ft

22. Evaluating the function, $s(t) = 5t^2$. [2.6]

a. Average velocity $= \dfrac{5(3)^2 - 5(2)^2}{3 - 2} = \dfrac{5(9) - 5(4)}{1}$

$= 45 - 20 = 25$ ft/sec

b. Average velocity $= \dfrac{5(2.5)^2 - 5(2)^2}{2.5 - 2}$

$= \dfrac{5(6.25) - 5(4)}{0.5}$

$= \dfrac{31.25 - 20}{0.5} = 22.5$ ft/sec

c. Average velocity $= \dfrac{5(2.01)^2 - 5(2)^2}{2.01 - 2}$

$= \dfrac{5(4.0401) - 5(4)}{0.01}$

$= \dfrac{20.2005 - 20}{0.01} = 20.05$ ft/sec

23. a. Enter the data on your calculator. The technique for a TI-83 calculator is illustrated here. Press STAT. [2.7]

```
EDIT CALC TESTS
1:Edit
2:SortA(
3:SortD(
4:ClrList
5:SetUpEditor
```

```
L1      L2     L3    3
93.2    28   ------
92.3    26
91.9    39
89.5    56
89.6    56
90.5    36
L3(1)=
```

```
EDIT CALC TEST
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg (ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
```

```
LinReg
y=ax+b
a=-7.98245614
b=767.122807
r2=.805969575
r=-.8977580826
```

$y = -7.98245614x + 767.122807$

b. Evaluating the equation from part (a) at 89.

$y = -7.98245614(89) + 767.122807$

≈ 57 calories

Cumulative Review Exercises

1. Determine the property for $3(a + b) = 3(b + a)$. [P.1]

Commutative Property of Addition

2. $\dfrac{6}{\pi}, \sqrt{2}$ are not rational numbers [P.1]

3. Simplifying. [P.1]

$3 + 4(2x - 9)$
$= 3 + 8x - 36$
$= 8x - 33$

4. Simplifying. [P.2]

$(-4xy^2)^3(-2x^2y^4) = (-64x^3y^6)(-2x^2y^4)$
$= (-64)(-2)(x^{3+2}y^{6+4})$
$= 128x^5y^{10}$

5. Simplifying. [P.2]

$\dfrac{24a^4b^3}{18a^4b^5} = \dfrac{4a^{4-4}b^{3-5}}{3} = \dfrac{4b^{-2}}{3} = \dfrac{4}{3b^2}$

6. Simplifying. [P.3]

$(2x + 3)(3x - 7) = 6x^2 - 5x - 21$

7. Simplifying. [P.5]

$\dfrac{x^2 + 6x - 27}{x^2 - 9} = \dfrac{(x+9)(x-3)}{(x+3)(x-3)} = \dfrac{x+9}{x+3}$

8. Simplifying. [P.5]

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

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

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

9. Solving for x. [1.1]

$6 - 2(2x - 4) = 14$
$6 - 4x + 8 = 14$
$-4x = 0$
$x = 0$

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10. Solving for x. [1.3]

$$x^2 - x - 1 = 0$$

$$x = \frac{-(-1) \pm \sqrt{(-1)^2 - 4(1)(-1)}}{2(1)}$$

$$= \frac{1 \pm \sqrt{1+4}}{2} = \frac{1 \pm \sqrt{5}}{2}$$

11. Solving for x. [1.3]

$$(2x-1)(x+3) = 4$$

$$2x^2 + 5x - 3 = 4$$

$$2x^2 + 5x - 7 = 0$$

$$(2x+7)(x-1) = 0$$

$$x = -\frac{7}{2} \text{ or } x = 1$$

12. Solving for x. [1.1]

$$3x + 2y = 15$$

$$3x = -2y + 15$$

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

13. Solving for x. [1.4]

$$x^4 - x^2 - 2 = 0$$

Let $u = x^2$.

$$u^2 - u - 2 = 0$$

$$(u-2)(u+1) = 0$$

$$u - 2 = 0 \quad \text{or} \quad u + 1 = 0$$
$$u = 2 \qquad\qquad u = -1$$
$$x^2 = 2 \qquad\qquad x^2 = -1$$
$$x = \pm\sqrt{2} \qquad\quad x = \pm i$$

14. Solving for x. [1.5]

$$3x - 1 < 5x + 7$$

$$-2x < 8$$

$$x > -4$$

15. Finding the distance. [2.1]

$$\text{distance} = \sqrt{[-2-2]^2 + [-4-(-3)]^2}$$

$$= \sqrt{(-4)^2 + (-1)^2} = \sqrt{16+1}$$

$$= \sqrt{17}$$

16. Finding $G(-2)$. [2.2]

$$G(x) = 2x^3 - 4x - 7$$

$$G(-2) = 2(-2)^3 - 4(-2) - 7 = 2(-8) + 8 - 7 = -15$$

17. Finding the equation of the line. [2.3]

The slope is $m = \dfrac{-1-(-3)}{-2-2} = \dfrac{-1+3}{-2-2} = \dfrac{2}{-4} = -\dfrac{1}{2}$

The equation is $y - (-3) = -\dfrac{1}{2}(x-2)$

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

18. Solving a mixture problem. [1.1]

0	x
0.08	60
0.03	$60 + x$

$$0.08(60) + 0x = 0.03(60 + x)$$

$$4.8 = 1.8 + 0.03x$$

$$3 = 0.03x$$

$$100 = x$$

100 ounces of water

19. Evaluating a quadratic function. [2.4]

$$h(x) = -0.002x^2 - 0.03x + 8$$

$$h(39) = -0.002(39)^2 - 0.03(39) + 8 = 3.788 \text{ ft}$$

Yes.

20. Finding the rate, or slope. [2.3]

0.04°F/min