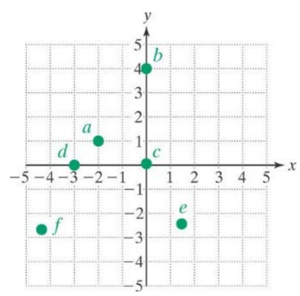
Chapter 5 Linear Equations in Two Variables

Section 5.1 Practice Exercises

1. **a.** x; y-axis
b. ordered
c. origin; (0, 0)
d. quadrants
e. negative
f. III
g. $Ax + By = C$
h. x-intercept
i. y-intercept
j. vertical
k. horizontal

3. For (x, y), if $x > 0$, $y > 0$, the point is in quadrant I. If $x < 0$, $y > 0$, the point is in quadrant II. If $x < 0$, $y < 0$, the point is in quadrant III. If $x > 0$, $y < 0$, the point is in quadrant IV.

5.



7. 0

9. A (–4, 5), II
B (–2, 0), x-axis
C (1, 1), I
D (4, –2), IV
E (–5, –3), III

11. **a.**
$$2(0)-3(-3)=9$$
$$0+9=9$$
$$9=9$$
$(0,-3)$ is a solution.

b.
$$2(-6)-3(1)=9$$
$$-12-3=9$$
$$-15=9$$
$(-6,1)$ is not a solution.

c.
$$2(1)-3\left(-\frac{7}{3}\right)=9$$
$$2+7=9$$
$$9=9$$
$\left(1,-\frac{7}{3}\right)$ is a solution.

13. **a.**

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

$(-1, 0)$ is not a solution.

b.

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

$(2, 3)$ is a solution.

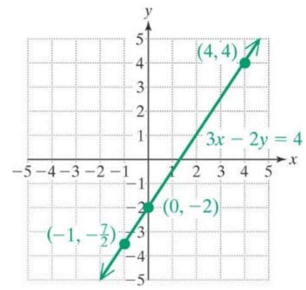
c.

$$-6 = \frac{1}{3}(1) + 1$$
$$-6 = \frac{4}{3}$$

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

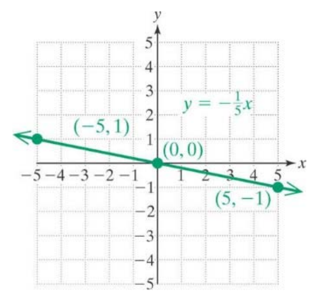
15. $3x - 2y = 4$

x	y
0	–2
4	4
–1	$-\frac{7}{2}$

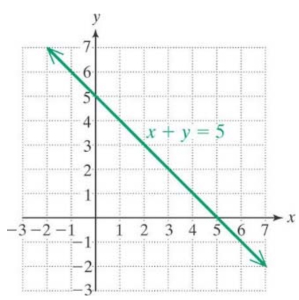


17. $y = -\frac{1}{5}x$

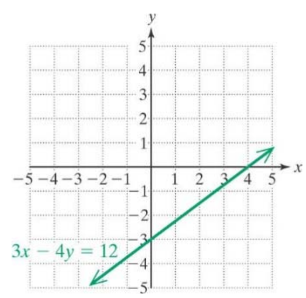
x	y
0	0
5	–1
–5	1



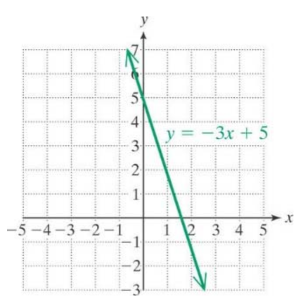
19.



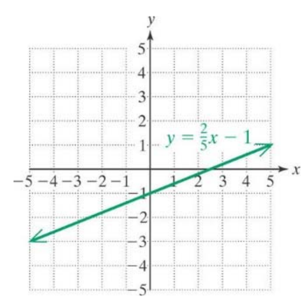
21.



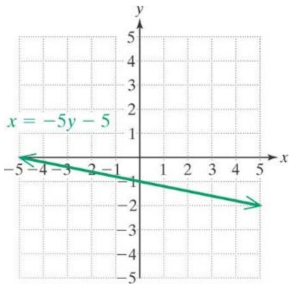
23.



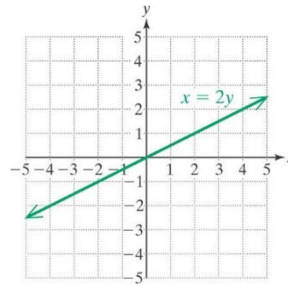
25.



27.



29.



31. To find an x -intercept, substitute $y = 0$ and solve for x. To find a y-intercept, substitute $x = 0$ and solve for y.

33. **a.**

$$2x + 3y = 18$$
$$2x + 3(0) = 18$$
$$2x = 18$$
$$x = 9$$

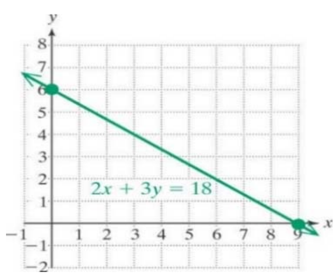
The x -intercept is (9, 0).

b.

$$2(0) + 3y = 18$$
$$3y = 18 \Rightarrow y = 6$$

The y-intercept is (0, 6).

c.



35. **a.**

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

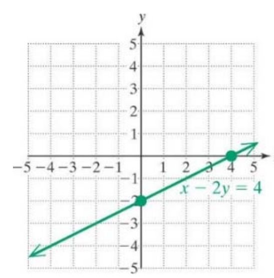
The x -intercept is (4, 0).

b.

$$0 - 2y = 4$$
$$-2y = 4 \Rightarrow y = -2$$

The y-intercept is (0, –2).

c.



37. **a.**

$$5x = 3y$$
$$5x = 3(0)$$
$$5x = 0$$
$$x = 0$$

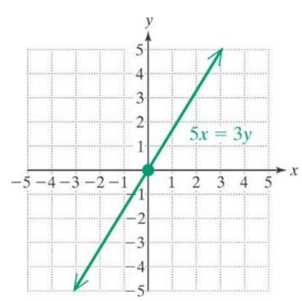
The x -intercept is (0, 0).

b.

$$5(0) = 3y$$
$$0 = 3y$$
$$0 = y$$

The y-intercept is (0, 0).

c.

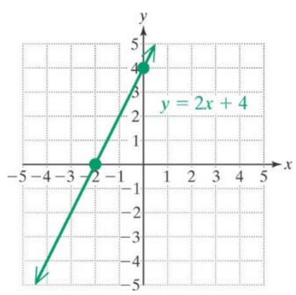


39. **a.**
$$y = 2x + 4$$
$$0 = 2x + 4$$
$$-2x = 4$$
$$x = \frac{4}{-2}$$
$$x = -2$$
The x -intercept is (–2, 0).

b.
$$y = 2(0) + 4$$
$$y = 4$$

The y-intercept is (0, 4).

c.

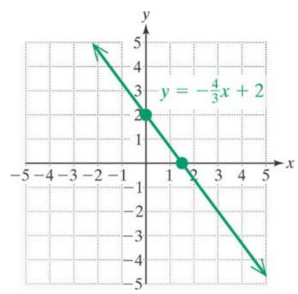


41. **a.**
$$y = -\frac{4}{3}x + 2$$
$$0 = -\frac{4}{3}x + 2$$
$$\frac{4}{3}x = 2$$
$$x = \frac{3}{4} \cdot 2 = \frac{3}{2}$$
The x -intercept is $\left(\frac{3}{2}, 0\right)$.

b.
$$y = -\frac{4}{3}(0) + 2$$
$$y = 2$$

The y-intercept is (0, 2).

c.



43.
$$x = \frac{1}{4}y$$
$$x = \frac{1}{4}(0)$$
$$x = 0$$

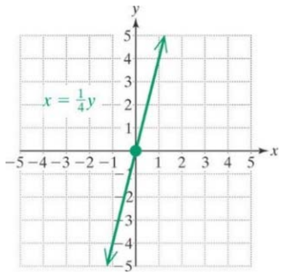
The x -intercept is $(0, 0)$.

$$0 = \frac{1}{4}y$$
$$0 = y$$

The y-intercept is (0, 0).

45. **a.**
$$y = 15{,}000 + 0.08x$$
$$y = 15{,}000 + 0.08(500{,}000)$$
$$= 15{,}000 + 40{,}000$$
$$= 55{,}000$$
The salary is $55,000.

b.
$$y = 15{,}000 + 0.08(300{,}000)$$
$$= 15{,}000 + 24{,}000$$
$$= 39{,}000$$
$$y = 39{,}000$$
The salary is $39,000.



c. $y = 15{,}000 + 0.08(0)$
$= 15{,}000 + 0$
$= 15{,}000$
The y-intercept is (0, 15,000).
For \$0 in sales, the salary is \$15,000.

d. Total sales cannot be negative.

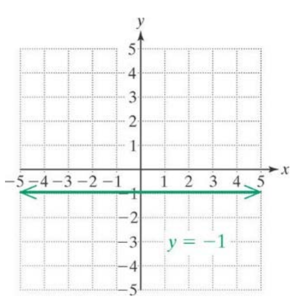
47. **a.** $y = 1500 - 300x$
$= 1500 - 300(1)$
$= 1500 - 300$
$= 1200$
A computer will be worth \$1200 1 yr after purchase.

b. $y = 1500 - 300x$
$300 = 1500 - 300x$
$-1200 = -300x$
$4 = x$
After 4 yr the computer will be worth \$300.

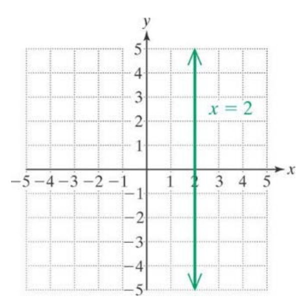
c. $y = 1500 - 300x$
$= 1500 - 300(0)$
$= 1500$
(0, 1500);
The y-intercept represents the initial value of the computer.

d. $y = 1500 - 300x$
$0 = 1500 - 300x$
$300x = 1500$
$x = 5$
(5, 0);
The x-intercept indicates that once the computer is 5 yr old, its value is \$0.

49. $y = -1$ Horizontal;
No x-intercept;
y-intercept (0, –1)



51. $x = 2$ Vertical;
x-intercept (2, 0);
No y-intercept



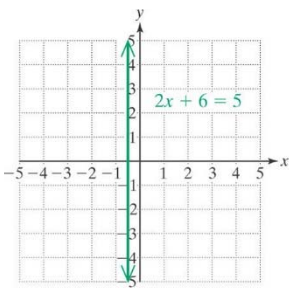
53. $2x+6=5$

$2x=-1$

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

Vertical;

x-intercept $\left(-\frac{1}{2},0\right)$; No y-intercept



55. $-2y+1=9$

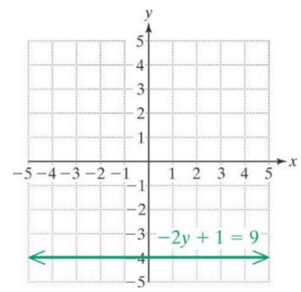
$-2y=8$

$y=-4$

Horizontal;

No x-intercept;

y-intercept (0, –4)



57. A horizontal line parallel to the x-axis will not have an x-intercept. A vertical line parallel to the y-axis will not have a y-intercept.

59. b, c, d

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

$\frac{x}{2}+\frac{0}{3}=1$

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

$x=2$

$\frac{0}{2}+\frac{y}{3}=1$

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

$y=3$

The x-intercept is (2, 0) and the y-intercept is (0, 3).

63. $\frac{x}{a}+\frac{y}{b}=1$

$\frac{x}{a}+\frac{0}{b}=1$

$\frac{x}{a}=1$

$x=a$

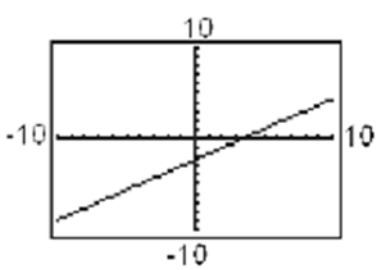
$\frac{0}{a}+\frac{y}{b}=1$

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

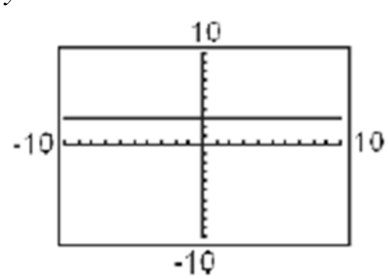
$y=b$

The x-intercept is (a, 0) and the y-intercept is (0, b).

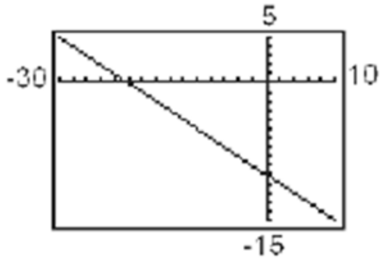
65. $y=\frac{2}{3}x-\frac{7}{3}$



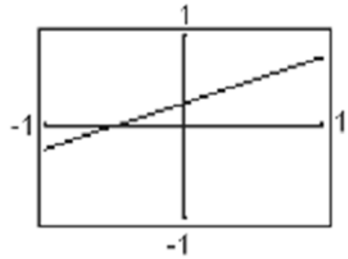
67. $y=3$



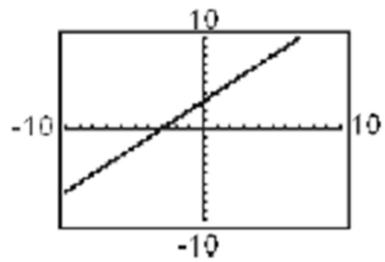
69.



71.



73. The lines look nearly indistinguishable. However, the linear equations are different so the lines are different.



Section 5.2 Practice Exercises

1. **a.** slope; $\dfrac{y_2 - y_1}{x_2 - x_1}$

b. parallel; same

c. right

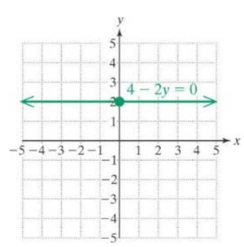
d. -1

3. **a.**
$$\frac{1}{2}x + y = 4$$
$$\frac{1}{2}(0) + y = 4 \Rightarrow y = 4$$
The ordered pair is (0, 4).

b.
$$\frac{1}{2}x + 0 = 4$$
$$\frac{1}{2}x = 4 \Rightarrow x = 8$$
The ordered pair is (8, 0).

c.
$$\frac{1}{2}(-4) + y = 4$$
$$-2 + y = 4$$
$$y = 6$$
The ordered pair is (–4, 6).

5.
$$4 - 2y = 0$$
$$-2y = -4 \Rightarrow y = 2$$
There is no *x*-intercept.
The *y*-intercept is (0, 2).



7. $m = \frac{24}{7} = \frac{24}{7}$

9. $m = \frac{8}{72} = \frac{1}{9}$

11. $m = \frac{4}{100} = \frac{1}{25}$

13.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-3-0}{0-6} \\ &= \frac{-3}{-6} = \frac{1}{2} \end{aligned}$$

15.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-7-3}{4-(-2)} \\ &= \frac{-10}{6} = -\frac{5}{3} \end{aligned}$$

17.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-3-5}{2-(-2)} \\ &= \frac{-8}{4} \\ &= -2 \end{aligned}$$

19.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-0.8-(-1.1)}{-0.1-0.3} \\ &= \frac{0.3}{-0.4} \\ &= -\frac{3}{4} \end{aligned}$$

21.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{7-3}{2-2} \\ &= \frac{4}{0} \text{ Undefined} \end{aligned}$$

23.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{-1-(-1)}{-3-5} = \frac{0}{-8} = 0 \end{aligned}$$

25.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{6.4-4.1}{0-(-4.6)} \\ &= \frac{2.3}{4.6} \\ &= \frac{1}{2} \end{aligned}$$

27.
$$\begin{aligned} m &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{1-\frac{4}{3}}{\frac{7}{2}-\frac{3}{2}} = \frac{-\frac{1}{3}}{\frac{4}{2}} \\ &= -\frac{1}{3} \cdot \frac{1}{2} \\ &= -\frac{1}{6} \end{aligned}$$

29. $m = \dfrac{y_2 - y_1}{x_2 - x_1}$

$= \dfrac{2\frac{1}{3} - \frac{7}{3}}{\frac{1}{2} - \frac{3}{4}} = \dfrac{\frac{7}{3} - \frac{7}{3}}{\frac{2}{4} - \frac{3}{4}} = \dfrac{0}{-\frac{1}{4}} = 0$

31. The slope of a line is positive if the graph increases from left to right. The slope of a line is negative if the graph decreases from left to right. The slope of a line is *z*ero if the graph is hori*z*ontal. The slope of a line is undefined if the graph is vertical.

33. $m = 0$

35. $m = \dfrac{1}{10}$

37. $m = -1$

39. **a.** $m = 5$

b. $m = -\dfrac{1}{5}$

41. **a.** $m = -\dfrac{4}{7}$

b. $m = \dfrac{7}{4}$

43. **a.** $m = 0$

b. m is undefined.

45. No, because the product of the slopes of perpendicular lines must be –1. The product of two positive numbers is not negative.

47. $y = -5$ is the equation of a horizontal line; thus a perpendicular line will be a vertical line whose slope is undefined.

49. $m = 0$

51. undefined

53. $m_{L_1} = \dfrac{9-5}{4-2} = \dfrac{4}{2} = 2$

$m_{L_2} = \dfrac{2-4}{3-(-1)}$

$= \dfrac{-2}{4}$

$= -\dfrac{1}{2}$

The lines are perpendicular.

55. $m_{L_1} = \dfrac{-1-(-2)}{3-4}$

$= \dfrac{1}{-1} = -1$

$m_{L_2} = \dfrac{-16-(-1)}{-10-(-5)} = \dfrac{-15}{-5} = 3$

The lines are neither parallel nor perpendicular.

57.
$$m_{L_1} = \frac{9-3}{5-5} = \frac{6}{0} \text{ Undefined}$$
$$m_{L_2} = \frac{2-2}{0-4} = \frac{0}{-4} = 0$$

The lines are perpendicular. One line is horizontal and the other is vertical.

59.
$$m_{L_1} = \frac{3-(-2)}{2-(-3)} = \frac{5}{5} = 1$$
$$m_{L_2} = \frac{5-1}{0-(-4)}$$
$$= \frac{4}{4} = 1$$

The lines are parallel.

61. **a.**
$$m = \frac{313-70}{2010-1998} = \frac{243}{12} = 20.25$$

b. The number of cell phone subscriptions increased at a rate of 20.25 million per year during this period.

63. **a.**
$$m = \frac{74.5-44.5}{10-5} = \frac{30}{5} = 6$$

b. The weight of boys tends to increase by 6 lb/yr during this period of growth.

65. **a.** (–1, –4) and (0, –2)
$$m = \frac{-2-(-4)}{0-(-1)} = \frac{2}{1} = 2$$

b. (0, –2) and (3, 4)
$$m = \frac{4-(-2)}{3-0} = \frac{6}{3} = 2$$

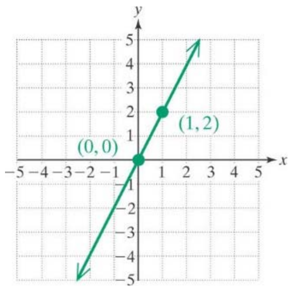
c. (–1, –4) and (3, 4)
$$m = \frac{4-(-4)}{3-(-1)} = \frac{8}{4} = 2$$

67. **a.** (–2, 0) and (0, –4)
$$m = \frac{-4-0}{0-(-2)} = \frac{-4}{2} = -2$$

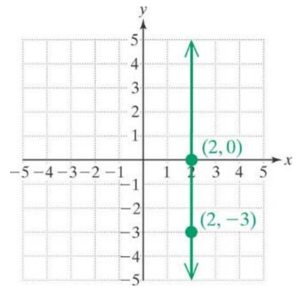
b. (0, –4) and (2, 0)
$$m = \frac{0-(-4)}{2-0} = \frac{4}{2} = 2$$

c. (0, –4) and (3, 5)
$$m = \frac{5-(-4)}{3-0} = \frac{9}{3} = 3$$

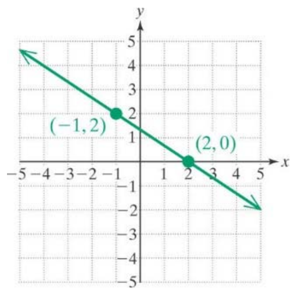
69. For example: (1, 2)



71. For example: (2, 0)



73. For example: (2, 0)



75.
$$\frac{6-y}{4-(-2)}=-\frac{3}{2}$$
$$\frac{6-y}{6}=-\frac{3}{2}$$
$$6-y=6\left(-\frac{3}{2}\right)$$
$$6-y=-9$$
$$-y=-15 \Rightarrow y=15$$

77. **a.** $\text{Pitch}=\frac{4}{24}=\frac{1}{6}$

Section 5.3 Practice Exercises

1. **a.** $y=mx+b$

b. standard

c. horizontal

d. vertical

e. slope; y-intercept

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

3. **a.** 0

b. undefined

5. If the slope of one line is the opposite of the reciprocal of the slope of the other line, then the lines are perpendicular.

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

Slope: $-\frac{2}{3}$

y-intercept: (0, –4)

9. $y=2+3x$

$y=3x+2$

Slope: 3

y-intercept: (0, 2)

11. $17x + y = 0$

$y = -17x$

Slope: -17

y-intercept: $(0, 0)$

13. $18 = 2y$

$9 = y$

$y = 0x + 9$

Slope: 0

y-intercept: $(0, 9)$

15. $8x + 12y = 9$

$12y = -8x + 9$

$y = -\frac{8}{12}x + \frac{9}{12}$

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

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

17. $y = 0.625x - 1.2$

Slope: 0.625

y-intercept: $(0, -1.2)$

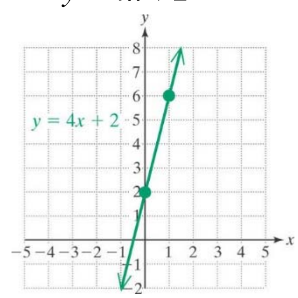
19. d

21. f

23. b

25. $y - 2 = 4x$

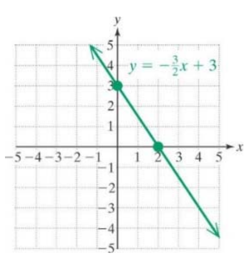
$y = 4x + 2$



27. $3x + 2y = 6$

$2y = -3x + 6$

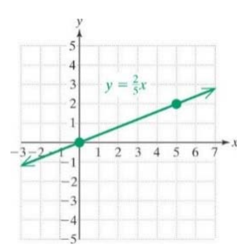
$y = -\frac{3}{2}x + 3$



29. $2x - 5y = 0$

$-5y = -2x$

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



31. $Ax + By = C$

$$By = -Ax + C$$

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

The slope is given by $m = -\frac{A}{B}$.

The y-intercept is $\left(0, \frac{C}{B}\right)$.

33. $-3y = 5x - 1$

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

$$m_1 = -\frac{5}{3}$$

$$6x = 10y - 12$$

$$10y = 6x + 12$$

$$y = \frac{3}{5}x + \frac{6}{5}$$

$$m_2 = \frac{3}{5}$$

The lines are perpendicular.

35. $3x - 4y = 12$

$$-4y = -3x + 12$$

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

$$m_1 = \frac{3}{4}$$

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

$$6\left(\frac{1}{2}x - \frac{2}{3}y\right) = 6 \cdot 1$$

$$3x - 4y = 6$$

$$-4y = -3x + 6$$

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

$$m_2 = \frac{3}{4}$$

The lines are parallel.

37. $3y = 5x + 6$

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

$$m_1 = \frac{5}{3}$$

$$5x + 3y = 9$$

$$3y = -5x + 9$$

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

$$m_2 = -\frac{5}{3}$$

The lines are neither parallel nor perpendicular.

39. $m = 3$, point: $(0, 5)$

$$y = mx + b$$

$$y = 3x + 5$$

41. $m = 2$,

point: $(4, -3)$

$$y = mx + b$$

$$-3 = 2(4) + b$$

$$-3 = 8 + b$$

$$-3 - 8 = b$$

$$-11 = b$$

$$y = 2x - 11$$

43. $m = -\frac{4}{5}$, point: $(10, 0)$

$$y = mx + b$$

$$0 = -\frac{4}{5}(10) + b$$

$$0 = -8 + b$$

$$8 = b$$

$$y = -\frac{4}{5}x + 8$$

45. $m = 3,\quad y\text{-intercept: } (0,-2)$

$y = 3x - 2$
or
$3x - y = 2$

47. $m = 2,\quad \text{point: } (2,7)$

$$y - y_1 = m(x - x_1)$$
$$y - 7 = 2(x - 2)$$
$$y - 7 = 2x - 4$$
$$y = 2x + 3 \text{ or } 2x - y = -3$$

49. $m = -3,\quad \text{point: } (-2,-5)$

$$y - y_1 = m(x - x_1)$$
$$y - (-5) = -3(x - (-2))$$
$$y + 5 = -3x - 6$$
$$y = -3x - 11 \text{ or } 3x + y = -11$$

51. $m = -\frac{4}{5},\quad \text{point: } (6,-3)$

$$y - y_1 = m(x - x_1)$$
$$y - (-3) = -\frac{4}{5}(x - 6)$$
$$y + 3 = -\frac{4}{5}x + \frac{24}{5}$$
$$y = -\frac{4}{5}x + \frac{9}{5}$$
or
$$\frac{4}{5}x + y = \frac{9}{5}$$
$$4x + 5y = 9$$

53. $m = \frac{0-4}{3-0} = \frac{-4}{3} = -\frac{4}{3}$

$$y - y_1 = m(x - x_1)$$
$$y - 4 = -\frac{4}{3}(x - 0)$$
$$y - 4 = -\frac{4}{3}x + 0$$
$$y = -\frac{4}{3}x + 4$$
or
$$\frac{4}{3}x + y = 4$$
$$4x + 3y = 12$$

55. $m = \frac{10-12}{4-6} = \frac{-2}{-2} = 1$

$$y - y_1 = m(x - x_1)$$
$$y - 12 = 1(x - 6)$$
$$y - 12 = x - 6$$
$$y = x + 6$$
or
$$x - y = -6$$

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

$$= \frac{0}{4}$$
$$= 0$$
$$y - y_1 = m(x - x_1)$$
$$y - 2 = 0(x - (-5))$$
$$y - 2 = 0 \Rightarrow y = 2$$

59. $m = -\frac{3}{4},\quad \text{point: } (3,2)$

61. $m = \frac{4}{3},\quad \text{point: } (3,2)$

$$y - y_1 = m(x - x_1)$$
$$y - 2 = -\frac{3}{4}(x - 3)$$
$$y - 2 = -\frac{3}{4}x + \frac{9}{4}$$
$$y = -\frac{3}{4}x + \frac{17}{4}$$
or
$$\frac{3}{4}x + y = \frac{17}{4}$$
$$3x + 4y = 17$$

$$y - y_1 = m(x - x_1)$$
$$y - 2 = \frac{4}{3}(x - 3)$$
$$y - 2 = \frac{4}{3}x - 4$$
$$y = \frac{4}{3}x - 2$$
or
$$\frac{4}{3}x - y = 2$$
$$4x - 3y = 6$$

63. $3x - 4y = -7$
$$-4y = -3x - 7$$
$$y = \frac{3}{4}x + \frac{7}{4}$$
$$m = \frac{3}{4}, \quad \text{point: } (2, -5)$$
$$y - y_1 = m(x - x_1)$$
$$y - (-5) = \frac{3}{4}(x - 2)$$
$$y + 5 = \frac{3}{4}x - \frac{3}{2}$$
$$y = \frac{3}{4}x - \frac{13}{2}$$
or $\frac{3}{4}x - y = \frac{13}{2}$
$$3x - 4y = 26$$

65. $-15x + 3y = 9$
$$3y = 15x + 9$$
$$y = 5x + 3$$
$$m = 5, \quad m_\perp = -\frac{1}{5}, \quad \text{point: } (-8, -1)$$
$$y - y_1 = m(x - x_1)$$
$$y - (-1) = -\frac{1}{5}(x - (-8))$$
$$y + 1 = -\frac{1}{5}x - \frac{8}{5}$$
$$y = -\frac{1}{5}x - \frac{13}{5}$$
or $\frac{1}{5}x + y = -\frac{13}{5}$
$$x + 5y = -13$$

67. $3x = 2y$
$$y = \frac{3}{2}x$$
$$m = \frac{3}{2}, \quad \text{point: } (4, 0)$$
$$y - y_1 = m(x - x_1)$$
$$y - 0 = \frac{3}{2}(x - 4)$$
$$y = \frac{3}{2}x - 6$$

69. $3y + 2x = 21$
$$3y = -2x + 21$$
$$y = -\frac{2}{3}x + 7$$
$$m_\perp = \frac{3}{2}, \quad \text{point: } (2, 4)$$
$$y - y_1 = m(x - x_1)$$
$$y - 4 = \frac{3}{2}(x - 2)$$
$$y - 4 = \frac{3}{2}x - 3$$

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

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

71. $\frac{1}{2}y = x$

$y = 2x$

$m_{\perp} = -\frac{1}{2}$, point: $(-3, 5)$

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

$y - 5 = -\frac{1}{2}(x - (-3))$

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

$y = -\frac{1}{2}x + \frac{7}{2}$ or $\frac{1}{2}x + y = \frac{7}{2}$

$x + 2y = 7$

73. $3x + y = 7$

$y = -3x + 7$

$m_{||} = -3$, point: $(0, 0)$

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

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

$y = -3x$

or

$3x + y = 0$

75. $m = 0$, point: $(2, -3)$

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

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

$y + 3 = 0$

$y = -3$

77. A line with an undefined slope is a vertical line, which is in the form $x = c$. Therefore, a line containing (2, –3) would have the equation $x = 2$.

79. A line parallel to the *x*-axis has the form $y = c$. Therefore, a line containing the point (4, 5) would have the equation $y = 5$.

81. A line parallel to the line $x = 4$ is a vertical line and has the form $x = c$. Therefore, a line containing the point (5, 1) would have the equation $x = 5$.

83. $x = -2$ is not in the slope-intercept form. It has no *y*-intercept and its slope is undefined.

85. $y = 3$ is in the slope-intercept form, $y = 0x + 3$. Its slope is 0 and the *y*-intercept is (0, 3).

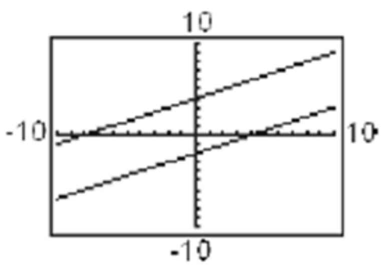
87. Two points on the line are (0, 3) and (1, 1).

$m = \frac{1-3}{1-0} = \frac{-2}{1} = -2$

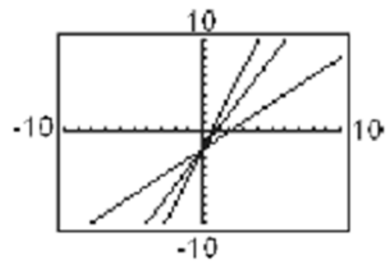
89. This is a horizontal line of the form $y = k$. The *y*-intercept is 2, so the line is $y = 2$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \qquad (x_1, y_1) = (0, 3) \\ y - 3 &= -2(x - 0) \\ y &= -2x + 3 \end{aligned}$$

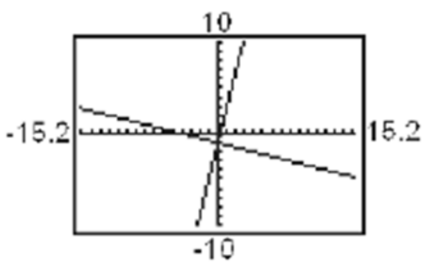
91. The lines have the same slope but different y-intercepts; they are parallel lines.



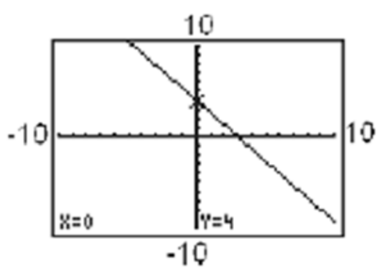
93. The lines have different slopes but the same y-intercept.

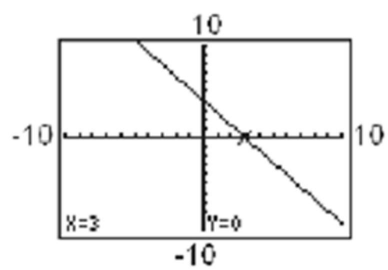


95. The lines are perpendicular.



97.





Problem Recognition Exercises

1. b, f

3. a

5. c, e

7. c, h

9. e

11. c, h

13. g

15. h

17. e

19. d, h

Section 5.4 Practice Exercises

1.
a. linear
b. is not; is
c. dashed; is not
d. solid; is

3.
$5 - x \le 4$ and $6 > 3x - 3$
$-x \le -1$ and $9 > 3x$
$x \ge 1$ and $x < 3$ $\quad [1,3)$

5.
$-2x < 4$ or $3x - 1 \le -13$
$x > -2$ or $3x \le -12$
$x > -2$ or $x \le -4$
$(-\infty,-4] \cup (-2,\infty)$

7.
$3y + x < 5$
a. $3(7)+(-1) = 21-1 = 20 \not< 5$ No
b. $3(0)+(5) = 0+5 = 5 \not< 5$ No
c. $3(0)+(0) = 0+0 = 0 < 5$ Yes
d. $3(-3)+(2) = -9+2 = -7 < 5$ Yes

9.
$x \ge 5$
a. $4 \not\ge 5$ No
b. $5 \ge 5$ Yes
c. $8 \ge 5$ Yes
d. $0 \not\ge 5$ No

11. To choose the correct inequality symbol, three observations must be made. First, notice the shading occurs below the line. Second, since the coefficient of *y* is negative in the given statement, the direction of the inequality will change. Third, the boundary line is dashed indicating no equality.
Thus use the symbol > for the inequality: $x - y > 2$.

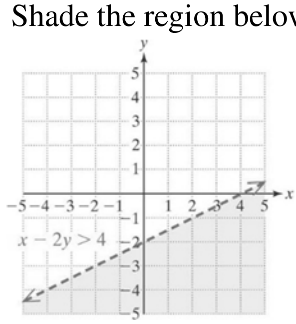
13. To choose the correct inequality symbol, three observations must be made. First, notice the shading occurs above the line. Second, since the coefficient of *y* is positive in the given statement, the direction of the inequality will not change. Third, the boundary line is solid indicating equality. Thus use the symbol ≥ for the inequality:
$y \geq -4$.

15. The graph of $x \geq 0$ includes Quadrant I and Quadrant IV.
The graph of $y \leq 0$ includes Quadrant III and Quadrant IV.
The intersection of the graphs occurs in Quadrant IV.
Thus, the statements are $x \geq 0$ and $y \leq 0$.

17. $x - 2y > 4$
Graph the related equation $x - 2y = 4$ by using a dashed line.

Test point above $(0,0)$:	Test point below $(0,-3)$:
$0 - 2(0) > 4$	$0 - 2(-3) > 4$
$0 > 4$	$6 > 4$
$(0,0)$ is not a solution.	$(0,-3)$ is a solution.

Shade the region below the boundary line.



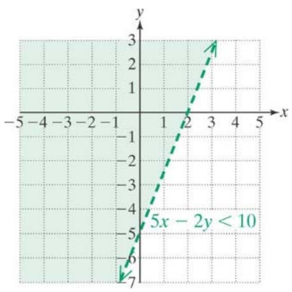
19. $5x - 2y < 10$
Graph the related equation $5x - 2y = 10$ by using a dashed line.

Test point above $(0,0)$:	Test point below $(2,-3)$:
$5(0) - 2(0) < 10$	$5(2) - 2(-3) < 10$

$0 < 10$ $\quad$ $16 < 10$

$(0,0)$ is a solution. $\quad$ $(2,-3)$ is not a solution.

Shade the region above the boundary line.



21. $2x \le -6y + 12$

Graph the related equation $2x = -6y + 12$ by using a solid line.

Test point above $(0,3)$:

$2(0) \le -6(3) + 12$

$0 \le -6$

$(0,3)$ is not a solution.

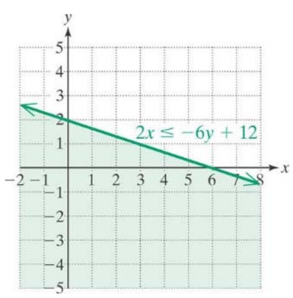
Test point below $(0,0)$:

$2(0) \le -6(0) + 12$

$0 \le 12$

$(0,0)$ is a solution.

Shade the region below the boundary line.



23. $2y \le 4x$

Graph the related equation $2y = 4x$ by using a solid line.

Test point above $(0,1)$:

$2(1) \le 4(0)$

$2 \le 0$

$(0,1)$ is not a solution.

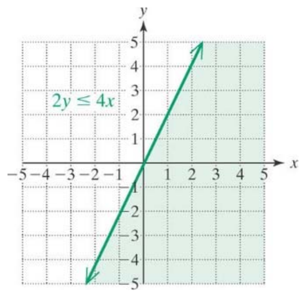
Test point below $(0,-1)$:

$2(-1) \le 4(0)$

$-2 \le 0$

$(0,-1)$ is a solution.

Shade the region below the boundary line.



25. $y \ge -2$

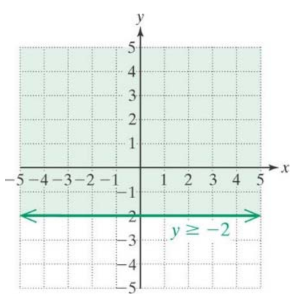
Graph the related equation $y = -2$ by using a solid line.

Test point above $(0,0)$: Test point below $(0,-3)$:

$0 \ge -2$ $-3 \ge -2$

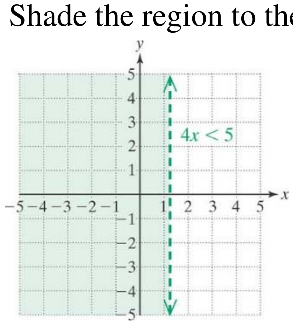
$(0,0)$ is a solution. $(0,-3)$ is not a solution.

Shade the region above the boundary line.



27. $4x < 5$ or $x < \frac{5}{4}$ represents all the points to the left of the vertical line $x = \frac{5}{4}$. The boundary is a dashed line.

Shade the region to the left of the boundary line.



29. $y \ge \frac{2}{5}x - 4$

Graph the related equation $y = \frac{2}{5}x - 4$ by using a solid line.

Test point above $(0,0)$:

$$0 \ge \frac{2}{5}(0) - 4$$
$$0 \ge -4$$

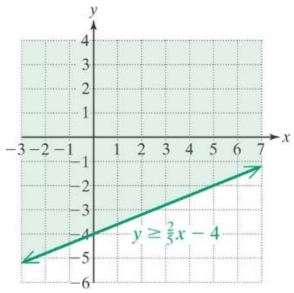
$(0,0)$ is a solution.

Test point below $(0,-5)$:

$$-5 \ge \frac{2}{5}(0) - 4$$
$$-5 \ge -4$$

$(0,-5)$ is not a solution.

Shade the region above the boundary line.



31. $y \le \frac{1}{3}x + 6$

Graph the related equation $y = \frac{1}{3}x + 6$ by using a solid line.

Test point above $(0,7)$:

$$7 \le \frac{1}{3}(0) + 6$$
$$7 \le 6$$

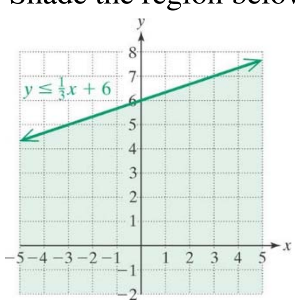
$(0,7)$ is not a solution.

Test point below $(0,0)$:

$$0 \le \frac{1}{3}(0) + 6$$
$$0 \le 6$$

$(0,0)$ is a solution.

Shade the region below the boundary line.



33. $y - 5x > 0$

Graph the related equation $y - 5x = 0$ by using a dashed line.

Test point above $(0,3)$:

$$3 - 5(0) > 0$$
$$3 > 0$$

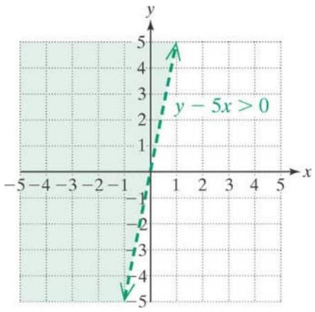
$(0,3)$ is a solution.

Test point below $(0,-3)$:

$$-3 - 5(0) > 0$$
$$-3 > 0$$

$(0,-3)$ is not a solution.

Shade the region above the boundary line.



35. $\frac{x}{5}+\frac{y}{4}<1$

Graph the related equation $\frac{x}{5}+\frac{y}{4}=1$ by using a dashed line.

Test point above $(0,5)$:

$$\frac{0}{5}+\frac{5}{4}<1$$
$$\frac{5}{4}<1$$

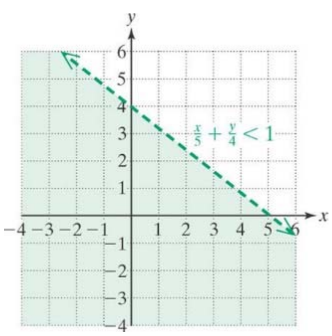
$(0,5)$ is not a solution.

Test point below $(0,0)$:

$$\frac{0}{5}+\frac{0}{4}<1$$
$$0<1$$

$(0,0)$ is a solution.

Shade the region below the boundary line.



37. $0.1x+0.2y\le 0.6$

Graph the related equation $0.1x+0.2y=0.6$ by using a solid line.

Test point above $(0,5)$:

$$0.1(0)+0.2(5)\le 0.6$$
$$1\le 0.6$$

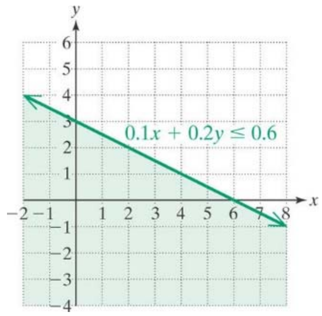
$(0,5)$ is not a solution.

Test point below $(0,0)$:

$$0.1(0)+0.2(0)\le 0.6$$
$$0\le 0.6$$

$(0,0)$ is a solution.

Shade the region below the boundary line.



39. $x \le -\frac{2}{3}y$

Graph the related equation $x = -\frac{2}{3}y$ by using a solid line.

Test point above $(0,3)$:

$$0 \le -\frac{2}{3}(3)$$
$$0 \le -2$$

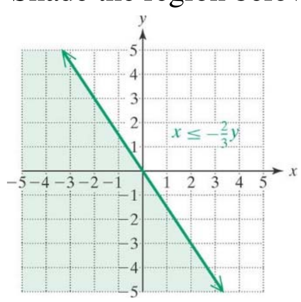
$(0,3)$ is not a solution.

Test point below $(0,-3)$:

$$0 \le -\frac{2}{3}(-3)$$
$$0 \le 2$$

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

Shade the region below the boundary line.



41. $y < 4$ and $y > -x + 2$

$y < 4$ represents the points below the horizontal line $y = 4$.

Shade the region below the boundary line using a dashed line border.

Graph the related equation $y = -x + 2$ by using a dashed line.

Test point above $(0,3)$:

$$3 > -(0) + 2$$
$$3 > 2$$

$(0,3)$ is a solution.

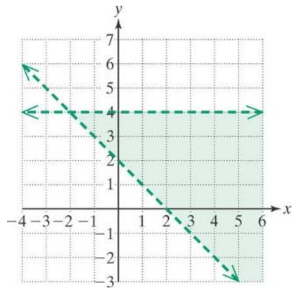
Test point below $(0,0)$:

$$0 > -(0) + 2$$
$$0 > 2$$

$(0,0)$ is not a solution.

Shade the region above the boundary line.

The solution is the intersection of the graphs.



43. $2x + y \le 5$ or $x \ge 3$

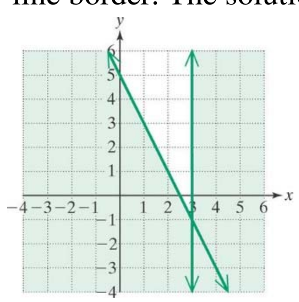
Graph the related equation $2x + y = 5$ by using a solid line.

Test point above $(0,6)$:	Test point below $(0,0)$:
$2(0)+6 \le 5$	$2(0)+0 \le 5$
$6 \le 5$	$0 \le 5$
$(0,6)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.

$x \ge 3$ represents the points to the right of the vertical line $x = 3$.

Shade the region to the right of the boundary line using a solid line border. The solution is the union of the graphs.



45. $x + y < 3$ and $4x + y < 6$

Graph the related equation $x + y = 3$ by using a dashed line.

Test point above $(0,4)$:	Test point below $(0,0)$:
$0+4 < 3$	$0+0 < 3$
$4 < 3$	$0 < 3$
$(0,4)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.

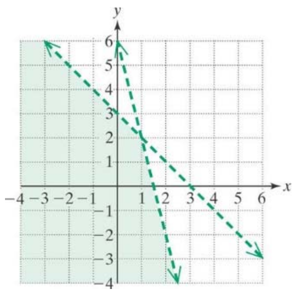
Graph the related equation $4x + y = 6$ by using a dashed line.

Test point above $(0,7)$:	Test point below $(0,0)$:
$4(0)+7 < 6$	$4(0)+0 < 6$
$7 < 6$	$0 < 6$

$(0,7)$ is not a solution. $(0,0)$ is a solution.

Shade the region below the boundary line.

The solution is the intersection of the graphs.



47. $2x - y \le 2$ or $2x + 3y \ge 6$

Graph the related equation $2x - y = 2$ by using a solid line.

Test point above $(0,0)$:

$$2(0) - 0 \le 2$$
$$0 \le 2$$

$(0,0)$ is a solution.

Test point below $(0,-3)$:

$$2(0) - (-3) \le 2$$
$$3 \le 2$$

$(0,-3)$ is not a solution.

Shade the region above the boundary line.

Graph the related equation $2x + 3y = 6$ by using a solid line.

Test point above $(0,3)$:

$$2(0) + 3(3) \ge 6$$
$$9 \ge 6$$

$(0,3)$ is a solution.

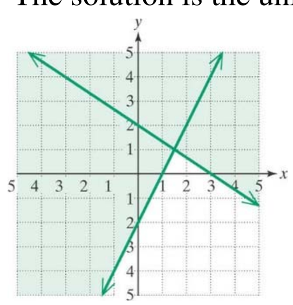
Test point below $(0,0)$:

$$2(0) + 3(0) \ge 6$$
$$0 \ge 6$$

$(0,0)$ is not a solution.

Shade the region above the boundary line.

The solution is the union of the graphs.

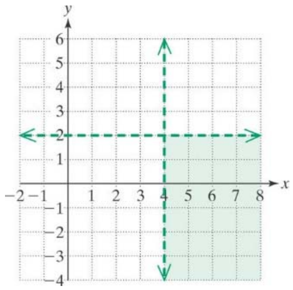


49. $x > 4$ and $y < 2$

$x > 4$ represents the points to the right of the vertical line $x = 4$.

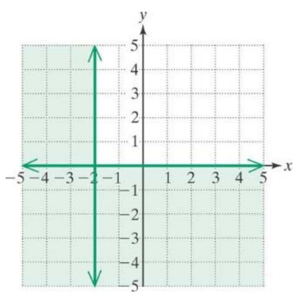
Shade the region to the right of the boundary line using a dashed line border.

$y < 2$ represents the points below the horizontal line $y = 2$.
Shade the region below the boundary line using a dashed line border. The solution is the intersection of the graphs.



51. $x \le -2$ or $y \le 0$

$x \le -2$ represents the points to the left of the vertical line $x = -2$.
Shade the region to the left of the boundary line using a solid line border.
$y \le 0$ represents the points below the horizontal line $y = 0$.
Shade the region below the boundary line using a solid line border. The solution is the union of the graphs.

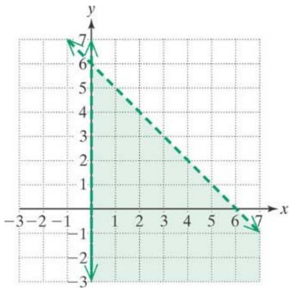


53. $x > 0$ and $x + y < 6$

$x > 0$ represents the points to the right of the vertical line $x = 0$.
Shade the region to the right of the boundary line using a dashed line border.
Graph the related equation $x + y = 6$ by using a dashed line.

Test point above $(0,7)$:	Test point below $(0,0)$:
$0 + 7 < 6$	$0 + 0 < 6$
$7 < 6$	$0 < 6$
$(0,7)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.
The solution is the intersection of the graphs.



55. $y \le 0$ or $x - y \le -4$

$y \le 0$ represents the points below the horizontal line $y = 0$.

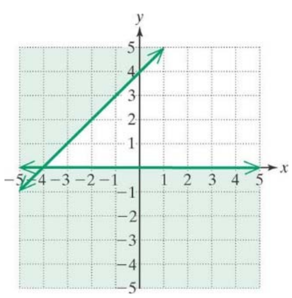
Shade the region below the boundary line using a solid line border.

Graph the related equation $x - y = -4$ by using a solid line.

Test point above $(0,5)$:	Test point below $(0,0)$:
$0 - 5 \le -4$	$0 - 0 \le -4$
$-5 \le -4$	$0 \le -4$
$(0,5)$ is a solution.	$(0,0)$ is not a solution.

Shade the region above the boundary line.

The solution is the union of the graphs.



57. $x - y \le 2$ and $x \ge 0$ and $y \ge 0$

Graph the related equation $x - y = 2$ by using a solid line.

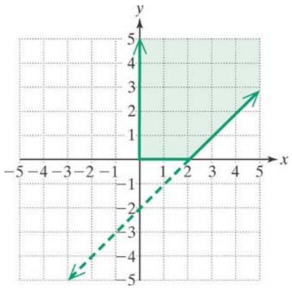
Test point above $(0,0)$:	Test point below $(0,-3)$:
$0 - 0 \le 2$	$0 - (-3) \le 2$
$0 \le 2$	$3 \le 2$
$(0,0)$ is a solution.	$(0,-3)$ is not a solution.

Shade the region above the boundary line.

$x \ge 0$ represents the points to the right of the vertical line $x = 0$.

Shade the region to the right of the boundary line using a solid line border.

$y \geq 0$ represents the points above the horizontal line $y = 0$.
Shade the region above the boundary line using a solid line border.
The solution is the intersection of the graphs.



59. $x \geq 0$ and $y \geq 0$ and $x + y \leq 5$ and $x + 2y \leq 6$

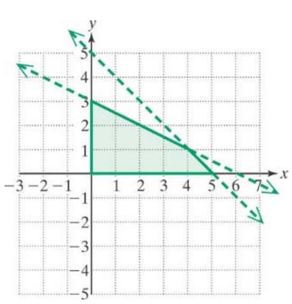
$x \geq 0$ represents the points to the right of the vertical line $x = 0$.
Shade the region to the right of the boundary line using a solid line border.
$y \geq 0$ represents the points above the horizontal line $y = 0$.
Shade the region above the boundary line using a solid line border.
Graph the related equation $x + y = 5$ by using a solid line.

Test point above $(0,6)$:	Test point below $(0,0)$:
$0 + 6 \leq 5$	$0 + 0 \leq 5$
$6 \leq 5$	$0 \leq 5$
$(0,6)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.
Graph the related equation $x + 2y = 6$ by using a solid line.

Test point above $(0,4)$:	Test point below $(0,0)$:
$0 + 2(4) \leq 6$	$0 + 2(0) \leq 6$
$8 \leq 6$	$0 \leq 6$
$(0,4)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.
The solution is the intersection of the graphs.



61. **a.** $2x + 2y \le 40$

b. $x \ge 0$ and $y \ge 0$ and $2x + 2y \le 40$

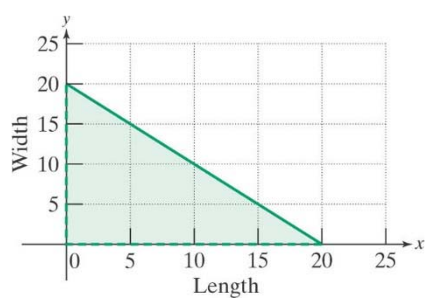
$x \ge 0$ represents the points to the right of the vertical line $x = 0$. Shade the region to the right of the boundary line using a solid line border.

$y \ge 0$ represents the points above the horizontal line $y = 0$. Shade the region above the boundary line using a solid line border.

Graph the related equation $2x + 2y = 40$ by using a solid line.

Test point above $(0,21)$:	Test point below $(0,0)$:
$2(0) + 2(21) \le 40$	$2(0) + 2(0) \le 40$
$42 \le 40$	$0 \le 40$
$(0,21)$ is not a solution.	$(0,0)$ is a solution.

Shade the region below the boundary line.



63. **a.** $x \ge 0, \ y \ge 0$

b. $x \le 40, \ y \le 40$

c. $x + y \ge 65$

d. $x \ge 0$ and $y \ge 0$ and $x \le 40$ and $y \le 40$ and $x + y \ge 65$

$x \ge 0$ represents the points to the right of the vertical line $x = 0$. Shade the region to the right of the boundary line using a solid line border.

$y \ge 0$ represents the points above the horizontal line $y = 0$. Shade the region above the boundary line using a solid line border.

$x \le 40$ represents the points to the left of the vertical line $x = 40$. Shade the region to the left of the boundary line using a solid line border.

$y \le 40$ represents the points below the horizontal line $y = 40$. Shade the region below the boundary line using a solid line border.

Graph the related equation $x + y = 65$ by using a solid line.

Test point above $(0,66)$:

$$0+66 \geq 65$$
$$66 \geq 65$$

$(0,66)$ is a solution.

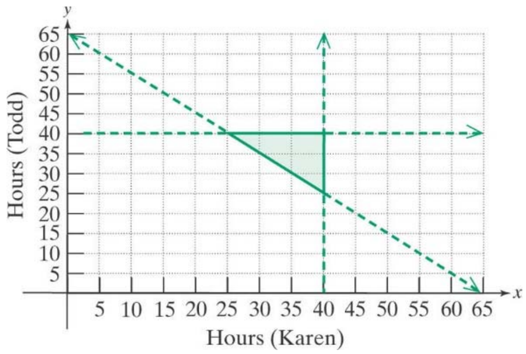
Test point below $(0,0)$:

$$0+0 \geq 65$$
$$0 \geq 65$$

$(0,0)$ is not a solution.

Shade the region above the boundary line.

The solution is the intersection of the graphs.



e. Yes. The point (35, 40) means that Karen works 35 hours and Todd works 40 hours.

f. No. The point (20, 40) means that Karen works 20 hours and Todd works 40 hours. This does not satisfy the constraint that there must be at least 65 hours total.