# Chapter 2

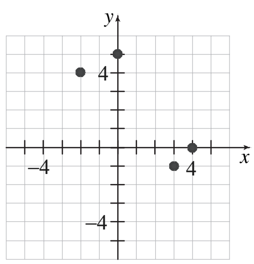
## Section 2.1

### Are You Prepared for This Section?

**P1.** Inequality: $-4 \le x \le 4$
Interval: $[-4, 4]$
The square brackets in interval notation indicate that the inequalities are not strict.

**P2.** Interval: $[2, \infty)$
Inequality: $x \ge 2$
The square bracket indicates that the inequality is not strict.

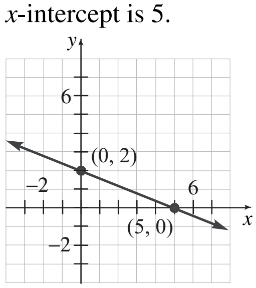
**P3.**




**P4.** $2x + 5y = 10$

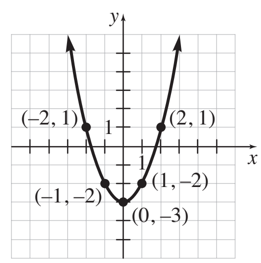
Let $x = 0$: $2(0) + 5y = 10$
$$0 + 5y = 10$$
$$5y = 10$$
$$y = 2$$
$y$-intercept is 2.

Let $y = 0$: $2x + 5(0) = 10$
$$2x + 0 = 10$$
$$2x = 10$$
$$x = 5$$
$x$-intercept is 5.




**P5.** $y = x^2 - 3$

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

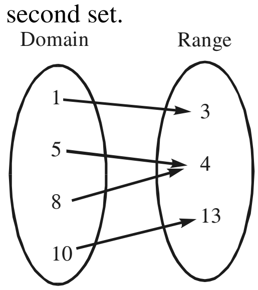



### Section 2.1 Quick Checks

**1.** If a relation exists between $x$ and $y$, then say that $x$ corresponds to $y$ or that $y$ depends on $x$, and we write $x \to y$.

**2.** The first element of the ordered pair comes from the set 'Friend' and the second element is the corresponding element from the set 'Birthday'. {(Max, November 8), (Alesia, January 20), (Trent, March 3), (Yolanda, November 8), (Wanda, July 6), (Elvis, January 8)}

**3.** The first elements of the ordered pairs make up the first set and the second elements make up the second set.



**4.** The <u>domain</u> of a relation is the set of all inputs of the relation. The <u>range</u> is the set of all outputs of the relation.

**5.** The domain is the set of all inputs and the range is the set of all outputs. The inputs are the elements in the set 'Friend' and the outputs are the elements in the set 'Birthday'.
Domain:
{Max, Alesia, Trent, Yolanda, Wanda, Elvis}

Range:
{January 20, March 3, July 6, November 8, January 8}

**6.** The domain is the set of all inputs and the range is the set of all outputs. The inputs are the first elements in the ordered pairs and the outputs are the second elements in the ordered pairs.
Domain: {1, 5, 8, 10}
Range: {3, 4, 13}

**7.** First notice that the ordered pairs on the graph are (–2, 0), (–1, 2), (–1, –2), (2, 3), (3, 0), and (4, –3).
The domain is the set of all *x*-coordinates and the range is the set of all *y*-coordinates.
Domain: {–2, –1, 2, 3, 4}
Range: {–3, –2, 0, 2, 3}

**8.** True

**9.** False

**10.** To find the domain, first determine the *x*-values for which the graph exists. The graph exists for all *x*-values between $-2$ and 4, inclusive. Thus, the domain is $\{x \mid -2 \le x \le 4\}$, or [–2, 4] in interval notation.

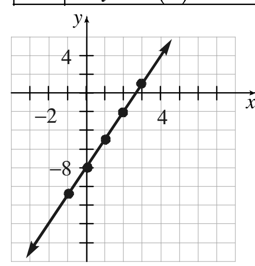
To find the range, first determine the *y*-values for which the graph exists. The graph exists for all *y*-values between $-2$ and 2, inclusive. Thus, the range is $\{y \mid -2 \le y \le 2\}$, or [–2, 2] in interval notation.

**11.** To find the domain, first determine the *x*-values for which the graph exists. The graph exists for all *x*-values on a real number line. Thus, the domain is $\{x \mid x \text{ is any real number}\}$, or (–∞, ∞) in interval notation.

To find the range, first determine the *y*-values for which the graph exists. The graph exists for all *y*-values on a real number line. Thus, the range is $\{y \mid y \text{ is any real number}\}$, or (–∞, ∞) in interval notation.

**12.** $y = 3x - 8$

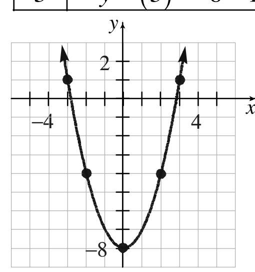
| $x$ | $y = 3x - 8$ | $(x, y)$ |
|---|---|---|
| $-1$ | $y = 3(-1) - 8 = -11$ | $(-1, -11)$ |
| 0 | $y = 3(0) - 8 = -8$ | $(0, -8)$ |
| 1 | $y = 3(1) - 8 = -5$ | $(1, -5)$ |
| 2 | $y = 3(2) - 8 = -2$ | $(2, -2)$ |
| 3 | $y = 3(3) - 8 = 1$ | $(3, 1)$ |




Domain: $\{x \mid x \text{ is any real number}\}$ or $(-\infty, \infty)$
Range: $\{y \mid y \text{ is any real number}\}$ or $(-\infty, \infty)$

**13.** $y = x^2 - 8$

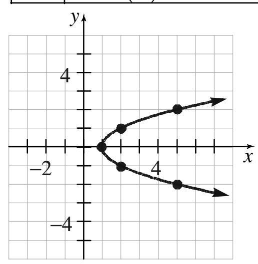
| $x$ | $y = x^2 - 8$ | $(x, y)$ |
|---|---|---|
| $-3$ | $y = (-3)^2 - 8 = 1$ | $(-3, 1)$ |
| $-2$ | $y = (-2)^2 - 8 = -4$ | $(-2, -4)$ |
| 0 | $y = (0)^2 - 8 = -8$ | $(0, -8)$ |
| 2 | $y = (2)^2 - 8 = -4$ | $(2, -4)$ |
| 3 | $y = (3)^2 - 8 = 1$ | $(3, 1)$ |




Domain: $\{x \mid x \text{ is any real number}\}$ or (–∞, ∞)
Range: $\{y \mid y \ge -8\}$ or [–8, ∞)

**14.** $x = y^2 + 1$

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




Domain: $\{x \mid x \geq 1\}$ or $[1, \infty)$

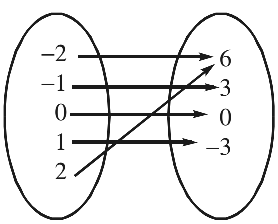
Range: $\{y \mid y \text{ is any real number}\}$ or $(-\infty, \infty)$

## 2.1 Exercises

**16.** {(30, $9), (35, $9), (40, $11), (45, $17)}
**Domain:** {30, 35, 40, 45}
**Range:** {$9, $11, $17}

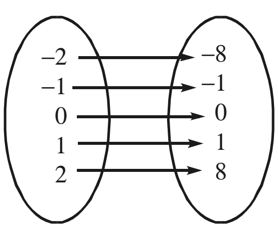
**18.** {(Northeast, $59,210), (Midwest, $54,267), (South, $49,655), (West, $57,688)}
**Domain:** {Northeast, Midwest, South, West}
**Range:** {$49,655, $54,267, $57,688, $59,210}

**20.**



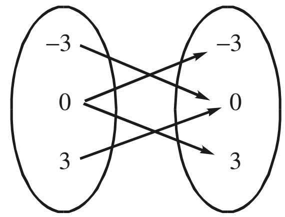

Domain: {−2, −1, 0, 1, 2}
Range: {−3, 0, 3, 6}

**22.**




Domain: {−2, −1, 0, 1, 2}
Range: {−8, −1, 0, 1, 8}

**24.**




Domain: {−3, 0, 3}
Range: {−3, 0, 3}

**26.** Domain: {−3, −2, −1, 1, 3}
Range: {−3, −1, 0, 1, 3}

**28.** Domain: $\{x \mid -3 \leq x \leq 3\}$ or $[-3, 3]$

Range: $\{y \mid -2 \leq y \leq 4\}$ or $[-2, 4]$

**30.** Domain: $\{x \mid -5 \leq x \leq 3\}$ or $[-5, 3]$

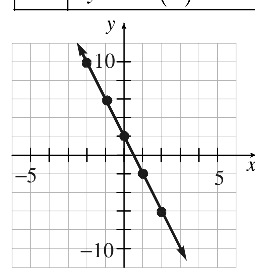
Range: $\{y \mid -1 \leq y \leq 3\}$ or $[-1, 3]$

**32.** Domain: $\{x \mid x \geq -2\}$ or $[-2, \infty)$

Range: $\{y \mid y \geq -1\}$ or $[-1, \infty)$

**34.** $y = -4x + 2$

| $x$ | $y = -4x + 2$ | $(x, y)$ |
|---|---|---|
| $-2$ | $y = -4(-2) + 2 = 10$ | $(-2, 10)$ |
| $-1$ | $y = -4(-1) + 2 = 6$ | $(-1, 6)$ |
| $0$ | $y = -4(0) + 2 = 2$ | $(0, 2)$ |
| $1$ | $y = -4(1) + 2 = -2$ | $(1, -2)$ |
| $2$ | $y = -4(2) + 2 = -6$ | $(2, -6)$ |

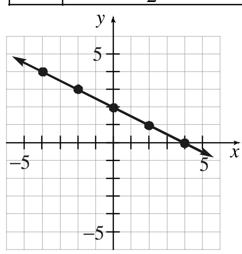



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

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

| $x$ | $y = -\frac{1}{2}x + 2$ | $(x, y)$ |
|---|---|---|
| −4 | $y = -\frac{1}{2}(-4) + 2 = 4$ | $(-4, 4)$ |
| −2 | $y = -\frac{1}{2}(-2) + 2 = 3$ | $(-2, 3)$ |
| 0 | $y = -\frac{1}{2}(0) + 2 = 2$ | $(0, 2)$ |
| 2 | $y = -\frac{1}{2}(2) + 2 = 1$ | $(2, 1)$ |
| 4 | $y = -\frac{1}{2}(4) + 2 = 0$ | $(4, 0)$ |



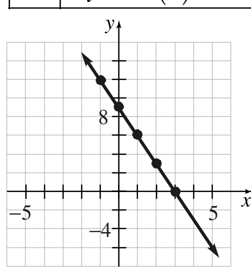
Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**38.** $3x + y = 9$

$y = -3x + 9$

| $x$ | $y = -3x + 9$ | $(x, y)$ |
|---|---|---|
| −1 | $y = -3(-1) + 9 = 12$ | $(-1, 12)$ |
| 0 | $y = -3(0) + 9 = 9$ | $(0, 9)$ |
| 1 | $y = -3(1) + 9 = 6$ | $(1, 6)$ |
| 2 | $y = -3(2) + 9 = 3$ | $(2, 3)$ |
| 3 | $y = -3(3) + 9 = 0$ | $(3, 0)$ |

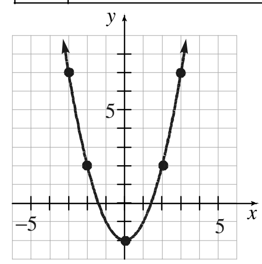


Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**40.** $y = x^2 - 2$

| $x$ | $y = x^2 - 2$ | $(x, y)$ |
|---|---|---|
| −3 | $y = (-3)^2 - 2 = 7$ | $(-3, 7)$ |
| −2 | $y = (-2)^2 - 2 = 2$ | $(-2, 2)$ |
| 0 | $y = (0)^2 - 2 = -2$ | $(0, -2)$ |
| 2 | $y = (2)^2 - 2 = 2$ | $(2, 2)$ |
| 3 | $y = (3)^2 - 2 = 7$ | $(3, 7)$ |

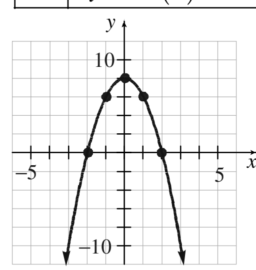


Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \ge -2\}$ or $[-2, \infty)$

**42.** $y = -2x^2 + 8$

| $x$ | $y = -2x^2 + 8$ | $(x, y)$ |
|---|---|---|
| −2 | $y = -2(-2)^2 + 8 = 0$ | $(-2, 0)$ |
| −1 | $y = -2(-1)^2 + 8 = 6$ | $(-1, 6)$ |
| 0 | $y = -2(0)^2 + 8 = 8$ | $(0, 8)$ |
| 1 | $y = -2(1)^2 + 8 = 6$ | $(1, 6)$ |
| 2 | $y = -2(2)^2 + 8 = 0$ | $(2, 0)$ |

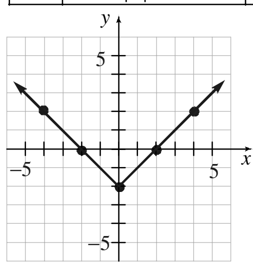


Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \le 8\}$ or $(-\infty, 8]$

**44.** $y = |x| - 2$

| $x$ | $y = \|x\| - 2$ | $(x, y)$ |
|---|---|---|
| −4 | $y = \|-4\| - 2 = 2$ | $(-4, 2)$ |
| −2 | $y = \|-2\| - 2 = 0$ | $(-2, 0)$ |
| 0 | $y = \|0\| - 2 = -2$ | $(0, -2)$ |
| 2 | $y = \|2\| - 2 = 0$ | $(2, 0)$ |
| 4 | $y = \|4\| - 2 = 2$ | $(4, 2)$ |

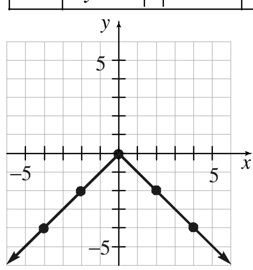



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \ge -2\}$ or $[-2, \infty)$

**46.** $y = -|x|$

| $x$ | $y = -\|x\|$ | $(x, y)$ |
|---|---|---|
| −4 | $y = -\|-4\| = -4$ | $(-4, -4)$ |
| −2 | $y = -\|-2\| = -2$ | $(-2, -2)$ |
| 0 | $y = -\|0\| = 0$ | $(0, 0)$ |
| 2 | $y = -\|2\| = -2$ | $(2, -2)$ |
| 4 | $y = -\|4\| = -4$ | $(4, -4)$ |

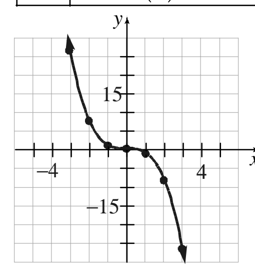



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \le 0\}$ or $(-\infty, 0]$

**48.** $y = -x^3$

| $x$ | $y = -x^3$ | $(x, y)$ |
|---|---|---|
| −3 | $y = -(-3)^3 = 27$ | $(-3, 27)$ |
| −2 | $y = -(-2)^3 = 8$ | $(-2, 8)$ |
| −1 | $y = -(-1)^3 = 1$ | $(-1, 1)$ |
| 0 | $y = -(0)^3 = 0$ | $(0, 0)$ |
| 1 | $y = -(1)^3 = -1$ | $(1, -1)$ |
| 2 | $y = -(2)^3 = -8$ | $(2, -8)$ |
| 3 | $y = -(3)^3 = -27$ | $(3, -27)$ |

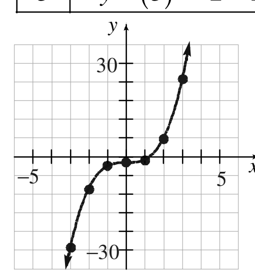



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**50.** $y = x^3 - 2$

| $x$ | $y = x^3 - 2$ | $(x, y)$ |
|---|---|---|
| −3 | $y = (-3)^3 - 2 = -29$ | $(-3, -29)$ |
| −2 | $y = (-2)^3 - 2 = -10$ | $(-2, -10)$ |
| −1 | $y = (-1)^3 - 2 = -3$ | $(-1, -3)$ |
| 0 | $y = (0)^3 - 2 = -2$ | $(0, -2)$ |
| 1 | $y = (1)^3 - 2 = -1$ | $(1, -1)$ |
| 2 | $y = (2)^3 - 2 = 6$ | $(2, 6)$ |
| 3 | $y = (3)^3 - 2 = 25$ | $(3, 25)$ |



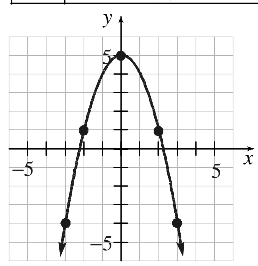

Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**52.** $x^2 + y = 5$
$y = -x^2 + 5$

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

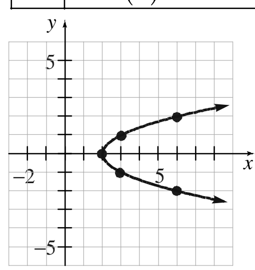



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \le 5\}$ or $(-\infty, 5]$

**54.** $x = y^2 + 2$

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




Domain: $\{x \mid x \ge 2\}$ or $[2, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**56.** According to the graph:
Domain: $\{x \mid 0 \le x \le 6\}$ or $[0, 6]$
Range: $\{y \mid 0 \le y \le 196\}$ or $[0, 196]$

**58.** According to the graph:
Domain: $\{x \mid x \ge 0\}$ or $[0, \infty]$
Range: $\{y \mid -4 < y \le 10\}$ or $(-4, 10]$

**60.** Actual graphs will vary but each graph should be a vertical line.

**62.** The four methods for describing a relation are maps, ordered pairs, graph, and equations. Ordered pairs are appropriate if there is a finite number of values in the domain. If there is an infinite (or very large) number of elements in the domain, a graph is more appropriate.

**Section 2.2**

**Are You Prepared for This Section?**

**P1. a.** Let $x = 1$:
$$2x^2 - 5x = 2(1)^2 - 5(1) = 2 - 5 = -3$$

**b.** Let $x = 4$:
$$\begin{aligned} 2x^2 - 5x &= 2(4)^2 - 5(4) \\ &= 2(16) - 20 \\ &= 32 - 20 \\ &= 12 \end{aligned}$$

**c.** Let $x = -3$:
$$\begin{aligned} 2x^2 - 5x &= 2(-3)^2 - 5(-3) \\ &= 2(9) + 15 \\ &= 18 + 15 \\ &= 33 \end{aligned}$$

**P2.** $\dfrac{3}{2x+1}$
$\dfrac{3}{2\left(-\frac{1}{2}\right)+1} = \dfrac{3}{-1+1} = \dfrac{3}{0}$ is undefined.

**P3.** Inequality: $x \le 5$
Interval: $(-\infty, 5]$

**P4.** Interval: $(2, \infty)$
Set notation: $\{x \mid x > 2\}$
The inequality is strict since the parenthesis was used instead of a square bracket.

**Section 2.2 Quick Checks**

**1.** A <u>function</u> is a relation in which each element in the domain of the relation corresponds to exactly one element in the range of the relation.

**2.** False

**3.** The relation is a function because each element in the domain (Friend) corresponds to exactly one element in the range (Birthday).
Domain: {Max, Alesia, Trent, Yolanda, Wanda, Elvis}
Range: {January 20, March 3, July 6, November 8, January 8}

**4.** The relation is not a function because there is an element in the domain, 210, that corresponds to more than one element in the range. If 210 is selected from the domain, a single sugar content cannot be determined.

**5.** The relation is a function because there are no ordered pairs with the same first coordinate but different second coordinates.
Domain: {–3, –2, –1, 0, 1}
Range: {0, 1, 2, 3}

**6.** The relation is not a function because there are two ordered pairs, (–3, 2) and (–3, 6), with the same first coordinate but different second coordinates.

**7.** $y = -2x + 5$
The relation is a function since there is only one output than can result for each input.

**8.** $y = \pm 3x$
The relation is not a function since a single input for *x* will yield two output values for *y*. For example, if $x = 1$, then $y = \pm 3$.

**9.** $y = x^2 + 5x$
The relation is a function since there is only one output than can result for each input.

**10.** True

**11.** The graph is that of a function because every vertical line will cross the graph in at most one point.

**12.** The graph is not that of a function because a vertical line can cross the graph in more than one point.

**13.** $f(x) = 3x + 2$

$$\begin{aligned} f(x) &= 3(4) + 2 \\ &= 12 + 2 \\ &= 14 \end{aligned}$$

**14.** $f(x) = 3x + 2$
$f(-2) = 3(-2) + 2 = -6 + 2 = -4$

**15.** $g(x) = -2x^2 + x + 3$

$$\begin{aligned} g(-3) &= -2(-3)^2 + (-3) + 3 \\ &= -2(9) - 3 + 3 \\ &= -18 - 3 + 3 \\ &= -18 \end{aligned}$$

**16.** $g(x) = -2x^2 + x + 3$

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

**17.** In the function $H(q) = 2q^2 - 5q + 1$, $H$ is called the <u>dependent</u> variable, and *q* is called the <u>independent</u> variable or <u>argument</u>.

**18.**

$$\begin{aligned} f(x) &= 2x - 5 \\ f(x-2) &= 2(x-2) - 5 \\ &= 2x - 4 - 5 \\ &= 2x - 9 \end{aligned}$$

**19.**

$$\begin{aligned} f(x) - f(2) &= [2x - 5] - [2(2) - 5] \\ &= 2x - 5 - (-1) \\ &= 2x - 5 + 1 \\ &= 2x - 4 \end{aligned}$$

**20.** When only the equation of a function *f* is given, the <u>domain</u> of *f* is the set of real numbers *x* for which *f*(*x*) is a real number.

**21.** $f(x) = 3x^2 + 2$
The function squares a number *x*, multiplies it by 3, and then adds 2. Since these operations can be performed on any real number, the domain of *f* is the set of all real numbers.
The domain can be written as $\{x \mid x \text{ is any real number}\}$, or $(-\infty, \infty)$ in interval notation.

**22.** $h(x) = \dfrac{x+1}{x-3}$
The function *h* involves division. Since division by 0 is not defined, the denominator $x - 3$ can never be 0. Therefore, *x* can never equal 3. The domain of *h* is $\{x \mid x \neq 3\}$.

**23.** $A(r)=\pi r^2$

Since $r$ represents the radius of the circle, it must take on positive values. Therefore, the domain is $\{r|r>0\}$, or $(0, \infty)$ in interval notation.

**24. a.** Independent variable: $t$ (number of days)
Dependent variable: $A$ (square miles)

**b.** $A(t)=0.25\pi t^2$

$A(30)=0.25\pi(30)^2 \approx 706.86$ sq. miles

After oil has been leaking for 30 days, the circular oil slick will cover about 706.86 square miles.

**2.2 Exercises**

**26.** Function. Each animal in the domain corresponds to exactly one gestation period in the range.
Domain: {Cat, Dog, Goat, Pig, Rabbit}
Range: {31, 63, 115, 151}

**28.** Not a function. The domain element *A* for the exam grade corresponds to two different study times in the range.
Domain: {A, B, C, D}
Range: {1, 3.5, 4, 5, 6}

**30.** Function. There are no ordered pairs that have the same first coordinate, but different second coordinates.
Domain: {–1, 0, 1, 2}
Range: {–2, –5, 1, 4}

**32.** Not a function. Each ordered pair has the same first coordinate but different second coordinates.
Domain: {–2}
Range: {–3, 1, 3, 9}

**34.** Function. There are no ordered pairs that have the same first coordinate but different second coordinates.
Domain: {–5, –2, 5, 7}
Range: {–3, 1, 3}

**36.** $y=-6x+3$

Since there is only one output $y$ that can result from any given input $x$, this relation is a function.

**38.** $6x-3y=12$

$$-3y=-6x+12$$
$$y=\frac{-6x+12}{-3}$$
$$y=2x-4$$

Since there is only one output $y$ that can result from any given input $x$, this relation is a function.

**40.** $y=\pm 2x^2$

Since a given input $x$ can result in more than one output $y$, this relation is not a function.

**42.** $y=x^3-3$

Since there is only one output $y$ that can result from any given input $x$, this relation is a function.

**44.** $y^2=x$

Since a given input $x$ can result in more than one output $y$, this relation is not a function. For example, if $x=1$ then $y^2=1$ which means that $y=1$ or $y=-1$.

**46.** Not a function. The graph fails the vertical line test so it is not the graph of a function.

**48.** Not a function. The graph fails the vertical line test so it is not the graph of a function.

**50.** Function. The graph passes the vertical line test so it is the graph of a function.

**52.** Not a function. The graph fails the vertical line test so it is not the graph of a function.

**54. a.** $f(0) = 3(0) + 1 = 0 + 1 = 1$

**b.** $f(3) = 3(3) + 1 = 9 + 1 = 10$

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

**56. a.** $f(0) = -2(0) - 3 = 0 - 3 = -3$

**b.** $f(3) = -2(3) - 3 = -6 - 3 = -9$

**c.** $f(-2) = -2(-2) - 3 = 4 - 3 = 1$

**58. a.** $f(0)=2(0)^2+5(0)=2(0)+0=0$

**b.** $f(3) = 2(3)^2 + 5(3)$
$= 2(9) + 5(3)$
$= 18 + 15$
$= 33$

**c.** $f(-2) = 2(-2)^2 + 5(-2)$
$= 2(4) + 5(-2)$
$= 8 + (-10)$
$= -2$

**60. a.** $f(0) = -(0)^2 + 2(0) - 5 = 0 + 0 - 5 = -5$

**b.** $f(3) = -(3)^2 + 2(3) - 5 = -9 + 6 - 5 = -8$

**c.** $f(-2) = -(-2)^2 + 2(-2) - 5$
$= -4 - 4 - 5$
$= -13$

**62. a.** $f(-x) = 4(-x) + 3 = -4x + 3$

**b.** $f(x+2) = 4(x+2) + 3 = 4x + 8 + 3 = 4x + 11$

**c.** $f(2x) = 4(2x) + 3 = 8x + 3$

**d.** $-f(x) = -(4x + 3) = -4x - 3$

**e.** $f(x + h) = 4(x + h) + 3 = 4x + 4h + 3$

**64. a.** $f(-x) = 8 - 3(-x) = 8 + 3x$

**b.** $f(x + 2) = 8 - 3(x + 2) = 8 - 3x - 6 = 2 - 3x$

**c.** $f(2x) = 8 - 3(2x) = 8 - 6x$

**d.** $-f(x) = -(8 - 3x) = -8 + 3x$

**e.** $f(x + h) = 8 - 3(x + h) = 8 - 3x - 3h$

**66.** $f(x) = -2x^2 + x + 1$
$f(-3) = -2(-3)^2 + (-3) + 1$
$= -2(9) - 3 + 1$
$= -20$

**68.** $g(h) = -h^2 + 5h - 1$
$g(4) = -(4)^2 + 5(4) - 1$
$= -16 + 20 - 1$
$= 3$

**70.** $G(z) = 2|z + 5|$
$G(-6) = 2|-6 + 5| = 2|-1| = 2 \cdot 1 = 2$

**72.** $h(q) = \dfrac{3q^2}{q+2}$
$h(2) = \dfrac{3(2)^2}{2+2} = \dfrac{3(4)}{4} = 3$

**74.** $G(x) = -8x + 3$
Since each operation in the function can be performed for any real number, the domain of the function is all real numbers.
Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

**76.** $H(x) = \dfrac{x+5}{2x+1}$
The function involves division by $2x + 1$. Since division by 0 is not defined, the denominator can never equal 0.
$2x + 1 = 0$
$2x = -1$
$x = -\dfrac{1}{2}$
Domain: $\left\{x \,\middle|\, x \neq -\dfrac{1}{2}\right\}$

**78.** $s(t) = 2t^2 - 5t + 1$
Since each operation in the function can be performed for any real number, the domain of the function is all real numbers.
Domain: $\{t \mid t \text{ is a real number}\}$ or $(-\infty, \infty)$

**80.** $H(q) = \dfrac{1}{6q+5}$
The function involves division by $6q + 5$. Since division by 0 is not defined, the denominator can never equal 0.
$6q + 5 = 0$
$6q = -5$
$q = -\dfrac{5}{6}$
Domain: $\left\{q \,\middle|\, q \neq -\dfrac{5}{6}\right\}$

**82.** $f(x) = -2x^2 + 5x + C;\ f(-2) = -15$
$-15 = -2(-2)^2 + 5(-2) + C$
$-15 = -2(4) - 10 + C$
$-15 = -8 - 10 + C$
$-15 = -18 + C$
$3 = C$

**84.** $f(x)=\dfrac{-x+B}{x-5};\quad f(3)=-1$

$$-1=\frac{-3+B}{3-5}$$
$$-1=\frac{-3+B}{-2}$$
$$2=-3+B$$
$$5=B$$

**86.** $A=\dfrac{1}{2}bh$

If $b$ = 8 cm, we have $A(h)=\dfrac{1}{2}(8)h=4h$.

$A(5)=4(5)=20$ square centimeters

**88.** Let $p$ = price of items sold, and $G$ = gross weekly salary.

$G(p)=250+0.15p$

$G(10{,}000)=250+0.15(10{,}000)=1750$

Roberta's gross weekly salary is $1750.

**90. a.** The dependent variable is the number of housing units, $N$, and the independent variable is the number of rooms, $r$.

**b.** $N(3)=-1.33(3)^2+14.68(3)-17.09$
$=-11.97+44.04-17.09$
$=14.98$

In 2015, there were 14.98 million housing units with 3 rooms.

**c.** $N(0)$ would be the number of housing units with 0 rooms. It is impossible to have a housing unit with no rooms.

**92. a.** The dependent variable is the trip length, $T$, and the independent variable is the number of years since 1969, $x$.

**b.** $T(35)=0.01(35)^2-0.12(35)+8.89$
$=12.25-4.2+8.89$
$=16.94$

In 2004 (35 years after 1969), the average vehicle trip length was 16.94 miles.

**c.** $T(0)=0.01(0)^2-0.12(0)+8.89$
$=8.89$

In 1969, the average vehicle trip length was 8.89 miles.

**94.** $A(h)=\dfrac{5}{2}h$

Since the height must have a positive length, the domain is all positive real numbers.

Domain: $\{h\,|\,h>0\}$ or $(0, \infty)$

**96.** $G(p)=350+0.12p$

Since price will not be negative and there is no necessary upper limit, the domain is all non-negative real numbers, or $\{p\,|\,p\ge 0\}$ or $[0, \infty)$.

**98.** Answers may vary. For values of $p$ that are greater than \$200, the revenue function will be negative. Since revenue is nonnegative, values greater than \$200 are not in the domain.

**100. a.** $f(x)=3x+7$

$f(x+h)=3(x+h)+7=3x+3h+7$

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

**b.** $f(x)=-2x+1$

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

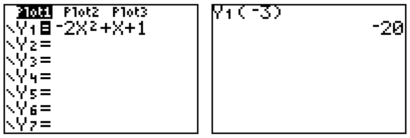
$$\frac{f(x+h)-f(x)}{h}=\frac{[-2x-2h+1]-[-2x+1]}{h}=\frac{-2x-2h+1+2x-1}{h}=\frac{-2h}{h}=-2$$

**102.** Not all relations are functions because a relation can have a single input corresponding to two different outputs, whereas functions are a special type of relation where no single input corresponds to more than one output.

**104.** A vertical line is a graph comprising a single $x$-coordinate. The $x$-coordinate represents the value of the independent variable in a function. If a vertical line intersects a graph in two (or more) different places, then a single input ($x$-coordinate) corresponds to two different outputs ($y$-coordinates), which violates the definition of a function.

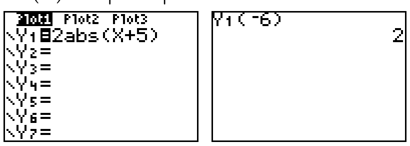
**106.** The word "independent" implies that the $x$-variable is free to be any value in the domain of the function. The choice of the word "dependent" for $y$ makes sense because the value of $y$ depends on the value of $x$ from the domain.

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



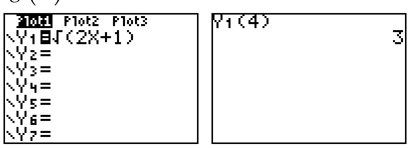

$f(-3) = -20$

**110.** $G(z) = 2|z + 5|$



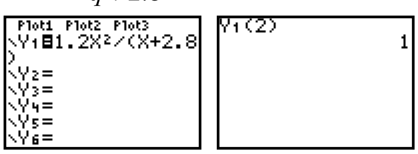

$G(-6) = 2$

**112.** $g(h) = \sqrt{2h+1}$




$g(4) = 3$

**114.** $h(q) = \dfrac{1.2q^2}{q + 2.8}$




$h(2) = 1$

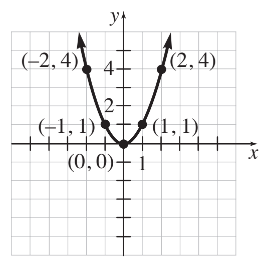
**Section 2.3**

**Are You Prepared for This Section?**

**P1.**
$$\begin{aligned} 3x - 12 &= 0 \\ 3x - 12 + 12 &= 0 + 12 \\ 3x &= 12 \\ \frac{3x}{3} &= \frac{12}{3} \\ x &= 4 \end{aligned}$$
The solution set is $\{4\}$.

**P2.** $y = x^2$

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



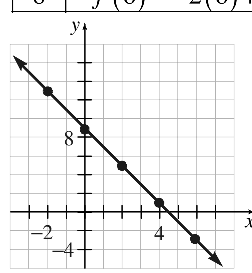

**Section 2.3 Quick Checks**

1. When a function is defined by an equation in $x$ and $y$, the <u>graph</u> of the <u>function</u> is the set of all ordered pairs $(x, y)$ such that $y = f(x)$.

2. If $f(4) = -7$, then the point whose ordered pair is (<u>4</u>, <u>−7</u>) is on the graph of $y = f(x)$.

3. $f(x) = -2x + 9$

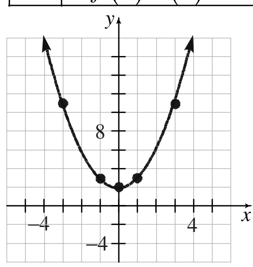
| $x$ | $y = f(x) = -2x + 9$ | $(x, y)$ |
|---|---|---|
| $-2$ | $f(-2) = -2(-2) + 9 = 13$ | $(-2, 13)$ |
| $0$ | $f(0) = -2(0) + 9 = 9$ | $(0, 9)$ |
| $2$ | $f(2) = -2(2) + 9 = 5$ | $(2, 5)$ |
| $4$ | $f(4) = -2(4) + 9 = 1$ | $(4, 1)$ |
| $6$ | $f(6) = -2(6) + 9 = -3$ | $(6, -3)$ |



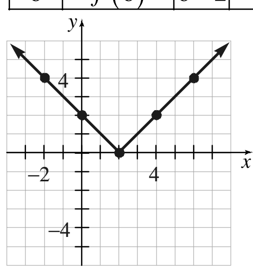
**4.** $f(x) = x^2 + 2$

| $x$ | $y = f(x) = x^2 + 2$ | $(x, y)$ |
|---|---|---|
| $-3$ | $f(-3) = (-3)^2 + 2 = 11$ | $(-3, 11)$ |
| $-1$ | $f(-1) = (-1)^2 + 2 = 3$ | $(-1, 3)$ |
| $0$ | $f(0) = (0)^2 + 2 = 2$ | $(0, 2)$ |
| $1$ | $f(1) = (1)^2 + 2 = 3$ | $(1, 3)$ |
| $3$ | $f(3) = (3)^2 + 2 = 11$ | $(3, 11)$ |




**5.** $f(x) = |x - 2|$

| $x$ | $y = f(x) = \|x-2\|$ | $(x, y)$ |
|---|---|---|
| $-2$ | $f(-2) = \|-2-2\| = 4$ | $(-2, 4)$ |
| $0$ | $f(0) = \|0-2\| = 2$ | $(0, 2)$ |
| $2$ | $f(2) = \|2-2\| = 0$ | $(2, 0)$ |
| $4$ | $f(4) = \|4-2\| = 2$ | $(4, 2)$ |
| $6$ | $f(6) = \|6-2\| = 4$ | $(6, 4)$ |




**6. a.** The arrows on the ends of the graph indicate that the graph continues indefinitely. Therefore, the domain is $\{x \mid x \text{ is any real number}\}$, or $(-\infty, \infty)$ in interval notation.
The function reaches a maximum value of 2, but has no minimum value. Therefore, the range is $\{y \mid y \le 2\}$, or $(-\infty, 2]$ in interval notation.

**b.** The intercepts are $(-2, 0)$, $(0, 2)$, and $(2, 0)$. The $x$-intercepts are $(-2, 0)$ and $(2, 0)$, and the $y$-intercept is $(0, 2)$.

**7.** If the point (3, 8) is on the graph of a function $f$, then $f(\underline{3}) = \underline{8}$. $f(-2) = 4$, then $(\underline{-2}, \underline{4})$ is a point on the graph of $g$.

**8. a.** Since $(-3, -15)$ and $(1, -3)$ are on the graph of $f$, then $f(-3) = -15$ and $f(1) = -3$.

**b.** To determine the domain, notice that the graph exists for all real numbers. Thus, the domain is $\{x \mid x \text{ is any real number}\}$, or $(-\infty, \infty)$ in interval notation.

**c.** To determine the range, notice that the function can assume any real number. Thus, the range is $\{y \mid y \text{ is any real number}\}$, or $(-\infty, \infty)$ in interval notation.

**d.** The intercepts are $(-2, 0)$, $(0, 0)$, and $(2, 0)$. The $x$-intercepts are $(-2, 0)$, $(0, 0)$, and $(2, 0)$. The $y$-intercept is $(0, 0)$.

**e.** Since (3, 15) is the only point on the graph where $y = f(x) = 15$, the solution set to $f(x) = 15$ is $\{3\}$.

**9. a.** When $x = -2$, then

$$\begin{aligned} f(x) &= -3x + 7 \\ f(-2) &= -3(-2) + 7 \\ &= 6 + 7 \\ &= 13 \end{aligned}$$

Since $f(-2) = 13$, the point $(-2, 13)$ is on the graph. This means the point $(-2, 1)$ is **not** on the graph.

**b.** If $x = 3$, then

$$\begin{aligned} f(x) &= -3x + 7 \\ f(3) &= -3(3) + 7 \\ &= -9 + 7 \\ &= -2 \end{aligned}$$

The point $(3, -2)$ is on the graph.

**c.** If $f(x) = -8$, then

$$\begin{aligned} f(x) &= -8 \\ -3x + 7 &= -8 \\ -3x &= -15 \\ x &= 5 \end{aligned}$$

If $f(x) = -8$, then $x = 5$. The point $(5, -8)$ is on the graph.

**10.** $f(x) = 2x + 6$

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

Yes, $-3$ is a zero of $f$.

**11.** $g(x) = x^2 - 2x - 3$

$g(1) = (1)^2 - 2(1) - 3 = 1 - 2 - 3 = -4$

No, 1 is not a zero of $g$.

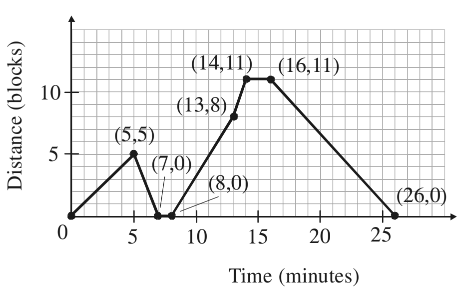
**12.** $h(z) = -z^3 + 4z$

$h(2) = -(2)^3 + 4(2) = -8 + 8 = 0$

Yes, 2 is a zero of $h$.

**13.** The zeros of the function are the $x$-intercepts: –2 and 2.

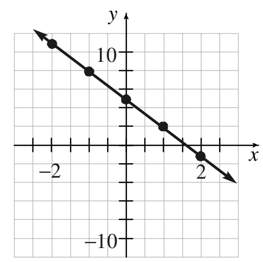
**14.** Clara's distance from home is a function of time so we put time (in minutes) on the horizontal axis and distance (in blocks) on the vertical axis. Starting at the origin (0, 0), draw a straight line to the point (5, 5). The ordered pair (5, 5) represents Clara being 5 blocks from home after 5 minutes. From the point (5, 5), draw a straight line to the point (7, 0) that represents her trip back home. The ordered pair (7, 0) represents Clara being back at home after 7 minutes. Draw a line segment from (7, 0) to (8, 0) to represent the time it takes Clara to find her keys and lock the door. Next, draw a line segment from (8, 0) to (13, 8) that represents her 8 block run in 5 minutes. Then draw a line segment from (13, 8) to (14, 11) that represents her 3 block run in 1 minute. Now draw a horizontal line from (14, 11) to (16, 11) that represents Clara's resting period. Finally, draw a line segment from (16, 11) to (26, 0) that represents her walk home.




### 2.3 Exercises

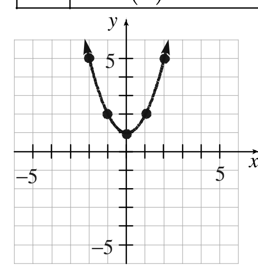
**16.** $g(x) = -3x + 5$

| $x$ | $y = g(x) = -3x + 5$ | $(x, y)$ |
|---|---|---|
| –2 | $g(-2) = -3(-2) + 5 = 11$ | (–2, 11) |
| –1 | $g(-1) = -3(-1) + 5 = 8$ | (–1, 8) |
| 0 | $g(0) = -3(0) + 5 = 5$ | (0, 5) |
| 1 | $g(1) = -3(1) + 5 = 2$ | (1, 2) |
| 2 | $g(2) = -3(2) + 5 = -1$ | (2, –1) |



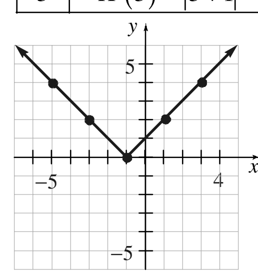
**18.** $F(x) = x^2 + 1$

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



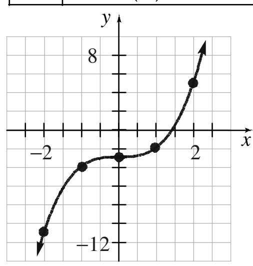
**20.** $H(x) = |x + 1|$

| $x$ | $y = H(x) = \|x + 1\|$ | $(x, y)$ |
|---|---|---|
| –5 | $H(-5) = \|-5 + 1\| = 4$ | (–5, 4) |
| –3 | $H(-3) = \|-3 + 1\| = 2$ | (–3, 2) |
| –1 | $H(-1) = \|-1 + 1\| = 0$ | (–1, 0) |
| 1 | $H(1) = \|1 + 1\| = 2$ | (1, 2) |
| 3 | $H(3) = \|3 + 1\| = 4$ | (3, 4) |



**22.** $h(x) = x^3 - 3$

| $x$ | $y = h(x) = x^3 - 3$ | $(x, y)$ |
|---|---|---|
| $-2$ | $h(-2) = (-2)^3 - 3 = -11$ | $(-2, -11)$ |
| $-1$ | $h(-1) = (-1)^3 - 3 = -4$ | $(-1, -4)$ |
| $0$ | $h(0) = 0^3 - 3 = -3$ | $(0, -3)$ |
| $1$ | $h(1) = 1^3 - 3 = -2$ | $(1, -2)$ |
| $2$ | $h(2) = 2^3 - 3 = 5$ | $(2, 5)$ |




**24. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$
Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**b.** The intercepts are (0, −1) and (3, 0). The *x*-intercept is (3, 0) and the *y*-intercept is (0, −1).

**c.** Zero: 3

**26. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$
Range: $\{y \mid y \le 4\}$ or $(-\infty, 4]$

**b.** The intercepts are (−1, 0), (3, 0), and (0, 3). The *x*-intercepts are (−1, 0) and (3, 0), and the *y*-intercept is (0, 3).

**c.** Zeros: −1, 3

**28. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$
Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**b.** The intercepts are (−2, 0), (1, 0), and (4, 0). The *x*-intercepts are (−2, 0), (1, 0), and (4, 0), and the *y*-intercept is (0, 2).

**c.** Zeros: −2, 1, 4

**30. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$
Range: $\{y \mid y \ge 0\}$ or $[0, \infty)$

**b.** The intercepts are (−1, 0), (2, 0), and (0, 4). The *x*-intercepts are (−1, 0) and (2, 0), and the *y*-intercept is (0, 4).

**c.** Zeros: −1, 2

**32. a.** Domain: $\{x \mid x \le 2\}$ or $(-\infty, 2]$
Range: $\{y \mid y \le 3\}$ or $(-\infty, 3]$

**b.** The intercepts are (−2, 0), (2, 0), and (0, 3). The *x*-intercepts are (−2, 0) and (2, 0), and the *y*-intercept is (0, 3).

**c.** Zeros: −2, 2

**34. a.** $g(-3) = -2$

**b.** $g(5) = 2$

**c.** $g(6) = 3$

**d.** $g(-5)$ is positive since the graph is above the *x*-axis when $x = -5$.

**e.** $g(x) = 0$ for $\{-4, 3\}$

**f.** Domain: $\{x \mid -6 \le x \le 6\}$ or $[-6, 6]$

**g.** Range: $\{y \mid -3 \le y \le 4\}$ or $[-3, 4]$

**h.** The *x*-intercepts are (−4, 0) and (3, 0).

**i.** The *y*-intercept is (0, −3).

**j.** $g(x) = -2$ for $\{-3, 2\}$

**k.** $g(x) = 3$ for $\{-5, 6\}$

**l.** The zeros are −4 and 3.

**36. a.** From the table, when $x = 3$ the value of the function is 8. Therefore, $G(3) = 8$

**b.** From the table, when $x = 7$ the value of the function is 5. Therefore, $G(7) = 5$

**c.** From the table, $G(x) = 5$ when $x = 0$ and when $x = 7$.

**d.** The $x$-intercept is the point for which the function value is 0. From the table, $G(x)=0$ when $x=-4$. Therefore, the $x$-intercept is (–4, 0).

**e.** The $y$-intercept is the point for which $x = 0$. From the table, when $x=0$ the value of the function is 5. Therefore, the $y$-intercept is (0, 5).

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

Since $f(-2) = -1$, the point (–2, 1) is not on the graph of the function.

**b.** $f(4)=3(4)+5=12+5=17$

The point (4, 17) is on the graph.

**c.** $3x+5=-4$

$3x=-9$

$x=-3$

The point (–3, –4) is on the graph.

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

–2 is not a zero of $f$.

**40. a.** $H(3)=\frac{2}{3}(3)-4=2-4=-2$

Since $H(3) = -2$, the point (3, –2) is on the graph of the function.

**b.** $H(6)=\frac{2}{3}(6)-4=4-4=0$

The point (6, 0) is on the graph.

**c.** $\frac{2}{3}x-4=-4$

$\frac{2}{3}x=0$

$x=0$

The point (0, –4) is on the graph.

**d.** $H(6)=\frac{2}{3}(6)-4=4-4=0$

6 is a zero of $H$.

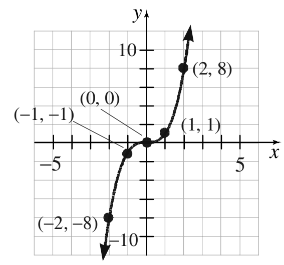
**42.** Constant function, (a)

**44.** Identity function, (f)

**46.** Linear function, (b)

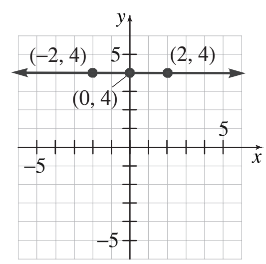
**48.** $f(x)=x^3$

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




**50.** $f(x) = 4$

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




**52. a.** Graph (II). Temperatures generally fluctuate during the year from very cold in the winter to very hot in the summer. Thus, the graph oscillates.

**b.** Graph (I). The height of a human increases rapidly at first, then levels off. Thus, the graph increases rapidly at first, then levels off.

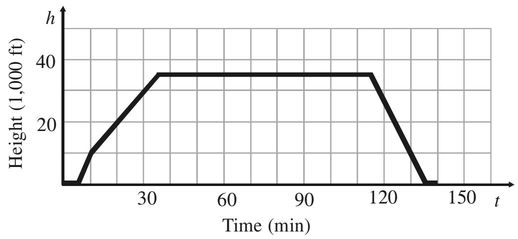
**c.** Graph (V). Since the person is riding at a constant speed, the distance increases at a constant rate. The graph should be linear with a positive slope.

**d.** Graph (III). The pizza cools off quickly when it is first removed from the oven. The rate of cooling should slow as time goes on as the pizza temperature approaches the room temperature.

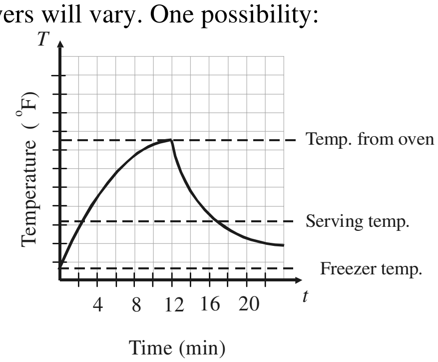
 

**e.** Graph (IV). The value of a car decreases rapidly at first and then more slowly as time goes on. The value should approach 0 as time goes on (ignoring antique autos).

**54.**

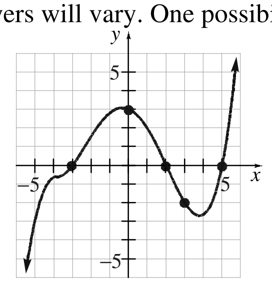



**56.** Answers will vary. One possibility:




**58.** Answers will vary. One possibility: For the first 100 days, the depth of the lake is fairly constant. Then there is a increase in depth, possibly due to spring rains, followed by a large decrease, possibly due to a hot summer. Towards the end of the year the depth increases back to its original level, possibly due to snow and ice accumulation.

**60.** Answers will vary. One possibility:




**62.** The domain of a function is the set of all values of the independent variable such that the output of the function is a real number and "makes sense." It is this aspect of "making sense" that leads to finding domains in applications. Domains in applications are often found based on determining reasonable values of the variable. For example, the length of a side of a rectangle must be positive.

**64.** The *x*-intercepts of the graph of a function are the same as the zeros of the function.

**Putting the Concepts Together (Sections 2.1–2.3)**

**1.** The relation is a function because each element in the domain corresponds to exactly one element in the range.
{(−2, 1), (−1, 0), (0, 1), (1, 2), (2, 3)}

**2. a.** $y = x^3 - 4x$ is a function because any specific value of *x* (input) yields exactly one value of *y* (output).

**b.** $y = \pm 4x + 3$ is not a function because with the exception of 0, any value of *x* can yield two values of *y*. For instance, if $x = 1$, then $y = 7$ or $y = -1$.

**3.** Yes, the graph represents a function.
Domain: {−4, −1, 0, 3, 6}
Range: {−3, −2, 2, 6}

**4.** This relation is a function because it passes the vertical line test.
$f(5) = -6$

**5.** The zero is 4.

**6. a.** $f(4) = -5(4) + 3 = -20 + 3 = -17$

**b.**
$$\begin{aligned} g(-3) &= -2(-3)^2 + 5(-3) - 1 \\ &= -2(9) - 15 - 1 \\ &= -18 - 15 - 1 \\ &= -34 \end{aligned}$$

**c.**
$$\begin{aligned} f(x) - f(4) &= [-5x + 3] - [-17] \\ &= -5x + 3 + 17 \\ &= -5x + 20 \end{aligned}$$

**d.**
$$\begin{aligned} f(x-4) &= -5(x-4) + 3 \\ &= (-5)x - (-5)4 + 3 \\ &= -5x + 20 + 3 \\ &= -5x + 23 \end{aligned}$$

**7. a.** Domain: $\{h \mid h \text{ is a real number}\}$ or $(-\infty, \infty)$

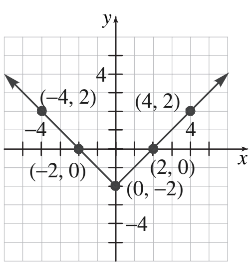
**b.** Since we cannot divide by zero, we must find the values of $w$ which make the denominator equal to zero.

$$3w+1=0$$
$$3w+1-1=0-1$$
$$3w=-1$$
$$\frac{3w}{3}=\frac{-1}{3}$$
$$w=-\frac{1}{3}$$

Domain: $\left\{w \middle| w \neq -\frac{1}{3}\right\}$

**8.** $y=|x|-2$

| $x$ | $y=\|x\|-2$ | $(x, y)$ |
|---|---|---|
| –4 | $y=\|-4\|-2=2$ | $(-4, 2)$ |
| –2 | $y=\|-2\|-2=0$ | $(-2, 0)$ |
| 0 | $y=\|0\|-2=-2$ | $(0, -2)$ |
| 2 | $y=\|2\|-2=0$ | $(2, 0)$ |
| 4 | $y=\|4\|-2=2$ | $(4, 2)$ |




**9. a.** $h(2.5)=80$
The ball is 80 feet high after 2.5 seconds.

**b.** [0, 3.8]

**c.** [0, 105]

**d.** 1.25 seconds

**10. a.** $f(3) = 5(3) - 2 = 15 - 2 = 13$
Since the point (3, 13) is on the graph, the point (3, 12) is not on the graph of the function.

**b.** $f(-2)=5(-2)-2=-10-2=-12$
The point (–2, –12) is on the graph of the function.

**c.**
$$f(x)=-22$$
$$5x-2=-22$$
$$5x-2+2=-22+2$$
$$5x=-20$$
$$\frac{5x}{5}=\frac{-20}{5}$$
$$x=-4$$
The point (–4, –22) is on the graph of $f$.

**d.** $f\left(\frac{2}{5}\right)=\cancel{5}\left(\frac{2}{\cancel{5}}\right)-2=2-2=0$

$\frac{2}{5}$ is a zero of $f$.

## Section 2.4

### Are You Prepared for This Section?

**P1.** $y=2x-3$
Let $x = -1, 0, 1$, and 2.

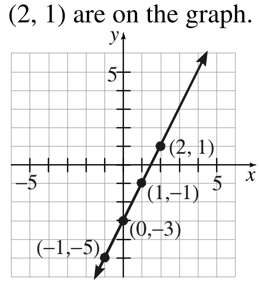
$x=-1$: $y=2(-1)-3$
$y=-2-3$
$y=-5$

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

$x=1$: $y=2(1)-3$
$y=2-3$
$y=-1$

$x=2$: $y=2(2)-3$
$y=4-3$
$y=1$

Thus, the points (–1, –5), (0, –3), (1, –1), and (2, 1) are on the graph.



**P2.** $\frac{1}{2}x + y = 2$

Let $x = -2$, 0, 2, and 4.

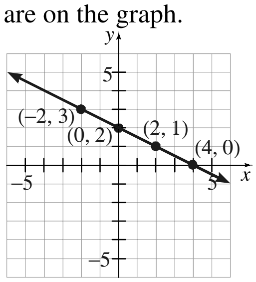
$x = -2$: $\frac{1}{2}(-2) + y = 2$
$$-1 + y = 2$$
$$y = 3$$

$x = 0$: $\frac{1}{2}(0) + y = 2$
$$0 + y = 2$$
$$y = 2$$

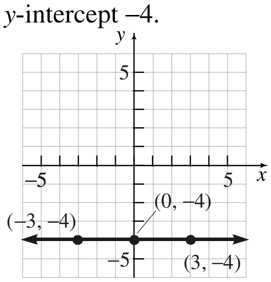
$x = 2$: $\frac{1}{2}(2) + y = 2$
$$1 + y = 2$$
$$y = 1$$

$x = 4$: $\frac{1}{2}(4) + y = 2$
$$2 + y = 2$$
$$y = 0$$

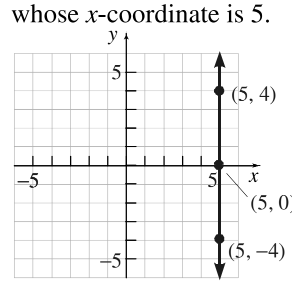
Thus, the points (–2, 3), (0, 2), (2, 1), and (4, 0) are on the graph.




**P3.** The graph of $y = -4$ is a horizontal line with $y$-intercept –4.




**P4.** The graph of $x = 5$ is a vertical line with $x$-intercept 5. It consists of all ordered pairs whose $x$-coordinate is 5.




**P5.** $m = \frac{-4-3}{3-(-1)} = \frac{-7}{4} = -\frac{7}{4}$

Using $m = \frac{-7}{4}$ we would interpret the slope as saying that $y$ will decrease 7 units if $x$ increases by 4 units. We could also say $m = \frac{7}{-4}$ in which case we would interpret the slope as saying that $y$ will increase by 7 units if $x$ decreases by 4 units. In either case, the slope is the average rate of change of $y$ with respect to $x$.

**P6.** Start by finding the slope of the line using the two given points.

$$m = \frac{9-3}{4-1} = \frac{6}{3} = 2$$

Now use the point-slope form of the equation of a line:

$$y - y_1 = m(x - x_1)$$
$$y - 3 = 2(x - 1)$$
$$y - 3 = 2x - 2$$
$$y = 2x + 1$$

The equation of the line is $y = 2x + 1$.

**P7.**
$$0.5(x-40) + 100 = 84$$
$$(0.5)x - (0.5)40 + 100 = 84$$
$$0.5x - 20 + 100 = 84$$
$$0.5x + 80 = 84$$
$$0.5x + 80 - 80 = 84 - 80$$
$$0.5x = 4$$
$$\frac{0.5x}{0.5} = \frac{4}{0.5}$$
$$x = 8$$

**P8.**
$$\begin{aligned} 4x+20 &\ge 32 \\ 4x+20-20 &\ge 32-20 \\ 4x &\ge 12 \\ \frac{4x}{4} &\ge \frac{12}{4} \\ x &\ge 3 \end{aligned}$$
$\{x \mid x \ge 3\}$ or $[3, \infty)$

**Section 2.4 Quick Checks**

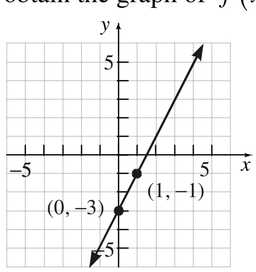
1. For the graph of a linear function $f(x) = mx + b$, $m$ is the <u>slope</u> and $(0, b)$ is the <u>$y$-intercept</u>.

2. The graph of a linear function is called a <u>line</u>.

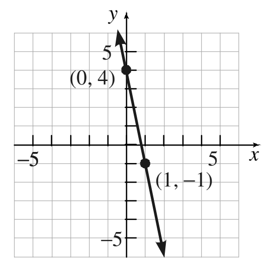
3. False

4. For the linear function $G(x) = -2x + 3$, the slope is <u>$-2$</u> and the $y$-intercept is <u>$(0, 3)$</u>.

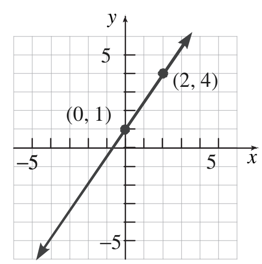
5. Comparing $f(x) = 2x - 3$ to $f(x) = mx + b$, the slope $m$ is 2 and the $y$-intercept $b$ is $-3$. Begin by plotting the point $(0, -3)$. Because $m = 2 = \frac{2}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point $(0, -3)$ go up 2 units and to the right 1 unit and end up at $(1, -1)$. Draw a line through these points and obtain the graph of $f(x) = 2x - 3$.



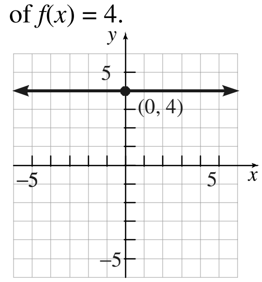

6. Comparing $G(x) = -5x + 4$ to $G(x) = mx + b$, the slope $m$ is $-5$ and the $y$-intercept $b$ is 4. Begin by plotting the point $(0, 4)$. Because $m = -5 = \frac{-5}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point $(0, 4)$ go down 5 units and to the right 1 unit and end up at $(1, -1)$. Draw a line through these points and obtain the graph of $G(x) = -5x + 4$.




7. Comparing $h(x) = \frac{3}{2}x + 1$ to $h(x) = mx + b$, the slope $m$ is $\frac{3}{2}$ and the $y$-intercept $b$ is 1. Begin by plotting the point $(0, 1)$. Because $m = \frac{3}{2} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point $(0, 1)$ go up 3 units and to the right 2 units and end up at $(2, 4)$. Draw a line through these points and obtain the graph of $h(x) = \frac{3}{2}x + 1$.




8. Comparing $f(x) = 4$ to $f(x) = mx + b$, the slope $m$ is 0 and the $y$-intercept $b$ is 4. Since the slope is 0, this is a horizontal line. Draw a horizontal line through the point $(0, 4)$ to obtain the graph of $f(x) = 4$.




9.
$$\begin{aligned} f(x) &= 0 \\ 3x-15 &= 0 \\ 3x &= 15 \\ x &= 5 \end{aligned}$$
5 is the zero.

**10.** $G(x) = 0$

$$\frac{1}{2}x + 4 = 0$$
$$\frac{1}{2}x = -4$$
$$x = -8$$

−8 is the zero.

**11.** $F(p) = 0$

$$-\frac{2}{3}p + 8 = 0$$
$$-\frac{2}{3}p = -8$$
$$-2p = -24$$
$$p = 12$$

12 is the zero.

**12. a.** The independent variable is the number of miles driven, $x$. It does not make sense to drive a negative number of miles, so the domain of the function is $\{x \mid x \geq 0\}$ or, using interval notation, $[0, \infty)$.

**b.** To determine the $C$-intercept, find $C(0) = 0.35(0) + 40 = 40$. The $C$-intercept is (0, 40).

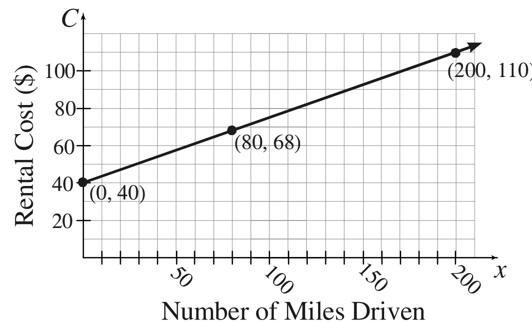
**c.** $C(80) = 0.35(80) + 40 = 28 + 40 = 68$. If the truck is driven 80 miles, the rental cost will be \$68.

**d.** Solve $C(x) = 85.50$:

$$0.35x + 40 = 85.50$$
$$0.35x = 45.50$$
$$x = 130$$

If the rental cost is \$85.50, then the truck was driven 130 miles.

**e.** Plot the independent variable, *number of miles driven*, on the horizontal axis and the dependent variable, *rental cost*, on the vertical axis. From parts (b) and (c), the points (0, 40) and (80, 68) are on the graph. Find one more point by evaluating the function for $x = 200$:
$C(200) = 0.35(200) + 40 = 70 + 40 = 110$.
The point (200, 110) is also on the graph.




**f.** Solve $C(x) \leq 127.50$:

$$0.35x + 40 \leq 127.50$$
$$0.35x \leq 87.50$$
$$x \leq 250$$

You can drive up to 250 miles if you can spend up to \$127.50.

**13. a.** From Example 4, the daily fixed costs were \$2000 with a variable cost of \$80 per bicycle. The tax of \$1 per bicycle changes the variable cost to \$81 per bicycle. Thus, the cost function is $C(x) = 81x + 2000$.

**b.** $C(5) = 81(5) + 2000 = 2405$

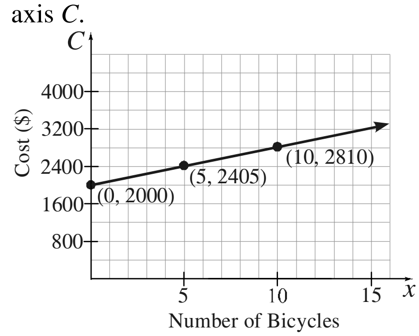
So, the cost of manufacturing 5 bicycles in a day is \$2405.

**c.**

$$C(x) = 2810$$
$$81x + 2000 = 2810$$
$$81x = 810$$
$$x = 10$$

So, 10 bicycles can be manufactured for a cost of \$2810.

**d.** Label the horizontal axis $x$ and the vertical axis $C$.




**14. a.** Let $C(x)$ represent the monthly cost of operating the car after driving $x$ miles, so $C(x) = mx + b$. The monthly cost before the car is driven is \$250, so $C(0) = 250$. The $C$-intercept of the linear function is 250. Because the maintenance and gas cost is

\$0.18 per mile, the slope of the linear function is 0.18. The linear function that relates the monthly cost of operating the car as a function of miles driven is $C(x) = 0.18x + 250$.

**b.** The car cannot be driven a negative distance, the number of miles driven, $x$, must be greater than or equal to zero. In addition, there is no definite maximum number of miles that the car can be driven. Therefore, the implied domain of the function is $\{x \mid x \geq 0\}$, or using interval notation $[0, \infty)$.

**c.** $C(320) = 0.18(320) + 250 = 307.6$

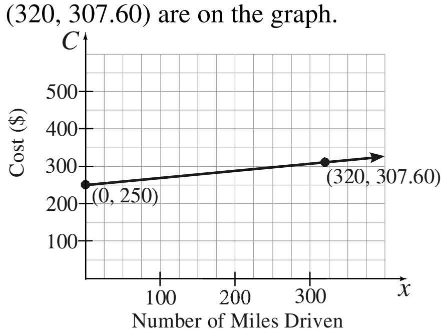
So, the monthly cost of driving 320 miles is \$307.60.

**d.**

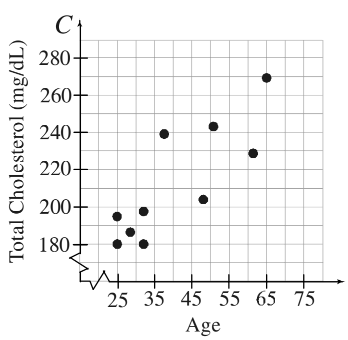
$$\begin{aligned} C(x) &= 282.40 \\ 0.18x + 250 &= 282.40 \\ 0.18x &= 32.40 \\ x &= 180 \end{aligned}$$

So, Roberta can drive 180 miles each month for the monthly cost of \$282.40.

**e.** Label the horizontal axis $x$ and the vertical axis $C$. From part (a) $C(0) = 250$, and from part (c) $C(320) = 307.6$, so (0, 250) and (320, 307.60) are on the graph.




**15. a.**




**b.** The scatter diagram reveals that, as the age increases, the total cholesterol also increases.

**16.** Nonlinear

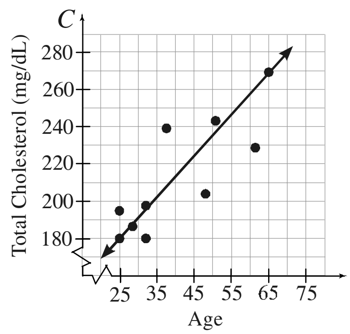
**17.** Linear with a positive slope.

**18. a.** Answers will vary. Use the points (25, 180) and (65, 269).

$$m = \frac{269-180}{65-25} = \frac{89}{40} = 2.225$$

$$\begin{aligned} y - 180 &= 2.225(x - 25) \\ y - 180 &= 2.225x - 55.625 \\ y = f(x) &= 2.225x + 124.375 \end{aligned}$$

**b.**



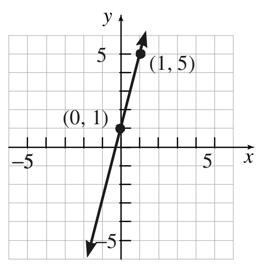

**c.** $f(39) = 2.225(39) + 124.375 = 211.15$

We predict that the total cholesterol of a 39-year-old male will be approximately 211 mg/dL.

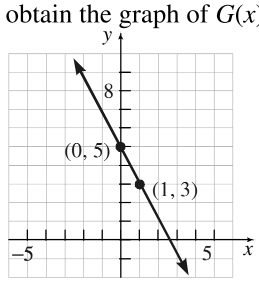
**d.** The slope of the linear function is 2.225. This means that, for males, the total cholesterol increases by 2.225 mg/dL for each one-year increase in age. The $y$-intercept, 124.375, would represent the total cholesterol of a male who is 0 years old. Thus, it does not make sense to interpret this $y$-intercept.

## 2.4 Exercises

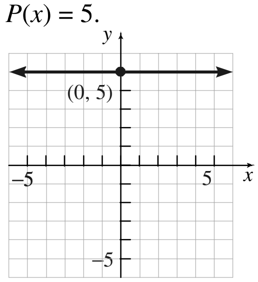
**20.** Comparing $F(x) = 4x + 1$ to $F(x) = mx + b$, the slope $m$ is 4 and $b$ is 1. Begin by plotting the point (0, 1). Because $m = 4 = \frac{4}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, 1) we go up 4 units and to the right 1 unit and end up at (1, 5). Draw a line through these points and obtain the graph of $F(x) = 4x + 1$.



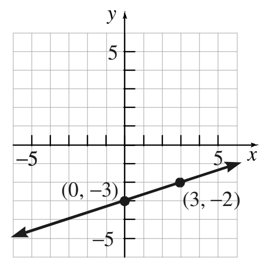

**22.** Comparing $G(x) = -2x + 5$ to $G(x) = mx + b$, the slope $m$ is $-2$ and $b$ is 5. Begin by plotting the point (0, 5). Because $m = -2 = \frac{-2}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, 5) go down 2 units and to the right 1 unit and end up at (1, 3). Draw a line through these points and obtain the graph of $G(x) = -2x + 5$.



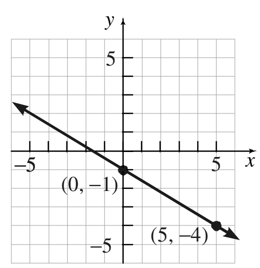

**24.** Comparing $P(x) = 5$ to $P(x) = mx + b$, the slope $m$ is $0$ and $b$ is 5. The graph is a horizontal line through the point (0, 5). Draw a horizontal line through this point and obtain the graph of $P(x) = 5$.



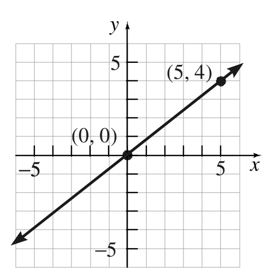

**26.** Comparing $f(x) = \frac{1}{3}x - 3$ to $f(x) = mx + b$, the slope $m$ is $\frac{1}{3}$ and $b$ is $-3$. Begin by plotting the point $(0, -3)$. Because $m = \frac{1}{3} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point $(0, -3)$ go up 1 unit and to the right 3 units and end up at $(3, -2)$. Draw a line through these points and obtain the graph of $f(x) = \frac{1}{3}x - 3$.




**28.** Comparing $P(x) = -\frac{3}{5}x - 1$ to $P(x) = mx + b$, the slope $m$ is $-\frac{3}{5}$ and $b$ is $-1$. Begin by plotting the point $(0, -1)$. Because $m = -\frac{3}{5} = \frac{-3}{5} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point $(0, -1)$ go down 3 units and to the right 5 units and end up at $(5, -4)$. Draw a line through these points and obtain the graph of $P(x) = -\frac{3}{5}x - 1$.




**30.** Comparing $f(x) = \frac{4}{5}x$ to $f(x) = mx + b$, the slope $m$ is $\frac{4}{5}$ and $b$ is 0. Begin by plotting the point (0, 0). Because $m = \frac{4}{5} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, 0) go up 4 units and to the right 5 units and end up at (5, 4). Draw a line through these points and obtain the graph of $f(x) = \frac{4}{5}x$.



**32.** $f(x) = 0$
$3x + 18 = 0$
$3x = -18$
$x = -6$
$-6$ is the zero.

**34.** $H(x) = 0$
$-4x + 36 = 0$
$-4x = -36$
$x = 9$
9 is the zero.

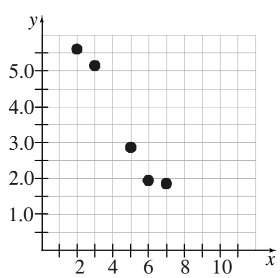
**36.** $p(q) = 0$
$\frac{1}{4}q + 2 = 0$
$\frac{1}{4}q = -2$
$q = -8$
$-8$ is the zero.

**38.** $F(t) = 0$
$-\frac{3}{2}t + 6 = 0$
$-\frac{3}{2}t = -6$
$-3t = -12$
$t = 4$
4 is the zero.

**40.** Linear with negative slope

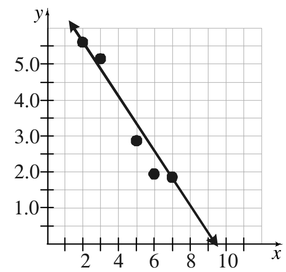
**42.** Nonlinear

**44. a.**

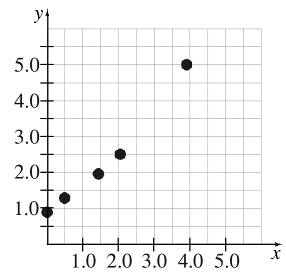



**b.** Answers will vary. Use the points (2, 5.7) and (7, 1.8).
$m = \frac{1.8 - 5.7}{7 - 2} = \frac{-3.9}{5} = -0.78$
$y - 5.7 = -0.78(x - 2)$
$y - 5.7 = -0.78x + 1.56$
$y = -0.78x + 7.26$

**c.**

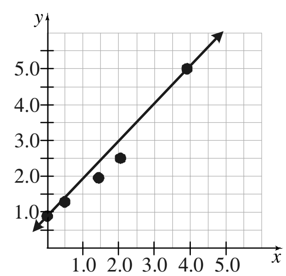



**46. a.**




**b.** Answers will vary. Use the points (0, 0.8) and (3.9, 5.0).
$m = \frac{5.0 - 0.8}{3.9 - 0} = \frac{4.2}{3.9} \approx 1.08$
$y - 0.8 = 1.08(x - 0)$
$y - 0.8 = 1.08x$
$y = 1.08x + 0.8$

**c.**




**48. a.** 8

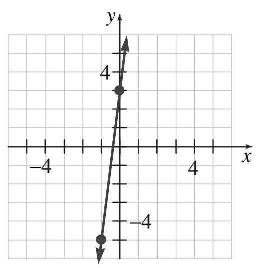
**b.** (0, 3)

**c.** $g(x) = 0$
$8x + 3 = 0$
$8x = -3$
$x = -\frac{3}{8}$
$-\frac{3}{8}$ is the zero.

**d.** $g(x) = 19$
$8x + 3 = 19$
$8x = 16$
$x = 2$
The point (2, 19) is on the graph of $g$.

**e.** $g(x) > -5$
$8x + 3 > -5$
$8x > -8$
$x > -1$
$\{x \mid x > -1\}$ or $(-1, \infty)$

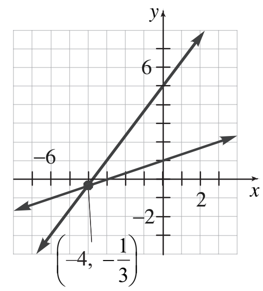
**f.**




**50. a.** $f(x) = g(x)$
$\frac{4}{3}x + 5 = \frac{1}{3}x + 1$
$\frac{4}{3}x - \frac{1}{3}x = 1 - 5$
$x = -4$
$f(-4) = \frac{4}{3}(-4) + 5 = -\frac{16}{3} + \frac{15}{3} = -\frac{1}{3}$
$\left(-4, -\frac{1}{3}\right)$ is on the graph of $f(x)$ and $g(x)$.

**b.** $f(x) \le g(x)$
$\frac{4}{3}x + 5 \le \frac{1}{3}x + 1$
$\frac{4}{3}x - \frac{1}{3}x \le 1 - 5$
$x \le -4$
$\{x \mid x \le -4\}$ or $(-\infty, -4]$

**c.**




**52.** Since $g(1) = 5$ and $g(5) = 17$, the points (1, 5) and (5, 17) are on the graph of $g$. Thus,
$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{17 - 5}{5 - 1} = \frac{12}{4} = 3$.
$y - y_1 = m(x - x_1)$
$y - 5 = 3(x - 1)$
$y - 5 = 3x - 3$
$y = 3x + 2$ or $g(x) = 3x + 2$
Finally, $g(-3) = 3(-3) + 2 = -9 + 2 = -7$.

**54.** Since $F(2) = 5$ and $F(-3) = 9$, the points (2, 5) and (–3, 9) are on the graph of $F$. Thus,
$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9 - 5}{-3 - 2} = \frac{4}{-5} = -\frac{4}{5}$.
$y - y_1 = m(x - x_1)$
$y - 5 = -\frac{4}{5}(x - 2)$
$y - 5 = -\frac{4}{5}x + \frac{8}{5}$
$y = -\frac{4}{5}x + \frac{33}{5}$ or $F(x) = -\frac{4}{5}x + \frac{33}{5}$
Finally,
$F\left(-\frac{3}{2}\right) = -\frac{4}{5}\left(-\frac{3}{2}\right) + \frac{33}{5} = \frac{6}{5} + \frac{33}{5} = \frac{39}{5}$.

**56. a.** The point (2, 1) is on the graph of $g$, so $g(2) = 1$. Thus, the solution of $g(x) = 1$ is $x = 2$.

**b.** The point (6, –1) is on the graph of $g$, so $g(6) = -1$. Thus, the solution of $g(x) = -1$ is $x = 6$.

**c.** The point (–4, 4) is on the graph of g, so $g(-4) = 4$.

**d.** The intercepts of $y = g(x)$ are (0, 2) and (4, 0). The $y$-intercept is (0, 2) and the $x$-intercept is (4, 0).

**e.** Use any two points to determine the slope. Here we use (2, 1) and (6, –1):

$$m = \frac{-1-1}{6-2} = \frac{-2}{4} = -\frac{1}{2}$$

From part (d), the *y*-intercept is 2, so the equation of the function is $g(x) = -\frac{1}{2}x + 2$.

**58. a.** The independent variable is total sales, *s*. It would not make sense for total sales to be negative. Thus, the domain of *I* is $\{s \mid s \geq 0\}$ or, using interval notation, [0, ∞).

**b.** $I(0) = 0.01(0) + 20,000 = 20,000$

If Tanya's total sales for the year are \$0, her income will be \$20,000. In other words, her base salary is \$20,000.

**c.** Evaluate *I* at *s* = 500,000.

$$I(500,000) = 0.01(500,000) + 20,000 = 25,000$$

If Tanya sells \$500,000 in books for the year, her salary will be \$25,000.

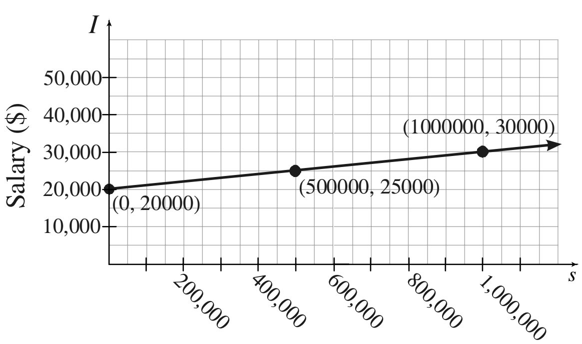
**d.** Evaluate *I* at $m = 0$, 500,000, and 1,000,000.

$$I(0) = 0.01(0) + 20,000 = 20,000$$

$$I(500,000) = 0.01(500,000) + 20,000 = 25,000$$

$$I(1,000,000) = 0.01(1,000,000) + 20,000 = 30,000$$

Thus, the points (0, 20,000), (500,000, 25,000), and (1,000,000, 30,000) are on the graph.




**e.** Solve *I*(*s*) = 45,000.

$$0.01s + 20,000 = 45,000$$
$$0.01s = 25,000$$
$$s = 2,500,000$$

For Tanya's income to be \$45,000, her total sales would have to be \$2,500,000.

**60. a.** The independent variable is payroll, *p*. The payroll tax only applies if the payroll exceeds \$189 million. Thus, the domain of *T* is $\{p \mid p > 189\}$ or, using interval notation, (189, ∞).

**b.** Evaluate *T* at *p* = 200.

*T*(200) = 0.175(200 – 189) = 1.925

The luxury tax for a payroll of \$200 million was \$1.925 million.

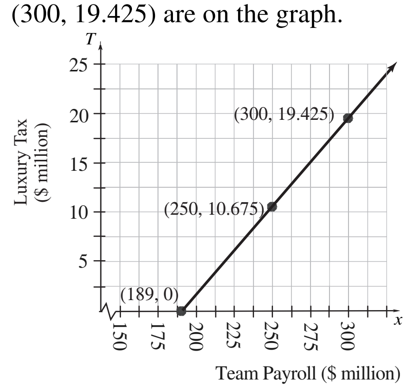
**c.** Evaluate *T* at *p* = 189, 250, and 300.

*T*(189) = 0.175(189 – 189) = 0

*T*(250) = 0.175(250 – 189) = 10.675

*T*(300) = 0.175(300 – 189) = 19.425

Thus, the points (189, 0), (250, 10.675) and (300, 19.425) are on the graph.




**d.** Solve *T*(*p*) = 1.3

$$0.175(p - 189) = 1.3$$
$$0.175p - 33.075 = 1.3$$
$$0.175p = 34.375$$
$$p \approx 196.4$$

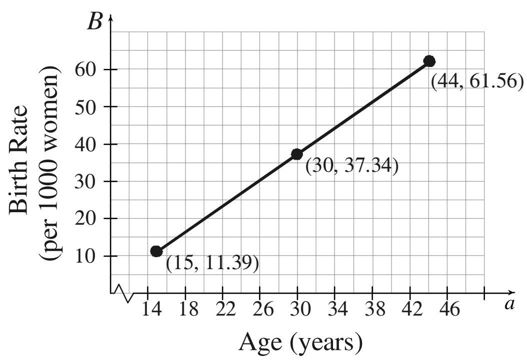
For the luxury tax to be \$1.3 million, the payroll of the team would be about \$196 million.

**62. a.** The independent variable is age, *a*. The dependent variable is the birth rate, *B*.

**b.** We are told in the problem that *a* is restricted from 15 to 44, inclusive. Thus, the domain of *B* is $\{a \mid 15 \leq a \leq 44\}$ or, using interval notation, [15, 44].

**c.** Evaluate $B$ at $a = 22$.
$$B(22) = 1.73(22) - 14.56$$
$$= 23.5$$
The multiple birth rate of 22 year-old women is 23.5 births per 1000 women.

**d.** Evaluate $H$ at $a = 15$, 30, and 44.
$$B(15) = 1.73(15) - 14.56$$
$$= 11.39$$
$$B(30) = 1.73(30) - 14.56$$
$$= 37.34$$
$$B(44) = 1.73(44) - 14.56$$
$$= 61.56$$
Thus, the points (15, 11.39), (30, 37.34), and (44, 61.56) are on the graph.




**e.** Solve $B(a) = 49.45$.
$$1.73a - 14.56 = 49.45$$
$$1.73a = 64.01$$
$$a = 37$$
The age of women with a multiple birth rate of 49.45 is 37 years.

**64. a.** $R(m) = 0.32m + 129$

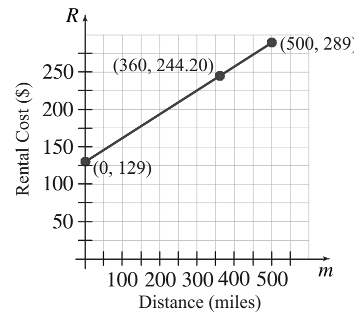
**b.** The number of miles, $m$, is the independent variable. The rental cost, $R$, is the dependent variable.

**c.** Because the number miles cannot be negative, the number of miles must be greater than or equal to zero. Also, there is a maximum of 500 miles. The domain is $\{m | 0 \le m \le 500\}$, or using interval notation [0, 500].

**d.** $R(360) = 0.32(360) + 129 = 244.20$
If 360 miles are driven, the rental cost will be \$244.20.

**e.**
$$0.32m + 129 = 275.56$$
$$0.32m = 146.56$$
$$m = 458$$
If the rental cost is \$275.56, then 458 miles were driven.

**f.**




**g.**
$$0.32m + 129 \le 273$$
$$0.32m \le 144$$
$$m \le 450$$
You can drive from 0 to 450 miles, included, if your budget is \$273. Or using interval notation, [0, 450].

**66. a.** The machine will depreciate by $\frac{\$1,200,000}{20} = \$60,000$ per year. Thus, the slope is $-60,000$. The $y$-intercept will be \$1,200,000, the initial value of the machine. The linear function that represents book value, $V$, of the machine after $x$ years is $V(x) = -60,000x + 1,200,000$.

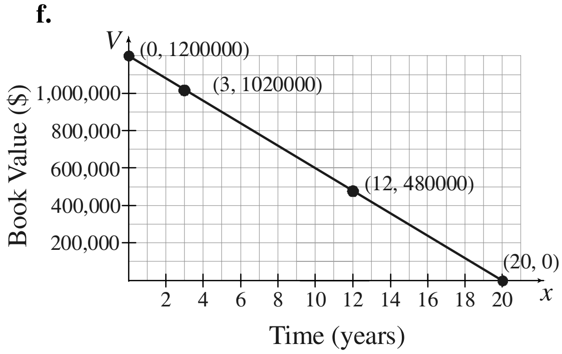
**b.** Because the machine cannot have a negative age, the age, $x$, must be greater than or equal to 0. After 20 years, the book value will be $V(20) = -60,000(20) + 1,200,000 = 0$, and the book value cannot be negative. Therefore the implied domain of function is $\{x | 0 \le x \le 20\}$, or using interval notation [0, 20].

**c.** $V(3) = -60,000(3) + 1,200,000 = 1,020,000$
After three years, the book value of the machine will be \$1,020,000.

**d.** The intercepts are (0, 1,200,000) and (20, 0). The $V$-intercept is (0, 1,200,000) and the $x$-intercept is (20, 0).

**e.** $-60,000x+1,200,000=480,000$
$$-60,000x=-720,000$$
$$x=12$$
The book value of the machine will be $480,000 after 12 years.

**f.**




**68. a.** Let $x$ represent the area of the North Chicago apartment and $R$ represent the rent.
$$m=\frac{1660-1507}{970-820}=\$1.02 \text{ per square foot}$$
$$R-1507=1.02(x-820)$$
$$R-1507=1.02x-836.4$$
$$R=1.02x+670.6$$
Using function notation, $R(x) = 1.02x + 670.6$.

**b.** $R(900)=1.02(900)+670.6$
$$=1588.6$$
The rent for a 900-square-foot apartment in North Chicago would be $1588.60.

**c.** The slope indicates that if square footage increases by 1, rent increases by $1.02.

**d.** $1.02x+670.6=1300$
$$1.02x=629.4$$
$$x=\frac{629.4}{1.02}\approx 617$$
If the rent is $1300, then the area of the apartment would be approximately 617 square feet.

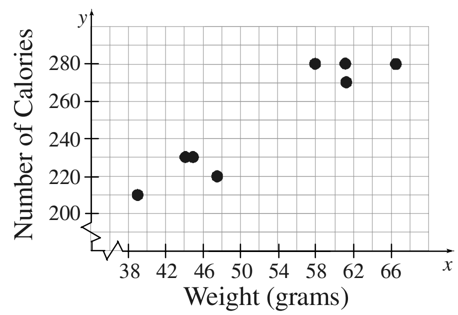
**70. a.** Let $a$ represent the age of the mother and $W$ represent the birth weight of the baby.
$$m=\frac{3370-3280}{32-22}=9$$
$$W-3370=9(a-32)$$
$$W-3370=9a-288$$
$$W=9a+3082$$
In function notation, we have $W(a) = 9a + 3082$.

**b.** $W(30)=9(30)+3082=3352$
According to this model, a 30 year old mother can expect a baby that weighs 3352 grams.

**c.** The slope indicates that for every one year increase in the mother's age, the baby's birth weight increases by 9 grams.

**d.** $9a+3082=3310$
$$9a=228$$
$$a=25.\overline{3}$$
If a baby weighs 3310 grams, we would expect the mother to be 25 years old.

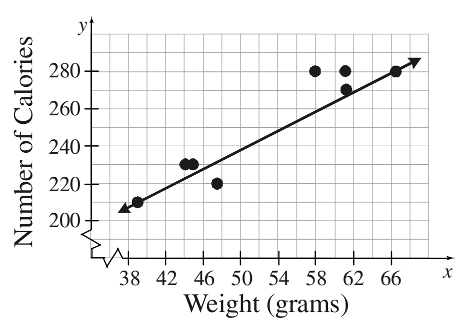
**72. a.**




**b.** Linear

**c.** Answers will vary. We will use the points (39.52, 210) and (66.45, 280).
$$m=\frac{280-210}{66.45-39.52}=\frac{70}{26.93}\approx 2.599$$
$$y-210=2.599(x-39.52)$$
$$y-210=2.599x-102.712$$
$$y=2.599x+107.288$$

**d.**

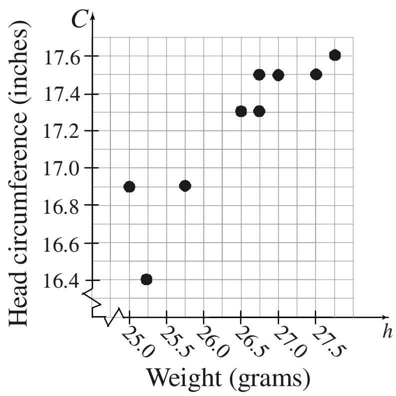



**e.** $x=62.3$: $y=2.599(62.3)+107.288$
$$\approx 269$$
We predict that a candy bar weighing 62.3 grams will contain 269 calories.

**f.** The slope of the line found is 2.599 calories per gram. This means that if the weight of a candy bar is increased by 1 gram, then the number of calories will increase by 2.599.

**74. a.** No, the relation does not represent a function. The $h$-coordinate 26.75 is paired with the two different $C$-coordinates 17.3 and 17.5.

**b.**




**c.** Answers will vary. We will use the points (25, 16.9) and (27.75, 17.6).

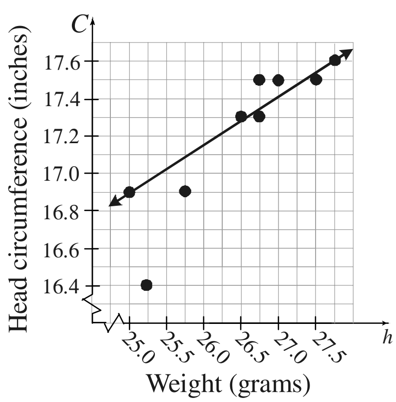
$$m = \frac{17.6 - 16.9}{27.75 - 25} = \frac{0.7}{2.75} \approx 0.255$$

$$C - 16.9 = 0.255(h - 25)$$

$$C - 16.9 = 0.255h - 6.375$$

$$C = 0.255h + 10.525$$

**d.**




**e.** Let $C$ represent the head circumference (in inches), and let $h$ represent the height (in inches).

$$C(h) = 0.255h + 10.525$$

**f.** $C(26.5) = 0.255(26.5) + 10.525 \approx 17.28$

We predict that the head circumference will be 17.28 inches if the height is 26.5 inches.

**g.** The slope of the line found is 0.255. This means that if the height increases by one inch, then the head circumference increases by 0.255 inch.

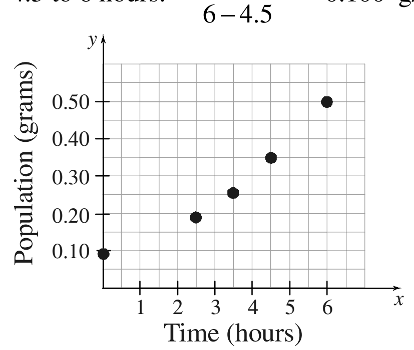
**76.** No, the data are not linearly related. Even though the graph of the data appears to look somewhat linear, a closer examination of the average growth rates between consecutive points shows that the function increases at a steadily increasing rate:

0 to 2.5 hours: $\dfrac{0.18 - 0.09}{2.5 - 0} = 0.036$ g/hr

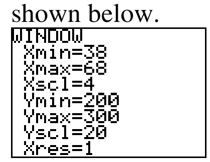
2.5 to 3.5 hours: $\dfrac{0.26 - 0.18}{3.5 - 2.5} = 0.080$ g/hr

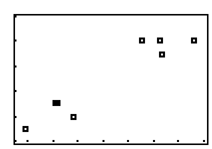
3.5 to 4.5 hours: $\dfrac{0.35 - 0.26}{4.5 - 3.5} = 0.090$ g/hr

4.5 to 6 hours: $\dfrac{0.50 - 0.35}{6 - 4.5} = 0.100$ g/hr

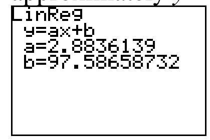



**78. a.** The scatter diagram and window settings are shown below.



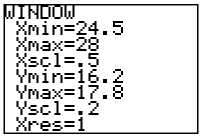



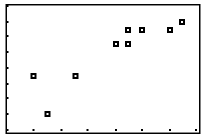
**b.** As shown below, the line of best fit is approximately $y = 2.884x + 97.587$.



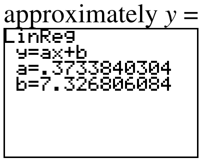

 

**80. a.** The scatter diagram and window settings are shown below.



**b.** As shown below, the line of best fit is approximately $y = 0.373x + 7.327$.



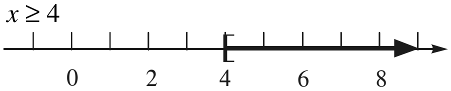

**Section 2.5**

**Are You Prepared for This Section?**

**P1.** Set-builder: $\{x \mid -2 \le x \le 5\}$

Interval: [2, 5]

**P2.** $x \ge 4$



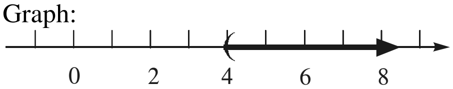

**P3.** The parenthesis indicates that $-1$ is not included in the interval, while the square bracket indicates that 3 is included. The interval is (–1, 3].

**P4.**
$$\begin{aligned} 2(x+3)-5x &= 15 \\ 2x+6-5x &= 15 \\ -3x+6 &= 15 \\ -3x &= 9 \\ x &= -3 \end{aligned}$$
The solution set is {–3}.

**P5.**
$$\begin{aligned} 2x+3 &> 11 \\ 2x+3-3 &> 11-3 \\ 2x &> 8 \\ \frac{2x}{2} &> \frac{8}{2} \\ x &> 4 \end{aligned}$$
Set-builder: $\{x \mid x > 4\}$

Interval: (4, ∞)

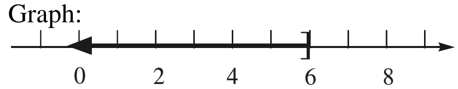
Graph:




**P6.**
$$\begin{aligned} x+8 &\ge 4(x-1)-x \\ x+8 &\ge 4x-4-x \\ x+8 &\ge 3x-4 \\ x+8-x &\ge 3x-4-x \\ 8 &\ge 2x-4 \\ 8+4 &\ge 2x-4+4 \\ 12 &\ge 2x \\ \frac{12}{2} &\ge \frac{2x}{2} \\ 6 &\ge x \quad \text{or} \quad x \le 6 \end{aligned}$$
Set-builder: $\{x \mid x \le 6\}$

Interval: (–∞, 6]

Graph:




**Section 2.5 Quick Checks**

**1.** The <u>intersection</u> of two sets *A* and *B*, denoted $A \cap B$, is the set of all elements that belong to both set *A* and set *B*.

**2.** The word <u>and</u> implies intersection. The word <u>or</u> implies union.

**3.** True. If the two sets have no elements in common, the intersection will be the empty set.

**4.** False. The symbol for the union of two sets is $\cup$ while the symbol for intersection is $\cap$.

**5.** $A \cap B = \{1, 3, 5\}$

**6.** $A \cap C = \{2, 4, 6\}$

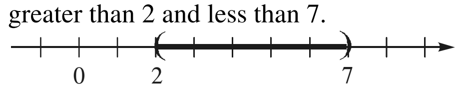
**7.** $A \cup B = \{1, 2, 3, 4, 5, 6, 7\}$

**8.** $A \cup C = \{1, 2, 3, 4, 5, 6, 8\}$

**9.** $B \cap C = \{\ \}$ or $\varnothing$

**10.** $B \cup C = \{1, 2, 3, 4, 5, 6, 7, 8\}$

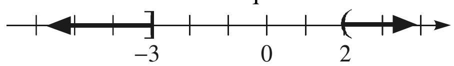
**11.** $A \cap B$ is the set of all real numbers that are greater than 2 and less than 7.




Set-builder: $\{x \mid 2 < x < 7\}$

Interval: (2, 7)

**12.** $A \cup C$ is the set of real numbers that are greater than 2 or less than or equal to $-3$.




Set-builder: $\{x \mid x \le -3 \text{ or } x > 2\}$

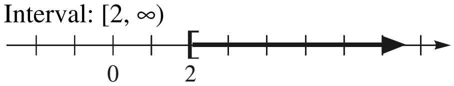
Interval: $(-\infty, -3] \cup (2, \infty)$

**13.**
$$\begin{array}{lcl} 2x+1 \ge 5 & \text{and} & -3x+2 < 5 \\ 2x \ge 4 & & -3x < 3 \\ x \ge 2 & & x > -1 \end{array}$$

The intersection of $x \ge 2$ and $x > -1$ is $x \ge 2$.

Set-builder: $\{x \mid x \ge 2\}$

Interval: $[2, \infty)$

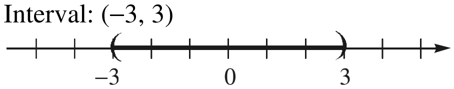



**14.**
$$\begin{array}{lcl} 4x-5 < 7 & \text{and} & 3x-1 > -10 \\ 4x < 12 & & 3x > -9 \\ x < 3 & & x > -3 \end{array}$$

The intersection of $x < 3$ and $x > -3$ is $-3 < x < 3$.

Set-builder: $\{x \mid -3 < x < 3\}$

Interval: $(-3, 3)$

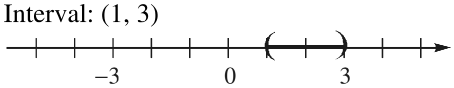



**15.**
$$\begin{array}{lcl} -8x+3 < -5 & \text{and} & \frac{2}{3}x+1 < 3 \\ -8x < -8 & & \frac{2}{3}x < 2 \\ x > 1 & & x < 3 \end{array}$$

The intersection of $x > 1$ and $x < 3$ is $1 < x < 3$.

Set-builder: $\{x \mid 1 < x < 3\}$

Interval: $(1, 3)$




**16.**
$$\begin{array}{lcl} 3x-5 < -8 & \text{and} & 2x+1 > 5 \\ 3x < -3 & & 2x > 4 \\ x < -1 & & x > 2 \end{array}$$

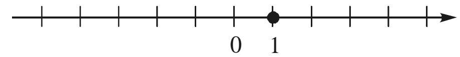
There are no numbers that satisfy both inequalities. Therefore, the solution set is empty.

Solution set: { } or $\varnothing$

**17.**
$$\begin{array}{lcl} 5x+1 \le 6 & \text{and} & 3x+2 \ge 5 \\ 5x \le 5 & & 3x \ge 3 \\ x \le 1 & & x \ge 1 \end{array}$$

Looking at the graphs of the inequalities separately the only number that is both less than or equal to 1 and greater than or equal to 1 is the number 1.

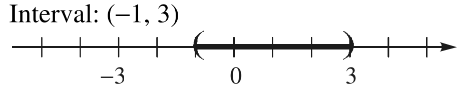
Solution set: $\{1\}$




**18.**
$$\begin{aligned} -2 &< 3x+1 < 10 \\ -2-1 &< 3x+1-1 < 10-1 \\ -3 &< 3x < 9 \\ \frac{-3}{3} &< \frac{3x}{3} < \frac{9}{3} \\ -1 &< x < 3 \end{aligned}$$

Set-builder: $\{x \mid -1 < x < 3\}$

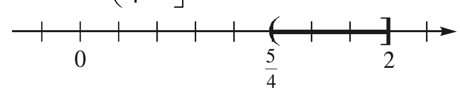
Interval: $(-1, 3)$




**19.**
$$\begin{aligned} 0 &< 4x-5 \le 3 \\ 0+5 &< 4x-5+5 \le 3+5 \\ 5 &< 4x \le 8 \\ \frac{5}{4} &< \frac{4x}{4} \le \frac{8}{4} \\ \frac{5}{4} &< x \le 2 \end{aligned}$$

Set-builder: $\left\{x \mid \frac{5}{4} < x \le 2\right\}$

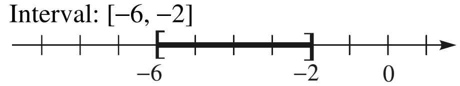
Interval: $\left(\frac{5}{4}, 2\right]$




**20.**
$$\begin{aligned} 3 &\le -2x-1 \le 11 \\ 3+1 &\le -2x-1+1 \le 11+1 \\ 4 &\le -2x \le 12 \\ \frac{4}{-2} &\ge \frac{-2x}{-2} \ge \frac{12}{-2} \\ -2 &\ge x \ge -6 \quad \text{or} \quad -6 \le x \le -2 \end{aligned}$$

Set-builder: $\{x \mid -6 \le x \le -2\}$

Interval: $[-6, -2]$

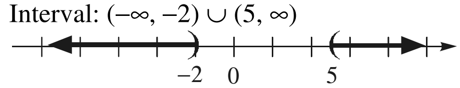



**21.**
$$\begin{array}{lcl} x+3 < 1 & \text{or} & x-2 > 3 \\ x < -2 & & x > 5 \end{array}$$

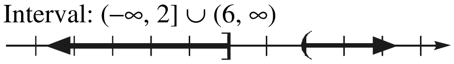
The union of the two solution sets is $x < -2$ or $x > 5$.

Set-builder: $\{x \mid x < -2 \text{ or } x > 5\}$

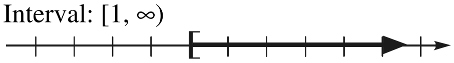
Interval: $(-\infty, -2) \cup (5, \infty)$



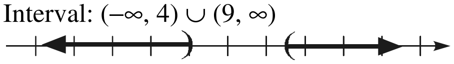
**22.** $3x+1\le 7$ or $2x-3>9$
$3x\le 6$ $\quad 2x>12$
$x\le 2$ $\quad x>6$
The union of the two solution sets is $x\le 2$ or $x>6$.
Set-builder: $\{x\,|\,x\le 2 \text{ or } x>6\}$
Interval: $(-\infty, 2]\cup(6,\infty)$



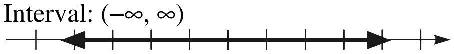

**23.** $2x-3\ge 1$ or $6x-5\ge 1$
$2x\ge 4$ $\quad 6x\ge 6$
$x\ge 2$ $\quad x\ge 1$
The union of the two solution set is $x\ge 2$ or $x\ge 1$.
Set-builder: $\{x\,|\,x\ge 1\}$
Interval: $[1,\infty)$



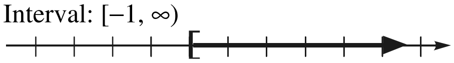

**24.** $\frac{3}{4}(x+4)<6$ or $\frac{3}{2}(x+1)>15$
$x+4<8$ $\quad x+1>10$
$x<4$ $\quad x>9$
The union of the two solution sets is $x<4$ or $x>9$.
Set-builder: $\{x\,|\,x<4 \text{ or } x>9\}$
Interval: $(-\infty, 4)\cup(9,\infty)$




**25.** $3x-2>-5$ or $2x-5\le 1$
$3x>-3$ $\quad 2x\le 6$
$x>-1$ $\quad x\le 3$
The union of the two solution sets is the set of real numbers.
Set-builder: $\{x\,|\,x \text{ is any real number}\}$
Interval: $(-\infty,\infty)$




**26.** $-5x-2\le 3$ or $7x-9>5$
$-5x\le 5$ $\quad 7x>14$
$x\ge -1$ $\quad x>2$
Since the solution set of the inequality $x>2$ is a subset of the solution set of the inequality $x\ge -1$, the union of the two solution sets is $x\ge -1$.
Set-builder: $\{x\,|\,x\ge -1\}$
Interval: $[-1,\infty)$



**27.** Let $x$ = taxable income (in dollars). The federal income tax in the 25% bracket was \$5156.25 plus 25% of the amount over \$37,450. In general, the income tax for the 25% bracket was 5156.25 + 0.25($x$ – 37,450). The federal income tax for this bracket was between \$5156.25 and \$18,481.25.

$5156.25 \le 5156.25 + 0.25(x - 37,450) \le 18,481.25$

$5156.25 \le 5156.25 + 0.25x - 9362.5 \le 18,481.25$

$5156.25 \le 0.25x - 4206.25 \le 18,481.25$

$9362.5 \le 0.25x \le 22,687.50$

$37,450 \le x \le 90,750$

To be in the 25% tax bracket an individual would have had an income between \$37,450 and \$90,750.

**28.** Let $x$ = the miles per month. The monthly payment is \$260 while gas and maintenance is \$0.20 per mile. In general, the monthly cost is 260 + 0.2$x$. Juan's total monthly cost ranges between \$420 and \$560.

$420 \le 260 + 0.2x \le 560$

$160 \le 0.2x \le 300$

$800 \le x \le 1500$

Juan drives between 800 and 1500 miles each month.

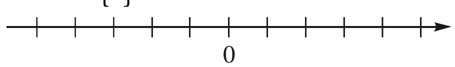
**2.5 Exercises**

**30.** $A \cup C = \{2, 3, 4, 5, 6, 7, 8, 9\}$

**32.** $A \cap C = \{4, 6\}$

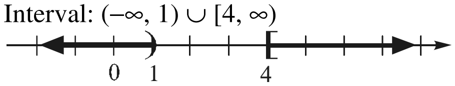
**34.** $B \cup C = \{1, 2, 3, 4, 5, 6, 7, 9\}$

**36. a.** $A \cap B = \{\ \}$ or $\varnothing$



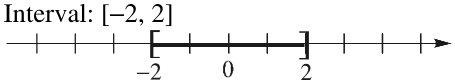
**b.** $A \cup B = \{x \mid x < 1 \text{ or } x \ge 4\}$

Interval: $(-\infty, 1) \cup [4, \infty)$



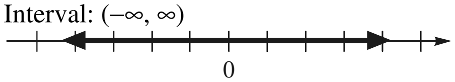
**38. a.** $E \cap F = \{x \mid -2 \le x \le 2\}$

Interval: $[-2, 2]$



**b.** $E \cup F = \{x \mid x \text{ is a real number}\}$

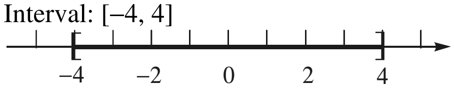
Interval: $(-\infty, \infty)$



**40. a.** Find the set of all values for $x$ such that $\frac{1}{2}x + 1 \le 3$ and $\frac{1}{2}x + 1 \ge -1$. On the graph, find where the graph of $g(x) = \frac{1}{2}x + 1$ is between the horizontal lines $f(x) = -1$ and $h(x) = 3$ (inclusive).

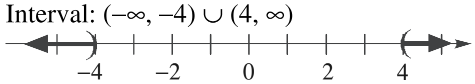
Set-builder: $\{x \mid -4 \le x \le 4\}$

Interval: $[-4, 4]$

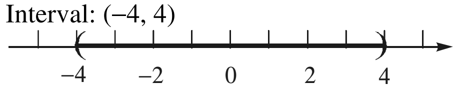


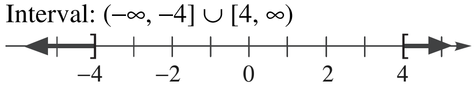
**b.** Find the set of all values for $x$ such that $\frac{1}{2}x+1<-1$ or $\frac{1}{2}x+1>3$. On the graph, find where the graph of $g(x)=\frac{1}{2}x+1$ is below the horizontal line $f(x)=-1$ or above the horizontal line $h(x)=3$.
Set-builder: $\{x|x<-4 \text{ or } x>4\}$
Interval: $(-\infty, -4)\cup(4, \infty)$



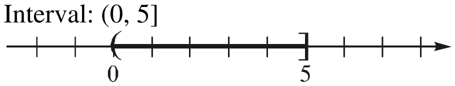

**42. a.** Find the set of all values for $x$ such that $\frac{5}{4}x+2<7$ and $\frac{5}{4}x+2>-3$. On the graph, find where the graph of $g(x)=\frac{5}{4}x+2$ is between the horizontal lines $f(x)=-3$ and $h(x)=7$, not inclusive.
Set-builder: $\{x|-4<x<4\}$
Interval: $(-4, 4)$




**b.** Find the set of all values for $x$ such that $\frac{5}{4}x+2\le-3$ or $\frac{5}{4}x+2\ge7$ on the graph, find where the graph of $g(x)=\frac{5}{4}x+2$ is below the horizontal line $f(x)=-3$ or above the horizontal line $h(x)=7$ (inclusive).
Set-builder: $\{x|x\le-4 \text{ or } x\ge4\}$
Interval: $(-\infty, -4]\cup[4, \infty)$



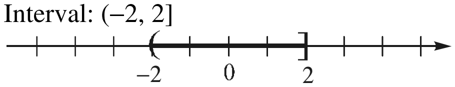

**44.** $x\le5$ and $x>0$
Set-builder: $\{x|0<x\le5\}$
Interval: $(0, 5]$




**46.** $6x-2\le10$ and $10x>-20$

$$6x\le12 \qquad x>-2$$
$$x\le2$$

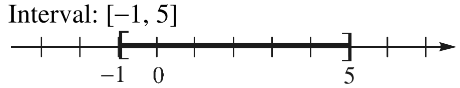
The intersection of $x\le2$ and $x>-2$ is $-2<x\le2$.
Set-builder: $\{x|-2<x\le2\}$
Interval: $(-2, 2]$




**48.** $x-3\le2$ and $6x+5\ge-1$

$$x\le5 \qquad 6x\ge-6$$
$$x\ge-1$$

The intersection of $x\le5$ and $x\ge-1$ is $-1\le x\le5$.
Set-builder: $\{x|-1\le x\le5\}$
Interval: $[-1, 5]$




**50.** $-4x-1<3$ and $-x-2>3$

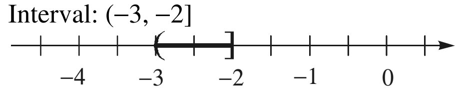
$$-4x<4 \qquad -x>5$$
$$x>-1 \qquad x<-5$$

The intersection of $x>-1$ and $x<-5$ is the empty set.
Solution set: $\varnothing$ or $\{\ \}$

**52.**

$$-10<6x+8\le-4$$
$$-10-8<6x+8-8\le-4-8$$
$$-18<6x\le-12$$
$$\frac{-18}{6}<\frac{6x}{6}\le\frac{-12}{6}$$
$$-3<x\le-2$$

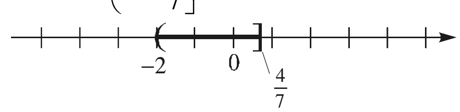
Set-builder: $\{x|-3<x\le-2\}$
Interval: $(-3, -2]$




**54.**

$$-12<7x+2\le6$$
$$-12-2<7x+2-2\le6-2$$
$$-14<7x\le4$$
$$\frac{-14}{7}<\frac{7x}{7}\le\frac{4}{7}$$
$$-2<x\le\frac{4}{7}$$

Set-builder: $\left\{x\middle|-2<x\le\frac{4}{7}\right\}$
Interval: $\left(-2, \frac{4}{7}\right]$

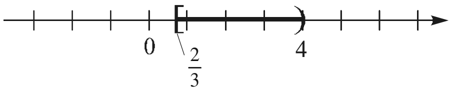



**56.**

$$-6<-3x+6\le4$$
$$-6-6<-3x+6-6\le4-6$$
$$-12<-3x\le-2$$
$$\frac{-12}{-3}>\frac{-3x}{-3}\ge\frac{-2}{-3}$$
$$4>x\ge\frac{2}{3} \quad \text{or} \quad \frac{2}{3}\le x<4$$

Set-builder: $\left\{x \middle| \frac{2}{3} \le x < 4\right\}$

Interval: $\left[\frac{2}{3}, 4\right)$



**58.** $0 < \frac{3}{2}x - 3 \le 3$

$0 + 3 < \frac{3}{2}x - 3 + 3 \le 3 + 3$

$3 < \frac{3}{2}x \le 6$

$2 \cdot 3 < 2 \cdot \frac{3}{2}x \le 2 \cdot 6$

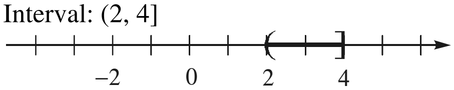
$6 < 3x \le 12$

$\frac{6}{3} < \frac{3x}{3} \le \frac{12}{3}$

$2 < x \le 4$

Set-builder: $\{x \mid 2 < x \le 4\}$

Interval: (2, 4]



**60.** $-3 < -4x + 1 < 17$

$-3 - 1 < -4x + 1 - 1 < 17 - 1$

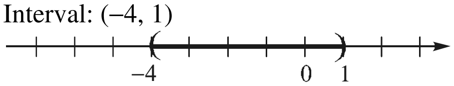
$-4 < -4x < 16$

$\frac{-4}{-4} > \frac{-4x}{-4} > \frac{16}{-4}$

$1 > x > -4$ or $-4 < x < 1$

Set-builder: $\{x \mid -4 < x < 1\}$

Interval: (–4, 1)



**62.** $x - \frac{3}{2} \le \frac{5}{4}$ and $-\frac{2}{3}x - \frac{2}{9} < \frac{8}{9}$

$4\left(x - \frac{3}{2}\right) \le 4\left(\frac{5}{4}\right)$

$4x - 6 \le 5$

$4x \le 11$

$x \le \frac{11}{4}$

$9\left(-\frac{2}{3}x - \frac{2}{9}\right) < 9\left(\frac{8}{9}\right)$

$-6x - 2 < 8$

$-6x < 10$

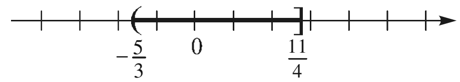
$\frac{-6x}{-6} > \frac{10}{-6}$

$x > -\frac{5}{3}$

The intersection of $x > -\frac{5}{3}$ and $x \le \frac{11}{4}$ is $-\frac{5}{3} < x \le \frac{11}{4}$.

Set-builder: $\left\{x \middle| -\frac{5}{3} < x \le \frac{11}{4}\right\}$

Interval: $\left(-\frac{5}{3}, \frac{11}{4}\right]$



**64.** $-4 \le \frac{4x-3}{3} < 3$

$3(-4) \le 3\left(\frac{4x-3}{3}\right) < 3(3)$

$-12 \le 4x - 3 < 9$

$-12 + 3 \le 4x - 3 + 3 < 9 + 3$

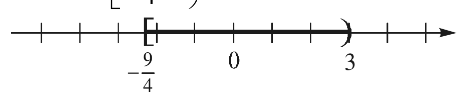
$-9 \le 4x < 12$

$\frac{-9}{4} \le \frac{4x}{4} < \frac{12}{4}$

$-\frac{9}{4} \le x < 3$

Set-builder: $\left\{x \middle| -\frac{9}{4} \le x < 3\right\}$

Interval: $\left[-\frac{9}{4}, 3\right)$



**66.** $-6 < -3(x - 2) < 15$

$-6 < -3x + 6 < 15$

$-6 - 6 < -3x + 6 - 6 < 15 - 6$

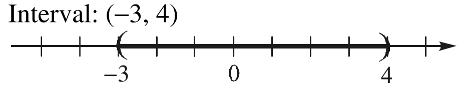
$-12 < -3x < 9$

$\frac{-12}{-3} > \frac{-3x}{-3} > \frac{9}{-3}$

$4 > x > -3$ or $-3 < x < 4$

Set-builder: $\{x \mid -3 < x < 4\}$

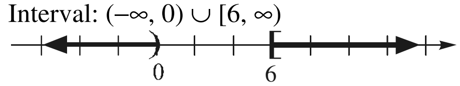
Interval: (–3, 4)



**68.** $x < 0$ or $x \ge 6$

Set-builder: $\{x \mid x < 0 \text{ or } x \ge 6\}$

Interval: (–∞, 0) ∪ [6, ∞)



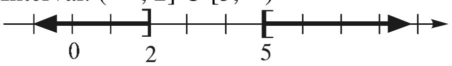
**70.** $x+3\le 5$ or $x-2\ge 3$

$x\le 2$ $\quad$ $x\ge 5$

The union of the two sets is $x\le 2$ or $x\ge 5$.

Set-builder: $\{x\,|\,x\le 2 \text{ or } x\ge 5\}$

Interval: $(-\infty, 2]\cup[5,\infty)$




**72.** $4x+3>-5$ or $8x-5<3$

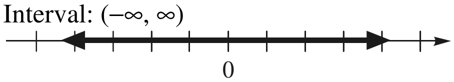
$4x>-8$ $\quad$ $8x<8$

$x>-2$ $\quad$ $x<1$

The union of the two sets is $x>-2$ or $x<1$.

Set-builder: $\{x\,|\,x \text{ is a real number}\}$

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




**74.** $3x\ge 7x+8$ or $x<4x-9$

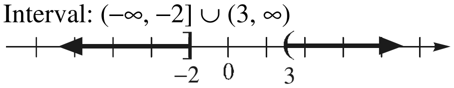
$-4x\ge 8$ $\quad$ $-3x<-9$

$x\le -2$ $\quad$ $x>3$

The union of the two sets is $x\le -2$ or $x>3$.

Set-builder: $\{x\,|\,x\le -2 \text{ or } x>3\}$

Interval: $(-\infty,-2]\cup(3,\infty)$




**76.** $-\dfrac{4}{5}x-5>3$ or $7x-3>4$

$-\dfrac{4}{5}x>8$ $\quad$ $7x>7$

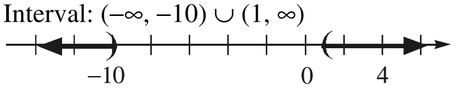
$-4x>40$ $\quad$ $x>1$

$x<-10$

The union of the two sets is $x<-10$ or $x>1$.

Set-builder: $\{x\,|\,x<-10 \text{ or } x>1\}$

Interval: $(-\infty,-10)\cup(1,\infty)$




**78.** $\dfrac{2}{3}x+2\le 4$ or $\dfrac{5x-3}{3}\ge 4$

$\dfrac{2}{3}x\le 2$ $\quad$ $5x-3\ge 12$

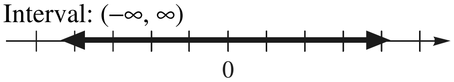
$x\le 3$ $\quad$ $5x\ge 15$

$x\ge 3$

The union of the two sets is $x\le 3$ or $x\ge 3$.

Set-builder: $\{x\,|\,x \text{ is a real number}\}$

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




**80.** $2(x+1)-5\le 4$ or $-(x+3)\le -2$

$2x+2-5\le 4$ $\quad$ $-x-3\le -2$

$2x-3\le 4$ $\quad$ $-x\le 1$

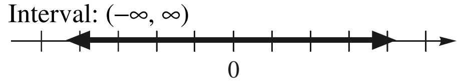
$2x\le 7$ $\quad$ $x\ge -1$

$x\le \dfrac{7}{2}$

The union of the two sets is $x\ge -1$ or $x\le \dfrac{7}{2}$.

Set-builder: $\{x\,|\,x \text{ is a real number}\}$

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




**82.** $5x-1<9$ and $5x>-20$

$5x-1+1<9+1$ $\quad$ $\dfrac{5x}{5}>\dfrac{-20}{5}$

$5x<10$ $\quad$ $x>-4$

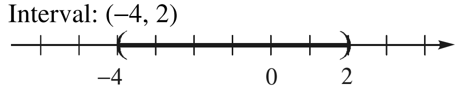
$\dfrac{5x}{5}<\dfrac{10}{5}$

$x<2$

The intersection of $x<2$ and $x>-4$ is $-4<x<2$.

Set-builder: $\{x\,|\,-4<x<2\}$

Interval: $(-4, 2)$




**84.** $3(x+7)<24$ or $6(x-4)>-30$

$\dfrac{3(x+7)}{3}<\dfrac{24}{3}$ $\quad$ $\dfrac{6(x-4)}{6}>\dfrac{-30}{6}$

$x+7<8$ $\quad$ $x-4>-5$

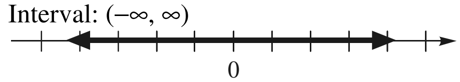
$x+7-7<8-7$ $\quad$ $x-4+4>-5+4$

$x<1$ $\quad$ $x>-1$

The union of the two sets is $x<1$ or $x>-1$.

Set-builder: $\{x\,|\,x \text{ is a real number}\}$

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




**86.** $-8\le 5x-3\le 4$

$-8+3\le 5x-3+3\le 4+3$

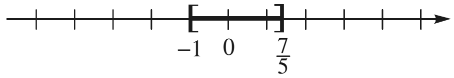
$-5\le 5x\le 7$

$\dfrac{-5}{5}\le\dfrac{5x}{5}\le\dfrac{7}{5}$

$-1\le x\le\dfrac{7}{5}$

Set-builder: $\left\{x\,\middle|\,-1\le x\le\dfrac{7}{5}\right\}$

Interval: $\left[-1, \frac{7}{5}\right]$

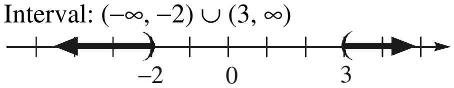



**88.**
$$3x-8<-14 \quad \text{or} \quad 4x-5>7$$
$$3x-8+8<-14+8 \qquad 4x-5+5>7+5$$
$$3x<-6 \qquad 4x>12$$
$$\frac{3x}{3}<\frac{-6}{3} \qquad \frac{4x}{4}>\frac{12}{4}$$
$$x<-2 \qquad x>3$$

The union of the two sets is $x<-2$ or $x>3$.

Set-builder: $\{x \mid x<-2 \text{ or } x>3\}$

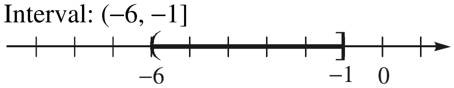
Interval: $(-\infty, -2) \cup (3, \infty)$




**90.**
$$-5<2x+7\le 5$$
$$-5-7<2x+7-7\le 5-7$$
$$-12<2x\le -2$$
$$\frac{-12}{2}<\frac{2x}{2}\le\frac{-2}{2}$$
$$-6<x\le -1$$

Set-builder: $\{x \mid -6<x\le -1\}$

Interval: $(-6, -1]$

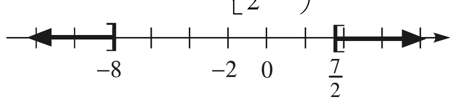



**92.**
$$\frac{x}{2}\le -4 \quad \text{or} \quad \frac{2x-1}{3}\ge 2$$
$$2\cdot\frac{x}{2}\le 2\cdot(-4) \qquad 3\cdot\frac{2x-1}{3}\ge 3\cdot 2$$
$$x\le -8 \qquad 2x-1\ge 6$$
$$2x-1+1\ge 6+1$$
$$2x\ge 7$$
$$\frac{2x}{2}\ge\frac{7}{2}$$
$$x\ge\frac{7}{2}$$

The union of the two sets is $x\le -8$ or $x\ge\frac{7}{2}$.

Set-builder: $\left\{x \,\middle|\, x\le -8 \text{ or } x\ge\frac{7}{2}\right\}$

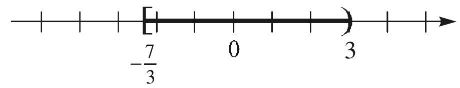
Interval: $(-\infty, -8]\cup\left[\frac{7}{2}, \infty\right)$




**94.**
$$-15<-3(x+2)\le 1$$
$$-15<-3x-6\le 1$$
$$-15+6<-3x-6+6\le 1+6$$
$$-9<-3x\le 7$$
$$\frac{-9}{-3}>\frac{-3x}{-3}\ge\frac{7}{-3}$$
$$3>x\ge -\frac{7}{3} \quad \text{or} \quad -\frac{7}{3}\le x<3$$

Set-builder: $\left\{x \,\middle|\, -\frac{7}{3}\le x<3\right\}$

Interval: $\left[-\frac{7}{3}, 3\right)$




**96.**
$$-2<x<3$$
$$-2-3<x-3<3-3$$
$$-5<x-3<0$$
$a=-5$ and $b=0$.

**98.**
$$2<x<12$$
$$\frac{2}{2}<\frac{x}{2}<\frac{12}{2}$$
$$1<\frac{x}{2}<6$$
$a=1$ and $b=6$.

**100.**
$$-4<x<3$$
$$2(-4)<2x<2(3)$$
$$-8<2x<6$$
$$-8-7<2x-7<6-7$$
$$-15<2x-7<-1$$
$a=-15$ and $b=-1$.

**102.** Let $x$ = diastolic blood pressure.
$60<x<90$

**104.** Let $x$ = final exam score.

$$70 \le \frac{67+72+81+75+3x}{7} \le 79$$
$$70 \le \frac{295+3x}{7} \le 79$$
$$7(70) \le 7\left(\frac{295+3x}{7}\right) \le 7(79)$$
$$490 \le 295+3x \le 553$$
$$490-295 \le 295+3x-295 \le 553-295$$
$$195 \le 3x \le 258$$
$$\frac{195}{3} \le \frac{3x}{3} \le \frac{258}{3}$$
$$65 \le x \le 86$$

Jack needs to score between 65 and 86 (inclusive) on the final exam to earn a C.

**106.** Let $x$ = weekly wages.

$$1000 \le x \le 1100$$
$$1000-436 \le x-436 \le 1100-436$$
$$564 \le x-436 \le 664$$
$$0.15(564) \le 0.15(x-436) \le 0.15(664)$$
$$84.6 \le 0.15(x-436) \le 99.6$$
$$84.6+34.9 \le 0.15(x-436)+34.9 \le 99.6+34.9$$
$$119.5 \le 0.15(x-436)+34.9 \le 134.5$$

The amount withheld ranges between \$119.50 and \$134.50, inclusive.

**108.** Let $x$ = total sales.

$$4000 \le 1500+0.025x \le 6000$$
$$2500 \le 0.025x \le 4500$$
$$100,000 \le x \le 180,000$$

To earn between \$4000 and \$6000 per month, total sales must be between \$100,000 and \$180,000.

**110.** Let $x$ = number of kwh.

$$55.04 \le 0.084192(x-350)+42.41 \le 89.56$$
$$12.63 \le 0.084192(x-350) \le 47.15$$
$$\frac{12.63}{0.084192} \le x-350 \le \frac{47.15}{0.084192}$$
$$\frac{12.63}{0.084192}+350 \le x \le \frac{47.15}{0.084192}+350$$
$$500 \le x \le 910 \text{ (approx.)}$$

The electricity usage ranged from 500 to 910 kwh.

**112. a.** Here $a = 3$, $b = 4$, and $c = 5$.

$$b-a < c < b+a$$
$$4-3 < 5 < 4+3$$
$$1 < 5 < 7 \text{ T}$$

These sides could form a triangle.

**b.** Here $a = 4$, $b = 7$, and $c = 12$.

$$b-a < c < b+a$$
$$7-4 < 12 < 7+4$$
$$3 < 12 < 11 \quad \text{false}$$

These sides could not form a triangle.

**c.** Here $a = 3$, $b = 3$, and $c = 5$.

$$b-a < c < b+a$$
$$3-3 < 5 < 3+3$$
$$0 < 5 < 6 \text{ T}$$

These sides could form a triangle.

**d.** Here $a = 1$, $b = 9$, and $c = 10$.

$$b-a < c < b+a$$
$$9-1 < 10 < 9+1$$
$$8 < 10 < 10 \quad \text{false}$$

These sides could not form a triangle.

**114.**

$$x-3 \le 3x+1 \le x+11$$
$$x-3-x \le 3x+1-x \le x+11-x$$
$$-3 \le 2x+1 \le 11$$
$$-3-1 \le 2x+1-1 \le 11-1$$
$$-4 \le 2x \le 10$$
$$\frac{-4}{2} \le \frac{2x}{2} \le \frac{10}{2}$$
$$-2 \le x \le 5$$

Set-builder: $\{x \mid -2 \le x \le 5\}$

Interval: [–2, 5]

**116.**

$$4x-2 > 2(2x-1)$$
$$4x-2 > 4x-2$$
$$4x-2-4x > 4x-2-4x$$
$$-2 > -2$$

This is not true. There is no solution, or $\varnothing$ or { }.

**Section 2.6**

**Are You Prepared for This Section?**

**P1.** $|3| = 3$ because the distance from 0 to 3 on a real number line is 3 units.

**P2.** $|-4| = 4$ because the distance from 0 to $-4$ on a real number line is 4 units.

**P3.** $|-1.6| = 1.6$ because the distance from 0 to $-1.6$ on a real number line is 1.6 units.

**P4.** $|0| = 0$ because the distance from 0 to 0 on a real number line is 0 units.

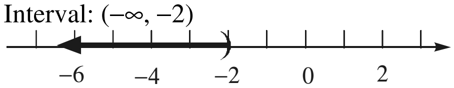
**P5.** The distance between 0 and 5 on a real number line can be expressed as $|5|$.

**P6.** The distance between 0 and −8 on a real number line can be expressed as $|-8|$.

**P7.**
$$\begin{aligned} 4x+5&=-9\\ 4x+5-5&=-9-5\\ 4x&=-14\\ \frac{4x}{4}&=\frac{-14}{4}\\ x&=-\frac{7}{2} \end{aligned}$$
The solution set is $\left\{-\frac{7}{2}\right\}$.

**P8.**
$$\begin{aligned} -2x+1&>5\\ -2x+1-1&>5-1\\ -2x&>4\\ \frac{-2x}{-2}&<\frac{4}{-2}\\ x&<-2 \end{aligned}$$
Set-builder: $\{x \mid x<-2\}$

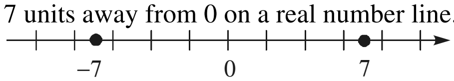
Interval: $(-\infty, -2)$




**Section 2.6 Quick Checks**

**1.** $|x|=7$

$x=7$ or $x=-7$ because both numbers are 7 units away from 0 on a real number line.



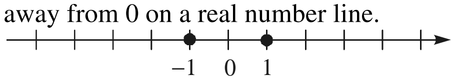

If $x\ge 0$: $|x|=7$, $x=7$

If $x<0$: $|x|=7$, $-x=7$, $x=-7$

Solution set: $\{-7, 7\}$

**2.** $|z|=1$

$z=1$ or $z=-1$ because both numbers are 1 unit away from 0 on a real number line.




If $z\ge 0$: $|z|=1$, $z=1$

If $z<0$: $|z|=1$, $-z=1$, $z=-1$

Solution set: $\{-1, 1\}$

**3.** $|u| = a$ is equivalent to $u = \underline{a}$ or $u = \underline{-a}$.

**4.** $|2x + 3| = 5$ is equivalent to $2x + 3 = 5$ or $\underline{2x + 3 = -5}$.

**5.** $|2x-3|=7$

$2x-3=7$ or $2x-3=-7$

$2x=10$ $\quad$ $2x=-4$

$x=5$ $\quad$ $x=-2$

Check:

Let $x=5$:
$$\begin{aligned} |2(5)-3| &\stackrel{?}{=} 7\\ |10-3| &\stackrel{?}{=} 7\\ 7&=7 \text{ T} \end{aligned}$$

Let $x=-2$:
$$\begin{aligned} |2(-2)-3| &\stackrel{?}{=} 7\\ |-4-3| &\stackrel{?}{=} 7\\ 7&=7 \text{ T} \end{aligned}$$

Solution set: $\{-2, 5\}$

**6.** $|3x-2|+3=10$

$|3x-2|=7$

$3x-2=7$ or $3x-2=-7$

$3x=9$ $\quad$ $3x=-5$

$x=3$ $\quad$ $x=-\frac{5}{3}$

Check:

Let $x=3$:
$$\begin{aligned} |3(3)-2|+3 &\stackrel{?}{=} 10\\ |9-2|+3 &\stackrel{?}{=} 10\\ 7+3 &\stackrel{?}{=} 10\\ 10&=10 \text{ T} \end{aligned}$$

Let $x=-\frac{5}{3}$:
$$\begin{aligned} \left|3\left(-\frac{5}{3}\right)-2\right|+3 &\stackrel{?}{=} 10\\ |-5-2|+3 &\stackrel{?}{=} 10\\ 7+3 &\stackrel{?}{=} 10\\ 10&=10 \text{ T} \end{aligned}$$

Solution set: $\left\{-\frac{5}{3}, 3\right\}$

**7.** $|-5x+2|-2=5$

$|-5x+2|=7$

$-5x+2=7$ or $-5x+2=-7$

$-5x=5$ $\quad$ $-5x=-9$

$x=-1$ $\quad$ $x=\frac{9}{5}$

Check:

Let $x = -1$:

$$\begin{aligned} |-5(-1)+2|-2 &\stackrel{?}{=} 5 \\ |5+2|-2 &\stackrel{?}{=} 5 \\ 7-2 &\stackrel{?}{=} 5 \\ 5 &= 5 \text{ T} \end{aligned}$$

Let $x = \frac{9}{5}$

$$\begin{aligned} \left|-5\left(\frac{9}{5}\right)+2\right|-2 &\stackrel{?}{=} 5 \\ |-9+2|-2 &\stackrel{?}{=} 5 \\ 7-2 &\stackrel{?}{=} 5 \\ 5 &= 5 \text{ T} \end{aligned}$$

Solution set: $\left\{-1, \frac{9}{5}\right\}$

**8.** $$\begin{aligned} 3|x+2|-4 &= 5 \\ 3|x+2| &= 9 \\ |x+2| &= 3 \end{aligned}$$

$x+2=3$ or $x+2=-3$

$x=1$ $\quad$ $x=-5$

Check:

Let $x = 1$:

$$\begin{aligned} 3|1+2|-4 &\stackrel{?}{=} 5 \\ 3(3)-4 &\stackrel{?}{=} 5 \\ 9-4 &\stackrel{?}{=} 5 \\ 5 &= 5 \text{ T} \end{aligned}$$

Let $x = -5$:

$$\begin{aligned} 3|-5+2|-4 &\stackrel{?}{=} 5 \\ 3(3)-4 &\stackrel{?}{=} 5 \\ 9-4 &\stackrel{?}{=} 5 \\ 5 &= 5 \text{ T} \end{aligned}$$

Solution set: {−5, 1}

**9.** True. The absolute value of a number represents the distance of the number from 0 on a real number line. Since distance is never negative, absolute value is never negative.

**10.** $|5x+3| = -2$

Since absolute values are never negative, this equation has no solution.

Solution set: { } or ∅

**11.** $$\begin{aligned} |2x+5|+7 &= 3 \\ |2x+5| &= -4 \end{aligned}$$

Since absolute values are never negative, this equation has no solution.

Solution set: { } or ∅

**12.** $$\begin{aligned} |x+1|+3 &= 3 \\ |x+1| &= 0 \\ x+1 &= 0 \\ x &= -1 \end{aligned}$$

Check:

Let $x = -1$:

$$\begin{aligned} |-1+1|+3 &\stackrel{?}{=} 3 \\ 0+3 &\stackrel{?}{=} 3 \\ 3 &\stackrel{?}{=} 3 \text{ T} \end{aligned}$$

Solution set: {−1}

**13.** $|u| = |v|$ is equivalent to $\underline{u} = \underline{v}$ or $\underline{u} = \underline{-v}$.

**14.** $|x-3| = |2x+5|$

$$\begin{aligned} x-3 &= 2x+5 \\ x &= 2x+8 \\ -x &= 8 \\ x &= -8 \end{aligned}$$

or

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

Check:

Let $x = -8$:

$$\begin{aligned} |-8-3| &\stackrel{?}{=} |2(-8)+5| \\ |-11| &\stackrel{?}{=} |-16+5| \\ 11 &= 11 \text{ T} \end{aligned}$$

Let $x = -\frac{2}{3}$:

$$\begin{aligned} \left|-\frac{2}{3}-3\right| &\stackrel{?}{=} \left|2\left(-\frac{2}{3}\right)+5\right| \\ \left|-\frac{11}{3}\right| &\stackrel{?}{=} \left|-\frac{4}{3}+5\right| \\ \frac{11}{3} &= \frac{11}{3} \text{ T} \end{aligned}$$

Solution set: $\left\{-8, -\frac{2}{3}\right\}$

**15.** $|8z+11| = |6z+17|$

$$\begin{aligned} 8z+11 &= 6z+17 \\ 8z &= 6z+6 \\ 2z &= 6 \\ z &= 3 \end{aligned}$$

or

$$\begin{aligned} 8z+11 &= -(6z+17) \\ 8z+11 &= -6z-17 \\ 8z &= -6z-28 \\ 14z &= -28 \\ z &= -2 \end{aligned}$$

Check:

Let $z = -2$:

$$\begin{aligned} |8(-2)+11| &\stackrel{?}{=} |6(-2)+17| \\ |-16+11| &\stackrel{?}{=} |-12+17| \\ 5 &= 5 \text{ T} \end{aligned}$$

Let $z = 3$:

$$\begin{aligned} |8(3)+11| &\stackrel{?}{=} |6(3)+17| \\ |24+11| &\stackrel{?}{=} |18+17| \\ 35 &= 35 \text{ T} \end{aligned}$$

Solution set: {−2, 3}

**16.** $|3-2y|=|4y+3|$

$3-2y=4y+3$ or $3-2y=-(4y+3)$

$-2y=4y \qquad 3-2y=-4y-3$

$-6y=0 \qquad -2y=-4y-6$

$y=0 \qquad 2y=-6$

$y=-3$

Check:

Let $y=0$: Let $y=-3$:

$|3-2(0)| \stackrel{?}{=} |4(0)+3| \qquad |3-2(-3)| \stackrel{?}{=} |4(-3)+3|$

$|3| \stackrel{?}{=} |3| \qquad |3+6| \stackrel{?}{=} |-12+3|$

$3=3$ T $\qquad 9=9$ T

Solution set: $\{-3, 0\}$

**17.** $|2x-3|=|5-2x|$

$2x-3=5-2x$ or $2x-3=-(5-2x)$

$2x=8-2x \qquad 2x-3=-5+2x$

$4x=8 \qquad 2x=-2+2x$

$x=2 \qquad 0=-2$ false

The second equation leads to a contradiction. Therefore, the only solution is $x = 2$.

Check:

Let $x=2$:

$|2(2)-3| \stackrel{?}{=} |5-2(2)|$

$|4-3| \stackrel{?}{=} |5-4|$

$1=1$ T

Solution set: $\{2\}$

**18.** If $a > 0$, then $|u| < a$ is equivalent to $\underline{-a < u < a}$.

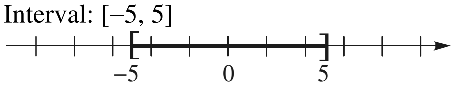
**19.** To solve $|3x+4| < 10$, solve $\underline{-10} < 3x + 10 < \underline{10}$.

**20.** $|x| \le 5$

$-5 \le x \le 5$

Set-builder: $\{x \mid -5 \le x \le 5\}$

Interval: $[-5, 5]$

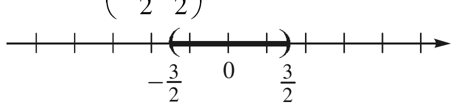


**21.** $|x| < \frac{3}{2}$

$-\frac{3}{2} < x < \frac{3}{2}$

Set-builder: $\left\{x \middle| -\frac{3}{2} < x < \frac{3}{2}\right\}$

Interval: $\left(-\frac{3}{2}, \frac{3}{2}\right)$



**22.** $|x+3| < 5$

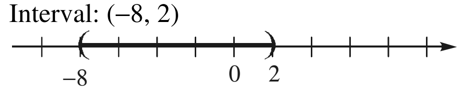
$-5 < x+3 < 5$

$-5-3 < x+3-3 < 5-3$

$-8 < x < 2$

Set-builder: $\{x \mid -8 < x < 2\}$

Interval: $(-8, 2)$



**23.** $|2x-3| \le 7$

$-7 \le 2x-3 \le 7$

$-7+3 \le 2x-3+3 \le 7+3$

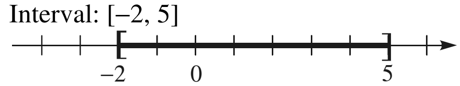
$-4 \le 2x \le 10$

$\frac{-4}{2} \le \frac{2x}{2} \le \frac{10}{2}$

$-2 \le x \le 5$

Set-builder: $\{x \mid -2 \le x \le 5\}$

Interval: $[-2, 5]$



**24.** $|7x+2| < -3$

Since absolute values are never negative, this inequality has no solution.

Solution set: $\{\ \}$ or $\varnothing$

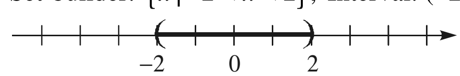
**25.** True

**26.** $|x|+4 < 6$

$|x| < 2$

$-2 < x < 2$

Set-builder: $\{x \mid -2 < x < 2\}$; Interval: $(-2, 2)$



**27.** $|x-3|+4 \le 8$

$|x-3| \le 4$

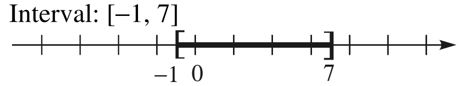
$-4 \le x-3 \le 4$

$-4+3 \le x-3+3 \le 4+3$

$-1 \le x \le 7$

Set-builder: $\{x \mid -1 \le x \le 7\}$

Interval: $[-1, 7]$



**28.** $3|2x+1| \le 9$

$|2x+1| \le 3$

$-3 \le 2x+1 \le 3$

$-3-1 \le 2x+1-1 \le 3-1$

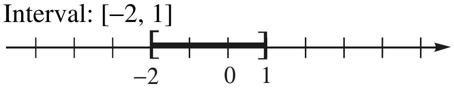
$-4 \le 2x \le 2$

$\frac{-4}{2} \le \frac{2x}{2} \le \frac{2}{2}$

$-2 \le x \le 1$

Set-builder: $\{x \mid -2 \le x \le 1\}$

Interval: $[-2, 1]$




**29.** $|-3x+1|-5 < 3$

$|-3x+1| < 8$

$-8 < -3x+1 < 8$

$-8-1 < -3x+1-1 < 8-1$

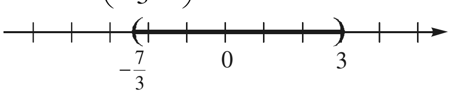
$-9 < -3x < 7$

$\frac{-9}{-3} > \frac{-3x}{-3} > \frac{7}{-3}$

$3 > x > -\frac{7}{3}$ or $-\frac{7}{3} < x < 3$

Set-builder: $\left\{x \middle| -\frac{7}{3} < x < 3\right\}$

Interval: $\left(-\frac{7}{3}, 3\right)$




**30.** $|u| > a$ is equivalent to $\underline{u < -a}$ or $\underline{u > a}$.

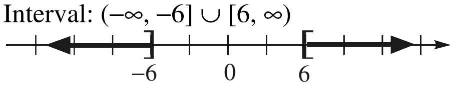
**31.** $|5x-2| \ge 7$ is equivalent to $5x-2 \le \underline{-7}$ or $5x-2 \ge \underline{7}$.

**32.** $|x| \ge 6$

$x \le -6$ or $x \ge 6$

Set-builder: $\{x \mid x \le -6 \text{ or } x \ge 6\}$

Interval: $(-\infty, -6] \cup [6, \infty)$

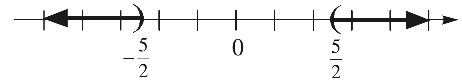



**33.** $|x| > \frac{5}{2}$

$x < -\frac{5}{2}$ or $x > \frac{5}{2}$

Set-builder: $\left\{x \middle| x < -\frac{5}{2} \text{ or } x > \frac{5}{2}\right\}$

Interval: $\left(-\infty, -\frac{5}{2}\right) \cup \left(\frac{5}{2}, \infty\right)$




**34.** $|x-9| > 6$ is equivalent to $x-9 \underline{>} 6$ or $x-9 \underline{<} -6$.

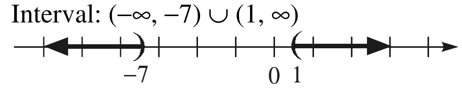
**35.** $|x+3| > 4$

$x+3 < -4$ or $x+3 > 4$

$x < -7$ $\quad$ $x > 1$

Set-builder: $\{x \mid x < -7 \text{ or } x > 1\}$

Interval: $(-\infty, -7) \cup (1, \infty)$




**36.** $|4x-3| \ge 5$

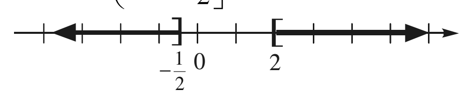
$4x-3 \le -5$ or $4x-3 \ge 5$

$4x \le -2$ $\quad$ $4x \ge 8$

$x \le -\frac{1}{2}$ $\quad$ $x \ge 2$

Set-builder: $\left\{x \middle| x \le -\frac{1}{2} \text{ or } x \ge 2\right\}$

Interval: $\left(-\infty, -\frac{1}{2}\right] \cup [2, \infty)$




**37.** $|-3x+2| > 7$

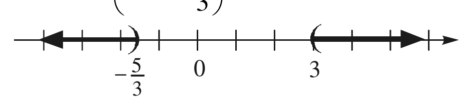
$-3x+2 < -7$ or $-3x+2 > 7$

$-3x < -9$ $\quad$ $-3x > 5$

$x > 3$ $\quad$ $x < -\frac{5}{3}$

Set-builder: $\left\{x \middle| x < -\frac{5}{3} \text{ or } x > 3\right\}$

Interval: $\left(-\infty, -\frac{5}{3}\right) \cup (3, \infty)$




**38.** $|2x+5|-2 > -2$

$|2x+5| > 0$

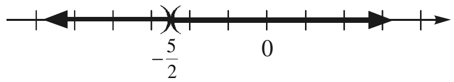
$2x+5 < 0$ or $2x+5 > 0$

$2x < -5$ $\quad$ $2x > -5$

$x < -\frac{5}{2}$ $\quad$ $x > -\frac{5}{2}$

Set-builder: $\left\{x \middle| x \neq -\frac{5}{2}\right\}$

Interval: $\left(-\infty, -\frac{5}{2}\right) \cup \left(-\frac{5}{2}, \infty\right)$

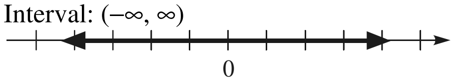



**39.** $|6x-5| \geq 0$

Since absolute values are always nonnegative, all real numbers are solutions to this inequality.

Set-builder: $\{x \mid x \text{ is any real number}\}$

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

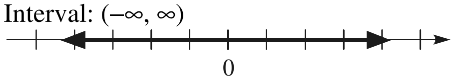



**40.** $|2x+1| > -3$

Since absolute values are always nonnegative, all real numbers are solutions to this inequality.

Set-builder: $\{x \mid x \text{ is any real number}\}$

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




**41.** $|x-4| \leq \frac{1}{32}$

$$-\frac{1}{32} \leq x-4 \leq \frac{1}{32}$$
$$-\frac{1}{32}+4 \leq x-4+4 \leq \frac{1}{32}+4$$
$$-\frac{1}{32}+\frac{128}{32} \leq x \leq \frac{1}{32}+\frac{128}{32}$$
$$\frac{127}{32} \leq x \leq \frac{129}{32}$$

The acceptable belt widths are between $\frac{127}{32}$ inches and $\frac{129}{32}$ inches.

**42.** $|p-9| \leq 1.7$

$$-1.7 \leq p-9 \leq 1.7$$
$$-1.7+9 \leq p-9+9 \leq 1.7+9$$
$$7.3 \leq p \leq 10.7$$

The percentage of people that have been shot at is between 7.3 percent and 10.7 percent.

**2.6 Exercises**

**44.** $|z| = 9$

$z = -9$ or $z = 9$

Solution set: $\{-9, 9\}$

**46.** $|4| = -1$

Since absolute values are never negative, this equation has no solution.

Solution set: { } or ∅

**48.** $|x+3| = 5$

$x+3=5$ or $x+3=-5$

$x=2$ $\quad$ $x=-8$

Solution set: $\{-8, 2\}$

**50.** $|-4y+3| = 9$

$-4y+3=-9$ or $-4y+3=9$

$-4y=-12$ $\quad$ $-4y=6$

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

Solution set: $\left\{-\frac{3}{2}, 3\right\}$

**52.** $|x|+3=5$

$|x|=2$

$x=-2$ or $x=2$

Solution set: $\{-2, 2\}$

**54.** $|3y+1|-5=-3$

$|3y+1|=2$

$3y+1=-2$ or $3y+1=2$

$3y=-3$ $\quad$ $3y=1$

$y=-1$ $\quad$ $y=\frac{1}{3}$

Solution set: $\left\{-1, \frac{1}{3}\right\}$

**56.** $3|y-4|+4=16$

$3|y-4|=12$

$|y-4|=4$

$y-4=-4$ or $y-4=4$

$y=0$ $\quad$ $y=8$

Solution set: $\{0, 8\}$

**58.** $|-2x|+9=9$

$|-2x|=0$

$-2x=0$

$x=0$

Solution set: $\{0\}$

**60.** $\left|\frac{2x-3}{5}\right| = 2$

$\frac{2x-3}{5} = 2$ or $\frac{2x-3}{5} = -2$

$2x-3 = 10$ $\quad$ $2x-3 = -10$

$2x = 13$ $\quad$ $2x = -7$

$x = \frac{13}{2}$ $\quad$ $x = -\frac{7}{2}$

Solution set: $\left\{-\frac{7}{2}, \frac{13}{2}\right\}$

**62.** $|5y-2| = |4y+7|$

$5y-2 = 4y+7$ or $5y-2 = -(4y+7)$

$5y = 4y+9$ $\quad$ $5y-2 = -4y-7$

$y = 9$ $\quad$ $5y = -4y-5$

$9y = -5$

$y = -\frac{5}{9}$

Solution set: $\left\{-\frac{5}{9}, 9\right\}$

**64.** $|5x+3| = |12-4x|$

$5x+3 = 12-4x$ or $5x+3 = -(12-4x)$

$5x = 9-4x$ $\quad$ $5x+3 = -12+4x$

$9x = 9$ $\quad$ $5x = -15+4x$

$x = 1$ $\quad$ $x = -15$

Solution set: $\{-15, 1\}$

**66.** $|5x-1| = |9-5x|$

$5x-1 = 9-5x$ or $5x-1 = -(9-5x)$

$5x = 10-5x$ $\quad$ $5x-1 = -9+5x$

$10x = 10$ $\quad$ $-1 \neq -9$

$x = 1$

Solution set: $\{1\}$

**68.** $-|x+1| = |3x-2|$

Since absolute values are never negative, this equation has no solution unless both absolute values are 0 for the same value of $x$.

$|x+1| = 0$ $\quad$ $|3x-2| = 0$

$x+1 = 0$ $\quad$ $3x-2 = 0$

$x = -1$ $\quad$ $3x = 2$

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

Thus, the equation has no solution.

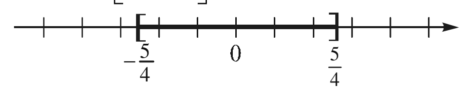
Solution set: { } or $\varnothing$

**70.** $|x| \le \frac{5}{4}$

$-\frac{5}{4} \le x \le \frac{5}{4}$

Set-builder: $\left\{x \middle| -\frac{5}{4} \le x \le \frac{5}{4}\right\}$

Interval: $\left[-\frac{5}{4}, \frac{5}{4}\right]$



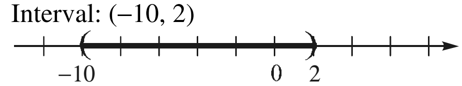

**72.** $|y+4| < 6$

$-6 < y+4 < 6$

$-10 < y < 2$

Set-builder: $\{y \mid -10 < y < 2\}$

Interval: $(-10, 2)$




**74.** $|4x-3| \le 9$

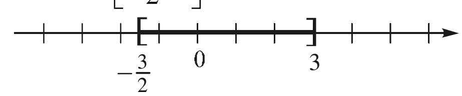
$-9 \le 4x-3 \le 9$

$-6 \le 4x \le 12$

$-\frac{3}{2} \le x \le 3$

Set-builder: $\left\{x \middle| -\frac{3}{2} \le x \le 3\right\}$

Interval: $\left[-\frac{3}{2}, 3\right]$



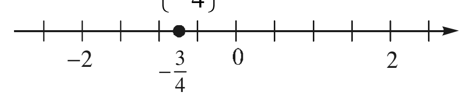

**76.** $|4x+3| \le 0$

$4x+3 = 0$

$4x = -3$

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

Solution set: $\left\{-\frac{3}{4}\right\}$



**78.** $3|y+2|-2<7$

$3|y+2|<9$

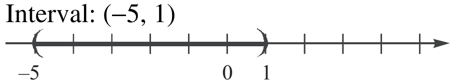
$|y+2|<3$

$-3<y+2<3$

$-5<y<1$

Set-builder: $\{y \mid -5<y<1\}$

Interval: $(-5, 1)$




**80.** $|-3x+2|-7\le -2$

$|-3x+2|\le 5$

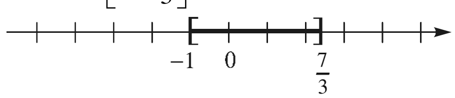
$-5\le -3x+2\le 5$

$-7\le -3x\le 3$

$\frac{7}{3}\ge x\ge -1$ or $-1\le x\le \frac{7}{3}$

Set-builder: $\left\{x \middle| -1\le x\le \frac{7}{3}\right\}$

Interval: $\left[-1, \frac{7}{3}\right]$




**82.** $|(3x+2)-8|<0.01$

$|3x+2-8|<0.01$

$|3x-6|<0.01$

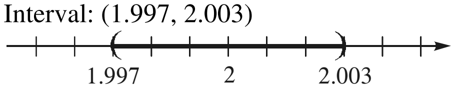
$-0.01<3x-6<0.01$

$5.99<3x<6.01$

$1.997<x<2.003$ (approx.)

Set-builder: $\{x \mid 1.997<x<2.003\}$

Interval: $(1.997, 2.003)$



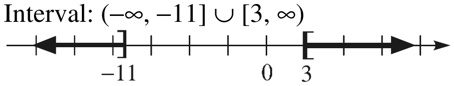

**84.** $|x+4|\ge 7$

$x+4\le -7$ or $x+4\ge 7$

$x\le -11$ $\quad$ $x\ge 3$

Set-builder: $\{x \mid x\le -11 \text{ or } x\ge 3\}$

Interval: $(-\infty, -11]\cup[3, \infty)$




**86.** $|-5y+3|>7$

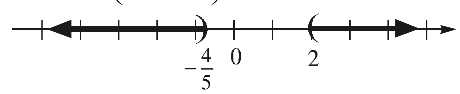
$-5y+3<-7$ or $-5y+3>7$

$-5y<-10$ $\quad$ $-5y>4$

$y>2$ $\quad$ $y<-\frac{4}{5}$

Set-builder: $\left\{y \middle| y<-\frac{4}{5} \text{ or } y>2\right\}$

Interval: $\left(-\infty, -\frac{4}{5}\right)\cup(2, \infty)$




**88.** $3|z|+8>2$

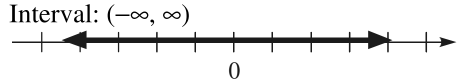
$3|z|>-6$

$|z|>-2$

Since $|z|\ge 0>-2$ for all $z$, all real numbers are solutions.

Set-builder: $\{z \mid z \text{ is a real number}\}$

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




**90.** $|-9x+2|-11\ge 0$

$|-9x+2|\ge 11$

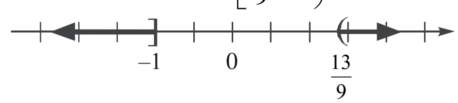
$-9x+2\le -11$ or $-9x+2\ge 11$

$-9x\le -13$ or $-9x\ge 9$

$x\ge \frac{13}{9}$ or $x\le -1$

Set-builder: $\left\{x \middle| x\le -1 \text{ or } x\ge \frac{13}{9}\right\}$

Interval: $(-\infty, -1]\cup\left[\frac{13}{9}, \infty\right)$




**92.** $3|8x+3|\ge 9$

$|8x+3|\ge 3$

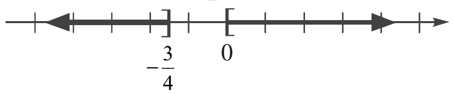
$8x+3\le -3$ or $8x+3\ge 3$

$8x\le -6$ or $8x\ge 0$

$x\le -\frac{3}{4}$ or $x\ge 0$

Set-builder: $\left\{x \middle| x\le -\frac{3}{4} \text{ or } x\ge 0\right\}$

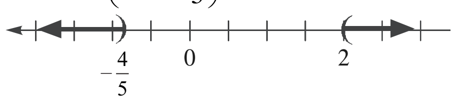
Interval: $\left(-\infty, -\frac{3}{4}\right] \cup [0, \infty)$




**94.** $|3-5x| > |-7|$
$|3-5x| > 7$
$3-5x < -7$ or $3-5x > 7$
$-5x < -10$ or $-5x > 4$
$x > 2$ or $x < -\frac{4}{5}$

Set-builder: $\left\{x \middle| x < -\frac{4}{5} \text{ or } x > 2\right\}$

Interval: $\left(-\infty, -\frac{4}{5}\right) \cup (2, \infty)$




**96.** **a.** $f(x) = g(x)$ when $x = -6$ and $x = 6$.
The solution set is $\{-6, 6\}$.

**b.** $f(x) \le g(x)$ when $-6 \le x \le 6$.
Set-builder: $\{x \mid -6 \le x \le 6\}$
Interval: $[-6, 6]$

**c.** $f(x) > g(x)$ for $x < -6$ or $x > 6$.
Set-builder: $\{x \mid x < -6 \text{ or } x > 6\}$
Interval: $(-\infty, -6) \cup (6, \infty)$

**98.** **a.** $f(x) = g(x)$ when $x = -5$ and $x = 5$.
The solution set is $\{-5, 5\}$.

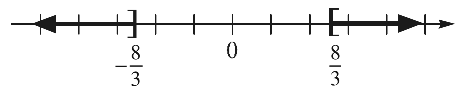
**b.** $f(x) < g(x)$ when $-5 < x < 5$.
Set-builder: $\{x \mid -5 < x < 5\}$
Interval: $(-5, 5)$

**c.** $f(x) \ge g(x)$ for $x \le -5$ or $x \ge 5$.
Set-builder: $\{x \mid x \le -5 \text{ or } x \ge 5\}$
Interval: $(-\infty, -5] \cup [5, \infty)$

**100.** $|x| \ge \frac{8}{3}$
$x \le -\frac{8}{3}$ or $x \ge \frac{8}{3}$

Set-builder: $\left\{x \middle| x \le -\frac{8}{3} \text{ or } x \ge \frac{8}{3}\right\}$

Interval: $\left(-\infty, -\frac{8}{3}\right] \cup \left[\frac{8}{3}, \infty\right)$




**102.** $|4x+3| = 1$
$4x+3 = -1$ or $4x+3 = 1$
$4x = -4$ $4x = -2$
$x = -1$ $x = -\frac{1}{2}$

Solution set: $\left\{-1, -\frac{1}{2}\right\}$

**104.** $8|y| = 32$
$|y| = 4$
$y = -4$ or $y = 4$
Solution set: $\{-4, 4\}$

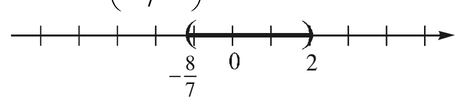
**106.** $|3x-2| + 1 = 8$
$|3x-2| = 7$
$3x-2 = -7$ or $3x-2 = 7$
$3x = -5$ or $3x = 9$
$x = -\frac{5}{3}$ or $x = 3$

Solution set: $\left\{-\frac{5}{3}, 3\right\}$

**108.** $|7y-3| < 11$
$-11 < 7y-3 < 11$
$-8 < 7y < 14$
$-\frac{8}{7} < y < 2$

Set-builder: $\left\{y \middle| -\frac{8}{7} < y < 2\right\}$

Interval: $\left(-\frac{8}{7}, 2\right)$




**110.** $|3x-4| = -9$
No solution. Absolute value is never negative.
Solution set: $\varnothing$ or $\{\ \}$

**112.** $|5y+3|>2$

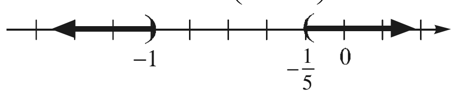
$5y+3<-2$ or $5y+3>2$

$5y<-5$ $\quad$ $5y>-1$

$y<-1$ $\quad$ $y>-\frac{1}{5}$

Set-builder: $\left\{y \middle| y<-1 \text{ or } y>-\frac{1}{5}\right\}$

Interval: $(-\infty, -1)\cup\left(-\frac{1}{5}, \infty\right)$




**114.** $|4y+3|-8\ge -3$

$|4y+3|\ge 5$

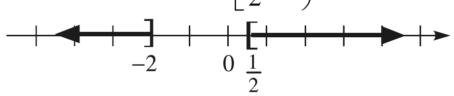
$4y+3\le -5$ or $4y+3\ge 5$

$4y\le -8$ $\quad$ $4y\ge 2$

$y\le -2$ $\quad$ $y\ge \frac{1}{2}$

Set-builder: $\left\{y \middle| y\le -2 \text{ or } y\ge \frac{1}{2}\right\}$

Interval: $(-\infty, -2]\cup\left[\frac{1}{2}, \infty\right)$




**116.** $|3z-2|=|z+6|$

$3z-2=z+6$ or $3z-2=-(z+6)$

$3z=z+8$ $\quad$ $3z-2=-z-6$

$2z=8$ $\quad$ $3z=-z-4$

$z=4$ $\quad$ $4z=-4$

$z=-1$

Solution set: $\{-1, 4\}$

**118.** $|4x+1|>0$

Since absolute value is always nonnegative, all real numbers are solutions except where

$4x+1=0$

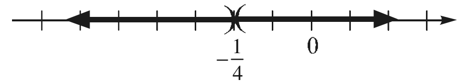
$4x=-1$

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

Thus, all real numbers are solutions except $x=-\frac{1}{4}$.

Set-builder: $\left\{x \middle| x\ne -\frac{1}{4}\right\}$

Interval: $\left(-\infty, -\frac{1}{4}\right)\cup\left(-\frac{1}{4}, \infty\right)$




**120.** $\left|\frac{1}{2}x-3\right|=\left|\frac{2}{3}x+1\right|$

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

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

$6\left(\frac{1}{2}x\right)=6\left(\frac{2}{3}x+4\right)$ $\quad$ $6\left(\frac{1}{2}x\right)=6\left(-\frac{2}{3}x+2\right)$

$3x=4x+24$ $\quad$ $3x=-4x+12$

$-x=24$ $\quad$ $7x=12$

$x=-24$ $\quad$ $x=\frac{12}{7}$

Solution set: $\left\{-24, \frac{12}{7}\right\}$

**122.** $|x-(-4)|<2$

$|x+4|<2$

$-2<x+4<2$

$-2-4<x+4-4<2-4$

$-6<x<-2$

Set-builder: $\{x|-6<x<-2\}$

Interval: $(-6, -2)$

**124.** $|2x-7|>3$

$2x-7<-3$ or $2x-7>3$

$2x<4$ $\quad$ $2x>10$

$x<2$ $\quad$ $x>5$

Set-builder: $\{x\,|\,x<2 \text{ or } x>5\}$

Interval: $(-\infty, 2)\cup(5, \infty)$

**126.** $|x-6.125|\le 0.0005$

$-0.0005\le x-6.125\le 0.0005$

$6.1245\le x\le 6.1255$

The acceptable rod lengths are between 6.1245 inches and 6.1255 inches, inclusive.

**128.** $\left|\frac{x-266}{16}\right|>1.96$

$\frac{x-266}{16}<-1.96$ or $\frac{x-266}{16}>1.96$

$x-266<-31.36$ $\quad$ $x-266>31.36$

$x<234.64$ $\quad$ $x>297.36$

Gestation periods less than 234.64 days or more than 297.36 days would be considered unusual.

**130.** $|y| + y = 3$

$|y| = 3 - y$

$y = 3 - y$ or $y = -(3 - y)$

$2y = 3$    $y = y - 3$

$y = \frac{3}{2}$    $0 \neq -3$

Check $\frac{3}{2}$: $\left|\frac{3}{2}\right| + \left(\frac{3}{2}\right) \overset{?}{=} 3$

$\frac{3}{2} + \frac{3}{2} \overset{?}{=} 3$

$3 = 3$ T

Solution set: $\left\{\frac{3}{2}\right\}$

**132.** $y - |-y| = 12$

$|-y| = y - 12$

$-y = y - 12$ or $-y = -(y - 12)$

$-2y = -12$    $-y = -y + 12$

$y = 6$    $0 \neq 12$

Check 6: $6 - |-(6)| \overset{?}{=} 12$

$6 - 6 \overset{?}{=} 12$

$0 \neq 12$

Solution set: $\{\ \}$ or $\varnothing$

**134.** $|2x + 1| = x - 3$

$2x + 1 = x - 3$ or $2x + 1 = -(x - 3)$

$2x = x - 4$    $2x + 1 = -x + 3$

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

$3x = 2$

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

Check $-4$: $|2(-4) + 1| \overset{?}{=} (-4) - 3$

$|-8 + 1| \overset{?}{=} -7$

$|-7| \overset{?}{=} -7$

$7 \neq -7$

Check $\frac{2}{3}$: $\left|2\left(\frac{2}{3}\right) + 1\right| \overset{?}{=} \left(\frac{2}{3}\right) - 3$

$\left|\frac{4}{3} + \frac{3}{3}\right| \overset{?}{=} \frac{2}{3} - \frac{9}{3}$

$\left|\frac{7}{3}\right| \overset{?}{=} -\frac{7}{3}$

$\frac{7}{3} \neq -\frac{7}{3}$

Solution set: $\{\ \}$ or $\varnothing$

**136.** $|y - 4| = y - 4$

Since we have $|u| = u$, we need $u \geq 0$ so the absolute value will not be negative. Thus, $y - 4 \geq 0$ or $y \geq 4$.

Set-builder: $\{y \mid y \geq 4\}$.

Interval: $[4, \infty)$

**138.** $|5x - 3| > -5$ has a solution set containing all real numbers because $|5x - 3| \geq 0 > -5$ for any $x$.

**140.** $|x - 5| = |5 - x|$

$x - 5 = 5 - x$ or $x - 5 = -(5 - x)$

$x = 10 - x$    $x - 5 = x - 5$

$2x = 10$    $0 = 0$

$x = 5$

Solution set: $\{x \mid x \text{ is a real number}\}$

The result is reasonable

$|a - b| = |-1(-a + b)| = |-1||b - a| = |b - a|$

This is an identity.

**Chapter 2 Review**

**1.** {(Cent, 2.500), (Nickel, 5.000), (Dime, 2.268), (Quarter, 5.670), (Half Dollar, 11.340), (Dollar, 8.100)}

**Domain:**

{Cent, Nickel, Dime, Quarter, Half Dollar, Dollar}

**Range:**

{2.268, 2.500, 5.000, 5.670, 8.100, 11.340}

**2.** {(16, \$12.99), (28, \$14.99), (30, \$14.99), (59, \$24.99), (85, \$29.99)}

**Domain:**

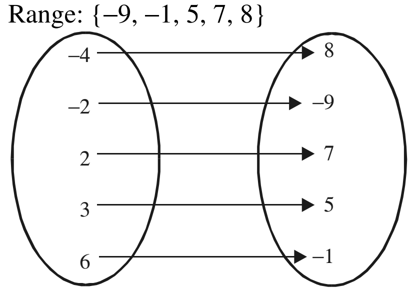
{16, 28, 30, 59, 85}

**Range:**

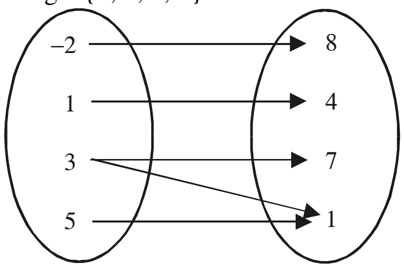
{\$12.99, \$14.99, \$24.99, \$29.99}

**3.** Domain: {–4, –2, 2, 3, 6}

Range: {–9, –1, 5, 7, 8}



**4.** Domain: {−2, 1, 3, 5}
Range: {1, 4, 7, 8}




**5.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**6.** Domain: $\{x \mid -6 \le x \le 4\}$ or $[-6, 4]$

Range: $\{y \mid -4 \le y \le 6\}$ or $[-4, 6]$

**7.** Domain: $\{2\}$

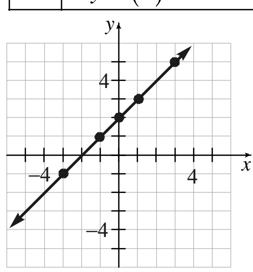
Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**8.** Domain: $\{x \mid x \ge -1\}$ or $[-1, \infty)$

Range: $\{y \mid y \ge -2\}$ or $[-2, \infty)$

**9.** $y = x + 2$

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

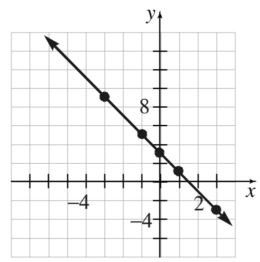



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**10.** $2x + y = 3$
$y = -2x + 3$

| $x$ | $y = -2x + 3$ | $(x, y)$ |
|---|---|---|
| −3 | $y = -2(-3) + 3 = 9$ | $(-3, 9)$ |
| −1 | $y = -2(-1) + 3 = 5$ | $(-1, 5)$ |
| 0 | $y = -2(0) + 3 = 3$ | $(0, 3)$ |
| 1 | $y = -2(1) + 3 = 1$ | $(1, 1)$ |
| 3 | $y = -2(3) + 3 = -3$ | $(3, -3)$ |

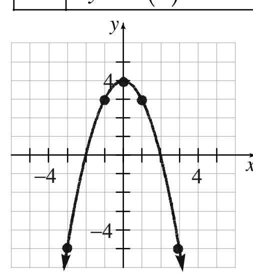



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**11.** $y = -x^2 + 4$

| $x$ | $y = -x^2 + 4$ | $(x, y)$ |
|---|---|---|
| −3 | $y = -(-3)^2 + 4 = -5$ | $(-3, -5)$ |
| −1 | $y = -(-1)^2 + 4 = 3$ | $(-1, 3)$ |
| 0 | $y = -(0)^2 + 4 = 4$ | $(0, 4)$ |
| 1 | $y = -(1)^2 + 4 = 3$ | $(1, 3)$ |
| 3 | $y = -(3)^2 + 4 = -5$ | $(3, -5)$ |

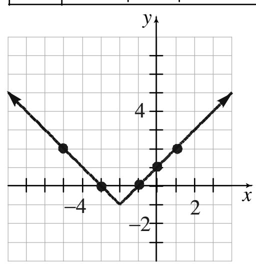



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \le 4\}$ or $(-\infty, 4]$

**12.** $y = |x+2| - 1$

| $x$ | $y = \|x+2\| - 1$ | $(x, y)$ |
|---|---|---|
| $-5$ | $y = \|-5+2\| - 1 = 2$ | $(-5, 2)$ |
| $-3$ | $y = \|-3+2\| - 1 = 0$ | $(-3, 0)$ |
| $-1$ | $y = \|-1+2\| - 1 = 0$ | $(-1, 0)$ |
| $0$ | $y = \|0+2\| - 1 = 1$ | $(0, 1)$ |
| $1$ | $y = \|1+2\| - 1 = 2$ | $(1, 2)$ |

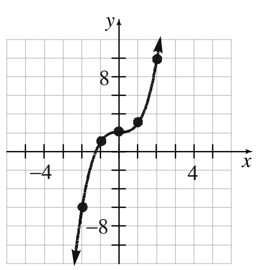



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \geq -1\}$ or $[-1, \infty)$

**13.** $y = x^3 + 2$

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

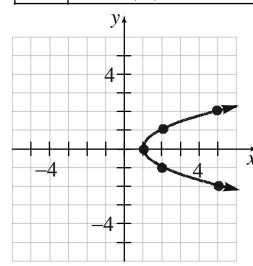



Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**14.** $x = y^2 + 1$

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




Domain: $\{x \mid x \geq 1\}$ or $[1, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**15. a.** Domain: $\{x | 0 \leq x \leq 44{,}640\}$ or [0, 44,640]
Range: $\{y \mid 40 \leq y \leq 2122\}$ or [40, 2122]
The monthly cost will be at least $40 but no more than $2122. The number of minutes used must be between 0 and 44,640.

**b.** Answer may vary.

**16.** Domain: $\{t \mid 0 \leq t \leq 4\}$ or [0, 4]

Range: $\{y \mid 0 \leq y \leq 121\}$ or [0, 121]

The ball will be in the air from 0 to 4 seconds and will reach heights from 0 feet up to a maximum of 121 feet.

**17. a.** Not a function. The domain element $-1$ corresponds to two different values in the range.
Domain: $\{-1, 5, 7, 9\}$
Range: $\{-2, 0, 2, 3, 4\}$

**b.** Function. Each animal corresponds to exactly one typical lifespan.
Domain: {Camel, Macaw, Deer, Fox, Tiger, Crocodile}
Range: {14, 22, 35, 45, 50}

**18. a.** Function. There are no ordered pairs that have the same first coordinate but different second coordinates.
Domain: $\{-3, -2, 2, 4, 5\}$
Range: $\{-1, 3, 4, 7\}$

**b.** Not a function. The domain element 'Blue' corresponds to two different types of cars in the range.
Domain: {Red, Blue, Green, Black}
Range: {Camry, Taurus, Windstar, Durango}

**19.** $3x-5y=18$
$-5y=-3x+18$
$y=\frac{-3x+18}{-5}$
$y=\frac{3}{5}x-\frac{18}{5}$
Since there is only one output *y* that can result from any given input *x*, this relation is a function.

**20.** $x^2+y^2=81$
$y^2=81-x^2$
Since a given input *x* can result in more than one output *y*, this relation is not a function. For example, if $x=0$ then $y=9$ or $y=-9$.

**21.** $y=\pm 10x$
Since a given input *x* can result in more than one output *y*, this relation is not a function.

**22.** $y=x^2-14$
Since there is only one output *y* that can result from any given input *x*, this relation is a function.

**23.** Not a function. The graph fails the vertical line test so it is not the graph of a function.

**24.** Function. The graph passes the vertical line test so it is the graph of a function.

**25.** Function. The graph passes the vertical line test so it is the graph of a function.

**26.** Not a function. The graph fails the vertical line test so it is not the graph of a function.

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

**b.** $f(3)=(3)^2+2(3)-5$
$=9+6-5$
$=10$

**28.** **a.** $g(0)=\frac{2(0)+1}{(0)-3}$
$=\frac{0+1}{-3}$
$=-\frac{1}{3}$

**b.** $g(2)=\frac{2(2)+1}{(2)-3}$
$=\frac{4+1}{-1}$
$=-5$

**29.** **a.** $F(5)=-2(5)+7$
$=-10+7$
$=-3$

**b.** $F(-x)=-2(-x)+7$
$=2x+7$

**30.** **a.** $G(7)=2(7)+1$
$=14+1$
$=15$

**b.** $G(x+h)=2(x+h)+1$
$=2x+2h+1$

**31.** $f(x)=-\frac{3}{2}x+5$
Since each operation in the function can be performed for any real number, the domain of the function is all real numbers.
Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

**32.** $g(w)=\frac{w-9}{2w+5}$
The function involves division by $2w + 5$. Since division by 0 is not defined, the denominator can never equal 0.
$2w+5=0$
$2w=-5$
$w=-\frac{5}{2}$

Thus, the domain is all real numbers except $-\frac{5}{2}$.

Domain: $\left\{w \middle| w \neq -\frac{5}{2}\right\}$

**33.** $h(t)=\dfrac{t+2}{t-5}$

The function involves division by $t-5$. Since division by 0 is not defined, the denominator can never equal 0.

$t-5=0$

$t=5$

Thus, the domain of the function is all real numbers except 5.

Domain: $\{t \mid t \neq 5\}$

**34.** $G(t)=3t^2+4t-9$

Since each operation in the function can be performed for any real number, the domain of the function is all real numbers.

Domain: $\{t \mid t \text{ is a real number}\}$ or $(-\infty, \infty)$

**35.** **a.** The dependent variable is the population, $P$, and the independent variable is the number of years after 1900, $t$.

**b.** $P(120)$

$=0.136(120)^2-5.043(120)+46.927$

$=1400.167$

According to the model, the population of Orange County will be roughly 1,400,167 in 2020.

**c.** $P(-70)$

$=0.136(-70)^2-5.043(-70)+46.927$

$=1066.337$

According to the model, the population of Orange County was roughly 1,066,337 in 1830. This is not reasonable. (The population of the entire Florida territory was roughly 35,000 in 1830.)

**36.** **a.** The dependent variable is the percent of the population with an advanced degree, $P$, and the independent variable is the age of the population, $a$.

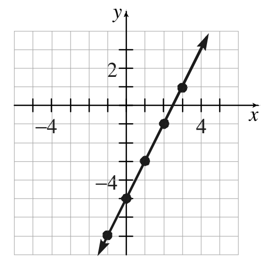
**b.** $P(30)=-0.0064(30)^2+0.6826(30)-6.82$

$=7.898$

Approximately 7.9% of 30 year olds have an advanced degree.

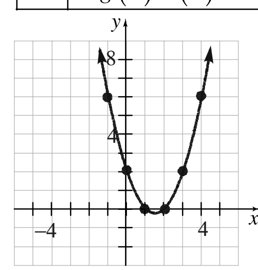
**37.** $f(x)=2x-5$

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



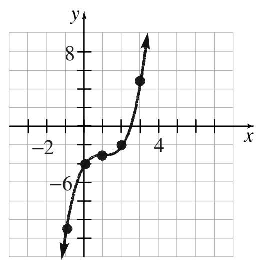

**38.** $g(x)=x^2-3x+2$

| $x$ | $y=g(x)=x^2-3x+2$ | $(x, y)$ |
|---|---|---|
| $-1$ | $g(-1)=(-1)^2-3(-1)+2=6$ | $(-1, 6)$ |
| 0 | $g(0)=(0)^2-3(0)+2=2$ | $(0, 2)$ |
| 1 | $g(1)=(1)^2-3(1)+2=0$ | $(1, 0)$ |
| 2 | $g(2)=(2)^2-3(2)+2=0$ | $(2, 0)$ |
| 3 | $g(3)=(3)^2-3(3)+2=2$ | $(3, 2)$ |
| 4 | $g(4)=(4)^2-3(4)+2=6$ | $(4, 6)$ |



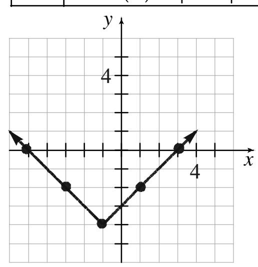

**39.** $h(x)=(x-1)^3-3$

| $x$ | $y=h(x)=(x-1)^3-3$ | $(x, y)$ |
|---|---|---|
| $-1$ | $h(-1)=(-1-1)^3-3=-11$ | $(-1, -11)$ |
| 0 | $h(0)=(0-1)^3-3=-4$ | $(0, -4)$ |
| 1 | $h(1)=(1-1)^3-3=-3$ | $(1, -3)$ |
| 2 | $h(2)=(2-1)^3-3=-2$ | $(2, -2)$ |
| 3 | $h(3)=(3-1)^3-3=5$ | $(3, 5)$ |




**40.** $f(x)=|x+1|-4$

| $x$ | $y=f(x)=\|x+1\|-4$ | $(x,\ y)$ |
|---|---|---|
| −5 | $f(-5)=\|-5+1\|-4=0$ | $(-5,\ 0)$ |
| −3 | $f(-3)=\|-3+1\|-4=-2$ | $(-3,\ -2)$ |
| −1 | $f(-1)=\|-1+1\|-4=-4$ | $(-1,\ -4)$ |
| 1 | $f(1)=\|1+1\|-4=-2$ | $(1,\ -2)$ |
| 3 | $f(3)=\|3+1\|-4=0$ | $(3,\ 0)$ |




**41. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**b.** The intercepts are (0, 2) and (4, 0). The $x$-intercept is 4 and the $y$-intercept is 2.

**42. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \geq -3\}$ or $[-3, \infty)$

**b.** The intercepts are (–2, 0), (2, 0), and (0, –3). The $x$-intercepts are $-2$ and 2, and the $y$-intercept is –3.

**43. a.** Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**b.** The intercepts are (0, 0) and (2, 0). The $x$-intercepts are 0 and 2; the $y$-intercept is 0.

**44. a.** Domain: $\{x \mid x \geq -3\}$ or $[-3, \infty)$

Range: $\{y \mid y \geq 1\}$ or $[1, \infty)$

**b.** The only intercept is (0, 3). There are no $x$-intercepts, but there is a $y$-intercept of 3.

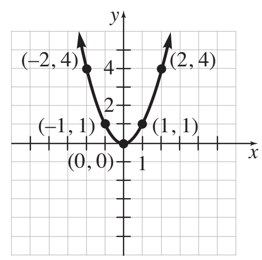
**45. a.** Since the point (–3, 4) is on the graph, $f(-3) = 4$.

**b.** Since the point (1, –4) is on the graph, when $x = 1$, $f(x) = 4$.

**c.** Since the $x$-intercepts are −1 and 3, the zeroes of $f$ are −1 and 3.

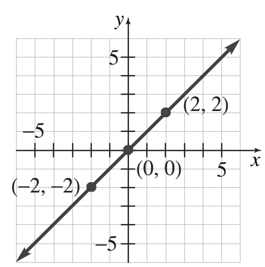
**46. a.** $y = x^2$

| $x$ | $y=x^2$ | $(x,\ y)$ |
|---|---|---|
| −2 | $y=(-2)^2=4$ | $(-2,\ 4)$ |
| −1 | $y=(-1)^2=1$ | $(-1,\ 1)$ |
| 0 | $y=(0)^2=0$ | $(0,\ 0)$ |
| 1 | $y=(1)^2=1$ | $(1,\ 1)$ |
| 2 | $y=(2)^2=4$ | $(2,\ 4)$ |




**b.** $y = x$

| $x$ | $y=x$ | $(x,\ y)$ |
|---|---|---|
| −2 | $y=-2$ | $(-2,\ -2)$ |
| 0 | $y=0$ | $(0, 0)$ |
| 2 | $y=2$ | $(2,\ 2)$ |




**47. a.** $h(3)=2(3)-7=6-7=-1$

Since $h(3) = -1$, the point (3, −1) is on the graph of the function.

**b.** $h(-2)=2(-2)-7=-4-7=-11$

The point $(-2,-11)$ is on the graph of the function.

**c.** $h(x) = 4$

$2x - 7 = 4$

$2x = 11$

$x = \frac{11}{2}$

The point $\left(\frac{11}{2}, 4\right)$ is on the graph of $h$.

**48. a.** $g(-5) = \frac{3}{5}(-5) + 4 = -3 + 4 = 1$

Since $g(-5) = 1$, the point (–5, 2) is not on the graph of the function.

**b.** $g(3) = \frac{3}{5}(3) + 4 = \frac{9}{5} + 4 = \frac{29}{5}$

The point $\left(3, \frac{29}{5}\right)$ is on the graph of the function.

**c.** $g(x) = -2$

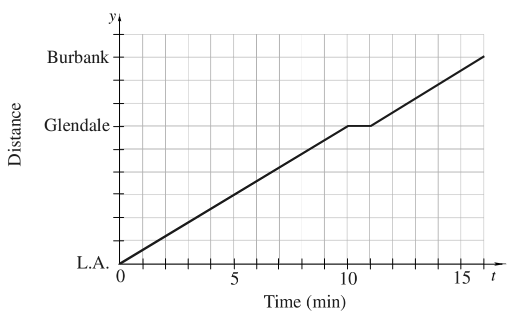
$\frac{3}{5}x + 4 = -2$

$\frac{3}{5}x = -6$

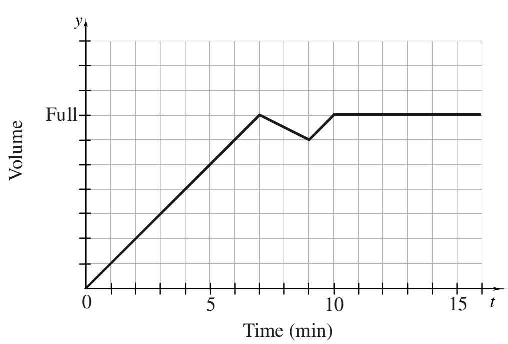
$x = -10$

The point (–10, –2) is on the graph of $g$.

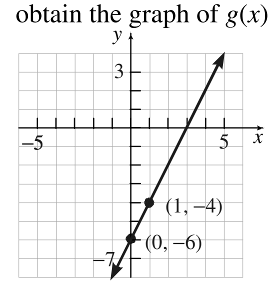
**49.**




**50.**




**51.** Comparing $g(x) = 2x - 6$ to $g(x) = mx + b$, the slope $m$ is 2 and the $y$-intercept $b$ is –6. Begin by plotting the point (0, –6). Because $m = 2 = \frac{2}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, –6) go up 2 units and to the right 1 unit and end up at (1, –4). Draw a line through these points and obtain the graph of $g(x) = 2x - 6$.




$g(x) = 0$

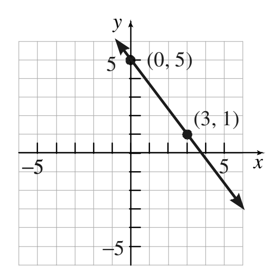
$2x - 6 = 0$

$2x = 6$

$x = 3$

The zero of $g$ is 3.

**52.** Comparing $H(x) = -\frac{4}{3}x + 5$ to $H(x) = mx + b$, the slope $m$ is $-\frac{4}{3}$ and the $y$-intercept $b$ is 5. Begin by plotting the point (0, 5). Because $m = -\frac{4}{3} = \frac{-4}{3} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, 5) go down 4 units and to the right 3 units and end up at (3, 1). Draw a line through these points and obtain the graph of $H(x) = -\frac{4}{3}x + 5$.




$H(x) = 0$

$-\frac{4}{3}x + 5 = 0$

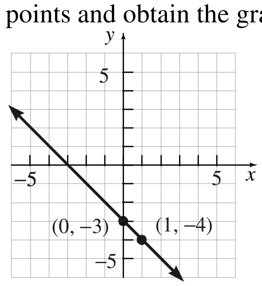
$-\frac{4}{3}x = -5$

$x = \frac{15}{4}$

The zero of $H$ is $\frac{15}{4}$.

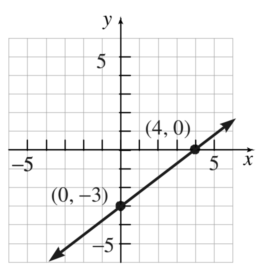
**53.** Comparing $F(x) = -x - 3$ to $F(x) = mx + b$, the slope $m$ is $-1$ and the $y$-intercept $b$ is $-3$. Begin by plotting the point (0, −3). Because $m = -1 = \frac{-1}{1} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, −3) go down 1 unit and to the right 1 unit and end up at (1, −4). Draw a line through these points and obtain the graph of $F(x) = -x - 3$.




$$\begin{aligned} F(x) &= 0 \\ -x - 3 &= 0 \\ -x &= 3 \\ x &= -3 \end{aligned}$$

The zero of $F$ is −3.

**54.** Comparing $f(x) = \frac{3}{4}x - 3$ to $f(x) = mx + b$, the slope $m$ is $\frac{3}{4}$ and the $y$-intercept $b$ is −3. Begin by plotting the point (0, −3). Because $m = \frac{3}{4} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}}$, from the point (0, −3) go up 3 units and to the right 4 units and end up at (4, 0). Draw a line through these points and obtain the graph of $f(x) = \frac{3}{4}x - 3$.



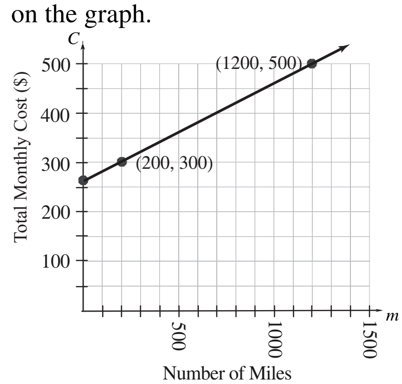

From the graph, we see that the $x$-intercept is 4, so the zero of $f$ is 4.

**55. a.** The independent variable is the number of miles driven, $m$. It would not make sense to drive for a negative number of miles. Thus, the domain of $C$ is $\{m | m \geq 0\}$ or, using interval notation, $[0, \infty)$.

**b.** $C(0) = 0.20(0) + 260 = 260$
The monthly cost is \$260 if no miles are driven—this is her monthly payment on the car.

**c.** $$\begin{aligned} C(1000) &= 0.20(1000) + 260 \\ &= 200 + 260 \\ &= 460 \end{aligned}$$
Her monthly cost is \$460 if she drives 1000 miles.

**d.** Evaluate $C$ at $m = 200$ and 1200.
$C(200) = 0.20(200) + 260 = 40 + 260 = 300$
$$\begin{aligned} C(1200) &= 0.20(1200) + 260 \\ &= 240 + 260 \\ &= 500 \end{aligned}$$
Using also parts b and c, the points (0, 260), (200, 300), (1000, 460), and (1200, 500) are on the graph.




**e.** Solve $C(m) \leq 550$.
$$\begin{aligned} 0.20m + 260 &\leq 550 \\ 0.20m &\leq 290 \\ m &\leq 14560 \end{aligned}$$
She can drive at most 1450 miles, so the range of miles she can drive is [0, 1450].

**56. a.** The independent variable is the number of years after purchase, $x$. The dependent variable is the value of the computer, $V$.

**b.** The value function $V$ is for 0 to 5 years, inclusive. Thus, the domain is $\{x |\ 0 \leq x \leq 5\}$ or, using interval notation, [0, 5].

**c.** The initial value of the computer will be the value at $x = 0$ years.
$V(0) = 1800 - 360(0) = 1800$
The initial value of the computer is \$1800.

**d.** $V(2) = 1800 - 360(2) = 1080$

After 2 years, the value of the computer is \$1080.

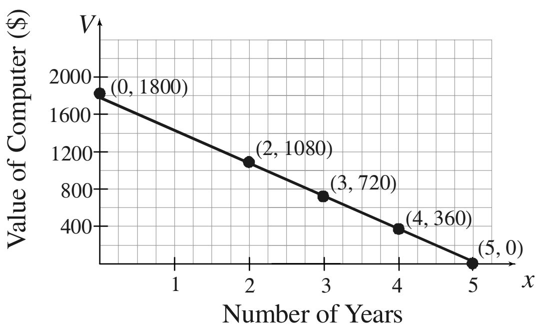
**e.** Evaluate $V$ at $x = 3$, 4, and 5.

$V(3) = 1800 - 360(3) = 720$

$V(4) = 1800 - 360(4) = 360$

$V(5) = 1800 - 360(5) = 0$

Thus, the points (3, 720), (4, 360), and (5, 0) are on the graph.




**f.** Solve $V(x) = 0$.

$$1800 - 360x = 0$$
$$-360x = -1800$$
$$x = 5$$

After 5 years, the computer's value will be \$0.

**57. a.** Let $x$ = FICO score. Let $L$ = loan rate.

$$m = \frac{5-9}{750-675} = \frac{-4}{75}$$

$$L - 5 = -\frac{4}{75}(x - 750)$$

$$L - 5 = -\frac{4}{75}x + 40$$

$$L = -\frac{4}{75}x + 45$$

In function notation,

$$L(x) = -\frac{4}{75}x + 45.$$

**b.** $L(710) = -\frac{4}{75}(710) + 45 = 7$

With a FICO credit score of 710, the auto loan rate should be approximately 7%.

**c.** The slope, $-\frac{4}{75} \approx -0.053$, indicates that the loan rate decreases approximately 0.05% for every 1-unit increase in the FICO score.

**d.** $-\frac{4}{75}x + 45 = 6.5$

$$-\frac{4}{75}x = -38.5$$
$$x \approx 722$$

A bank will offer a rate of 6.5% for a FICO score of 722.

**58. a.** Let $x$ represent the age of men and $H$ represent the maximum recommended heart rate for men under stress.

$$m = \frac{160-200}{60-20}$$
$$= -1 \text{ beat per minute per year}$$

$$H - 200 = -1(x - 20)$$
$$H - 200 = -x + 20$$
$$H = -x + 220$$

In function notation, $H(x) = -x + 220$.

**b.** $H(45) = -(45) + 220 = 175$

The maximum recommended heart rate for a 45 year old man under stress is 175 beats per minute.

**c.** The slope (–1) indicates that the maximum recommended heart rate for men under stress decreases at a rate of 1 beat per minute per year.

**d.** $-x + 220 = 168$

$$-x = -52$$
$$x = 52$$

The maximum recommended heart rate under stress is 168 beats per minute for 52-year-old men.

**59. a.** $C(m) = 0.12m + 35$

**b.** The number of miles driven, $m$, is the independent variable. The rental cost, $C$, is the dependent variable.

**c.** Because the number of miles cannot be negative, the it must be greater than or equal to zero. That is, the implied domain is $\{m \mid m \geq 0\}$ or, using interval notation, $[0, \infty)$.

**d.** $C(124) = 0.12(124) + 35 = 49.88$

If 124 miles are driven during a one-day rental, the charge will be \$49.88.

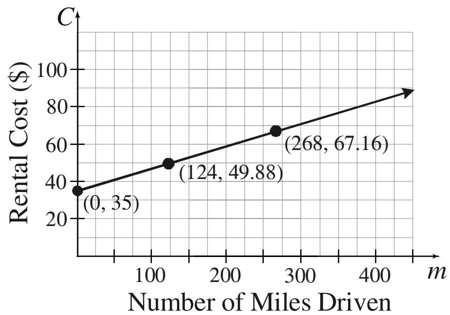
**e.** $0.12m + 35 = 67.16$

$0.12m = 32.16$

$m = 268$

If the charge for a one-day rental is \$67.16, then 268 miles were driven.

**f.**




**60. a.** $B(x) = 3.50x + 33.99$

**b.** The number of pay-per-view movies watched, $x$, is the independent variable. The monthly bill, $B$, is the dependent variable.

**c.** Because the number pay-per-view movies watched cannot be negative, it must be greater than or equal to zero. That is, the implied domain is $\{x \mid x \geq 0\}$ or, using interval notation, $[0, \infty)$.

**d.** $B(5) = 3.50(5) + 33.99 = 51.49$

If 5 pay-per-view movies are watched one month, the bill will be \$51.49.

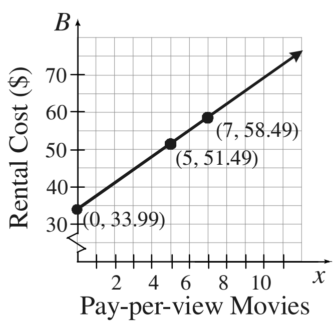
**e.** $3.50x + 33.99 = 58.49$

$3.50x = 24.50$

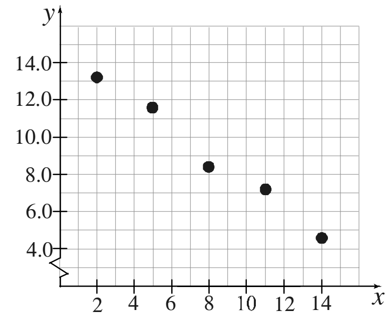
$x = 7$

If the bill one month is \$58.49, then 7 pay-per-view movies were watched.

**f.**




**61. a.**




**b.** Answers will vary. We will use the points (2, 13.3) and (14, 4.6).

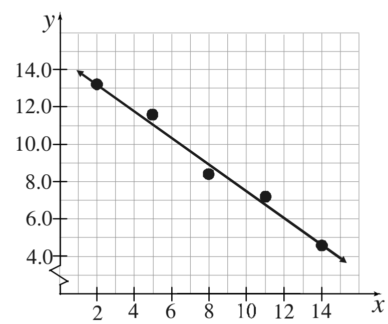
$$m = \frac{4.6 - 13.3}{14 - 2} = \frac{-8.7}{12} = -0.725$$

$$y - 13.3 = -0.725(x - 2)$$

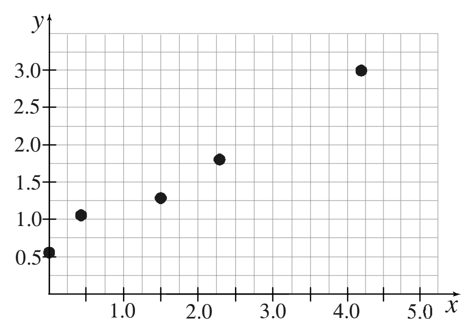
$$y - 13.3 = -0.725x + 1.45$$

$$y = -0.725x + 14.75$$

**c.**




**62. a.**




**b.** Answers will vary. We will use the points (0, 0.6) and (4.2, 3.0).

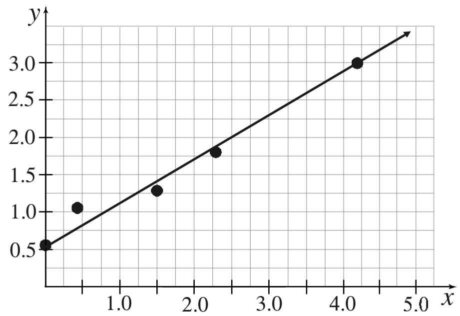
$$m = \frac{3.0 - 0.6}{4.2 - 0} = \frac{2.4}{4.2} = \frac{4}{7}$$

$$y - 0.6 = \frac{4}{7}(x - 0)$$

$$y - 0.6 = \frac{4}{7}x$$

$$y = \frac{4}{7}x + 0.6$$

**c.**

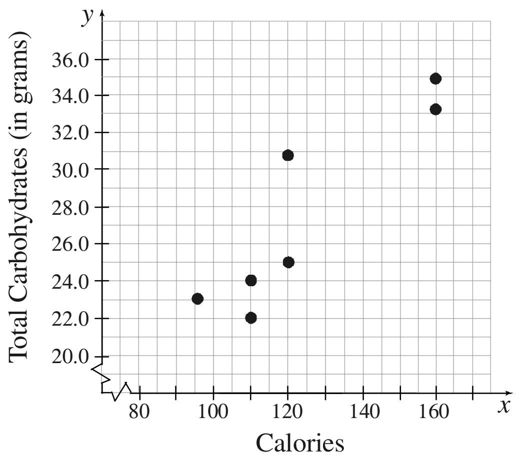



**e.** $x = 140$: $y = 0.158(140) + 8.032$
$= 30.152$

We predict that a one-cup serving of cereal having 140 calories will have approximately 30.2 grams of total carbohydrates.

**f.** The slope of the line found is 0.158. This means that, in a one-cup serving of cereal, total carbohydrates will increase by 0.158 gram for each one-calorie increase.

**63. a.**




**b.** Approximately linear

**c.** Answers will vary. We will use the points (96, 23.2) and (160, 33.3).

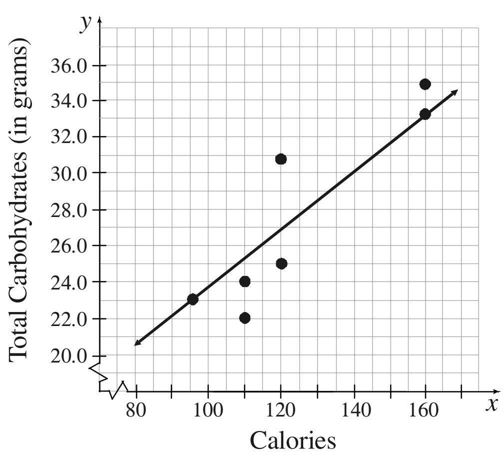
$$m = \frac{33.3 - 23.2}{160 - 96} = \frac{10.1}{64} \approx 0.158$$

$$y - 23.2 = 0.158(x - 96)$$

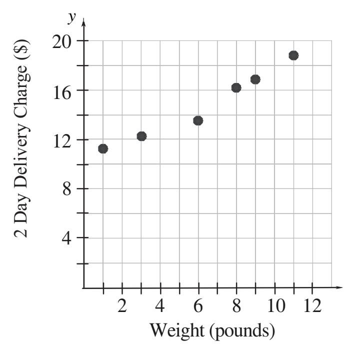
$$y - 23.2 = 0.158x - 15.168$$

$$y = 0.158x + 8.032$$

**d.**




**64. a.**




**b.** Approximately linear

**c.** Answers will vary. We will use the points (3, 12.2) and (9, 16.9).

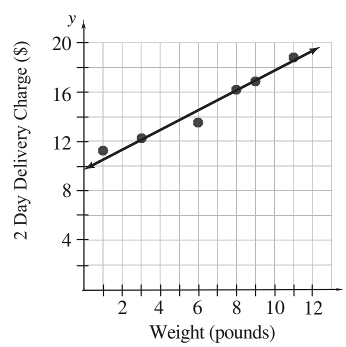
$$m = \frac{16.9 - 12.2}{9 - 3} = \frac{4.7}{6} \approx 0.78$$

$$y - 16.9 \approx 0.78(x - 9)$$

$$y - 16.9 = 0.78x - 7.05$$

$$y = 0.78x + 9.85$$

**d.**




**e.** $x = 5$: $y = 0.78(5) + 9.85 = 13.75$

We predict that the FedEx 2Day delivery charge for a 5-pound package would be $13.75.

**f.** The slope of the line is 0.78. If the weight of a package increases by 1 pound, the shipping charge increases by $0.78.

**65.** $A \cup B = \{-1, 0, 1, 2, 3, 4, 6, 8\}$

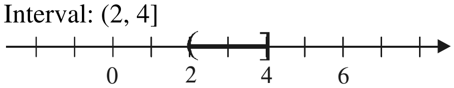
**66.** $A \cap C = \{2, 4\}$

**67.** $B \cap C = \{1, 2, 3, 4\}$

**68.** $A \cup C = \{1, 2, 3, 4, 6, 8\}$

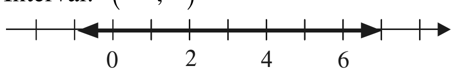
**69.** **a.** $A \cap B = \{x \mid 2 < x \leq 4\}$

Interval: (2, 4]




**b.** $A \cup B = \{x \mid x \text{ is a real number}\}$

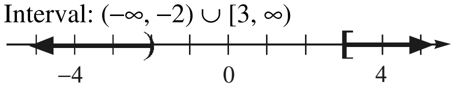
Interval: $(-\infty, \infty)$




**70.** **a.** $E \cap F = \{\ \}$ or $\varnothing$

**b.** $E \cup F = \{x \mid x < -2 \text{ or } x \geq 3\}$

Interval: $(-\infty, -2) \cup [3, \infty)$




**71.** $x < 4$ and $x + 3 > 2$

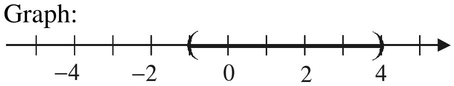
$x > -1$

The intersection of $x < 4$ and $x > -1$ is $-1 < x < 4$.

Set-builder: $\{x \mid -1 < x < 4\}$

Interval: (–1, 4)

Graph:



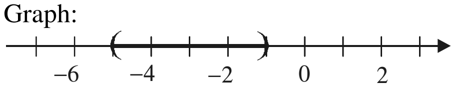

**72.**

$$3 < 2 - x < 7$$
$$3 - 2 < 2 - x - 2 < 7 - 2$$
$$1 < -x < 5$$
$$-1(1) > -1(-x) > -1(5)$$
$$-1 > x > -5$$
$$-5 < x < -1$$

Set-builder: $\{x \mid -5 < x < -1\}$

Interval: (–5, –1)

Graph:




**73.** $x + 3 < 1$ or $x > 2$

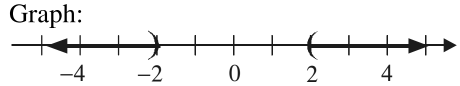
$x < -2$

The union of the two sets is $x < -2$ or $x > 2$.

Set-builder: $\{x \mid x < -2 \text{ or } x > 2\}$

Interval: $(-\infty, -2) \cup (2, \infty)$

Graph:




**74.** $x + 6 \geq 10$ or $x \leq 0$

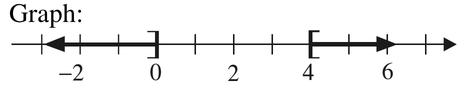
$x \geq 4$

The union of the two sets is $x \geq 4$ or $x \leq 0$.

Set-builder: $\{x \mid x \leq 0 \text{ or } x \geq 4\}$

Interval: $(-\infty, 0] \cup [4, \infty)$

Graph:




**75.** $3x + 2 \leq 5$ and $-4x + 2 \leq -10$

$3x \leq 3$ $\quad -4x \leq -12$

$x \leq 1$ $\quad x \geq 3$

The intersection of $x \leq 1$ and $x \geq 3$ is the empty set.

Solution set: $\{\ \}$ or $\varnothing$

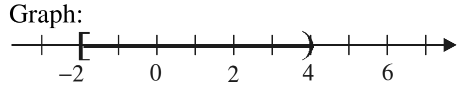
**76.**

$$1 \leq 2x + 5 < 13$$
$$1 - 5 \leq 2x + 5 - 5 < 13 - 5$$
$$-4 \leq 2x < 8$$
$$\frac{-4}{2} \leq \frac{2x}{2} < \frac{8}{2}$$
$$-2 \leq x < 4$$

Set-builder: $\{x \mid -2 \leq x < 4\}$

Interval: [–2, 4)

Graph:




**77.** $x - 3 \leq -5$ or $2x + 1 > 7$

$x \leq -2$ $\quad 2x > 6$

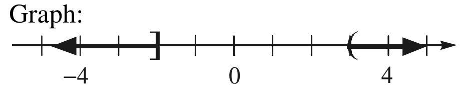
$x > 3$

The union of the two sets is $x \leq -2$ or $x > 3$.

Set-builder: $\{x \mid x \leq -2 \text{ or } x > 3\}$

Interval: $(-\infty, -2] \cup (3, \infty)$

Graph:




**78.** $3x + 4 > -2$ or $4 - 2x \geq -6$

$3x > -6$ $\quad -2x \geq -10$

$x > -2$ $\quad x \leq 5$

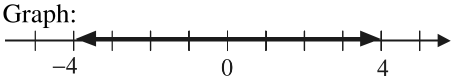
The union of the two sets is $x > -2$ or $x \leq 5$.

Set-builder: $\{x \mid x \text{ is any real number}\}$

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

Graph:




**79.** $\frac{1}{3}x > 2$ or $\frac{2}{5}x < -4$

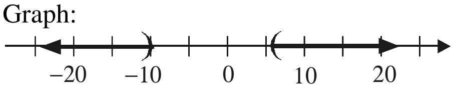
$x > 6$ $\quad$ $x < -10$

The union of the two sets is $x < -10$ or $x > 6$.

Set-builder: $\{x \mid x < -10 \text{ or } x > 6\}$

Interval: $(-\infty, -10) \cup (6, \infty)$

Graph:




**80.** $x + \frac{3}{2} \geq 0$ and $-2x + \frac{3}{2} > \frac{1}{4}$

$x \geq -\frac{3}{2}$ $\quad$ $-2x > -\frac{5}{4}$

$x < \frac{5}{8}$

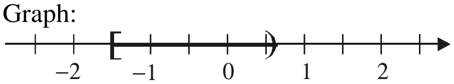
The intersection of $x \geq -\frac{3}{2}$ and $x < \frac{5}{8}$ is

$-\frac{3}{2} \leq x < \frac{5}{8}$.

Set-builder: $\left\{x \,\middle|\, -\frac{3}{2} \leq x < \frac{5}{8}\right\}$

Interval: $\left[-\frac{3}{2}, \frac{5}{8}\right)$

Graph:




**81.** $70 \leq x \leq 75$

**82.** Let $x$ = number of kilowatt-hours. Then, the number of kilowatt-hours for usage above 800 kwh is given by the expression $x - 800$. Solve the following inequality:

$$52.62 \leq 43.56 + 0.038752(x - 800) \leq 88.22$$
$$9.06 \leq 0.038752(x - 800) \leq 44.66$$
$$\frac{9.06}{0.038752} \leq x - 800 \leq \frac{44.66}{0.038752}$$
$$\frac{9.06}{0.038752} + 800 \leq x \leq \frac{44.66}{0.038752} + 800$$
$$1033.8 \leq x \leq 1952.5 \text{ (approx.)}$$

The electric usage varied from roughly 1033.8 kilowatt-hours to roughly 1952.5 kilowatt-hours.

**83.** $|x| = 4$

$x = 4$ or $x = -4$

Solution set: $\{-4, 4\}$

**84.** $|3x - 5| = 4$

$3x - 5 = 4$ or $3x - 5 = -4$

$3x = 9$ $\quad$ $3x = 1$

$x = 3$ $\quad$ $x = \frac{1}{3}$

Solution set: $\left\{\frac{1}{3}, 3\right\}$

**85.** $|-y + 4| = 9$

$-y + 4 = 9$ or $-y + 4 = -9$

$-y = 5$ $\quad$ $-y = -13$

$y = -5$ $\quad$ $y = 13$

Solution set: $\{-5, 13\}$

**86.** $-3|x + 2| - 5 = -8$

$-3|x + 2| = -3$

$|x + 2| = 1$

$x + 2 = 1$ or $x + 2 = -1$

$x = -1$ $\quad$ $x = -3$

Solution set: $\{-3, -1\}$

**87.** $|2w - 7| = -3$

This equation has no solution since an absolute value can never yield a negative result.

Solution set: $\{\ \}$ or $\varnothing$

**88.** $|x + 3| = |3x - 1|$

$x + 3 = 3x - 1$ or $x + 3 = -(3x - 1)$

$-2x = -4$ $\quad$ $x + 3 = -3x + 1$

$x = 2$ $\quad$ $4x = -2$

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

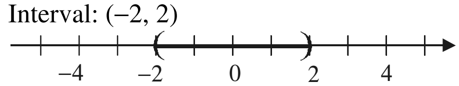
Solution set: $\left\{-\frac{1}{2}, 2\right\}$

**89.** $|x| < 2$

$-2 < x < 2$

Set-builder: $\{x \mid -2 < x < 2\}$

Interval: $(-2, 2)$

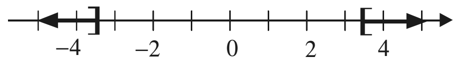


**90.** $|x| \ge \frac{7}{2}$

$x \le -\frac{7}{2}$ or $x \ge \frac{7}{2}$

Set-builder: $\left\{x \middle| x \le -\frac{7}{2} \text{ or } x \ge \frac{7}{2}\right\}$

Interval: $\left(-\infty, -\frac{7}{2}\right] \cup \left[\frac{7}{2}, \infty\right)$




**91.** $|x+2| \le 3$

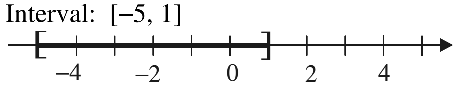
$-3 \le x+2 \le 3$

$-3-2 \le x+2-2 \le 3-2$

$-5 \le x \le 1$

Set-builder: $\{x \mid -5 \le x \le 1\}$

Interval: $[-5, 1]$




**92.** $|4x-3| \ge 1$

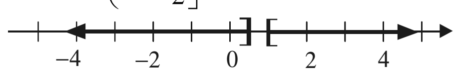
$4x-3 \le -1$ or $4x-3 \ge 1$

$4x \le 2$ $\qquad$ $4x \ge 4$

$x \le \frac{1}{2}$ $\qquad$ $x \ge 1$

Set-builder: $\left\{x \middle| x \le \frac{1}{2} \text{ or } x \ge 1\right\}$

Interval: $\left(-\infty, \frac{1}{2}\right] \cup [1, \infty)$




**93.** $3|x|+6 \ge 1$

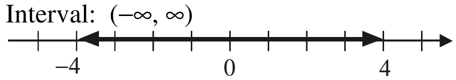
$3|x| \ge -5$

$|x| \ge -\frac{5}{3}$

Since the result of an absolute value is always nonnegative, any real number is a solution to this inequality.

Set-builder: $\{x \mid x \text{ is a real number}\}$

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




**94.** $|7x+5|+4 < 3$

$|7x+5| < -1$

Since the result of an absolute value is never negative, this inequality has no solutions.

Solution set: $\{\ \}$ or $\varnothing$

**95.** $|(x-3)-2| \le 0.01$

$|x-3-2| \le 0.01$

$|x-5| \le 0.01$

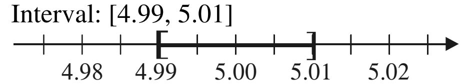
$-0.01 \le x-5 \le 0.01$

$-0.01+5 \le x-5+5 \le 0.01+5$

$4.99 \le x \le 5.01$

Set-builder: $\{x \mid 4.99 \le x \le 5.01\}$

Interval: $[4.99, 5.01]$




**96.** $\left|\frac{2x-3}{4}\right| > 1$

$\frac{2x-3}{4} < -1$ or $\frac{2x-3}{4} > 1$

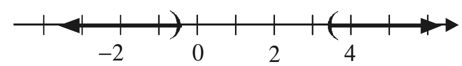
$2x-3 < -4$ $\qquad$ $2x-3 > 4$

$2x < -1$ $\qquad$ $2x > 7$

$x < -\frac{1}{2}$ $\qquad$ $x > \frac{7}{2}$

Solution set: $\left\{x \middle| x < -\frac{1}{2} \text{ or } x > \frac{7}{2}\right\}$

Interval: $\left(-\infty, -\frac{1}{2}\right) \cup \left(\frac{7}{2}, \infty\right)$




**97.** $|x-0.503| \le 0.001$

$-0.001 \le x-0.503 \le 0.001$

$0.502 \le x \le 0.504$

The acceptable diameters of the bearing are between 0.502 inch and 0.504 inch, inclusive.

**98.** $\left|\frac{x-40}{2}\right| > 1.96$

$\frac{x-40}{2} < -1.96$ or $\frac{x-40}{2} > 1.96$

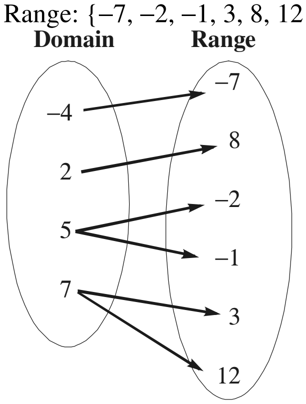
$x-40 < -3.92$ $\qquad$ $x-40 > 3.92$

$x < 36.08$ $\qquad$ $x > 43.92$

Tensile strengths below $36.08 \text{ lb/in.}^2$ or above $43.92 \text{ lb/in.}^2$ would be considered unusual.

## Chapter 2 Test

**1.** Domain: $\{-4, 2, 5, 7\}$
Range: $\{-7, -2, -1, 3, 8, 12\}$

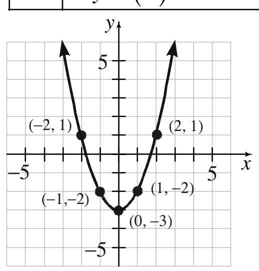



**2.** Domain: $\left\{x \middle| -\frac{5\pi}{2} \le x \le \frac{5\pi}{2}\right\}$ or $\left[-\frac{5\pi}{2}, \frac{5\pi}{2}\right]$

Range: $\{y \mid 1 \le y \le 5\}$ or $[1, 5]$

**3.** $y = x^2 - 3$

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




Domain: $\{x \mid x \text{ is a real number}\}$ or $(-\infty, \infty)$

Range: $\{y \mid y \ge -3\}$ or $[-3, \infty)$

**4.** Function. Each element in the domain corresponds to exactly one element in the range.
Domain: $\{-5, -3, 0, 2\}$
Range: $\{3, 7\}$

**5.** Not a function. The graph fails the vertical line test so it is not the graph of a function.
Domain: $\{x \mid x \le 3\}$ or $(-\infty, 3]$

Range: $\{y \mid y \text{ is a real number}\}$ or $(-\infty, \infty)$

**6.** No, $y = \pm 5x$ is not a function because a single input, $x$, can yield two different outputs. For example, if $x = 1$ then $y = -5$ or $y = 5$.

**7.** $f(x+h) = -3(x+h) + 11 = -3x - 3h + 11$

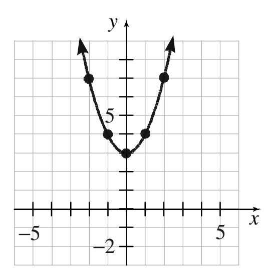
**8. a.** $g(-2) = 2(-2)^2 + (-2) - 1 = 2(4) - 3$
$= 8 - 3 = 5$

**b.** $g(0) = 2(0)^2 + (0) - 1 = 0 + 0 - 1 = -1$

**c.** $g(3) = 2(3)^2 + (3) - 1$
$= 2(9) + 2$
$= 18 + 2$
$= 20$

**9.** $f(x) = x^2 + 3$

| $x$ | $y = f(x) = x^2 + 3$ | $(x, y)$ |
|---|---|---|
| $-2$ | $f(-2) = (-2)^2 + 3 = 7$ | $(-2, 7)$ |
| $-1$ | $f(-1) = (-1)^2 + 3 = 4$ | $(-1, 4)$ |
| $0$ | $f(0) = (0)^2 + 3 = 3$ | $(0, 3)$ |
| $1$ | $f(1) = (1)^2 + 3 = 4$ | $(1, 4)$ |
| $2$ | $f(2) = (2)^2 + 3 = 7$ | $(2, 7)$ |




**10. a.** The dependent variable is the ticket price, $P$, and the independent variable is the number of years after 1996, $x$.

**b.** $P(25) = 0.22(25) + 4.44 = 9.94$
According to the model, the average ticket price in 2021 ($x = 25$) will be \$9.94.

**c.** $12 = 0.22x + 4.44$
$7.56 = 0.22x$
$34 \approx x$
According to the model, the average movie ticket price will be \$12.00 in 2030 ($x = 34$).

**11.** The function involves division by $x + 2$. Since we can't divide by zero, we need $x \neq -2$.
Domain: $\{x \mid x \neq -2\}$

**12. a.**
$$h(2) = -5(2) + 12 \\ = -10 + 12 \\ = 2$$
Since $h(2) = 2$, the point (2, 2) is on the graph of the function.

**b.**
$$h(3) = -5(3) + 12 \\ = -15 + 12 \\ = -3$$
Since $h(3) = -3$, the point (3, −3) is on the graph of the function.

**c.**
$$h(x) = 27 \\ -5x + 12 = 27 \\ -5x = 15 \\ x = -3$$
The point (−3, 27) is on the graph of $h$.

**d.**
$$h(x) = 0 \\ -5x + 12 = 0 \\ -5x = -12 \\ x = \frac{12}{5}$$
$\frac{12}{5}$ is the zero of $h$.

**13. a.** The car stops accelerating when the speed stops increasing. Thus, the car stops accelerating after 6 seconds.

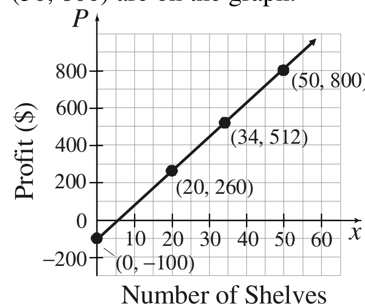
**b.** The car has a constant speed when the graph is horizontal. Thus, the car maintains a constant speed for 18 seconds.

**14. a.** The profit is $18 times the number of shelves sold $x$, minus the $100 for renting the booth. Thus, the function is $P(x) = 18x - 100$.

**b.** The independent variable is the number of shelves sold, $x$. Henry could not sell a negative number of shelves. Thus, the domain of $P$ is $\{x \mid x \geq 0\}$ or, using interval notation, $[0, \infty)$.

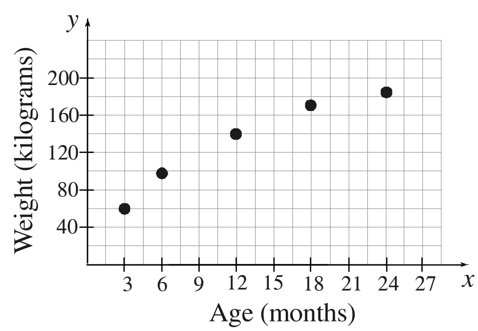
**c.**
$$P(34) = 18(34) - 100 \\ = 512$$
If Henry sells 34 shelves, his profit will be $512.

**d.** Evaluate $P$ at $x$ = 0, 20, and 50.
$$P(0) = 18(0) - 100 \\ = -100$$
$$P(20) = 18(20) - 100 \\ = 260$$
$$P(50) = 18(50) - 100 \\ = 800$$
Thus, the points (0, −100), (20, 260), and (50, 800) are on the graph.




**e.** Solve $P(x) = 764$.
$$18x - 100 = 764 \\ 18x = 864 \\ x = 48$$
If Henry sells 48 shelves, his profit will be $764.

**15. a.**




**b.** Approximately linear

**c.** Answers will vary. We will use the points (6, 95) and (18, 170).
$$m = \frac{170 - 95}{18 - 6} = \frac{75}{12} = 6.25$$
$$y - 95 = 6.25(x - 6) \\ y - 95 = 6.25x - 37.5 \\ y = 6.25x + 57.5$$

**d.**

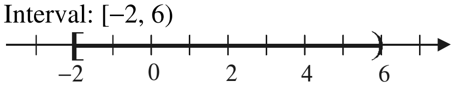

**e.** $x = 9$: $y = 6.25(9) + 57.5$
$= 113.75$

We predict that a 9-month-old Shetland pony will weigh 113.75 kilograms.

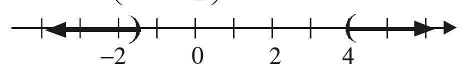
**f.** The slope of the line found is 6.25. This means that a Shetland pony's weight will increase by 6.25 kilograms for each one-month increase in age.

**16.** $|2x+5|-3=0$
$|2x+5|=3$
$2x+5=-3$ or $2x+5=3$
$2x=-8$ $\quad$ $2x=-2$
$x=-4$ $\quad$ $x=-1$
Solution set: $\{-4, -1\}$

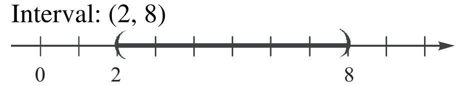
**17.** $x+2<8$ and $2x+5 \ge 1$
$x<6$ $\quad$ $2x \ge -4$
$x \ge -2$
The intersection of $x \ge -2$ and $x < 6$ is $-2 \le x < 6$.
Set-builder: $\{x \mid -2 \le x < 6\}$
Interval: $[-2, 6)$




**18.** $x > 4$ or $2(x-1)+3<-2$
$2x-2+3<-2$
$2x+1<-2$
$2x+1-1<-2-1$
$2x<-3$
$\frac{2x}{2}<\frac{-3}{2}$
$x<-\frac{3}{2}$
The union of the two sets is $x > 4$ or $x<-\frac{3}{2}$.
Set-builder: $\left\{x \middle| x<-\frac{3}{2} \text{ or } x>4\right\}$
Interval: $\left(-\infty, -\frac{3}{2}\right) \cup (4, \infty)$




**19.** $2|x-5|+1<7$
$2|x-5|<6$
$|x-5|<3$
$-3<x-5<3$
$2<x<8$
Set-builder: $\{x \mid 2<x<8\}$
Interval: $(2, 8)$




**20.** $|-2x+1| \ge 5$
$-2x+1 \le -5$ or $-2x+1 \ge 5$
$-2x \le -6$ $\quad$ $-2x \ge 4$
$x \ge 3$ $\quad$ $x \le -2$
Set-builder: $\{x \mid x \le -2 \text{ or } x \ge 3\}$
Interval: $(-\infty, -2] \cup [3, \infty)$