Chapter 1

Graphs, Functions, and Models

Exercise Set 1.1

1. Point A is located 5 units to the left of the y-axis and 4 units up from the x-axis, so its coordinates are $(-5, 4)$.

Point B is located 2 units to the right of the y-axis and 2 units down from the x-axis, so its coordinates are $(2, -2)$.

Point C is located 0 units to the right or left of the y-axis and 5 units down from the x-axis, so its coordinates are $(0, -5)$.

Point D is located 3 units to the right of the y-axis and 5 units up from the x-axis, so its coordinates are $(3, 5)$.

Point E is located 5 units to the left of the y-axis and 4 units down from the x-axis, so its coordinates are $(-5, -4)$.

Point F is located 3 units to the right of the y-axis and 0 units up or down from the x-axis, so its coordinates are $(3, 0)$.

2. G: $(2, 1)$; H: $(0, 0)$; I: $(4, -3)$; J: $(-4, 0)$; K: $(-2, 3)$; L: $(0, 5)$

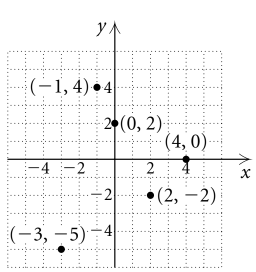
3. To graph $(4, 0)$ we move from the origin 4 units to the right of the y-axis. Since the second coordinate is 0, we do not move up or down from the x-axis.

To graph $(-3, -5)$ we move from the origin 3 units to the left of the y-axis. Then we move 5 units down from the x-axis.

To graph $(-1, 4)$ we move from the origin 1 unit to the left of the y-axis. Then we move 4 units up from the x-axis.

To graph $(0, 2)$ we do not move to the right or the left of the y-axis since the first coordinate is 0. From the origin we move 2 units up.

To graph $(2, -2)$ we move from the origin 2 units to the right of the y-axis. Then we move 2 units down from the x-axis.



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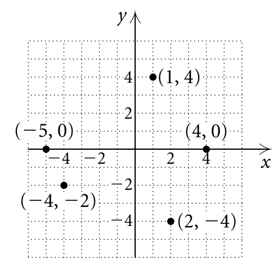


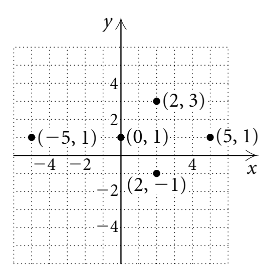
5. To graph $(-5, 1)$ we move from the origin 5 units to the left of the y-axis. Then we move 1 unit up from the x-axis.

To graph $(5, 1)$ we move from the origin 5 units to the right of the y-axis. Then we move 1 unit up from the x-axis.

To graph $(2, 3)$ we move from the origin 2 units to the right of the y-axis. Then we move 3 units up from the x-axis.

To graph $(2, -1)$ we move from the origin 2 units to the right of the y-axis. Then we move 1 unit down from the x-axis.

To graph $(0, 1)$ we do not move to the right or the left of the y-axis since the first coordinate is 0. From the origin we move 1 unit up.



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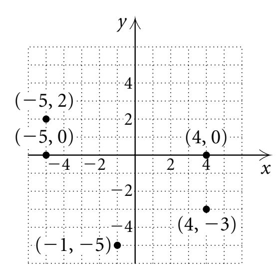


7. The first coordinate represents the year and the second coordinate represents the number of Sprint Cup Series races in which Tony Stewart finished in the top five. The ordered pairs are (2008, 10), (2009, 15), (2010, 9), (2011, 9), (2012, 12), and (2013, 5).

8. The first coordinate represents the year and the second coordinate represents the percent of Marines who are women. The ordered pairs are (1960, 1%), (1970, 0.9%), (1980, 3.6%), (1990, 4.9%), (2000, 6.1%), and (2011, 6.8%).

9. To determine whether $(-1,-9)$ is a solution, substitute -1 for x and -9 for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{y = 7x - 2} \\ \hline -9 \ ? & 7(-1) - 2 \\ & -7 - 2 \\ -9 & -9 \qquad \text{TRUE} \end{array}$$

The equation $-9 = -9$ is true, so $(-1,-9)$ is a solution.

To determine whether $(0,2)$ is a solution, substitute 0 for x and 2 for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{y = 7x - 2} \\ \hline 2 \ ? & 7 \cdot 0 - 2 \\ & 0 - 2 \\ 2 & -2 \qquad \text{FALSE} \end{array}$$

The equation $2 = -2$ is false, so $(0,2)$ is not a solution.

10. For $\left(\frac{1}{2}, 8\right)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{y = -4x + 10} \\ \hline 8 \ ? & -4 \cdot \frac{1}{2} + 10 \\ & -2 + 10 \\ 8 & 8 \qquad \text{TRUE} \end{array}$$

$\left(\frac{1}{2}, 8\right)$ is a solution.

For $(-1, 6)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{y = -4x + 10} \\ \hline 6 \ ? & -4(-1) + 10 \\ & 4 + 10 \\ 6 & 14 \qquad \text{FALSE} \end{array}$$

$(-1, 6)$ is not a solution.

11. To determine whether $\left(\frac{2}{3}, \frac{3}{4}\right)$ is a solution, substitute $\frac{2}{3}$ for x and $\frac{3}{4}$ for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{6x - 4y = 1} \\ \hline 6 \cdot \frac{2}{3} - 4 \cdot \frac{3}{4} \ ? & 1 \\ 4 - 3 & \\ 1 & 1 \quad \text{TRUE} \end{array}$$

The equation $1 = 1$ is true, so $\left(\frac{2}{3}, \frac{3}{4}\right)$ is a solution.

To determine whether $\left(1, \frac{3}{2}\right)$ is a solution, substitute 1 for x and $\frac{3}{2}$ for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{6x - 4y = 1} \\ \hline 6 \cdot 1 - 4 \cdot \frac{3}{2} \ ? & 1 \\ 6 - 6 & \\ 0 & 1 \quad \text{FALSE} \end{array}$$

The equation $0 = 1$ is false, so $\left(1, \frac{3}{2}\right)$ is not a solution.

12. For $(1.5, 2.6)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{x^2 + y^2 = 9} \\ \hline (1.5)^2 + (2.6)^2 \ ? & 9 \\ 2.25 + 6.76 & \\ 9.01 & 9 \quad \text{FALSE} \end{array}$$

$(1.5, 2.6)$ is not a solution.

For $(-3, 0)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{x^2 + y^2 = 9} \\ \hline (-3)^2 + 0^2 \ ? & 9 \\ 9 + 0 & \\ 9 & 9 \quad \text{TRUE} \end{array}$$

$(-3, 0)$ is a solution.

13. To determine whether $\left(-\frac{1}{2}, -\frac{4}{5}\right)$ is a solution, substitute $-\frac{1}{2}$ for a and $-\frac{4}{5}$ for b.

$$\begin{array}{r|l} \multicolumn{2}{c}{2a + 5b = 3} \\ \hline 2\left(-\frac{1}{2}\right) + 5\left(-\frac{4}{5}\right) \ ? & 3 \\ -1 - 4 & \\ -5 & 3 \quad \text{FALSE} \end{array}$$

The equation $-5 = 3$ is false, so $\left(-\frac{1}{2}, -\frac{4}{5}\right)$ is not a solution.

To determine whether $\left(0, \frac{3}{5}\right)$ is a solution, substitute 0 for a and $\frac{3}{5}$ for b.

$$\begin{array}{r|l} \multicolumn{2}{c}{2a + 5b = 3} \\ \hline 2 \cdot 0 + 5 \cdot \frac{3}{5} \ ? & 3 \\ 0 + 3 & \\ 3 & 3 \quad \text{TRUE} \end{array}$$

The equation $3 = 3$ is true, so $\left(0, \frac{3}{5}\right)$ is a solution.

14. For $\left(0, \frac{3}{2}\right)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{3m + 4n = 6} \\ \hline 3 \cdot 0 + 4 \cdot \frac{3}{2} \ ? & 6 \\ 0 + 6 & \\ 6 & 6 \quad \text{TRUE} \end{array}$$

$\left(0, \frac{3}{2}\right)$ is a solution.

For $\left(\frac{2}{3}, 1\right)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{3m + 4n = 6} \\ \hline 3 \cdot \frac{2}{3} + 4 \cdot 1 \ ? & 6 \\ 2 + 4 & \\ 6 & 6 \quad \text{TRUE} \end{array}$$

The equation $6 = 6$ is true, so $\left(\frac{2}{3}, 1\right)$ is a solution.

15. To determine whether $(-0.75, 2.75)$ is a solution, substitute -0.75 for x and 2.75 for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{x^2 - y^2 = 3} \\ \hline (-0.75)^2 - (2.75)^2 \ ? & 3 \\ 0.5625 - 7.5625 & \\ -7 & 3 \quad \text{FALSE} \end{array}$$

The equation $-7 = 3$ is false, so $(-0.75, 2.75)$ is not a solution.

To determine whether $(2, -1)$ is a solution, substitute 2 for x and -1 for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{x^2 - y^2 = 3} \\ \hline 2^2 - (-1)^2 \ ? & 3 \\ 4 - 1 & \\ 3 & 3 \quad \text{TRUE} \end{array}$$

The equation $3 = 3$ is true, so $(2, -1)$ is a solution.

16. For $(2, -4)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{5x + 2y^2 = 70} \\ \hline 5 \cdot 2 + 2(-4)^2 \ ? & 70 \\ 10 + 2 \cdot 16 & \\ 10 + 32 & \\ 42 & 70 \quad \text{FALSE} \end{array}$$

$(2, -4)$ is not a solution.

For $(4, -5)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{5x + 2y^2 = 70} \\ \hline 5 \cdot 4 + 2(-5)^2 \ ? & 70 \\ 20 + 2 \cdot 25 & \\ 20 + 50 & \\ 70 & 70 \quad \text{TRUE} \end{array}$$

$(4, -5)$ is a solution.

17. Graph $5x - 3y = -15$.

To find the x-intercept we replace y with 0 and solve for x.

$$\begin{aligned} 5x - 3 \cdot 0 &= -15 \\ 5x &= -15 \\ x &= -3 \end{aligned}$$

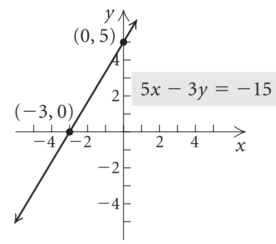
The x-intercept is $(-3, 0)$.

To find the y-intercept we replace x with 0 and solve for y.

$$\begin{aligned} 5 \cdot 0 - 3y &= -15 \\ -3y &= -15 \\ y &= 5 \end{aligned}$$

The y-intercept is $(0, 5)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



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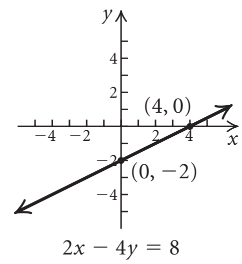


19. Graph $2x + y = 4$.

To find the x-intercept we replace y with 0 and solve for x.

$$\begin{aligned} 2x + 0 &= 4 \\ 2x &= 4 \\ x &= 2 \end{aligned}$$

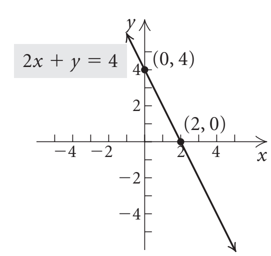
The x-intercept is $(2, 0)$.

To find the y-intercept we replace x with 0 and solve for y.

$$\begin{aligned} 2 \cdot 0 + y &= 4 \\ y &= 4 \end{aligned}$$

The y-intercept is $(0, 4)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



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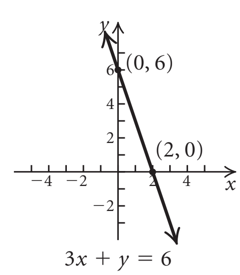


21. Graph $4y - 3x = 12$.

To find the x-intercept we replace y with 0 and solve for x.

$$\begin{aligned} 4 \cdot 0 - 3x &= 12 \\ -3x &= 12 \\ x &= -4 \end{aligned}$$

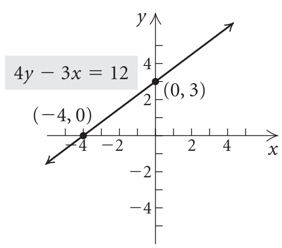
The x-intercept is $(-4, 0)$.

To find the y-intercept we replace x with 0 and solve for y.

$$\begin{aligned} 4y - 3 \cdot 0 &= 12 \\ 4y &= 12 \\ y &= 3 \end{aligned}$$

The y-intercept is $(0, 3)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



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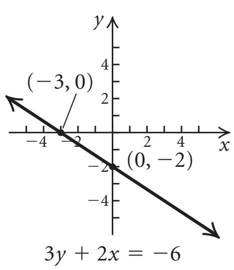


23. Graph $y = 3x + 5$.

We choose some values for x and find the corresponding y-values.

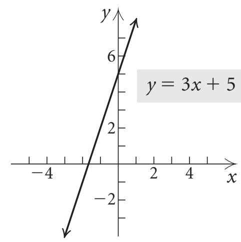
When $x = -3$, $y = 3x + 5 = 3(-3) + 5 = -9 + 5 = -4$.

When $x = -1$, $y = 3x + 5 = 3(-1) + 5 = -3 + 5 = 2$.

When $x = 0$, $y = 3x + 5 = 3 \cdot 0 + 5 = 0 + 5 = 5$

We list these points in a table, plot them, and draw the graph.

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



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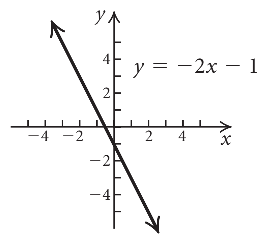
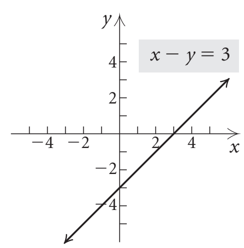


25. Graph $x - y = 3$.

Make a table of values, plot the points in the table, and draw the graph.

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



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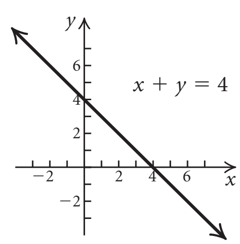
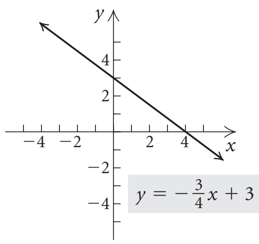


27. Graph $y = -\dfrac{3}{4}x + 3$.

By choosing multiples of 4 for x, we can avoid fraction values for y. Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-4	6	$(-4, 6)$
0	3	$(0, 3)$
4	0	$(4, 0)$



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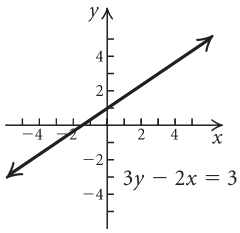


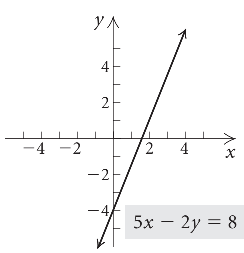
29. Graph $5x - 2y = 8$.

We could solve for y first.

$$
\begin{aligned}
5x - 2y &= 8 \\
-2y &= -5x + 8 && \text{Subtracting } 5x \text{ on both sides} \\
y &= \frac{5}{2}x - 4 && \text{Multiplying by } -\frac{1}{2} \text{ on both sides}
\end{aligned}
$$

By choosing multiples of 2 for x we can avoid fraction values for y. Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
0	−4	$(0, -4)$
2	1	$(2, 1)$
4	6	$(4, 6)$



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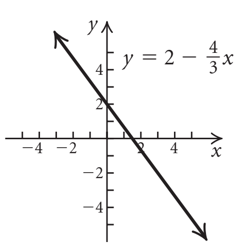
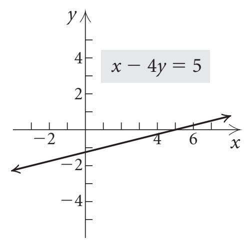


31. Graph $x - 4y = 5$.

Make a table of values, plot the points in the table, and draw the graph.

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



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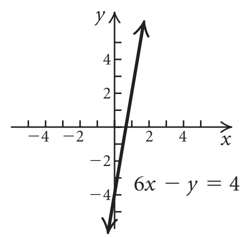
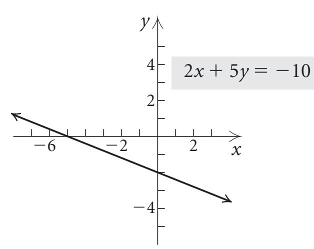


33. Graph $2x + 5y = -10$.

In this case, it is convenient to find the intercepts along with a third point on the graph. Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
−5	0	$(-5, 0)$
0	−2	$(0, -2)$
5	−4	$(5, -4)$



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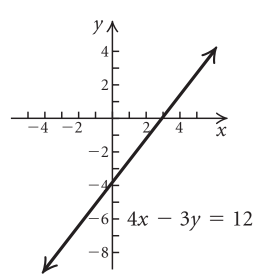
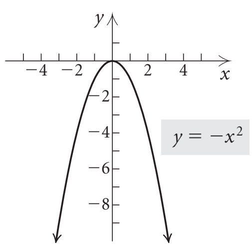


35. Graph $y = -x^2$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-2	-4	$(-2, -4)$
-1	-1	$(-1, -1)$
0	0	$(0, 0)$
1	-1	$(1, -1)$
2	-4	$(2, -4)$



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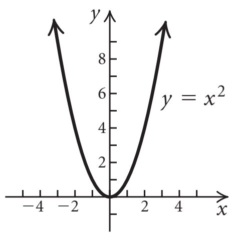
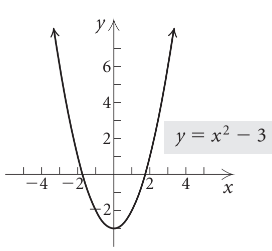


37. Graph $y = x^2 - 3$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-3	6	$(-3, 6)$
-1	-2	$(-1, -2)$
0	-3	$(0, -3)$
1	-2	$(1, -2)$
3	6	$(3, 6)$



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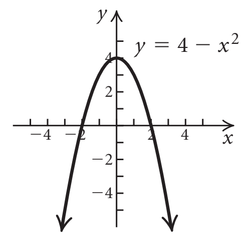
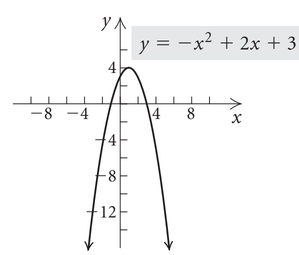


39. Graph $y = -x^2 + 2x + 3$.

Make a table of values, plot the points in the table, and draw the graph.

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



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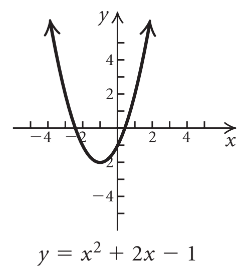


41. Either point can be considered as (x_1, y_1).

$$\begin{aligned} d &= \sqrt{(4-5)^2 + (6-9)^2} \\ &= \sqrt{(-1)^2 + (-3)^2} = \sqrt{10} \approx 3.162 \end{aligned}$$

42. $d = \sqrt{(-3-2)^2 + (7-11)^2} = \sqrt{41} \approx 6.403$

43. Either point can be considered as (x_1, y_1).

$$\begin{aligned} d &= \sqrt{(-13-(-8))^2 + (1-(-11))^2} \\ &= \sqrt{(-5)^2 + 12^2} = \sqrt{169} = 13 \end{aligned}$$

44. $d = \sqrt{(-20-(-60))^2 + (35-5)^2} = \sqrt{2500} = 50$

45. Either point can be considered as (x_1, y_1).

$$d = \sqrt{(6-9)^2 + (-1-5)^2}$$
$$= \sqrt{(-3)^2 + (-6)^2} = \sqrt{45} \approx 6.708$$

46. $d = \sqrt{(-4-(-1))^2 + (-7-3)^2} = \sqrt{109} \approx 10.440$

47. Either point can be considered as (x_1, y_1).

$$d = \sqrt{(-8-8)^2 + \left(\frac{7}{11} - \frac{7}{11}\right)^2}$$
$$= \sqrt{(-16)^2 + 0^2} = 16$$

48. $d = \sqrt{\left(\frac{1}{2} - \frac{1}{2}\right)^2 + \left(-\frac{4}{25} - \left(-\frac{13}{25}\right)\right)^2} = \sqrt{\left(\frac{9}{25}\right)^2} = \frac{9}{25}$

49. $d = \sqrt{\left[-\frac{3}{5} - \left(-\frac{3}{5}\right)\right]^2 + \left(-4 - \frac{2}{3}\right)^2}$

$$= \sqrt{0^2 + \left(-\frac{14}{3}\right)^2} = \frac{14}{3}$$

50. $d = \sqrt{\left(-\frac{11}{3} - \frac{1}{3}\right)^2 + \left(-\frac{1}{2} - \frac{5}{2}\right)^2} = \sqrt{16+9} = \sqrt{25} = 5$

51. Either point can be considered as (x_1, y_1).

$$d = \sqrt{(-4.2-2.1)^2 + [3-(-6.4)]^2}$$
$$= \sqrt{(-6.3)^2 + (9.4)^2} = \sqrt{128.05} \approx 11.316$$

52. $d = \sqrt{[0.6-(-8.1)]^2 + [-1.5-(-1.5)]^2} =$
$\sqrt{(8.7)^2} = 8.7$

53. Either point can be considered as (x_1, y_1).

$d = \sqrt{(0-a)^2 + (0-b)^2} = \sqrt{a^2+b^2}$

54. $d = \sqrt{[r-(-r)]^2 + [s-(-s)]^2} = \sqrt{4r^2+4s^2} =$
$2\sqrt{r^2+s^2}$

55. First we find the length of the diameter:

$$d = \sqrt{(-3-9)^2 + (-1-4)^2}$$
$$= \sqrt{(-12)^2 + (-5)^2} = \sqrt{169} = 13$$

The length of the radius is one-half the length of the diameter, or $\frac{1}{2}(13)$, or 6.5.

56. Radius $= \sqrt{(-3-0)^2 + (5-1)^2} = \sqrt{25} = 5$

Diameter $= 2 \cdot 5 = 10$

57. First we find the distance between each pair of points.

For $(-4, 5)$ and $(6, 1)$:

$$d = \sqrt{(-4-6)^2 + (5-1)^2}$$
$$= \sqrt{(-10)^2 + 4^2} = \sqrt{116}$$

For $(-4, 5)$ and $(-8, -5)$:

$$d = \sqrt{(-4-(-8))^2 + (5-(-5))^2}$$
$$= \sqrt{4^2 + 10^2} = \sqrt{116}$$

For $(6, 1)$ and $(-8, -5)$:

$$d = \sqrt{(6-(-8))^2 + (1-(-5))^2}$$
$$= \sqrt{14^2 + 6^2} = \sqrt{232}$$

Since $(\sqrt{116})^2 + (\sqrt{116})^2 = (\sqrt{232})^2$, the points could be the vertices of a right triangle.

58. For $(-3, 1)$ and $(2, -1)$:

$$d = \sqrt{(-3-2)^2 + (1-(-1))^2} = \sqrt{29}$$

For $(-3, 1)$ and $(6, 9)$:

$$d = \sqrt{(-3-6)^2 + (1-9)^2} = \sqrt{145}$$

For $(2, -1)$ and $(6, 9)$:

$$d = \sqrt{(2-6)^2 + (-1-9)^2} = \sqrt{116}$$

Since $(\sqrt{29})^2 + (\sqrt{116})^2 = (\sqrt{145})^2$, the points could be the vertices of a right triangle.

59. First we find the distance between each pair of points.

For $(-4, 3)$ and $(0, 5)$:

$$d = \sqrt{(-4-0)^2 + (3-5)^2}$$
$$= \sqrt{(-4)^2 + (-2)^2} = \sqrt{20}$$

For $(-4, 3)$ and $(3, -4)$:

$$d = \sqrt{(-4-3)^2 + [3-(-4)]^2}$$
$$= \sqrt{(-7)^2 + 7^2} = \sqrt{98}$$

For $(0, 5)$ and $(3, -4)$:

$$d = \sqrt{(0-3)^2 + [5-(-4)]^2}$$
$$= \sqrt{(-3)^2 + 9^2} = \sqrt{90}$$

The greatest distance is $\sqrt{98}$, so if the points are the vertices of a right triangle, then it is the hypotenuse. But $(\sqrt{20})^2 + (\sqrt{90})^2 \neq (\sqrt{98})^2$, so the points are not the vertices of a right triangle.

60. See the graph of this rectangle in Exercise 71.

The segments with endpoints $(-3, 4)$, $(2, -1)$ and $(5, 2)$, $(0, 7)$ are one pair of opposite sides. We find the length of each of these sides.

For $(-3, 4)$, $(2, -1)$:

$$d = \sqrt{(-3-2)^2 + (4-(-1))^2} = \sqrt{50}$$

For $(5, 2)$, $(0, 7)$:

$$d = \sqrt{(5-0)^2 + (2-7)^2} = \sqrt{50}$$

The segments with endpoints $(2, -1)$, $(5, 2)$ and $(0, 7)$, $(-3, 4)$ are the second pair of opposite sides. We find their lengths.

For $(2, -1)$, $(5, 2)$:

$$d = \sqrt{(2-5)^2 + (-1-2)^2} = \sqrt{18}$$

For $(0, 7)$, $(-3, 4)$:

$$d = \sqrt{(0-(-3))^2 + (7-4)^2} = \sqrt{18}$$

The endpoints of the diagonals are $(-3, 4)$, $(5, 2)$ and $(2, -1)$, $(0, 7)$. We find the length of each.

For $(-3, 4)$, $(5, 2)$:

$$d = \sqrt{(-3-5)^2 + (4-2)^2} = \sqrt{68}$$

For $(2,-1)$, $(0,7)$:

$$d=\sqrt{(2-0)^2+(-1-7)^2}=\sqrt{68}$$

The opposite sides of the quadrilateral are the same length and the diagonals are the same length, so the quadrilateral is a rectangle.

61. We use the midpoint formula.

$$\left(\frac{4+(-12)}{2},\frac{-9+(-3)}{2}\right)=\left(-\frac{8}{2},-\frac{12}{2}\right)=(-4,-6)$$

62. $\left(\frac{7+9}{2},\frac{-2+5}{2}\right)=\left(8,\frac{3}{2}\right)$

63. We use the midpoint formula.

$$\left(\frac{0+\left(-\frac{2}{5}\right)}{2},\frac{\frac{1}{2}-0}{2}\right)=\left(\frac{-\frac{2}{5}}{2},\frac{\frac{1}{2}}{2}\right)=\left(-\frac{1}{5},\frac{1}{4}\right)$$

64. $\left(\frac{0+\left(-\frac{7}{13}\right)}{2},\frac{0+\frac{2}{7}}{2}\right)=\left(-\frac{7}{26},\frac{1}{7}\right)$

65. We use the midpoint formula.

$$\left(\frac{6.1+3.8}{2},\frac{-3.8+(-6.1)}{2}\right)=\left(\frac{9.9}{2},-\frac{9.9}{2}\right)=$$

$(4.95,-4.95)$

66. $\left(\frac{-0.5+4.8}{2},\frac{-2.7+(-0.3)}{2}\right)=(2.15,-1.5)$

67. We use the midpoint formula.

$$\left(\frac{-6+(-6)}{2},\frac{5+8}{2}\right)=\left(-\frac{12}{2},\frac{13}{2}\right)=\left(-6,\frac{13}{2}\right)$$

68. $\left(\frac{1+(-1)}{2},\frac{-2+2}{2}\right)=(0,0)$

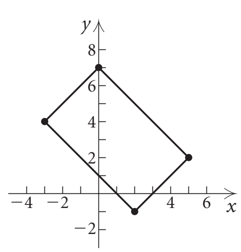
69. We use the midpoint formula.

$$\left(\frac{-\frac{1}{6}+\left(-\frac{2}{3}\right)}{2},\frac{-\frac{3}{5}+\frac{5}{4}}{2}\right)=\left(\frac{-\frac{5}{6}}{2},\frac{\frac{13}{20}}{2}\right)=$$

$$\left(-\frac{5}{12},\frac{13}{40}\right)$$

70. $\left(\frac{\frac{2}{9}+\left(-\frac{2}{5}\right)}{2},\frac{\frac{1}{3}+\frac{4}{5}}{2}\right)=\left(-\frac{4}{45},\frac{17}{30}\right)$

71.



For the side with vertices $(-3,4)$ and $(2,-1)$:

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

For the side with vertices $(2,-1)$ and $(5,2)$:

$$\left(\frac{2+5}{2},\frac{-1+2}{2}\right)=\left(\frac{7}{2},\frac{1}{2}\right)$$

For the side with vertices $(5,2)$ and $(0,7)$:

$$\left(\frac{5+0}{2},\frac{2+7}{2}\right)=\left(\frac{5}{2},\frac{9}{2}\right)$$

For the side with vertices $(0,7)$ and $(-3,4)$:

$$\left(\frac{0+(-3)}{2},\frac{7+4}{2}\right)=\left(-\frac{3}{2},\frac{11}{2}\right)$$

For the quadrilateral whose vertices are the points found above, the diagonals have endpoints

$\left(-\frac{1}{2},\frac{3}{2}\right)$, $\left(\frac{5}{2},\frac{9}{2}\right)$ and $\left(\frac{7}{2},\frac{1}{2}\right)$, $\left(-\frac{3}{2},\frac{11}{2}\right)$.

We find the length of each of these diagonals.

For $\left(-\frac{1}{2},\frac{3}{2}\right)$, $\left(\frac{5}{2},\frac{9}{2}\right)$:

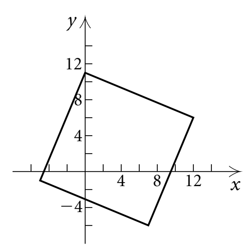
$$d=\sqrt{\left(-\frac{1}{2}-\frac{5}{2}\right)^2+\left(\frac{3}{2}-\frac{9}{2}\right)^2}$$
$$=\sqrt{(-3)^2+(-3)^2}=\sqrt{18}$$

For $\left(\frac{7}{2},\frac{1}{2}\right)$, $\left(-\frac{3}{2},\frac{11}{2}\right)$:

$$d=\sqrt{\left(\frac{7}{2}-\left(-\frac{3}{2}\right)\right)^2+\left(\frac{1}{2}-\frac{11}{2}\right)^2}$$
$$=\sqrt{5^2+(-5)^2}=\sqrt{50}$$

Since the diagonals do not have the same lengths, the midpoints are not vertices of a rectangle.

72.



For the side with vertices $(-5,-1)$ and $(7,-6)$:

$$\left(\frac{-5+7}{2},\frac{-1+(-6)}{2}\right)=\left(1,-\frac{7}{2}\right)$$

For the side with vertices $(7,-6)$ and $(12,6)$:

$$\left(\frac{7+12}{2},\frac{-6+6}{2}\right)=\left(\frac{19}{2},0\right)$$

For the side with vertices $(12,6)$ and $(0,11)$:

$$\left(\frac{12+0}{2},\frac{6+11}{2}\right)=\left(6,\frac{17}{2}\right)$$

For the side with vertices $(0,11)$ and $(-5,-1)$:

$$\left(\frac{0+(-5)}{2},\frac{11+(-1)}{2}\right)=\left(-\frac{5}{2},5\right)$$

For the quadrilateral whose vertices are the points found above, one pair of opposite sides has endpoints $\left(1,-\frac{7}{2}\right)$, $\left(\frac{19}{2},0\right)$ and $\left(6,\frac{17}{2}\right)$, $\left(-\frac{5}{2},5\right)$. The length of each of these sides is $\dfrac{\sqrt{338}}{2}$. The other pair of opposite sides has endpoints $\left(\dfrac{19}{2}, 0\right), \left(6, \dfrac{17}{2}\right)$ and $\left(-\dfrac{5}{2}, 5\right), \left(1, -\dfrac{7}{2}\right)$. The length of each of these sides is also $\dfrac{\sqrt{338}}{2}$. The endpoints of the diagonals of the quadrilateral are $\left(1, -\dfrac{7}{2}\right)$, $\left(6, \dfrac{17}{2}\right)$ and $\left(\dfrac{19}{2}, 0\right), \left(-\dfrac{5}{2}, 5\right)$. The length of each diagonal is 13. Since the four sides of the quadrilateral are the same length and the diagonals are the same length, the midpoints are vertices of a square.

73. We use the midpoint formula.

$$\left(\frac{\sqrt{7}+\sqrt{2}}{2}, \frac{-4+3}{2}\right) = \left(\frac{\sqrt{7}+\sqrt{2}}{2}, -\frac{1}{2}\right)$$

74. $\left(\dfrac{-3+1}{2}, \dfrac{\sqrt{5}+\sqrt{2}}{2}\right) = \left(-1, \dfrac{\sqrt{5}+\sqrt{2}}{2}\right)$

75.
$$(x-h)^2 + (y-k)^2 = r^2$$
$$(x-2)^2 + (y-3)^2 = \left(\frac{5}{3}\right)^2 \quad \text{Substituting}$$
$$(x-2)^2 + (y-3)^2 = \frac{25}{9}$$

76.
$$(x-4)^2 + (y-5)^2 = (4.1)^2$$
$$(x-4)^2 + (y-5)^2 = 16.81$$

77. The length of a radius is the distance between $(-1, 4)$ and $(3, 7)$:

$$r = \sqrt{(-1-3)^2 + (4-7)^2}$$
$$= \sqrt{(-4)^2 + (-3)^2} = \sqrt{25} = 5$$

$$(x-h)^2 + (y-k)^2 = r^2$$
$$[x-(-1)]^2 + (y-4)^2 = 5^2$$
$$(x+1)^2 + (y-4)^2 = 25$$

78. Find the length of a radius:

$$r = \sqrt{(6-1)^2 + (-5-7)^2} = \sqrt{169} = 13$$

$$(x-6)^2 + [y-(-5)]^2 = 13^2$$
$$(x-6)^2 + (y+5)^2 = 169$$

79. The center is the midpoint of the diameter:

$$\left(\frac{7+(-3)}{2}, \frac{13+(-11)}{2}\right) = (2, 1)$$

Use the center and either endpoint of the diameter to find the length of a radius. We use the point $(7, 13)$:

$$r = \sqrt{(7-2)^2 + (13-1)^2}$$
$$= \sqrt{5^2 + 12^2} = \sqrt{169} = 13$$

$$(x-h)^2 + (y-k)^2 = r^2$$
$$(x-2)^2 + (y-1)^2 = 13^2$$
$$(x-2)^2 + (y-1)^2 = 169$$

80. The points $(-9, 4)$ and $(-1, -2)$ are opposite vertices of the square and hence endpoints of a diameter of the circle. We use these points to find the center and radius.

Center: $\left(\dfrac{-9+(-1)}{2}, \dfrac{4+(-2)}{2}\right) = (-5, 1)$

Radius: $\dfrac{1}{2}\sqrt{(-9-(-1))^2+(4-(-2))^2} = \dfrac{1}{2}\cdot 10 = 5$

$$[x-(-5)]^2 + (y-1)^2 = 5^2$$
$$(x+5)^2 + (y-1)^2 = 25$$

81. Since the center is 2 units to the left of the y-axis and the circle is tangent to the y-axis, the length of a radius is 2.

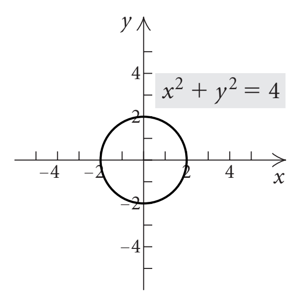
$$(x-h)^2 + (y-k)^2 = r^2$$
$$[x-(-2)]^2 + (y-3)^2 = 2^2$$
$$(x+2)^2 + (y-3)^2 = 4$$

82. Since the center is 5 units below the x-axis and the circle is tangent to the x-axis, the length of a radius is 5.

$$(x-4)^2 + [y-(-5)]^2 = 5^2$$
$$(x-4)^2 + (y+5)^2 = 25$$

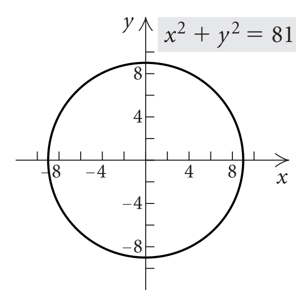
83.
$$x^2 + y^2 = 4$$
$$(x-0)^2 + (y-0)^2 = 2^2$$

Center: $(0, 0)$; radius: 2



84.
$$x^2 + y^2 = 81$$
$$(x-0)^2 + (y-0)^2 = 9^2$$

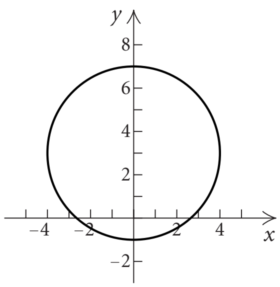
Center: $(0, 0)$; radius: 9



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

$(x-0)^2 + (y-3)^2 = 4^2$

Center: $(0,3)$; radius: 4

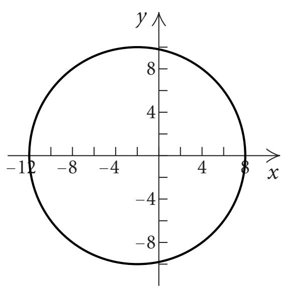


$x^2 + (y-3)^2 = 16$

86. $(x+2)^2 + y^2 = 100$

$[x-(-2)]^2 + (y-0)^2 = 10^2$

Center: $(-2,0)$; radius: 10

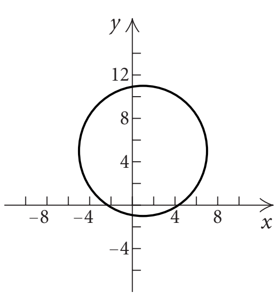


$(x+2)^2 + y^2 = 100$

87. $(x-1)^2 + (y-5)^2 = 36$

$(x-1)^2 + (y-5)^2 = 6^2$

Center: $(1,5)$; radius: 6

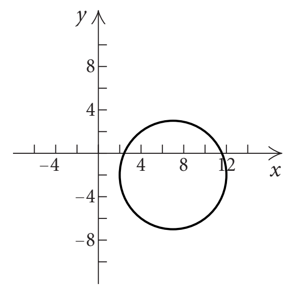


$(x-1)^2 + (y-5)^2 = 36$

88. $(x-7)^2 + (y+2)^2 = 25$

$(x-7)^2 + [y-(-2)]^2 = 5^2$

Center: $(7,-2)$; radius: 5

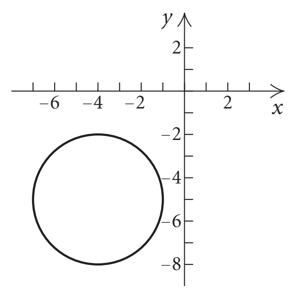


$(x-7)^2 + (y+2)^2 = 25$

89. $(x+4)^2 + (y+5)^2 = 9$

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

Center: $(-4,-5)$; radius: 3

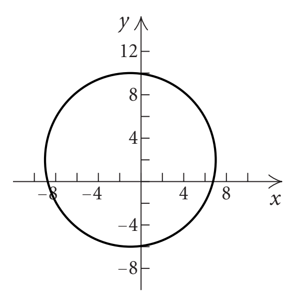


$(x+4)^2 + (y+5)^2 = 9$

90. $(x+1)^2 + (y-2)^2 = 64$

$[x-(-1)]^2 + (y-2)^2 = 8^2$

Center: $(-1,2)$; radius: 8



$(x+1)^2 + (y-2)^2 = 64$

91. From the graph we see that the center of the circle is $(-2,1)$ and the radius is 3. The equation of the circle is $[x-(-2)]^2 + (y-1)^2 = 3^2$, or $(x+2)^2 + (y-1)^2 = 3^2$.

92. Center: $(3,-5)$, radius: 4

Equation: $(x-3)^2 + [y-(-5)]^2 = 4^2$, or

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

93. From the graph we see that the center of the circle is $(5,-5)$ and the radius is 15. The equation of the circle is $(x-5)^2 + [y-(-5)]^2 = 15^2$, or $(x-5)^2 + (y+5)^2 = 15^2$.

94. Center: $(-8, 2)$, radius: 4

Equation: $[x-(-8)]^2+(y-2)^2=4^2$, or

$(x+8)^2+(y-2)^2=4^2$

95. If the point (p, q) is in the fourth quadrant, then $p > 0$ and $q < 0$. If $p > 0$, then $-p < 0$ so both coordinates of the point $(q, -p)$ are negative and $(q, -p)$ is in the third quadrant.

96. Use the distance formula:

$$d=\sqrt{(a+h-a)^2+\left(\frac{1}{a+h}-\frac{1}{a}\right)^2}=$$
$$\sqrt{h^2+\left(\frac{-h}{a(a+h)}\right)^2}=\sqrt{h^2+\frac{h^2}{a^2(a+h)^2}}=$$
$$\sqrt{\frac{h^2a^2(a+h)^2+h^2}{a^2(a+h)^2}}=\sqrt{\frac{h^2(a^2(a+h)^2+1)}{a^2(a+h)^2}}=$$
$$\left|\frac{h}{a(a+h)}\right|\sqrt{a^2(a+h)^2+1}$$

Find the midpoint:

$$\left(\frac{a+a+h}{2}, \frac{\frac{1}{a}+\frac{1}{a+h}}{2}\right)=\left(\frac{2a+h}{2}, \frac{2a+h}{2a(a+h)}\right)$$

97. Use the distance formula. Either point can be considered as (x_1, y_1).

$$\begin{aligned} d &= \sqrt{(a+h-a)^2+(\sqrt{a+h}-\sqrt{a})^2} \\ &= \sqrt{h^2+a+h-2\sqrt{a^2+ah}+a} \\ &= \sqrt{h^2+2a+h-2\sqrt{a^2+ah}} \end{aligned}$$

Next we use the midpoint formula.

$$\left(\frac{a+a+h}{2}, \frac{\sqrt{a}+\sqrt{a+h}}{2}\right)=\left(\frac{2a+h}{2}, \frac{\sqrt{a}+\sqrt{a+h}}{2}\right)$$

98.
$$\begin{aligned} C &= 2\pi r \\ 10\pi &= 2\pi r \\ 5 &= r \end{aligned}$$

Then $[x-(-5)]^2+(y-8)^2=5^2$, or $(x+5)^2+(y-8)^2=25$.

99. First use the formula for the area of a circle to find r^2:

$$\begin{aligned} A &= \pi r^2 \\ 36\pi &= \pi r^2 \\ 36 &= r^2 \end{aligned}$$

Then we have:

$$\begin{aligned} (x-h)^2+(y-k)^2 &= r^2 \\ (x-2)^2+[y-(-7)]^2 &= 36 \\ (x-2)^2+(y+7)^2 &= 36 \end{aligned}$$

100. Let the point be $(x, 0)$. We set the distance from $(-4, -3)$ to $(x, 0)$ equal to the distance from $(-1, 5)$ to $(x, 0)$ and solve for x.

$$\begin{aligned} \sqrt{(-4-x)^2+(-3-0)^2} &= \sqrt{(-1-x)^2+(5-0)^2} \\ \sqrt{16+8x+x^2+9} &= \sqrt{1+2x+x^2+25} \\ \sqrt{x^2+8x+25} &= \sqrt{x^2+2x+26} \\ x^2+8x+25 &= x^2+2x+26 \\ &\qquad \text{Squaring both sides} \\ 8x+25 &= 2x+26 \\ 6x &= 1 \\ x &= \frac{1}{6} \end{aligned}$$

The point is $\left(\frac{1}{6}, 0\right)$.

101. Let $(0, y)$ be the required point. We set the distance from $(-2, 0)$ to $(0, y)$ equal to the distance from $(4, 6)$ to $(0, y)$ and solve for y.

$$\begin{aligned} \sqrt{[0-(-2)]^2+(y-0)^2} &= \sqrt{(0-4)^2+(y-6)^2} \\ \sqrt{4+y^2} &= \sqrt{16+y^2-12y+36} \\ 4+y^2 &= 16+y^2-12y+36 \\ &\qquad \text{Squaring both sides} \\ -48 &= -12y \\ 4 &= y \end{aligned}$$

The point is $(0, 4)$.

102. We first find the distance between each pair of points.

For $(-1, -3)$ and $(-4, -9)$:

$$\begin{aligned} d_1 &= \sqrt{[-1-(-4)]^2+[-3-(-9)]^2} \\ &= \sqrt{3^2+6^2}=\sqrt{9+36} \\ &= \sqrt{45}=3\sqrt{5} \end{aligned}$$

For $(-1, -3)$ and $(2, 3)$:

$$\begin{aligned} d_2 &= \sqrt{(-1-2)^2+(-3-3)^2} \\ &= \sqrt{(-3)^2+(-6)^2}=\sqrt{9+36} \\ &= \sqrt{45}=3\sqrt{5} \end{aligned}$$

For $(-4, -9)$ and $(2, 3)$:

$$\begin{aligned} d_3 &= \sqrt{(-4-2)^2+(-9-3)^2} \\ &= \sqrt{(-6)^2+(-12)^2}=\sqrt{36+144} \\ &= \sqrt{180}=6\sqrt{5} \end{aligned}$$

Since $d_1+d_2=d_3$, the points are collinear.

103. a) When the circle is positioned on a coordinate system as shown in the text, the center lies on the y-axis and is equidistant from $(-4, 0)$ and $(0, 2)$.

Let $(0, y)$ be the coordinates of the center.

$$\begin{aligned} \sqrt{(-4-0)^2+(0-y)^2} &= \sqrt{(0-0)^2+(2-y)^2} \\ 4^2+y^2 &= (2-y)^2 \\ 16+y^2 &= 4-4y+y^2 \\ 12 &= -4y \\ -3 &= y \end{aligned}$$

The center of the circle is $(0, -3)$.

b) Use the point $(-4, 0)$ and the center $(0, -3)$ to find the radius.

$$(-4-0)^2 + [0-(-3)]^2 = r^2$$
$$25 = r^2$$
$$5 = r$$

The radius is 5 ft.

104. The coordinates of P are $\left(\frac{b}{2}, \frac{h}{2}\right)$ by the midpoint formula. By the distance formula, each of the distances from P to $(0, h)$, from P to $(0, 0)$, and from P to $(b, 0)$ is $\frac{\sqrt{b^2+h^2}}{2}$.

105.
$$\begin{array}{r|l} x^2 + y^2 & = 1 \\ \hline \left(\frac{\sqrt{3}}{2}\right)^2 + \left(-\frac{1}{2}\right)^2 & ?\ 1 \\ \frac{3}{4} + \frac{1}{4} & \\ 1 & 1 \quad \text{TRUE} \end{array}$$

$\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$ lies on the unit circle.

106.
$$\begin{array}{r|l} x^2 + y^2 & = 1 \\ \hline 0^2 + (-1)^2 & ?\ 1 \\ 1 & 1 \quad \text{TRUE} \end{array}$$

$(0, -1)$ lies on the unit circle.

107.
$$\begin{array}{r|l} x^2 + y^2 & = 1 \\ \hline \left(-\frac{\sqrt{2}}{2}\right)^2 + \left(\frac{\sqrt{2}}{2}\right)^2 & ?\ 1 \\ \frac{2}{4} + \frac{2}{4} & \\ 1 & 1 \quad \text{TRUE} \end{array}$$

$\left(-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right)$ lies on the unit circle.

108.
$$\begin{array}{r|l} x^2 + y^2 & = 1 \\ \hline \left(\frac{1}{2}\right)^2 + \left(-\frac{\sqrt{3}}{2}\right)^2 & ?\ 1 \\ \frac{1}{4} + \frac{3}{4} & \\ 1 & 1 \quad \text{TRUE} \end{array}$$

$\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$ lies on the unit circle.

109. a), b) See the answer section in the text.

Exercise Set 1.2

1. This correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

2. This correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

3. This correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

4. This correspondence is not a function, because there is a member of the domain (1) that corresponds to more than one member of the range (4 and 6).

5. This correspondence is not a function, because there is a member of the domain (m) that corresponds to more than one member of the range (A and B).

6. This correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

7. This correspondence is a function, because each member of the domain corresponds to exactly one member of the range.

8. This correspondence is not a function, because there is a member of the domain that corresponds to more than one member of the range. In fact, Sean Connery, Roger Moore, and Pierce Brosnan all correspond to two members of the range.

9. This correspondence is a function, because each car has exactly one license number.

10. This correspondence is not a function, because we can safely assume that at least one person uses more than one doctor.

11. This correspondence is a function, because each integer less than 9 corresponds to exactly one multiple of 5.

12. This correspondence is not a function, because we can safely assume that at least one band member plays more than one instrument.

13. This correspondence is not a function, because at least one student will have more than one neighboring seat occupied by another student.

14. This correspondence is a function, because each bag has exactly one weight.

15. The relation is a function, because no two ordered pairs have the same first coordinate and different second coordinates.

The domain is the set of all first coordinates: $\{2, 3, 4\}$.

The range is the set of all second coordinates: $\{10, 15, 20\}$.

16. The relation is a function, because no two ordered pairs have the same first coordinate and different second coordinates.

Domain: $\{3, 5, 7\}$

Range: $\{1\}$

17. The relation is not a function, because the ordered pairs $(-2,1)$ and $(-2,4)$ have the same first coordinate and different second coordinates.

The domain is the set of all first coordinates: $\{-7,-2,0\}$.

The range is the set of all second coordinates: $\{3,1,4,7\}$.

18. The relation is not a function, because each of the ordered pairs has the same first coordinate and different second coordinates.

Domain: $\{1\}$

Range: $\{3,5,7,9\}$

19. The relation is a function, because no two ordered pairs have the same first coordinate and different second coordinates.

The domain is the set of all first coordinates: $\{-2,0,2,4,-3\}$.

The range is the set of all second coordinates: $\{1\}$.

20. The relation is not a function, because the ordered pairs $(5,0)$ and $(5,-1)$ have the same first coordinates and different second coordinates. This is also true of the pairs $(3,-1)$ and $(3,-2)$.

Domain: $\{5,3,0\}$

Range: $\{0,-1,-2\}$

21. $g(x)=3x^2-2x+1$

a) $g(0)=3\cdot 0^2-2\cdot 0+1=1$

b) $g(-1)=3(-1)^2-2(-1)+1=6$

c) $g(3)=3\cdot 3^2-2\cdot 3+1=22$

d) $g(-x)=3(-x)^2-2(-x)+1=3x^2+2x+1$

e) $g(1-t)=3(1-t)^2-2(1-t)+1=$
$3(1-2t+t^2)-2(1-t)+1=3-6t+3t^2-2+2t+1=$
$3t^2-4t+2$

22. $f(x)=5x^2+4x$

a) $f(0)=5\cdot 0^2+4\cdot 0=0+0=0$

b) $f(-1)=5(-1)^2+4(-1)=5-4=1$

c) $f(3)=5\cdot 3^2+4\cdot 3=45+12=57$

d) $f(t)=5t^2+4t$

e) $f(t-1)=5(t-1)^2+4(t-1)=5t^2-6t+1$

23. $g(x)=x^3$

a) $g(2)=2^3=8$

b) $g(-2)=(-2)^3=-8$

c) $g(-x)=(-x)^3=-x^3$

d) $g(3y)=(3y)^3=27y^3$

e) $g(2+h)=(2+h)^3=8+12h+6h^2+h^3$

24. $f(x)=2|x|+3x$

a) $f(1)=2|1|+3\cdot 1=2+3=5$

b) $f(-2)=2|-2|+3(-2)=4-6=-2$

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

d) $f(2y)=2|2y|+3\cdot 2y=4|y|+6y$

e) $f(2-h)=2|2-h|+3(2-h)=$
$2|2-h|+6-3h$

25. $g(x)=\dfrac{x-4}{x+3}$

a) $g(5)=\dfrac{5-4}{5+3}=\dfrac{1}{8}$

b) $g(4)=\dfrac{4-4}{4+7}=0$

c) $g(-3)=\dfrac{-3-4}{-3+3}=\dfrac{-7}{0}$

Since division by 0 is not defined, $g(-3)$ does not exist.

d) $g(-16.25)=\dfrac{-16.25-4}{-16.25+3}=\dfrac{-20.25}{-13.25}=\dfrac{81}{53}\approx 1.5283$

e) $g(x+h)=\dfrac{x+h-4}{x+h+3}$

26. $f(x)=\dfrac{x}{2-x}$

a) $f(2)=\dfrac{2}{2-2}=\dfrac{2}{0}$

Since division by 0 is not defined, $f(2)$ does not exist.

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

c) $f(-16)=\dfrac{-16}{2-(-16)}=\dfrac{-16}{18}=-\dfrac{8}{9}$

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

e) $f\left(-\dfrac{2}{3}\right)=\dfrac{-\dfrac{2}{3}}{2-\left(-\dfrac{2}{3}\right)}=\dfrac{-\dfrac{2}{3}}{\dfrac{8}{3}}=-\dfrac{1}{4}$

27. $g(x)=\dfrac{x}{\sqrt{1-x^2}}$

$g(0)=\dfrac{0}{\sqrt{1-0^2}}=\dfrac{0}{\sqrt{1}}=\dfrac{0}{1}=0$

$g(-1)=\dfrac{-1}{\sqrt{1-(-1)^2}}=\dfrac{-1}{\sqrt{1-1}}=\dfrac{-1}{\sqrt{0}}=\dfrac{-1}{0}$

Since division by 0 is not defined, $g(-1)$ does not exist.

$g(5)=\dfrac{5}{\sqrt{1-5^2}}=\dfrac{5}{\sqrt{1-25}}=\dfrac{5}{\sqrt{-24}}$

Since $\sqrt{-24}$ is not defined as a real number, $g(5)$ does not exist as a real number.

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

$$\frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}}=\frac{1}{2}\cdot\frac{2}{\sqrt{3}}=\frac{1\cdot 2}{2\sqrt{3}}=\frac{1}{\sqrt{3}},\text{ or }\frac{\sqrt{3}}{3}$$

28. $h(x)=x+\sqrt{x^2-1}$

$h(0)=0+\sqrt{0^2-1}=0+\sqrt{-1}$

Since $\sqrt{-1}$ is not defined as a real number, $h(0)$ does not exist as a real number.

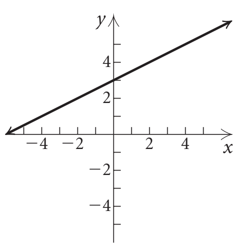
$h(2)=2+\sqrt{2^2-1}=2+\sqrt{3}$

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

29. Graph $f(x)=\frac{1}{2}x+3$.

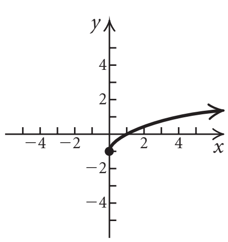
We select values for x and find the corresponding values of $f(x)$. Then we plot the points and connect them with a smooth curve.

x	$f(x)$	$(x, f(x))$
-4	1	$(-4, 1)$
0	3	$(0, 3)$
2	4	$(2, 4)$



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

30.

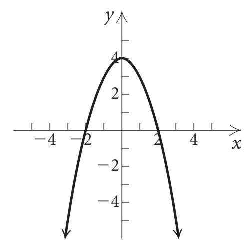


$f(x)=\sqrt{x}-1$

31. Graph $f(x)=-x^2+4$.

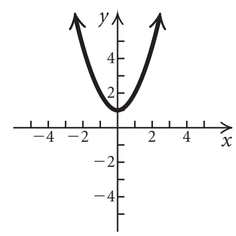
We select values for x and find the corresponding values of $f(x)$. Then we plot the points and connect them with a smooth curve.

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



$f(x)=-x^2+4$

32.

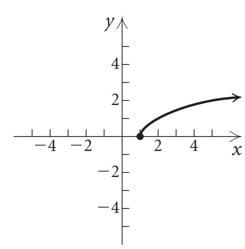


$f(x)=x^2+1$

33. Graph $f(x)=\sqrt{x-1}$.

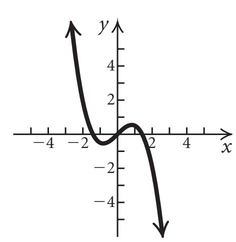
We select values for x and find the corresponding values of $f(x)$. Then we plot the points and connect them with a smooth curve.

x	$f(x)$	$(x, f(x))$
1	0	$(1, 0)$
2	1	$(2, 1)$
4	1.7	$(4, 1.7)$
5	2	$(5, 2)$



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

34.



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

35. From the graph we see that, when the input is 1, the output is -2, so $h(1)=-2$. When the input is 3, the output is 2, so $h(3)=2$. When the input is 4, the output is 1, so $h(4)=1$.

36. $t(-4) = 3$; $t(0) = 3$; $t(3) = 3$

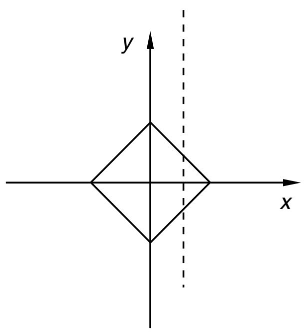
37. From the graph we see that, when the input is -4, the output is 3, so $s(-4) = 3$. When the input is -2, the output is 0, so $s(-2) = 0$. When the input is 0, the output is -3, so $s(0) = -3$.

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

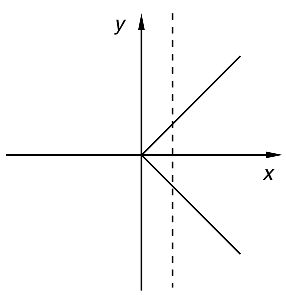
39. From the graph we see that, when the input is -1, the output is 2, so $f(-1) = 2$. When the input is 0, the output is 0, so $f(0) = 0$. When the input is 1, the output is -2, so $f(1) = -2$.

40. $g(-2) = 4$; $g(0) = -4$; $g(2.4) = -2.6176$

41. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.



42. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.



43. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

44. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

45. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

46. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

47. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.

48. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.

49. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty, \infty)$.

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52. The input 0 results in a denominator of 0. Thus, the domain is $\{x|x \neq 0\}$, or $(-\infty, 0) \cup (0, \infty)$.

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54. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty, \infty)$.

55. We can substitute any real number in the numerator, but we must avoid inputs that make the denominator 0. We find these inputs.

$$\begin{aligned} 2 - x &= 0 \\ 2 &= x \end{aligned}$$

The domain is $\{x|x \neq 2\}$, or $(-\infty, 2) \cup (2, \infty)$.

56. We find the inputs that make the denominator 0:

$$\begin{aligned} x + 4 &= 0 \\ x &= -4 \end{aligned}$$

The domain is $\{x|x \neq -4\}$, or $(-\infty, -4) \cup (-4, \infty)$.

57. We find the inputs that make the denominator 0:

$$\begin{aligned} x^2 - 4x - 5 &= 0 \\ (x - 5)(x + 1) &= 0 \\ x - 5 = 0 \quad &or \quad x + 1 = 0 \\ x = 5 \quad &or \qquad x = -1 \end{aligned}$$

The domain is $\{x|x \neq 5 \text{ and } x \neq -1\}$, or $(-\infty, -1) \cup (-1, 5) \cup (5, \infty)$.

58. We can substitute any real number in the numerator, but the input 0 makes the denominator 0. Thus, the domain is $\{x|x \neq 0\}$, or $(-\infty, 0) \cup (0, \infty)$.

59. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty, \infty)$.

60. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty, \infty)$.

61. We can substitute any real number in the numerator, but we must avoid inputs that make the denominator 0. We find these inputs.

$$\begin{aligned} x^2 - 7x &= 0 \\ x(x - 7) &= 0 \\ x = 0 \text{ or } x - 7 &= 0 \\ x = 0 \text{ or } \qquad x &= 7 \end{aligned}$$

The domain is $\{x|x \neq 0 \text{ and } x \neq 7\}$, or $(-\infty, 0) \cup (0, 7) \cup (7, \infty)$.

62. We can substitute any real number in the numerator, but we must avoid inputs that make the denominator 0. We find these inputs.

$$\begin{aligned} 3x^2 - 10x - 8 &= 0 \\ (3x + 2)(x - 4) &= 0 \end{aligned}$$

$$3x+2=0 \quad or \; x-4=0$$
$$3x=-2 \quad or \quad x=4$$
$$x=-\frac{2}{3} \quad or \quad x=4$$

The domain is $\left\{x \middle| x \neq -\frac{2}{3} \text{ and } x \neq 4\right\}$, or $\left(-\infty,-\frac{2}{3}\right) \cup \left(-\frac{2}{3},4\right) \cup (4,\infty)$.

63. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

64. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

65. The inputs on the x-axis that correspond to points on the graph extend from 0 to 5, inclusive. Thus, the domain is $\{x|0 \leq x \leq 5\}$, or $[0,5]$.

The outputs on the y-axis extend from 0 to 3, inclusive. Thus, the range is $\{y|0 \leq y \leq 3\}$, or $[0,3]$.

66. The inputs on the x-axis that correspond to points on the graph extend from -3 up to but not including 5. Thus, the domain is $\{x|-3 \leq x < 5\}$, or $[-3,5)$.

The outputs on the y-axis extend from -4 up to but not including 1. Thus, the range is $\{y|-4 \leq y < 1\}$, or $[-4,1)$.

67. The inputs on the x-axis that correspond to points on the graph extend from -2π to 2π inclusive. Thus, the domain is $\{x|-2\pi \leq x \leq 2\pi\}$, or $[-2\pi,2\pi]$.

The outputs on the y-axis extend from -1 to 1, inclusive. Thus, the range is $\{y|-1 \leq y \leq 1\}$, or $[-1,1]$.

68. The inputs on the x-axis that correspond to points on the graph extend from -2 to 1, inclusive. Thus, the domain is $\{x|-2 \leq x \leq 1\}$, or $[-2,1]$.

The outputs on the y-axis extend from -1 to 4, inclusive. Thus, the range is $\{y|-1 \leq y \leq 4\}$, or $[-1,4]$.

69. The graph extends to the left and to the right without bound. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

The only output is -3, so the range is $\{-3\}$.

70. The graph extends to the left and to the right without bound. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

The outputs on the y-axis start at -3 and increase without bound. Thus, the range is $[-3,\infty)$.

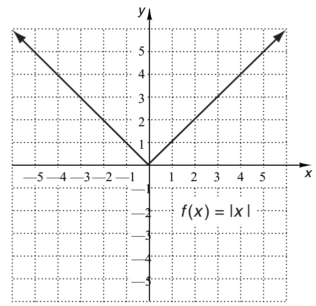
71. The inputs on the x-axis extend from -5 to 3, inclusive. Thus, the domain is $[-5,3]$.

The outputs on the y-axis extend from -2 to 2, inclusive. Thus, the range is $[-2,2]$.

72. The inputs on the x-axis extend from -2 to 4, inclusive. Thus, the domain is $[-2,4]$.

The only output is 4. Thus, the range is $\{4\}$.

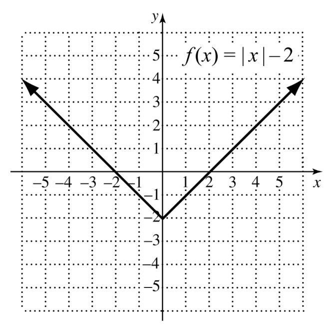
73.



To find the domain we look for the inputs on the x-axis that correspond to a point on the graph. We see that each point on the x-axis corresponds to a point on the graph so the domain is the set of all real numbers, or $(-\infty,\infty)$.

To find the range we look for outputs on the y-axis. The number 0 is the smallest output, and every number greater than 0 is also an output. Thus, the range is $[0,\infty)$.

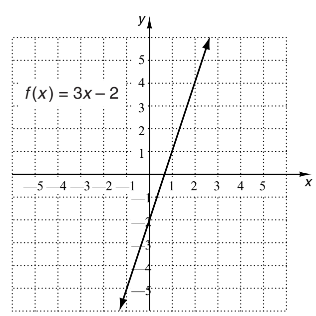
74.



Domain: all real numbers $(-\infty,\infty)$

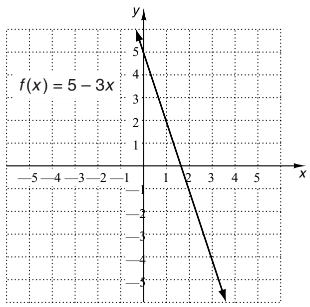
Range: $[-2,\infty)$

75.



We see that each point on the x-axis corresponds to a point on the graph so the domain is the set of all real numbers, or $(-\infty,\infty)$. We also see that each point on the y-axis corresponds to an output so the range is the set of all real numbers, or $(-\infty,\infty)$.

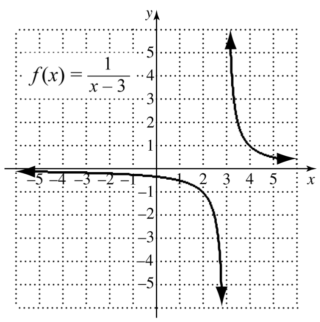
76.



Domain: all real numbers, or $(-\infty, \infty)$

Range: all real numbers, or $(-\infty, \infty)$

77.

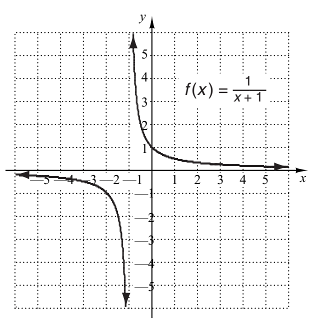


Since the graph does not touch or cross either the vertical line $x = 3$ or the x-axis, $y = 0$, 3 is excluded from the domain and 0 is excluded from the range.

Domain: $(-\infty, 3) \cup (3, \infty)$

Range: $(-\infty, 0) \cup (0, \infty)$

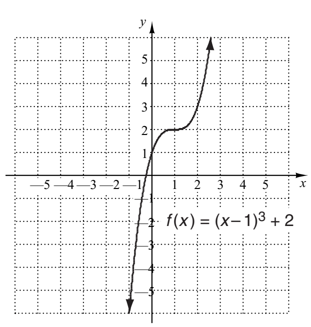
78.



Domain: $(-\infty, -1) \cup (-1, \infty)$

Range: $(-\infty, 0) \cup (0, \infty)$

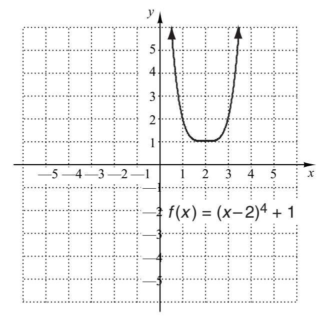
79.



Each point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty, \infty)$.

Each point on the y-axis also corresponds to a point on the graph, so the range is the set of all real numbers, $(-\infty, \infty)$.

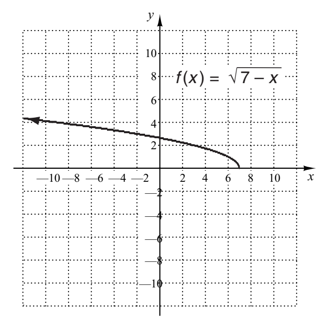
80.



Domain: all real numbers, or $(-\infty, \infty)$

Range: $[1, \infty)$

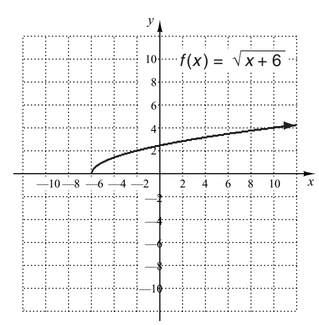
81.



The largest input on the x-axis is 7 and every number less than 7 is also an input. Thus, the domain is $(-\infty, 7]$.

The number 0 is the smallest output, and every number greater than 0 is also an output. Thus, the range is $[0, \infty)$.

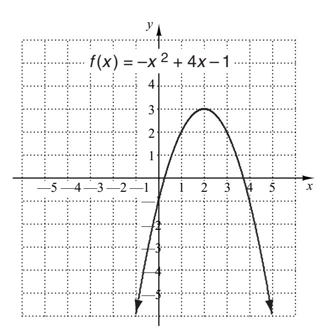
82.



Domain: $[-8, \infty)$

Range: $[0, \infty)$

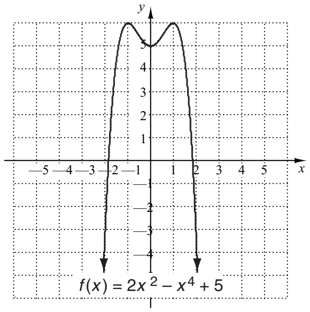
83.



Each point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty, \infty)$.

The largest output is 3 and every number less than 3 is also an output. Thus, the range is $(-\infty, 3]$.

84.



Domain: all real numbers, or $(-\infty, \infty)$

Range: $(-\infty, 6]$

85. a) $V(33) = 0.4306(33) + 11.0043 \approx \$25.21$

$V(40) = 0.4306(40) + 11.0043 \approx \$28.23$

b) Substitute 32 for $V(x)$ and solve for x.

$$32 = 0.4306x + 11.0043$$
$$20.9957 = 0.4306x$$
$$49 \approx x$$

It will take approximately \$32 to equal the value of \$1 in 1913 about 49 years after 1985, or in 2034.

86. a) $P(30) = 2,578,409(30) + 151,116,864 = 228,469,134$

$P(68) = 2,578,409(68) + 151,116,864 = 326,448,676$

b)
$$400,000,000 = 2,578,409x + 151,116,864$$
$$248,883,136 = 2,578,409x$$
$$97 \approx x$$

The population will be approximately 400,000,000 about 97 years after 1950, or in 2047.

87. $E(t) = 1000(100 - t) + 580(100 - t)^2$

a)
$$\begin{aligned} E(99.5) &= 1000(100-99.5)+580(100-99.5)^2 \\ &= 1000(0.5) + 580(0.5)^2 \\ &= 500 + 580(0.25) = 500 + 145 \\ &= 645 \text{ m above sea level} \end{aligned}$$

b)
$$\begin{aligned} E(100) &= 1000(100 - 100) + 580(100 - 100)^2 \\ &= 1000 \cdot 0 + 580(0)^2 = 0 + 0 \\ &= 0 \text{ m above sea level, or at sea level} \end{aligned}$$

88. $P(15) = 0.015(15)^3 = 50.625$ watts per hour

$P(35) = 0.015(35)^3 = 643.125$ watts per hour

89. For $(-3, -2)$:
$$\begin{array}{r|l} \multicolumn{2}{c}{y^2 - x^2 = -5} \\ \hline (-2)^2 - (-3)^2 \ ? & -5 \\ 4 - 9 & \\ -5 & -5 \quad \text{TRUE} \end{array}$$

The equation $-5 = -5$ is true, so $(-3, -2)$ is a solution.

For $(2, -3)$:
$$\begin{array}{r|l} \multicolumn{2}{c}{y^2 - x^2 = -5} \\ \hline (-3)^2 - 2^2 \ ? & -5 \\ 9 - 4 & \\ 5 & -5 \quad \text{FALSE} \end{array}$$

The equation $5 = -5$ is false, so $(2, -3)$ is not a solution.

90. To determine whether $(0, -7)$ is a solution, substitute 0 for x and -7 for y.
$$\begin{array}{r|l} \multicolumn{2}{c}{y = 0.5x + 7} \\ \hline -7 \ ? & 0.5(0) + 7 \\ & 0 + 7 \\ -7 & 7 \qquad \text{FALSE} \end{array}$$

The equation $-7 = 7$ is false, so $(0, -7)$ is not a solution.

To determine whether $(8, 11)$ is a solution, substitute 8 for x and 11 for y.
$$\begin{array}{r|l} \multicolumn{2}{c}{y = 0.5x + 7} \\ \hline 11 \ ? & 0.5(8) + 7 \\ & 4 + 7 \\ 11 & 11 \qquad \text{TRUE} \end{array}$$

The equation $11 = 11$ is true, so $(8, 11)$ is a solution.

91. For $\left(\frac{4}{5}, -2\right)$:
$$\begin{array}{r|l} \multicolumn{2}{c}{15x - 10y = 32} \\ \hline 15 \cdot \frac{4}{5} - 10(-2) \ ? & 32 \\ 12 + 20 & \\ 32 & 32 \quad \text{TRUE} \end{array}$$

The equation $32 = 32$ is true, so $\left(\frac{4}{5}, -2\right)$ is a solution.

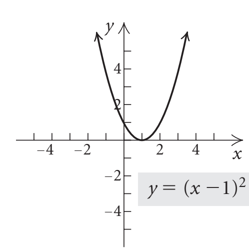
For $\left(\frac{11}{5}, \frac{1}{10}\right)$:
$$\begin{array}{r|l} \multicolumn{2}{c}{15x - 10y = 32} \\ \hline 15 \cdot \frac{11}{5} - 10 \cdot \frac{1}{10} \ ? & 32 \\ 33 - 1 & \\ 32 & 32 \quad \text{TRUE} \end{array}$$

The equation $32 = 32$ is true, so $\left(\frac{11}{5}, \frac{1}{10}\right)$ is a solution.

92. Graph $y = (x - 1)^2$.

Make a table of values, plot the points in the table, and draw the graph.

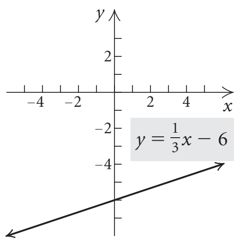
x	y	(x, y)
-1	4	$(-1, 4)$
0	1	$(0, 1)$
1	0	$(1, 0)$
2	1	$(2, 1)$
3	4	$(3, 4)$



93. Graph $y = \frac{1}{3}x - 6$.

Make a table of values, plot the points in the table, and draw the graph. If we choose values of x that are multiples of 3, we can avoid adding or subtracting fractions.

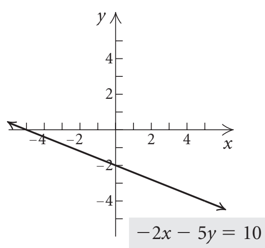
x	y	(x, y)
-3	-7	$(-3, -7)$
0	-6	$(0, -6)$
3	-5	$(0, -5)$



94. Graph $-2x - 5y = 10$.

Make a table of values, plot the points in the table, and draw the graph.

x	y	(x, y)
-5	0	$(-5, 0)$
0	-2	$(0, -2)$
5	-4	$(5, -4)$

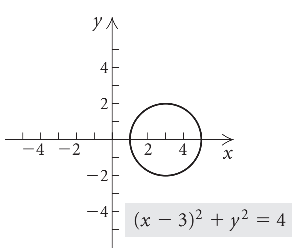


95. Graph $(x-3)^2 + y^2 = 4$.

This is the equation of a circle. Writing it in standard form, we have

$$(x-3)^2 + (y-0)^2 = 2^2.$$

The circle has center $(3, 0)$ and radius 2.



96. We find the inputs for which $2x + 5$ is nonnegative.

$$2x + 5 \ge 0$$
$$2x \ge -5$$
$$x \ge -\frac{5}{2}$$

Thus, the domain is $\left\{x \middle| x \ge -\frac{5}{2}\right\}$, or $\left[-\frac{5}{2}, \infty\right)$.

97. In the numerator we can substitute any real number for which the radicand is nonnegative. We see that $x + 1 \ge 0$ for $x \ge -1$. The denominator is 0 when $x = 0$, so 0 cannot be an input. Thus the domain is $\{x | x \ge -1 \textit{ and } x \ne 0\}$, or $[-1, 0) \cup (0, \infty)$.

98. $\sqrt{x+6}$ is not defined for values of x for which $x + 6$ is negative. We find the inputs for which $x+6$ is nonnegative.

$$x + 6 \ge 0$$
$$x \ge -6$$

We must also avoid inputs that make the denominator 0.

$$(x+2)(x-3) = 0$$
$$x + 2 = 0 \quad \textit{or} \quad x - 3 = 0$$
$$x = -2 \quad \textit{or} \quad x = 3$$

Then the domain is $\{x | x \ge -6 \textit{ and } x \ne -2 \textit{ and } x \ne 3\}$, or $[-6, -2) \cup (-2, 3) \cup (3, \infty)$.

99. $\sqrt{x}$ is defined for $x \ge 0$.

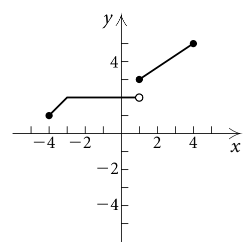
We find the inputs for which $4 - x$ is nonnegative.

$$4 - x \ge 0$$
$$4 \ge x, \text{ or } x \le 4$$

The domain is $\{x | 0 \le x \le 4\}$, or $[0, 4]$.

100. Answers may vary. Two possibilities are $f(x) = x$, $g(x) = x + 1$ and $f(x) = x^2$, $g(x) = x^2 - 4$.

101.



102. First find the value of x for which $x + 3 = -1$.

$$x + 3 = -1$$
$$x = -4$$

Then we have:

$$g(x+3) = 2x + 1$$
$$g(-1) = g(-4+3) = 2(-4) + 1 = -8 + 1 = -7$$

103. $f(x) = |x+3| - |x-4|$

a) If x is in the interval $(-\infty, -3)$, then $x + 3 < 0$ and $x - 4 < 0$. We have:

$$\begin{aligned} f(x) &= |x+3| - |x-4| \\ &= -(x+3) - [-(x-4)] \\ &= -(x+3) - (-x+4) \\ &= -x - 3 + x - 4 \\ &= -7 \end{aligned}$$

b) If x is in the interval $[-3, 4)$, then $x + 3 \ge 0$ and $x - 4 < 0$. We have:

$$\begin{aligned} f(x) &= |x+3| - |x-4| \\ &= x + 3 - [-(x-4)] \\ &= x + 3 - (-x+4) \\ &= x + 3 + x - 4 \\ &= 2x - 1 \end{aligned}$$

c) If x is in the interval $[4, \infty)$, then $x+3>0$ and $x-4 \geq 0$. We have:

$$\begin{aligned} f(x) &= |x+3| - |x-4| \\ &= x+3-(x-4) \\ &= x+3-x+4 \\ &= 7 \end{aligned}$$

Exercise Set 1.3

1. a) Yes. Each input is 1 more than the one that precedes it.

b) Yes. Each output is 3 more than the one that precedes it.

c) Yes. Constant changes in inputs result in constant changes in outputs.

2. a) Yes. Each input is 10 more than the one that precedes it.

b) No. The change in the outputs varies.

c) No. Constant changes in inputs do not result in constant changes in outputs.

3. a) Yes. Each input is 15 more than the one that precedes it.

b) No. The change in the outputs varies.

c) No. Constant changes in inputs do not result in constant changes in outputs.

4. a) Yes. Each input is 2 more than the one that precedes it.

b) Yes. Each output is 4 less than the one that precedes it.

c) Yes. Constant changes in inputs result in constant changes in outputs.

5. Two points on the line are $(-4,-2)$ and $(1,4)$.

$$m = \frac{y_2-y_1}{x_2-x_1} = \frac{4-(-2)}{1-(-4)} = \frac{6}{5}$$

6. $m = \dfrac{-5-1}{3-(-3)} = \dfrac{-6}{6} = -1$

7. Two points on the line are $(0,3)$ and $(5,0)$.

$$m = \frac{y_2-y_1}{x_2-x_1} = \frac{0-3}{5-0} = \frac{-3}{5}, \text{ or } -\frac{3}{5}$$

8. $m = \dfrac{0-(-3)}{-2-(-2)} = \dfrac{3}{0}$

The slope is not defined.

9. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{3-3}{3-0} = \dfrac{0}{3} = 0$

10. $m = \dfrac{1-(-4)}{5-(-3)} = \dfrac{5}{8}$

11. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{2-4}{-1-9} = \dfrac{-2}{-10} = \dfrac{1}{5}$

12. $m = \dfrac{-1-7}{5-(-3)} = \dfrac{-8}{8} = -1$

13. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{6-(-9)}{4-4} = \dfrac{15}{0}$

Since division by 0 is not defined, the slope is not defined.

14. $m = \dfrac{-13-(-1)}{2-(-6)} = \dfrac{-12}{8} = -\dfrac{3}{2}$

15. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{-0.4-(-0.1)}{-0.3-0.7} = \dfrac{-0.3}{-1} = 0.3$

16. $m = \dfrac{-\frac{5}{7}-\left(-\frac{1}{4}\right)}{\frac{2}{7}-\left(-\frac{3}{4}\right)} = \dfrac{-\frac{20}{28}+\frac{7}{28}}{\frac{8}{28}+\frac{21}{28}} = \dfrac{-\frac{13}{28}}{\frac{29}{28}} =$

$-\dfrac{13}{28}\cdot\dfrac{28}{29} = -\dfrac{13}{29}$

17. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{-2-(-2)}{4-2} = \dfrac{0}{2} = 0$

18. $m = \dfrac{-6-8}{7-(-9)} = \dfrac{-14}{16} = -\dfrac{7}{8}$

19. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{\frac{3}{5}-\left(-\frac{3}{5}\right)}{-\frac{1}{2}-\frac{1}{2}} = \dfrac{\frac{6}{5}}{-1} = -\dfrac{6}{5}$

20. $m = \dfrac{-2.16-4.04}{3.14-(-8.26)} = \dfrac{-6.2}{11.4} = -\dfrac{62}{114} = -\dfrac{31}{57}$

21. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{-5-(-13)}{-8-16} = \dfrac{8}{-24} = -\dfrac{1}{3}$

22. $m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{2-(-3)}{\pi-\pi} = \dfrac{5}{0}$

The slope is not defined.

23. $m = \dfrac{7-(-7)}{-10-(-10)} = \dfrac{14}{0}$

Since division by 0 is not defined, the slope is not defined.

24. $m = \dfrac{-4-(-4)}{0.56-\sqrt{2}} = \dfrac{0}{0.56-\sqrt{2}} = 0$

25. We have the points $(4,3)$ and $(-2,15)$.

$$m = \frac{y_2-y_1}{x_2-x_1} = \frac{15-3}{-2-4} = \frac{12}{-6} = -2$$

26. $m = \dfrac{-5-1}{-4-4} = \dfrac{-6}{-8} = \dfrac{3}{4}$

27. We have the points $\left(\dfrac{1}{5}, \dfrac{1}{2}\right)$ and $\left(-1, -\dfrac{11}{2}\right)$.

$$m = \frac{y_2-y_1}{x_2-x_1} = \frac{-\frac{11}{2}-\frac{1}{2}}{-1-\frac{1}{5}} = \frac{-6}{-\frac{6}{5}} = -6\cdot\left(-\frac{5}{6}\right) = 5$$

28. $m = \dfrac{\frac{10}{3}-(-1)}{-\frac{2}{3}-8} = \dfrac{\frac{13}{3}}{-\frac{26}{3}} = \dfrac{13}{3}\cdot\left(-\dfrac{3}{26}\right) = -\dfrac{1}{2}$

29. We have the points $\left(-6, \frac{4}{5}\right)$ and $\left(0, \frac{4}{5}\right)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{4}{5} - \frac{4}{5}}{-6 - 0} = \frac{0}{-6} = 0$$

30. $m = \dfrac{-\frac{5}{2} - \frac{2}{9}}{\frac{2}{5} - \left(-\frac{9}{2}\right)} = \dfrac{-\frac{49}{18}}{\frac{49}{10}} = -\frac{49}{18} \cdot \frac{10}{49} = -\frac{5}{9}$

31. $y = 1.3x - 5$ is in the form $y = mx + b$ with $m = 1.3$, so the slope is 1.3.

32. $-\frac{2}{5}$

33. The graph of $x = -2$ is a vertical line, so the slope is not defined.

34. 4

35. $f(x) = -\frac{1}{2}x + 3$ is in the form $y = mx + b$ with $m = -\frac{1}{2}$, so the slope is $-\frac{1}{2}$.

36. The graph of $y = \frac{3}{4}$ is a horizontal line, so the slope is 0. (We also see this if we write the equation in the form $y = 0x + \frac{3}{4}$.)

37. $y = 9 - x$ can be written as $y = -x + 9$, or $y = -1 \cdot x + 9$. Now we have an equation in the form $y = mx + b$ with $m = -1$, so the slope is -1.

38. The graph of $x = 8$ is a vertical line, so the slope is not defined.

39. The graph of $y = 0.7$ is a horizontal line, so the slope is 0. (We also see this if we write the equation in the form $y = 0x + 0.7$).

40. $y = \frac{4}{5} - 2x$, or $y = -2x + \frac{4}{5}$

The slope is -2.

41. We have the points $(2013, 8.4)$ and $(2020, 10.8)$. We find the average rate of change, or slope.

$m = \dfrac{10.8 - 8.4}{2020 - 2013} = \dfrac{2.4}{7} \approx 0.343$

The average rate of change in sales of electric bicycles from 2013 to 2020 is expected to be about \$0.343 billion per year, or \$343 million per year.

42. $m = \dfrac{701,475 - 1,027,974}{2012 - 1990} = \dfrac{-326,499}{22} \approx -14,841$

The average rate of change in the population in Detroit, Michigan, over the 22-year period was about $-14,841$ people per year.

43. We have the data points $(2000, 478, 403)$ and $(2012, 390, 928)$. We find the average rate of change, or slope.

$m = \dfrac{390,928 - 478,403}{2012 - 2000} = \dfrac{-87,475}{12} \approx -7290$

The average rate of change in the population of Cleveland, Ohio, over the 12-year period was about -7290 people per year.

44. $m = \dfrac{320 - 141}{2012 - 1998} = \dfrac{179}{14} \approx 12.8$

The average rate of change in the revenue from fireworks in the United States from 1998 to 2012 was about \$12.8 million per year.

45. We have the data points $(2003, 550, 000)$ and $(2012, 810, 000)$. We find the average rate of change, or slope.

$m = \dfrac{810,000 - 550,000}{2012 - 2003} = \dfrac{260,000}{9} \approx 28,889$

The average rate of change in the number of acres used for growing almonds in California from 2003 to 2012 was about 28,889 acres per year.

46. $m = \dfrac{58.4 - 42.5}{2011 - 1990} = \dfrac{15.9}{21} \approx 0.8$

The average rate of change in per capita consumption of chicken from 1990 to 2011 was about 0.8 lb per year.

47. We have the data points $(1970,\ 25.3)$ and $(2011,\ 5.5)$. We find the average rate of change, or slope.

$m = \dfrac{5.5 - 25.3}{2011 - 1970} = \dfrac{-19.8}{41} \approx -0.5$

The average rate of change in the per capita consumption of whole milk from 1970 to 2011 was about -0.5 gallons per year.

48. $m = \dfrac{7.25 - 0.25}{2009 - 1938} = \dfrac{7}{71} \approx 0.099$

The average rate of change in the minimum wage from 1938 to 2009 was about \$0.099 per year.

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

The equation is in the form $y = mx + b$ where $m = \frac{3}{5}$ and $b = -7$. Thus, the slope is $\frac{3}{5}$, and the y-intercept is $(0, -7)$.

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

Slope: -2; y-intercept: $(0, 3)$

51. $x = -\frac{2}{5}$

This is the equation of a vertical line $\frac{2}{5}$ unit to the left of the y-axis. The slope is not defined, and there is no y-intercept.

52. $y = \frac{4}{7} = 0 \cdot x + \frac{4}{7}$

Slope: 0; y-intercept: $\left(0, \frac{4}{7}\right)$

53. $f(x) = 5 - \frac{1}{2}x$, or $f(x) = -\frac{1}{2}x + 5$

The second equation is in the form $y = mx + b$ where $m = -\frac{1}{2}$ and $b = 5$. Thus, the slope is $-\frac{1}{2}$ and the y-intercept is $(0, 5)$.

54. $y = 2 + \dfrac{3}{7}x$

Slope: $\dfrac{3}{7}$; y-intercept: $(0, 2)$

55. Solve the equation for y.

$$\begin{aligned} 3x + 2y &= 10 \\ 2y &= -3x + 10 \\ y &= -\frac{3}{2}x + 5 \end{aligned}$$

Slope: $-\dfrac{3}{2}$; y-intercept: $(0, 5)$

56.

$$\begin{aligned} 2x - 3y &= 12 \\ -3y &= -2x + 12 \\ y &= \frac{2}{3}x - 4 \end{aligned}$$

Slope: $\dfrac{2}{3}$; y-intercept: $(0, -4)$

57. $y = -6 = 0 \cdot x - 6$

Slope: 0; y-intercept: $(0, -6)$

58. $x = 10$

This is the equation of a vertical line 10 units to the right of the y-axis. The slope is not defined, and there is no y-intercept.

59. Solve the equation for y.

$$\begin{aligned} 5y - 4x &= 8 \\ 5y &= 4x + 8 \\ y &= \frac{4}{5}x + \frac{8}{5} \end{aligned}$$

Slope: $\dfrac{4}{5}$; y-intercept: $\left(0, \dfrac{8}{5}\right)$

60.

$$\begin{aligned} 5x - 2y + 9 &= 0 \\ -2y &= -5x - 9 \\ y &= \frac{5}{2}x + \frac{9}{2} \end{aligned}$$

Slope: $\dfrac{5}{2}$; y-intercept: $\left(0, \dfrac{9}{2}\right)$

61. Solve the equation for y.

$$\begin{aligned} 4y - x + 2 &= 0 \\ 4y &= x - 2 \\ y &= \frac{1}{4}x - \frac{1}{2} \end{aligned}$$

Slope: $\dfrac{1}{4}$; y-intercept: $\left(0, -\dfrac{1}{2}\right)$

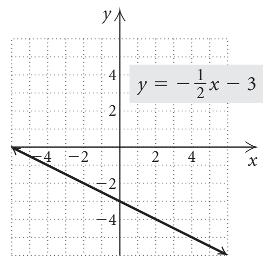
62. $f(x) = 0.3 + x$; or $f(x) = x + 0.3$

Slope: 1; y-intercept: $(0, 0.3)$

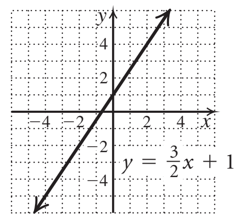
63. Graph $y = -\dfrac{1}{2}x - 3$.

Plot the y-intercept, $(0, -3)$. We can think of the slope as $\dfrac{-1}{2}$. Start at $(0, -3)$ and find another point by moving down 1 unit and right 2 units. We have the point $(2, -4)$.

We could also think of the slope as $\dfrac{1}{-2}$. Then we can start at $(0, -3)$ and get another point by moving up 1 unit and left 2 units. We have the point $(-2, -2)$. Connect the three points to draw the graph.

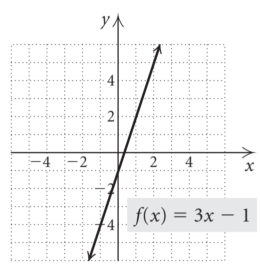


64.



65. Graph $f(x) = 3x - 1$.

Plot the y-intercept, $(0, -1)$. We can think of the slope as $\dfrac{3}{1}$. Start at $(0, -1)$ and find another point by moving up 3 units and right 1 unit. We have the point $(1, 2)$. We can move from the point $(1, 2)$ in a similar manner to get a third point, $(2, 5)$. Connect the three points to draw the graph.



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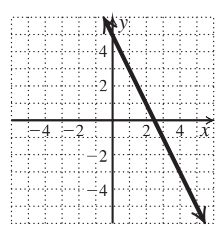


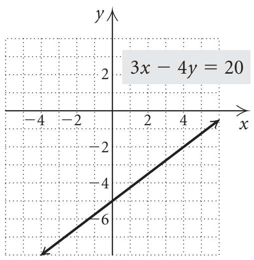
$f(x) = -2x + 5$

67. First solve the equation for y.

$$\begin{aligned} 3x - 4y &= 20 \\ -4y &= -3x + 20 \\ y &= \frac{3}{4}x - 5 \end{aligned}$$

Plot the y-intercept, $(0, -5)$. Then using the slope, $\dfrac{3}{4}$, start at $(0, -5)$ and find another point by moving up

3 units and right 4 units. We have the point $(4, -2)$. We can move from the point $(4, -2)$ in a similar manner to get a third point, $(8, 1)$. Connect the three points to draw the graph.



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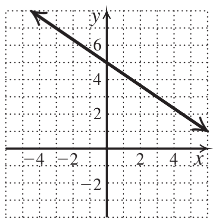
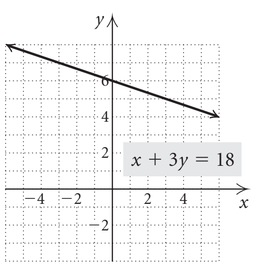


$2x + 3y = 15$

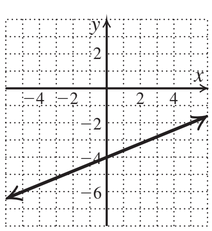
69. First solve the equation for y.

$$x + 3y = 18$$
$$3y = -x + 18$$
$$y = -\frac{1}{3}x + 6$$

Plot the y-intercept, $(0, 6)$. We can think of the slope as $\frac{-1}{3}$. Start at $(0, 6)$ and find another point by moving down 1 unit and right 3 units. We have the point $(3, 5)$. We can move from the point $(3, 5)$ in a similar manner to get a third point, $(6, 4)$. Connect the three points and draw the graph.



70.



$5y - 2x = -20$

71. $P(0) = \frac{1}{33} \cdot 0 + 1 = 1$ atm

$P(33) = \frac{1}{33} \cdot 33 + 1 = 2$ atm

$P(1000) = \frac{1}{33} \cdot 1000 + 1 = 31\frac{10}{33}$ atm

$P(5000) = \frac{1}{33} \cdot 5000 + 1 = 152\frac{17}{33}$ atm

$P(7000) = \frac{1}{33} \cdot 7000 + 1 = 213\frac{4}{33}$ atm

72. $D(F) = 2F + 115$

a) $D(0) = 2 \cdot 0 + 115 = 115$ ft

$D(-20) = 2(-20) + 115 = -40 + 115 = 75$ ft

$D(10) = 2 \cdot 10 + 115 = 20 + 115 = 135$ ft

$D(32) = 2 \cdot 32 + 115 = 64 + 115 = 179$ ft

b) Below $-57.5°$, stopping distance is negative; above $32°$, ice doesn't form. The domain should be restricted to $[-57.5°, 32°]$.

73. a) $D(r) = \frac{11}{10}r + \frac{1}{2}$

The slope is $\frac{11}{10}$.

For each mph faster the car travels, it takes $\frac{11}{10}$ ft longer to stop.

b) $D(5) = \frac{11}{10} \cdot 5 + \frac{1}{2} = \frac{11}{2} + \frac{1}{2} = \frac{12}{2} = 6$ ft

$D(10) = \frac{11}{10} \cdot 10 + \frac{1}{2} = 11 + \frac{1}{2} = 11\frac{1}{2}$, or 11.5 ft

$D(20) = \frac{11}{10} \cdot 20 + \frac{1}{2} = 22 + \frac{1}{2} = 22\frac{1}{2}$, or 22.5 ft

$D(50) = \frac{11}{10} \cdot 50 + \frac{1}{2} = 55 + \frac{1}{2} = 55\frac{1}{2}$, or 55.5 ft

$D(65) = \frac{11}{10} \cdot 65 + \frac{1}{2} = \frac{143}{2} + \frac{1}{2} = \frac{144}{2} = 72$ ft

c) The speed cannot be negative. $D(0) = \frac{1}{2}$ which says that a stopped car travels $\frac{1}{2}$ ft before stopping. Thus, 0 is not in the domain. The speed can be positive, so the domain is $\{r|r > 0\}$, or $(0, \infty)$.

74. $V(t) = \$38,000 - \$4300t$

a) $V(0) = \$38,000 - \$4300 \cdot 0 = \$38,000$

$V(1) = \$38,000 - \$4300 \cdot 1 = \$33,700$

$V(2) = \$38,000 - \$4300 \cdot 2 = \$29,400$

$V(3) = \$38,000 - \$4300 \cdot 3 = \$25,100$

$V(5) = \$38,000 - \$4300 \cdot 5 = \$16,500$

b) Since the time must be nonnegative and not more than 5 years, the domain is $[0, 5]$. The value starts at \$38,000 and declines to \$16,500, so the range is $[16,500,\ 38,000]$.

75. $C(t) = 2250 + 3380t$

$C(20) = 2250 + 3380 \cdot 20 = \$69,850$

76. $C(t) = 95 + 125t$
$C(18) = 95 + 125(18) = \$2345$

77. $C(x) = 750 + 15x$
$C(32) = 750 + 15 \cdot 32 = \$1230$

78. $C(x) = 1250 + 4.25x$
$C(85) = 1250 + 4.25(85) = \$1611.25$

79. $f(x) = x^2 - 3x$
$$f\left(\frac{1}{2}\right) = \left(\frac{1}{2}\right)^2 - 3 \cdot \frac{1}{2} = \frac{1}{4} - \frac{3}{2} = -\frac{5}{4}$$

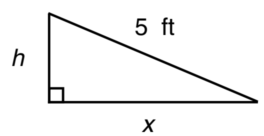
80. $f(5) = 5^2 - 3 \cdot 5 = 10$

81. $f(x) = x^2 - 3x$
$f(-5) = (-5)^2 - 3(-5) = 25 + 15 = 40$

82. $f(x) = x^2 - 3x$
$f(-a) = (-a)^2 - 3(-a) = a^2 + 3a$

83. $f(x) = x^2 - 3x$
$f(a+h) = (a+h)^2 - 3(a+h) = a^2 + 2ah + h^2 - 3a - 3h$

84. We make a drawing and label it. Let $h =$ the height of the triangle, in feet.



Using the Pythagorean theorem we have:
$$\begin{aligned} x^2 + h^2 &= 25 \\ x^2 &= 25 - h^2 \\ x &= \sqrt{25 - h^2} \end{aligned}$$

We know that the grade of the treadmill is 8%, or 0.08. Then we have
$$\begin{aligned} \frac{h}{x} &= 0.08 \\ \frac{h}{\sqrt{25-h^2}} &= 0.08 \quad \text{Substituting } \sqrt{25-h^2} \text{ for } x \\ \frac{h^2}{25-h^2} &= 0.0064 \quad \text{Squaring both sides} \\ h^2 &= 0.16 - 0.0064h^2 \\ 1.0064h^2 &= 0.16 \\ h^2 &= \frac{0.16}{1.0064} \\ h &\approx 0.4 \text{ ft} \end{aligned}$$

85. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{(a+h)^2 - a^2}{a + h - a} = \dfrac{a^2 + 2ah + h^2 - a^2}{h} =$
$\dfrac{2ah + h^2}{h} = \dfrac{h(2a+h)}{h} = 2a + h$

86. $m = \dfrac{s - (s+t)}{r - r} = \dfrac{s - s - t}{0}$
The slope is not defined.

87. False. For example, let $f(x) = x + 1$. Then $f(c-d) = c - d + 1$, but $f(c) - f(d) = c + 1 - (d+1) = c - d$.

88. False. For example, let $f(x) = x+1$. Then $f(kx) = kx+1$, but $kf(x) = k(x+1) = kx + k \neq kx + 1$ for $k \neq 1$.

89.
$$\begin{aligned} f(x) &= mx + b \\ f(x+2) &= f(x) + 2 \\ m(x+2) + b &= mx + b + 2 \\ mx + 2m + b &= mx + b + 2 \\ 2m &= 2 \\ m &= 1 \end{aligned}$$
Thus, $f(x) = 1 \cdot x + b$, or $f(x) = x + b$.

90.
$$\begin{aligned} 3mx + b &= 3(mx + b) \\ 3mx + b &= 3mx + 3b \\ b &= 3b \\ 0 &= 2b \\ 0 &= b \end{aligned}$$
Thus, $f(x) = mx + 0$, or $f(x) = mx$.

Chapter 1 Mid-Chapter Mixed Review

1. The statement is false. The x-intercept of a line that passes through the origin is $(0,0)$.

2. The statement is true. See the definitions of a function and a relation on pages 18 and 19, respectively.

3. The statement is false. The line parallel to the y-axis that passes through $(-5, 25)$ is $x = -5$.

4. To find the x-intercept we replace y with 0 and solve for x.
$$\begin{aligned} -8x + 5y &= -40 \\ -8x + 5 \cdot 0 &= -40 \\ -8x &= -40 \\ x &= 5 \end{aligned}$$
The x-intercept is $(5, 0)$.
To find the y-intercept we replace x with 0 and solve for y.
$$\begin{aligned} -8x + 5y &= -40 \\ -8 \cdot 0 + 5y &= -40 \\ 5y &= -40 \\ y &= -8 \end{aligned}$$
The y-intercept is $(0, -8)$.

5. Distance:
$$\begin{aligned} d &= \sqrt{(-8-3)^2 + (-15-7)^2} \\ &= \sqrt{(-11)^2 + (-22)^2} \\ &= \sqrt{121 + 484} \\ &= \sqrt{605} \approx 24.6 \end{aligned}$$

Midpoint: $\left(\dfrac{-8+3}{2}, \dfrac{-15+7}{2}\right) = \left(\dfrac{-5}{2}, \dfrac{-8}{2}\right) =$
$\left(-\dfrac{5}{2}, -4\right)$

6. Distance:

$$d = \sqrt{\left(-\frac{3}{4}-\frac{1}{4}\right)^2 + \left[\frac{1}{5}-\left(-\frac{4}{5}\right)\right]^2}$$
$$= \sqrt{(-1)^2+1^2} = \sqrt{1+1}$$
$$= \sqrt{2} \approx 1.4$$

Midpoint: $\left(\dfrac{-\frac{3}{4}+\frac{1}{4}}{2}, \dfrac{\frac{1}{5}+\left(-\frac{4}{5}\right)}{2}\right) = \left(\dfrac{-\frac{1}{2}}{2}, \dfrac{-\frac{3}{5}}{2}\right) =$
$\left(-\dfrac{1}{4}, -\dfrac{3}{10}\right)$

7.
$$(x-h)^2+(y-k)^2 = r^2$$
$$(x-(-5))^2+(y-2)^2 = 13^2$$
$$(x+5)^2+(y-2)^2 = 169$$

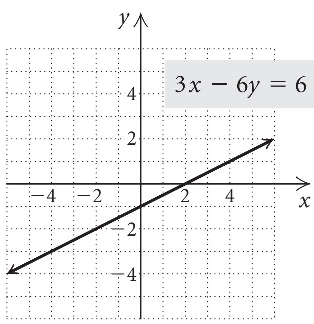
8.
$$(x-3)^2+(y+1)^2 = 4$$
$$(x-3)^2+(y-(-1))^2 = 2^2$$

Center: $(3,-1)$; radius: 2

9. Graph $3x-6y=6$.

We will find the intercepts along with a third point on the graph. Make a table of values, plot the points, and draw the graph.

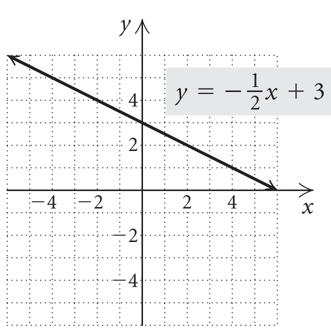
x	y	(x,y)
2	0	$(2,0)$
0	-1	$(0,-1)$
4	1	$(4,1)$



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

We choose some values for x and find the corresponding y-values. We list these points in a table, plot them, and draw the graph.

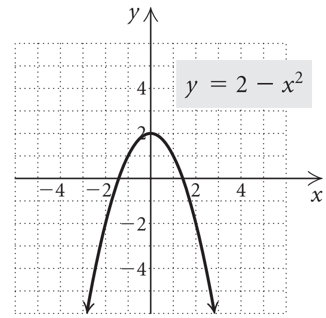
x	y	(x,y)
-2	4	$(-2,4)$
0	3	$(0,3)$
2	2	$(2,2)$



11. Graph $y = 2-x^2$.

We choose some values for x and find the corresponding y-values. We list these points in a table, plot them, and draw the graph.

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

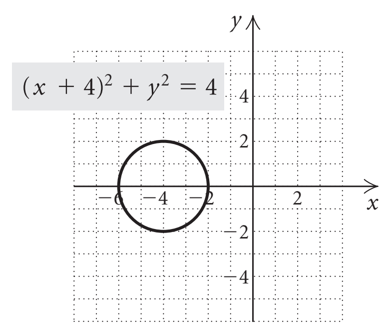


12. Graph $(x+4)^2+y^2=4$.

This is an equation of a circle. We write it in standard form.

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

The center is $(-4,0)$, and the radius is 2. We draw the graph.



13. $f(x) = x-2x^2$
$f(-4) = -4-2(-4)^2 = -4-2\cdot 16 = -4-32 = -36$
$f(0) = 0-2\cdot 0^2 = 0-0 = 0$
$f(1) = 1-2\cdot 1^2 = 1-2\cdot 1 = 1-2 = -1$

14. $g(x) = \dfrac{x+6}{x-3}$

$g(-6) = \dfrac{-6+6}{-6-3} = \dfrac{0}{-9} = 0$

$g(0) = \dfrac{0+6}{0-3} = \dfrac{6}{-3} = -2$

$g(3) = \dfrac{3+6}{3-3} = \dfrac{9}{0}$

Since division by 0 is not defined, $g(3)$ does not exist.

15. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

16. We find the inputs for which the denominator is 0.

$$x+5 = 0$$
$$x = -5$$

The domain is $\{x|x \neq -5\}$, or $(-\infty,-5)\cup(-5,\infty)$.

17. We find the inputs for which the denominator is 0.

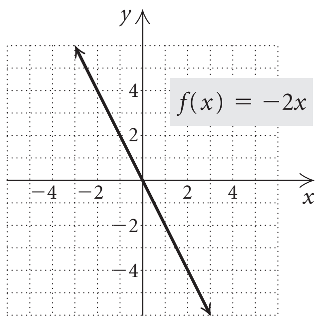
$$x^2 + 2x - 3 = 0$$
$$(x+3)(x-1) = 0$$
$$x + 3 = 0 \quad or \quad x - 1 = 0$$
$$x = -3 \quad or \quad x = 1$$

The domain is $\{x | x \neq -3 \; and \; x \neq 1\}$, or $(-\infty, -3) \cup (-3, 1) \cup (1, \infty)$.

18. Graph $f(x) = -2x$.

Make a table of values, plot the points in the table, and draw the graph.

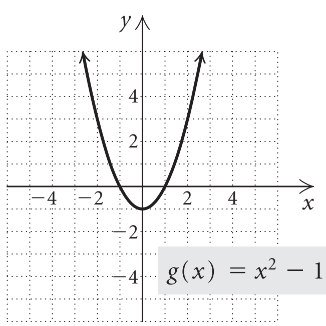
x	$f(x)$	$(x, f(x))$
-2	4	$(-2, 4)$
0	0	$(0, 0)$
2	-4	$(2, -4)$



19. Graph $g(x) = x^2 - 1$.

Make a table of values, plot the points in the table, and draw the graph.

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



20. The inputs on the x-axis that correspond to points on the graph extend from -4 to 3, not including 3. Thus the domain is $[-4, 3)$.

The outputs on the y-axis extend from -4 to 5, not including 5. Thus, the range is $[-4, 5)$.

21. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-5 - 13}{-2 - (-2)} = \dfrac{-18}{0}$

Since division by 0 is not defined, the slope is not defined.

22. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3 - (-1)}{-6 - 10} = \dfrac{4}{-16} = -\dfrac{1}{4}$

23. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\frac{1}{3} - \frac{1}{3}}{\frac{2}{7} - \frac{5}{7}} = \dfrac{0}{-\frac{3}{7}} = 0$

24. $f(x) = -\dfrac{1}{9}x + 12$ is in the form $y = mx + b$ with $m = -\dfrac{1}{9}$ and $b = 12$, so the slope is $-\dfrac{1}{9}$ and the y-intercept is $(0, 12)$.

25. We can write $y = -6$ as $y = 0x - 6$, so the slope is 0 and the y-intercept is $(0, -6)$.

26. The graph of $x = 2$ is a vertical line 2 units to the right of the y-axis. The slope is not defined and there is no y-intercept.

27.
$$3x - 16y + 1 = 0$$
$$3x + 1 = 16y$$
$$\frac{3}{16}x + \frac{1}{16} = y$$

Slope: $\dfrac{3}{16}$; y-intercept: $\left(0, \dfrac{1}{16}\right)$

28. The sign of the slope indicates the slant of a line. A line that slants up from left to right has positive slope because corresponding changes in x and y have the same sign. A line that slants down from left to right has negative slope, because corresponding changes in x and y have opposite signs. A horizontal line has zero slope, because there is no change in y for a given change in x. A vertical line has undefined slope, because there is no change in x for a given change in y and division by 0 is undefined. The larger the absolute value of slope, the steeper the line. This is because a larger absolute value corresponds to a greater change in y, compared to the change in x, than a smaller absolute value.

29. A vertical line $(x = a)$ crosses the graph more than once.

30. The domain of a function is the set of all inputs of the function. The range is the set of all outputs. The range depends on the domain.

31. Let $A = (a, b)$ and $B = (c, d)$. The coordinates of a point C one-half of the way from A to B are $\left(\dfrac{a+c}{2}, \dfrac{b+d}{2}\right)$. A point D that is one-half of the way from C to B is $\dfrac{1}{2} + \dfrac{1}{2} \cdot \dfrac{1}{2}$, or $\dfrac{3}{4}$ of the way from A to B. Its coordinates are $\left(\dfrac{\frac{a+c}{2} + c}{2}, \dfrac{\frac{b+d}{2} + d}{2}\right)$, or $\left(\dfrac{a+3c}{4}, \dfrac{b+3d}{4}\right)$. Then a point E that is one-half of the way from D to B is $\dfrac{3}{4} + \dfrac{1}{2} \cdot \dfrac{1}{4}$, or $\dfrac{7}{8}$ of the way from A to B. Its coordinates are $\left(\dfrac{\frac{a+3c}{4} + c}{2}, \dfrac{\frac{b+3d}{4} + d}{2}\right)$, or $\left(\dfrac{a+7c}{8}, \dfrac{b+7d}{8}\right)$.

Exercise Set 1.4

1. We see that the y-intercept is $(0, -2)$. Another point on the graph is $(1, 2)$. Use these points to find the slope.

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{2 - (-2)}{1 - 0} = \dfrac{4}{1} = 4$

We have $m = 4$ and $b = -2$, so the equation is $y = 4x - 2$.

2. We see that the y-intercept is $(0,2)$. Another point on the graph is $(4,-1)$.

$m = \dfrac{-1-2}{4-0} = -\dfrac{3}{4}$

The equation is $y = -\dfrac{3}{4}x + 2$.

3. We see that the y-intercept is $(0,0)$. Another point on the graph is $(3,-3)$. Use these points to find the slope.

$m = \dfrac{y_2-y_1}{x_2-x_1} = \dfrac{-3-0}{3-0} = \dfrac{-3}{3} = -1$

We have $m=-1$ and $b=0$, so the equation is $y = -1\cdot x + 0$, or $y=-x$.

4. We see that the y-intercept is $(0,-1)$. Another point on the graph is $(3,1)$.

$m = \dfrac{1-(-1)}{3-0} = \dfrac{2}{3}$

The equation is $y = \dfrac{2}{3}x - 1$.

5. We see that the y-intercept is $(0,-3)$. This is a horizontal line, so the slope is 0. We have $m=0$ and $b=-3$, so the equation is $y = 0\cdot x - 3$, or $y=-3$.

6. We see that the y-intercept is $(0,0)$. Another point on the graph is $(3,3)$.

$m = \dfrac{3-0}{3-0} = \dfrac{3}{3} = 1$

The equation is $y = 1\cdot x + 0$, or $y = x$.

7. We substitute $\dfrac{2}{9}$ for m and 4 for b in the slope-intercept equation.

$$y = mx+b$$
$$y = \frac{2}{9}x + 4$$

8. $y = -\dfrac{3}{8}x + 5$

9. We substitute -4 for m and -7 for b in the slope-intercept equation.

$$y = mx+b$$
$$y = -4x-7$$

10. $y = \dfrac{2}{7}x - 6$

11. We substitute -4.2 for m and $\dfrac{3}{4}$ for b in the slope-intercept equation.

$$y = mx+b$$
$$y = -4.2x + \frac{3}{4}$$

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

13. Using the point-slope equation:

$$\begin{aligned} y - y_1 &= m(x-x_1) \\ y - 7 &= \frac{2}{9}(x-3) \quad \text{Substituting} \\ y-7 &= \frac{2}{9}x - \frac{2}{3} \\ y &= \frac{2}{9}x + \frac{19}{3} \quad \text{Slope-intercept equation} \end{aligned}$$

Using the slope-intercept equation:

Substitute $\dfrac{2}{9}$ for m, 3 for x, and 7 for y in the slope-intercept equation and solve for b.

$$\begin{aligned} y &= mx+b \\ 7 &= \frac{2}{9}\cdot 3 + b \\ 7 &= \frac{2}{3} + b \\ \frac{19}{3} &= b \end{aligned}$$

Now substitute $\dfrac{2}{9}$ for m and $\dfrac{19}{3}$ for b in $y = mx+b$.

$$y = \frac{2}{9}x + \frac{19}{3}$$

14. Using the point-slope equation:

$$\begin{aligned} y-6 &= -\frac{3}{8}(x-5) \\ y &= -\frac{3}{8}x + \frac{63}{8} \end{aligned}$$

Using the slope-intercept equation:

$$\begin{aligned} 6 &= -\frac{3}{8}\cdot 5 + b \\ \frac{63}{8} &= b \end{aligned}$$

We have $y = -\dfrac{3}{8}x + \dfrac{63}{8}$.

15. The slope is 0 and the second coordinate of the given point is 8, so we have a horizontal line 8 units above the x-axis. Thus, the equation is $y=8$.

We could also use the point-slope equation or the slope-intercept equation to find the equation of the line.

Using the point-slope equation:

$$\begin{aligned} y-y_1 &= m(x-x_1) \\ y-8 &= 0(x-(-2)) \quad \text{Substituting} \\ y-8 &= 0 \\ y &= 8 \end{aligned}$$

Using the slope-intercept equation:

$$\begin{aligned} y &= mx+b \\ y &= 0(-2)+8 \\ y &= 8 \end{aligned}$$

16. Using the point-slope equation:

$$\begin{aligned} y-1 &= -2(x-(-5)) \\ y &= -2x-9 \end{aligned}$$

Using the slope-intercept equation:

$$1 = -2(-5) + b$$
$$-9 = b$$

We have $y = -2x - 9$.

17. Using the point-slope equation:

$$y - y_1 = m(x - x_1)$$
$$y - (-1) = -\frac{3}{5}(x - (-4))$$
$$y + 1 = -\frac{3}{5}(x + 4)$$
$$y + 1 = -\frac{3}{5}x - \frac{12}{5}$$
$$y = -\frac{3}{5}x - \frac{17}{5} \quad \text{Slope-intercept equation}$$

Using the slope-intercept equation:

$$y = mx + b$$
$$-1 = -\frac{3}{5}(-4) + b$$
$$-1 = \frac{12}{5} + b$$
$$-\frac{17}{5} = b$$

Then we have $y = -\frac{3}{5}x - \frac{17}{5}$.

18. Using the point-slope equation:

$$y - (-5) = \frac{2}{3}(x - (-4))$$
$$y = \frac{2}{3}x - \frac{7}{3}$$

Using the slope-intercept equation:

$$-5 = \frac{2}{3}(-4) + b$$
$$-\frac{7}{3} = b$$

We have $y = \frac{2}{3}x - \frac{7}{3}$.

19. First we find the slope.

$$m = \frac{-4-5}{2-(-1)} = \frac{-9}{3} = -3$$

Using the point-slope equation:

Using the point $(-1, 5)$, we get

$y - 5 = -3(x - (-1))$, or $y - 5 = -3(x + 1)$.

Using the point $(2, -4)$, we get

$y - (-4) = -3(x - 2)$, or $y + 4 = -3(x - 2)$.

In either case, the slope-intercept equation is $y = -3x + 2$.

Using the slope-intercept equation and the point $(-1, 5)$:

$$y = mx + b$$
$$5 = -3(-1) + b$$
$$5 = 3 + b$$
$$2 = b$$

Then we have $y = -3x + 2$.

20. First we find the slope:

$$m = \frac{\frac{1}{2} - \frac{1}{2}}{-3-1} = \frac{0}{-4} = 0$$

We have a horizontal line $\frac{1}{2}$ unit above the x-axis. The equation is $y = \frac{1}{2}$.

(We could also have used the point-slope equation or the slope-intercept equation.)

21. First we find the slope.

$$m = \frac{4-0}{-1-7} = \frac{4}{-8} = -\frac{1}{2}$$

Using the point-slope equation:

Using the point $(7, 0)$, we get

$$y - 0 = -\frac{1}{2}(x - 7).$$

Using the point $(-1, 4)$, we get

$$y - 4 = -\frac{1}{2}(x - (-1)), \text{ or}$$
$$y - 4 = -\frac{1}{2}(x + 1).$$

In either case, the slope-intercept equation is $y = -\frac{1}{2}x + \frac{7}{2}$.

Using the slope-intercept equation and the point $(7, 0)$:

$$0 = -\frac{1}{2} \cdot 7 + b$$
$$\frac{7}{2} = b$$

Then we have $y = -\frac{1}{2}x + \frac{7}{2}$.

22. First we find the slope.

$$m = \frac{-5-7}{-1-(-3)} = \frac{-12}{2} = -6$$

Using the point-slope equation:

Using $(-3, 7)$: $y - 7 = -6(x - (-3))$, or

$$y - 7 = -6(x + 3)$$

Using $(-1, -5)$: $y - (-5) = -6(x - (-1))$, or

$$y + 5 = -6(x + 1)$$

In either case, we have $y = -6x - 11$.

Using the slope-intercept equation and the point $(-1, -5)$:

$$-5 = -6(-1) + b$$
$$-11 = b$$

We have $y = -6x - 11$.

23. First we find the slope.

$$m = \frac{-4-(-6)}{3-0} = \frac{2}{3}$$

We know the y-intercept is $(0, -6)$, so we substitute in the slope-intercept equation.

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

24. First we find the slope.

$$m = \frac{\frac{4}{5} - 0}{0 - (-5)} = \frac{\frac{4}{5}}{5} = \frac{4}{25}$$

We know the y-intercept is $\left(0, \frac{4}{5}\right)$, so we substitute in the slope-intercept equation.

$$y = \frac{4}{25}x + \frac{4}{5}$$

25. First we find the slope.

$$m = \frac{7.3 - 7.3}{-4 - 0} = \frac{0}{-4} = 0$$

We know the y-intercept is $(0,\ 7.3)$, so we substitute in the slope-intercept equation.

$$y = mx + b$$
$$y = 0 \cdot x + 7.3$$
$$y = 7.3$$

26. First we find the slope.

$$m = \frac{-5 - 0}{-13 - 0} = \frac{5}{13}$$

We know the y-intercept is $(0, 0)$, so we substitute in the slope intercept equation.

$$y = \frac{5}{13}x + 0$$
$$y = \frac{5}{13}x$$

27. The equation of the horizontal line through $(0, -3)$ is of the form $y = b$ where b is -3. We have $y = -3$.

The equation of the vertical line through $(0, -3)$ is of the form $x = a$ where a is 0. We have $x = 0$.

28. Horizontal line: $y = 7$

Vertical line: $x = -\frac{1}{4}$

29. The equation of the horizontal line through $\left(\frac{2}{11}, -1\right)$ is of the form $y = b$ where b is -1. We have $y = -1$.

The equation of the vertical line through $\left(\frac{2}{11}, -1\right)$ is of the form $x = a$ where a is $\frac{2}{11}$. We have $x = \frac{2}{11}$.

30. Horizontal line: $y = 0$

Vertical line: $x = 0.03$

31. We have the points $(1, 4)$ and $(-2, 13)$. First we find the slope.

$$m = \frac{13 - 4}{-2 - 1} = \frac{9}{-3} = -3$$

We will use the point-slope equation, choosing $(1, 4)$ for the given point.

$$y - 4 = -3(x - 1)$$
$$y - 4 = -3x + 3$$
$$y = -3x + 7, \text{ or}$$
$$h(x) = -3x + 7$$

Then $h(2) = -3 \cdot 2 + 7 = -6 + 7 = 1$.

32. $m = \dfrac{3 - (-6)}{2 - \left(-\frac{1}{4}\right)} = \dfrac{9}{\frac{9}{4}} = 9 \cdot \dfrac{4}{9} = 4$

Using the point-slope equation and the point $(2, 3)$:

$$y - 3 = 4(x - 2)$$
$$y - 3 = 4x - 8$$
$$y = 4x - 5, \text{ or}$$
$$g(x) = 4x - 5$$

Then $g(-3) = 4(-3) - 5 = -12 - 5 = -17$.

33. We have the points $(5, 1)$ and $(-5, -3)$. First we find the slope.

$$m = \frac{-3 - 1}{-5 - 5} = \frac{-4}{-10} = \frac{2}{5}$$

We will use the slope-intercept equation, choosing $(5, 1)$ for the given point.

$$y = mx + b$$
$$1 = \frac{2}{5} \cdot 5 + b$$
$$1 = 2 + b$$
$$-1 = b$$

Then we have $f(x) = \frac{2}{5}x - 1$.

Now we find $f(0)$.

$$f(0) = \frac{2}{5} \cdot 0 - 1 = -1.$$

34. $m = \dfrac{2 - 3}{0 - (-3)} = \dfrac{-1}{3} = -\dfrac{1}{3}$

Using the slope-intercept equation and the point $(0, 2)$, which is the y-intercept, we have $h(x) = -\frac{1}{3}x + 2$.

Then $h(-6) = -\frac{1}{3}(-6) + 2 = 2 + 2 = 4$.

35. The slopes are $\frac{26}{3}$ and $-\frac{3}{26}$. Their product is -1, so the lines are perpendicular.

36. The slopes are -3 and $-\frac{1}{3}$. The slopes are not the same and their product is not -1, so the lines are neither parallel nor perpendicular.

37. The slopes are $\frac{2}{5}$ and $-\frac{2}{5}$. The slopes are not the same and their product is not -1, so the lines are neither parallel nor perpendicular.

38. The slopes are the same $\left(\frac{3}{2} = 1.5\right)$ and the y-intercepts, -8 and 8, are different, so the lines are parallel.

39. We solve each equation for y.

$$x + 2y = 5 \qquad\qquad 2x + 4y = 8$$
$$y = -\frac{1}{2}x + \frac{5}{2} \qquad\qquad y = -\frac{1}{2}x + 2$$

We see that $m_1 = -\frac{1}{2}$ and $m_2 = -\frac{1}{2}$. Since the slopes are the same and the y-intercepts, $\frac{5}{2}$ and 2, are different, the lines are parallel.

40. $2x - 5y = -3$ $\qquad$ $2x + 5y = 4$

$$y = \frac{2}{5}x + \frac{3}{5} \qquad y = -\frac{2}{5}x + \frac{4}{5}$$

$m_1 = \frac{2}{5}$, $m_2 = -\frac{2}{5}$; $m_1 \neq m_2$; $m_1 m_2 = -\frac{4}{25} \neq -1$

The lines are neither parallel nor perpendicular.

41. We solve each equation for y.

$$y = 4x - 5 \qquad 4y = 8 - x$$
$$y = -\frac{1}{4}x + 2$$

We see that $m_1 = 4$ and $m_2 = -\frac{1}{4}$. Since $m_1 m_2 = 4\left(-\frac{1}{4}\right) = -1$, the lines are perpendicular.

42. $y = 7 - x$,
$y = x + 3$

$m_1 = -1$, $m_2 = 1$; $m_1 m_2 = -1 \cdot 1 = -1$

The lines are perpendicular.

43. $y = \frac{2}{7}x + 1$; $m = \frac{2}{7}$

The line parallel to the given line will have slope $\frac{2}{7}$. We use the point-slope equation for a line with slope $\frac{2}{7}$ and containing the point $(3, 5)$:

$$y - y_1 = m(x - x_1)$$
$$y - 5 = \frac{2}{7}(x - 3)$$
$$y - 5 = \frac{2}{7}x - \frac{6}{7}$$
$$y = \frac{2}{7}x + \frac{29}{7} \quad \text{Slope-intercept form}$$

The slope of the line perpendicular to the given line is the opposite of the reciprocal of $\frac{2}{7}$, or $-\frac{7}{2}$. We use the point-slope equation for a line with slope $-\frac{7}{2}$ and containing the point $(3, 5)$:

$$y - y_1 = m(x - x_1)$$
$$y - 5 = -\frac{7}{2}(x - 3)$$
$$y - 5 = -\frac{7}{2}x + \frac{21}{2}$$
$$y = -\frac{7}{2}x + \frac{31}{2} \quad \text{Slope-intercept form}$$

44. $f(x) = 2x + 9$

$m = 2$, $-\frac{1}{m} = -\frac{1}{2}$

Parallel line: $y - 6 = 2(x - (-1))$

$$y = 2x + 8$$

Perpendicular line: $y - 6 = -\frac{1}{2}(x - (-1))$

$$y = -\frac{1}{2}x + \frac{11}{2}$$

45. $y = -0.3x + 4.3$; $m = -0.3$

The line parallel to the given line will have slope -0.3. We use the point-slope equation for a line with slope -0.3 and containing the point $(-7, 0)$:

$$y - y_1 = m(x - x_1)$$
$$y - 0 = -0.3(x - (-7))$$
$$y = -0.3x - 2.1 \quad \text{Slope-intercept form}$$

The slope of the line perpendicular to the given line is the opposite of the reciprocal of -0.3, or $\frac{1}{0.3} = \frac{10}{3}$.

We use the point-slope equation for a line with slope $\frac{10}{3}$ and containing the point $(-7, 0)$:

$$y - y_1 = m(x - x_1)$$
$$y - 0 = \frac{10}{3}(x - (-7))$$
$$y = \frac{10}{3}x + \frac{70}{3} \quad \text{Slope-intercept form}$$

46. $2x + y = -4$

$$y = -2x - 4$$

$m = -2$, $-\frac{1}{m} = \frac{1}{2}$

Parallel line: $y - (-5) = -2(x - (-4))$

$$y = -2x - 13$$

Perpendicular line: $y - (-5) = \frac{1}{2}(x - (-4))$

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

47. $3x + 4y = 5$

$$4y = -3x + 5$$
$$y = -\frac{3}{4}x + \frac{5}{4}; \; m = -\frac{3}{4}$$

The line parallel to the given line will have slope $-\frac{3}{4}$. We use the point-slope equation for a line with slope $-\frac{3}{4}$ and containing the point $(3, -2)$:

$$y - y_1 = m(x - x_1)$$
$$y - (-2) = -\frac{3}{4}(x - 3)$$
$$y + 2 = -\frac{3}{4}x + \frac{9}{4}$$
$$y = -\frac{3}{4}x + \frac{1}{4} \quad \text{Slope-intercept form}$$

The slope of the line perpendicular to the given line is the opposite of the reciprocal of $-\frac{3}{4}$, or $\frac{4}{3}$. We use the point-slope equation for a line with slope $\frac{4}{3}$ and containing the point $(3, -2)$:

$$y - y_1 = m(x - x_1)$$
$$y - (-2) = \frac{4}{3}(x - 3)$$
$$y + 2 = \frac{4}{3}x - 4$$
$$y = \frac{4}{3}x - 6 \quad \text{Slope-intercept form}$$

48. $y = 4.2(x - 3) + 1$

$y = 4.2x - 11.6$

$m = 4.2;\ -\frac{1}{m} = -\frac{1}{4.2} = -\frac{5}{21}$

Parallel line: $y - (-2) = 4.2(x - 8)$

$y = 4.2x - 35.6$

Perpendicular line: $y - (-2) = -\frac{5}{21}(x - 8)$

$y = -\frac{5}{21}x - \frac{2}{21}$

49. $x = -1$ is the equation of a vertical line. The line parallel to the given line is a vertical line containing the point $(3, -3)$, or $x = 3$.

The line perpendicular to the given line is a horizontal line containing the point $(3, -3)$, or $y = -3$.

50. $y = -1$ is a horizontal line.

Parallel line: $y = -5$

Perpendicular line: $x = 4$

51. $x = -3$ is a vertical line and $y = 5$ is a horizontal line, so it is true that the lines are perpendicular.

52. The slope of $y = 2x - 3$ is 2, and the slope of $y = -2x - 3$ is -2. Since $2(-2) = -4 \neq -1$, it is false that the lines are perpendicular.

53. The lines have the same slope, $\frac{2}{5}$, and different y-intercepts, $(0, 4)$ and $(0, -4)$, so it is true that the lines are parallel.

54. $y = 2$ is a horizontal line 2 units above the x-axis; $x = -\frac{3}{4}$ is a vertical line $\frac{3}{4}$ unit to the left of the y-axis. Thus it is true that their intersection is the point $\frac{3}{4}$ unit to the left of the y-axis and 2 units above the x-axis, or $\left(-\frac{3}{4}, 2\right)$.

55. $x = -1$ and $x = 1$ are both vertical lines, so it is false that they are perpendicular.

56. The slope of $2x+3y = 4$, or $y = -\frac{2}{3}x + \frac{4}{3}$ is $-\frac{2}{3}$; the slope of $3x - 2y = 4$, or $y = \frac{3}{2}x - 2$, is $\frac{3}{2}$. Since $-\frac{2}{3} \cdot \frac{3}{2} = -1$, it is true that the lines are perpendicular.

57. No. The data points fall faster from 0 to 2 than after 2 (that is, the rate of change is not constant), so they cannot be modeled by a linear function.

58. Yes. The rate of change seems to be constant, so the data points might be modeled by a linear function.

59. Yes. The rate of change seems to be constant, so the data points might be modeled by a linear function.

60. No. The data points rise, fall, and then rise again in a way that cannot be modeled by a linear function.

61. a) Answers may vary depending on the data points used. We will use $(1,\ 1.319)$ and $(7,\ 2.749)$.

$$m = \frac{2.749 - 1.319}{7 - 1} = \frac{1.43}{6} \approx 0.238$$

We will use the point-slope equation, letting $(x_1, y_1) = (1,\ 1.319)$.

$$y - 1.319 = 0.238(x - 1)$$
$$y - 1.319 = 0.238x - 0.238$$
$$y = 0.238x + 1.081,$$

where x is the number of years after 2006 and y is in billions.

b) In 2017, $x = 2017 - 2006 = 11$.

$y = 0.238(11) + 1.081 = 3.699$ billion Internet users

In 2020, $x = 2020 - 2006 = 14$.

$y = 0.238(14) + 1.081 = 4.413$ billion users

62. a) Answers may vary depending on the data points used. We will use $(1,\ 33.5)$ and $(4,\ 36.7)$.

$$m = \frac{36.7 - 33.5}{4 - 1} = \frac{3.2}{3} \approx 1.1$$

Now use the point-slope equation with the point $(1,\ 33.5)$.

$$y - 33.5 = 1.1(x - 1)$$
$$y - 33.5 = 1.1x - 1.1$$
$$y = 1.1x + 32.4,$$

where x is the number of years after 2005 and y is a percent.

b) For 2011, $y = 1.1(6) + 32.4 = 39\%$

For 2016, $y = 1.1(11) + 32.4 = 44.5\%$

63. Answers may vary depending on the data points used. We will use $(0,\ 11{,}504)$ and $(3,\ 10{,}819)$.

$$m = \frac{10{,}819 - 11{,}504}{3 - 0} = \frac{-685}{3} \approx -228$$

We see that the y-intercept is $(0,\ 11{,}504)$, so using the slope-intercept equation, we have $y = -228x + 11{,}504$, where x is the number of years after 2010 and y is in kilowatt-hours.

In 2019, $x = 2019 - 2010 = 9$.

$y = -228(9) + 11{,}504 = 9452$ kilowatt-hours

64. Answers may vary depending on the data points used. We will use $(0,\ 54{,}892)$ and $(6,\ 51{,}017)$.

$$m = \frac{51{,}017 - 54{,}892}{6 - 0} = \frac{-3875}{6} \approx -646$$

We see that the y-intercept is $(0,\ 54{,}892)$, so the equation is $y = -646x + 54{,}892$, where x is the number of years after 2006 and y is in dollars.

For 2009, $y = -646(3) + 54,892 = \$52,954$.

For 2017, $y = -646(11) + 54,892 = \$47,786$.

65. Answers may vary depending on the data points used. We will use (1, 28.3) and (3, 30.8).

$$m = \frac{30.8 - 28.3}{3-1} = \frac{2.5}{2} = 1.25$$

We will use the point-slope equation, letting $(x_1, y_1) = (1,\ 28.3)$

$$\begin{aligned} y - 28.3 &= 1.25(x-1) \\ y - 28.3 &= 1.25x - 1.25 \\ y &= 1.25x + 27.05, \end{aligned}$$

where x is the number of years after 2009 and y is in gallons.

In 2017, $x = 2017 - 2009 = 8$.

$y = 1.25(8) + 27.05 \approx 37.1$ gallons

66. Answers may vary depending on the data points used. We will use (1, 43) and (3, 55).

$$m = \frac{55-43}{3-1} = \frac{12}{2} = 6$$

We will use the point-slope equation with the point $(1, 43)$.

$$\begin{aligned} y - 43 &= 6(x-1) \\ y - 43 &= 6x - 6 \\ y &= 6x + 37, \end{aligned}$$

where x is the number of years after 2009 and y is a percent.

In 2016, $y = 6 \cdot 7 + 37 = 79\%$.

67. $m = \dfrac{-7-7}{5-5} = \dfrac{-14}{0}$

The slope is not defined.

68. $$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-1-(-8)}{-5-2} = \frac{-1+8}{-7} \\ &= \frac{7}{-7} = -1 \end{aligned}$$

69. $r = \dfrac{d}{2} = \dfrac{5}{2}$

$$\begin{aligned} (x-0)^2 + (y-3)^2 &= \left(\frac{5}{2}\right)^2 \\ x^2 + (y-3)^2 &= \frac{25}{4}, \text{ or} \\ x^2 + (y-3)^2 &= 6.25 \end{aligned}$$

70. $$\begin{aligned} (x-h)^2 + (y-k)^2 &= r^2 \\ [x-(-7)]^2 + [y-(-1)]^2 &= \left(\frac{9}{5}\right)^2 \\ (x+7)^2 + (y+1)^2 &= \frac{81}{25} \end{aligned}$$

71. The slope of the line containing $(-3, k)$ and $(4, 8)$ is
$\dfrac{8-k}{4-(-3)} = \dfrac{8-k}{7}$.

The slope of the line containing $(5, 3)$ and $(1, -6)$ is
$\dfrac{-6-3}{1-5} = \dfrac{-9}{-4} = \dfrac{9}{4}$.

The slopes must be equal in order for the lines to be parallel:

$$\begin{aligned} \frac{8-k}{7} &= \frac{9}{4} \\ 32 - 4k &= 63 \quad \text{Multiplying by 28} \\ -4k &= 31 \\ k &= -\frac{31}{4}, \text{ or } -7.75 \end{aligned}$$

72. The slope of the line containing $(-1, 3)$ and $(2, 9)$ is
$\dfrac{9-3}{2-(-1)} = \dfrac{6}{3} = 2$.

Then the slope of the desired line is $-\dfrac{1}{2}$. We find the equation of that line:

$$\begin{aligned} y - 5 &= -\frac{1}{2}(x-4) \\ y - 5 &= -\frac{1}{2}x + 2 \\ y &= -\frac{1}{2}x + 7 \end{aligned}$$

73. $m = \dfrac{920.58}{13,740} = 0.067$

The road grade is 6.7%.

We find an equation of the line with slope 0.067 and containing the point $(13,740, 920.58)$:

$$\begin{aligned} y - 920.58 &= 0.067(x - 13,740) \\ y - 920.58 &= 0.067x - 920.58 \\ y &= 0.067x \end{aligned}$$

Exercise Set 1.5

1. $$\begin{aligned} 4x + 5 &= 21 \\ 4x &= 16 \quad \text{Subtracting 5 on both sides} \\ x &= 4 \quad \text{Dividing by 4 on both sides} \end{aligned}$$

The solution is 4.

2. $$\begin{aligned} 2y - 1 &= 3 \\ 2y &= 4 \\ y &= 2 \end{aligned}$$

The solution is 2.

3. $$\begin{aligned} 23 - \frac{2}{5}x &= -\frac{2}{5}x + 23 \\ 23 &= 23 \qquad \text{Adding } \frac{2}{5}x \text{ on both sides} \end{aligned}$$

We get an equation that is true for any value of x, so the solution set is the set of real numbers,
$\{x|x \text{ is a real number}\}$, or $(-\infty, \infty)$.

4.
$$\begin{aligned}\frac{6}{5}y+3&=\frac{3}{10} \quad \text{The LCD is 10.}\\ 10\left(\frac{6}{5}y+3\right)&=10\cdot\frac{3}{10}\\ 12y+30&=3\\ 12y&=-27\\ y&=-\frac{9}{4}\end{aligned}$$
The solution is $-\frac{9}{4}$.

5.
$$\begin{aligned}4x+3&=0\\ 4x&=-3 \quad \text{Subtracting 3 on both sides}\\ x&=-\frac{3}{4} \quad \text{Dividing by 4 on both sides}\end{aligned}$$
The solution is $-\frac{3}{4}$.

6.
$$\begin{aligned}3x-16&=0\\ 3x&=16\\ x&=\frac{16}{3}\end{aligned}$$
The solution is $\frac{16}{3}$.

7.
$$\begin{aligned}3-x&=12\\ -x&=9 \quad \text{Subtracting 3 on both sides}\\ x&=-9 \quad \text{Multiplying (or dividing) by } -1 \text{ on both sides}\end{aligned}$$
The solution is -9.

8.
$$\begin{aligned}4-x&=-5\\ -x&=-9\\ x&=9\end{aligned}$$
The solution is 9.

9.
$$\begin{aligned}3-\frac{1}{4}x&=\frac{3}{2} \quad \text{The LCD is 4.}\\ 4\left(3-\frac{1}{4}x\right)&=4\cdot\frac{3}{2} \quad \text{Multiplying by the LCD to clear fractions}\\ 12-x&=6\\ -x&=-6 \quad \text{Subtracting 12 on both sides}\\ x&=6 \quad \text{Multiplying (or dividing) by } -1 \text{ on both sides}\end{aligned}$$
The solution is 6.

10.
$$\begin{aligned}10x-3&=8+10x\\ -3&=8 \quad \text{Subtracting } 10x \text{ on both sides}\end{aligned}$$
We get a false equation. Thus, the original equation has no solution.

11.
$$\begin{aligned}\frac{2}{11}-4x&=-4x+\frac{9}{11}\\ \frac{2}{11}&=\frac{9}{11} \quad \text{Adding } 4x \text{ on both sides}\end{aligned}$$
We get a false equation. Thus, the original equation has no solution.

12.
$$\begin{aligned}8-\frac{2}{9}x&=\frac{5}{6} \quad \text{The LCD is 18.}\\ 18\left(8-\frac{2}{9}x\right)&=18\cdot\frac{5}{6}\\ 144-4x&=15\\ -4x&=-129\\ x&=\frac{129}{4}\end{aligned}$$
The solution is $\frac{129}{4}$.

13.
$$\begin{aligned}8&=5x-3\\ 11&=5x \quad \text{Adding 3 on both sides}\\ \frac{11}{5}&=x \quad \text{Dividing by 5 on both sides}\end{aligned}$$
The solution is $\frac{11}{5}$.

14.
$$\begin{aligned}9&=4x-8\\ 17&=4x\\ \frac{17}{4}&=x\end{aligned}$$
The solution is $\frac{17}{4}$.

15.
$$\begin{aligned}\frac{2}{5}y-2&=\frac{1}{3} \quad \text{The LCD is 15.}\\ 15\left(\frac{2}{5}y-2\right)&=15\cdot\frac{1}{3} \quad \text{Multiplying by the LCD to clear fractions}\\ 6y-30&=5\\ 6y&=35 \quad \text{Adding 30 on both sides}\\ y&=\frac{35}{6} \quad \text{Dividing by 6 on both sides}\end{aligned}$$
The solution is $\frac{35}{6}$.

16.
$$\begin{aligned}-x+1&=1-x\\ 1&=1 \quad \text{Adding } x \text{ on both sides}\end{aligned}$$
We get an equation that is true for any value of x, so the solution set is the set of real numbers, $\{x|x \text{ is a real number}\}$, or $(-\infty,\infty)$.

17.
$$\begin{aligned}y+1&=2y-7\\ 1&=y-7 \quad \text{Subtracting } y \text{ on both sides}\\ 8&=y \quad \text{Adding 7 on both sides}\end{aligned}$$
The solution is 8.

18.
$$\begin{aligned}5-4x&=x-13\\ 18&=5x\\ \frac{18}{5}&=x\end{aligned}$$
The solution is $\frac{18}{5}$.

19.
$$\begin{aligned}2x+7&=x+3\\ x+7&=3 \quad \text{Subtracting } x \text{ on both sides}\\ x&=-4 \quad \text{Subtracting 7 on both sides}\end{aligned}$$
The solution is -4.

20. $5x - 4 = 2x + 5$

$3x - 4 = 5$

$3x = 9$

$x = 3$

The solution is 3.

21. $3x - 5 = 2x + 1$

$x - 5 = 1$ Subtracting $2x$ on both sides

$x = 6$ Adding 5 on both sides

The solution is 6.

22. $4x + 3 = 2x - 7$

$2x = -10$

$x = -5$

The solution is -5.

23. $4x - 5 = 7x - 2$

$-5 = 3x - 2$ Subtracting $4x$ on both sides

$-3 = 3x$ Adding 2 on both sides

$-1 = x$ Dividing by 3 on both sides

The solution is -1.

24. $5x + 1 = 9x - 7$

$8 = 4x$

$2 = x$

The solution is 2.

25. $5x - 2 + 3x = 2x + 6 - 4x$

$8x - 2 = 6 - 2x$ Collecting like terms

$8x + 2x = 6 + 2$ Adding $2x$ and 2 on both sides

$10x = 8$ Collecting like terms

$x = \frac{8}{10}$ Dividing by 10 on both sides

$x = \frac{4}{5}$ Simplifying

The solution is $\frac{4}{5}$.

26. $5x - 17 - 2x = 6x - 1 - x$

$3x - 17 = 5x - 1$

$-2x = 16$

$x = -8$

The solution is -8.

27. $7(3x + 6) = 11 - (x + 2)$

$21x + 42 = 11 - x - 2$ Using the distributive property

$21x + 42 = 9 - x$ Collecting like terms

$21x + x = 9 - 42$ Adding x and subtracting 42 on both sides

$22x = -33$ Collecting like terms

$x = -\frac{33}{22}$ Dividing by 22 on both sides

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

The solution is $-\frac{3}{2}$.

28. $4(5y + 3) = 3(2y - 5)$

$20y + 12 = 6y - 15$

$14y = -27$

$y = -\frac{27}{14}$

The solution is $-\frac{27}{14}$.

29. $3(x + 1) = 5 - 2(3x + 4)$

$3x + 3 = 5 - 6x - 8$ Removing parentheses

$3x + 3 = -6x - 3$ Collecting like terms

$9x + 3 = -3$ Adding $6x$

$9x = -6$ Subtracting 3

$x = -\frac{2}{3}$ Dividing by 9

The solution is $-\frac{2}{3}$.

30. $4(3x + 2) - 7 = 3(x - 2)$

$12x + 8 - 7 = 3x - 6$

$12x + 1 = 3x - 6$

$9x + 1 = -6$

$9x = -7$

$x = -\frac{7}{9}$

The solution is $-\frac{7}{9}$.

31. $2(x - 4) = 3 - 5(2x + 1)$

$2x - 8 = 3 - 10x - 5$ Using the distributive property

$2x - 8 = -10x - 2$ Collecting like terms

$12x = 6$ Adding $10x$ and 8 on both sides

$x = \frac{1}{2}$ Dividing by 12 on both sides

The solution is $\frac{1}{2}$.

32. $3(2x - 5) + 4 = 2(4x + 3)$

$6x - 15 + 4 = 8x + 6$

$6x - 11 = 8x + 6$

$-2x = 17$

$x = -\frac{17}{2}$

The solution is $-\frac{17}{2}$.

33. ***Familiarize***. Let $w =$ the number of new words that appeared in the English language in the seventeenth century. Then the number of new words that appeared in the nineteenth century is $w + 46.9\%$ of w, or $w + 0.469w$, or $1.469w$.

Translate. The number of new words that appeared in the nineteenth century is 75,029, so we have

$$75,029 = 1.469w.$$

Carry out.

$$75,029 = 1.469w$$
$$51,075 \approx w \qquad \text{Dividing by 1.469}$$

Check. 46.9% of $51,075 = 0.469(51,075) \approx 23,954$, and $51,075 + 23,954 = 75,029$. This is the number of new words that appeared in the nineteenth century, so the answer checks.

State. In the seventeenth century about 51,075 new words appeared in the English language.

34. Let $d =$ the daily caloric intake per person in Haiti.

Solve: $3688 = 1.864d$

$d \approx 1979$ calories

35. ***Familiarize***. Let $P =$ the amount Kea borrowed. We will use the formula $I = Prt$ to find the interest owed. For $r = 5\%$, or 0.05, and $t = 1$, we have $I = P(0.05)(1)$, or $0.05P$.

Translate.

$$\begin{array}{ccccc} \underbrace{\text{Amount borrowed}} & \text{plus} & \text{interest} & \text{is} & \$1365. \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ P & + & 0.05P & = & 1365 \end{array}$$

Carry out. We solve the equation.

$$P + 0.05P = 1365$$
$$1.05P = 1365 \qquad \text{Adding}$$
$$P = 1300 \qquad \text{Dividing by 1.05}$$

Check. The interest due on a loan of \$1300 for 1 year at a rate of 5% is \$1300(0.05)(1), or \$65, and \$1300 + \$65 = \$1365. The answer checks.

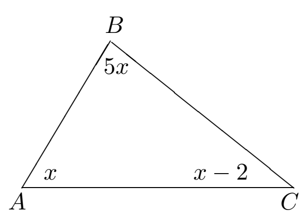
State. Kea borrowed \$1300.

36. Let $P =$ the amount invested.

Solve: $P + 0.04P = \$1560$

$P = \$1500$

37. ***Familiarize***. We make a drawing.



We let $x =$ the measure of angle A. Then $5x =$ the measure of angle B, and $x - 2 =$ the measure of angle C. The sum of the angle measures is 180°.

Translate.

$$\begin{array}{ccccccc} \underbrace{\begin{array}{c}\text{Measure}\\ \text{of}\\ \text{angle A}\end{array}} & + & \underbrace{\begin{array}{c}\text{Measure}\\ \text{of}\\ \text{angle B}\end{array}} & + & \underbrace{\begin{array}{c}\text{Measure}\\ \text{of}\\ \text{angle C}\end{array}} & = & 180. \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ x & + & 5x & + & x-2 & = & 180 \end{array}$$

Carry out. We solve the equation.

$$x + 5x + x - 2 = 180$$
$$7x - 2 = 180$$
$$7x = 182$$
$$x = 26$$

If $x = 26$, then $5x = 5 \cdot 26$, or 130, and $x - 2 = 26 - 2$, or 24.

Check. The measure of angle B, 130°, is five times the measure of angle A, 26°. The measure of angle C, 24°, is 2° less than the measure of angle A, 26°. The sum of the angle measures is $26° + 130° + 24°$, or 180°. The answer checks.

State. The measure of angles A, B, and C are 26°, 130°, and 24°, respectively.

38. Let $x =$ the measure of angle A.

Solve: $x + 2x + x + 20 = 180$

$x = 40°$, so the measure of angle A is 40°; the measure of angle B is $2 \cdot 40°$, or 80°; and the measure of angle C is $40° + 20°$, or 60°.

39. ***Familiarize***. Let $c =$ the amount of clothing exports from the United States in 2012, in billions of dollars.

Translate.

$$\begin{array}{cccccc} \underbrace{\begin{array}{c}\text{Clothing}\\ \text{imports}\\ \text{in 2012}\end{array}} & \text{were} & \text{25} & \text{times} & \underbrace{\begin{array}{c}\text{clothing}\\ \text{exports}\\ \text{in 2012}\end{array}} & \text{less} & \underbrace{\begin{array}{c}\$1.459\\ \text{billion.}\end{array}} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 84.916 & = & 25 & \cdot & c & - & 1.459. \end{array}$$

Carry out.

$$84.916 = 25c - 1.459$$
$$86.375 = 25c$$
$$3.455 = c$$

Check. $25(3.455) - 1.459 = 86.37 - 1.459 = 84.916$. This is the amount of clothing imports, so the answer checks.

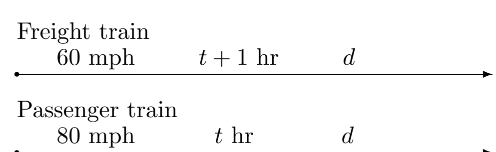
State. In 2012, clothing exports from the United States were \$3.455 billion.

40. Let $v =$ the value of imports to the United States in 2012.

Solve: $2,210,585,000,000 = \dfrac{1}{2}v + 837,965,000,000$

$v = \$2,745,240,000,000$

41. ***Familiarize***. We make a drawing. Let $t =$ the number of hours the passenger train travels before it overtakes the freight train. Then $t+1 =$ the number of hours the freight train travels before it is overtaken by the passenger train. Also let $d =$ the distance the trains travel.



We can also organize the information in a table.

$d \quad = \quad r \quad \cdot \quad t$

	Distance	Rate	Time
Freight train	d	60	$t+1$
Passenger train	d	80	t

Translate. Using the formula $d = rt$ in each row of the table, we get two equations.

$d = 60(t+1)$ and $d = 80t$.

Since the distances are the same, we have the equation

$60(t+1) = 80t$.

Carry out. We solve the equation.

$$\begin{aligned} 60(t+1) &= 80t \\ 60t + 60 &= 80t \\ 60 &= 20t \\ 3 &= t \end{aligned}$$

When $t = 3$, then $t + 1 = 3 + 1 = 4$.

Check. In 4 hr the freight train travels $60 \cdot 4$, or 240 mi. In 3 hr the passenger train travels $80 \cdot 3$, or 240 mi. Since the distances are the same, the answer checks.

State. It will take the passenger train 3 hr to overtake the freight train.

42. Let $t =$ the time the private airplane travels.

	Distance	Rate	Time
Private airplane	d	180	t
Jet	d	900	$t-2$

From the table we have the following equations:

$d = 180t \quad$ and $\quad d = 900(t-2)$

Solve: $180t = 900(t-2)$

$t = 2.5$

In 2.5 hr the private airplane travels 180(2.5), or 450 km. This is the distance from the airport at which it is overtaken by the jet.

43. ***Familiarize***. Let $p =$ the percentage of federal tax filers in 2000 who had zero or negative tax liability. Then the percentage of filers in 2010 who had zero or negative tax liability was $p + 15.7$.

Translate. In 2010, 40.9% of filers had zero or negative tax liability, so we have

$40.9 = p + 15.7$.

Carry out.

$$\begin{aligned} 40.9 &= p + 15.7 \\ 25.2 &= p \qquad \text{Subtracting 15.7} \end{aligned}$$

Check. $25.2 + 15.7 = 40.9$, so the answer checks.

State. In 2000, about 25.2% of federal tax filers had zero or negative tax liability.

44. Let $s =$ the average annual salary of an office manager.

Solve: $48,533 = 0.752s$

$s \approx \$64,539$

45. ***Familiarize***. Let $a =$ the amount of sales for which the two choices will be equal.

Translate.

$$\begin{array}{ccccccc} \$1800 & \text{equals} & \$1600 & \text{plus} & 4\% & \text{of} & \underbrace{\text{amount sold.}} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 1800 & = & 1600 & + & 0.04 & \cdot & a \end{array}$$

Carry out.

$$\begin{aligned} 1800 &= 1600 + 0.04a \\ 200 &= 0.04a \\ 5000 &= a \end{aligned}$$

Check. $\$1600 + 4\%$ of $\$5000 = \$1600 + 0.04 \cdot \$5000 = \$1600 + \$200 = \$1800$, so the answer checks.

State. For sales of \$5000, the two choices will be equal.

46. Let $s =$ Edward's sales for the month.

Solve: $1270 + 0.06s = 3154$

$s = \$31,400$

47. ***Familiarize***. Let $s =$ the number of U.S. students who studied abroad during the 2012-2013 school year.

Translate.

$$\begin{array}{ccccc} \underbrace{\begin{array}{c}\text{Number of}\\ \text{U.S. students}\\ \text{abroad}\end{array}} & \text{was} & \begin{array}{c}\text{seven-}\\ \text{twentieths}\end{array} & \text{of} & \underbrace{\begin{array}{c}\text{number of}\\ \text{foreign students}\\ \text{in U.S.}\end{array}} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ s & = & \dfrac{7}{20} & \cdot & 820,000 \end{array}$$

Carry out.

$$\begin{aligned} s &= \frac{7}{20} \cdot 820,000 \\ s &= 287,000 \end{aligned}$$

Check. We repeat the calculation. The answer checks.

State. About 287,000 U.S. students studied abroad during the 2012-2013 school year.

48. Let $p =$ the population density in the United States.

Solve: $p = \dfrac{1}{4} \cdot 365.3$

$p \approx 91.3$ persons per square mile

49. ***Familiarize***. Let $l =$ the length of the soccer field and $l - 35 =$ the width, in yards.

Translate. We use the formula for the perimeter of a rectangle. We substitute 330 for P and $l - 35$ for w.

$$\begin{aligned} P &= 2l + 2w \\ 330 &= 2l + 2(l - 35) \end{aligned}$$

Carry out. We solve the equation.

$$\begin{aligned} 330 &= 2l + 2(l-35) \\ 330 &= 2l + 2l - 70 \\ 330 &= 4l - 70 \\ 400 &= 4l \\ 100 &= l \end{aligned}$$

If $l = 100$, then $l - 35 = 100 - 35 = 65$.

Check. The width, 65 yd, is 35 yd less than the length, 100 yd. Also, the perimeter is

$$2 \cdot 100 \text{ yd} + 2 \cdot 65 \text{ yd} = 200 \text{ yd} + 130 \text{ yd} = 330 \text{ yd}.$$

The answer checks.

State. The length of the field is 100 yd, and the width is 65 yd.

50. Let h = the height of the poster and $\frac{2}{3}h$ = the width, in inches.

Solve: $100 = 2 \cdot h + 2 \cdot \frac{2}{3}h$

$h = 30$, so the height is 30 in. and the width is $\frac{2}{3} \cdot 30$, or 20 in.

51. ***Familiarize***. Using the labels on the drawing in the text, we let w = the width of the test plot and $w + 25$ = the length, in meters. Recall that for a rectangle, Perimeter = 2 · length + 2 · width.

Translate.

$$\begin{array}{ccccccc} \underbrace{\text{Perimeter}} & = & \underbrace{2 \cdot \text{ length}} & + & \underbrace{2 \cdot \text{ width}} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 322 & = & 2(w+25) & + & 2 \cdot w \end{array}$$

Carry out. We solve the equation.

$$\begin{aligned} 322 &= 2(w+25) + 2 \cdot w \\ 322 &= 2w + 50 + 2w \\ 322 &= 4w + 50 \\ 272 &= 4w \\ 68 &= w \end{aligned}$$

When $w = 68$, then $w + 25 = 68 + 25 = 93$.

Check. The length is 25 m more than the width: $93 = 68 + 25$. The perimeter is $2 \cdot 93 + 2 \cdot 68$, or $186 + 136$, or 322 m. The answer checks.

State. The length is 93 m; the width is 68 m.

52. Let w = the width of the garden.

Solve: $2 \cdot 2w + 2 \cdot w = 39$

$w = 6.5$, so the width is 6.5 m, and the length is 2(6.5), or 13 m.

53. ***Familiarize***. Let t = the number of hours it will take the plane to travel 1050 mi into the wind. The speed into the headwind is $450 - 30$, or 420 mph.

Translate. We use the formula $d = rt$.

$$1050 = 420 \cdot t$$

Carry out. We solve the equation.

$$\begin{aligned} 1050 &= 420 \cdot t \\ 2.5 &= t \end{aligned}$$

Check. At a rate of 420 mph, in 2.5 hr the plane travels 420(2.5), or 1050 mi. The answer checks.

State. It will take the plane 2.5 hr to travel 1050 mi into the wind.

54. Let t = the number of hours it will take the plane to travel 700 mi with the wind. The speed with the wind is $375+25$, or 400 mph.

Solve: $700 = 400t$

$t = 1.75$ hr

55. ***Familiarize***. Let x = the amount invested at 3% interest. Then $5000 - x$ = the amount invested at 4%. We organize the information in a table, keeping in mind the simple interest formula, $I = Prt$.

	Amount invested	Interest rate	Time	Amount of interest
3% invest-ment	x	3%, or 0.03	1 yr	$x(0.03)(1)$, or $0.03x$
4% invest-ment	$5000-x$	4%, or 0.04	1 yr	$(5000-x)(0.04)(1)$, or $0.04(5000-x)$
Total	5000			176

Translate.

$$\begin{array}{ccccccc} \underbrace{\begin{array}{c}\text{Interest on}\\ \text{3\% investment}\end{array}} & \text{plus} & \underbrace{\begin{array}{c}\text{interest on}\\ \text{4\% investment}\end{array}} & \text{is} & \$176. \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 0.03x & + & 0.04(5000-x) & = & 176 \end{array}$$

Carry out. We solve the equation.

$$\begin{aligned} 0.03x + 0.04(5000-x) &= 176 \\ 0.03x + 200 - 0.04x &= 176 \\ -0.01x + 200 &= 176 \\ -0.01x &= -24 \\ x &= 2400 \end{aligned}$$

If $x = 2400$, then $5000 - x = 5000 - 2400 = 2600$.

Check. The interest on \$2400 at 3% for 1 yr is \$2400(0.03)(1) = \$72. The interest on \$2600 at 4% for 1 yr is \$2600(0.04)(1) = \$104. Since \$72 + \$104 = \$176, the answer checks.

State. \$2400 was invested at 3%, and \$2600 was invested at 4%.

56. Let x = the amount borrowed at 5%. Then $9000 - x$ = the amount invested at 6%.

Solve: $0.05x + 0.06(9000 - x) = 492$

$x = 4800$, so \$4800 was borrowed at 5% and \$9000 − \$4800 = \$4200 was borrowed at 6%.

57. ***Familiarize***. Let p = the number of patents Samsung received in 2013. Then $p + 2133$ = the number of patents IBM received.

Translate.

$$\underbrace{\text{Samsung patents}}_{\displaystyle\downarrow\atop\displaystyle p} \quad \overset{\text{plus}}{\downarrow\atop +} \quad \underbrace{\text{IBM patents}}_{\displaystyle\downarrow\atop\displaystyle (p+2133)} \quad \overset{\text{is}}{\downarrow\atop =} \quad \underbrace{\text{total number of patents.}}_{\displaystyle\downarrow\atop\displaystyle 11,485}$$

Carry out.

$$\begin{aligned} p+(p+2133) &= 11,485 \\ 2p+2133 &= 11,485 \\ 2p &= 9352 \\ p &= 4676 \end{aligned}$$

Check. If $p = 4676$, then $p + 2133 = 4676 + 2133 = 6809$, and $4676 + 6809 = 11,485$, the total number of patents, so the answer checks.

State. In 2013, Samsung received 4676 patents, and IBM received 6809 patents.

58. Let $b =$ the number of books written about George Washington. Then $b + 1675 =$ the number of books written about Abraham Lincoln.

Solve: $b + (b + 1675) = 5493$

$b = 1909$, so 1909 books are written about George Washington and $1909 + 1675$, or 3584, books are written about Abraham Lincoln.

59. ***Familiarize***. Let $d =$ the average depth of the Atlantic Ocean, in feet. Then $\frac{4}{5}d - 272 =$ the average depth of the Indian Ocean.

Translate.

$$\underbrace{\text{Average depth of Pacific Ocean}}_{\displaystyle\downarrow\atop\displaystyle 14,040} \quad \overset{\text{is}}{\downarrow\atop =} \quad \underbrace{\text{Average depth of Atlantic Ocean}}_{\displaystyle\downarrow\atop\displaystyle d} \quad \overset{\text{plus}}{\downarrow\atop +} \quad \underbrace{\text{Average depth of Indian Ocean}}_{\displaystyle\downarrow\atop\displaystyle \frac{4}{5}d-272} \quad \overset{\text{less}}{\downarrow\atop -} \quad \overset{\text{8890 ft}}{\downarrow\atop 8890}$$

Carry out. We solve the equation.

$$\begin{aligned} 14,040 &= d + \frac{4}{5}d - 272 - 8890 \\ 14,040 &= \frac{9}{5}d - 9162 \\ 23,202 &= \frac{9}{5}d \\ \frac{5}{9}\cdot 23,202 &= d \\ 12,890 &= d \end{aligned}$$

If $d = 12,890$, then the average depth of the Indian Ocean is $\frac{4}{5}\cdot 12,890 - 272 = 10,040$.

Check. $12,890 + 10,040 - 8890 = 14,040$, so the answer checks.

State. The average depth of the Indian Ocean is 10,040 ft.

60. Let $c =$ the calcium content of the cheese, in mg. Then $2c + 4 =$ the calcium content of the yogurt.

Solve: $c + 2c + 4 = 676$

$c = 224$, so the cheese has 224 mg of calcium, and the yogurt has $2 \cdot 224 + 4$, or 452 mg of calcium.

61. ***Familiarize***. Let $w =$ the number of pounds of Lily's body weight that is water.

Translate.

$$\overset{55\%}{\downarrow\atop 0.55} \quad \overset{\text{of}}{\downarrow\atop \times} \quad \overbrace{\text{body weight}}^{}\!{\atop\displaystyle\downarrow\atop\displaystyle 135} \quad \overset{\text{is}}{\downarrow\atop =} \quad \overset{\text{water.}}{\downarrow\atop w}$$

Carry out. We solve the equation.

$$\begin{aligned} 0.55 \times 135 &= w \\ 74.25 &= w \end{aligned}$$

Check. Since 55% of 135 is 74.25, the answer checks.

State. 74.25 lb of Lily's body weight is water.

62. Let $w =$ the number of pounds of Jake's body weight that is water.

Solve: $0.6 \times 186 = w$

$w = 111.6$ lb

63. ***Familiarize***. Let $t =$ the number of hours it takes the kayak to travel 36 mi upstream. The kayak travels upstream at a rate of $12 - 4$, or 8 mph.

Translate. We use the formula $d = rt$.

$36 = 8 \cdot t$

Carry out. We solve the equation.

$$\begin{aligned} 36 &= 8 \cdot t \\ 4.5 &= t \end{aligned}$$

Check. At a rate of 8 mph, in 4.5 hr the kayak travels 8(4.5), or 36 mi. The answer checks.

State. It takes the kayak 4.5 hr to travel 36 mi upstream.

64. Let $t =$ the number of hours it will take Angelo to travel 20 km downstream. The kayak travels downstream at a rate of $14 + 2$, or 16 km/h.

Solve: $20 = 16t$

$t = 1.25$ hr

65. ***Familiarize***. Let $w =$ Rosalyn's regular hourly wage. She earned $40w$ for working the first 40 hr. She worked $48 - 40$, or 8 hr, of overtime. She earned $8(1.5w)$ for working 8 hr of overtime.

Translate. The total earned was \$1066, so we write an equation.

$40w + 8(1.5w) = 1066$

Carry out. We solve the equation.

$$\begin{aligned} 40w + 8(1.5)w &= 1066 \\ 40w + 12w &= 1066 \\ 52w &= 1066 \\ w &= 20.5 \end{aligned}$$

Check. $40(\$20.50) + 8[1.5(\$20.50)] = \$820 + \$246 = \$1066$, so the answer checks.

State. Rosalyn's regular hourly wage is \$20.50.

66. Let $d =$ the number of miles Diego traveled in the cab.

Solve: $1.75 + 1.50d = 19.75$

$d = 12$ mi

67. ***Familiarize***. Let $p =$ the percent of the world's olive oil consumed in the United States. Then the percent consumed in Italy is $3\frac{3}{4} \cdot p$, or $\frac{15}{4}p$, and the percent consumed in Spain is $\frac{2}{3} \cdot \frac{15}{4}p$, or $\frac{5}{2}p$.

Translate.

$$\underbrace{\text{Percent of olive oil consumed in Italy, Spain, and the U.S.}}_{p + \frac{15}{4}p + \frac{5}{2}p} \ \underset{=}{\text{is}} \ \underset{58}{58\%}.$$

Carry out.

$$\begin{aligned} p + \frac{15}{4}p + \frac{5}{2}p &= 58 \\ 4\left(p + \frac{15}{4}p + \frac{5}{2}p\right) &= 4 \cdot 58 \\ 4p + 15p + 10p &= 232 \\ 29p &= 232 \\ p &= 8 \end{aligned}$$

If $p = 8$, then $\frac{15}{4}p = \frac{15}{4} \cdot 8 = 30$ and $\frac{5}{2}p = \frac{5}{2} \cdot 8 = 20$.

Check. 30% is $3\frac{3}{4}$ times 8%, and 20% is $\frac{2}{3}$ of 30%. Also, $8\% + 30\% + 20\% = 58\%$, so the answer checks.

State. Italy, Spain, and the United States consume 30%, 20%, and 8% of the world's olive oil, respectively.

68. Let $s =$ the elevation of Lucas Oil Stadium.

Solve: $5280 = 7s + 275$

$s = 715$ ft

69.
$$\begin{aligned} x + 5 &= 0 && \text{Setting } f(x) = 0 \\ x + 5 - 5 &= 0 - 5 && \text{Subtracting 5 on both sides} \\ x &= -5 \end{aligned}$$

The zero of the function is -5.

70.
$$\begin{aligned} 5x + 20 &= 0 \\ 5x &= -20 \\ x &= -4 \end{aligned}$$

71.
$$\begin{aligned} -2x + 11 &= 0 && \text{Setting } f(x) = 0 \\ -2x + 11 - 11 &= 0 - 11 && \text{Subtracting 11 on both sides} \\ -2x &= -11 \\ x &= \frac{11}{2} && \text{Dividing by } -2 \text{ on both sides} \end{aligned}$$

The zero of the function is $\frac{11}{2}$.

72.
$$\begin{aligned} 8 + x &= 0 \\ x &= -8 \end{aligned}$$

73.
$$\begin{aligned} 16 - x &= 0 && \text{Setting } f(x) = 0 \\ 16 - x + x &= 0 + x && \text{Adding } x \text{ on both sides} \\ 16 &= x \end{aligned}$$

The zero of the function is 16.

74.
$$\begin{aligned} -2x + 7 &= 0 \\ -2x &= -7 \\ x &= \frac{7}{2} \end{aligned}$$

75.
$$\begin{aligned} x + 12 &= 0 && \text{Setting } f(x) = 0 \\ x + 12 - 12 &= 0 - 12 && \text{Subtracting 12 on both sides} \\ x &= -12 \end{aligned}$$

The zero of the function is -12.

76.
$$\begin{aligned} 8x + 2 &= 0 \\ 8x &= -2 \\ x &= -\frac{1}{4}, \text{ or } -0.25 \end{aligned}$$

77.
$$\begin{aligned} -x + 6 &= 0 && \text{Setting } f(x) = 0 \\ -x + 6 + x &= 0 + x && \text{Adding } x \text{ on both sides} \\ 6 &= x \end{aligned}$$

The zero of the function is 6.

78.
$$\begin{aligned} 4 + x &= 0 \\ x &= -4 \end{aligned}$$

79.
$$\begin{aligned} 20 - x &= 0 && \text{Setting } f(x) = 0 \\ 20 - x + x &= 0 + x && \text{Adding } x \text{ on both sides} \\ 20 &= x \end{aligned}$$

The zero of the function is 20.

80.
$$\begin{aligned} -3x + 13 &= 0 \\ -3x &= -13 \\ x &= \frac{13}{3}, \text{ or } 4.\overline{3} \end{aligned}$$

81.
$$\begin{aligned} \frac{2}{5}x - 10 &= 0 && \text{Setting } f(x) = 0 \\ \frac{2}{5}x &= 10 && \text{Adding 10 on both sides} \\ \frac{5}{2} \cdot \frac{2}{5}x &= \frac{5}{2} \cdot 10 && \text{Multiplying by } \frac{5}{2} \text{ on both sides} \\ x &= 25 \end{aligned}$$

The zero of the function is 25.

82.
$$\begin{aligned} 3x - 9 &= 0 \\ 3x &= 9 \\ x &= 3 \end{aligned}$$

83.
$$\begin{aligned} -x + 15 &= 0 && \text{Setting } f(x) = 0 \\ 15 &= x && \text{Adding } x \text{ on both sides} \end{aligned}$$

The zero of the function is 15.

84.
$$\begin{aligned} 4 - x &= 0 \\ 4 &= x \end{aligned}$$

85. a) The graph crosses the x-axis at $(4, 0)$. This is the x-intercept.

b) The zero of the function is the first coordinate of the x-intercept. It is 4.

86. a) $(5, 0)$

b) 5

87. a) The graph crosses the x-axis at $(-2, 0)$. This is the x-intercept.

b) The zero of the function is the first coordinate of the x-intercept. It is -2.

88. a) $(2, 0)$

b) 2

89. a) The graph crosses the x-axis at $(-4, 0)$. This is the x-intercept.

b) The zero of the function is the first coordinate of the x-intercept. It is -4.

90. a) $(-2, 0)$

b) -2

91. First find the slope of the given line.

$$\begin{aligned} 3x + 4y &= 7 \\ 4y &= -3x + 7 \\ y &= -\frac{3}{4}x + \frac{7}{4} \end{aligned}$$

The slope is $-\frac{3}{4}$. Now write a slope-intercept equation of the line containing $(-1, 4)$ with slope $-\frac{3}{4}$.

$$\begin{aligned} y - 4 &= -\frac{3}{4}[x - (-1)] \\ y - 4 &= -\frac{3}{4}(x + 1) \\ y - 4 &= -\frac{3}{4}x - \frac{3}{4} \\ y &= -\frac{3}{4}x + \frac{13}{4} \end{aligned}$$

92. $m = \dfrac{4 - (-2)}{-5 - 3} = \dfrac{6}{-8} = -\dfrac{3}{4}$

$$\begin{aligned} y - 4 &= -\frac{3}{4}(x - (-5)) \\ y - 4 &= -\frac{3}{4}x - \frac{15}{4} \\ y &= -\frac{3}{4}x + \frac{1}{4} \end{aligned}$$

93.
$$\begin{aligned} d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(-10 - 2)^2 + (-3 - 2)^2} \\ &= \sqrt{144 + 25} = \sqrt{169} = 13 \end{aligned}$$

94. $\left(\dfrac{x_1 + x_2}{2}, \dfrac{y_1 + y_2}{2}\right) = \left(\dfrac{-\frac{1}{2} + \left(-\frac{3}{2}\right)}{2}, \dfrac{\frac{2}{5} + \frac{3}{5}}{2}\right) = \left(-\dfrac{2}{2}, \dfrac{1}{2}\right) = \left(-1, \dfrac{1}{2}\right)$

95. $f(x) = \dfrac{x}{x - 3}$

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

$f(0) = \dfrac{0}{0 - 3} = \dfrac{0}{-3} = 0$

$f(3) = \dfrac{3}{3 - 3} = \dfrac{3}{0}$

Since division by 0 is not defined, $f(3)$ does not exist.

96.
$$\begin{aligned} 7x - y &= \frac{1}{2} \\ -y &= -7x + \frac{1}{2} \\ y &= 7x - \frac{1}{2} \end{aligned}$$

With the equation in the form $y = mx + b$, we see that the slope is 7 and the y-intercept is $\left(0, -\frac{1}{2}\right)$.

97. $f(x) = 7 - \frac{3}{2}x = -\frac{3}{2}x + 7$

The function can be written in the form $y = mx + b$, so it is a linear function.

98. $f(x) = \frac{3}{2x} + 5$ cannot be written in the form $f(x) = mx + b$, so it is not a linear function.

99. $f(x) = x^2 + 1$ cannot be written in the form $f(x) = mx + b$, so it is not a linear function.

100. $f(x) = \frac{3}{4}x - (2.4)^2$ is in the form $f(x) = mx + b$, so it is a linear function.

101.
$$\begin{aligned} 2x - \{x - [3x - (6x + 5)]\} &= 4x - 1 \\ 2x - \{x - [3x - 6x - 5]\} &= 4x - 1 \\ 2x - \{x - [-3x - 5]\} &= 4x - 1 \\ 2x - \{x + 3x + 5\} &= 4x - 1 \\ 2x - \{4x + 5\} &= 4x - 1 \\ 2x - 4x - 5 &= 4x - 1 \\ -2x - 5 &= 4x - 1 \\ -6x - 5 &= -1 \\ -6x &= 4 \\ x &= -\frac{2}{3} \end{aligned}$$

The solution is $-\frac{2}{3}$.

102.
$$\begin{aligned} 14 - 2[3 + 5(x - 1)] &= 3\{x - 4[1 + 6(2 - x)]\} \\ 14 - 2[3 + 5x - 5] &= 3\{x - 4[1 + 12 - 6x]\} \\ 14 - 2[5x - 2] &= 3\{x - 4[13 - 6x]\} \\ 14 - 10x + 4 &= 3\{x - 52 + 24x\} \\ 18 - 10x &= 3\{25x - 52\} \\ 18 - 10x &= 75x - 156 \\ 174 &= 85x \\ \frac{174}{85} &= x \end{aligned}$$

103. The size of the cup was reduced 8 oz − 6 oz, or 2 oz, and $\dfrac{2 \text{ oz}}{8 \text{ oz}} = 0.25$, so the size was reduced 25%. The price per ounce of the 8 oz cup was $\dfrac{89¢}{8 \text{ oz}}$, or 11.125¢/oz. The price per ounce of the 6 oz cup is $\dfrac{71¢}{6 \text{ oz}}$, or $11.8\overline{3}$¢/oz. Since the price per ounce was not reduced, it is clear that the price per ounce was not reduced by the same percent as the size of the cup. The price was increased by $11.8\overline{3} - 11.125$¢, or $0.708\overline{3}$¢ per ounce. This is an increase of $\dfrac{0.708\overline{3}¢}{11.125¢} \approx 0.064$, or about 6.4% per ounce.

104. Let x = the number of copies of *The Last Song* that were sold. Then $10,919 - x$ = the number of copies of *Deliver Us From Evil* that were sold.

Solve: $\dfrac{x}{10,919 - x} = \dfrac{10}{7.9}$

$x = 6100$, so 6100 copies of *The Last Song* were sold, and $10,919 - 6100$, or 4819 copies of *Deliver Us From Evil* were sold.

105. We use a proportion to determine the number of calories c burned running for 75 minutes, or 1.25 hr.

$$\frac{720}{1} = \frac{c}{1.25}$$
$$720(1.25) = c$$
$$900 = c$$

Next we use a proportion to determine how long the person would have to walk to use 900 calories. Let t represent this time, in hours. We express 90 min as 1.5 hr.

$$\frac{1.5}{480} = \frac{t}{900}$$
$$\frac{900(1.5)}{480} = t$$
$$2.8125 = t$$

Then, at a rate of 4 mph, the person would have to walk 4(2.8125), or 11.25 mi.

Exercise Set 1.6

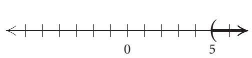
1. $4x - 3 > 2x + 7$

$2x - 3 > 7$ Subtracting $2x$

$2x > 10$ Adding 3

$x > 5$ Dividing by 2

The solution set is $\{x|x > 5\}$, or $(5, \infty)$. The graph is shown below.

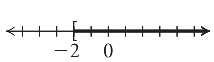


2. $8x + 1 \geq 5x - 5$

$3x \geq -6$

$x \geq -2$

The solution set is $\{x|x \geq -2\}$, or $[-2, \infty)$. The graph is shown below.



3. $x + 6 < 5x - 6$

$6 + 6 < 5x - x$ Subtracting x and adding 6 on both sides

$12 < 4x$

$\dfrac{12}{4} < x$ Dividing by 4 on both sides

$3 < x$

This inequality could also be solved as follows:

$x + 6 < 5x - 6$

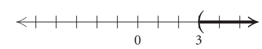
$x - 5x < -6 - 6$ Subtracting $5x$ and 6 on both sides

$-4x < -12$

$x > \dfrac{-12}{-4}$ Dividing by −4 on both sides and reversing the inequality symbol

$x > 3$

The solution set is $\{x|x > 3\}$, or $(3, \infty)$. The graph is shown below.

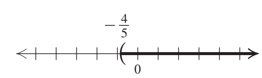


4. $3 - x < 4x + 7$

$-5x < 4$

$x > -\dfrac{4}{5}$

The solution set is $\left\{x\middle|x > -\dfrac{4}{5}\right\}$, or $\left(-\dfrac{4}{5}, \infty\right)$. The graph is shown below.



5. $4 - 2x \leq 2x + 16$

$4 - 4x \leq 16$ Subtracting $2x$

$-4x \leq 12$ Subtracting 4

$x \geq -3$ Dividing by −4 and reversing the inequality symbol

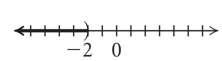
The solution set is $\{x|x \geq -3\}$, or $[-3, \infty)$. The graph is shown below.

6. $3x - 1 > 6x + 5$

$-3x > 6$

$x < -2$

The solution set is $\{x|x < -2\}$, or $(-\infty, -2)$. The graph is shown below.



7. $14 - 5y \leq 8y - 8$

$14 + 8 \leq 8y + 5y$

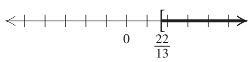
$22 \leq 13y$

$\dfrac{22}{13} \leq y$

This inequality could also be solved as follows:

$$\begin{aligned} 14-5y &\le 8y-8 \\ -5y-8y &\le -8-14 \\ -13y &\le -22 \\ y &\ge \frac{22}{13} \quad \text{Dividing by } -13 \text{ on both sides and reversing the inequality symbol} \end{aligned}$$

The solution set is $\left\{y \middle| y \ge \frac{22}{13}\right\}$, or $\left[\frac{22}{13}, \infty\right)$. The graph is shown below.

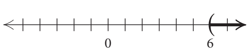


8. $$\begin{aligned} 8x-7 &< 6x+3 \\ 2x &< 10 \\ x &< 5 \end{aligned}$$

The solution set is $\{x|x<5\}$, or $(-\infty, 5)$. The graph is shown below.

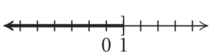
9. $$\begin{aligned} 7x-7 &> 5x+5 \\ 2x-7 &> 5 \quad \text{Subtracting } 5x \\ 2x &> 12 \quad \text{Adding 7} \\ x &> 6 \quad \text{Dividing by 2} \end{aligned}$$

The solution set is $\{x|x>6\}$, or $(6, \infty)$. The graph is shown below.



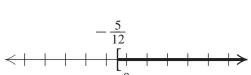
10. $$\begin{aligned} 12-8y &\ge 10y-6 \\ -18y &\ge -18 \\ y &\le 1 \end{aligned}$$

The solution set is $\{y|y \le 1\}$, or $(-\infty, 1]$. The graph is shown below.



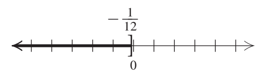
11. $$\begin{aligned} 3x-3+2x &\ge 1-7x-9 \\ 5x-3 &\ge -7x-8 \quad \text{Collecting like terms} \\ 5x+7x &\ge -8+3 \quad \text{Adding } 7x \text{ and 3 on both sides} \\ 12x &\ge -5 \\ x &\ge -\frac{5}{12} \quad \text{Dividing by 12 on both sides} \end{aligned}$$

The solution set is $\left\{x \middle| x \ge -\frac{5}{12}\right\}$, or $\left[-\frac{5}{12}, \infty\right)$. The graph is shown below.



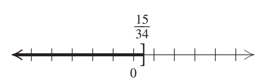
12. $$\begin{aligned} 5y-5+y &\le 2-6y-8 \\ 6y-5 &\le -6y-6 \\ 12y &\le -1 \\ y &\le -\frac{1}{12} \end{aligned}$$

The solution set is $\left\{y \middle| y \le -\frac{1}{12}\right\}$, or $\left(-\infty, -\frac{1}{12}\right]$. The graph is shown below.



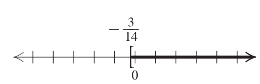
13. $$\begin{aligned} -\frac{3}{4}x &\ge -\frac{5}{8}+\frac{2}{3}x \\ \frac{5}{8} &\ge \frac{3}{4}x+\frac{2}{3}x \\ \frac{5}{8} &\ge \frac{9}{12}x+\frac{8}{12}x \\ \frac{5}{8} &\ge \frac{17}{12}x \\ \frac{12}{17}\cdot\frac{5}{8} &\ge \frac{12}{17}\cdot\frac{17}{12}x \\ \frac{15}{34} &\ge x \end{aligned}$$

The solution set is $\left\{x \middle| x \le \frac{15}{34}\right\}$, or $\left(-\infty, \frac{15}{34}\right]$. The graph is shown below.



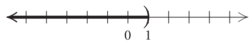
14. $$\begin{aligned} -\frac{5}{6}x &\le \frac{3}{4}+\frac{8}{3}x \\ -\frac{21}{6}x &\le \frac{3}{4} \\ x &\ge -\frac{3}{14} \end{aligned}$$

The solution set is $\left\{x \middle| x \ge -\frac{3}{14}\right\}$, or $\left[-\frac{3}{14}, \infty\right)$. The graph is shown below.



15. $$\begin{aligned} 4x(x-2) &< 2(2x-1)(x-3) \\ 4x(x-2) &< 2(2x^2-7x+3) \\ 4x^2-8x &< 4x^2-14x+6 \\ -8x &< -14x+6 \\ -8x+14x &< 6 \\ 6x &< 6 \\ x &< \frac{6}{6} \\ x &< 1 \end{aligned}$$

The solution set is $\{x|x<1\}$, or $(-\infty, 1)$. The graph is shown below.



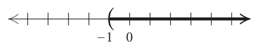
16. $(x+1)(x+2) > x(x+1)$

$x^2+3x+2 > x^2+x$

$2x > -2$

$x > -1$

The solution set is $\{x|x > -1\}$, or $(-1, \infty)$. The graph is shown below.



17. The radicand must be nonnegative, so we solve the inequality $x - 7 \geq 0$.

$x - 7 \geq 0$

$x \geq 7$

The domain is $\{x|x \geq 7\}$, or $[7, \infty)$.

18. $x + 8 \geq 0$

$x \geq -8$

The domain is $\{x|x \geq -8\}$, or $[-8, \infty)$.

19. The radicand must be nonnegative, so we solve the inequality $1 - 5x \geq 0$.

$1 - 5x \geq 0$

$1 \geq 5x$

$\frac{1}{5} \geq x$

The domain is $\left\{x\middle|x \leq \frac{1}{5}\right\}$, or $\left(-\infty, \frac{1}{5}\right]$.

20. $2x + 3 \geq 0$

$2x \geq -3$

$x \geq -\frac{3}{2}$

The domain is $\left\{x\middle|x \geq -\frac{3}{2}\right\}$, or $\left[-\frac{3}{2}, \infty\right)$.

21. The radicand must be positive, so we solve the inequality $4 + x > 0$.

$4 + x > 0$

$x > -4$

The domain is $\{x|x > -4\}$, or $(-4, \infty)$.

22. $8 - x > 0$

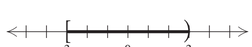
$8 > x$

The domain is $\{x|x < 8\}$, or $(-\infty, 8)$.

23. $-2 \leq x + 1 < 4$

$-3 \leq x < 3$ Subtracting 1

The solution set is $[-3, 3)$. The graph is shown below.



24. $-3 < x + 2 \leq 5$

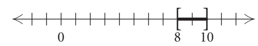
$-5 < x \leq 3$

$(-5, 3]$

25. $5 \leq x - 3 \leq 7$

$8 \leq x \leq 10$ Adding 3

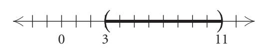
The solution set is $[8, 10]$. The graph is shown below.



26. $-1 < x - 4 < 7$

$3 < x < 11$

$(3, 11)$



27. $-3 \leq x + 4 \leq 3$

$-7 \leq x \leq -1$ Subtracting 4

The solution set is $[-7, -1]$. The graph is shown below.

28. $-5 < x + 2 < 15$

$-7 < x < 13$

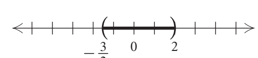
$(-7, 13)$

29. $-2 < 2x + 1 < 5$

$-3 < 2x < 4$ Adding -1

$-\frac{3}{2} < x < 2$ Multiplying by $\frac{1}{2}$

The solution set is $\left(-\frac{3}{2}, 2\right)$. The graph is shown below.

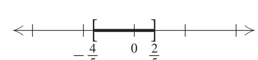


30. $-3 \leq 5x + 1 \leq 3$

$-4 \leq 5x \leq 2$

$-\frac{4}{5} \leq x \leq \frac{2}{5}$

$\left[-\frac{4}{5}, \frac{2}{5}\right]$



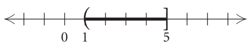
31. $-4 \leq 6 - 2x < 4$

$-10 \leq -2x < -2$ Adding -6

$5 \geq x > 1$ Multiplying by $-\dfrac{1}{2}$

or $1 < x \leq 5$

The solution set is $(1, 5]$. The graph is shown below.

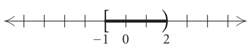


32. $-3 < 1 - 2x \leq 3$

$-4 < -2x \leq 2$

$2 > x \geq -1$

$[-1, 2)$



33. $-5 < \dfrac{1}{2}(3x+1) < 7$

$-10 < 3x + 1 < 14$ Multiplying by 2

$-11 < 3x < 13$ Adding -1

$-\dfrac{11}{3} < x < \dfrac{13}{3}$ Multiplying by $\dfrac{1}{3}$

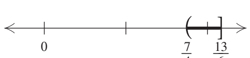
The solution set is $\left(-\dfrac{11}{3}, \dfrac{13}{3}\right)$. The graph is shown below.

34. $\dfrac{2}{3} \leq -\dfrac{4}{5}(x-3) < 1$

$-\dfrac{5}{6} \geq x - 3 > -\dfrac{5}{4}$

$\dfrac{13}{6} \geq x > \dfrac{7}{4}$

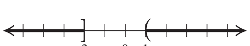
$\left(\dfrac{7}{4}, \dfrac{13}{6}\right]$



35. $3x \leq -6$ *or* $x - 1 > 0$

$x \leq -2$ *or* $x > 1$

The solution set is $(-\infty, -2] \cup (1, \infty)$. The graph is shown below.



36. $2x < 8$ *or* $x + 3 \geq 10$

$x < 4$ *or* $x \geq 7$

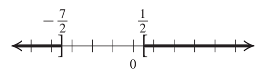
$(-\infty, 4) \cup [7, \infty)$

37. $2x + 3 \leq -4$ *or* $2x + 3 \geq 4$

$2x \leq -7$ *or* $2x \geq 1$

$x \leq -\dfrac{7}{2}$ *or* $x \geq \dfrac{1}{2}$

The solution set is $\left(-\infty, -\dfrac{7}{2}\right] \cup \left[\dfrac{1}{2}, \infty\right)$. The graph is shown below.

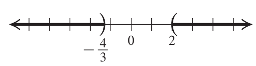


38. $3x - 1 < -5$ *or* $3x - 1 > 5$

$3x < -4$ *or* $3x > 6$

$x < -\dfrac{4}{3}$ *or* $x > 2$

$\left(-\infty, -\dfrac{4}{3}\right) \cup (2, \infty)$



39. $2x - 20 < -0.8$ *or* $2x - 20 > 0.8$

$2x < 19.2$ *or* $2x > 20.8$

$x < 9.6$ *or* $x > 10.4$

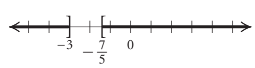
The solution set is $(-\infty, 9.6) \cup (10.4, \infty)$. The graph is shown below.

40. $5x + 11 \leq -4$ *or* $5x + 11 \geq 4$

$5x \leq -15$ *or* $5x \geq -7$

$x \leq -3$ *or* $x \geq -\dfrac{7}{5}$

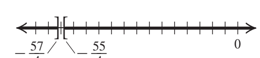
$(-\infty, -3] \cup \left[-\dfrac{7}{5}, \infty\right)$



41. $x + 14 \leq -\dfrac{1}{4}$ *or* $x + 14 \geq \dfrac{1}{4}$

$x \leq -\dfrac{57}{4}$ *or* $x \geq -\dfrac{55}{4}$

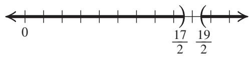
The solution set is $\left(-\infty, -\dfrac{57}{4}\right] \cup \left[-\dfrac{55}{4}, \infty\right)$. The graph is shown below.



42. $x - 9 < -\dfrac{1}{2}$ *or* $x - 9 > \dfrac{1}{2}$

$x < \dfrac{17}{2}$ *or* $x > \dfrac{19}{2}$

$\left(-\infty, \dfrac{17}{2}\right) \cup \left(\dfrac{19}{2}, \infty\right)$



43. ***Familiarize and Translate.*** World rice production is given by the equation $y = 9.06x + 410.81$. We want to know when production will be more than 820 million metric tons, so we have

$$9.06x + 410.81 > 820.$$

Carry out. We solve the equation.

$$\begin{aligned} 9.06x + 410.81 &> 820 \\ 9.06x &> 409.19 \\ x &> 45 \qquad \text{Rounding} \end{aligned}$$

Check. When $x \approx 45$, $y = 9.06(45) + 410.81 = 818.51 \approx 820$. As a partial check, we could try a value of x less than 45 and one greater than 45. When $x = 44.8$, we have $y = 9.06(44.8) + 410.81 = 816.698 < 820$; when $x = 45.2$, we have $y = 9.06(45.2) + 410.81 = 820.322 > 820$. Since $y \approx 820$ when $x = 45$ and $y > 820$ when $x > 45$, the answer is probably correct.

State. World rice production will exceed 820 million metric tons more than 45 years after 1980.

44. Solve: $0.326x + 7.148 > 12$

$x > 15$, so more than 12 million people will be collecting Social Security disability payments more than 15 years after 2007.

45. ***Familiarize.*** Let t = the number of hours worked. Then Acme Movers charge $200 + 45t$ and Leo's Movers charge $65t$.

Translate.

$$\begin{array}{ccc} \underbrace{\text{Leo's charge}} & \underbrace{\text{is less than}} & \underbrace{\text{Acme's charge.}} \\ \downarrow & \downarrow & \downarrow \\ 65t & < & 200 + 45t \end{array}$$

Carry out. We solve the inequality.

$$\begin{aligned} 65t &< 200 + 45t \\ 20t &< 200 \\ t &< 10 \end{aligned}$$

Check. When $t = 10$, Leo's Movers charge $65 \cdot 10$, or \$650 and Acme Movers charge $200 + 45 \cdot 10$, or \$650, so the charges are the same. As a partial check, we find the charges for a value of $t < 10$. When $t = 9.5$, Leo's Movers charge $65(9.5) = \$617.50$ and Acme Movers charge $200 + 45(9.5) = \$627.50$. Since Leo's charge is less than Acme's, the answer is probably correct.

State. For times less than 10 hr it costs less to hire Leo's Movers.

46. Let x = the amount invested at 4%. Then $12,000 - x$ = the amount invested at 6%.

Solve: $0.04x + 0.06(12,000 - x) \geq 650$

$x \leq 3500$, so at most \$3500 can be invested at 4%.

47. ***Familiarize.*** Let x = the amount invested at 4%. Then $7500 - x$ = the amount invested at 5%. Using the simple-interest formula, $I = Prt$, we see that in one year the 4% investment earns $0.04x$ and the 5% investment earns $0.05(7500 - x)$.

Translate.

$$\begin{array}{ccccc} \underbrace{\text{Interest at 4\%}} & \text{plus} & \underbrace{\text{interest at 5\%}} & \underbrace{\text{is at least}} & \$325. \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 0.04x & + & 0.05(7500 - x) & \geq & 325 \end{array}$$

Carry out. We solve the inequality.

$$\begin{aligned} 0.04x + 0.05(7500 - x) &\geq 325 \\ 0.04x + 375 - 0.05x &\geq 325 \\ -0.01x + 375 &\geq 325 \\ -0.01x &\geq -50 \\ x &\leq 5000 \end{aligned}$$

Check. When \$5000 is invested at 4%, then \$7500−\$5000, or \$2500, is invested at 5%. In one year the 4% investment earns 0.04(\$5000), or \$200, in simple interest and the 5% investment earns 0.05(\$2500), or \$125, so the total interest is \$200 + \$125, or \$325. As a partial check, we determine the total interest when an amount greater than \$5000 is invested at 4%. Suppose \$5001 is invested at 4%. Then \$2499 is invested at 5%, and the total interest is 0.04(\$5001) + 0.05(\$2499), or \$324.99. Since this amount is less than \$325, the answer is probably correct.

State. The most that can be invested at 4% is \$5000.

48. Let x = the amount invested at 7%. Then $2x$ = the amount invested at 4%, and $150,000 - x - 2x$, or $150,000 - 3x$ = the amount invested at 5.5%. The interest earned is $0.07x + 0.04 \cdot 2x + 0.055(150,000 - 3x)$, or $0.07x + 0.08x + 8250 - 0.165x$, or $-0.015x + 8250$.

Solve: $-0.015x + 8250 \geq 7575$

$x \leq 45,000$, so $2x \leq 90,000$

Thus the most that can be invested at 4% is \$90,000.

49. ***Familiarize and Translate.*** Let x = the amount invested at 5%. Then
$\dfrac{1}{2}x$ = the amount invested at 3.5%, and
$1,400,000 - x - \dfrac{1}{2}x$, or $1,400,000 - \dfrac{3}{2}x$ = the amount invested at 5.5%. The interest earned is
$0.05x + 0.035\left(\dfrac{1}{2}x\right) + 0.055\left(1,400,000 - \dfrac{3}{2}x\right)$, or
$0.05x + 0.0175x + 77,000 - 0.0825x$, or $-0.015x + 77,000$. The foundation wants the interest to be at least \$68,000, so we have

$$-0.015x + 77,000 \geq 68,000.$$

Carry out. We solve the inequality.

$$\begin{aligned} -0.015x + 77,000 &\geq 68,000 \\ -0.015x &\geq -9000 \\ x &\leq 600,000 \end{aligned}$$

If $x \leq 600,000$ then $\dfrac{1}{2}x \leq 300,000$.

Check. If \$600,000 is invested at 5% and \$300,000 is invested at 3.5%, then the amount invested at 5.5% is $\$1,400,000 - \$600,000 - \$300,000 = \$500,000$. The interest earned is $0.05(\$600,000) + 0.035(\$300,000) +$

$0.055(\$500,000)$, or $\$30,000 + \$10,500 + \$27,500$, or \$68,000. As a partial check, we can determine if the total interest earned when more than \$300,000 is invested at 3.5% is less than \$68,000. This is the case, so the answer is probably correct.

State. The most than can be invested at 3.5% is \$300,000.

50. Let $s =$ the monthly sales.

Solve: $750 + 0.1s > 1000 + 0.08(s - 2000)$

$s > 4500$, so Plan A is better for monthly sales greater than \$4500.

51. ***Familiarize***. Let $s =$ the monthly sales. Then the amount of sales in excess of \$8000 is $s - 8000$.

Translate.

$$\underbrace{\text{Income from plan B}}_{1200+0.15(s-8000)} \quad \underbrace{\text{is greater than}}_{>} \quad \underbrace{\text{income from plan A.}}_{900+0.1s}$$

Carry out. We solve the inequality.

$$\begin{aligned} 1200 + 0.15(s - 8000) &> 900 + 0.1s \\ 1200 + 0.15s - 1200 &> 900 + 0.1s \\ 0.15s &> 900 + 0.1s \\ 0.05s &> 900 \\ s &> 18,000 \end{aligned}$$

Check. For sales of \$18,000 the income from plan A is $\$900+0.1(\$18,000)$, or \$2700, and the income from plan B is $1200 + 0.15(18,000 - 8000)$, or \$2700 so the incomes are the same. As a partial check we can compare the incomes for an amount of sales greater than \$18,000. For sales of \$18,001, for example, the income from plan A is $\$900 + 0.1(\$18,001)$, or \$2700.10, and the income from plan B is $\$1200 + 0.15(\$18,001 - \$8000)$, or \$2700.15. Since plan B is better than plan A in this case, the answer is probably correct.

State. Plan B is better than plan A for monthly sales greater than \$18,000.

52. Solve: $200 + 12n > 20n$

$n < 25$

53. Function; domain; range; domain; exactly one; range

54. Midpoint formula

55. x-intercept

56. Constant; identity

57. $2x \le 5 - 7x < 7 + x$

$$\begin{array}{lcl} 2x \le 5 - 7x & and & 5 - 7x < 7 + x \\ 9x \le 5 & and & -8x < 2 \\ x \le \frac{5}{9} & and & x > -\frac{1}{4} \end{array}$$

The solution set is $\left(-\frac{1}{4}, \frac{5}{9}\right]$.

58. $x \le 3x - 2 \le 2 - x$

$$\begin{array}{lcl} x \le 3x - 2 & and & 3x - 2 \le 2 - x \\ -2x \le -2 & and & 4x \le 4 \\ x \ge 1 & and & x \le 1 \end{array}$$

The solution is 1.

59. $3y < 4 - 5y < 5 + 3y$

$$\begin{array}{ll} 0 < 4 - 8y < 5 & \text{Subtracting } 3y \\ -4 < -8y < 1 & \text{Subtracting } 4 \\ \frac{1}{2} > y > -\frac{1}{8} & \text{Dividing by } -8 \text{ and reversing the inequality symbols} \end{array}$$

The solution set is $\left(-\frac{1}{8}, \frac{1}{2}\right)$.

60. $y - 10 < 5y + 6 \le y + 10$

$$\begin{array}{ll} -10 < 4y + 6 \le 10 & \text{Subtracting } y \\ -16 < 4y \le 4 & \\ -4 < y \le 1 & \end{array}$$

The solution set is $(-4, 1]$.

Chapter 1 Review Exercises

1. First we solve each equation for y.

$$\begin{array}{ll} ax + y = c & x - by = d \\ y = -ax + c & -by = -x + d \\ & y = \frac{1}{b}x - \frac{d}{b} \end{array}$$

If the lines are perpendicular, the product of their slopes is -1, so we have $-a \cdot \frac{1}{b} = -1$, or $-\frac{a}{b} = -1$, or $\frac{a}{b} = 1$. The statement is true.

2. For the lines $y = \frac{1}{2}$ and $x = -5$, the x-coordinate of the point of intersection is -5 and the y-coordinate is $\frac{1}{2}$, so the statement is true.

3. $f(-3) = \frac{\sqrt{3 - (-3)}}{-3} = \frac{\sqrt{6}}{-3}$, so -3 is in the domain of $f(x)$. Thus, the statement is false.

4. The line parallel to the x-axis that passes through $\left(-\frac{1}{4}, 7\right)$ is 7 units above the x-axis. Thus, its equation is $y = 7$. The given statement is false.

5. The statement is true. See page 72 in the text.

6. The statement is false. See page 80 in the text.

7. For $\left(3, \frac{24}{9}\right)$:

$$\begin{array}{r|l} \multicolumn{2}{c}{2x - 9y = -18} \\ \hline 2 \cdot 3 - 9 \cdot \frac{24}{9} & ?\ -18 \\ 6 - 24 & \\ -18 & -18 \quad \text{TRUE} \end{array}$$

$\left(3, \frac{24}{9}\right)$ is a solution.

For $(0,-9)$:
$$\begin{array}{r|l} 2x-9y & = -18 \\ \hline 2(0)-9(-9) & ?\ -18 \\ 0+81 & \\ 81 & -18 \quad \text{FALSE} \end{array}$$

$(0,-9)$ is not a solution.

8. For $(0,7)$:
$$\begin{array}{c|c} y & = 7 \\ \hline 7 & ?\ 7 \quad \text{TRUE} \end{array}$$

$(0,7)$ is a solution.

For $(7,1)$:
$$\begin{array}{c|c} y & = 7 \\ \hline 1 & ?\ 7 \quad \text{FALSE} \end{array}$$

$(7,1)$ is not a solution.

9. $2x-3y=6$

To find the x-intercept we replace y with 0 and solve for x.

$$\begin{aligned} 2x-3\cdot 0 &= 6 \\ 2x &= 6 \\ x &= 3 \end{aligned}$$

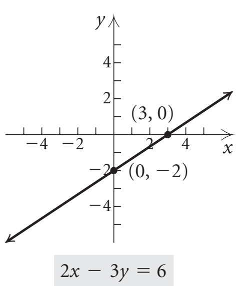
The x-intercept is $(3,0)$.

To find the y-intercept we replace x with 0 and solve for y.

$$\begin{aligned} 2\cdot 0-3y &= 6 \\ -3y &= 6 \\ y &= -2 \end{aligned}$$

The y-intercept is $(0,-2)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



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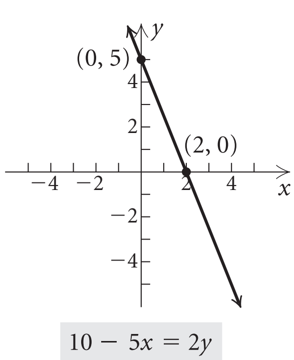

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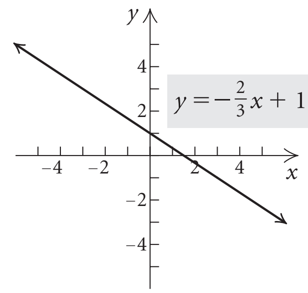

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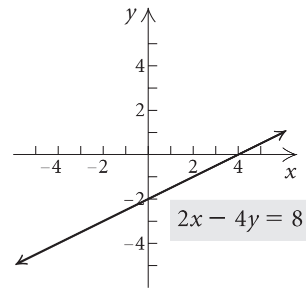

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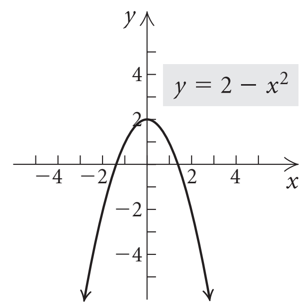
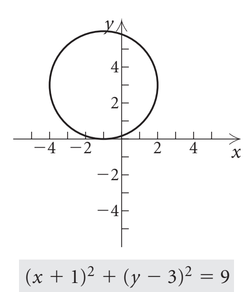


14.
$$\begin{aligned} d &= \sqrt{(x_1-x_2)^2+(y_1-y_2)^2} \\ &= \sqrt{(3-(-2))^2+(7-4)^2} \\ &= \sqrt{5^2+3^2}=\sqrt{34}\approx 5.831 \end{aligned}$$

15.
$$\begin{aligned} m &= \left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) \\ &= \left(\frac{3+(-2)}{2}, \frac{7+4}{2}\right) \\ &= \left(\frac{1}{2}, \frac{11}{2}\right) \end{aligned}$$

16.
$$\begin{aligned} (x+1)^2+(y-3)^2 &= 9 \\ [x-(-1)]^2+(y-3)^2 &= 3^2 \quad \text{Standard form} \end{aligned}$$

The center is $(-1,3)$ and the radius is 3.



17. $(x-h)^2+(y-k)^2=r^2$

$(x-0)^2+[y-(-4)]^2=\left(\dfrac{3}{2}\right)^2$ Substituting

$x^2+(y+4)^2=\dfrac{9}{4}$

18. $(x-h)^2+(y-k)^2=r^2$

$[x-(-2)]^2+(y-6)^2=(\sqrt{13})^2$

$(x+2)^2+(y-6)^2=13$

19. The center is the midpoint of the diameter:

$\left(\dfrac{-3+7}{2},\dfrac{5+3}{2}\right)=\left(\dfrac{4}{2},\dfrac{8}{2}\right)=(2,4)$

Use the center and either endpoint of the diameter to find the radius. We use the point $(7,3)$.

$r=\sqrt{(7-2)^2+(3-4)^2}=\sqrt{5^2+(-1)^2}=\sqrt{25+1}=\sqrt{26}$

The equation of the circle is $(x-2)^2+(y-4)^2=(\sqrt{26})^2$, or $(x-2)^2+(y-4)^2=26$.

20. The correspondence is not a function because one member of the domain, 2, corresponds to more than one member of the range.

21. The correspondence is a function because each member of the domain corresponds to exactly one member of the range.

22. The relation is not a function, because the ordered pairs $(3,1)$ and $(3,5)$ have the same first coordinate and different second coordinates.

Domain: $\{3,5,7\}$

Range: $\{1,3,5,7\}$

23. The relation is a function, because no two ordered pairs have the same first coordinate and different second coordinates. The domain is the set of first coordinates: $\{-2,0,1,2,7\}$. The range is the set of second coordinates: $\{-7,-4,-2,2,7\}$.

24. $f(x)=x^2-x-3$

a) $f(0)=0^2-0-3=-3$

b) $f(-3)=(-3)^2-(-3)-3=9+3-3=9$

c) $f(a-1)=(a-1)^2-(a-1)-3$
$\quad=a^2-2a+1-a+1-3$
$\quad=a^2-3a-1$

d) $f(-x)=(-x)^2-(-x)-3$
$\quad=x^2+x-3$

25. $f(x)=\dfrac{x-7}{x+5}$

a) $f(7)=\dfrac{7-7}{7+5}=\dfrac{0}{12}=0$

b) $f(x+1)=\dfrac{x+1-7}{x+1+5}=\dfrac{x-6}{x+6}$

c) $f(-5)=\dfrac{-5-7}{-5+5}=\dfrac{-12}{0}$

Since division by 0 is not defined, $f(-5)$ does not exist.

d) $f\left(-\dfrac{1}{2}\right)=\dfrac{-\frac{1}{2}-7}{-\frac{1}{2}+5}=\dfrac{-\frac{15}{2}}{\frac{9}{2}}=-\dfrac{15}{2}\cdot\dfrac{2}{9}=$

$-\dfrac{\cancel{3}\cdot 5\cdot\cancel{2}}{\cancel{2}\cdot\cancel{3}\cdot 3}=-\dfrac{5}{3}$

26. From the graph we see that when the input is 2, the output is -1, so $f(2)=-1$. When the input is -4, the output is -3, so $f(-4)=-3$. When the input is 0, the output is -1, so $f(0)=-1$.

27. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.

28. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

29. This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.

30. This is the graph of a function, because there is no vertical line that crosses the graph more than once.

31. We can substitute any real number for x. Thus, the domain is the set of all real numbers, or $(-\infty,\infty)$.

32. The input 0 results in a denominator of zero. Thus, the domain is $\{x|x\neq 0\}$, or $(-\infty,0)\cup(0,\infty)$.

33. Find the inputs that make the denominator zero:

$x^2-6x+5=0$

$(x-1)(x-5)=0$

$x-1=0$ *or* $x-5=0$

$x=1$ *or* $x=5$

The domain is $\{x|x\neq 1 \textit{ and } x\neq 5\}$, or $(-\infty,1)\cup(1,5)\cup(5,\infty)$.

34. Find the inputs that make the denominator zero:

$|16-x^2|=0$

$16-x^2=0$

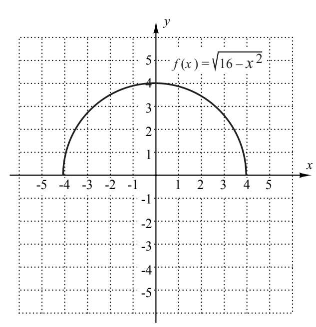
$(4+x)(4-x)=0$

$4+x=0$ *or* $4-x=0$

$x=-4$ *or* $4=x$

The domain is $\{x|x\neq -4 \textit{ and } x\neq 4\}$, or $(-\infty,-4)\cup(-4,4)\cup(4,\infty)$.

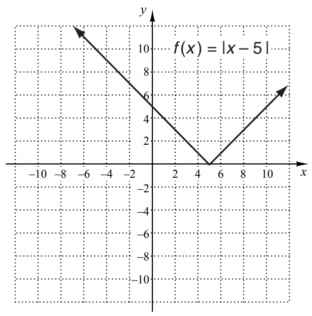
35.



The inputs on the x axis extend from -4 to 4, so the domain is $[-4,4]$.

The outputs on the y-axis extend from 0 to 4, so the range is $[0,4]$.

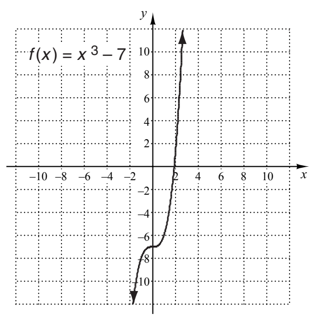
36.



Each point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty,\infty)$.

The number 0 is the smallest output on the y-axis and every number greater than 0 is also an output, so the range is $[0,\infty)$.

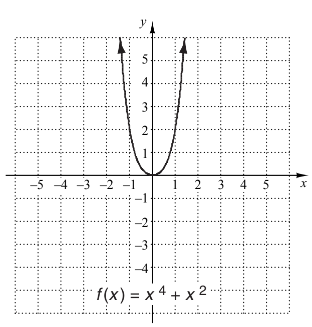
37.



Every point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty,\infty)$.

Each point on the y-axis also corresponds to a point on the graph, so the range is the set of all real numbers, or $(-\infty,\infty)$.

38.



Each point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty,\infty)$.

The number 0 is the smallest output on the y-axis and every number greater than 0 is also an output, so the range is $[0,\infty)$.

39. a) Yes. Each input is 1 more than the one that precedes it.

b) No. The change in the output varies.

c) No. Constant changes in inputs do not result in constant changes in outputs.

40. a) Yes. Each input is 10 more than the one that precedes it.

b) Yes. Each output is 12.4 more than the one that precedes it.

c) Yes. Constant changes in inputs result in constant changes in outputs.

41. $$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-6-(-11)}{5-2} = \frac{5}{3} \end{aligned}$$

42. $m = \dfrac{4-4}{-3-5} = \dfrac{0}{-8} = 0$

43. $$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{0-3}{\frac{1}{2}-\frac{1}{2}} = \frac{-3}{0} \end{aligned}$$

The slope is not defined.

44. We have the data points (1990, 26.8) and (2011, 24.7). We find the average rate of change, or slope.

$$m = \frac{24.7 - 26.8}{2011 - 1990} = \frac{-2.1}{21} = -0.1$$

The average rate of change in per capita coffee consumption from 1990 to 2011 was about -0.1 gallons per year.

45. $y = -\dfrac{7}{11}x - 6$

The equation is in the form $y = mx + b$. The slope is $-\dfrac{7}{11}$, and the y-intercept is $(0,-6)$.

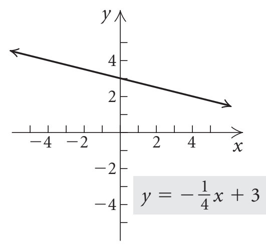
46. $$\begin{aligned} -2x - y &= 7 \\ -y &= 2x + 7 \\ y &= -2x - 7 \end{aligned}$$

Slope: -2; y-intercept: $(0,-7)$

47. Graph $y = -\dfrac{1}{4}x + 3$.

Plot the y-intercept, $(0,3)$. We can think of the slope as $\dfrac{-1}{4}$. Start at $(0,3)$ and find another point by moving down 1 unit and right 4 units. We have the point $(4,2)$.

We could also think of the slope as $\dfrac{1}{-4}$. Then we can start at $(0,3)$ and find another point by moving up 1 unit and left 4 units. We have the point $(-4, 4)$. Connect the three points and draw the graph.



48. Let t = number of months of basic service.

$$C(t) = 110 + 85t$$
$$C(12) = 110 + 85 \cdot 12 = \$1130$$

49. a) $T(d) = 10d + 20$

$$T(5) = 10(5) + 20 = 70°\text{C}$$
$$T(20) = 10(20) + 20 = 220°\text{C}$$
$$T(1000) = 10(1000) + 20 = 10,020°\text{C}$$

b) 5600 km is the maximum depth. Domain: $[0, 5600]$.

50. $y = mx + b$

$y = -\frac{2}{3}x - 4$ Substituting $-\frac{2}{3}$ for m and -4 for b

51.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-1) &= 3(x - (-2)) \\ y + 1 &= 3(x + 2) \\ y + 1 &= 3x + 6 \\ y &= 3x + 5 \end{aligned}$$

52. First we find the slope.

$$m = \frac{-1-1}{-2-4} = \frac{-2}{-6} = \frac{1}{3}$$

Use the point-slope equation:

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

Using $(-2, -1)$: $y - (-1) = \frac{1}{3}(x - (-2))$, or

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

In either case, we have $y = \frac{1}{3}x - \frac{1}{3}$.

53. The horizontal line that passes through $\left(-4, \frac{2}{5}\right)$ is $\frac{2}{5}$ unit above the x-axis. An equation of the line is $y = \frac{2}{5}$.

The vertical line that passes through $\left(-4, \frac{2}{5}\right)$ is 4 units to the left of the y-axis. An equation of the line is $x = -4$.

54. Two points on the line are $(-2, -9)$ and $(4, 3)$. First we find the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - (-9)}{4 - (-2)} = \frac{12}{6} = 2$$

Now we use the point-slope equation with the point $(4, 3)$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3 &= 2(x - 4) \\ y - 3 &= 2x - 8 \\ y &= 2x - 5, \text{ or} \\ h(x) &= 2x - 5 \end{aligned}$$

Then $h(0) = 2 \cdot 0 - 5 = -5$.

55. $3x - 2y = 8$ $\qquad$ $6x - 4y = 2$

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

The lines have the same slope, $\frac{3}{2}$, and different y-intercepts, $(0, -4)$ and $\left(0, -\frac{1}{2}\right)$, so they are parallel.

56. $y - 2x = 4$ $\qquad$ $2y - 3x = -7$

$y = 2x + 4$ $\qquad$ $y = \frac{3}{2}x - \frac{7}{2}$

The lines have different slopes, 2 and $\frac{3}{2}$, so they are not parallel. The product of the slopes, $2 \cdot \frac{3}{2}$, or 3, is not -1, so the lines are not perpendicular. Thus the lines are neither parallel nor perpendicular.

57. The slope of $y = \frac{3}{2}x + 7$ is $\frac{3}{2}$ and the slope of $y = -\frac{2}{3}x - 4$ is $-\frac{2}{3}$. Since $\frac{3}{2}\left(-\frac{2}{3}\right) = -1$, the lines are perpendicular.

58.
$$\begin{aligned} 2x + 3y &= 4 \\ 3y &= -2x + 4 \\ y &= -\frac{2}{3}x + \frac{4}{3};\ m = -\frac{2}{3} \end{aligned}$$

The slope of a line parallel to the given line is $-\frac{2}{3}$.

We use the point-slope equation.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-1) &= -\frac{2}{3}(x - 1) \\ y &= -\frac{2}{3}x - \frac{1}{3} \end{aligned}$$

59. From Exercise 58 we know that the slope of the given line is $-\frac{2}{3}$. The slope of a line perpendicular to this line is the negative reciprocal of $-\frac{2}{3}$, or $\frac{3}{2}$.

We use the slope-intercept equation to find the y-intercept.

$$\begin{aligned} y &= mx + b \\ -1 &= \frac{3}{2} \cdot 1 + b \\ -1 &= \frac{3}{2} + b \\ -\frac{5}{2} &= b \end{aligned}$$

Then the equation of the desired line is $y = \frac{3}{2}x - \frac{5}{2}$.

60. Answers may vary depending on the data points used and when rounding occurred. We will use (2, 7925) and (6, 8396).

$$m = \frac{8396 - 7925}{6 - 2} = \frac{471}{4} = 117.75$$

We will use the point-slope equation with (2, 7925).

$$\begin{aligned} W(x) - 7925 &= 117.75(x - 2) \\ W(x) - 7925 &= 117.75x - 235.5 \\ W(x) &= 117.75x + 7689.5, \end{aligned}$$

where x is the number of years after 2005.

In 2008, $x = 2008 - 2005 = 3$.

$W(3) = 117.75(3) + 7689.5 \approx 8043$ female medical school graduates.

In 2018, $x = 2018 - 2005 = 13$.

$W(13) = 117.75(13)+7689.5 \approx 9220$ female medical school graduates.

61. $$\begin{aligned} 4y - 5 &= 1 \\ 4y &= 6 \\ y &= \frac{3}{2} \end{aligned}$$

The solution is $\frac{3}{2}$.

62. $$\begin{aligned} 3x - 4 &= 5x + 8 \\ -12 &= 2x \\ -6 &= x \end{aligned}$$

63. $$\begin{aligned} 5(3x + 1) &= 2(x - 4) \\ 15x + 5 &= 2x - 8 \\ 13x &= -13 \\ x &= -1 \end{aligned}$$

The solution is -1.

64. $$\begin{aligned} 2(n - 3) &= 3(n + 5) \\ 2n - 6 &= 3n + 15 \\ -21 &= n \end{aligned}$$

65. $$\begin{aligned} \frac{3}{5}y - 2 &= \frac{3}{8} && \text{The LCD is 40} \\ 40\left(\frac{3}{5}y - 2\right) &= 40 \cdot \frac{3}{8} && \text{Multiplying to clear fractions} \\ 24y - 80 &= 15 \\ 24y &= 95 \\ y &= \frac{95}{24} \end{aligned}$$

The solution is $\frac{95}{24}$.

66. $$\begin{aligned} 5 - 2x &= -2x + 3 \\ 5 &= 3 && \text{False equation} \end{aligned}$$

The equation has no solution.

67. $$\begin{aligned} x - 13 &= -13 + x \\ -13 &= -13 && \text{Subtracting } x \end{aligned}$$

We have an equation that is true for any real number, so the solution set is the set of all real numbers, $\{x|x \text{ is a real number}\}$, or $(-\infty, \infty)$.

68. Let $q =$ the number of quarters produced in 2012, in millions.

Solve: $q + 1.56q = 1455$

$q \approx 568$ million quarters

69. ***Familiarize***. Let $a =$ the amount originally invested. Using the simple interest formula, $I = Prt$, we see that the interest earned at 5.2% interest for 1 year is $a(0.052) \cdot 1 = 0.052a$.

Translate.

$$\begin{array}{ccccc} \underbrace{\text{Amount invested}} & \text{plus} & \underbrace{\text{interest earned}} & \text{is} & \$2419.60 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ a & + & 0.052a & = & 2419.60 \end{array}$$

Carry out. We solve the equation.

$$\begin{aligned} a + 0.052a &= 2419.60 \\ 1.052a &= 2419.60 \\ a &= 2300 \end{aligned}$$

Check. 5.2% of \$2300 is 0.052(\$2300), or \$119.60, and \$2300 + \$119.60 = \$2419.60. The answer checks.

State. \$2300 was originally invested.

70. Let $t =$ the time it will take the plane to travel 1802 mi.

Solve: $1802 = (550 - 20)t$

$t = 3.4$ hr

71. $$\begin{aligned} 6x - 18 &= 0 \\ 6x &= 18 \\ x &= 3 \end{aligned}$$

The zero of the function is 3.

72. $$\begin{aligned} x - 4 &= 0 \\ x &= 4 \end{aligned}$$

The zero of the function is 4.

73. $$\begin{aligned} 2 - 10x &= 0 \\ -10x &= -2 \\ x &= \frac{1}{5}, \text{ or } 0.2 \end{aligned}$$

The zero of the function is $\frac{1}{5}$, or 0.2.

74. $$\begin{aligned} 8 - 2x &= 0 \\ -2x &= -8 \\ x &= 4 \end{aligned}$$

The zero of the function is 4.

75. $2x - 5 < x + 7$

$x < 12$

The solution set is $\{x|x < 12\}$, or $(-\infty, 12)$.

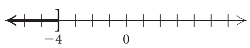
76. $3x + 1 \geq 5x + 9$

$-2x + 1 \geq 9$ Subtracting $5x$

$-2x \geq 8$ Subtracting 1

$x \leq -4$ Dividing by -2 and reversing the inequality symbol

The solution set is $\{x|x \leq -4\}$, or $(-\infty, -4]$.

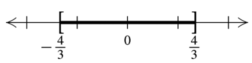


77. $-3 \leq 3x + 1 \leq 5$

$-4 \leq 3x \leq 4$

$-\frac{4}{3} \leq x \leq \frac{4}{3}$

$\left[-\frac{4}{3}, \frac{4}{3}\right]$

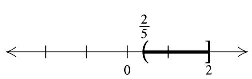


78. $-2 < 5x - 4 \leq 6$

$2 < 5x \leq 10$ Adding 4

$\frac{2}{5} < x \leq 2$ Dividing by 5

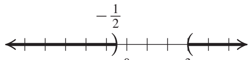
The solution set is $\left(\frac{2}{5}, 2\right]$.



79. $2x < -1$ *or* $x - 3 > 0$

$x < -\frac{1}{2}$ *or* $x > 3$

The solution set is $\left\{x \middle| x < -\frac{1}{2} \text{ or } x > 3\right\}$, or $\left(-\infty, -\frac{1}{2}\right) \cup (3, \infty)$.

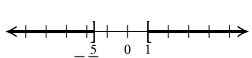


80. $3x + 7 \leq 2$ *or* $2x + 3 \geq 5$

$3x \leq -5$ *or* $2x \geq 2$

$x \leq -\frac{5}{3}$ *or* $x \geq 1$

The solution set is $\left(-\infty, -\frac{5}{3}\right] \cup [1, \infty)$.



81. ***Familiarize and Translate***. The number of homeschooled children in the U.S., in millions, is estimated by the equation $y = 0.073x + 0.848$, where x is the number of years after 1999. We want to know for what year this number will exceed 2.3 million, so we have

$0.073x + 0.848 > 2.3.$

Carry out. We solve the inequality.

$0.073x + 0.848 > 2.3$

$0.073x > 1.452$

$x > 20$ Rounding

Check. When $x = 20$, $y = 0.073(20) + 0.848 = 2.308 \approx 2.3$. As a partial check, we could try a value less than 20 and a value greater than 20. When $x = 19$, we have $y = 0.073(19) + 0.848 = 2.235 < 2.3$; when $x = 21$, we have $y = 0.073(21) + 0.848 = 2.381 > 2.3$. Since $y \approx 2.3$ when $x = 20$ and $y > 2.3$ when $x = 21 > 20$, the answer is probably correct.

State. In years more than about 20 years after 1999, or in years after 2019, the number of homeschooled children will exceed 2.3 million.

82. Solve: $\frac{5}{9}(F - 32) < 45$

$F < 113°$

83. $f(x) = \frac{x+3}{8-4x}$

When $x = 2$, the denominator is 0, so 2 is not in the domain of the function. Thus, the domain is $(-\infty, 2) \cup (2, \infty)$ and answer B is correct.

84. $(x - 1)^2 + y^2 = 9$

$(x - 1)^2 + (y - 0)^2 = 3^2$

The center is $(1, 0)$, so answer B is correct.

85. The graph of $f(x) = -\frac{1}{2}x - 2$ has slope $-\frac{1}{2}$, so it slants down from left to right. The y-intercept is $(0, -2)$. Thus, graph C is the graph of this function.

86. Let $(x, 0)$ be the point on the x-axis that is equidistant from the points $(1, 3)$ and $(4, -3)$. Then we have:

$\sqrt{(x-1)^2+(0-3)^2} = \sqrt{(x-4)^2+(0-(-3))^2}$

$\sqrt{x^2-2x+1+9} = \sqrt{x^2-8x+16+9}$

$\sqrt{x^2-2x+10} = \sqrt{x^2-8x+25}$

$x^2 - 2x + 10 = x^2 - 8x + 25$ Squaring both sides

$6x = 15$

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

The point is $\left(\frac{5}{2}, 0\right)$.

87. $f(x) = \frac{\sqrt{1-x}}{x - |x|}$

We cannot find the square root of a negative number, so $x \leq 1$. Division by zero is undefined, so $x < 0$.

Domain of f is $\{x|x < 0\}$, or $(-\infty, 0)$.

88. $f(x) = (x - 9x^{-1})^{-1} = \dfrac{1}{x - \dfrac{9}{x}}$

Division by zero is undefined, so $x \neq 0$. Also, note that we can write the function as $f(x) = \dfrac{x}{x^2 - 9}$, so $x \neq -3,\ 0,\ 3$.

Domain of f is $\{x|x \neq -3 \ \ and \ \ x \neq 0 \ and \ x \neq 3\}$, or $(-\infty, -3) \cup (-3, 0) \cup (0, 3) \cup (3, \infty)$.

89. Think of the slopes as $\dfrac{-3/5}{1}$ and $\dfrac{1/2}{1}$. The graph of $f(x)$ changes $\dfrac{3}{5}$ unit vertically for each unit of horizontal change while the graph of $g(x)$ changes $\dfrac{1}{2}$ unit vertically for each unit of horizontal change. Since $\dfrac{3}{5} > \dfrac{1}{2}$, the graph of $f(x) = -\dfrac{3}{5}x + 4$ is steeper than the graph of $g(x) = \dfrac{1}{2}x - 6$.

90. If an equation contains no fractions, using the addition principle before using the multiplication principle eliminates the need to add or subtract fractions.

91. The solution set of a disjunction is a union of sets, so it is not possible for a disjunction to have no solution.

92. The graph of $f(x) = mx + b$, $m \neq 0$, is a straight line that is not horizontal. The graph of such a line intersects the x-axis exactly once. Thus, the function has exactly one zero.

93. By definition, the notation $3 < x < 4$ indicates that $3 < x$ *and* $x < 4$. The disjunction $x < 3$ *or* $x > 4$ cannot be written $3 > x > 4$, or $4 < x < 3$, because it is not possible for x to be greater than 4 *and* less than 3.

94. A function is a correspondence between two sets in which each member of the first set corresponds to exactly one member of the second set.

Chapter 1 Test

1.
$$\begin{array}{r|l}
5y - 4 & x \\
\hline
5 \cdot \dfrac{9}{10} - 4 \ ? & \dfrac{1}{2} \\
\dfrac{9}{2} - 4 & \\
\dfrac{1}{2} & \dfrac{1}{2} \quad \text{TRUE}
\end{array}$$

$\left(\dfrac{1}{2}, \dfrac{9}{10}\right)$ is a solution.

2. $5x - 2y = -10$

To find the x-intercept we replace y with 0 and solve for x.

$$\begin{aligned} 5x - 2 \cdot 0 &= -10 \\ 5x &= -10 \\ x &= -2 \end{aligned}$$

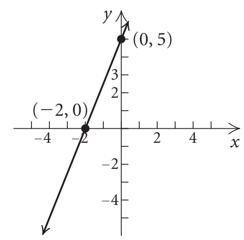
The x-intercept is $(-2, 0)$.

To find the y-intercept we replace x with 0 and solve for y.

$$\begin{aligned} 5 \cdot 0 - 2y &= -10 \\ -2y &= -10 \\ y &= 5 \end{aligned}$$

The y-intercept is $(0, 5)$.

We plot the intercepts and draw the line that contains them. We could find a third point as a check that the intercepts were found correctly.



$5x - 2y = -10$

3. $d = \sqrt{(5 - (-1))^2 + (8 - 5)^2} = \sqrt{6^2 + 3^2} = \sqrt{36 + 9} = \sqrt{45} \approx 6.708$

4. $m = \left(\dfrac{-2 + (-4)}{2}, \dfrac{6 + 3}{2}\right) = \left(\dfrac{-6}{2}, \dfrac{9}{2}\right) = \left(-3, \dfrac{9}{2}\right)$

5.
$$\begin{aligned} (x + 4)^2 + (y - 5)^2 &= 36 \\ [x - (-4)]^2 + (y - 5)^2 &= 6^2 \end{aligned}$$

Center: $(-4, 5)$; radius: 6

6.
$$\begin{aligned} [x - (-1)]^2 + (y - 2)^2 &= (\sqrt{5})^2 \\ (x + 1)^2 + (y - 2)^2 &= 5 \end{aligned}$$

7. a) The relation is a function, because no two ordered pairs have the same first coordinate and different second coordinates.

b) The domain is the set of first coordinates: $\{-4, 0, 1, 3\}$.

c) The range is the set of second coordinates: $\{0, 5, 7\}$.

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

a) $f(-1) = 2(-1)^2 - (-1) + 5 = 2 + 1 + 5 = 8$

b)
$$\begin{aligned} f(a + 2) &= 2(a + 2)^2 - (a + 2) + 5 \\ &= 2(a^2 + 4a + 4) - (a + 2) + 5 \\ &= 2a^2 + 8a + 8 - a - 2 + 5 \\ &= 2a^2 + 7a + 11 \end{aligned}$$

9. $f(x) = \dfrac{1 - x}{x}$

a) $f(0) = \dfrac{1 - 0}{0} = \dfrac{1}{0}$

Since the division by 0 is not defined, $f(0)$ does not exist.

b) $f(1) = \dfrac{1 - 1}{1} = \dfrac{0}{1} = 0$

10. From the graph we see that when the input is -3, the output is 0, so $f(-3) = 0$.

11. a) This is not the graph of a function, because we can find a vertical line that crosses the graph more than once.

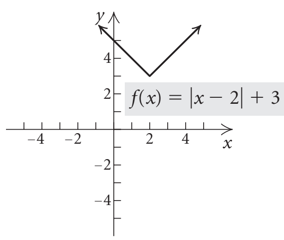
b) This is the graph of a function, because there is no vertical line that crosses the graph more than once.

12. The input 4 results in a denominator of 0. Thus the domain is $\{x|x \neq 4\}$, or $(-\infty, 4) \cup (4, \infty)$.

13. We can substitute any real number for x. Thus the domain is the set of all real numbers, or $(-\infty, \infty)$.

14. We cannot find the square root of a negative number. Thus $25 - x^2 \geq 0$ and the domain is $\{x| -5 \leq x \leq 5\}$, or $[-5, 5]$.

15. a)



b) Each point on the x-axis corresponds to a point on the graph, so the domain is the set of all real numbers, or $(-\infty, \infty)$.

c) The number 3 is the smallest output on the y-axis and every number greater than 3 is also an output, so the range is $[3, \infty)$.

16. $m = \dfrac{5 - \frac{2}{3}}{-2 - (-2)} = \dfrac{\frac{13}{3}}{0}$

The slope is not defined.

17. $m = \dfrac{12 - (-10)}{-8 - 4} = \dfrac{22}{-12} = -\dfrac{11}{6}$

18. $m = \dfrac{6 - 6}{\frac{3}{4} - (-5)} = \dfrac{0}{\frac{23}{4}} = 0$

19. We have the points $(1995, 21.6)$ and $(2012, 9.3)$.

$m = \dfrac{9.3 - 21.6}{2012 - 1995} = \dfrac{-12.3}{17} \approx -0.7$

The average rate of change in the percent of 12th graders who smoke daily decreased about 0.7% per year from 1995 to 2012.

20. $$\begin{aligned} -3x + 2y &= 5 \\ 2y &= 3x + 5 \\ y &= \frac{3}{2}x + \frac{5}{2} \end{aligned}$$

Slope: $\dfrac{3}{2}$; y-intercept: $\left(0, \dfrac{5}{2}\right)$

21. $C(t) = 65 + 48t$

$C(2.25) = 65 + 48(2.25) = \$173$

22. $y = mx + b$

$y = -\dfrac{5}{8}x - 5$

23. First we find the slope:

$m = \dfrac{-2 - 4}{3 - (-5)} = \dfrac{-6}{8} = -\dfrac{3}{4}$

Use the point-slope equation.

Using $(-5, 4)$: $y - 4 = -\dfrac{3}{4}(x - (-5))$, or

$y - 4 = -\dfrac{3}{4}(x + 5)$

Using $(3, -2)$: $y - (-2) = -\dfrac{3}{4}(x - 3)$, or

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

In either case, we have $y = -\dfrac{3}{4}x + \dfrac{1}{4}$.

24. The vertical line that passes through $\left(-\dfrac{3}{8}, 11\right)$ is $\dfrac{3}{8}$ unit to the left of the y-axis. An equation of the line is $x = -\dfrac{3}{8}$.

25. $$\begin{aligned} 2x + 3y &= -12 & \qquad 2y - 3x &= 8 \\ y &= -\frac{2}{3}x - 4 & y &= \frac{3}{2}x + 4 \end{aligned}$$

$m_1 = -\dfrac{2}{3}$, $m_2 = \dfrac{3}{2}$; $m_1 m_2 = -1$.

The lines are perpendicular.

26. First find the slope of the given line.

$$\begin{aligned} x + 2y &= -6 \\ 2y &= -x - 6 \\ y &= -\frac{1}{2}x - 3;\ m = -\frac{1}{2} \end{aligned}$$

A line parallel to the given line has slope $-\dfrac{1}{2}$. We use the point-slope equation.

$$\begin{aligned} y - 3 &= -\frac{1}{2}(x - (-1)) \\ y - 3 &= -\frac{1}{2}(x + 1) \\ y - 3 &= -\frac{1}{2}x - \frac{1}{2} \\ y &= -\frac{1}{2}x + \frac{5}{2} \end{aligned}$$

27. First we find the slope of the given line.

$$\begin{aligned} x + 2y &= -6 \\ 2y &= -x - 6 \\ y &= -\frac{1}{2}x - 3,\ m = -\frac{1}{2} \end{aligned}$$

The slope of a line perpendicular to this line is the negative reciprocal of $-\dfrac{1}{2}$, or 2. Now we find an equation of the line with slope 2 and containing $(-1, 3)$.

Using the slope-intercept equation:

$$\begin{aligned} y &= mx + b \\ 3 &= 2(-1) + b \\ 3 &= -2 + b \\ 5 &= b \end{aligned}$$

The equation is $y = 2x + 5$.

Using the point-slope equation.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3 &= 2(x - (-1)) \\ y - 3 &= 2(x + 1) \\ y - 3 &= 2x + 2 \\ y &= 2x + 5 \end{aligned}$$

28. Answers may vary depending on the data points used. We will use (2, 507.03) and (12, 666.99).

$$m = \frac{666.99 - 507.03}{12 - 2} = \frac{159.96}{10} = 15.996$$

We will use the point-slope equation with the point (2, 507.03).

$$\begin{aligned} y - 507.03 &= 15.996(x - 2) \\ y - 507.03 &= 15.996x - 31.992 \\ y &= 15.996x + 475.038, \end{aligned}$$

where x is the number of years after 2000.

For 2016: $y = 15.996(16) + 475.038 \approx \$730.97$

For 2020: $y = 15.996(20) + 475.038 \approx \$794.96$

29.
$$\begin{aligned} 6x + 7 &= 1 \\ 6x &= -6 \\ x &= -1 \end{aligned}$$

The solution is -1.

30.
$$\begin{aligned} 2.5 - x &= -x + 2.5 \\ 2.5 &= 2.5 \qquad \text{True equation} \end{aligned}$$

The solution set is $\{x|x \text{ is a real number}\}$, or $(-\infty, \infty)$.

31.
$$\begin{aligned} \frac{3}{2}y - 4 &= \frac{5}{3}y + 6 \qquad \text{The LCD is 6.} \\ 6\left(\frac{3}{2}y - 4\right) &= 6\left(\frac{5}{3}y + 6\right) \\ 9y - 24 &= 10y + 36 \\ -24 &= y + 36 \\ -60 &= y \end{aligned}$$

The solution is -60.

32.
$$\begin{aligned} 2(4x + 1) &= 8 - 3(x - 5) \\ 8x + 2 &= 8 - 3x + 15 \\ 8x + 2 &= 23 - 3x \\ 11x + 2 &= 23 \\ 11x &= 21 \\ x &= \frac{21}{11} \end{aligned}$$

The solution is $\dfrac{21}{11}$.

33. ***Familiarize***. Let l = the length, in meters. Then $\dfrac{3}{4}l$ = the width. Recall that the formula for the perimeter P of a rectangle with length l and width w is $P = 2l + 2w$.

Translate.

$$\begin{array}{ccc} \underbrace{\text{The perimeter}} & \text{is} & \underbrace{210 \text{ m.}} \\ \downarrow & \downarrow & \downarrow \\ 2l + 2 \cdot \frac{3}{4}l & = & 210 \end{array}$$

Carry out. We solve the equation.

$$\begin{aligned} 2l + 2 \cdot \frac{3}{4}l &= 210 \\ 2l + \frac{3}{2}l &= 210 \\ \frac{7}{2}l &= 210 \\ l &= 60 \end{aligned}$$

If $l = 60$, then $\dfrac{3}{4}l = \dfrac{3}{4} \cdot 60 = 45$.

Check. The width, 45 m, is three-fourths of the length, 60 m. Also, $2 \cdot 60 \text{ m} + 2 \cdot 45 \text{ m} = 210 \text{ m}$, so the answer checks.

State. The length is 60 m and the width is 45 m.

34. ***Familiarize***. Let p = the wholesale price of the juice.

Translate. We express 25¢ as \$0.25.

$$\begin{array}{ccccccc} \text{Wholesale price} & \text{plus} & \text{50\% of wholesale price} & \text{plus} & \$0.25 & \text{is} & \$2.95. \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ p & + & 0.5p & + & 0.25 & = & 2.95 \end{array}$$

Carry out. We solve the equation.

$$\begin{aligned} p + 0.5p + 0.25 &= 2.95 \\ 1.5p + 0.25 &= 2.95 \\ 1.5p &= 2.7 \\ p &= 1.8 \end{aligned}$$

Check. 50% of \$1.80 is \$0.90 and \$1.80 + \$0.90 + \$0.25 = \$2.95, so the answer checks.

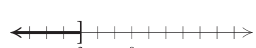
State. The wholesale price of a bottle of juice is \$1.80.

35.
$$\begin{aligned} 3x + 9 &= 0 \qquad \text{Setting } f(x) = 0 \\ 3x &= -9 \\ x &= -3 \end{aligned}$$

The zero of the function is -3.

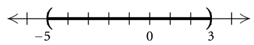
36.
$$\begin{aligned} 5 - x &\geq 4x + 20 \\ 5 - 5x &\geq 20 \\ -5x &\geq 15 \\ x &\leq -3 \qquad \text{Dividing by } -5 \text{ and reversing the inequality symbol} \end{aligned}$$

The solution set is $\{x|x \leq -3\}$, or $(-\infty, -3]$.



37.
$$\begin{aligned} -7 < 2x + 3 &< 9 \\ -10 < 2x &< 6 \qquad \text{Subtracting 3} \\ -5 < x &< 3 \qquad \text{Dividing by 2} \end{aligned}$$

The solution set is $(-5, 3)$.

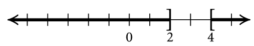


38. $2x - 1 \leq 3$ *or* $5x + 6 \geq 26$

$2x \leq 4$ *or* $5x \geq 20$

$x \leq 2$ *or* $x \geq 4$

The solution set is $(-\infty, 2] \cup [4, \infty)$.



39. ***Familiarize***. Let $t =$ the number of hours a move requires. Then Morgan Movers charges $200 + 40t$ to make a move and McKinley Movers charges $75t$.

Translate.

$$\underbrace{\text{Morgan Movers' charge}}_{\displaystyle\downarrow \atop \displaystyle 200 + 40t} \quad \underbrace{\text{is less than}}_{\displaystyle\downarrow \atop \displaystyle <} \quad \underbrace{\text{McKinley Movers' charge.}}_{\displaystyle\downarrow \atop \displaystyle 75t}$$

Carry out. We solve the inequality.

$$200 + 40t < 75t$$
$$200 < 35t$$
$$5.7 < t \qquad \text{Rounding}$$

Check. For $t = 5.7$, Morgan Movers charge $200 + 40(5.7)$, or \$428, and McKinley Movers charge $75(5.7)$, or $\$427.5 \approx 428$. (Remember that we rounded the answer.) So the charge is the same for 5.7 hours. As a partial check, we can find the charges for a value of t greater than 5.7. For instance, for 6 hr Morgan Movers charge $200 + 40 \cdot 6$, or \$440, and McKinley Movers charge $75 \cdot 6$, or \$450. Since Morgan Movers cost less for a value of t greater than 5.7, the answer is probably correct.

State. It costs less to hire Morgan Movers when a move takes more than 5.7 hr.

40. The slope is $-\frac{1}{2}$, so the graph slants down from left to right. The y-intercept is $(0, 1)$. Thus, graph B is the graph of $g(x) = 1 - \frac{1}{2}x$.

41. First we find the value of x for which $x + 2 = -2$:

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

Now we find $h(-4 + 2)$, or $h(-2)$.

$$h(-4 + 2) = \frac{1}{2}(-4) = -2$$