Chapter 3

Introduction to Graphing

Exercise Set 3.1

1. The x-values extend from -9 to 4 and the y-values range from -1 to 5, so (a) is the best choice.

3. The x-values extend from -2 to 4 and the y-values range from -9 to 1, so (b) is the best choice.

5. We go to the top of the bar that is above the body weight 100 lb. Then we move horizontally from the top of the bar to the vertical scale listing numbers of drinks. It appears that consuming approximately 2 drinks in one hour will give a 100 lb person a blood-alcohol level of 0.08%.

7. For 3 drinks in one hour, we use the horizontal line at 3. For persons weighing 140 lb or less, their blood-alcohol level is 0.08% or more For persons weighing more than 140 lbs. their blood-alcohol level is under 0.08%. Therefore the person weighs more than 140 lbs.

9. ***Familiarize***. From the pie chart we see that 51% of student aid is Federal loans. The average aid is the total aid distributed of \$134.8 billion divided by the total number of full-time students, 13,334,170, or

$$\frac{\$134.8\text{billion}}{13,334,170}$$

Let f = the average federal loan per full-time student.

Translate. We reword and translate the problem.

$$\begin{array}{ccccc} \text{What} & \text{is} & 51\% & \text{of} & \frac{\$134.8}{13,334,170}\text{ billion?} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ f & = & 51\% & \cdot & \dfrac{134.8}{13,334,170} \end{array}$$

Carry out. We solve the equation.

$$f = 0.51 \cdot \frac{134.8}{13,334,170} = \$5156$$

Check. We repeat the calculations. The answer checks.

State. The average federal loan per full-time equivalent student is \$5156.

11. ***Familiarize***. From the pie chart we see that 2% of the total aid is Federal campus-based, or 2% of \$134.8 billion = \$2.696 billion. Let t = the amount given to students in two-year public institutions.

Translate. We reword the problem.

$$\begin{array}{ccccc} \text{What} & \text{is} & 8.6\% & \text{of} & 2.696? \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ t & = & 8.6\% & \cdot & 2.696 \end{array}$$

Carry out.

$$t = 0.086 \cdot 2.696 = 0.231856 \text{ billion}$$

Check. We repeat the calculations.

State. In 2006 the campus-based aid given to students at

13. ***Familiarize***. From the pie chart we see that 11.9% of solid waste is plastic. We let p = the amount of plastic, in millions of tons, in the waste generated in 2005.

Translate. We reword the problem.

$$\begin{array}{ccccc} \text{What} & \text{is} & 11.9\% & \text{of} & 245? \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ x & = & 11.9\% & \cdot & 245 \end{array}$$

Carry out.

$$p = 0.119 \cdot 245 \approx 29.2$$

Check. We can repeat the calculations.

State. In 2005, about 29.2 million tons of waste was plastic.

15. ***Familiarize***. From the pie chart we see that 5.2% of solid waste is glass. From Exercise 13 we know that Americans generated 245 million tons of waste in 2005. Then the amount of this that is glass is

$$0.052(245), \text{ or } 12.74 \text{ million tons}$$

We let g = the amount of glass, in millions of tons, that Americans recycled in 2005.

Translate. We reword the problem.

$$\begin{array}{ccccc} \text{What} & \text{is} & 25.3\% & \text{of} & 12.74 \text{ million tons?} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ g & = & 25.3\% & \cdot & 12.74 \end{array}$$

Carry out.

$$x = 0.253(12.74) \approx 3.2$$

Check. The result checks.

State. Americans recycled about 3.2 million tons of glass in 2005.

17. We locate 2002 on the horizontal axis and then move up to the line. From there we move left to the vertical axis and read the value of home videos, in billions. We estimate that about \$12 billion was spent on home videos in 2002.

19. We locate 10.5 on the vertical axis and move right to the line. From there we move down to the horizontal scale and read the year. We see that approximately \$10.5 billion was spent on home videos in 2001.

21. Starting at the origin:

(1,2) is 1 unit right and 2 units up;

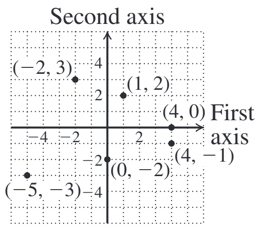
$(-2, 3)$ is 2 units left and 3 units up;

$(4, -1)$ is 4 units right and 1 unit down;

$(-5, -3)$ is 5 units left and 3 units down;

(4,0) is 4 units right and 0 units up or down;

$(0,-2)$ is 0 units right or left and 2 units down.



23. Starting at the origin:

(4,4) is 4 units right and 4 units up;

$(-2,4)$ is 2 units left and 4 units up;

$(5,-3)$ is 5 units right and 3 units down;

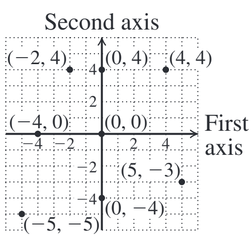
$(-5,-5)$ is 5 units left and 5 units down;

(0,4) is 0 units right or left and 4 units up;

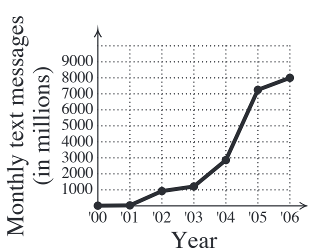
$(0,-4)$ is 0 units right or left and 4 units down;

(0,0) is 0 units right and 0 units up or down;

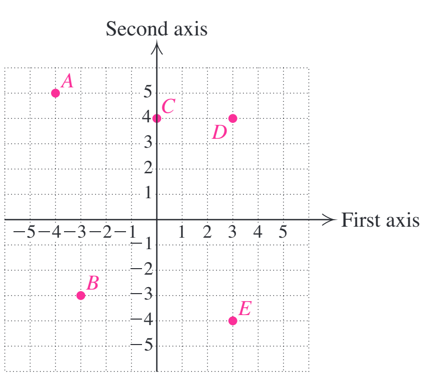
$(-4,0)$ is 4 units left and 0 units up or down.



25. We plot the points (2000, 12), (2001, 34), (2002, 931), (2003, 1221), (2004, 2862), (2005, 7253) and (2006, 8000)and connect adjacent points with line segments.



27.



Point A is 4 units left and 5 units up. The coordinates of A are $(-4,5)$.

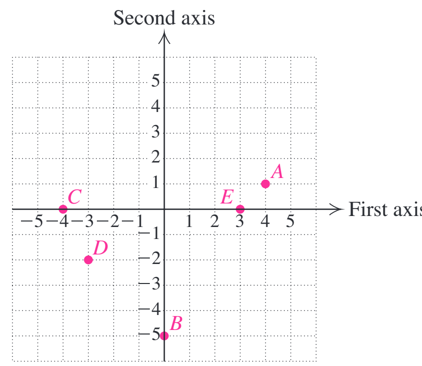
Point B is 3 units left and 3 units down. The coordinates of B are $(-3,-3)$.

Point C is 0 units right or left and 4 units up. The coordinates of C are (0,4).

Point D is 3 units right and 4 units up. The coordinates of D are (3,4).

Point E is 3 units right and 4 units down. The coordinates of E are $(3,-4)$.

29.



Point A is 4 units right and 1 unit up. The coordinates of A are (4,1).

Point B is 0 units right or left and 5 units down. The coordinates of B are $(0,-5)$.

Point C is 4 units left and 0 units up or down. The coordinates of C are $(-4,0)$.

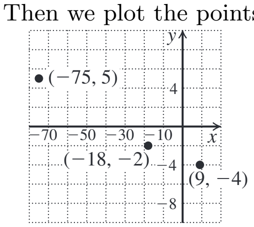
Point D is 3 units left and 2 units down. The coordinates of D are $(-3,-2)$.

Point E is 3 units right and 0 units up or down. The coordinates of E are (3,0).

31. Since the x-values range from -75 to 9, the 10 horizontal squares must span $9-(-75)$, or 84 units. Since 84 is close to 100 and it is convenient to count by 10's, we can count backward from 0 eight squares to -80 and forward from 0 two squares to 20 for a total of $8+2$, or 10 squares.

Since the y-values range from -4 to 5, the 10 vertical squares must span $5-(-4)$, or 9 units. It will be convenient to count by 2's in this case. We count down from 0 five squares to -10 and up from 0 five squares to 10 for a total of $5+5$, or 10 squares. (Instead, we might have chosen to count by 1's from -5 to 5.)

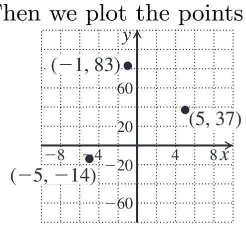
Then we plot the points $(-75,5)$, $(-18,-2)$, and $(9,-4)$.



33. Since the x-values range from -5 to 5, the 10 horizontal squares must span $5-(-5)$, or 10 units. It will be convenient to count by 2's in this case. We count backward from 0 five squares to -10 and forward from 0 five squares

Since the y-values range from -14 to 83, the 10 vertical squares must span $83-(-14)$, or 97 units. To include both -14 and 83, the squares should extend from about -20 to 90, or $90-(-20)$, or 110 units. We cannot do this counting by 10's, so we use 20's instead. We count down from 0 four units to -80 and up from 0 six units to 120 for a total of $4+6$, or 10 units. There are other ways to cover the values from -14 to 83 as well.

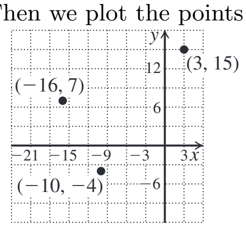
Then we plot the points $(-1, 83)$, $(-5, -14)$, and $(5, 37)$.



35. Since the x-values range from -16 to 3, the 10 horizontal squares must span $3-(-16)$, or 19 units. We could number by 2's or 3's. We number by 3's, going backward from 0 eight squares to -24 and forward from 0 two squares to 6 for a total of $8+2$, or 10 squares.

Since the y-values range from -4 to 15, the 10 vertical squares must span $15-(-4)$, or 19 units. We will number the vertical axis by 3's as we did the horizontal axis. We go down from 0 four squares to -12 and up from 0 six squares to 18 for a total of $4+6$, or 10 squares.

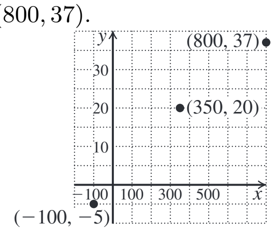
Then we plot the points $(-10, -4)$, $(-16, 7)$, and $(3, 15)$.



37. Since the x-values range from -100 and 800, the 10 horizontal squares must span $800-(-100)$, or 900 units. Since 900 is close to 1000 we can number by 100's. We go backward from 0 two squares to -200 and forward from 0 eight squares to 800 for a total of $2+8$, or 10 squares. (We could have numbered from -100 to 900 instead.)

Since the y-values range from -5 to 37, the 10 vertical squares must span $37-(-5)$, or 42 units. Since 42 is close to 50, we can count by 5's. We go down from 0 two squares to -10 and up from 0 eight squares to 40 for a total of $2+8$, or 10 squares.

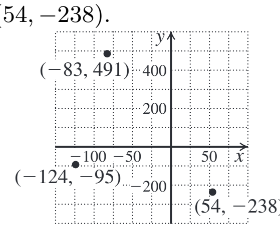
Then we plot the points $(-100, -5)$, $(350, 20)$, and $(800, 37)$.



39. Since the x-values range from -124 to 54, the 10 horizontal squares must span $54-(-124)$, or 178 units. We can number by 25's. We go backward from 0 six squares to -150 and forward from 0 four squares to 100 for a total of $6+4$, or 10 squares.

Since the y-values range from -238 to 491, the 10 vertical squares must span $491-(-238)$, or 729 units. We can number by 100's. We go down from 0 four squares to -400 and up from 0 six squares to 600 for a total of $4+6$, or 10 squares.

Then we plot the points $(-83, 491)$, $(-124, -95)$, and $(54, -238)$.



41. Since the first coordinate is positive and the second coordinate negative, the point $(7, -2)$ is located in quadrant IV.

43. Since both coordinates are negative, the point $(-4, -3)$ is in quadrant III.

45. Since both coordinates are positive, the point $(2, 1)$ is in quadrant I.

47. Since the first coordinate is negative and the second coordinate is positive, the point $(-4.9, 8.3)$ is in quadrant II.

49. First coordinates are positive in the quadrants that lie to the right of the origin, or in quadrants I and IV.

51. Points for which both coordinates are positive lie in quadrant I, and points for which both coordinates are negative life in quadrant III. Thus, both coordinates have the same sign in quadrants I and III.

53. Writing Exercise. The vertical scale above 80¢ is not labeled. The actual years in question are not given either.

55.

$$5y = 2x$$
$$y = \frac{2}{5}x \qquad \text{Divide both sides by 5}$$

57.

$$x - y = 8$$
$$-y = -x + 8 \qquad \text{Add } -x \text{ to both sides}$$
$$y = x - 8$$

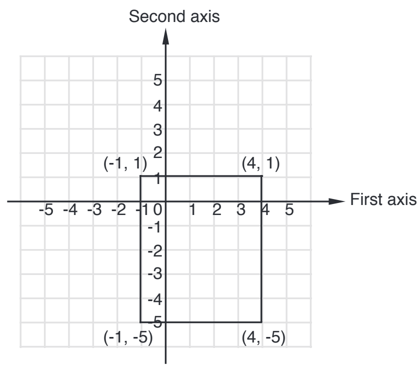
59.

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

61. Writing Exercise. As time passes from 2004-6, the line graph is almost horizontal. The indicates that there is no new business involving home videos.

63. The coordinates have opposite signs, so the point could be in quadrant II or quadrant IV.

65.

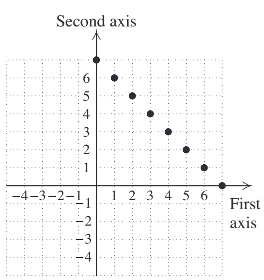


The coordinates of the fourth vertex are $(-1, -5)$.

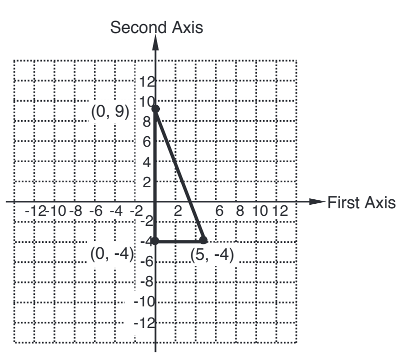
67. Answers may vary.

We select eight points such that the sum of the coordinates for each point is 7.

$$\begin{array}{ll} (0,7) & 0+7=7 \\ (1,6) & 1+6=7 \\ (2,5) & 2+5=7 \\ (3,4) & 3+4=7 \\ (4,3) & 4+3=7 \\ (5,2) & 5+2=7 \\ (6,1) & 6+1=7 \\ (7,0) & 7+0=7 \end{array}$$



69.



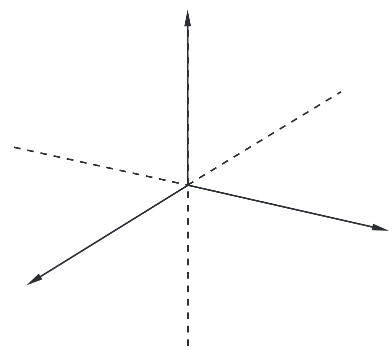
The base is 5 units and the height is 13 units.

$$A = \frac{1}{2}bh = \frac{1}{2}\cdot 5\cdot 13 = \frac{65}{2}\text{ sq units, or } 32\frac{1}{2}\text{ sq units}$$

71. Latitude $27^{\square}$ North,

Longitude $81^{\square}$ West

73. Writing Exercise. Eight "quadrants" will exist. Think of the coordinate system being formed by the intersection of one coordinate plane with another plane perpendicular to one of its axes such that the origins of the two planes coincide. Then there are four quadrants "above" the x,y-plane and four "below" it.



Exercise Set 3.2

1. False. A linear equation in two variables has infinitely many ordered pairs that are solutions.

3. True. All of the points on the graph of the line are solutions to the equation.

5. True. A solution may be found by selecting a value for x and solving for y. The ordered pair is a solution to the equation.

7. We substitute 2 for x and 1 for y.

$$\begin{array}{c|l} \multicolumn{2}{c}{y = 4x - 7} \\ \hline 1 & 4(2) - 7 \\ & 8 - 7 \\ \end{array}$$
$$1 \stackrel{?}{=} 1 \qquad \text{TRUE}$$

Since $1 = 1$ is true, the pair (2,1) is a solution.

9. We substitute 5 for x and 1 for y.

$$\begin{array}{r|l} \multicolumn{2}{c}{3y + 4x = 19} \\ \hline 3(1) + 4(5) & 19 \\ 3 + 20 & \\ \end{array}$$
$$23 \stackrel{?}{=} 19 \quad \text{FALSE}$$

Since $23 = 19$ is false, the pair $(5, 1)$ is not a solution.

11. We substitute 3 for m and -1 for n.

$$\begin{array}{r|l} \multicolumn{2}{c}{4m - 5n = 7} \\ \hline 4(3) - 5(-1) & 7 \\ 12 + 5 & \\ \end{array}$$
$$17 \stackrel{?}{=} 7 \quad \text{FALSE}$$

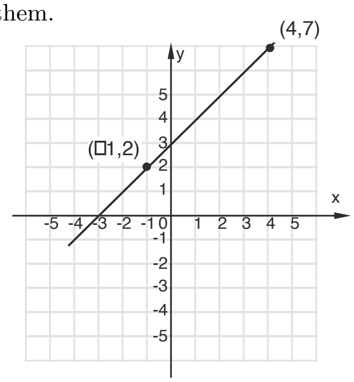
Since $17 = 7$ is false, the pair $(3, -1)$ is not a solution.

13. To show that a pair is a solution, we substitute, replacing x with the first coordinate and y with the second coordinate in each pair.

$$\begin{array}{c|c} \multicolumn{2}{c}{y = x + 3} \\ \hline 2 & -1 + 3 \\ \end{array}$$
$$2 \stackrel{?}{=} 2 \qquad \text{TRUE}$$

$$\begin{array}{c|c} \multicolumn{2}{c}{y = x + 3} \\ \hline 7 & 4 + 3 \\ \end{array}$$
$$7 \stackrel{?}{=} 7 \qquad \text{TRUE}$$

In each case the substitution results in a true equation. Thus, $(-1, 2)$ and $(4, 7)$ are both solutions of $y = x + 3$. We graph these points and sketch the line passing through them.



The line appears to pass through $(0, 3)$ also. We check to determine if $(0, 3)$ is a solution of $y = x + 3$.

$$\begin{array}{c|c} \multicolumn{2}{c}{y = x + 3} \\ \hline 3 & 0 + 3 \\ \end{array}$$
$$3 \stackrel{?}{=} 3 \qquad \text{TRUE}$$

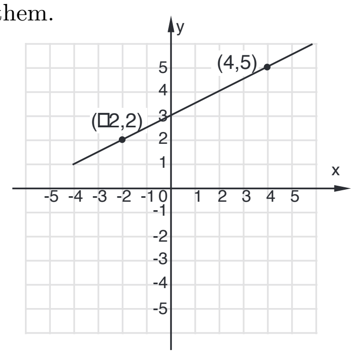
Thus, $(0, 3)$ is another solution. There are other correct answers, including $(-5, -2)$, $(-4, -1)$, $(-3, 0)$, $(-2, 1)$, $(1, 4)$, $(2, 5)$, and $(3, 6)$.

15. To show that a pair is a solution, we substitute, replacing x with the first coordinate and y with the second coordinate in each pair.

$$\begin{array}{c|l} \multicolumn{2}{c}{y = \frac{1}{2}x + 3} \\ \hline 5 & \frac{1}{2} \cdot 4 + 3 \\ & 2 + 3 \\ \end{array}$$
$$5 \stackrel{?}{=} 5 \qquad \text{TRUE}$$

$$\begin{array}{c|l} \multicolumn{2}{c}{y = \frac{1}{2}x + 3} \\ \hline 2 & \frac{1}{2}(-2) + 3 \\ & -1 + 3 \\ \end{array}$$
$$2 \stackrel{?}{=} 2 \qquad \text{TRUE}$$

In each case the substitution results in a true equation. Thus, $(4, 5)$ and $(-2, 2)$ are both solutions of $y = \frac{1}{2}x + 3$. We graph these points and sketch the line passing through them.



The line appears to pass through $(0, 3)$ also. We check to determine if $(0, 3)$ is a solution of $y = \frac{1}{2}x + 3$.

$$\begin{array}{c|l} \multicolumn{2}{c}{y = \frac{1}{2}x + 3} \\ \hline 3 & \frac{1}{2} \cdot 0 + 3 \\ \end{array}$$
$$3 \stackrel{?}{=} 3 \qquad \text{TRUE}$$

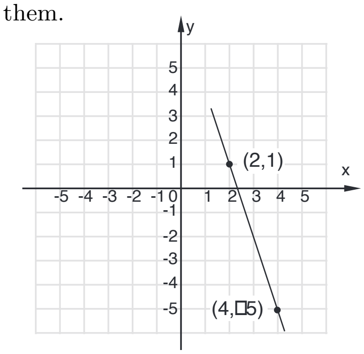
Thus, $(0, 3)$ is another solution. There are other correct answers, including $(-6, 0)$, $(-4, 1)$, $(2, 4)$, and $(6, 6)$.

17. To show that a pair is a solution, we substitute, replacing x with the first coordinate and y with the second coordinate in each pair.

$$\begin{array}{r|c} \multicolumn{2}{c}{y + 3x = 7} \\ \hline 1 + 3 \cdot 2 & 7 \\ 1 + 6 & \\ \end{array}$$
$$7 \stackrel{?}{=} 7 \quad \text{TRUE}$$

$$\begin{array}{r|c} \multicolumn{2}{c}{y + 3x = 7} \\ \hline -5 + 3 \cdot 4 & 7 \\ -5 + 12 & \\ \end{array}$$
$$7 \stackrel{?}{=} 7 \quad \text{TRUE}$$

In each case the substitution results in a true equation. Thus, $(2, 1)$ and $(4, -5)$ are both solutions of $y + 3x = 7$. We graph these points and sketch the line passing through them.



The line appears to pass through $(1, 4)$ also. We check to determine if $(1, 4)$ is a solution of $y + 3x = 7$.

$$\begin{array}{r|c} \multicolumn{2}{c}{y + 3x = 7} \\ \hline 4 + 3 \cdot 1 & 7 \\ 4 + 3 & \\ \end{array}$$
$$7 \stackrel{?}{=} 7 \quad \text{TRUE}$$

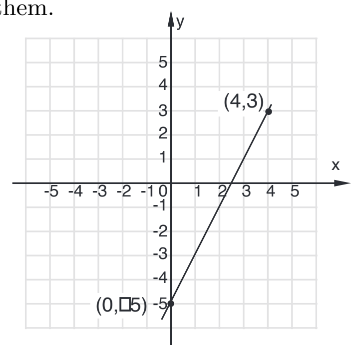
Thus, $(1, 4)$ is another solution. There are other correct answers, including $(3, -2)$.

19. To show that a pair is a solution, we substitute, replacing x with the first coordinate and y with the second coordinate in each pair.

$$\begin{array}{r|c} \multicolumn{2}{c}{4x - 2y = 10} \\ \hline 4 \cdot 0 - 2(-5) & 10 \\ \end{array}$$
$$10 \stackrel{?}{=} 10 \quad \text{TRUE}$$

$$\begin{array}{r|c} \multicolumn{2}{c}{4x - 2y = 10} \\ \hline 4 \cdot 4 - 2 \cdot 3 & 10 \\ 16 - 6 & \\ \end{array}$$
$$10 \stackrel{?}{=} 10 \quad \text{TRUE}$$

In each case the substitution results in a true equation. Thus, $(0, -5)$ and $(4, 3)$ are both solutions of $4x - 2y = 10$. We graph these points and sketch the line passing through them.



The line appears to pass through $(2,-1)$ also. We check to determine if $(2,-1)$ is a solution of $4x-2y=10$.

$$\begin{array}{r|l} \multicolumn{2}{c}{4x-2y=10} \\ \hline 4\cdot 2-2(-1) & 10 \\ 8+2 & \\ \end{array}$$

$$10 \stackrel{?}{=} 10 \quad \text{TRUE}$$

Thus, $(2,-1)$ is another solution. There are other correct answers, including $(1,-3)$, $(2,-1)$, $(3,1)$, and $(5,5)$.

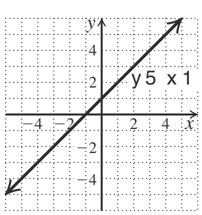
21. $y=x+1$

The equation is in the form $y=mx+b$. The y-intercept is $(0,1)$. We find two other pairs.

When $x=3$, $\quad y=3+1=4$.
When $x=-5$, $\quad y=-5+1=-4$.

x	y
0	1
3	4
-5	-4

Plot these points, draw the line they determine, and label the graph $y=x+1$.



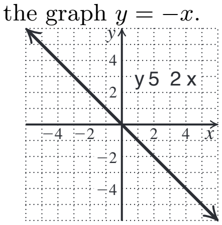
23. $y=-x$

The equation is equivalent to $y=-x+0$. The y-intercept is $(0,0)$. We find two other points.

When $x=-2$, $\quad y=-(-2)=2$.
When $x=3$, $\quad y=-3$.

x	y
0	0
-2	2
3	-3

Plot these points, draw the line they determine, and label the graph $y=-x$.



25. $y=2x$

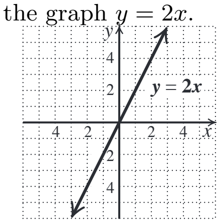
The y-intercept is $(0,0)$. We find two other points.

When $x=1$, $y=2(1)=2$.

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

x	y
0	0
1	2
-1	-2

Plot these points, draw the line they determine, and label the graph $y=2x$.



27. $y=2x+2$

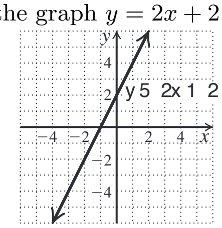
The y-intercept is $(0,2)$. We find two other points.

When $x=-3$, $y=2(-3)+2=-6+2=-4$.

When $x=1$, $y=2\cdot 1+2=2+2=4$.

x	y
0	2
-3	-4
1	4

Plot these points, draw the line they determine, and label the graph $y=2x+2$.



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

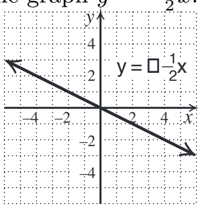
The y-intercept is $(0,0)$. We find two other points.

When $x=2$, $y=-\frac{1}{2}(2)=-1$.

When $x=-2$, $y=-\frac{1}{2}(-2)=1$.

x	y
0	0
2	-1
-2	1

Plot these points, draw the line they determine, and label the graph $y = -\frac{1}{2}x$.



31. $y = \dfrac{1}{3}x - 4 = \dfrac{1}{3}x + (-4)$

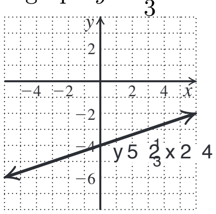
The y-intercept is $(0, -4)$. We find two other points, using multiples of 3 for x to avoid fractions.

When $x = -3$, $y = \dfrac{1}{3}(-3) - 4 = -1 - 4 = -5$.

When $x = 3$, $y = \dfrac{1}{3} \cdot 3 - 4 = 1 - 4 = -3$.

x	y
0	−4
−3	−5
3	−3

Plot these points, draw the line they determine, and label the graph $y = \dfrac{1}{3}x - 4$.



33. $x + y = 4$

$y = -x + 4$

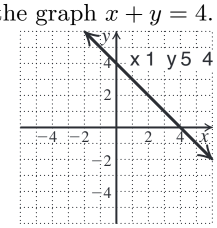
The y-intercept is $(0, 4)$. We find two other points.

When $x = -1$, $y = -(-1) + 4 = 1 + 4 = 5$.

When $x = 2$, $y = -2 + 4 = 2$.

x	y
0	4
−1	5
2	2

Plot these points, draw the line they determine, and label the graph $x + y = 4$.



35. $x - y = -2$

$y = x + 2$

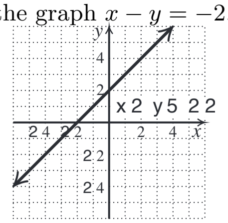
The y-intercept is $(0, 2)$. We find two other points.

When $x = 1$, $y = 1 + 2 = 3$.

When $x = -1$, $y = -1 + 2 = 1$.

x	y
0	2
1	3
−1	1

Plot these points, draw the line they determine, and label the graph $x - y = -2$.



37. $x + 2y = -6$

$2y = -x - 6$

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

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

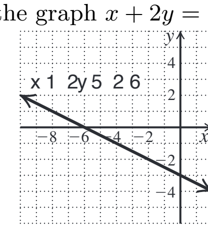
The y-intercept is $(0, -3)$. We find two other points, using multiples of 2 for x to avoid fractions.

When $x = -4$, $y = -\dfrac{1}{2}(-4) - 3 = 2 - 3 = -1$.

When $x = 2$, $y = -\dfrac{1}{2} \cdot 2 - 3 = -1 - 3 = -4$.

x	y
0	−3
−4	−1
2	−4

Plot these points, draw the line they determine, and label the graph $x + 2y = -6$.



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

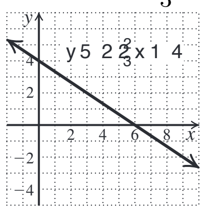
The y-intercept is $(0, 4)$. We find two other points, using multiples of 3 for x to avoid fractions.

When $x = 3$, $y = -\dfrac{2}{3} \cdot 3 + 4 = -2 + 4 = 2$.

When $x = 6$, $y = -\dfrac{2}{3} \cdot 6 + 4 = -4 + 4 = 0$.

x	y
0	4
3	2
6	0

Plot these points, draw the line they determine, and label the graph $y = -\dfrac{2}{3}x + 4$.



41. $4x = 3y$

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

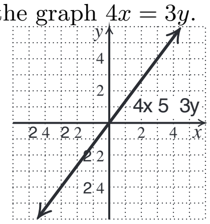
The y-intercept is $(0, 0)$. We find two other points.

When $x = 3$, $y = \frac{4}{3}(3) = 4$.

When $x = -3$, $y = \frac{4}{3}(-3) = -4$.

x	y
0	0
3	4
-3	-4

Plot these points, draw the line they determine, and label the graph $4x = 3y$.



43. $5x - y = 0$

$y = 5x = 5x + 0$

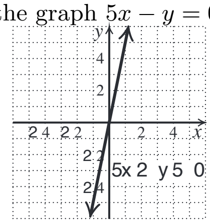
The y-intercept is $(0, 0)$. We find two other points.

When $x = 1$, $y = 5(1) = 5$.

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

x	y
0	0
1	5
-1	-5

Plot these points, draw the line they determine, and label the graph $5x - y = 0$.



45. $6x - 3y = 9$

$-3y = -6x + 9$

$y = 2x - 3$

$y = 2x + (-3)$

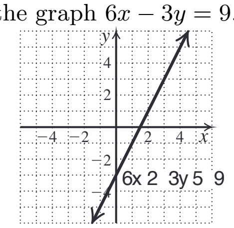
The y-intercept is $(0, -3)$. We find two other points.

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

When $x = 3$, $y = 2 \cdot 3 - 3 = 6 - 3 = 3$.

x	y
0	-3
-1	-5
3	3

Plot these points, draw the line they determine, and label the graph $6x - 3y = 9$.



47. $6y + 2x = 8$

$6y = -2x + 8$

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

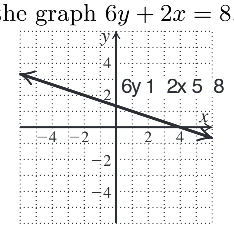
The y-intercept is $\left(0, \dfrac{4}{3}\right)$. We find two other points.

When $x = -2$, $y = -\dfrac{1}{3}(-2) + \dfrac{4}{3} = \dfrac{2}{3} + \dfrac{4}{3} = 2$.

When $x = 1$, $y = -\dfrac{1}{3} \cdot 1 + \dfrac{4}{3} = -\dfrac{1}{3} + \dfrac{4}{3} = 1$.

x	y
0	$\dfrac{4}{3}$
-2	2
1	1

Plot these points, draw the line they determine, and label the graph $6y + 2x = 8$.



49. We graph $a = 0.08t + 2.5$ by selecting values for t and then calculating the associated values for a.

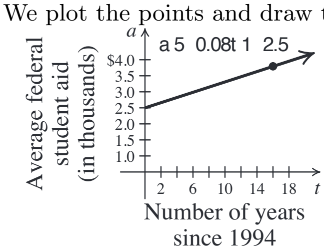
If $t = 0$, $a = 0.08(0) + 2.5 = 2.5$.

If $t = 10$, $a = 0.08(10) + 2.5 = 3.3$.

If $t = 20$, $a = 0.08(20) + 2.5 = 4.1$.

t	a
0	2.5
10	3.3
20	4.1

We plot the points and draw the graph.



Since 2010 − 1994 = 16, the year 2010 is 16 years after 1994. Thus, to estimate the average amount of federal student aid per student in 2010, we find the second coordinate associated with 16. Locate the point on the line that is above 16 and then find a value on the vertical axes that corresponds to that point. That value is about 3.8, so we estimate that the average amount of federal student aid per student in 2010 is \$3.8 thousand or \$3,800.

51. We graph $c = 3.1w + 29.07$ by selecting values for w and then calculating the associated values for c.

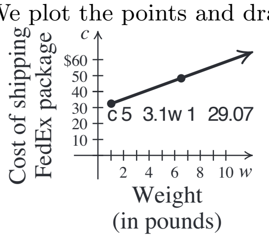
If $w = 1$, $c = 3.1(1) + 29.07 = 32.17$.

If $w = 5$, $c = 3.1(5) + 29.07 = 44.57$.

If $w = 10$, $c = 3.1(10) + 29.07 = 60.07$.

w	c
1	32.17
5	44.57
10	60.07

We plot the points and draw the graph.



Locate the point on the line that is above $6\frac{1}{2}$ and then find the value on the vertical axes that corresponds to that point. That value is 49, so we estimate the cost of shipping a $6\frac{1}{2}$-lb package to be \$49.

53. We graph $p = 3.5n + 9$ by selecting values for n and then calculating the associated values for p.

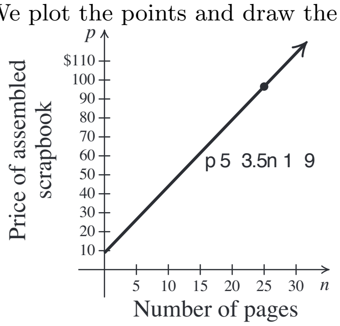
If $n = 10$, $p = 3.5(10) + 9 = 44$.

If $n = 20$, $p = 3.5(20) + 9 = 79$.

If $n = 30$, $p = 3.5(30) + 9 = 114$.

n	p
10	44
20	79
30	114

We plot the points and draw the graph.



Locate the point on the line that is above 25 and then find the value on the vertical axes that corresponds to that point. That value is 97, so we estimate the price of a scrapbook containing 25 pages as \$97.

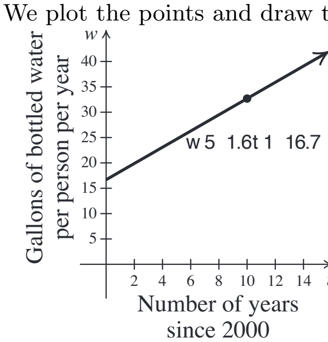
55. We graph $w = 1.6t + 16.7$ by selecting values for t and then calculating the associated values for w.

If $t = 5$, $w = 1.6(5) + 16.7 = 24.7$.

If $t = 7$, $w = 1.6(7) + 16.7 = 27.9$.

If $t = 10$, $w = 1.6(10) + 16.7 = 32.7$.

We plot the points and draw the graph.



To predict the number of gallons consumed per person in 2010 we find the second coordinate associated with 10. (2010 is 10 years after 2000.) The value is 32.7, so we predict that about 33 gallons of bottled water will be consumed per person in 2010.

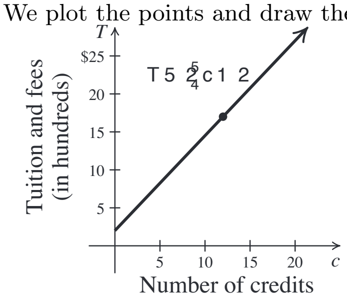
57. We graph $T = \frac{5}{4}c + 2$. Since number of credits cannot be negative, we select only nonnegative values for c.

If $c = 4$, $T = \frac{5}{4}(4) + 2 = 7$.

If $c = 8$, $T = \frac{5}{4}(8) + 2 = 12$.

If $c = 12$, $T = \frac{5}{4}(12) + 2 = 17$.

We plot the points and draw the graph.



Four three-credit courses total $4 \cdot 3$ or 12, credits. Locate the point in the graph, the value is 17. So tuition and fees will cost \$17 hundred, or \$1700.

59. Writing Exercise. Most would probably say that the second equation would be easier to graph because it has been solved for y. This makes it more efficient to find the y-value that corresponds to a given x-value.

61.
$$\begin{aligned} 5x + 3 \cdot 0 &= 12 \\ 5x + 0 &= 12 \\ 5x &= 12 \\ x &= \frac{12}{5} \end{aligned}$$

Check:

$$\begin{array}{c|c} 5x+3\cdot 0 & 12 \\ \hline 5\cdot\frac{12}{5}+3\cdot 0 & 12 \\ 12+0 & \\ 12 & 12 \end{array}$$

$12 \stackrel{?}{=} 12$ TRUE

The solution is $\frac{12}{5}$.

63. $5x+3(2-x)=12$

$$5x+6-3x=12$$
$$2x+6=12$$
$$2x=6$$
$$x=3$$

Check:

$$\begin{array}{c|c} 5x+3(2-x) & 12 \\ \hline 5(3)+3(2-3) & 12 \\ 15+3(-1) & \\ 15-3 & \\ 12 & \end{array}$$

$12 \stackrel{?}{=} 12$ TRUE

The solution is 3.

65. $A=\frac{T+Q}{2}$

$$2A=T+Q$$
$$2A-T=Q$$

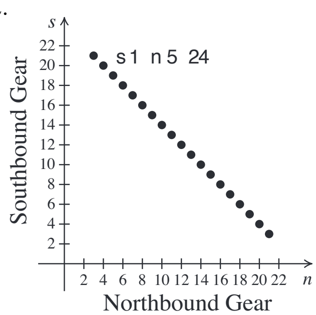
67. $Ax+By=C$

$By=C-Ax$ Subtracting Ax

$y=\frac{C-Ax}{B}$ Dividing by B

69. Writing Exercise. Her graph will be a reflection of the correct graph across the line $y=x$.

71. Let s represent the gear that Laura uses on the southbound portion of her ride and n represent the gear she uses on the northbound portion. Then we have $s+n=24$. We graph this equation, using only positive integer values for s and n.



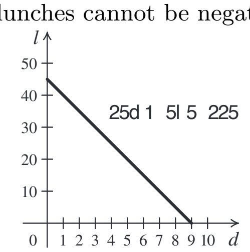
73. Note that the sum of the coordinates of each point on the graph is 5. Thus, we have $x+y=5$, or $y=-x+5$.

75. Note that each y-coordinate is 2 more than the corresponding x-coordinate. Thus, we have $y=x+2$.

77. The equation is $25d+5l=225$.

Since the number of dinners cannot be negative, we choose

The graph stops at the horizontal axis since the number of lunches cannot be negative.



We see that three points on the graph are $(1,40)$, $(5,20)$, and $(8,5)$. Thus, three combinations of dinners and lunches that total \$225 are

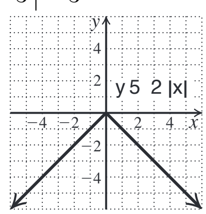
1 dinner, 40 lunches,

5 dinners, 20 lunches,

8 dinners, 5 lunches.

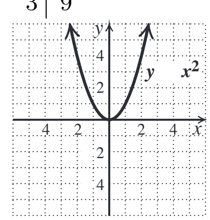
79. $y=-|x|$

x	y
-3	-3
-2	-2
-1	-1
0	0
1	-1
2	-2
3	-3

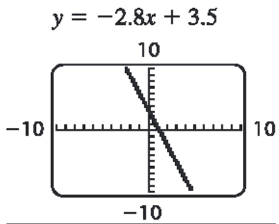


81. $y=x^2$

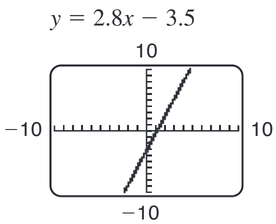
x	y
-3	9
-2	4
-1	1
0	0
1	1
2	4
3	9



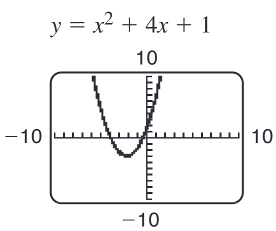
83.



85.



87.



89. $t = -0.1s + 13.1$

s	t
55	7.6
70	6.1

At 55 mph, the efficiency is 7.6 mpg, so a 500 mile trip will use $\frac{500}{7.6} \approx 65.79$ gal at a cost of \$230.27. At 70 mph, the efficiency is 6.1 mpg, so a 500 mile trip will use $\frac{500}{6.1} \approx 81.97$ gal at a cost of \$286.89. Driving at 55 mph instead of 70 mph will save \$56.62 and 16.2 gal.

Exercise Set 3.3

1. The graph of $x = -4$ is a vertical line, so (f) is the most appropriate choice.

3. The point $(0, 2)$ lies on the y-axis, so (d) is the most appropriate choice.

5. The point $(3, -2)$ does not lie on an axis, so it could be used as a check when we graph using intercepts. Thus (b) is the most appropriate choice.

7. (a) The graph crosses the y-axis at $(0, 5)$, so the y-intercept is $(0, 5)$.

(b) The graph crosses the x-axis at $(2, 0)$, so the x-intercept is $(2, 0)$.

9. (a) The graph crosses the y-axis at $(0, -4)$, so the y-intercept is $(0, -4)$.

(b) The graph crosses the x-axis at $(3, 0)$, so the x-

11. (a) The graph crosses the y-axis at $(0, -2)$, so the y-intercept is $(0, -2)$.

(b) The graph crosses the x-axis at $(-3, 0)$ and $(3, 0)$, so the x-intercepts are $(-3, 0)$ and $(3, 0)$.

13. (a) The graph crosses the y-axis at $(0, 0)$, so the y-intercept is $(0, 0)$.

(b) The graph crosses the x-axis at $(-2, 0)$, $(0, 0)$ and $(5, 0)$, so the x-intercepts are $(-2, 0)$, $(0, 0)$ and $(5, 0)$.

15. $3x + 5y = 15$

(a) To find the y-intercept, let $x = 0$. This is the same as temporarily ignoring the x-term and then solving.

$$5y = 15$$
$$y = 3$$

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

(b) To find the x-intercept, let $y = 0$. This is the same as temporarily ignoring the y-term and then solving.

$$3x = 15$$
$$x = 5$$

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

17. $9x - 2y = 36$

(a) To find the y-intercept, let $x = 0$. This is the same as temporarily ignoring the x-term and then solving.

$$-2y = 36$$
$$y = -18$$

The y-intercept is $(0, -18)$.

(b) To find the x-intercept, let $y = 0$. This is the same as temporarily ignoring the y-term and then solving.

$$9x = 36$$
$$x = 4$$

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

19. $-4x + 5y = 80$

(a) To find the y-intercept, let $x = 0$. This is the same as temporarily ignoring the x-term and then solving.

$$5y = 80$$
$$y = 16$$

The y-intercept is $(0, 16)$.

(b) To find the x-intercept, let $y = 0$. This is the same as temporarily ignoring the y-term and then solving.

$$-4x = 80$$
$$x = -20$$

The x-intercept is $(-20, 0)$.

21. $x = 12$

Observe that this is the equation of a vertical line 12 units to the right of the y-axis. Thus, (a) there is no y-intercept and (b) the x-intercept is $(12, 0)$.

23. $y = -9$

Observe that this is the equation of a horizontal line 9 units below the x-axis. Thus, (a) the y-intercept is $(0, -9)$ and

25. $3x + 5y = 15$

Find the y-intercept:

$$5y = 15 \quad \text{Ignoring the } x\text{-term}$$
$$y = 3$$

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

Find the x-intercept:

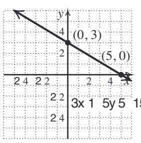
$$3x = 15 \quad \text{Ignoring the } y\text{-term}$$
$$x = 5$$

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

To find a third point we replace x with -5 and solve for y.

$$3(-5) + 5y = 15$$
$$-15 + 5y = 15$$
$$5y = 30$$
$$y = 6$$

The point $(-5, 6)$ appears to line up with the intercepts, so we draw the graph.



27. $x + 2y = 4$

Find the y-intercept:

$$2y = 4 \quad \text{Ignoring the } x\text{-term}$$
$$y = 2$$

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

Find the x-intercept:

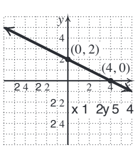
$$x = 4 \quad \text{Ignoring the } y\text{-term}$$

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

To find a third point we replace x with 2 and solve for y.

$$2 + 2y = 4$$
$$2y = 2$$
$$y = 1$$

The point $(2, 1)$ appears to line up with the intercepts, so we draw the graph.



29. $-x + 2y = 8$

Find the y-intercept:

$$2y = 8 \quad \text{Ignoring the } x\text{-term}$$
$$y = 4$$

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

Find the x-intercept:

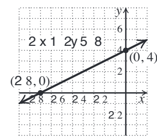
$$-x = 8 \quad \text{Ignoring the } y\text{-term}$$
$$x = -8$$

The x-intercept is $(-8, 0)$.

To find a third point we replace x with 4 and solve for y.

$$-4 + 2y = 8$$
$$2y = 12$$
$$y = 6$$

The point $(4, 6)$ appears to line up with the intercepts, so we draw the graph.



31. $3x + y = 9$

Find the y-intercept:

$$y = 9 \quad \text{Ignoring the } x\text{-term}$$

The y-intercept is $(0, 9)$.

Find the $x-$intercept:

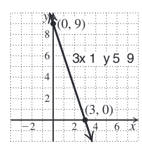
$$3x = 9 \quad \text{Ignoring the } y\text{-term}$$
$$x = 3$$

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

To find a third point we replace x with 2 and solve for y.

$$3 \cdot 2 + y = 9$$
$$6 + y = 9$$
$$y = 3$$

The point $(2, 3)$ appears to line up with the intercepts, so we draw the graph.



33. $y = 2x - 6$

Find the y-intercept:

$$y = -6 \quad \text{Ignoring the } x\text{-term}$$

The y-intercept is $(0, -6)$.

Find the $x-$intercept:

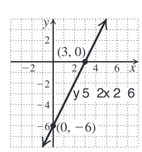
$$0 = 2x - 6 \quad \text{Replacing } y \text{ with } 0$$
$$6 = 2x$$
$$3 = x$$

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

To find a third point we replace x with 2 and find y.

$$y = 2 \cdot 2 - 6 = 4 - 6 = -2$$

The point $(2, -2)$ appears to line up with the intercepts, so we draw the graph.



35. $5x - 10 = 5y$

We can leave the equation in the given form or rewrite it

Find the y-intercept:

$$\begin{aligned} -10 &= 5y \quad \text{Ignoring the } x\text{-term} \\ -2 &= y \end{aligned}$$

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

To find the x-intercept, let $y = 0$.

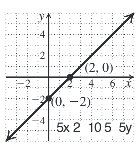
$$\begin{aligned} 5x - 10 &= 5 \cdot 0 \\ 5x - 10 &= 0 \\ 5x &= 10 \\ x &= 2 \end{aligned}$$

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

To find a third point we replace x with 5 and solve for y.

$$\begin{aligned} 5 \cdot 5 - 10 &= 5y \\ 25 - 10 &= 5y \\ 15 &= 5y \\ 3 &= y \end{aligned}$$

The point $(5, 3)$ appears to line up with the intercepts, so we draw the graph.



37. $2x - 5y = 10$

Find the y-intercept:

$$\begin{aligned} -5y &= 10 \quad \text{Ignoring the } x\text{-term} \\ y &= -2 \end{aligned}$$

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

Find the x-intercept:

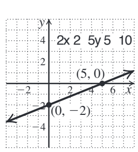
$$\begin{aligned} 2x &= 10 \quad \text{Ignoring the } y\text{-term} \\ x &= 5 \end{aligned}$$

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

To find a third point we replace x with -5 and solve for y.

$$\begin{aligned} 2(-5) - 5y &= 10 \\ -10 - 5y &= 10 \\ -5y &= 20 \\ y &= -4 \end{aligned}$$

The point $(-5, -4)$ appears to line up with the intercepts, so we draw the graph.



39. $6x + 2y = 12$

Find the y-intercept:

$$\begin{aligned} 2y &= 12 \quad \text{Ignoring the } x\text{-term} \\ y &= 6 \end{aligned}$$

The y-intercept is $(0, 6)$.

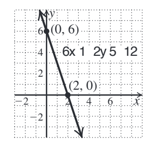
Find the x-intercept:

$$\begin{aligned} 6x &= 12 \quad \text{Ignoring the } y\text{-term} \\ x &= 2 \end{aligned}$$

To find a third point we replace x with 3 and solve for y.

$$\begin{aligned} 6 \cdot 3 + 2y &= 12 \\ 18 + 2y &= 12 \\ 2y &= -6 \\ y &= -3 \end{aligned}$$

The point $(3, -3)$ appears to line up with the intercepts, so we draw the graph.



41. $4x + 3y = 16$

Find the y-intercept:

$$\begin{aligned} 3y &= 16 \quad \text{Ignoring the } x\text{-term} \\ y &= \tfrac{16}{3} \end{aligned}$$

The y-intercept is $(0, \frac{16}{3})$.

Find the x-intercept:

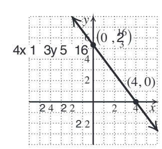
$$\begin{aligned} 4x &= 16 \quad \text{Ignoring the } y\text{-term} \\ x &= 4 \end{aligned}$$

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

To find a third point we replace x with -2 and solve for y.

$$\begin{aligned} 4(-2) + 3y &= 16 \\ -8 + 3y &= 16 \\ 3y &= 24 \\ y &= 8 \end{aligned}$$

The point $(-2, 8)$ appears to line up with the intercepts, so we draw the graph.



43. $2x + 4y = 1$

Find the y-intercept:

$$\begin{aligned} 4y &= 1 \quad \text{Ignoring the } x\text{-term} \\ y &= \frac{1}{4} \end{aligned}$$

The y-intercept is $\left(0, \dfrac{1}{4}\right)$.

Find the x-intercept:

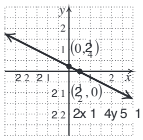
$$\begin{aligned} 2x &= 1 \quad \text{Ignoring the } y\text{-term} \\ x &= \tfrac{1}{2} \end{aligned}$$

The x-intercept is $\left(\frac{1}{2}, 0\right)$.

To find a third point we replace x with $-\frac{3}{2}$ and solve for y.

$$\begin{aligned} 2\left(-\tfrac{3}{2}\right) + 4y &= 1 \\ -3 + 4y &= 1 \\ 4y &= 4 \\ y &= 1 \end{aligned}$$

The point $\left(-\frac{3}{2}, 1\right)$ appears to line up with the intercepts, so we draw the graph.



45. $5x - 3y = 180$

Find the y-intercept:

$$-3y = 180 \quad \text{Ignoring the } x\text{-term}$$
$$y = -60$$

The y-intercept is $(0, -60)$.

Find the x-intercept:

$$5x = 180 \quad \text{Ignoring the } y\text{-term}$$
$$x = 36$$

The x-intercept is $(36, 0)$.

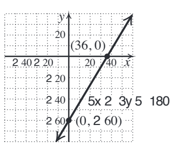
To find a third point we replace x with 6 and solve for y.

$$5 \cdot 6 - 3y = 180$$
$$30 - 3y = 180$$
$$-3y = 150$$
$$y = -50$$

This means that $(6, -50)$ is on the graph.

To graph all three points, the y-axis must go to at least 60 and the x-axis must go to at least 36. Using a scale of 10 units per square allows us to display both intercepts and $(6, -50)$ as well as the origin.

The point $(6, -50)$ appears to line up with the intercepts, so we draw the graph.



47. $y = -30 + 3x$

Find the y-intercept:

$$y = -30 \quad \text{Ignoring the } x\text{-term}$$

The y-intercept is $(0, -30)$.

To find the x-intercept, let $y = 0$.

$$0 = -30 + 3x$$
$$30 = 3x$$
$$10 = x$$

The x-intercept is $(10, 0)$.

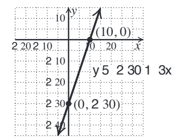
To find a third point we replace x with 5 and solve for y.

$$y = -30 + 3 \cdot 5$$
$$y = -30 + 15$$
$$y = -15$$

This means that $(5, -15)$ is on the graph.

To graph all three points, the y-axis must go to at least -30 and the x-axis must go to at least 10. Using a scale of 5 units per square allows us to display both intercepts and $(5, -15)$ as well as the origin.

The point $(5, -15)$ appears to line up with the intercepts, so we draw the graph.



49. $-4x = 20y + 80$

To find the y-intercept, we let $x = 0$.

$$-4 \cdot 0 = 20y + 80$$
$$0 = 20y + 80$$
$$-80 = 20y$$
$$-4 = y$$

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

Find the x-intercept:

$$-4x = 80 \quad \text{Ignoring the } y\text{-term}$$
$$x = -20$$

The x-intercept is $(-20, 0)$.

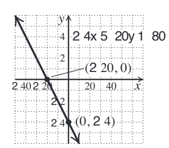
To find a third point we replace x with -40 and solve for y.

$$-4(-40) = 20y + 80$$
$$160 = 20y + 80$$
$$80 = 20y$$
$$4 = y$$

This means that $(-40, 4)$ is on the graph.

To graph all three points, the y-axis must go at least from -4 to 4 and the x-axis must go at least from -40 to -20. Since we also want to include the origin we can use a scale of 10 units per square on the x-axis and 1 unit per square on the y-axis.

The point $(-40, 4)$ appears to line up with the intercepts, so we draw the graph.



51. $y - 3x = 0$

Find the y-intercept:

$$y = 0 \quad \text{Ignoring the } x\text{-term}$$

The y-intercept is $(0, 0)$. Note that this is also the x-intercept.

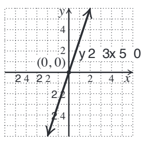
In order to graph the line, we will find a second point.

When $x = 1$, $y - 3 \cdot 1 = 0$
$$y - 3 = 0$$
$$y = 3$$

To find a third point we replace $x = -1$ and solve for y.

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

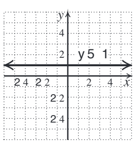
The point $(-1, -3)$ appears to line up with the other two points, so we draw the graph.



53. $y = 1$

Any ordered pair $(x, 1)$ is a solution. The variable y must be 1, but the x variable can be any number we choose. A few solutions are listed below. Plot these points and draw the line.

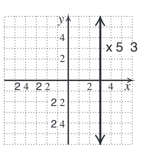
x	y
-3	1
0	1
2	1



55. $x = 3$

Any ordered pair $(3, y)$ is a solution. The variable x must be 3, but the y variable can be any number we choose. A few solutions are listed below. Plot these points and draw the line.

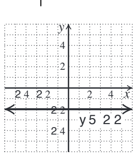
x	y
3	-2
3	0
3	4



57. $y = -2$

Any ordered pair $(x, -2)$ is a solution. The variable y must be -2, but the x variable can be any number we choose. A few solutions are listed below. Plot these points and draw the line.

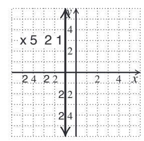
x	y
-3	-2
0	-2
4	-2



59. $x = -1$

Any ordered pair $(-1, y)$ is a solution. The variable x must be -1, but the y variable can be any number we choose. A few solutions are listed below. Plot these points and draw the line.

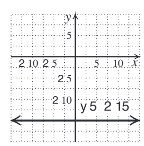
x	y
-1	-3
-1	0
-1	2



61. $y = -15$

Any ordered pair $(x, -15)$ is a solution. The variable y must be -15, but the x variable can be any number we choose. A few solutions are listed below. Plot these points and draw the line.

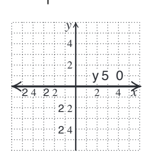
x	y
-1	-15
0	-15
3	-15



63. $y = 0$

Any ordered pair $(x, 0)$ is a solution. A few solutions are listed below. Plot these points and draw the line.

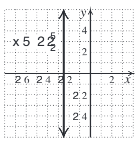
x	y
-4	0
0	0
2	0



65. $x = -\dfrac{5}{2}$

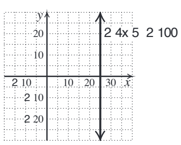
Any ordered pair $\left(-\dfrac{5}{2}, y\right)$ is a solution. A few solutions are listed below. Plot these points and draw the line.

x	y
$-\frac{5}{2}$	-3
$-\frac{5}{2}$	0
$-\frac{5}{2}$	5



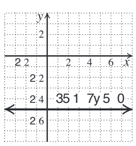
67. $-4x = -100$
$x = 25$ Dividing by -4

The graph is a vertical line 25 units to the right of the y-axis.



69. $35 + 7y = 0$
$7y = -35$
$y = -5$

The graph is a horizontal line 5 units below the x-axis.



71. Note that every point on the horizontal line passing through $(0, -1)$ has -1 as the y-coordinate. Thus, the equation of the line is $y = -1$.

73. Note that every point on the vertical line passing through $(4, 0)$ has 4 as the x-coordinate. Thus, the equation of the line is $x = 4$.

75. Note that every point on the vertical line passing through $(0, 0)$ has 0 as the x-coordinate. Thus, the equation of the line is $x = 0$.

77. Writing Exercise. Any solution of $y = 8$ is an ordered pair $(x, 8)$. Thus, all points on the graph of $y = 8$ are 8 units above the x-axis, so they lie on a horizontal line.

79. $d - 7$

81. Let n represent the number. Then we have $7 + 4n$.

83. Let x and y represent the numbers. Then we have $2(x+y)$.

85. Writing Exercise. The graph will be a line with y-intercept $(0, C)$ and x-intercept $(C, 0)$.

87. The x-axis is a horizontal line, so it is of the form $y = b$. All points on the x-axis are of the form $(x, 0)$, so b must be 0 and the equation is $y = 0$.

89. A line parallel to the y-axis has an equation of the form $x = a$. Since the x-coordinate of one point on the line is -2, then $a = -2$ and the equation is $x = -2$.

91. Since the x-coordinate of the point of intersection must be -3 and y must equal 4, the point of intersection is $(-3, 4)$.

93. The y-intercept is $(0, 5)$, so we have $y = mx + 5$. Another point on the line is $(-3, 0)$ so we have

$$0 = m(-3) + 5$$
$$-5 = -3m$$
$$\frac{5}{3} = m$$

The equation is $y = \frac{5}{3}x + 5$, or $5x - 3y = -15$, or $-5x + 3y = 15$.

95. Substitute 0 for x and -8 for y.

$$4 \cdot 0 = C - 3(-8)$$
$$0 = C + 24$$
$$-24 = C$$

97.
$$Ax + D = C$$
$$Ax = C - D$$
$$x = \frac{C - D}{A}$$

The x-intercept is $\left(\frac{C-D}{A}, 0\right)$

99. Find the y-intercept:

$-7y = 80$ Covering the x-term

$y = -\frac{80}{7} = -11.\overline{428571}$

The y-intercept is $\left(0, -\frac{80}{7}\right)$, or $(0, -11.\overline{428571})$.

Find the x-intercept:

$2x = 80$ Covering the y-term

$x = 40$

The x-intercept is $(40, 0)$.

101. From the equation we see that the y-intercept is $(0, -9)$.

To find the x-intercept, let $y = 0$.

$$0 = 0.2x - 9$$
$$9 = 0.2x$$
$$45 = x$$

The x-intercept is $(45, 0)$.

103. Find the y-intercept.

$25y = 1$ Covering the x-term

$y = \frac{1}{25}$, or 0.04

The y-intercept is $\left(0, \frac{1}{25}\right)$, or $(0, 0.04)$.

Find the x-intercept:

$50x = 1$ Covering the y-term

$x = \frac{1}{50}$, or 0.02

Exercise Set 3.4

1. $\dfrac{100 \text{ miles}}{5 \text{ hours}} = 20$ miles per hour, or miles/hour

3. $\dfrac{300 \text{ dollars}}{150 \text{ miles}} = 2$ dollars per mile, or dollars/mile

5. $\dfrac{40 \text{ minutes}}{8 \text{ errands}} = 5$ minutes per errand, or minutes/errand

7. a) We divide the number of miles traveled by the number of gallons of gas used for distance traveled.

Rate, in miles per gallon

$$= \frac{14,131 \text{ mi} - 13,741 \text{ mi}}{13 \text{ gal}}$$

$$= \frac{390 \text{ mi}}{13 \text{ gal}}$$

$= 30$ mi/gal

$= 30$ miles per gallon

b) We divide the cost of the rental by the number of days. From June 5 to June 8 is $8 - 5$, or 3 days.

Average cost, in dollars per day

$$= \frac{118 \text{ dollars}}{3 \text{ days}}$$

≈ 39.33 dollars/day

$\approx \$39.33$ per day

c) We divide the number of miles traveled by the number of days. The car was driven 390 miles, and was rented for 3 days.

Rate, in miles per day

$$= \frac{390 \text{ mi}}{3 \text{ days}}$$

$= 130$ mi/day

$= 130$ mi per day

d) Note that $\$118 = 11,800¢$. The car was driven 390 miles.

$$\text{Rate, in cents per mile} = \frac{11,800¢}{390 \text{ mi}}$$

$\approx 30¢$ per mi

9. a) From 9:00 to 11:00 is $11 - 9$, or 2 hr.

$$\text{Average speed, in miles per hour} = \frac{14 \text{ mi}}{2 \text{ hr}}$$

$= 7$ mph

b) From part (a) we know that the bike was rented for 2 hr.

$$\text{Rate, in dollars per hour} = \frac{\$15}{2 \text{ hr}}$$

$= \$7.50$ per hr

c) $$\text{Rate, in dollars per mile} = \frac{\$15}{14 \text{ mi}}$$

$\approx \$1.07$ per mi

11. a) It is 3 hr from 9:00 A.M. to noon and 2 more hours from noon to 2:00 P.M., so the proofreader worked $3 + 2$, or 5 hr.

$$\text{Rate, in dollars per hour} = \frac{\$110}{5 \text{ hr}}$$

$= \$22$ per hr

b) The number of pages proofread is $195 - 92$, or 103.

$$\text{Rate, in pages per hour} = \frac{103 \text{ pages}}{5 \text{ hr}}$$

$= 20.6$ pages per hr

c) $$\text{Rate, in dollars per page} = \frac{\$110}{103 \text{ pages}}$$

$\approx \$1.07$ per page

13. Increase in debt: 8612 billion −5770 billion or 2842 billion.

Change in time $2006 - 2001 = 5$ year

$$\text{Rate of increase} = \frac{\text{Change in debt}}{\text{Change in time}}$$

$$= \frac{\$2842 \text{ billion}}{5 \text{ yr}}$$

$\approx \$568.4$ billion/yr

15. a) The elevator traveled $34 - 5$, or 29 floors in 2:40 − 2:38, or 2 min.

$$\text{Average rate of travel} = \frac{29 \text{ floors}}{2 \text{ min}}$$

$= 14.5$ floors per min

b) In part (a) we found that the elevator traveled 29 floors in 2 min. Note that $2 \text{ min} = 2 \times 1 \text{ min} = 2 \times 60 \text{ sec} = 120 \text{ sec}$.

$$\text{Average rate of travel} = \frac{120 \text{ sec}}{29 \text{ floors}}$$

≈ 4.14 sec per floor

17. Ascended $29,028 \text{ ft} - 17,552 \text{ ft} = 11,476$ ft. The time of ascent: 8 hr, 10 min, or $8 \text{ hr} + 10 \text{ min} = 480 \text{ min} + 10 \text{ min} = 490$ min. a)

$$\text{Rate, in feet per minute} = \frac{11,476 \text{ ft}}{490 \text{ min}}$$

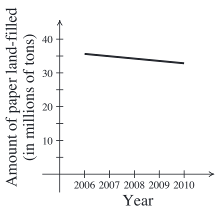
≈ 23.42 ft/min

b) $$\text{Rate, in minutes per foot} = \frac{490 \text{ min}}{11,476 \text{ ft}}$$

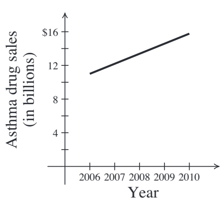
≈ 0.04 min/ft

19. The rate of decrease is given in tons per year, so we list the number of tons in the vertical axis and the year on the the horizontal axis. If we count by increments of 10 million on the vertical axis we can easily reach 35.7 million and beyond. We label the units on the vertical axis in millions of tons. We list the years on the horizontal axis, beginning with 2006. We plot the point (2006, 35.7 million). Then, to display the decreased rate we move from that point to a point that represents a decrease of 700,000 tons one year later. The coordinates of this point are $(2006 + 1, 35.7 -$

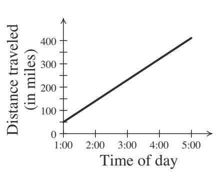
0.7 million), or (2007, 35 million). Finally, we draw a line through the two points.



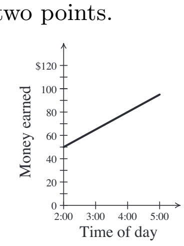
21. The rate is given in dollars per year, so we list the amount in sales of asthma drug products on the vertical axis and year on the horizontal axis. We can count by increments of 2 billion on the vertical axis. We plot the point (2006, \$11 billion). Then to display the rate of growth, we move from that point to a point that represents \$1.2 billion more a year later. The coordinates of this point are (2006+1, \$11+1.2 billion) or (2007, \$12.2 billion). Finally, we draw a line through the two points.



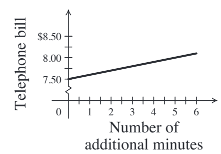
23. The rate is given in miles per hour, so we list the number of miles traveled on the vertical axis and the time of day on the horizontal axis. If we count by 100's of miles on the vertical axis we can easily reach 230 without needing a terribly large graph. We plot the point (3:00, 230). Then to display the rate of travel, we move from that point to a point that represents 90 more miles traveled 1 hour later. The coordinates of this point are (3:00 + 1 hr, 230 + 90), or (4:00, 320). Finally, we draw a line through the two points.



25. The rate is given in dollars per hour so we list money earned on the vertical axis and the time of day on the horizontal axis. We can count by \$20 on the vertical axis and reach \$50 without needing a terribly large graph. Next we plot the point (2:00 P.M., \$50). To display the rate we move from that point to a point that represents \$15 more 1 hour later. The coordinates of this point are (2 + 1, \$50 + \$15), or (3:00 P.M., \$65). Finally, we draw a line through the two points.



27. The rate is given in cost per minute so we list the amount of the telephone bill on the vertical axis and the number of additional minutes on the horizontal axis. We begin with \$7.50 on the vertical axis and count by \$0.50. A jagged line at the base of the axis indicates that we are not showing amounts smaller than \$7.50. We begin with 0 additional minutes on the horizontal axis and plot the point (0, \$7.50). We move from there to a point that represents \$0.10 more 1 minute later. The coordinates of this point are (0 + 1 min, \$7.50 + \$0.10), or (1 min, \$7.60). Then we draw a line through the two points.



29. The points (10:00, 30 calls) and (1:00, 90 calls) are on the graph. This tells us that in the 3 hr between 10:00 and 1:00 there were $90 - 30 = 60$ calls completed. The rate is

$$\frac{60 \text{ calls}}{3 \text{ hr}} = 20 \text{ calls/hour}.$$

31. The points (12:00, 100 mi) and (2:00, 250 mi) are on the graph. This tells us that in the 2 hr between 12:00 and 2:00 the train traveled $250 - 100 = 150$ mi. The rate is

$$\frac{150 \text{ mi}}{2\text{hr}} = 75 \text{ mi per hr}.$$

33. The points (5 min, 60¢) and (10 min, 120¢) are on the graph. This tells us that in $10 - 5 = 5$ min the cost of the call increased 120¢ − 60¢ = 60¢. The rate is

$$\frac{60\text{¢}}{5 \text{ min}} = 12\text{¢ per min}.$$

35. The points (1970, 140 thousand) and (2000, 80 thousand) are on the graph. This tells us that in $2000 - 1970 = 30$yrs the population decreases $80 - 140 = -60$thousand. The rate is

$$\frac{-60 \text{ thousand}}{30 \text{ yr}} = -2000 \text{ people/year}.$$

37. The points (90 mi, 2 gal) and (225 mi, 5 gal) are on the graph. This tells us that when driven $225 - 90 = 135$ mi the vehicle consumed $5 - 2 = 3$ gal of gas. The rate is

$$\frac{3 \text{ gal}}{135 \text{ mi}} = 0.02 \text{ gal/mi}.$$

39. Since swimming is the slowest of the three sports and biking is the fastest, the slope of the line representing swimming speed will be the least steep of the three and that representing biking speed will be the steepest. The second segment of graph (e) rises most steeply and the third segment is the least steep of the three segments. Thus this graph represents running followed by biking and then swimming.

41. Since swimming is the slowest of the three sports and biking is the fastest, the slope of the line representing swimming speed will be the least steep of the three and that representing biking speed will be the steepest. The first segment of graph (d) is the least steep and the second segment is the steepest of the three segments. Thus this graph

43. Since swimming is the slowest of the three sports and biking is the fastest, the slope of the line representing swimming speed will be the least steep of the three and that representing biking speed will be the steepest. The first segment of graph (b) is the steepest and the second segment is the least steep of the three segments. Thus this graph represents biking followed by swimming and then running.

45. Writing Exercise. A negative rate of travel indicates that an object is moving backwards.

47. $-2-(-7)=-2+7=5$

49. $\dfrac{5-(-4)}{-2-7}=\dfrac{9}{-9}=-1$

51. $\dfrac{-4-8}{11-2}=\dfrac{-12}{9}=\dfrac{-4}{3}$

53. $\dfrac{-6-(-6)}{-2-7}=\dfrac{-6+6}{-2-7}=\dfrac{0}{9}=0$

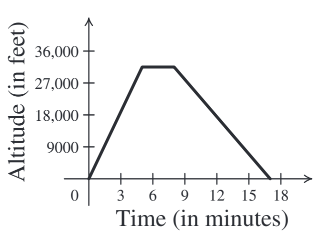
55. Writing Exercise. a) The graph of Jon's total earnings would be above Jenny's total earnings, with Jon's rate or slope steeper than Jenny's.

b) Jenny's graph is above Jon's but the slope or rate is the same.

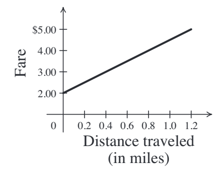
c) The final result (total earnings) can be compared, but not the rate.

57. Let t = flight time and a = altitude. While the plane is climbing at a rate of 6300 ft/min, the equation $a=6300t$ describes the situation. Solving $31,500=6300t$, we find that the cruising altitude of 31,500 ft is reached after about 5 min. Thus we graph $a=6300t$ for $0\le t\le 5$.

The plane cruises at 31,500 ft for 3 min, so we graph $a=31,500$ for $5<t\le 8$. After 8 min the plane descends at a rate of 3500 ft/min and lands. The equation $a=31,500-3500(t-8)$, or $a=-3500t+59,500$, describes this situation. Solving $0=-3500t+59,500$, we find that the plane lands after about 17 min. Thus we graph $a=-3500t+59,500$ for $8<t\le 17$. The entire graph is show below.



59. Let the horizontal axis represent the distance traveled, in miles, and let the vertical axis represent the fare, in dollars. Use increments of 1/5, or 0.2 mi, on the horizontal axis and of \$1 on the vertical axis. The fare for traveling 0.2 mi is \$2 + \$0.50 · 1, or \$2.50 and for 0.4 mi, or 0.2 mi × 2, we have \$2 + \$0.50(2), or \$3. Plot the points (0.2 mi, \$2.50) and (0.4 mi, \$3) and draw the line through them.



61. $95\text{ mph}+39\text{ mph}=134\text{ mph}$

$\dfrac{134\text{ mi}}{1\text{ hr}}$ gives us $\dfrac{1\text{ hr}}{134\text{ mi}}$.

$\dfrac{1\text{ hr}}{134\text{ min}}=\dfrac{1\text{ hr}}{134\text{ mi}}\cdot\dfrac{60\text{ min}}{1\text{ hr}}\approx 0.45\text{ min per mi}$

63. First we find Anne's speed in minutes per kilometer.

$\text{Speed}=\dfrac{15.5\text{ min}}{7\text{ km}-4\text{ km}}=\dfrac{15.5}{3}\dfrac{\text{min}}{\text{km}}$

Now we convert min/km to min/mi.

$\dfrac{15.5}{3}\dfrac{\text{min}}{\text{km}}\approx\dfrac{15.5}{3}\dfrac{\text{min}}{\text{km}}\cdot\dfrac{1\text{ km}}{0.621\text{ mi}}\approx\dfrac{15.5}{1.863}\dfrac{\text{min}}{\text{mi}}$

At a rate of $\dfrac{15.5}{1.863}\dfrac{\text{min}}{\text{mi}}$, to run a 5-mi race it would take $\dfrac{15.5}{1.863}\dfrac{\text{min}}{\text{mi}}\cdot 5\text{ mi}\approx 41.6\text{ min}$.

(Answers may vary slightly depending on the conversion factor used.)

65. First we find Ryan's rate. Then we double it to find Alex's rate. Note that 50 minutes $=\dfrac{50}{60}$ hr $=\dfrac{5}{6}$ hr.

$$\begin{aligned}\text{Ryan's rate}&=\frac{\text{change in number of bushels picked}}{\text{corresponding change in time}}\\&=\frac{5\frac{1}{2}-4\text{ bushels}}{\frac{5}{6}\text{ hr}}\\&=\frac{1\frac{1}{2}\text{ bushels}}{\frac{5}{6}\text{ hr}}\\&=\frac{3}{2}\cdot\frac{6}{5}\,\frac{\text{bushels}}{\text{hr}}\\&=\frac{9}{5}\text{ bushels per hour, or}\\&\quad 1.8\text{ bushels per hour}\end{aligned}$$

Then Alex's rate is $2(1.8)=3.6$ bushels per hour.

Exercise Set 3.5

1. A teenager's height increases over time, so the rate is positive.

3. The water level decreases during a drought, so the rate is negative.

5. The distance from the starting point increases during a race, so the rate is positive.

7. The number of U.S. senators does not change, so the rate is zero.

9. The number of people present decreases in the moments following the final buzzer, so the rate is negative.

11. The rate can be found using the coordinates of any two points on the line. We use $(10, \$600)$ and $(25, \$1500)$.

$$\begin{aligned}\text{Rate} &= \frac{\text{change in compensation}}{\text{corresponding change in number of blogs}}\\ &= \frac{\$1500 - \$600}{25 - 10}\\ &= \frac{\$900}{15 \text{ blogs}}\\ &= \$60 \text{ per blog}\end{aligned}$$

13. The rate can be found using the coordinates of any two points on the line. We use $(\text{May2005}, \$380)$ and $(\text{Mar2006}, \$320)$.

$$\begin{aligned}\text{Rate} &= \frac{\text{change in price}}{\text{corresponding change in time}}\\ &= \frac{\$320 - \$380}{\text{Mar2006} - \text{May2005}}\\ &= \frac{-\$60}{15 - 5 \text{ months}}\\ &= \frac{-60}{10}\\ &= -\$6 \text{ per month}\end{aligned}$$

15. The rate can be found using the coordinates of any two points on the line. We use $(35, 480)$ and $(65, 510)$, where 35 and 65 are in \$1000's.

$$\begin{aligned}\text{Rate} &= \frac{\text{change in score}}{\text{corresponding change in income}}\\ &= \frac{510 - 480 \text{ points}}{65 - 35}\\ &= \frac{30 \text{ points}}{30}\\ &= 1 \text{ point per } \$1000 \text{ income}\end{aligned}$$

17. The rate can be found using the coordinates of any two points on the line. We use $(0 \text{ min}, 54^{\square})$ and $(27 \text{ min}, -4^{\square})$.

$$\begin{aligned}\text{Rate} &= \frac{\text{change in temperature}}{\text{corresponding change in time}}\\ &= \frac{-4^{\square} - 54^{\square}}{27 \text{ min} - 0 \text{ min}}\\ &= \frac{-58^{\square}}{27 \text{ min}}\\ &\approx -2.1^{\square} \text{per min}\end{aligned}$$

19. We can use any two points on the line, such as $(0, 1)$ and $(3, 5)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{5 - 1}{3 - 0} = \frac{4}{3}\end{aligned}$$

21. We can use any two points on the line, such as $(1, 0)$ and $(3, 3)$.

$$m = \frac{\text{change in } y}{\text{change in } x}$$

23. We can use any two points on the line, such as $(2, 2)$ and $(4, 6)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{6 - 2}{4 - 2}\\ &= \frac{4}{2} = 2\end{aligned}$$

25. We can use any two points on the line, such as $(0, 2)$ and $(2, 0)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{2 - 0}{0 - 2} = \frac{2}{-2} = -1\end{aligned}$$

27. This is the graph of a horizontal line. Thus, the slope is 0.

29. We can use any two points on the line, such as $(0, 2)$ and $(3, 1)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{1 - 2}{3 - 0} = -\frac{1}{3}\end{aligned}$$

31. This is the graph of a vertical line. Thus, the slope is undefined.

33. We can use any two points on the line, such as $(-2, 1)$ and $(2, -2)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{-2 - 1}{2 - (-2)} = -\frac{3}{4}\end{aligned}$$

35. We can use any two points on the line, such as $(-2, 0)$ and $(2, 1)$.

$$\begin{aligned}m &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{1 - 0}{2 - (-2)} = \frac{1}{4}\end{aligned}$$

37. This is the graph of a horizontal line, so the slope is 0.

39. $(1, 3)$ and $(5, 8)$

$$m = \frac{8 - 3}{5 - 1} = \frac{5}{4}$$

41. $(-2, 4)$ and $(3, 0)$

$$m = \frac{4 - 0}{-2 - 3} = \frac{4}{-5} = -\frac{4}{5}$$

43. $(-4, 0)$ and $(5, 6)$

$$m = \frac{6 - 0}{5 - (-4)} = \frac{6}{9} = \frac{2}{3}$$

45. $(0, 7)$ and $(-3, 10)$

$$m = \frac{10 - 7}{-3 - 0} = \frac{3}{0 - 3} = -1$$

47. $(-2, 3)$ and $(-6, 5)$

49. $\left(-2, \frac{1}{2}\right)$ and $\left(-5, \frac{1}{2}\right)$

Observe that the points have the same y-coordinate. Thus, they lie on a horizontal line and its slope is 0. We could also compute the slope.

$$m = \frac{\frac{1}{2} - \frac{1}{2}}{-2-(-5)} = \frac{\frac{1}{2} - \frac{1}{2}}{-2+5} = \frac{0}{3} = 0$$

51. $(5, -4)$ and $(2, -7)$

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

53. $(6, -4)$ and $(6, 5)$

Observe that the points have the same x-coordinate. Thus, they lie on a vertical line and its slope is undefined. We could also compute the slope.

$$m = \frac{-4-5}{6-6} = \frac{-9}{0}, \text{ undefined}$$

55. The line $y = 5$ is a horizontal line. A horizontal line has slope 0.

57. The line $x = -8$ is a vertical line. Slope is undefined.

59. The line $x = 9$ is a vertical line. The slope is undefined.

61. The line $y = -10$ is a horizontal line. A horizontal line has slope 0.

63. The grade is expressed as a percent.

$$m = \frac{792}{5280} = 0.15 = 15\%$$

65. The slope is expressed as a percent.

$$m = \frac{28}{80} = 0.35 = 35\%.$$

67. 2 ft 5 in. $= 2 \cdot 12$ in. $+ 5$ in. $= 24$ in. $+ 5$ in. $= 29$ in.

8 ft 2 in. $= 8 \cdot 12$ in. $+ 2$ in. $= 96$ in. $+ 2$ in. $= 98$ in.

$m = \frac{29}{98}$, or about 30%

69. Dooley Mountain rises $5400 - 3500 = 1900$ ft.

$$m = \frac{1900}{37000} \approx 0.051 \approx 5.1\%$$

Yes, it qualifies as part of the Tour de France.

71. Writing Exercise.

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{-(y_1 - y_2)}{-(x_1 - x_2)} = \frac{y_1 - y_2}{x_1 - x_2}$$

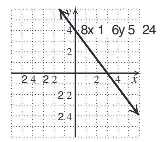
73.
$$ax + by = c$$
$$by = c - ax \quad \text{Adding } -ax \text{ to both sides}$$
$$y = \frac{c - ax}{b} \quad \text{Dividing both sides by } b$$

75.
$$ax - by = c$$
$$-by = c - ax \quad \text{Adding } -ax \text{ to both sides}$$
$$y = \frac{c - ax}{-b} \quad \text{Dividing both sides by } -b$$

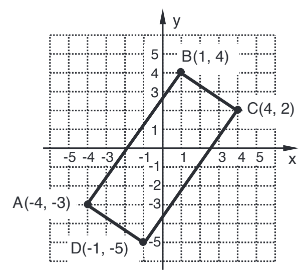
We could also express this result as $y = \frac{ax - c}{b}$.

77.
$$8x + 6y = 24$$
$$6y = -8x + 24$$
$$y = -\frac{4}{3}x + 4$$

x	y
0	4
3	0
6	-4



79. Writing Exercise.



We find the slope of each side of the quadrilateral.

For side $\overline{AB}$, $m = \frac{4-(-3)}{1-(-4)} = \frac{7}{5}$.

For side $\overline{BC}$, $m = \frac{2-4}{4-1} = -\frac{2}{3}$.

For side $\overline{CD}$, $m = \frac{2-(-5)}{4-(-1)} = \frac{7}{5}$.

For side $\overline{DA}$, $m = \frac{-5-(-3)}{-1-(-4)} = -\frac{2}{3}$.

Since the opposite sides of the quadrilateral have the same slopes but lie on different lines, the lines on which they lie never intersect so they are parallel. Thus the quadrilateral is a parallelogram.

81. From the dimensions on the drawing, we see that the ramps labeled A have a rise of 61 cm and a run of 167.6 cm.

$$m = \frac{61 \text{ cm}}{167.6 \text{ cm}} \approx 0.364, \text{ or } 36.4\%$$

83. If the line passes through $(2, 5)$ and never enters the second quadrant, then it slants up from left to right or is vertical. This means that its slope is positive. The line slants least steeply if it passes through $(0, 0)$. In this case, $m = \frac{5-0}{2-0} = \frac{5}{2}$. Thus, the numbers the line could have for it slope are $\left\{m \middle| m \geq \frac{5}{2}\right\}$.

85. Let $t =$ the number of units each tick mark on the vertical axis represents. Note that the graph drops 4 units for every 3 units of horizontal change. Then we have:

$$\frac{-4t}{3} = -\frac{2}{3}$$
$$-4t = -2 \quad \text{Multiplying by 3}$$
$$t = \frac{1}{2} \quad \text{Dividing by } -4$$

Each tick mark on the vertical axis represents $\frac{1}{2}$ unit.

Exercise Set 3.6

1. We can read the slope, 3, directly from the equation. Choice (f) is correct.

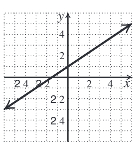
3. We can read the slope, $\frac{2}{3}$, directly from the equation. Choice (d) is correct.

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

The y-intercept is $(0, -2)$, so choice (e) is correct.

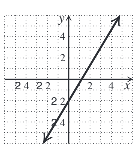
7. Slope $\frac{2}{3}$; y-intercept $(0, 1)$

We plot $(0, 1)$ and from there move up 2 units and right 3 units. This locates the point $(3, 3)$. We plot $(3, 3)$ and draw a line passing through $(0, 1)$ and $(3, 3)$.



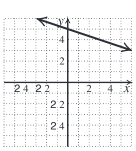
9. Slope $\frac{5}{3}$; y-intercept $(0, -2)$

We plot $(0, -2)$ and from there move up 5 units and right 3 units. This locates the point $(3, 3)$. We plot $(3, 3)$ and draw a line passing through $(0, -2)$ and $(3, 3)$.



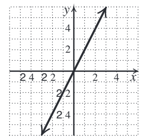
11. Slope $-\frac{1}{3}$; y-intercept $(0, 5)$

We plot $(0, 5)$. We can think of the slope as $\frac{-1}{3}$, so from $(0, 5)$ we move down 1 unit and right 3 units. This locates the point $(3, 4)$. We plot $(3, 4)$ and draw a line passing through $(0, 5)$ and $(3, 4)$.



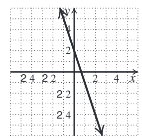
13. Slope 2; y-intercept $(0, 0)$

We plot $(0, 0)$. We can think of the slope as $\frac{2}{1}$, so from $(0, 0)$ we move up 2 units and right 1 unit. This locates the point $(1, 2)$. We plot $(1, 2)$ and draw a line passing through $(0, 0)$ and $(1, 2)$.



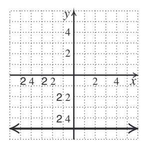
15. Slope -3; y-intercept $(0, 2)$

We plot $(0, 2)$. We can think of the slope as $\frac{-3}{1}$, so from $(0, 2)$ we move down 3 units and right 1 unit. This locates the point $(1, -1)$. We plot $(1, -1)$ and draw a line passing through $(0, 2)$ and $(1, -1)$.



17. Slope 0; y-intercept $(0, -5)$

Since the slope is 0, we know the line is horizontal, so from $(0, -5)$ we move right 1 unit. This locates the point $(1, -5)$. We plot $(1, -5)$ and draw a line passing through $(0, -5)$ and $(1, -5)$.



19. We read the slope and y-intercept from the equation.

$$y = -\frac{2}{7}x + 5$$

↑ The slope is $-\frac{2}{7}$. ↑ The y-intercept is $(0, 5)$.

21. We read the slope and y-intercept from the equation.

$$y = \frac{1}{3}x + 7$$

↑ The slope is $\frac{1}{3}$. ↑ The y-intercept is $(0, 7)$.

23. $y = \frac{9}{5}x - 4$

$y = \frac{9}{5}x + (-4)$

The slope is $\frac{9}{5}$, and the y-intercept is $(0, -4)$.

25. We solve for y to rewrite the equation in the form $y = mx + b$.

$-3x + y = 7$

$y = 3x + 7$

The slope is 3, and the y-intercept is $(0, 7)$.

27. $4x + 2y = 8$

$2y = -4x + 8$

$y = \frac{1}{2}(-4x + 8)$

$y = -2x + 4$

29. Observe that this is the equation of a horizontal line that lies 3 units above the x-axis. Thus, the slope is 0, and the y-intercept is $(0, 3)$. We could also write the equation in slope-intercept form.

$y = 3$

$y = 0x + 3$

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

31.
$$\begin{aligned} 2x - 5y &= -8 \\ -5y &= -2x - 8 \\ y &= -\frac{1}{5}(-2x - 8) \\ y &= \frac{2}{5}x + \frac{8}{5} \end{aligned}$$

The slope is $\frac{2}{5}$, and the y-intercept is $\left(0, \frac{8}{5}\right)$.

33.
$$\begin{aligned} 9x - 8y &= 0 \\ -8y &= -9x \\ y &= \frac{9}{8}x \text{ or } y = \frac{9}{8}x + 0 \end{aligned}$$

Slope: $\frac{9}{8}$, y-intercept: $(0, 0)$

35. We use the slope-intercept equation, substituting 5 for m and 7 for b:

$y = mx + b$

$y = 5x + 7$

37. We use the slope-intercept equation, substituting $\frac{7}{8}$ for m and -1 for b:

$y = mx + b$

$y = \frac{7}{8}x - 1$

39. We use the slope-intercept equation, substituting $-\frac{5}{3}$ for m and -8 for b:

$y = mx + b$

$y = -\frac{5}{3}x - 8$

41. We use the slope-intercept equation, substituting 0 for m and $\frac{1}{3}$ for b.

$y = mx + b$

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

$y = \frac{1}{3}$

43. From the graph we see that the y-intercept is $(0, 17)$. We also see that the point $(4, 23)$ is on the graph. We find the slope:

$$m = \frac{23 - 17}{4 - 0} = \frac{6}{4} = \frac{3}{2}$$

Substituting $\frac{3}{2}$ for m and 17 for b in the slope-intercept equation $y = mx + b$, we have

where y is the number of gallons of bottled water consumed per person and x is the number of years since 2000.

45. From the graph we see that the y-intercept is $(0, 15)$. We also see that the point $(5, 17)$ is on the graph. We find the slope:

$$m = \frac{17 - 15}{5 - 0} = \frac{2}{5}$$

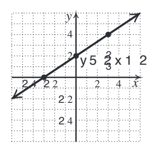
Substituting $\frac{2}{5}$ for m and 15 for b in the slope-intercept equation $y = mx + b$, we have

$y = \frac{2}{5}x + 15,$

where y is the number of jobs in millions, and x is the number of years since 2000.

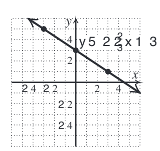
47. $y = \frac{2}{3}x + 2$

First we plot the y-intercept $(0, 2)$. We can start at the y-intercept and use the slope, $\frac{2}{3}$, to find another point. We move up 2 units and right 3 units to get a new point $(3, 4)$. Thinking of the slope as $\frac{-2}{-3}$ we can start at $(0, 2)$ and move down 2 units and left 3 units to get another point $(-3, 0)$.



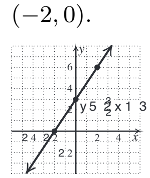
49. $y = -\frac{2}{3}x + 3$

First we plot the y-intercept $(0, 3)$. We can start at the y-intercept and, thinking of the slope as $\frac{-2}{3}$, find another point by moving down 2 units and right 3 units to the point $(3, 1)$. Thinking of the slope as $\frac{2}{-3}$ we can start at $(0, 3)$ and move up 2 units and left 3 units to get another point $(-3, 5)$.



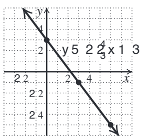
51. $y = \frac{3}{2}x + 3$

First we plot the y-intercept $(0, 3)$. We can start at the y-intercept and use the slope, $\frac{3}{2}$, to find another point. We move up 3 units and right 2 units to get a new point $(2, 6)$. Thinking of the slope as $\frac{-3}{-2}$ we can start at $(0, 3)$ and move down 3 units and left 2 units to get another point $(-2, 0)$.



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

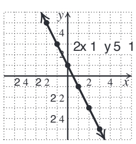
First we plot the y-intercept $(0, 3)$. We can start at the y-intercept and, thinking of the slope as $\frac{-4}{3}$, find another point by moving down 4 units and right 3 units to the point $(3, -1)$. Thinking of the slope as $\frac{4}{-3}$ we can start at $(0, 3)$ and move up 4 units and left 3 units to get another point $(-3, 7)$.



55. We first rewrite the equation in slope-intercept form.

$$2x + y = 1$$
$$y = -2x + 1$$

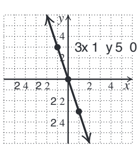
Now we plot the y-intercept $(0, 1)$. We can start at the y-intercept and, thinking of the slope as $\frac{-2}{1}$, find another point by moving down 2 units and right 1 unit to the point $(1, -1)$. In a similar manner, we can move from the point $(1, -1)$ to find a third point $(2, -3)$.



57. We first rewrite the equation in slope-intercept form.

$$3x + y = 0$$
$$y = -3x, \text{ or } y = -3x + 0$$

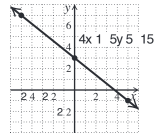
Now we plot the y-intercept $(0, 0)$. We can start at the y-intercept and, thinking of the slope as $\frac{-3}{1}$, find another point by moving down 3 units and right 1 unit to the point $(1, -3)$. Thinking of the slope as $\frac{3}{-1}$ we can start at $(0, 0)$ and move up 3 units and left 1 unit to get another point $(-1, 3)$.



59. We first rewrite the equation in slope-intercept form.

$$4x + 5y = 15$$
$$5y = -4x + 15$$
$$y = \frac{1}{5}(-4x + 15)$$
$$y = -\frac{4}{5}x + 3$$

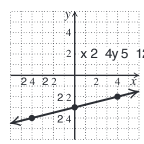
Now we plot the y-intercept $(0, 3)$. We can start at the y-intercept and, thinking of the slope as $\frac{-4}{5}$, find another point by moving down 4 units and right 5 units to the point $(5, -1)$. Thinking of the slope as $\frac{4}{-5}$ we can start at $(0, 3)$ and move up 4 units and left 5 units to get another point $(-5, 7)$.



61. We first rewrite the equation in slope-intercept form.

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

Now we plot the y-intercept $(0, -3)$. We can start at the y-intercept and use the slope, $\frac{1}{4}$, to find another point. We move up 1 unit and right 4 units to the point $(4, -2)$. Thinking of the slope as $\frac{-1}{-4}$ we can start at $(0, -3)$ and move down 1 unit and left 4 units to get another point $(-4, -4)$.



63. The equation $y = \frac{3}{4}x + 6$ represents a line with slope $\frac{3}{4}$, and the y-intercept is $(0, 6)$.

The equation $y = \frac{3}{4}x - 2$ represents a line with slope $\frac{3}{4}$, and the y-intercept is $(0, -2)$.

Since both lines have slope $\frac{3}{4}$ but different y-intercepts, their graphs are parallel.

65. The equation $y = 2x - 5$ represents a line with slope 2 and y-intercept $(0, -5)$. We rewrite the second equation in slope-intercept form.

$$4x + 2y = 9$$
$$2y = -4x + 9$$
$$y = \frac{1}{2}(-4x + 9)$$
$$y = -2x + \frac{9}{2}$$

The slope is -2 and the y-intercept is $\left(0, \frac{9}{2}\right)$. Since the lines have different slopes, their graphs are not parallel.

67. Rewrite each equation in slope-intercept form.

$$3x + 4y = 8$$
$$4y = -3x + 8$$
$$y = \frac{1}{4}(-3x + 8)$$
$$y = -\frac{3}{4}x + 2$$

$$7 - 12y = 9x$$
$$-12y = 9x - 7$$
$$y = -\frac{1}{12}(9x - 7)$$
$$y = -\frac{3}{4}x + \frac{7}{12}$$

The slope is $-\frac{3}{4}$, and the y-intercept is $\left(0, \frac{7}{12}\right)$.

Since both lines have slope $-\frac{3}{4}$ but different y-intercepts, their graphs are parallel.

69. $y = 4x - 5$,
$4y = 8 - x$

The first equation is in slope-intercept form. It represents a line with slope 4. Now we rewrite the second equation in slope-intercept form.

$$4y = 8 - x$$
$$y = \frac{1}{4}(8 - x)$$
$$y = 2 - \frac{1}{4}x$$
$$y = -\frac{1}{4}x + 2$$

The slope of the line is $-\frac{1}{4}$.

Since $4\left(-\frac{1}{4}\right) = -1$, the equations represent perpendicular lines.

71. $x - 2y = 5$,
$2x + 4y = 8$

We write each equation in slope-intercept form.

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

The slope is $\frac{1}{2}$.

$$2x + 4y = 8$$
$$4y = -2x + 8$$
$$y = \frac{1}{4}(-2x + 8)$$
$$y = -\frac{1}{2}x + 2$$

The slope is $-\frac{1}{2}$.

Since $\frac{1}{2}\left(-\frac{1}{2}\right) = -\frac{1}{4} \neq -1$, the equations do not represent perpendicular lines.

73. $2x + 3y = 1$,
$3x - 2y = 1$

We write each equation in slope-intercept form.

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

The slope is $-\frac{2}{3}$.

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

The slope is $\frac{3}{2}$.

Since $-\frac{2}{3}\left(\frac{3}{2}\right) = -1$, the equations represent perpendicular lines.

75. The slope of the line represented by $y = 5x - 7$ is 5. Then a line parallel to the graph of $y = 5x - 7$ has slope 5 also. Since the y-intercept is $(0, 11)$, the desired equation is $y = 5x + 11$.

77. First find the slope of the line represented by $2x + y = 0$.

$$2x + y = 0$$
$$y = -2x$$

The slope is -2. Then the slope of a line perpendicular to the graph of $2x + y = 0$ is the negative reciprocal of -2, or $\frac{1}{2}$. Since the y-intercept is $(0, 0)$, the desired equation is $y = \frac{1}{2}x + 0$, or $y = \frac{1}{2}x$.

79. The slope of the line represented by $y = x$ is 1. Then a line parallel to this line also has slope 1. Since the y-intercept is $(0, 3)$, the desired equation is
$y = 1 \cdot x + 3$, or $y = x + 3$.

81. First find the slope of the line represented by $x + y = 3$.

$$x + y = 3$$
$$y = -x + 3, \text{ or } y = -1 \cdot x + 3$$

The slope is -1. Then the slope of a line perpendicular to this line is the negative reciprocal is -1, or 1. Since the y-intercept is -4, the desired equation is $y = 1 \cdot x - 4$, or $y = x - 4$.

83. Writing Exercise. Yes; think of the slope as $\frac{0}{a}$ for any nonzero value of a.

85. $y - k = m(x - h)$
$y = m(x - h) + k$ Adding k to both sides

87. $-10 - (-3) = -10 + 3 = -7$

89. $-4 - 5 = -4 + (-5) = -9$

91. Writing Exercise. Some such circumstances include using an incorrect slope and/or y-intercept when drawing the graph.

93. When $x = 0$, $y = b$, so $(0, b)$ is on the line. When $x = 1$, $y = m + b$, so $(1, m + b)$ is on the line. Then,

slope$= \dfrac{(m+b)-b}{1-0} = m.$

95. Rewrite each equation in slope-intercept form.

$$2x - 6y = 10$$
$$-6y = -2x + 10$$
$$y = \frac{1}{3}x - \frac{5}{3}$$

The slope of the line is $\frac{1}{3}$.

$$9x + 6y = 18$$
$$6y = -9x + 18$$
$$y = -\frac{3}{2}x + 3$$

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

The equation of the line is $y = \frac{1}{3}x + 3$.

97. Rewrite the first equation in slope-intercept form.

$$3x - 5y = 8$$
$$-5y = -3x + 8$$
$$y = -\frac{1}{5}(-3x + 8)$$
$$y = \frac{3}{5}x - \frac{8}{5}$$

The slope is $\frac{3}{5}$.

The slope of a line perpendicular to this line is a number m such that

$$\frac{3}{5}m = -1, \text{ or}$$
$$m = -\frac{5}{3}.$$

Now rewrite the second equation in slope-intercept form.

$$2x + 4y = 12$$
$$4y = -2x + 12$$
$$y = \frac{1}{4}(-2x + 12)$$
$$y = -\frac{1}{2}x + 3$$

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

The equation of the line is $y = -\frac{5}{3}x + 3$.

99. Rewrite the first equation in slope-intercept form.

$$3x - 2y = 9$$
$$-2y = -3x + 9$$
$$y = -\frac{1}{2}(-3x + 9)$$
$$y = \frac{3}{2}x - \frac{9}{2}$$

The slope of a line perpendicular to this line is a number m such that

$$\frac{3}{2}m = -1, \text{ or}$$
$$m = -\frac{2}{3}.$$

Now rewrite the second equation in slope-intercept form.

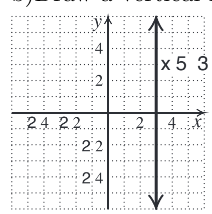
$$2x + 5y = 0$$
$$5y = -2x$$
$$y = -\frac{2}{5}x, \text{ or } y = -\frac{2}{5}x + 0$$

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

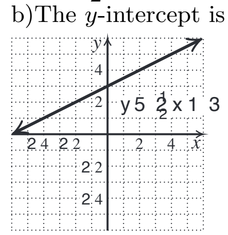
The equation of the line is $y = -\frac{2}{3}x + 0$, or $y = -\frac{2}{3}x$.

Connecting the Concepts 3.6

1. a) $x = 3$ is linear.
b)Draw a vertical line through $(3, 0)$.

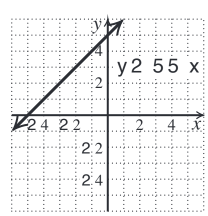


3. a) $y = \frac{1}{2}x + 3$ is linear.
b)The y-intercept is $(0, 3)$. Another point is $(2, 4)$.



5. **a)** $y - 5 = x$ is linear.

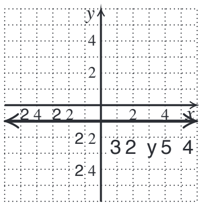
b) Rewriting in point-slope form $y = x + 5$. The y-intercept is $(0, 5)$. Another point is $(1, 6)$.



7. $3xy = 6$ is not linear.

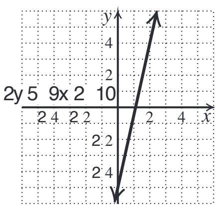
9. **a)** $3 - y = 4$ is linear.

b) Solving for y,
$3 - y = 4$
$-1 = y$
Draw a horizontal line through $(0, -1)$.



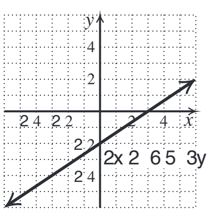
11. **a)** $2y = 9x - 10$ is linear.

b) Rewriting in slope-intercept form $y = \frac{9}{2}x - 5$. The y-intercept is $(0, -5)$. Another point is $(2, 4)$.



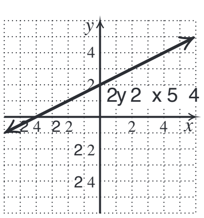
13. **a)** $2x - 6 = 3y$ is linear.

b) Solving for y,
$3y = 2x - 6$
$y = \frac{2}{3}x - 2$
The y-intercept is $(0, -2)$. Another point is $(3, 0)$.



15. **a)** $2y - x = 4$ is linear.

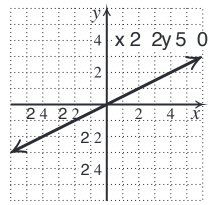
b) When $x = 0$,
$2y = 4$
$y = 2$
the y-intercept is $(0, 2)$.
When $y = 0$,
$-x = 4$
$x = -4$
the x-intercept is $(-4, 0)$.



17. **a)** $x - 2y = 0$ is linear.

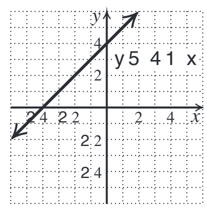
b) When $x = 0$,
$-2y = 0$

the y-intercept is $(0, 0)$, also the x-intercept.



19. **a)** $y = 4 + x$ is linear.

b) The y-intercept is $(0, 4)$. Another point is $(1, 5)$.



Exercise Set 3.7

1. Substituting 5 for m, 2 for x_1, and 3 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - 3 = 5(x - 2)$. Choice (g) is correct.

3. Substituting -5 for m, 2 for x_1, and 3 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - 3 = -5(x - 2)$. Choice (d) is correct.

5. Substituting -5 for m, -2 for x_1, and -3 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - (-3) = -5(x - (-2))$, or $y + 3 = -5(x + 2)$. Choice (e) is correct.

7. Substituting -5 for m, -3 for x_1, and -2 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - (-2) = -5(x - (-3))$, or $y + 2 = -5(x + 3)$. Choice (f) is correct.

9. We see that the points $(1, -4)$ and $(-3, 2)$ are on the line. To go from $(1, -4)$ to $(-3, 2)$ we go up 6 units and left 4 units so the slope of the line is $\frac{6}{-4}$, or $-\frac{3}{2}$. Then, substituting $-\frac{3}{2}$ for m, 1 for x_1, and -4 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - (-4) = -\frac{3}{2}(x - 1)$, or $y + 4 = -\frac{3}{2}(x - 1)$. Choice (c) is correct.

11. We see that the points $(1, -4)$ and $(5, 2)$ are on the line. To go from $(1, -4)$ to $(5, 2)$ we go up 6 units and right 4 units so the slope of the line is $\frac{6}{4}$, or $\frac{3}{2}$. Then, substituting $\frac{3}{2}$ for m, 1 for x_1, and -4 for y_1 in the point-slope equation $y - y_1 = m(x - x_1)$, we have $y - (-4) = \frac{3}{2}(x - 1)$, or $y + 4 = \frac{3}{2}(x - 1)$. Choice (d) is correct.

13. $y - y_1 = m(x - x_1)$
We substitute 3 for m, 1 for x_1, and 6 for y_1.

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

We substitute $\frac{3}{5}$ for m, 2 for x_1, and 8 for y_1.

$y - 8 = \frac{3}{5}(x - 2)$

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

We substitute -4 for m, 3 for x_1, and 1 for y_1.

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

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

We substitute $\frac{3}{2}$ for m, 5 for x_1, and -4 for y_1.

$y - (-4) = \frac{3}{2}(x - 5)$

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

We substitute $\frac{-5}{4}$ for m, -2 for x_1, and 6 for y_1.

$y - 6 = \frac{-5}{4}(x - (-2))$

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

We substitute -2 for m, -4 for x_1, and -1 for y_1.

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

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

We substitute 1 for m, -2 for x_1, and 8 for y_1.

$y - 8 = 1(x - (-2))$

27. First we write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - 5 = 4(x - 3) \quad \text{Substituting}$$

Next we find an equivalent equation of the form $y = mx + b$.

$$y - 5 = 4(x - 3)$$
$$y - 5 = 4x - 12$$
$$y = 4x - 7$$

29. First we write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - (-2) = \frac{7}{4}(x - 4) \quad \text{Substituting}$$

Next we find an equivalent equation of the form $y = mx + b$.

$$y - (-2) = \frac{7}{4}(x - 4)$$
$$y + 2 = \frac{7}{4}x - 7$$
$$y = \frac{7}{4}x - 9$$

31. First we write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - 7 = -2(x - (-3))$$

Next we find an equivalent equation of the form $y = mx + b$.

$$y - 7 = -2(x - (-3))$$
$$y - 7 = -2(x + 3)$$
$$y - 7 = -2x - 6$$

33. First we write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - (-1) = -4(x - (-2))$$

Next we find an equivalent equation of the form $y = mx + b$.

$$y - (-1) = -4(x - (-2))$$
$$y + 1 = -4(x + 2)$$
$$y + 1 = -4x - 8$$
$$y = -4x - 9$$

35. First we write the equation in point-slope form.

$$y - y_1 = m(x - x_1)$$
$$y - 6 = \frac{2}{3}(x - 5)$$

Next we find an equivalent equation of the form $y = mx + b$.

$$y - 6 = \frac{2}{3}x - \frac{10}{3}$$
$$y = \frac{2}{3}x + \frac{8}{3}$$

37. The slope is $-\frac{5}{6}$ and the y-intercept is $(0, 4)$. Substituting $-\frac{5}{6}$ for m and 4 for b in the slope-intercept equation $y = mx + b$, we have $y = -\frac{5}{6}x + 4$.

39. First solve the equation for y and determine the slope of the given line.

$$x - 2y = 3 \quad \text{Given line}$$
$$-2y = -x + 3$$
$$y = \tfrac{1}{2}x - \tfrac{3}{2}$$

The slope of the given line is $\frac{1}{2}$.

The slope of every line parallel to the given line must also be $\frac{1}{2}$. We find the equation of the line with slope $\frac{1}{2}$ and containing the point (2, 5).

$$y - y_1 = m(x - x_1) \quad \text{Point-slope equation}$$
$$y - 5 = \tfrac{1}{2}(x - 2) \quad \text{Substituting}$$
$$y - 5 = \tfrac{1}{2}x - 1$$
$$y = \tfrac{1}{2}x + 4$$

41. The slope of $y = 4x + 3$ is 4. The given point $(0, -5)$ is the y-intercept, so we substitute in the slope-intercept equation.

$y = 4x - 5$.

43. First solve the equation for y and determine the slope of the given line.

$$2x + 3y = -7 \quad \text{Given line}$$
$$3y = -2x - 7$$
$$y = -\tfrac{2}{3}x - \tfrac{7}{3}$$

The slope of every line parallel to the given line must also be $-\frac{2}{3}$. We find the equation of the line with slope $-\frac{2}{3}$ and containing the point $(-2, \ -3)$.

$$y - y_1 = m\,(x - x_1) \quad \text{Point-slope equation}$$

$$y - (-3) = -\tfrac{2}{3}[x - (-2)] \quad \text{Substituting}$$

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

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

$$y = -\tfrac{2}{3}x - \tfrac{13}{3}$$

45. $x = 2$ is a vertical line. A line parallel to it that passes through $(5, -4)$ is the vertical line 5 units to the right of the y-axis, or $x = 5$.

47. First solve the equation for y and determine the slope of the given line.

$$2x - 3y = 4 \quad \text{Given line}$$

$$-3y = -2x + 4$$

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

The slope of the given line is $\frac{2}{3}$.

The slope of perpendicular line is given by the opposite of the reciprocal of $\frac{2}{3}$, $-\frac{3}{2}$. We find the equation of the line with slope $-\frac{3}{2}$ and containing the point (3, 1).

$$y - y_1 = m\,(x - x_1) \quad \text{Point-slope equation}$$

$$y - 1 = -\tfrac{3}{2}\,(x - 3) \quad \text{Substituting}$$

$$y - 1 = -\tfrac{3}{2}x + \tfrac{9}{2}$$

$$y = -\tfrac{3}{2}x + \tfrac{11}{2}$$

49. First solve the equation for y and determine the slope of the given line.

$$x + y = 6 \quad \text{Given line}$$

$$y = -x + 6$$

The slope of the given line is -1.

The slope of perpendicular line is given by the opposite of the reciprocal of -1, 1. We find the equation of the line with slope 1 and containing the point (-4, 2).

$$y - y_1 = m\,(x - x_1) \quad \text{Point-slope equation}$$

$$y - 2 = 1\,(x - (-4)) \quad \text{Substituting}$$

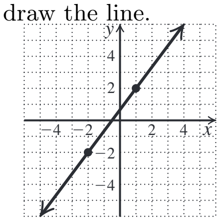
$$y - 2 = x + 4$$

$$y = x + 6$$

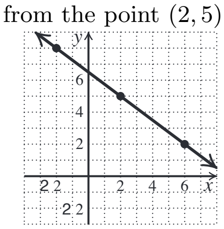
51. The slope of a line perpendicular to $2x - 5 = y$ is $-\frac{1}{2}$ and we are given the y-intercept of the desired line, (0, 6). Then we have $y = -\frac{1}{2}x + 6$.

53. $y = 5$ is a horizontal line, so a line perpendicular to it must be vertical. The equation of the vertical line containing (-3,

55. We plot $(1, 2)$, move up 4 and to the right 3 to $(4, 6)$ and draw the line.

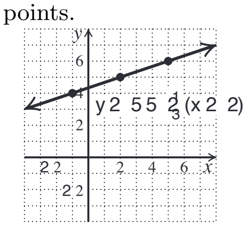


57. We plot $(2, 5)$, move down 3 and to the right 4 to $(6, 2)$ $\left(\text{since } -\dfrac{3}{4} = \dfrac{-3}{4}\right)$, and draw the line. We could also think of $-\dfrac{3}{4}$ and $\dfrac{3}{-4}$ and move up 3 and to the left 4 from the point $(2, 5)$ to $(-2, 8)$.



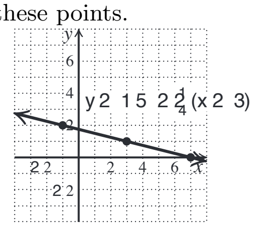
59. $y - 5 = \dfrac{1}{3}(x - 2)$ Point-slope form

The line has slope $\dfrac{1}{3}$ and passes through $(2, 5)$. We plot $(2, 5)$ and then find a second point by moving up 1 unit and right 3 units to $(5, 6)$. We draw the line through these points.



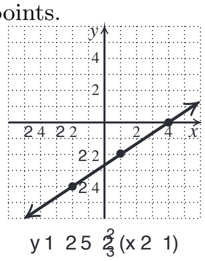
61. $y - 1 = -\dfrac{1}{4}(x - 3)$ Point-slope form

The line has slope $-\dfrac{1}{4}$, or $\dfrac{1}{-4}$ passes through $(3, 1)$. We plot $(3, 1)$ and then find a second point by moving up 1 unit and left 4 units to $(-1, 2)$. We draw the line through these points.



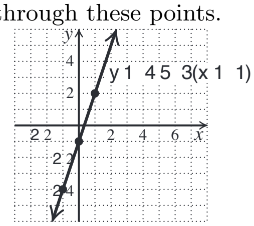
63. $y + 2 = \dfrac{2}{3}(x - 1)$, or $y - (-2) = \dfrac{2}{3}(x - 1)$

The line has slope $\dfrac{2}{3}$ and passes through $(1, -2)$. We plot $(1, -2)$ and then find a second point by moving up 2 units and right 3 units to $(4, 0)$. We draw the line through these points.



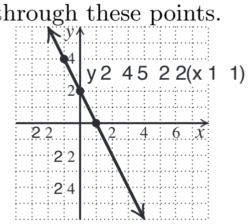
65. $y+4=3(x+1)$, or $y-(-4)=3(x-(-1))$

The line has slope 3, or $\frac{3}{1}$, and passes through $(-1,-4)$. We plot $(-1,-4)$ and then find a second point by moving up 3 units and right 1 unit to $(0,-1)$. We draw the line through these points.



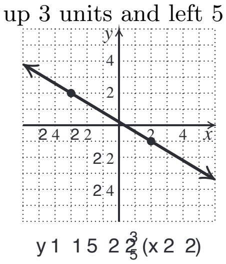
67. $y-4=-2(x+1)$, or $y-4=-2(x-(-1))$

The line has slope -2, or $\frac{-2}{1}$, and passes through $(-1,4)$. We plot $(-1,4)$ and then find a second point by moving down 2 units and right 1 unit to $(0,2)$. We draw the line through these points.



69. $y+1=-\frac{3}{5}(x-2)$, or $y-(-1)=-\frac{3}{5}(x-(-2))$

The line has slope $-\frac{3}{5}$, or $\frac{-3}{5}$ and passes through $(-2,-1)$. We plot $(2,-1)$ and then find a second point by moving up 3 units and left 5 units to $(-3,2)$, and draw the line.



71. First find the slope of the line passing through the points $(1,62.1)$ and $(17,41.1)$.

$$m=\frac{41.1-62.1}{17-1}=\frac{-21}{16}=-1.3125$$

Now write an equation of the line. We use $(1,62.1)$ in the point-slope equation and then write an equivalent slope-intercept equation.

$$y-y_1=m(x-x_1)$$
$$y-62.1=-1.3125(x-1)$$
$$y-62.1=-1.3125x+1.3125$$
$$y=-1.3125x+63.4125$$

a) Since 1999 is 9 yr after 1990, we substitute 9 for x to calculate the birth rate in 1999.

$y=-1.3125(9)+63.4125=-11.8125+63.4125=51.6$

In 1999, there were 51.6 births per 1000 females age 15 to 19.

b) 2008 is 18 yr after 1990 $(2008-1990=18)$, so we substitute 18 for x.

$y=-1.3125(18)+63.4125=-23.625+63.4125=39.7875\approx 39.8$

We predict that the birth rate among teenagers will be 39.8 births per 1000 females in 2008.

73. First find the slope of the line passing through the points $(0,14.2)$ and $(3,10.8)$. In each case, we let the first coordinate represent the number of years after 2000.

$$m=\frac{10.8-14.2}{3-0}=\frac{-3.4}{3}\approx -1.13$$

The y-intercept of the line is $(0,14.2)$. We write the slope-intercept equation: $y=-1.13x+14.2$.

a) Since $2002-2001=1$, we substitute 1 for x to calculate the percentage in 2002.

$y=-1.13(1)+14.2=-1.131+14.2\approx 13.1\%$

b) Since $2008-2001=7$, we substitute 7 for x to find the percentage in 2008.

$y=-1.13(7)+14.2=-10.17+14.2\approx 4\%$

(Answers will vary depending on how the slope was rounded in part (a).)

75. First find the slope of the line passing through $(0,14.3)$ and $(10,17.4)$. In each case, we let the first coordinate represent the number of years after 1995.

$$m=\frac{17.4-14.3}{10-0}=\frac{3.1}{10}=0.31$$

The y-intercept is $(0,14.3)$. We write the slope-intercept equation: $y=0.31x+14.3$.

a) Since 2002 is 7 yr after 1995, we substitute 7 for x to calculate the college enrollment in 2002.

$y=0.31(7)+14.3=2.17+14.3=16.47$ million students

b) Since $2010-1995=15$ yr after 1990, we substitute 15 for x to find the enrollment in 2010.

$y=0.31(15)+14.3=4.65+14.3=18.9$ million students

77. First find the slope of the line through $(0,31)$ and $(12,36.3)$. In each case, we let the first coordinate represent the number of years after 1990 and the second millions of residents.

$36.3-31 \quad 5.3$

The y-intercept is $(0, 31)$. We write the slope-intercept equation: $y = 0.38x + 31$.

a) Since 1997 is 7 yr after 1990, we substitute 7 for x to find the number of U.S. residents over the age of 65 in 1997.

$y = 0.38(7) + 31 = 33.6$ million residents

b) Since 2010 is 20 yr after 1990, we substitute 20 for x to find the number of U.S. residents over the age of 65 in 2010.

$y = 0.38(20) + 31 = 38.6$ million residents

(Answers will vary depending on how the slope is rounded.)

79. $(2, 3)$ and $(4, 1)$

First we find the slope.

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

Then we write an equation of the line in point-slope form using either of the points above.

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

Finally, we find an equivalent equation in slope-intercept form.

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

81. $(-3, 1)$ and $(3, 5)$

First we find the slope.

$$m = \frac{1-5}{-3-3} = \frac{-4}{-6} = \frac{2}{3}$$

Then we write an equation of the line in point-slope form using either of the points above.

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

Finally, we find an equivalent equation in slope-intercept form.

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

83. $(5, 0)$ and $(0, -2)$

First we find the slope.

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

Then we write an equation of the line in point-slope form using either of the points above.

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

Finally, we find an equivalent equation in slope-intercept form.

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

85. $(-4, -1)$ and $(1, 9)$

First we find the slope.

$$m = \frac{9-(-1)}{1-(-4)} = \frac{9+1}{1+4} = 2$$

Then we write an equation of the line in point-slope form using either of the points above.

$$y - 9 = 2(x - 1)$$

Finally, we find an equivalent equation in slope-intercept form.

$$y - 9 = 2(x - 1)$$
$$y - 9 = 2x - 2$$
$$y = 2x + 7$$

87. Writing Exercise. The equation of a horizontal line $y = b$ can be written in point-slope form:

$$y - b = 0(x - x_1)$$

The equation of a vertical line cannot be written in point-slope form because the slope of a vertical line is undefined.

89. $(-5)^3 = (-5)(-5)(-5) = -125$

91. $-2^6 = -2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = -64$

93. $2 - (3 - 2^2) + 10 \div 2 \cdot 5 = 2 - (3 - 4) + 10 \div 2 \cdot 5$
$= 2 - (-1) + 10 \div 2 \cdot 5 = 2 + 1 + 10 \div 2 \cdot 5$
$= 2 + 1 + 5 \cdot 5 = 2 + 1 + 25 = 28$

95. Writing Exercise.

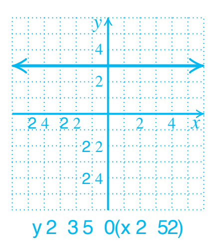
(1) Find the slope of the line using $m = \dfrac{y_2 - y_1}{x_2 - x_1}$.

(2) Substitute in the point-slope equation, $y - y_1 = m(x - x_1)$.

(3) Solve for y.

97. $y - 3 = 0(x - 52)$

Observe that the slope is 0. Then this is the equation of a horizontal line that passes through $(52, 3)$. Thus, its graph is a horizontal line 3 units above the x-axis.



99. First we find the slope of the line using any two points on the line. We will use $(3, -3)$ and $(4, -1)$.

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

Then we write an equation of the line in point-slope form using either of the points above.

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

Finally, we find an equivalent equation in slope-intercept form.

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

101. First we find the slope of the line using any two points on the line. We will use $(2, 5)$ and $(5, 1)$.

$$m = \frac{5-1}{2-5} = \frac{4}{-3} = -\frac{4}{3}$$

Then we write an equation of the line in point-slope form using either of the points above.

$$y - 5 = -\frac{4}{3}(x - 2)$$

Finally, we find an equivalent equation in slope-intercept form.

$$y - 5 = -\frac{4}{3}(x - 2)$$
$$y - 5 = -\frac{4}{3}x + \frac{8}{3}$$
$$y = -\frac{4}{3}x + \frac{23}{3}$$

103. The slope of $y = 3 - 4x$ is -4. We are given the y-intercept of the line, so we use slope-intercept form. The equation is $y = -4x + 7$.

105. First find the slope of the line passing through $(2, 7)$ and $(-1, -3)$.

$$m = \frac{-3-7}{-1-2} = \frac{-10}{-3} = \frac{10}{3}$$

Now find an equation of the line containing the point $(-1, 5)$ and having slope $\frac{10}{3}$.

$$y - 5 = \frac{10}{3}(x - (-1))$$
$$y - 5 = \frac{10}{3}(x + 1)$$
$$y - 5 = \frac{10}{3}x + \frac{10}{3}$$
$$y = \frac{10}{3}x + \frac{25}{3}$$

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

Using the form $\frac{x}{a} + \frac{y}{b} = 1$

The x-intercept is $(2, 0)$.
The y-intercept is $(0, 5)$.

109.

$$4y - 3x = 12$$
$$\frac{1}{12}(4y - 3x) = 12 \cdot \frac{1}{12}$$
$$\frac{y}{3} - \frac{x}{4} = 1$$
$$\frac{x}{-4} + \frac{y}{3} = 1$$

The x-intercept is $(-4, 0)$.
The y-intercept is $(0, 3)$.

111. Writing Exercise. Equations are entered on most graphing calculators in slope-intercept form. Writing point-slope form in the modified form $y = m(x - x_1) + y_1$ better ac-

Connecting the Concepts 3.7

1. $y = -\frac{1}{2}x - 7$ is in slope-intercept form.

3. $x = y + 2$ is none of these.

5. $y - 2 = 5(x + 1)$ is in point-slope form.

7.

$$2x = 5y + 10$$
$$2x - 5y = 10 \quad \text{Subtracting } 5y \text{ from both sides}$$

9.

$$y = 2x + 7$$
$$-2x + y = 7 \quad \text{Subtracting } 2x \text{ from both sides}$$
$$2x - y = -7 \quad \text{Multiplying } -1 \text{ to both sides}$$

11.

$$y - 2 = 3(x + 7)$$
$$y - 2 = 3x + 21 \quad \text{Using the distributive law}$$
$$y = 3x + 23 \quad \text{Adding 2}$$
$$-3x + y = 23 \quad \text{Subtracting } 3x$$
$$3x - y = -23 \quad \text{Multiplying by } -1$$

13.

$$2x - 7y = 8$$
$$-7y = -2x + 8 \quad \text{Subtracting } 2x$$
$$-\frac{1}{7}(-7y) = -\frac{1}{7}(-2x + 8) \quad \text{Multiplying } -\frac{1}{7}$$
$$y = \frac{2}{7}x - \frac{8}{7} \quad \text{Using distributive law}$$

15.

$$8x = y + 3$$
$$8x - 3 = y \quad \text{Subtracting 3}$$
$$y = 8x - 3 \quad \text{rewriting}$$

17.

$$9y = 5 - 8x$$
$$\frac{1}{9}(9y) = \frac{1}{9}(-8x + 5)$$
$$y = -\frac{8}{9}x + \frac{5}{9}$$

19.

$$2 - 3y = 5y + 6$$
$$-4 - 3y = 5y \quad \text{Subtracting 6}$$
$$-4 = 8y \quad \text{Adding } 3y$$
$$-\frac{4}{8} = y \quad \text{Multiplying } \frac{1}{8}$$
$$-\frac{1}{2} = y \quad \text{Simplifying}$$
$$y = -\frac{1}{2}$$

Chapter 3 Review

1. True, see page 153 of the text.

3. False, slope-intercept form is $y = mx + b$.

7. True, see page 187 of the text.

9. True, see page 207 in the text.

11. ***Familiarize.*** From the pie chart we see that 23.8% of the searches using Yahoo. We let $x =$ the number of searches using Yahoo, in billions in July 2006.

Translate. We reword the problem.

What	is	23.8%	of	5.6
↓	↓	↓	↓	↓
x	$=$	23.8%	$\cdot$	5.6

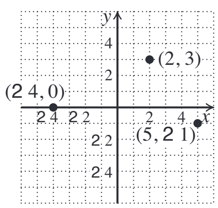
Carry out.

$$x = 0.238 \cdot 5 \cdot 6 \approx 1.3$$

Check. We can repeat the calculations.

State. About 1.3 billion searches were done using Yahoo.

13.-15. We plot the points $(5,-1)$, $(2,3)$ and $(-4,0)$.



17. Since the first coordinate is positive and the second point is negative, the point $(15.3,-13.8)$ is in quadrant IV.

19. Point A is 5 units left and 1 unit down. The coordinates of A $(-5,-1)$.

21. Point C is 3 units right and 0 units up or down. The coordinates of C are $(3,0)$

23. a) We substitute 3 for x and 1 for y.

$$\begin{array}{c|l} \multicolumn{2}{c}{y = 2x+7} \\ \hline 1 & 2(3)+7 \\ & 6+7 \end{array}$$

$1 \stackrel{?}{=} 13$ FALSE

No, the pair $(3,1)$ is not a solution.

b) We substitute -3 for x and 1 for y.

$$\begin{array}{c|l} \multicolumn{2}{c}{y = 2x+7} \\ \hline 1 & 2(-3)+7 \\ & -6+7 \end{array}$$

$1 \stackrel{?}{=} 1$ TRUE

Yes, the pair $(-3,1)$ is a solution.

25. $y = x - 5$

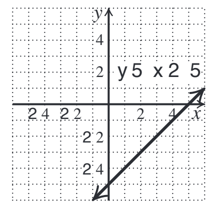
The y-intercept is $(0,-5)$. We find two other points.

When $x = 5$, $y = 5 - 5 = 0$.

When $x = 3$, $y = 3 - 5 = -2$.

x	y
0	-5
5	0

We plot these points, draw the line and label the graph $y = x - 5$.



27. $y = -x + 4$

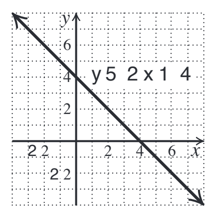
The y-intercept is $(0,4)$. We find two other points.

When $x = 4$, $y = -4 + 4 = 0$.

When $x = 2$, $y = -2 + 4 = 2$.

x	y
0	4
4	0
2	2

We plot these points, draw the line and label the graph $y = -x + 4$.



29. $4x + 5 = 3$

$x = -\dfrac{1}{2}$

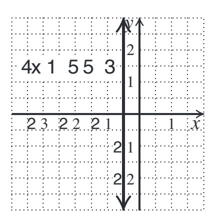
Any order pair $(-\frac{1}{2}, y)$ is a solution. The variable x must be $-\frac{1}{2}$, but the y variable can be any number. A few are listed below.

When $x = 5$, $y = 5 - 5 = 0$.

When $x = 3$, $y = 3 - 5 = -2$.

x	y
$-\frac{1}{2}$	0
$-\frac{1}{2}$	2
$-\frac{1}{2}$	-2

We plot these points, draw the line and label the graph $4x + 5 = 3$.



31. We graph $v = -\frac{1}{4}t + 9$ by selecting values of t and calculating the values for v.

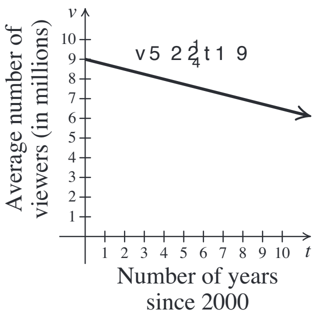
If $t = 0$, $v = -\frac{1}{4}(0) + 9 = 9$.

If $t = 4$, $v = -\frac{1}{4}(4) + 9 = 8$.

If $t = 8$, $v = -\frac{1}{4}(8) + 9 = 7$.

t	v
0	9
4	8
8	7

We plot these points, draw the line and label the graph.



Since $2008-2000 = 8$. Locate the point on the line above 8 and find the corresponding value on the vertical axis. The value is 7, so we estimate about 7 million daily viewers in 2008.

33. The points (60 mi, 5 gal) and (120 mi, 10 gal) are on the graph. This tells $120 - 60$ mi and $10 - 5 = 5$gal. The rate is

$$\frac{60 \text{ mi}}{5 \text{ gal}} = 12 \text{ mpg}$$

35. We can use any two points on the line, such as $(-1, -2)$ and $(2, 5)$.

$$m = \frac{\text{change in } y}{\text{change in } x}$$
$$= \frac{5-(-2)}{2-(-1)} = \frac{7}{3}$$

37. $(-2, 5)$ and $(3, -1)$
$$m = \frac{-1-5}{3-(-2)} = \frac{-6}{5}$$

39. $(-3, 0)$ and $(-3, 5)$
$$m = \frac{5-0}{-3-(-3)} = \frac{5}{0}, \text{ undefined}$$

41. The grade is expressed as a percent
$$m = \frac{1}{12} \approx 0.08\bar{3} \approx 8.\bar{3}\%$$

43. Rewrite the equation in slope-intercept form.
$3x + 5y = 45$:

$$5y = -3x + 45$$
$$y = -\tfrac{3}{5}x + 9$$

The slope is $-\frac{3}{5}$ and the y−intercept is $(0, 9)$.

45. First solve for y and determine the slope of each line.
$3x - 5 = 7y$

$$y = \tfrac{3}{7}x - \tfrac{5}{7}$$

The slope of $3x - 5 = 7y$ is $\frac{3}{7}$.

$$7y - 3x = 7$$

$$y = \tfrac{3}{7}x + 1$$

The slope of $7y - 3x = 7$ is $\frac{3}{7}$.

The slopes are the same, so the lines are parallel.

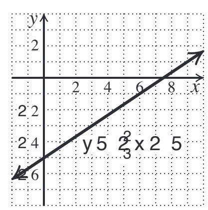
47. $y - y_1 = m(x - x_1)$
We substitute $-\frac{1}{3}$ for m, -2 for x_1, and 9 for y_1.
$y - 9 {=} -\frac{1}{3}(x - (-2))$

49. $y - y_1 = m(x - x_1)$
We substitute 5 for m, 3 for x_1, and -10 for y_1.

$$y - (-10) = 5(x - 3)$$
$$y + 10 = 5x - 15$$
$$y = 5x - 25$$

51. $y = \dfrac{2}{3}x - 5$

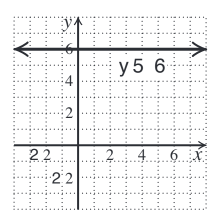
First we plot the y-intercept $(0, -5)$. We can start at the y-intercept and use the slope, $\frac{2}{3}$, to find another point. We move up 2 units and right 3 units to get a new point $(3, -3)$. Thinking of the slope as $\frac{-2}{-3}$ we move down 2 units and left 3 units to get another point $(-3, -7)$.



53. $y = 6$

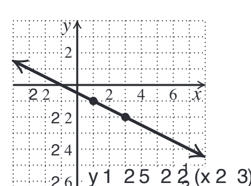
Any ordered pair $(x, 6)$ is a solution. The variable y must be 6, but the x variable can be any number. A few are listed below. Plot these points and draw the graph.

x	y
0	6
1	6
2	6



55. $y + 2 = -\dfrac{1}{2}(x - 3)$

We plot the $(3, -2)$. move down 1 unit and right 2 units to the point $(5, -3)$ and draw the line.



57. Writing Exercise. The graph of a vertical line has only an x-intercept. The graph of a horizontal line has only a y-intercept. The graph of a nonvertical, nonhorizontal line will have only one intercept if it passes through the origin: (0,0) is both the x-intercept and the y-intercept.

59. $y = -5x + b$, we substitute $(3, 4)$.

$4 = -5(3) + b$

$4 = -15 + b$

$19 = b$

61. $y = 4 - |x|$

x	y
0	4
1	3
−1	3

Answers may vary.

Chapter 3 Test

1. First determine the number of student volunteers:

$25\% \times 1200 = 0.25 \times 1200$
$= 300$

From the chart, 31.6% of the students will volunteer in education or youth services, so

$31.6\% \times 300 = 0.316 \times 300$
$= 94.8$

Therefore, about 95 students will volunteer in education or youth services.

3. The point having coordinates $(-2, -10)$ is located in quadrant III.

5. Point A has coordinates $(3, 4)$.

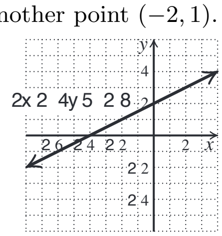
7. Point C has coordinates $(-5, 2)$.

9. $2x - 4y = -8$

We rewrite the equation in slope-intercept form.

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

Slope: $\frac{1}{2}$; y-intercept: $(0, 2)$. First we plot the y-intercept $(0, 2)$. We can start at the y-intercept and use the slope $\frac{1}{2}$ to find another point. We move up 1 unit and right 2 units to get a new point $(2, 3)$. Thinking of the slope as $\frac{-1}{-2}$ we can start at $(0, 2)$ and move down 1 unit and left 2 units to get another point $(-2, 1)$. To finish, we draw and label the line.



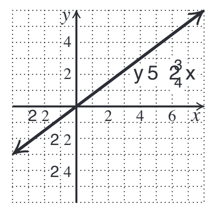
11. $y = \frac{3}{4}x$

We rewrite this equation in slope-intercept form.

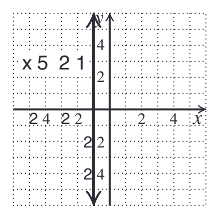
$y = \frac{3}{4}x + 0$

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

First we plot the y-intercept $(0, 0)$. We can start at the y-intercept and using the slope as $\frac{3}{4}$ we find another point. We move up 3 units and right 4 units to get a new point $(4, 3)$. Thinking of the slope as $\frac{-3}{-4}$ we can start at $(0, 0)$ and move down 3 units and left 4 units to get another point $(-4, -3)$. To finish, we draw and label the line.



13. $x = -1$ This is a vertical line with x-intercept $(-1, 0)$.



15. $(-5, 6)$ and $(-1, -3)$

$$m = \frac{-3-6}{-1-(-5)} = \frac{-3-6}{-1+5} = \frac{-9}{4}$$

17.

$$\text{rate} = \frac{\text{change in distance}}{\text{change in time}}$$

$$= \frac{6 \text{ km} - 3 \text{ km}}{\text{2:24 P.M.} - \text{2:15 P.M.}}$$

$$= \frac{3 \text{ km}}{9 \text{min}} = \frac{1}{3} \text{ km/min}$$

19. $5x - y = 30$

To find the x-intercept, we let $y = 0$ and solve for x.

$5x - 0 \cdot 0 = 30$
$5x - 0 = 30$
$5x = 30$
$x = 6$

The x-intercept is $(6, 0)$.

To find the y-intercept, we let $x = 0$ and solve for y.

$5 \cdot 0 - y = 30$
$-y = 30$
$y = -30$

The y-intercept is $(0, -30)$.

21. Slope: $-\dfrac{1}{3}$; y-intercept: $(0, -11)$.

The slope-intercept equation is $y = -\dfrac{1}{3}x - 11$.

23. Write both equations in slope-intercept form.

$$2y - x = 6$$

$$y = -2x + 5 \qquad y = \tfrac{1}{2}x + 3$$

$$m = -2 \qquad m = \tfrac{1}{2}$$

The product of their slopes is $(-2)\left(\frac{1}{2}\right)$, or -1; the lines are perpendicular.

25.

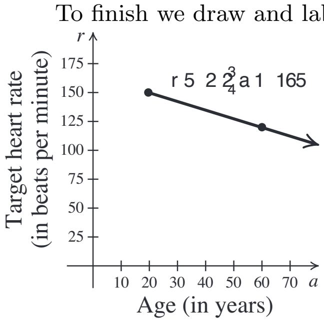
a. Plot $(20, 150)$
$(60, 120)$

$$m = \frac{150 - 120}{20 - 60} = \frac{30}{-40} = \frac{-3}{4}$$

Using point-slope form:

$$r - 120 = \frac{\square 3}{4}(a - 60)$$
$$r - 120 = \frac{\square 3}{4}(a - 60)$$
$$r = \frac{\square 3}{4}a + 165$$

To finish we draw and label the line.



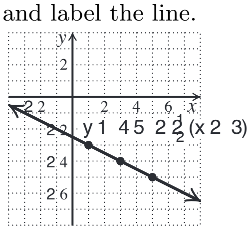
b. Using equation and let $a = 36$

$$r = -\tfrac{3}{4}(36) + 165$$
$$= -27 + 165$$
$$= 138$$

The target heart rate for a 36-year-old is 138 beats per minute.

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

Rewriting this equation in point-slope form, we have:
$y - (-4) = -\frac{1}{2}(x - 3)$
We have slope of $-\frac{1}{2}$ and a point having coordinates $(3, -4)$. Thinking of the slope as $\frac{\square 1}{2}$, we start at $(3, -4)$ and move down 1 unit and right 2 units to get a new point $(5, -5)$. Thinking of the slope as $\frac{1}{\square 2}$, we move up 1 unit and left 2 units to get the point $(1, -3)$. To finish, we draw and label the line.



29. First make a sketch.

The height of the square is $4 - (-1) = 4 + 1 = 5$ and the width is $5 \times 5 = 25$ square units and the perimeter is $4 \times 5 = 20$ units.