Start week 3 pg 75

WARM-UPS

True or false? Explain your answer.

1. The point (2, 4) satisfies the equation $2y - 3x = -8$. False
2. If (1, 5) satisfies an equation, then (5, 1) also satisfies the equation. False
3. The origin is in quadrant I. False
4. The point (4, 0) is on the y-axis. False
5. The graph of $x + 0 \cdot y = 9$ is the same as the graph of $x = 9$. True
6. The graph of $x = -5$ is a vertical line. True
7. The graph of $0 \cdot x + y = 6$ is a horizontal line. True
8. The y-intercept for the line $x + 2y = 5$ is (5, 0). False
9. The point (5, −3) is in quadrant II. False
10. The point (−349, 0) is on the x-axis. True

4.1 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is an ordered pair?
   An ordered pair is a pair of numbers in which there is a first number and a second number, usually written as (a, b).
2. What is the rectangular coordinate system?
   The rectangular coordinate system is a means of dividing up the plane with two number lines in order to picture all ordered pairs of real numbers.
3. What name is given to the point of intersection of the x-axis and the y-axis?
   The origin is the point of intersection of the x-axis and y-axis.
4. What is the graph of an equation?
   The graph of an equation is a picture of all ordered pairs that satisfy the equation drawn in the rectangular coordinate system.
5. What is a linear equation in two variables?
   A linear equation in two variables is an equation of the form $Ax + By = C$, where A and B are not both zero.
6. What are intercepts?
   Intercepts are the points at which a graph crosses the axes.

Complete each ordered pair so that it satisfies the given equation. See Example 1.

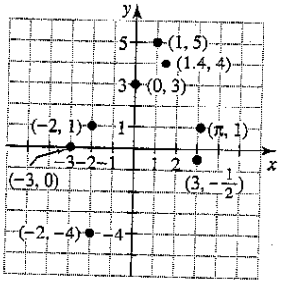
7. $y = 3x + 9$: (0,), (, 24), (2,)
   (0, 9), (5, 24), (2, 15)
8. $y = 2x + 5$: (8,), (−1,), (, −1)
   (8, 21), (−1, 3), (−3, −1)
9. $y = -3x - 7$: (0,), (−4,), (, −1)
   (0, −7), (−4, 5), (−2, −1)
10. $y = -5x - 3$: (, 2), (−3,), (0,)
    (−1, 2), (−3, 12), and (0, −3)
11. $y = -12x + 5$: (0,), (10,), (, 17)
    (0, 5), (10, −115), and (−1, 17)
12. $y = 18x + 200$: (1,), (−10,), (, 200)
    (1, 218), (−10, 20), (0, 200)
13. $2x - 3y = 6$: (3,), (, −2), (12,)
    (3, 0), (0, −2), (12, 6)
14. $3x + 5y = 0$: (−5,), (, −3), (10,)
    (−5, 3), (5, −3), (10, −6)
15. $0 \cdot y + x = 5$: (, −3), (, 5), (, 0)
    (5, −3), (5, 5), (5, 0)
16. $0 \cdot x + y = -6$: (3,), (−1,), (4,)
    (3, −6), (−1, −6), (4, −6)

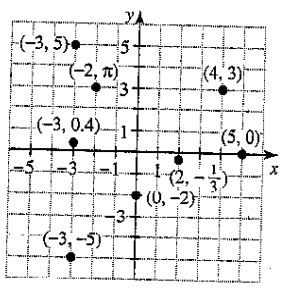
Plot the points on a rectangular coordinate system. See Example 2.

17. (1, 5)
18. (4, 3)
19. (−2, 1)
20. (−3, 5)
21. $\left(3, -\frac{1}{2}\right)$
22. $\left(2, -\frac{1}{3}\right)$
23. (−2, −4)
24. (−3, −5)
25. (0, 3)
26. (0, −2)
27. (−3, 0)
28. (5, 0)
29. $(\pi, 1)$
30. $(-2, \pi)$
31. (1.4, 4)
32. (−3, 0.4)

17–31 odd

18–32 even





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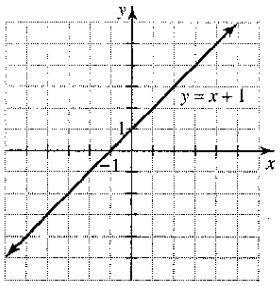
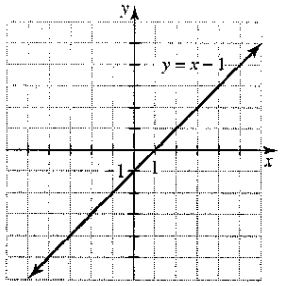
Graph each equation. Plot at least five points for each equation. Use graph paper. See Examples 3 and 4. If you have a graphing calculator, use it to check your graphs.

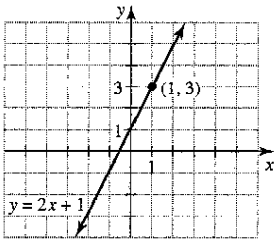
33. $y = x + 1$



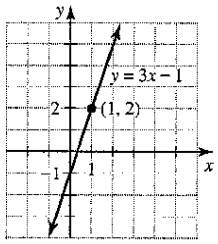
34. $y = x - 1$



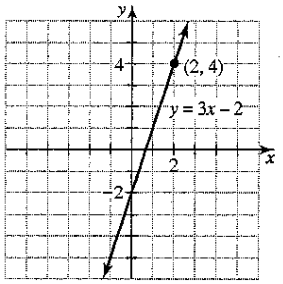
35. $y = 2x + 1$



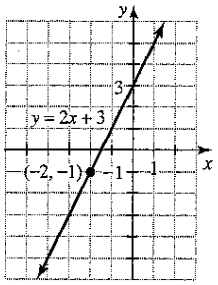
36. $y = 3x - 1$



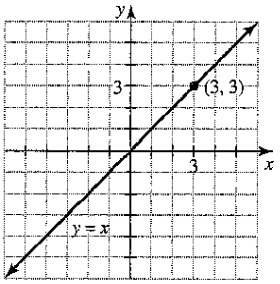
37. $y = 3x - 2$



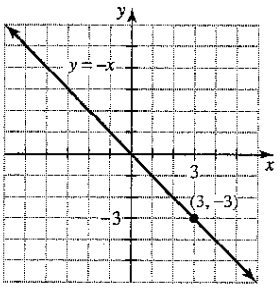
38. $y = 2x + 3$



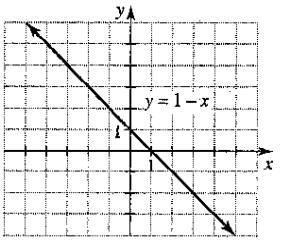
39. $y = x$



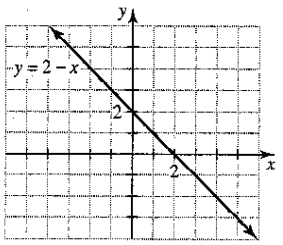
40. $y = -x$



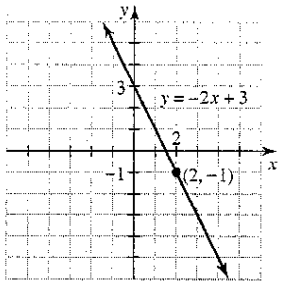
41. $y = 1 - x$



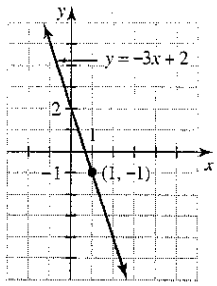
42. $y = 2 - x$



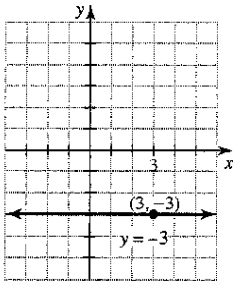
43. $y = -2x + 3$



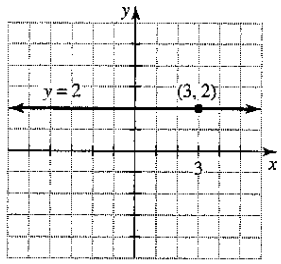
44. $y = -3x + 2$



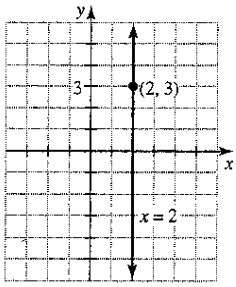
45. $y = -3$



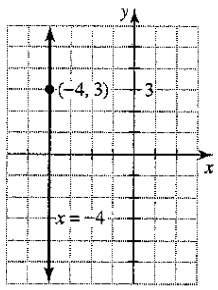
46. $y = 2$



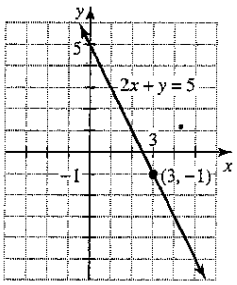
47. $x = 2$



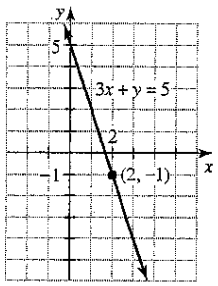
48. $x = -4$



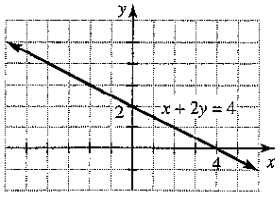
49. $2x + y = 5$



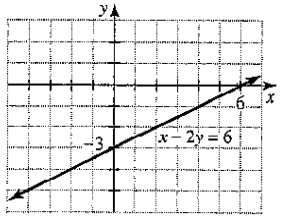
50. $3x + y = 5$



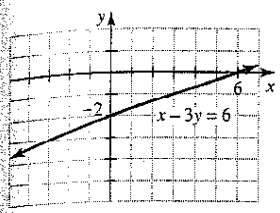
51. $x + 2y = 4$



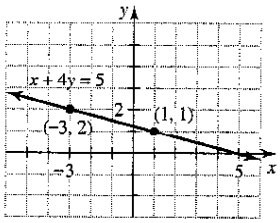
52. $x - 2y = 6$



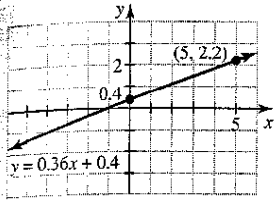
53. $x - 3y = 6$



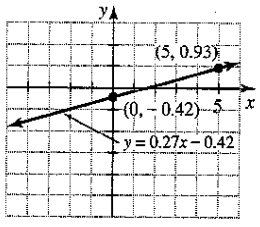
54. $x + 4y = 5$



55. $y = 0.36x + 0.4$



56. $y = 0.27x - 0.42$



For each point, name the quadrant in which it lies or the axis on which it lies.

57. $(-3, 45)$ Quadrant II

58. $(-33, 47)$ Quadrant II

59. $(-3, 0)$ x-axis

60. $(0, -9)$ y-axis

61. $(-2.36, -5)$ Quadrant III

62. $(89.6, 0)$ x-axis

63. $(3.4, 8.8)$ Quadrant I

64. $(4.1, 44)$ Quadrant I

65. $\left(-\frac{1}{2}, 50\right)$ Quadrant II

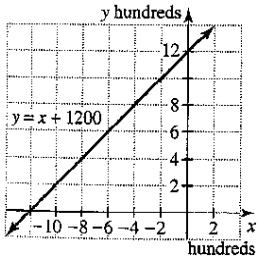
66. $\left(-6, -\frac{1}{2}\right)$ Quadrant III

67. $(0, -99)$ y-axis

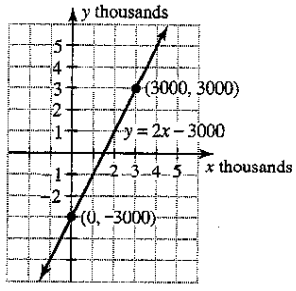
68. $(\pi, 0)$ x-axis

Graph each equation. Plot at least five points for each equation. Use graph paper. See Example 5. If you have a graphing calculator, use it to check your graphs.

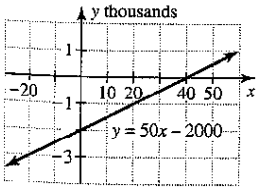
69. $y = x + 1200$



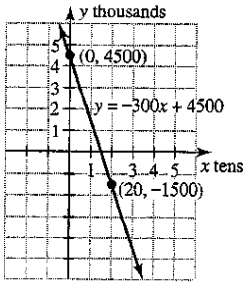
70. $y = 2x - 3000$



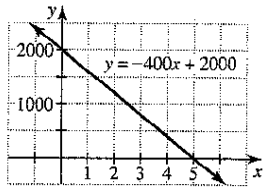
71. $y = 50x - 2000$



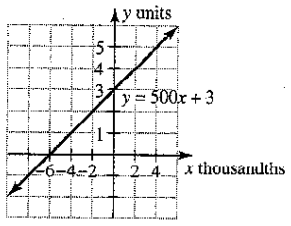
72. $y = -300x + 4500$



73. $y = -400x + 2000$

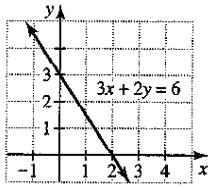


74. $y = 500x + 3$

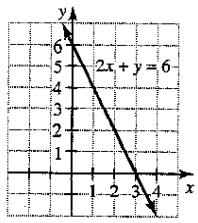


Graph each equation using the x- and y-intercepts. See Example 6. Use a third point to check.

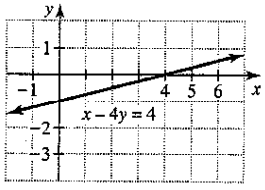
75. $3x + 2y = 6$



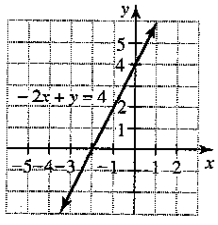
76. $2x + y = 6$



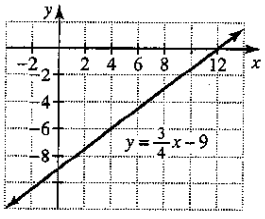
77. $x - 4y = 4$



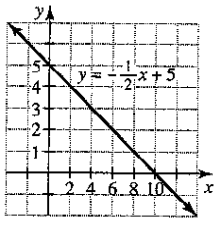
78. $-2x + y = 4$



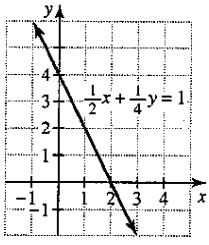
79. $y = \frac{3}{4}x - 9$



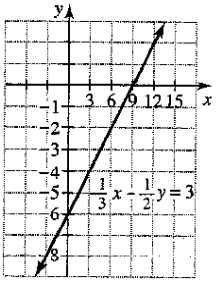
80. $y = -\frac{1}{2}x + 5$



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



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



p978

Solve each problem. See Example 7.

83. ***Percentage of full benefit.*** The age at which you retire affects your Social Security benefits. The accompanying graph gives the percentage of full benefit for each age from 62 through 70, based on current legislation and retirement after the year 2005 (Source: Social Security Administration). What percentage of full benefit does a person receive if that person retires at age 63? At what age will a retiree receive the full benefit? For what ages do you receive more than the full benefit?

75%, 67, 68 and up

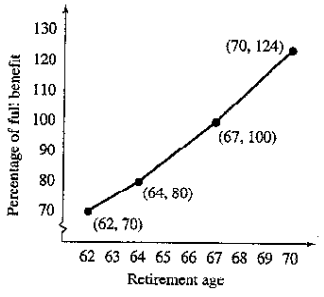
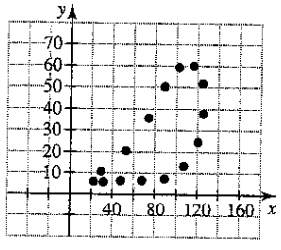


FIGURE FOR EXERCISE 83

84. ***Heel motion.*** When designing running shoes, Chris Edington studies the motion of a runner's foot. The following data gives the coordinates of the heel (in centimeters) at intervals of 0.05 millisecond during one cycle of level treadmill running at 3.8 meters per second (*Sagittal Plane Kinematics, Milliron and Cavanagh*):

(31.7, 5.7), (48.0, 5.7), (68.3, 5.8), (88.9, 6.9),
(107.2, 13.3), (119.4, 24.7), (127.2, 37.8),
(125.7, 52.0), (116.1, 60.2), (102.2, 59.5)
(88.7, 50.2), (73.9, 35.8), (52.6, 20.6),
(29.6, 10.7), (22.4, 5.9).

Graph these ordered pairs to see the heel motion.



85. ***Medicaid spending.*** The payment in billions by Medicaid (health care for the poor) can be modeled by the equation

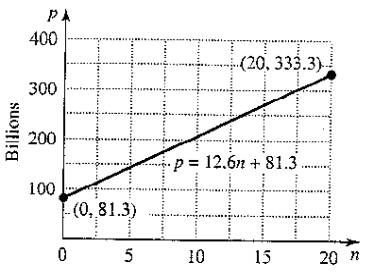
$$P = 12.6n + 81.3,$$

where n is the number of years since 1990 (Health Care Financing Administration, www.hcfa.gov).

a) What amount was paid out by Medicaid in 1995?
b) In what year will the payment reach $220 billion?
c) Graph the equation for n ranging from 0 through 20.

a) $144.3 billion **b)** 2001

c)



86. ***Women on the board.*** The percentage of companies with at least one woman on the board is growing steadily (*Forbes,* February 10, 1997). The percentage can be approximated with the linear equation

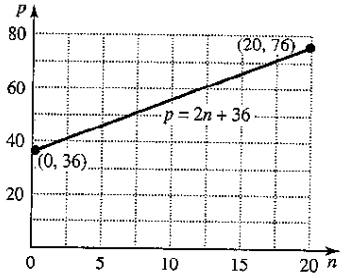
$$p = 2n + 36,$$

where n is the number of years since 1980.

a) Find and interpret the p-intercept for the line.
b) Find and interpret the n-intercept.
c) Graph the line for n ranging from 0 through 20.
d) If this trend continues, then in what year would you expect to find nearly all companies having at least one woman on the board?

a) (0, 36), 36% in 1980
b) (−18, 0), no companies with women on the board in 1962

c)



d) 2012

87. ***Hazards of depth.*** The table on page 169 shows the depth below sea level and atmospheric pressure (*Encyclopedia of Sports Science,* 1997). The equation

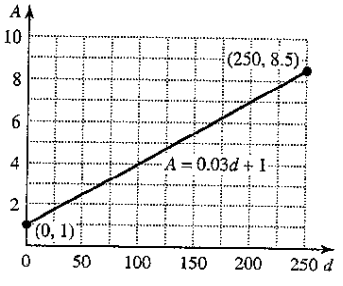
$$A = 0.03d + 1$$

expresses the atmospheric pressure in terms of the depth d.

a) Find the atmospheric pressure at the depth where nitrogen narcosis begins.
b) Find the maximum depth for intermediate divers.
c) Graph the equation for d ranging from 0 to 250 feet.

a) 4 atm **b)** 130 ft

c)



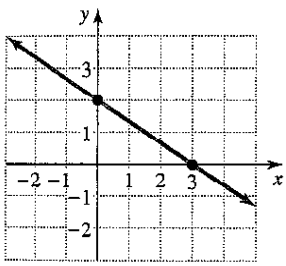
4.2 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is the slope of a line?
   The slope of a line is the ratio of its rise and run.
2. What is the difference between rise and run?
   Rise is the amount of vertical change and run is the amount of horizontal change.
3. For which lines is slope undefined?
   Slope is undefined for vertical lines.
4. Which lines have zero slope?
   Horizontal lines have zero slope.
5. What is the difference between lines with positive slope and lines with negative slope?
   Lines with positive slope are rising as you go from left to right, while lines with negative slope are falling as you go from left to right.
6. What is the relationship between the slopes of perpendicular lines?
   If m_1 and m_2 are slopes of perpendicular lines, then $m_1 \cdot m_2 = -1$.

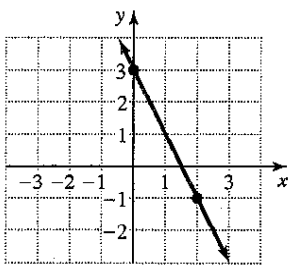
In Exercises 7–18, find the slope of each line. See Examples 1 and 2.

7.



$-\frac{2}{3}$

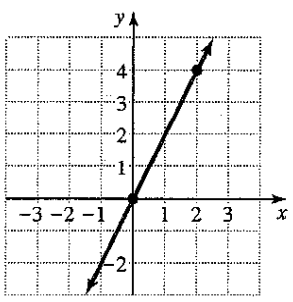
8.



-2

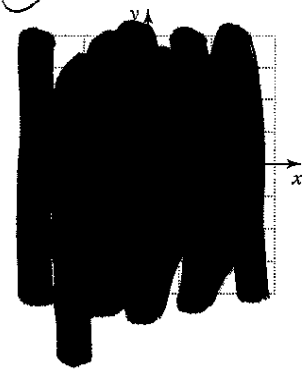
9.

10.

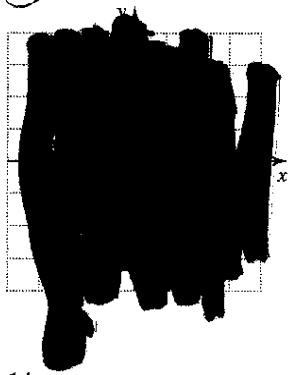


2

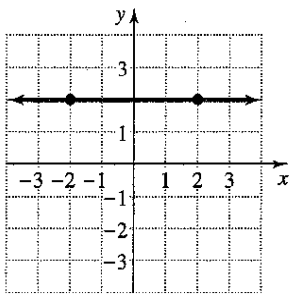
11.



12.

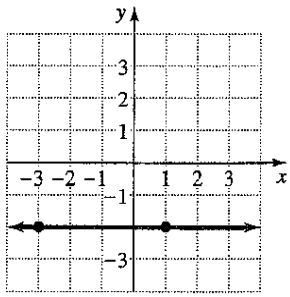


13.



0

14.



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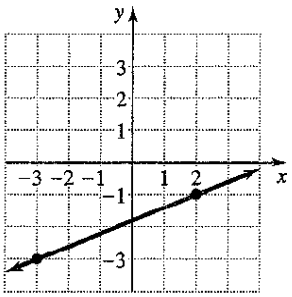
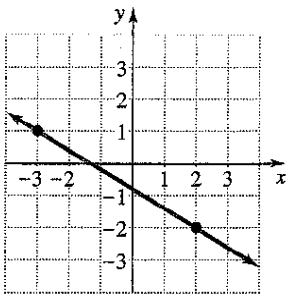


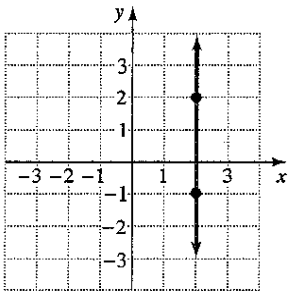
$\frac{2}{5}$

16.



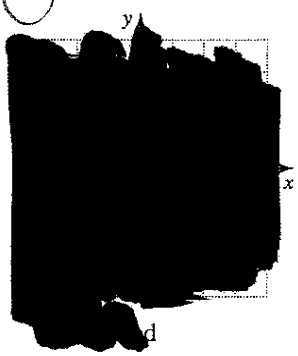
$-\frac{3}{5}$

17.



Undefined

18.

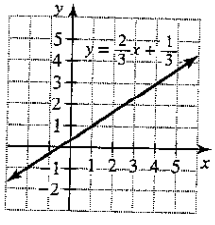


Find the slope of the line that goes through each pair of points. See Examples 3 and 4.

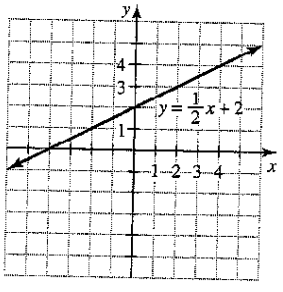
19. [redacted]
20. (2, 5), (6, 10) $\frac{5}{4}$
21. (2, 4), (5, −1) $-\frac{5}{3}$
22. (3, 1), (6, −2) -1
23. (−2, 4), (5, 9) $\frac{5}{7}$
24. (−1, 3), (3, 5) $\frac{1}{2}$
25. [redacted]
26. (−6, −3), (−1, 1) $\frac{4}{5}$
27. (−3, 4), (3, −2) -1
28. (−1, 3), (5, −2) $-\frac{5}{6}$
29. $\left(\frac{1}{2}, 2\right), \left(-1, \frac{1}{2}\right)$ 1
30. $\left(\frac{1}{3}, 2\right), \left(-\frac{1}{3}, 1\right)$ $\frac{3}{2}$
31. (2, 3), (2, −9) Undefined
32. (−3, 6), (8, 6) 0
33. (−2, −5), (9, −5) 0
34. (4, −9), (4, 6) Undefined
35. (0.3, 0.9), (−0.1, −0.3) 3
36. (−0.1, 0.2), (0.5, 0.8) 1

Graph the line with the given point and slope. See Example 5.

37. The line through (1, 1) with slope $\frac{2}{3}$

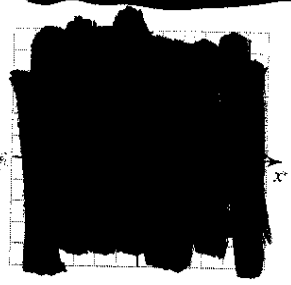


38. The line through (2, 3) with slope $\frac{1}{2}$

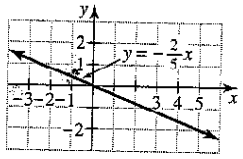


39. [redacted]

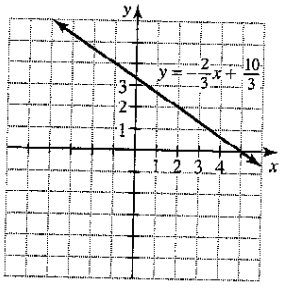
40. [redacted]



41. The line through (0, 0) with slope $-\frac{2}{5}$

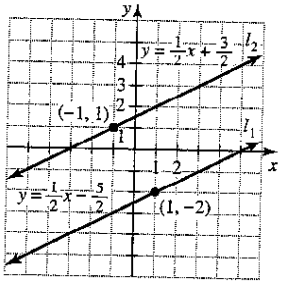


42. The line through (−1, 4) with slope $-\frac{2}{3}$



Solve each problem. See Examples 6 and 7.

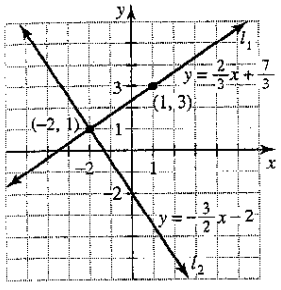
43. Draw line l_1 through (1, −2) with slope $\frac{1}{2}$ and line l_2 through (−1, 1) with slope $\frac{1}{2}$.



44. [redacted]

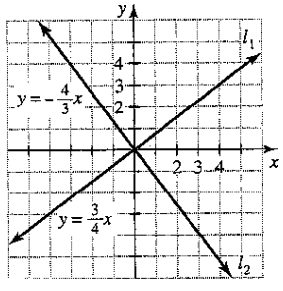
45. [illegible]

46. Draw l_1 through $(-2, 1)$ with slope $\frac{2}{3}$, and draw l_2 through $(-2, 1)$ with slope $-\frac{3}{2}$.



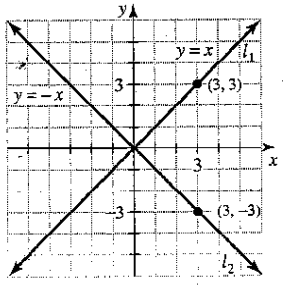
47. Draw any line l_1 with slope $\frac{3}{4}$. What is the slope of any line perpendicular to l_1? Draw any line l_2 perpendicular to l_1.

$-\frac{4}{3}$

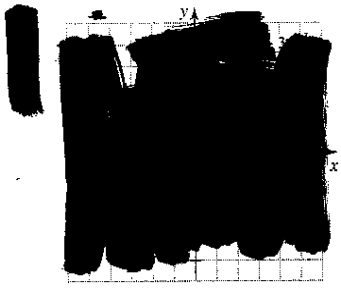


48. Draw any line l_1 with slope -1. What is the slope of any line perpendicular to l_1? Draw any line l_2 perpendicular to l_1.

1

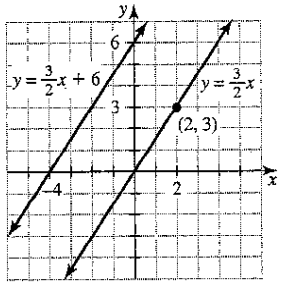


49. [illegible]

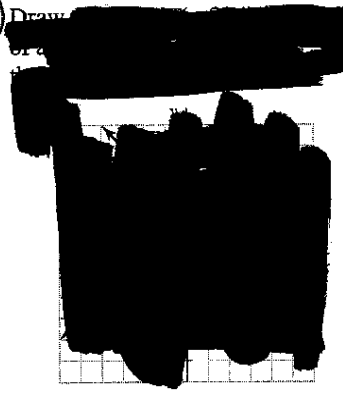


50. Draw l_1 through $(-4, 0)$ and $(0, 6)$. What is the slope of any line parallel to l_1? Draw l_2 through the origin and parallel to l_1.

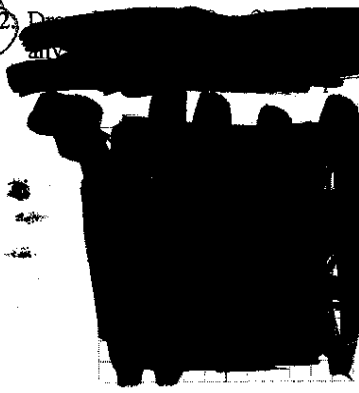
$\frac{3}{2}$



51. [illegible]



52. [illegible]



Solve each problem. See Example 8.

53. ***Super cost.*** The average cost of a 30-second ad during the 1995 super bowl was $1 million, and in 1998 it was $1.3 million (*Detroit Free Press,* January 6, 1998, www.freep.com).

a) Find the slope of the line through (95, 1,000,000) and (98, 1,300,000) and interpret your result.
$100,000 slope, average yearly increase is $100,000

b) Use the accompanying graph to estimate the average cost of an ad in 1997. $1.2 million

c) What do you think the average cost will be in 2005? $2 million

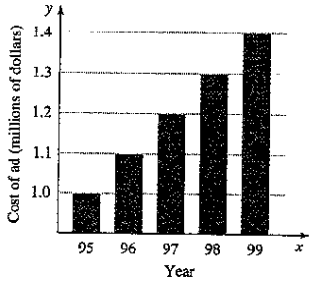
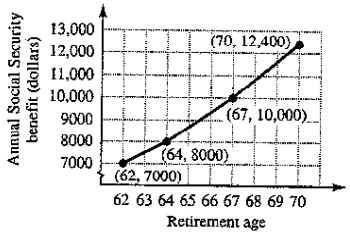


FIGURE FOR EXERCISE 53

54. ***Retirement pay.*** The annual Social Security benefit of a retiree depends on the age at the time of retirement. The accompanying graph gives the annual benefit for persons retiring at ages 62 through 70 in the year 2005 or later (Source: Social Security Administration). What is the annual benefit for a person who retires at age 64? At what retirement age does a person receive an annual benefit of $11,600? Find the slope of each line segment on the graph, and interpret your results. Why do people who postpone retirement until 70 years of age get the highest benefit?

$8000, 69, 500, 666.66, 800, the slopes are the yearly increases for each segment.



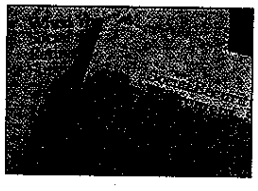


FIGURE FOR EXERCISE 54

55. ***Increasing training.*** The accompanying graph shows the percentage of U.S. workers receiving training by their employers. The percentage went from 5% in 1981 to 16% in 1995. Find the slope of this line. Interpret your result.

$\frac{11}{14}$, the percentage increases 0.79% per year

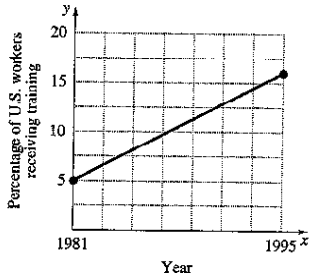
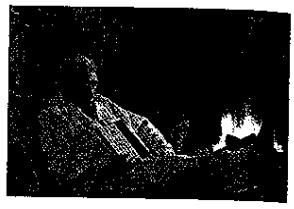


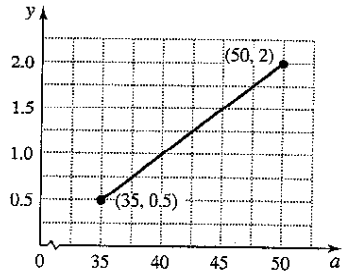
FIGURE FOR EXERCISE 55

56. ***Saving for retirement.*** Financial advisors at Fidelity Investments, Boston, use the accompanying table as a measure of whether a client is on the road to a comfortable retirement.

Age (a)	Years of Salary saved (y)
35	0.5
40	1.0
45	1.5
50	2.0



a) Graph these points and draw a line through them.



b) What is the slope of the line? 0.1

c) By what percentage of your salary should you be increasing your savings every year? 10%

Applications

The slope-intercept and standard forms are both important in applications.

EXAMPLE 7 **Changing forms**

A landscaper has a total of \$800 to spend on bushes at \$20 each and trees at \$50 each. So if x is the number of bushes and y is the number of trees he can buy, then $20x + 50y = 800$. Write this equation in slope-intercept form. Find and interpret the y-intercept and the slope.

Solution

Write in slope-intercept form:

$$\begin{aligned} 20x + 50y &= 800 \\ 50y &= -20x + 800 \\ y &= -\frac{2}{5}x + 16 \end{aligned}$$

The slope is $-\frac{2}{5}$ and the intercept is $(0, 16)$. So he can get 16 trees if he buys no bushes and he loses $\frac{2}{5}$ of a tree for each additional bush that he purchases. ■

WARM-UPS

True or false? Explain your answer.

1. There is only one line with y-intercept $(0, 3)$ and slope $-\frac{4}{3}$. True
2. The equation of the line through $(1, 2)$ with slope 3 is $y = 3x + 2$. False
3. The vertical line $x = -2$ has no y-intercept. True
4. The equation $x = 5$ has a graph that is a vertical line. True
5. The line $y = x - 3$ is perpendicular to the line $y = 5 - x$. True
6. The line $y = 2x - 3$ is parallel to the line $y = 4x - 3$. False
7. The line $2y = 3x - 8$ has a slope of 3. False
8. Every straight line in the coordinate plane has an equation in standard form. True
9. The line $x = 2$ is perpendicular to the line $y = 5$. True
10. The line $y = x$ has no y-intercept. False

4.3 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is the slope-intercept form for the equation of a line? Slope-intercept form is $y = mx + b$.
2. How can you determine the slope and y-intercept from the slope-intercept form.
   The slope is m and the y-intercept is $(0, b)$.
3. What is the standard form for the equation of a line?
   The standard form is $Ax + By = C$.
4. How can you graph a line when the equation is in slope-intercept form?
   From slope-intercept form, locate the intercept and a second point by counting the rise and run from the y-intercept.

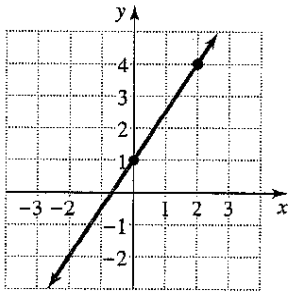
pg 84

5. What form is used in this section to write an equation of a line from a description of the line?
The slope-intercept form allows us to write the equation from the y-intercept and the slope.

6. What makes lines look perpendicular on a graph?
Lines with slopes m and $\frac{-1}{m}$ look perpendicular only if the same unit distance is used on both axes.

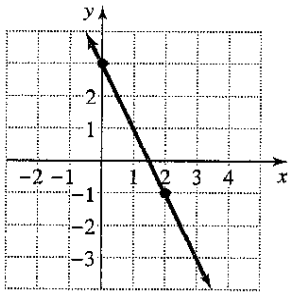
Write an equation for each line. Use slope-intercept form if possible. See Example 1.

7.



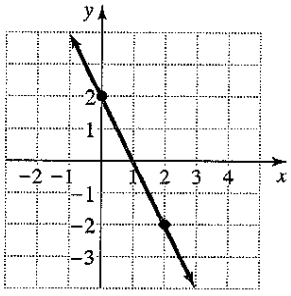
$y = \frac{3}{2}x + 1$

8.



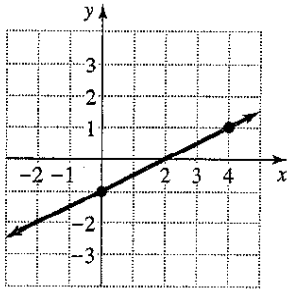
$y = -2x + 3$

9.



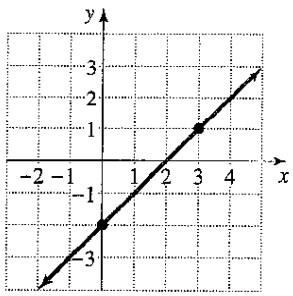
$y = -2x + 2$

10.



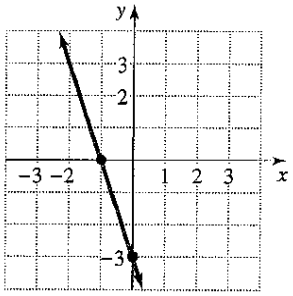
$y = \frac{1}{2}x - 1$

11.



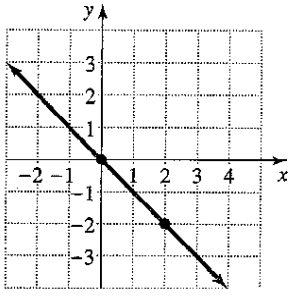
$y = x - 2$

12.



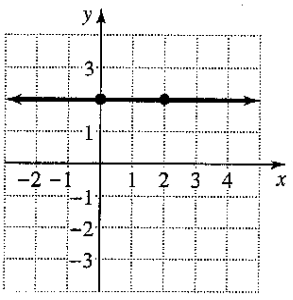
$y = -3x - 3$

13.



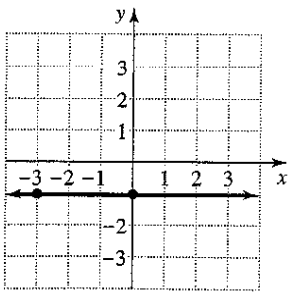
$y = -x$

14.



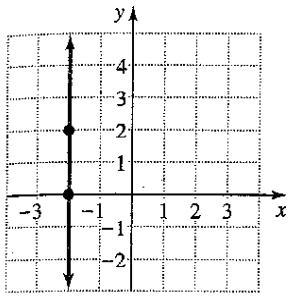
$y = 2$

15.

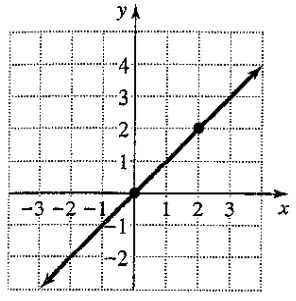


$y = -1$

16. [redacted]

17. 

$x = -2$

18. 

$y = x$

Find the slope and y-intercept for each line that has a slope and y-intercept. See Example 2.

19. $y = 3x - 9$
    3, (0, −9)

20. $y = -5x + 4$
    −5, (0, 4)

21. $y = 4$
    0, (0, 4)

22. $y = -5$
    0, (0, −5)

23. [redacted]

24. [redacted]

25. [redacted]

26. $x - y = 4$
    1, (0, −4)

27. $x - 2y = 4$
    $\frac{1}{2}$, (0, −2)

28. $x + 2y = 3$
    $-\frac{1}{2}, \left(0, \frac{3}{2}\right)$

29. $2x - 5y = 10$
    $\frac{2}{5}$, (0, −2)

30. $2x + 3y = 9$
    $-\frac{2}{3}$, (0, 3)

31. $2x - y + 3 = 0$
    2, (0, 3)

32. $3x - 4y - 8 = 0$
    $\frac{3}{4}$, (0, −2)

33. $x = -3$ Undefined slope, no y-intercept

34. $\frac{2}{3}x = 4$ Undefined slope, no y-intercept

Write each equation in standard form using only integers. See Example 3.

35. $y = -x + 2$
    $x + y = 2$

36. $y = 3x - 5$
    $3x - y = 5$

37. $y = \frac{1}{2}x + 3$
    $x - 2y = -6$

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

39. $y = \frac{3}{2}x - \frac{1}{3}$
    $9x - 6y = 2$

40. $y = \frac{4}{5}x + \frac{2}{3}$
    $12x - 15y = -10$

41. [redacted]

42. $y = -\frac{2}{3}x - \frac{5}{6}$
    $4x + 6y = -5$

43. $\frac{3}{5}x + 6 = 0$
    $x = -10$

44. $\frac{1}{2}x - 9 = 0$
    $x = 18$

45. $\frac{3}{4}y = \frac{5}{2}$
    $3y = 10$

46. $\frac{2}{3}y = \frac{1}{9}$
    $6y = 1$

47. [redacted]

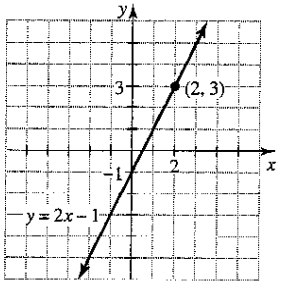
48. $\frac{x}{8} = -\frac{4y}{5}$
    $5x + 32y = 0$

49. $y = 0.02x + 0.5$
    $x - 50y = -25$

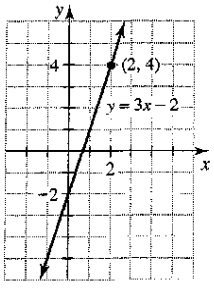
50. $0.2x = 0.03y - 0.1$
    $20x - 3y = -10$

Draw the graph of each line using its y-intercept and its slope. See Examples 4 and 5.

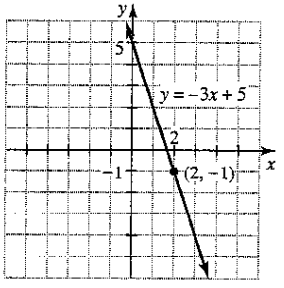
51. $y = 2x - 1$



52. $y = 3x - 2$



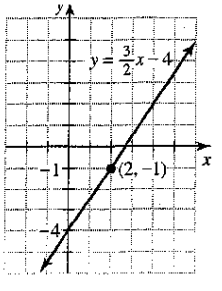
53. $y = -3x + 5$



54. [redacted]

55. [redacted]

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



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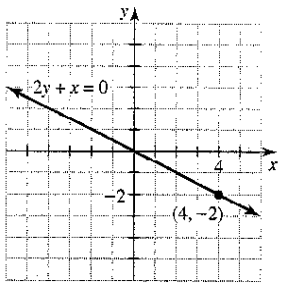
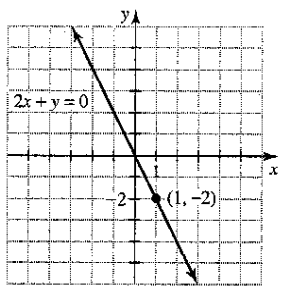
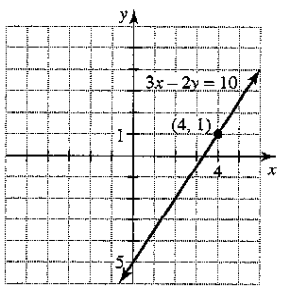
57. $2y + x = 0$



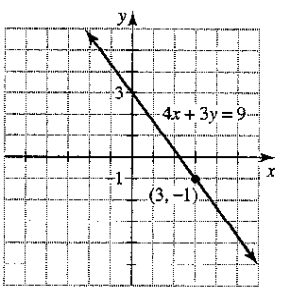
58. $2x + y = 0$



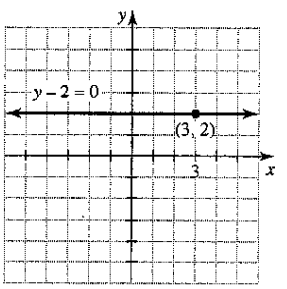
59. $3x - 2y = 10$



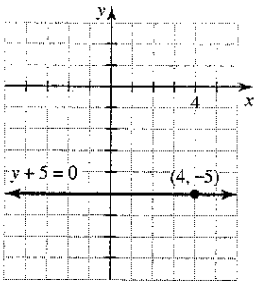
60. $4x + 3y = 9$



61. $y - 2 = 0$



62. $y + 5 = 0$



Write an equation in slope-intercept form, if possible, for each line. See Example 6. In each case, make a sketch.

63. The line through (0, 6) that is perpendicular to the line $y = 3x - 5$ $y = -\frac{1}{3}x + 6$

64. The line through $(0, -1)$ that is perpendicular to the line $y = x$ $y = -x - 1$

65. The line with y-intercept (0, 3) that is parallel to the line $2x + y = 5$ $y = -2x + 3$

66. The line through the origin that is parallel to the line $2x - 5y = 8$ $y = \frac{2}{5}x$

67. The line through (2, 3) that runs parallel to the x-axis $y = 3$

68. The line through $(-3, 5)$ that runs parallel to the y-axis $x = -3$

69. The line through (0, 4) and (5, 0) $y = -\frac{4}{5}x + 4$

70. The line through $(0, -3)$ and (4, 0) $y = \frac{3}{4}x - 3$

Solve each problem. See Example 7.

71. ***Marginal cost.*** A manufacturer plans to spend \$150,000 on research and development for a new lawn mower and then \$200 to manufacture each mower. The formula $C = 200n + 150{,}000$ gives the cost in dollars of n mowers. What is the cost of 5000 mowers? What is the cost of 5001 mowers? By how much did the one extra lawn mower increase the cost? (The increase in cost is called the *marginal cost* of the 5001st lawn mower.) \$1,150,000, \$1,150,200, \$200

72. ***Marginal revenue.*** A defense attorney charges her client \$4000 plus \$120 per hour. The formula $R = 120n + 4000$ gives her revenue in dollars for

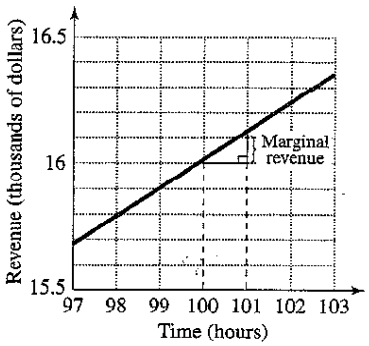


FIGURE FOR EXERCISE 72

n hours of work. What is her revenue for 100 hours of work? What is her revenue for 101 hours of work? By how much did the one extra hour of work increase the revenue? (The increase in revenue is called the *marginal revenue* for the 101st hour.) $16,000, $16,120, $120

73. ***In-house training.*** The accompanying graph shows the percentage of U.S. workers receiving training by their employers. The percentage went from 5% in year 0 (1981) to 16% in year 14 (1995).

a) Find the slope of this line.

b) Write the equation of the line in slope-intercept form.

c) Use your equation to predict the percentage that will be receiving training in the year 2000.

a) $\frac{11}{14}$ **b)** $y = \frac{11}{14}x + 5$ **c)** 19.9%

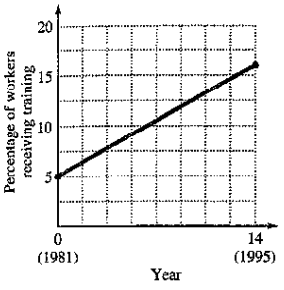


FIGURE FOR EXERCISE 73

74. ***Women and marriage.*** The percentage of women in the 20 to 24 age group who have never married went from 64% in year 0 (1970) to 33% in year 26 (1996) (Census Bureau, www.census.gov).

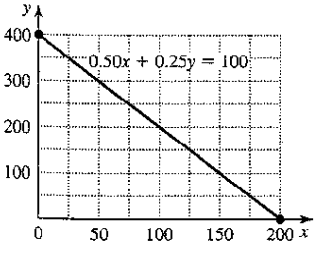
a) Find the equation of the line through the two points (0, 0.64) and (26, 0.33) in slope-intercept form. $y = -0.012x + 0.64$

b) Use your equation to predict what the percentage will be in the year 2000. 28%

75. ***Pansies and snapdragons.*** A nursery manager plans to spend $100 on 6-packs of pansies at 50 cents per pack and snapdragons at 25 cents per pack. The equation $0.50x + 0.25y = 100$ can be used to model this situation.

a) What do x and y represent?
x = the number of packs of pansies, y = the number of packs of snapdragons

b) Graph the equation.



c) Write the equation in slope-intercept form.
$y = -2x + 400$

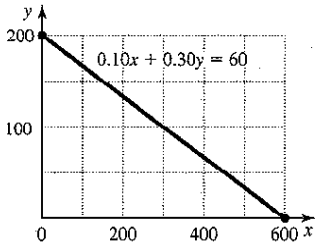
d) What is the slope of the line? -2

e) What does the slope tell you?
If the number of packs of pansies goes up by 1, then the number of packs of snapdragons goes down by 2.

76. ***Pens and pencils.*** A bookstore manager plans to spend $60 on pens at 30 cents each and pencils at 10 cents each. The equation $0.10x + 0.30y = 60$ can be used to model this situation.

a) What do x and y represent?
x = the number of pencils, y = the number of pens

b) Graph the equation.



c) Write the equation in slope-intercept form.
$y = -\frac{1}{3}x + 200$

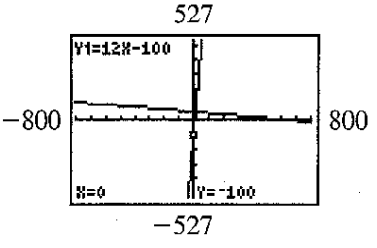
d) What is the slope of the line?
$-\frac{1}{3}$

e) What does the slope tell you?
If the number of pencils increases by 3, then the number of pens goes down by 1.

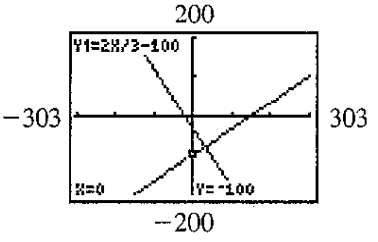
GRAPHING CALCULATOR EXERCISES

Graph each pair of straight lines on your graphing calculator using a viewing window that makes the lines look perpendicular. Answers may vary.

77. $y = 12x - 100, y = -\frac{1}{12}x + 50$



78. $2x - 3y = 300, 3x + 2y = -60$



4.4 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is the point-slope form for the equation of a line?
   Point-slope form is $y - y_1 = m(x - x_1)$.
2. For what is the point-slope form used?
   If we know any point and the slope of a line we can use point-slope form to write the equation.
3. What is the procedure for finding the equation of a line when given two points on the line?
   If you know two points on a line, find the slope. Then use it along with a point in point-slope form to write the equation of the line.
4. How can you find the slope of a line when given the equation of the line?
   Rewrite any equation in slope-intercept form to find the slope of the line.
5. What is the relationship between the slopes of parallel lines?
   Nonvertical parallel lines have equal slopes.
6. What is the relationship between the slopes of perpendicular lines?
   If lines with slopes m_1 and m_2 are perpendicular, then $m_1 \cdot m_2 = -1$.

Write each equation in slope-intercept form. See Example 1.

7. $y - 1 = 5(x + 2)$
   $y = 5x + 11$
8. $y + 3 = -3(x - 6)$
   $y = -3x + 15$
9. $3x - 4y = 80$
   $y = \frac{3}{4}x - 20$
10. $2x + 3y = 90$
    $y = -\frac{2}{3}x + 30$
11. $y - \frac{1}{2} = \frac{2}{3}\left(x - \frac{1}{4}\right)$
    $y = \frac{2}{3}x + \frac{1}{3}$
12. $y + \frac{2}{3} = -\frac{1}{2}\left(x - \frac{2}{5}\right)$
    $y = -\frac{1}{2}x - \frac{7}{15}$

Find the equation of each line. Write each answer in slope-intercept form. See Example 1.

13. The line through (2, 3) with slope $\frac{1}{3}$ $y = \frac{1}{3}x + \frac{7}{3}$
14. [illegible]
15. [illegible]
16. The line through $(-3, 1)$ with slope $-\frac{1}{3}$ $y = -\frac{1}{3}x$
17. [illegible]
18. [illegible]

Write each equation in standard form using only integers. See Example 2.

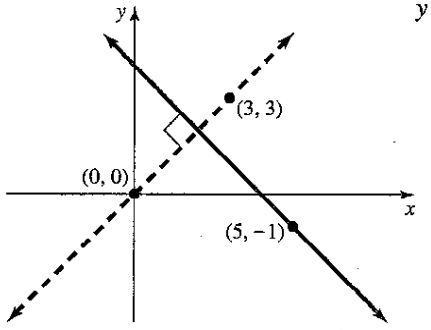
19. $y - 3 = 2(x - 5)$
    $2x - y = 7$
20. $y + 2 = -3(x - 1)$
    $3x + y = 1$
21. $y = \frac{1}{2}x - 3$
    $x - 2y = 6$
22. $y = \frac{1}{3}x + 5$
    $x - 3y = -15$
23. $y - 2 = \frac{2}{3}(x - 4)$
    $2x - 3y = 2$
24. $y + 1 = \frac{3}{2}(x + 4)$
    $3x - 2y = -10$

Find the equation of each line. Write each answer in standard form using only integers. See Example 2.

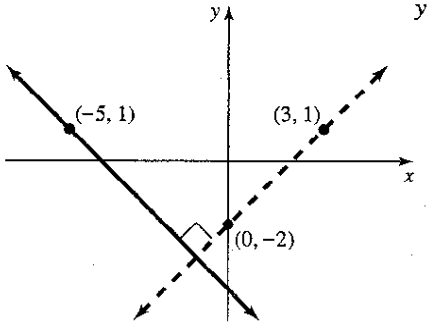
25. The line through the points (1, 2) and (5, 8)
    $3x - 2y = -1$
26. The line through the points (3, 5) and (8, 15)
    $2x - y = 1$
27. The line through the points $(-2, -1)$ and $(3, -4)$
    $3x + 5y = -11$
28. The line through the points $(-1, -3)$ and $(2, -1)$
    $2x - 3y = 7$
29. The line through the points $(-2, 0)$ and $(0, 2)$
    $x - y = -2$
30. The line through the points (0, 3) and (5, 0)
    $3x + 5y = 15$

The lines in each figure are perpendicular. Find the equation (in slope-intercept form) for the solid line.

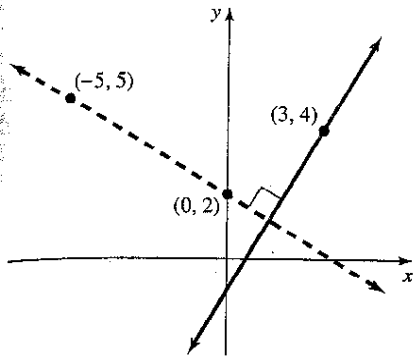
31. $y = -x + 4$



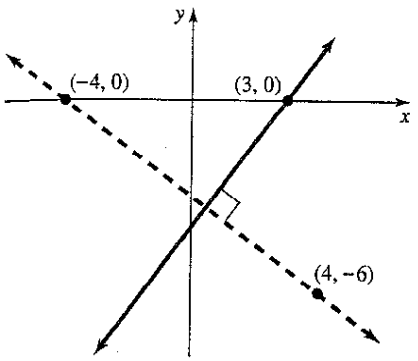
32. $y = -x - 4$



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



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



Find the equation of each line. Write each answer in slope-intercept form. See Examples 3 and 4.

35. The line contains the point (3, 4) and is perpendicular to $y = 3x - 1$. $y = -\frac{1}{3}x + 5$

36. The line contains the point $(-2, 3)$ and is perpendicular to $y = 2x + 7$. $y = -\frac{1}{2}x + 2$

37. The line is parallel to $y = x - 9$ and goes through the point (7, 10). $y = x + 3$

38. The line is parallel to $y = -x + 5$ and goes through the point $(-3, 6)$. $y = -x + 3$

39. The line is perpendicular to $3x - 2y = 10$ and passes through the point (1, 1). $y = -\frac{2}{3}x + \frac{5}{3}$

40. The line is perpendicular to $x - 5y = 4$ and passes through the point $(-1, 1)$. $y = -5x - 4$

41. The line is parallel to $2x + y = 8$ and contains the point $(-1, -3)$. $y = -2x - 5$

42. The line is parallel to $-3x + 2y = 9$ and contains the point $(-2, 1)$. $y = \frac{3}{2}x + 4$

43. The line goes through $(-1, 2)$ and is perpendicular to $3x + y = 5$. $y = \frac{1}{3}x + \frac{7}{3}$

44. The line goes through (1, 2) and is perpendicular to $y = \frac{1}{2}x - 3$. $y = -2x + 4$

45. The line goes through (2, 3) and is parallel to $-2x + y = 6$. $y = 2x - 1$

46. The line goes through (1, 4) and is parallel to $x - 2y = 6$. $y = \frac{1}{2}x + \frac{7}{2}$

Solve each problem.

47. ***Automated tellers.*** ATM volume reached 10.6 billion transactions in 1996 (Electronic Commerce Data Base). The accompanying graph shows the steady growth of automatic tellers.

a) Write the equation of the line through (92, 7.0) and (96, 10.6). $y = 0.9x - 75.8$

b) Use the equation to predict the number of transactions at automated teller machines in the year 2005? 18.7 billion

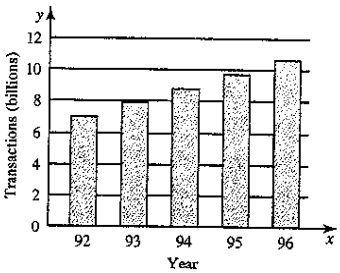


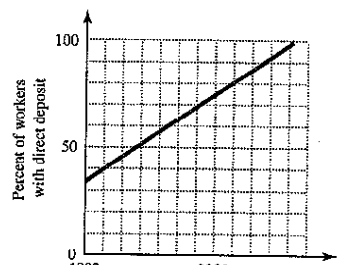
FIGURE FOR EXERCISE 47

48. ***Direct deposit.*** In 1994, one-third of all workers participated in direct deposit of their paychecks and this number is expected to reach three-fourths by the year 2000. (New York Automated Clearing House, www.nyach.org).

a) Write the equation of the line through (1993, 1/3) and (2000, 3/4). $y = 0.0595x - 118.2502$

b) Use the accompanying graph to predict the year in which 100% of all workers will participate in direct deposit of their paychecks. 2004

c) Use the equation from part (a) to predict the year in which 100% of all workers will participate in direct deposit of their paychecks. 2004



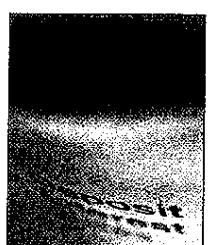


FIGURE FOR EXERCISE 48

49. ***Gross domestic product.*** The U.S. per capita gross domestic product went from $14,000 in 1970 to $18,000 in 1992 (*World Resources*, 1997).

a) Write the equation of the line through the points (1970, 14,000) and (1992, 18,000). $y = 181.818x - 344{,}181.46$

b) What do x and y represent in your equation? x = year, y = per capita gross domestic product in dollars.

1990

WARM-UPS

(continued)

8. In graphing the inequality $y \geq x$ we use a dashed boundary line. False

9. The point (0, 0) is on the graph of the inequality $y \geq x$. True

10. The point (0, 0) lies above the line $y = 2x + 1$. False

8.6 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is a linear inequality in two variables?
A linear inequality has the same form as a linear equation except that an inequality symbol is used.

2. How can you tell if an ordered pair satisfies a linear inequality in two variables?
An ordered pair satisfies a linear inequality if the inequality is correct when the variables are replaced by the coordinates of the ordered pair.

3. How do you determine whether to draw the boundary line of the graph of a linear inequality dashed or solid?
If the inequality symbol includes equality, then the boundary line is solid; otherwise it is dashed.

4. How do you decide which side of the boundary line to shade?
We shade the side that satisfies the inequality.

5. What is the test point method?
In the test point method we test a point to see which side of the boundary line satisfies the inequality.

6. What is the advantage of the test point method?
With the test point method you can use the inequality in any form.

Determine which of the points following each inequality satisfy that inequality. See Example 1.

7. $x - y > 5$ (2, 3), (−3, −9), (8, 3) (−3, −9)

8. $2x + y < 3$ (−2, 6), (0, 3), (3, 0) (−2, 6)

9. $y \geq -2x + 5$ (3, 0), (1, 3), (−2, 5) (3, 0), (1, 3)

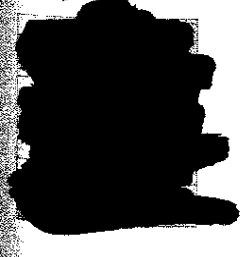
10. $y \leq -x + 6$ (2, 0), (−3, 9), (−4, 12) (2, 0), (−3, 9)

11. $x > -3y + 4$ (2, 3), (7, −1), (0, 5) (2, 3), (0, 5)

12. $x < -y - 3$ (1, 2), (−3, −4), (0, −3) (−3, −4)

Graph each inequality. See Examples 2 and 3.

13.



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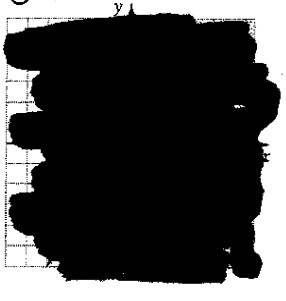

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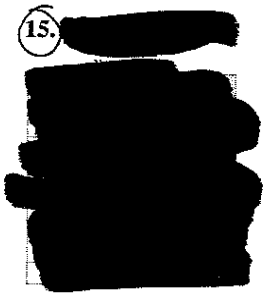

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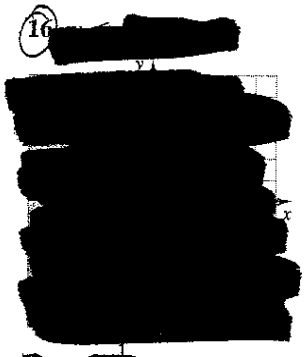

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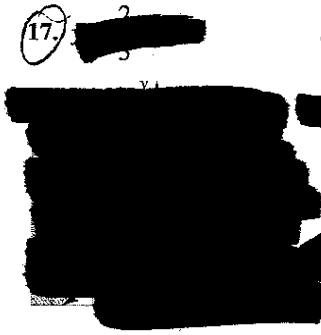

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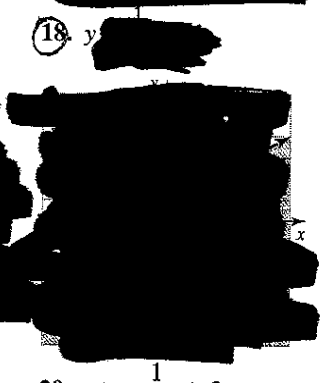

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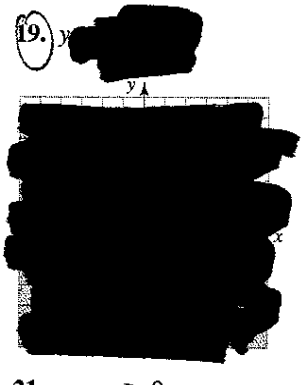
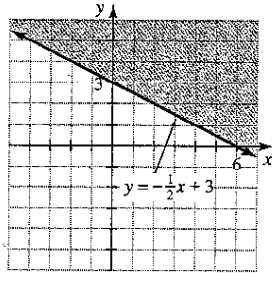
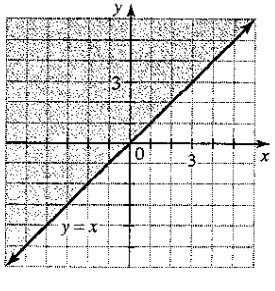


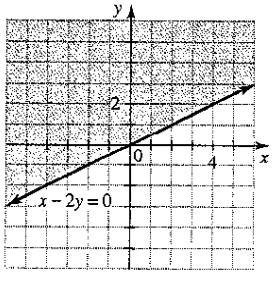
20. $y \geq -\frac{1}{2}x + 3$



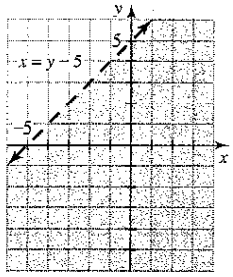
21. $y - x \geq 0$



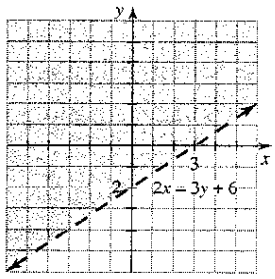
22. $x - 2y \leq 0$



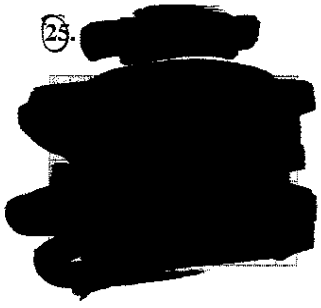
23. $x > y - 5$



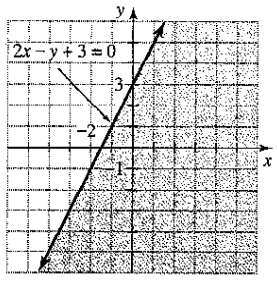
24. $2x < 3y + 6$



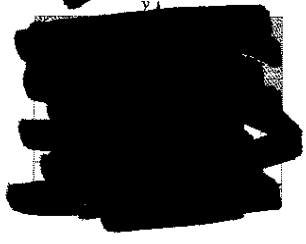
25. [redacted]



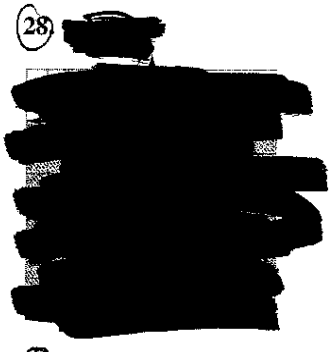
26. $2x - y + 3 \geq 0$



27. [redacted]

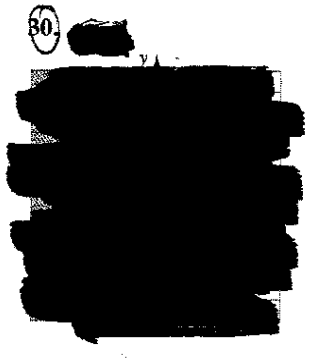


28. [redacted]

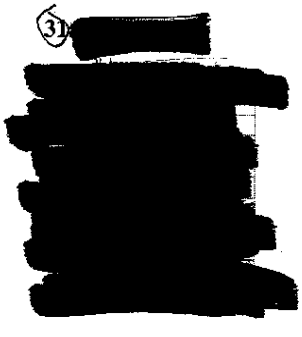


29. [redacted]

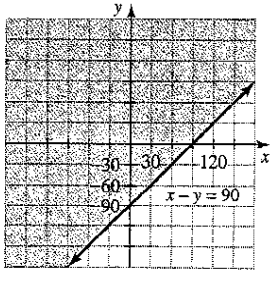
30. [redacted]



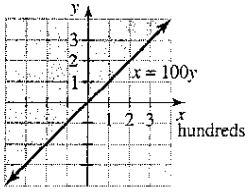
31. [redacted]



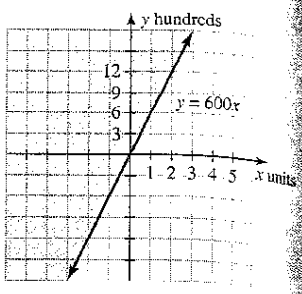
32. $x - y \leq 90$



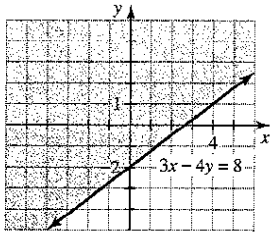
33. $x \leq 100y$



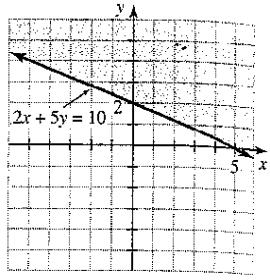
34. $y \geq 600x$



35. $3x - 4y \leq 8$

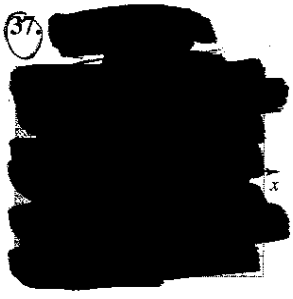


36. $2x + 5y \geq 10$

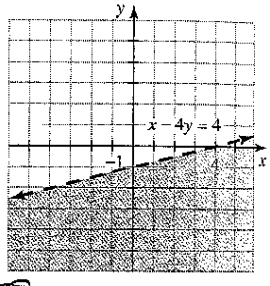


Graph each inequality. Use the test point method of Example 4.

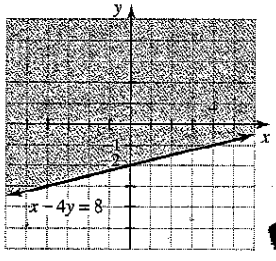
37. [redacted]



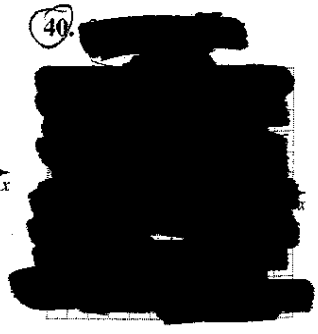
38. $x - 4y > 4$



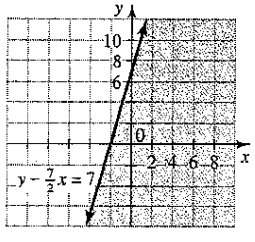
39. $x - 4y \leq 8$



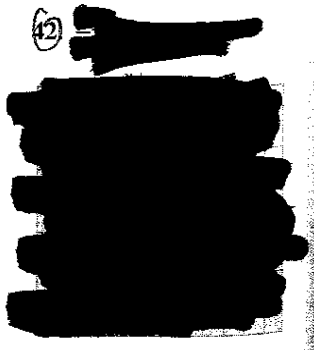
40. [redacted]



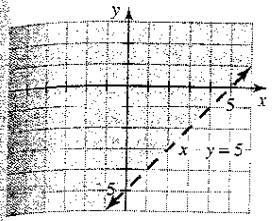
41. $y - \frac{7}{2}x \leq 7$



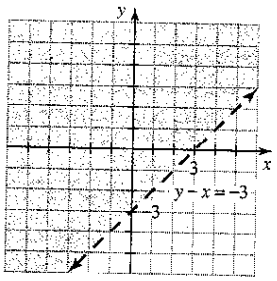
42. [redacted]



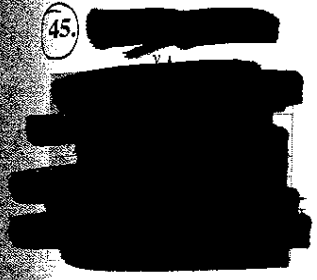
43. $x - y < 5$



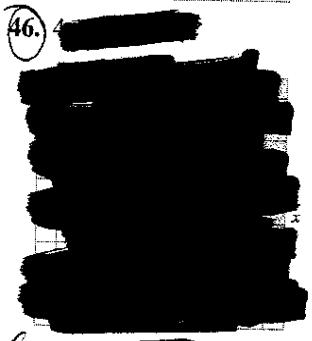
44. $y - x > -3$



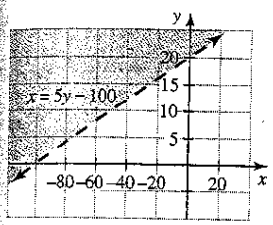
45. [redacted]



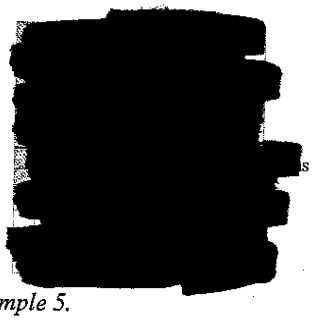
46. [redacted]



47. $x < 5y - 100$

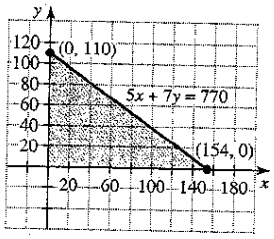


48. [redacted]



Solve each problem. See Example 5.

49. ***Storing the tables.*** Ozark Furniture Company must store its oak tables before shipping. A round table is packaged in a carton with a volume of 25 cubic feet (ft^3), and a rectangular table is packaged in a carton with a volume of 35 ft^3. The warehouse has at most 3850 ft^3 of space available for these tables. Write an inequality that limits the possible number of tables of each type that can be stored, and graph the inequality in the first quadrant.
$5x + 7y \leq 770$



50. ***Maple rockers.*** Ozark Furniture Company can obtain at most 3000 board feet of maple lumber for making its classic and modern maple rocking chairs. A classic maple rocker requires 15 board feet of maple, and a modern rocker requires 12 board feet of maple. Write an inequality that limits the possible number of maple rockers of each type that can be made, and graph the inequality in the first quadrant.
$5x + 4y \leq 1000$

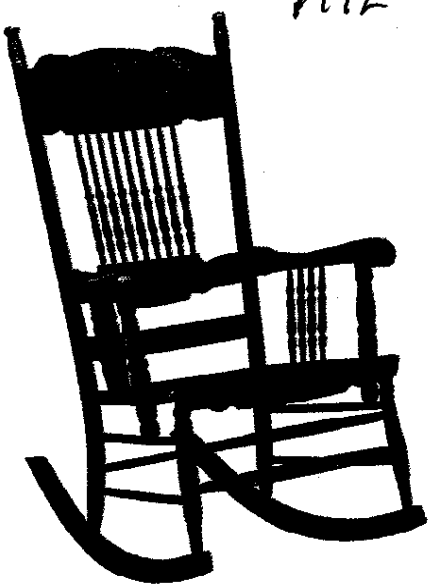
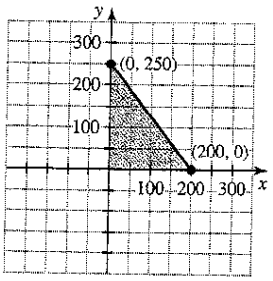
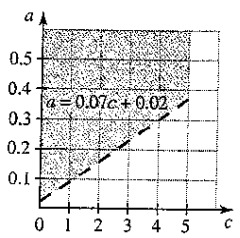


FIGURE FOR EXERCISE 50



51. ***Enzyme concentration.*** A food chemist tests enzymes for their ability to break down pectin in fruit juices (Dennis Callas, *Snapshots of Applications in Mathematics*). Excess pectin makes juice cloudy. In one test, the chemist measures the concentration of the enzyme, c, in milligrams per milliliter and the fraction of light absorbed by the liquid, a. If $a > 0.07c + 0.02$, then the enzyme is working as it should. Graph the inequality for $0 < c < 5$.



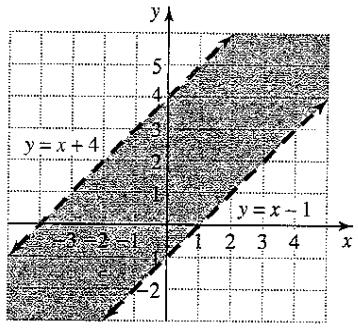


FIGURE 8.20

WARM-UPS

True or false? Explain your answer.

Use the following systems for Exercises 1–7.

a) $y > -3x + 5$, $y < 2x - 3$ **b)** $y > 2x - 3$, $y < 2x + 3$ **c)** $x + y > 4$, $x - y < 0$

1. The point $(2, -3)$ is a solution to system (a). False
2. The point $(5, 0)$ is a solution to system (a). True
3. The point $(0, 0)$ is a solution to system (b). True
4. The graph of system (b) is the region between two parallel lines. True
5. You can use $(0, 0)$ as a test point for system (c). False
6. The point $(2, 2)$ satisfies system (c). False
7. The point $(4, 5)$ satisfies system (c). True
8. The inequality $x + y > 4$ is equivalent to the inequality $y < -x + 4$. False
9. The graph of $y < 2x + 3$ is the region below the line $y = 2x + 3$. True
10. There is no ordered pair that satisfies $y < 2x - 3$ and $y > 2x + 3$. True

8.7 EXERCISES

Reading and Writing *After reading this section, write out the answers to these questions. Use complete sentences.*

1. What is a system of linear inequalities in two variables?
   A system of linear inequalities in two variables is a pair of linear inequalities in two variables.
2. How can you tell if an ordered pair satisfies a system of linear inequalities in two variables?
   To see if an ordered pair satisfies a system of inequalities, we can check to see if it satisfies both inequalities.
3. How do we usually describe the solution set to a system of inequalities in two variables?
   The solution set to a system of inequalities is usually described with a graph.
4. How do you decide whether the boundary lines are solid or dashed?
   A boundary line is solid if the inequality symbol includes equality; otherwise it is dashed.
5. How do you use the test point method for a system of linear inequalities?
   To use the test point method, select a point in each region determined by the graphs of the boundary lines.
6. How do you select test points?
   Any point will work as a test point, but it is usually simplest to select points on the axes.

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Determine which of the points following each system is a solution to the system. See Example 1.

7. $x - y < 5$ $(4, 3), (8, 2), (-3, 0)$
$2x + y > 3$ $(4, 3)$

8. $x + y < 4$ $(2, -3), (1, 1), (0, -1)$
$2x - y < 3$ $(1, 1), (0, -1)$

9. $y > -2x + 1$ $(-3, 2), (-1, 5), (3, 6)$
$y < 3x + 5$ $(3, 6)$

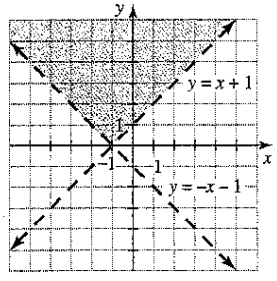
10. $y < -x + 7$ $(-3, 8), (0, 8), (-5, 15)$
$y < -x + 9$ $(-3, 8)$

11. $x > 3$ $(-5, 4), (9, -5), (6, 0)$
$y < -2$ $(9, -5)$

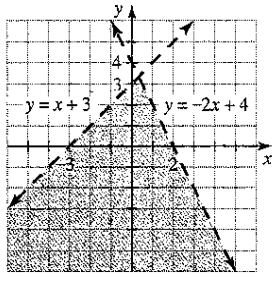
12. $y < -5$ $(-2, 4), (0, -7), (6, -9)$
$x < 1$ $(0, -7)$

Graph each system of inequalities. See Examples 2–5.

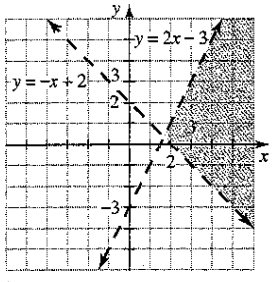
13. $y > -x - 1$
$y > x + 1$



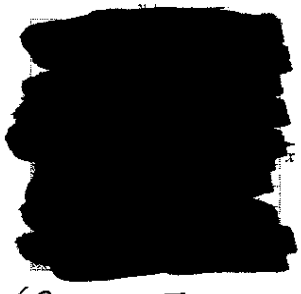
14. $y < x + 3$
$y < -2x + 4$



15. $y < 2x - 3$
$y > -x + 2$

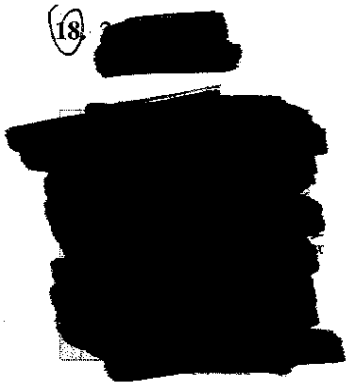


16. [illegible]

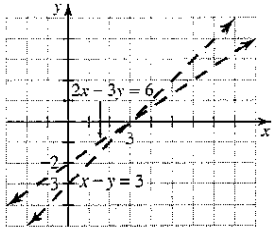


17. [illegible]

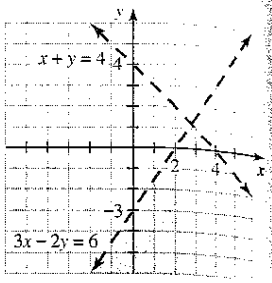
18. [illegible]



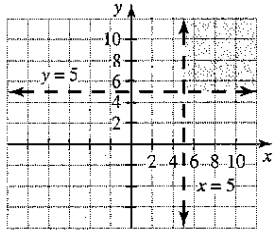
19. $2x - 3y < 6$
$x - y > 3$



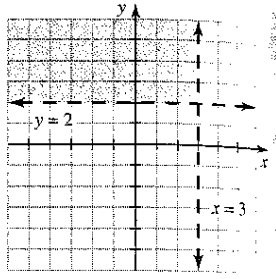
20. $3x - 2y > 6$
$x + y < 4$



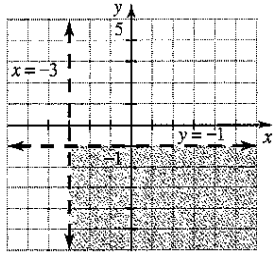
21. $x > 5$
$y > 5$



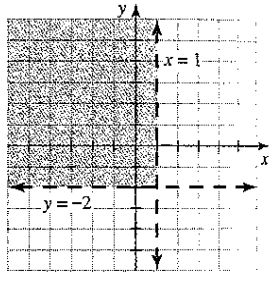
22. $x < 3$
$y > 2$



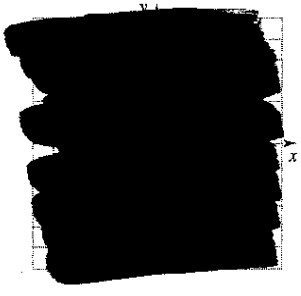
23. $y < -1$
$x > -3$



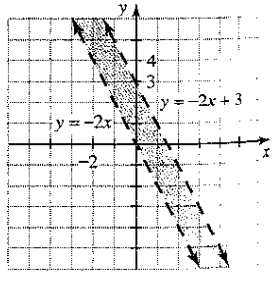
24. $y > -2$
$x < 1$



25. [illegible]



26. $y < -2x + 3$
$y > -2x$



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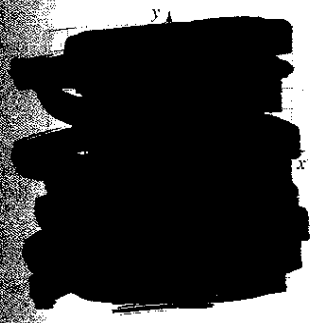
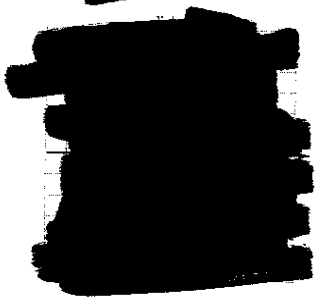
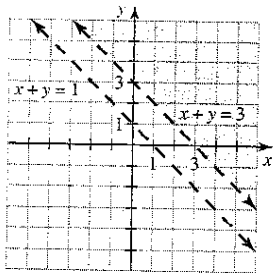
27. [redacted]



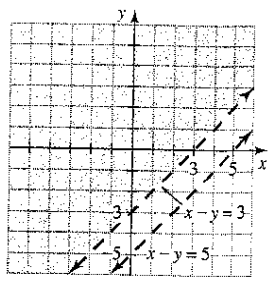
28. [redacted]



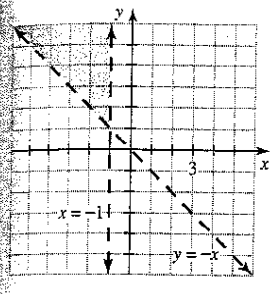
35. $x + y > 3$
$x + y > 1$



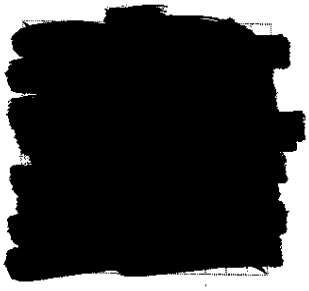
36. $x - y < 5$
$x - y < 3$



29. $y > -x$
$x < -1$



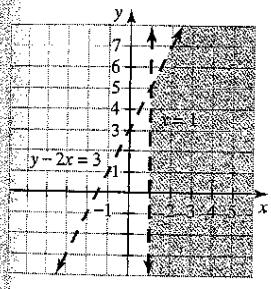
30. [redacted]



37. [redacted]

38. [redacted]

31. $x > 1$
$y - 2x < 3$

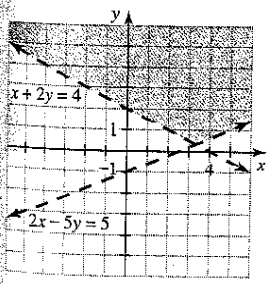


32. [redacted]

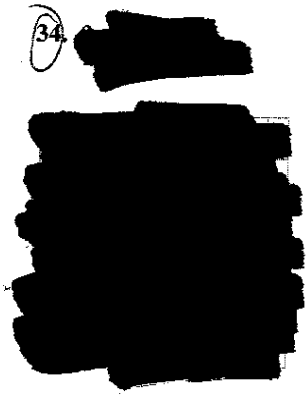
39. [redacted]

40. [redacted]

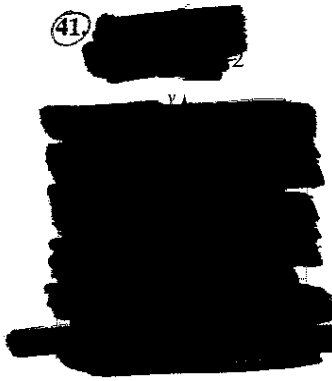
33. $2x - 5y < 5$
$x + 2y > 4$



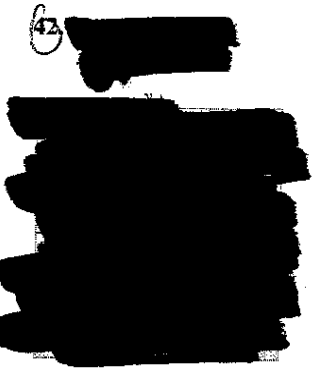
34. [redacted]



41. [redacted]



42. [redacted]



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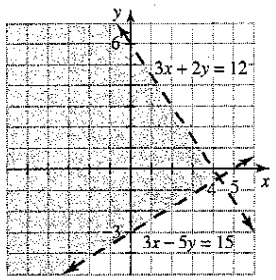
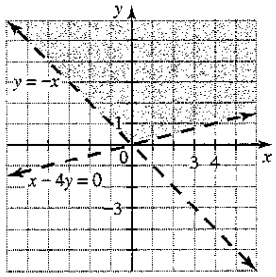
43. $3x - 5y < 15$
$3x + 2y < 12$



44. $x - 4y < 0$
$x + y > 0$

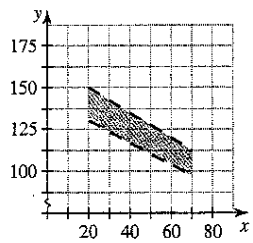


Solve each problem.

45. ***Target heart rate.*** For beneficial exercise, experts recommend that your target heart rate y should be between 65% and 75% of the maximum heart rate for your age x. That is,

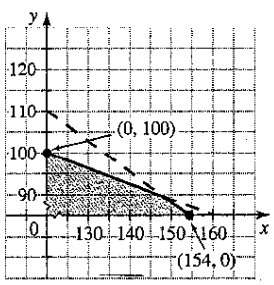
$$y > 0.65(220 - x) \quad \text{and} \quad y < 0.75(220 - x).$$

Graph this system of incqualitics for $20 < x < 70$.



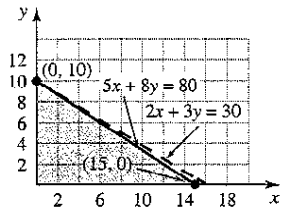
46. ***Making and storing the tables.*** The Ozark Furniture Company can obtain at most 8000 board feet of oak lumber for making round and rectangular tables. The tables must be stored in a warehouse that has at most 3850 ft^3 of space available for the tables. A round table requires 50 board feet of lumber and 25 ft^3 of warehouse space. A rectangular table requires 80 board feet of lumber and 35 ft^3 of warehouse space. Write a system of inequalities that limits the possible number of tables of each type that can be made and stored. Graph the system.

$5x + 8y \leq 800$
$5x + 7y \leq 770$



47. ***Allocating resources.*** Wausaukee Enterprises makes yard barns in two sizes. One small barn requires \$250 in materials and 20 hours of labor, and one large barn requires \$400 in materials and 30 hours of labor. Wausaukee has at most \$4000 to spend on materials and at most 300 hours of labor available. Write a system of inequalities that limits the possible number of barns of each type that can be built. Graph the system.

$5x + 8y \leq 80$
$2x + 3y \leq 30$



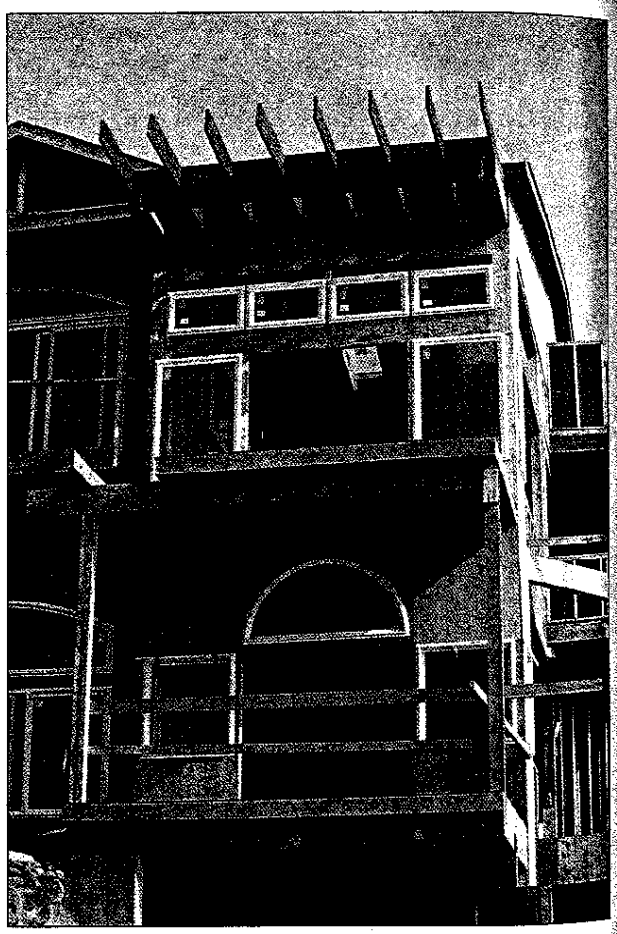


FIGURE FOR EXERCISE 47

Inequalities can be used to describe limitations on materials used in construction.