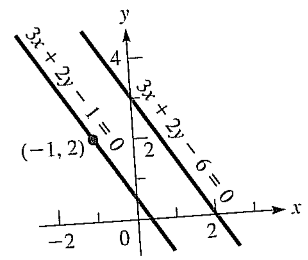


Fig. 21.24

EXAMPLE 6 General form

Find the general form of the equation of the line parallel to the line $3x + 2y - 6 = 0$ and that passes through the point $(-1, 2)$.

Since the line whose equation we want is parallel to the line $3x + 2y - 6 = 0$, it has the same slope. Thus, writing $3x + 2y - 6 = 0$ in slope-intercept form,

$$2y = -3x + 6 \quad \text{solving for } y$$
$$y = -\frac{3}{2}x + 3$$

Since the slope of $3x + 2y - 6 = 0$ is $-3/2$, the slope of the required line is also $-3/2$. Using $m = -3/2$, the point $(-1, 2)$, and the point-slope form, we have

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

This is the general form of the equation. Both lines are shown in Fig. 21.24.

With $y_1 = -3x/2 + 3$ and $y_2 = -3x/2 + 1/2$, these lines are shown in the calculator display in Fig. 21.25. ■

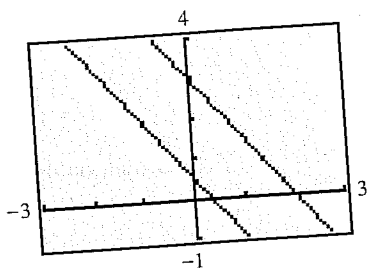


Fig. 21.25

In many physical situations, a linear relationship exists between variables. A few examples of this are (1) the distance traveled by an object and the elapsed time, when the velocity is constant, (2) the amount a spring stretches and the force applied, (3) the change in electric resistance and the change in temperature, (4) the force applied to an object and the resulting acceleration, and (5) the pressure at a certain point within a liquid and the depth of the point.

EXAMPLE 7 Straight line – application

For a period of 6.0 s, the velocity v of a rocket varies linearly with the elapsed time t. If $v = 40$ m/s when $t = 1.0$ s and $v = 55$ m/s when $t = 4.0$ s, find the equation relating v and t and graph the function. From the graph, find the initial velocity and the velocity after 6.0 s. What is the meaning of the slope of the line?

With v as the dependent variable and t as the independent variable, the slope is

$$m = \frac{v_2 - v_1}{t_2 - t_1}$$

Using the information given in the statement of the problem, we have

$$m = \frac{55 - 40}{4.0 - 1.0} = 5.0$$

Then using the point-slope form of the equation of a straight line, we have

$$v - 40 = 5.0(t - 1.0)$$
$$v = 5.0t + 35$$

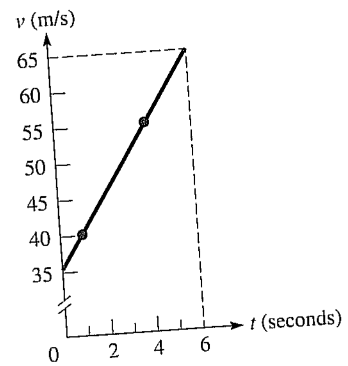


Fig. 21.26

The given values are sufficient to graph the line in Fig. 21.26. There is no need to include negative values of t, since they have no physical meaning. We see that the line crosses the v-axis at 35. This means that the initial velocity (for $t = 0$) is 35 m/s. Also, when $t = 6.0$ s, we see that $v = 65$ m/s.

The slope is the ratio of the change in velocity to the change in time. This is the rocket's *acceleration*. Here, the speed of the rocket increases 5.0 m/s each second. We can express this acceleration as $5.0\ (\text{m/s})/\text{s} = 5.0\ \text{m/s}^2$. ■

Practice Exercise

2. Write the general form of the equation of the straight line that passes through $(0, -1)$ with a slope of 3.

EXERCISES 21.2

In Exercises 1–4, make the given changes in the indicated examples of this section and then solve the resulting problems.

1. In Example 1, change $(-4, 1)$ to $(4, -1)$.
2. In Example 2, change $(2, -1)$ to $(-2, 1)$.
3. In Example 4, change the + before $4x$ to −.
4. In Example 6, change the + before $2y$ to −.

In Exercises 5–20, find the equation of each of the lines with the given properties. Sketch the graph of each line.

5. Passes through $(-3, 8)$ with a slope of 4.
6. Passes through $(-2, -1)$ with a slope of −2.
7. Passes through $(2, -5)$ and $(4, 2)$.
8. Has an x-intercept $(4, 0)$ and a y-intercept of $(0, -6)$.
9. Passes through $(-7, 12)$ with an inclination of 45°.
10. Has a y-intercept $(0, -2)$ and an inclination of 120°.
11. Passes through $(5.3, -2.7)$ and is parallel to the x-axis.
12. Passes through $(-15, 9)$ and is perpendicular to the x-axis.
13. Is parallel to the y-axis and is 3 units to the left of it.
14. Is parallel to the x-axis and is 4.1 units below it.
15. Perpendicular to line with slope of −3; passes through $(1, -2)$.
16. Parallel to line through $(-1, 7)$ and $(3, 1)$; passes through $(1, 2)$.
17. Has equal intercepts and passes through $(5, 2)$.
18. Is perpendicular to the line $6.0x - 2.4y - 3.9 = 0$ and passes through $(7.5, -4.7)$.
19. Has a slope of −3 and passes through the intersection of the lines $5x - y = 6$ and $x + y = 12$.
20. Passes through the point of intersection of $2x + y - 3 = 0$ and $x - y - 3 = 0$ and through the point $(4, -3)$.

In Exercises 21–28, reduce the equations to slope-intercept form and find the slope and the y-intercept. Sketch each line.

21. $4x - y = 8$
22. $2x - 3y - 6 = 0$
23. $3x + 5y - 10 = 0$
24. $4y = 6x - 9$
25. $3x - 2y - 1 = 0$
26. $4x + 2y - 5 = 0$
27. $11.2x + 1.6 = 3.2y$
28. $11.5x + 4.60y = 5.98$

In Exercises 29–36, determine whether the given lines are parallel, perpendicular, or neither.

29. $3x - 2y + 5 = 0$ and $4y = 6x - 1$
30. $8x - 4y + 1 = 0$ and $4x + 2y - 3 = 0$
31. $6x - 3y - 2 = 0$ and $x + 2y - 4 = 0$
32. $3y - 2x = 4$ and $6x - 9y = 5$
33. $5x + 2y - 3 = 0$ and $10y = 7 - 4x$
34. $48y - 36x = 71$ and $52x = 17 - 39y$
35. $4.5x - 1.8y = 1.7$ and $2.4x + 6.0y = 0.3$
36. $3.5y = 4.3 - 1.5x$ and $3.6x + 8.4y = 1.7$

In Exercises 37–60, solve the given problems. Exercises 45–56 show some applications of straight lines.

37. Find k if the lines $4x - ky = 6$ and $6x + 3y + 2 = 0$ are parallel.
38. Find k if the lines given in Exercise 37 are perpendicular.
39. (W) Find k if the lines $3x - y = 9$ and $kx + 3y = 5$ are perpendicular. Explain how this value is found.
40. (W) Find k such that the line through $(k, 2)$ and $(3, 1 - k)$ is perpendicular to the line $x - 2y = 5$. Explain your method.
41. Find the slope of the line joining points on the graph of $y = x^2$ that have x-coordinates of $-a$ and b $(a > 0, b > 0)$.
42. Show that the *intercept form* $\frac{x}{a} + \frac{y}{b} = 1$ is the equation of a line with x-intercept $(a, 0)$ and y-intercept $(0, b)$.
43. Find the distance from $(4, 1)$ to the line $4x - 3y + 12 = 0$.
44. Find the acute angle between the lines $x + y = 3$ and $2x - 5y = 4$.
45. Show that the following lines intersect to form a parallelogram. $8x + 10y = 3$; $2x - 3y = 5$; $4x - 6y = -3$; $5y + 4x = 1$.
46. For nonzero values of a, b, and c, find the intercepts of the line $ax + by + c = 0$.
47. For nonzero values of a, b, c, and d, show that (a) lines $ax + by + c = 0$ and $ax + by + d = 0$ are parallel, and (b) lines $ax + by + c = 0$ and $bx - ay + d = 0$ are perpendicular.
48. Find the equation of the line with positive intercepts that passes through $(3, 2)$ and forms with the axes a triangle of area 12.
49. In the 1700s, the French physicist Reaumur established a temperature scale on which the freezing point of water was 0° and the boiling point was 80°. Set up an equation for the Celsius temperature T (freezing point 0°, boiling point 100°) as a function of the Reaumur temperature R.
50. The voltage V across part of an electric circuit is given by $V = E - iR$, where E is a battery voltage, i is the current, and R is the resistance. If $E = 6.00$ V and $V = 4.35$ V for $i = 9.17$ mA, find V as a function of i. Sketch the graph (i and V may be negative.)
51. The velocity of sound v increases 0.607 m/s for each increase in temperature T of 1.00°C. If $v = 343$ m/s for $T = 20.0$°C, express v as a function of T.
52. An acid solution is made from x liters of a 20% solution and y liters of a 30% solution. If the final solution contains 20 L of acid, find the equation relating x and y.
53. (W) A wall is 15 cm thick. At the outside, the temperature is 3°C, and at the inside, it is 23°C. If the temperature changes at a constant rate through the wall, write an equation of the temperature T in the wall as a function of the distance x from the outside to the inside of the wall. What is the meaning of the slope of the line?

54. An oil-storage tank is emptied at a constant rate. At 10 A.M., 1800 barrels remain, and at 2 P.M., 600 barrels remain. If pumping started at 8 A.M., find the equation relating the number of barrels n at time t (in h) from 8 A.M. When will the tank be empty?

55. The power output P (in W) of a computer chip operating at 120°C is proportional to $120 - T_S$, where T_S is the temperature of the surroundings. If $P = 1.0$ W for $T_S = 80$°C, find the equation relating P and T_S.

(W) **56.** The length of a rectangular solar cell is 10 cm more than the width w. Express the perimeter p of the cell as a function of w. What is the meaning of the slope of the line?

57. A light beam is reflected off the edge of an optic fiber at an angle of 0.0032°. The diameter of the fiber is 48 μm. Find the equation of the reflected beam with the x-axis (at the center of the fiber) and the y-axis as shown in Fig. 21.27.

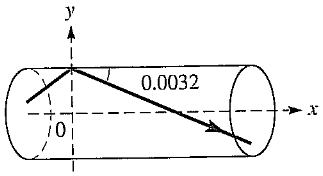


Fig. 21.27

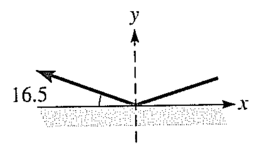


Fig. 21.28

58. A police report stated that a bullet caromed upward off a floor at an angle of 16.5° with the floor, as shown in Fig. 21.28. What is the equation of the bullet's path after impact?

(W) **59.** A survey of the traffic on a particular highway showed that the number of cars passing a particular point each minute varied linearly from 6:30 A.M. to 8:30 A.M. on workday mornings. The study showed that an average of 45 cars passed the point in 1 min at 7 A.M. and that 115 cars passed in 1 min at 8 A.M. If n is the number of cars passing the point in 1 min, and t is the number of minutes after 6:30 A.M., find the equation relating n and t, and graph the equation. From the graph, determine n at 6:30 A.M. and at 8:30 A.M. What is the meaning of the slope of the line?

60. In a research project on cancer, a tumor was determined to weigh 30 mg when first discovered. While being treated, it grew smaller by 2 mg each month. Find the equation relating the weight w of the tumor as a function of the time t in months. Graph the equation.

In Exercises 61–64, treat the given nonlinear functions as linear functions in order to sketch their graphs. At times, this can be useful in showing certain values of a function. For example, $y = 2 + 3x^2$ can be shown as a straight line by graphing y as a function of x^2. A table of values for this graph is shown along with the corresponding graph in Fig. 21.29.

x	0	1	2	3	4	5
x^2	0	1	4	9	16	25
y	2	5	14	29	50	77

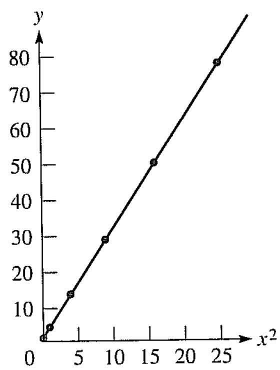


Fig. 21.29

61. The number n of memory cells of a certain computer that can be tested in t seconds is given by $n = 1200\sqrt{t}$. Sketch n as a function of $\sqrt{t}$.

62. The force F (in N) applied to a lever to balance a certain weight on the opposite side of the fulcrum is given by $F = 40/d$, where d is the distance (in m) of the force from the fulcrum. Sketch F as a function of $1/d$.

63. A spacecraft is launched such that its altitude h (in km) is given by $h = 300 + 2t^{3/2}$ for $0 \leq t < 100$ s. Sketch this as a linear function.

64. The current i (in A) in a certain electric circuit is given by $i = 6(1 - e^{-t})$. Sketch this as a linear function.

In Exercises 65–68, show that the given nonlinear functions are linear when plotted on semilogarithmic or logarithmic paper. In Section 13.7, we noted that graphs on this paper often become straight lines.

65. A function of the form $y = ax^n$ is straight when plotted on logarithmic paper, since $\log y = \log a + n \log x$ is in the form of a straight line. The variables are $\log y$ and $\log x$; the slope can be found from $(\log y - \log a)/\log x = n$, and the intercept is a. (To get the slope from the graph, it is necessary to measure vertical and horizontal distances between two points. The log y-intercept is found where $\log x = 0$, and this occurs when $x = 1$.) Plot $y = 3x^4$ on logarithmic paper to verify this analysis.

66. A function of the form $y = a(b^x)$ is a straight line on semilogarithmic paper, since $\log y = \log a + x \log b$ is in the form of a straight line. The variables are $\log y$ and x, the slope is $\log b$, and the intercept is a. (To get the slope from the graph, we calculate $(\log y - \log a)/x$ for some set of values x and y. The intercept is read directly off the graph where $x = 0$.) Plot $y = 3(2^x)$ on semilogarithmic paper to verify this analysis.

67. If experimental data are plotted on logarithmic paper and the points lie on a straight line, it is possible to determine the function (see Exercise 65). The following data come from an experiment to determine the functional relationship between the pressure p and the volume V of a gas undergoing an adiabatic (no heat loss) change. From the graph on logarithmic paper, determine p as a function of V.

V (m^3)	0.100	0.500	2.00	5.00	10.0
p (kPa)	20.1	2.11	0.303	0.0840	0.0318

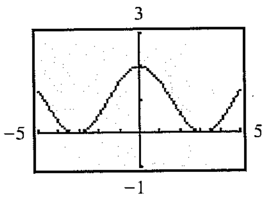
68. If experimental data are plotted on semilogarithmic paper, and the points lie on a straight line, it is possible to determine the function (see Exercise 66). The following data come from an experiment designed to determine the relationship between the voltage across an inductor and the time after the switch is opened. Determine v as a function of t.

v (V)	40	15	5.6	2.2	0.8
t (ms)	0.0	20	40	60	80

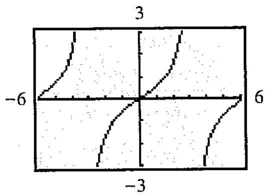
Answers to Practice Exercises

1. $2x + y + 8 = 0$ **2.** $3x - y - 1 = 0$

57.



59.



61. $x = \frac{1}{2}\cos^{-1}\frac{1}{2}y$ **63.** $x = \frac{1}{5}\sin\frac{1}{3}\left(\frac{1}{4}\pi - y\right)$

65. 1.2925, 4.4341 **67.** $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$ **69.** $0, \frac{\pi}{3}, \frac{5\pi}{3}$

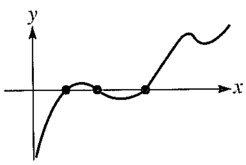
71. $0, \frac{2\pi}{3}$ **73.** 0.3142, 1.571, 2.827, 4.084, 4.712, 5.341

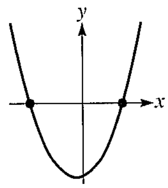
75. 0

77. Identity:

$$\tan x + \frac{1}{\tan x} = \frac{\tan^2 x + 1}{\tan x} = \sec^2 x(\cot x) = \frac{\sec^2 x \cos x}{\sin x}$$

79. $\frac{\pi}{2}, \pi$ **81.** 1.56, 2.16, 3.46 **83.** $-2.31, 1.14$





85. $\frac{1}{x}$ **87.** $2x\sqrt{1 - x^2}$ **89.** $\frac{\sqrt{1 - x^2} - xy}{\sqrt{1 + y^2}}$

91. $2\sqrt{1 - \cos^2\theta}$ **93.** $\frac{\tan\theta}{\sqrt{1 + \tan^2\theta}} = \frac{\tan\theta}{\sec\theta}$

95. $(\cos\theta + j\sin\theta)^2 = (\cos^2\theta - \sin^2\theta) + j(2\sin\theta\cos\theta)$

97. $\frac{\pi}{2} < x < \frac{3\pi}{2}$

99. $C\left(\frac{A}{C}\sin 2t + \frac{B}{C}\cos 2t\right)$
$= C(\cos\alpha\sin 2t + \sin\alpha\cos 2t)$

101. $R = \sqrt{(A\cos\theta - B\sin\theta)^2 + (A\sin\theta + B\cos\theta)^2}$
$= \sqrt{A^2(\cos^2\theta + \sin^2\theta) + B^2(\sin^2\theta + \cos^2\theta)}$

103. $\frac{k}{2}\cdot\frac{1}{\sin^2\frac{\theta}{2}} = \frac{k}{2}\cdot\frac{1}{\frac{1 - \cos\theta}{2}}$ **105.** $\theta = a + R\sin\omega t$

107. $\frac{\cos 2\alpha}{2\cos^2\alpha}$ **109.** $p = VI\cos\omega t[\cos(\phi + \omega t)]$

111. 6.8 m **113.** 54.7°

Exercises 21.1, page 562

1. $\sqrt{61}$ **3.** 150° **5.** $2\sqrt{29}$ **7.** 3 **9.** 55

11. $2\sqrt{53}$ **13.** 2.86 **15.** $\frac{5}{2}$ **17.** Undefined **19.** $-\frac{3}{4}$

21. $-\frac{5}{9}$ **23.** 0.747 **25.** $\frac{1}{3}\sqrt{3}$ **27.** -0.311 **29.** 20.0°

31. 98.50° **33.** Parallel **35.** Perpendicular **37.** 8, -2

39. -3 **41.** Two sides equal $2\sqrt{10}$. **43.** $m_1 = \frac{5}{12}, m_2 = \frac{4}{3}$

45. 10 **47.** $4\sqrt{10} + 4\sqrt{2} = 18.3$ **49.** (1, 5)

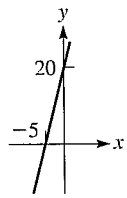
51. $(-2.8, 4.2)$ **53.** $x^2 + y^2 = 9$ **55.** $m_1 = 1, m_2 = -1$

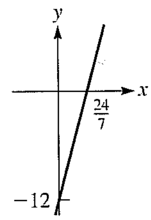
57. $\left(-\frac{11}{3}, 0\right)$ **59.** $\left(0, -\frac{7}{9}\right)$ **61.** $0, \sqrt{3}, -\sqrt{3}$

Exercises 21.2, page 567

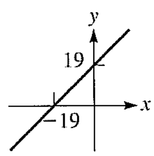
1. $y + 2x - 7 = 0$ **3.** $2, \left(0, \frac{5}{2}\right)$

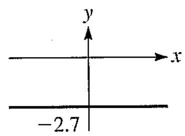
5. $4x - y + 20 = 0$ **7.** $7x - 2y - 24 = 0$



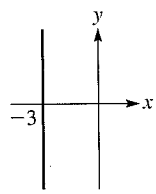


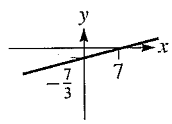
9. $x - y + 19 = 0$ **11.** $y = -2.7$



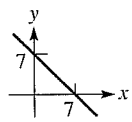


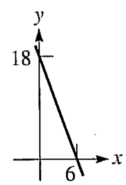
13. $x = -3$ **15.** $x - 3y - 7 = 0$



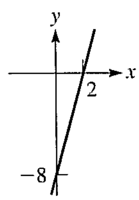


17. $x + y - 7 = 0$ **19.** $3x + y - 18 = 0$

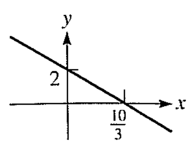


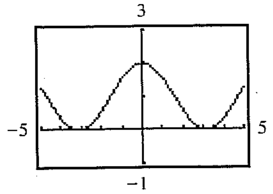


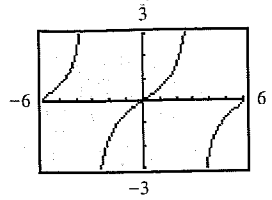
21. $y = 4x - 8; m = 4, (0, -8)$



23. $y = -\frac{3}{5}x + 2; m = -\frac{3}{5}, (0, 2)$



57. 

59. 

61. $x = \frac{1}{2}\cos^{-1}\frac{1}{2}y$ 63. $x = \frac{1}{5}\sin\frac{1}{3}\left(\frac{1}{4}\pi - y\right)$

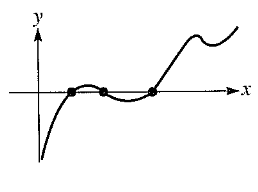
65. 1.2925, 4.4341 67. $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$ 69. $0, \frac{\pi}{3}, \frac{5\pi}{3}$

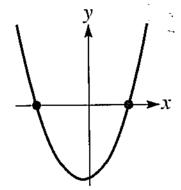
71. $0, \frac{2\pi}{3}$ 73. 0.3142, 1.571, 2.827, 4.084, 4.712, 5.341

75. 0

77. Identity:
$\tan x + \frac{1}{\tan x} = \frac{\tan^2 x + 1}{\tan x} = \sec^2 x(\cot x) = \frac{\sec^2 x \cos x}{\sin x}$

79. $\frac{\pi}{2}, \pi$ 81. 1.56, 2.16, 3.46 83. −2.31, 1.14





85. $\frac{1}{x}$ 87. $2x\sqrt{1 - x^2}$ 89. $\frac{\sqrt{1 - x^2} - xy}{\sqrt{1 + y^2}}$

91. $2\sqrt{1 - \cos^2\theta}$ 93. $\frac{\tan\theta}{\sqrt{1 + \tan^2\theta}} = \frac{\tan\theta}{\sec\theta}$

95. $(\cos\theta + j\sin\theta)^2 = (\cos^2\theta - \sin^2\theta) + j(2\sin\theta\cos\theta)$

97. $\frac{\pi}{2} < x < \frac{3\pi}{2}$

99. $C\left(\frac{A}{C}\sin 2t + \frac{B}{C}\cos 2t\right)$
$= C(\cos\alpha\sin 2t + \sin\alpha\cos 2t)$

101. $R = \sqrt{(A\cos\theta - B\sin\theta)^2 + (A\sin\theta + B\cos\theta)^2}$
$= \sqrt{A^2(\cos^2\theta + \sin^2\theta) + B^2(\sin^2\theta + \cos^2\theta)}$

103. $\frac{k}{2}\cdot\frac{1}{\sin^2\frac{\theta}{2}} = \frac{k}{2}\cdot\frac{1}{\frac{1 - \cos\theta}{2}}$ 105. $\theta = a + R\sin\omega t$

107. $\frac{\cos 2\alpha}{2\cos^2\alpha}$ 109. $p = VI\cos\omega t[\cos(\phi + \omega t)]$

111. 6.8 m 113. 54.7°

Exercises 21.1, page 562

1. $\sqrt{61}$ 3. 150° 5. $2\sqrt{29}$ 7. 3 9. 55

11. $2\sqrt{53}$ 13. 2.86 15. $\frac{5}{2}$ 17. Undefined 19. $-\frac{3}{4}$

21. $-\frac{5}{9}$ 23. 0.747 25. $\frac{1}{3}\sqrt{3}$ 27. −0.311 29. 20.0°

31. 98.50° 33. Parallel 35. Perpendicular 37. 8, −2

39. −3 41. Two sides equal $2\sqrt{10}$. 43. $m_1 = \frac{5}{12}, m_2 = \frac{4}{3}$

45. 10 47. $4\sqrt{10} + 4\sqrt{2} = 18.3$ 49. (1, 5)

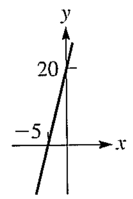
51. (−2.8, 4.2) 53. $x^2 + y^2 = 9$ 55. $m_1 = 1, m_2 = -1$

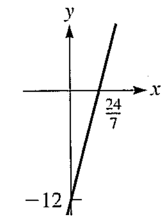
57. $\left(-\frac{11}{3}, 0\right)$ 59. $\left(0, -\frac{7}{9}\right)$ 61. $0, \sqrt{3}, -\sqrt{3}$

Exercises 21.2, page 567

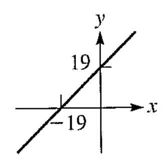
1. $y + 2x - 7 = 0$ 3. $2, \left(0, \frac{5}{2}\right)$

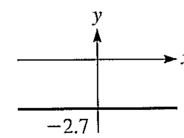
5. $4x - y + 20 = 0$ 7. $7x - 2y - 24 = 0$



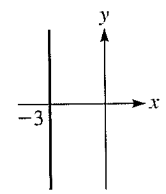


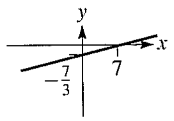
9. $x - y + 19 = 0$ 11. $y = -2.7$



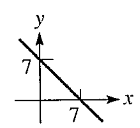


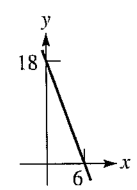
13. $x = -3$ 15. $x - 3y - 7 = 0$



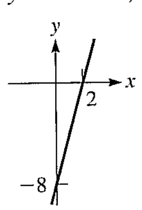


17. $x + y - 7 = 0$ 19. $3x + y - 18 = 0$

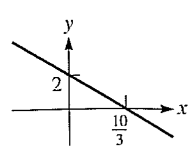




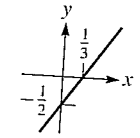
21. $y = 4x - 8$; $m = 4$, $(0, -8)$



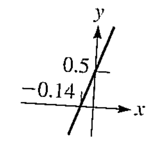
23. $y = -\frac{3}{5}x + 2$; $m = -\frac{3}{5}$, $(0, 2)$



25. $y = \frac{3}{2}x - \frac{1}{2}$; $m = \frac{3}{2}$, $\left(0, -\frac{1}{2}\right)$



27. $y = 3.5x + 0.5$; $m = 3.5$, $(0, 0.5)$ 29. Parallel



31. Perpendicular 33. Neither 35. Perpendicular

37. −2

39. The slope of the first line is 3. A line perpendicular to it has a slope of $-\frac{1}{3}$. The slope of the second line is $-\frac{k}{3}$, so $k = 1$.

41. $b - a$ 43. 5

45. $m_1 = -\frac{4}{5}, m_2 = \frac{2}{3}, m_3 = \frac{2}{3}, m_4 = -\frac{4}{5}$; $m_1 = m_4, m_2 = m_3$

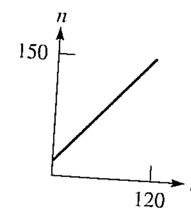
47. $m_1 = -\frac{a}{b}, m_2 = -\frac{a}{b}, m_1 = m_2$; $m_3 = -\frac{a}{b}, m_4 = \frac{b}{a}, m_3 = 1/m_4$

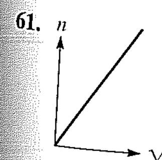
49. $C = \frac{5}{4}R$ 51. $v = 0.607T + 331$

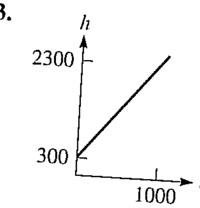
53. $T = \frac{4}{3}x + 3$ 55. $P = 3.0 - 0.025T_S$

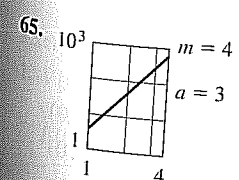
57. $y = 10^{-5}(2.4 - 5.6x)$

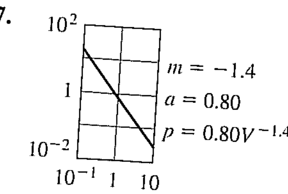
59. $n = \frac{7}{6}t + 10$; at 6:30, $n = 10$; at 8:30, $n = 150$



61. 

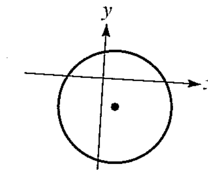
63. 

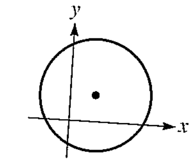
65. 

67. 

Exercises 21.3, page 572

1. $C(1, -1), r = 4$ 3. $C(3, 4), r = 7$





5. $(2, 1), r = 5$ 7. $C(-1, 0), r = \frac{11}{2}$ 9. $x^2 + y^2 = 9$

11. $(x - 2)^2 + (y - 2)^2 = 16$, or $x^2 + y^2 - 4x - 4y - 8 = 0$

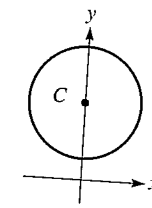
13. $(x - 12)^2 + (y + 15)^2 = 324$, or $x^2 + y^2 - 24x + 30y + 45 = 0$

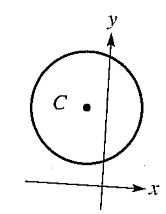
15. $(x + 3)^2 + (y - 4)^2 = 25$ 17. $(x - 2)^2 + (y - 1)^2 = 8$

19. $(x + 3)^2 + (y - 5)^2 = 25$, or $x^2 + y^2 + 6x - 10y + 9 = 0$

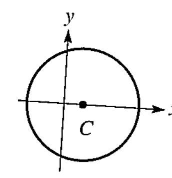
21. $(x + 2)^2 + (y - 2)^2 = 4$ or $x^2 + y^2 + 4x - 4y + 4 = 0$ 23. $x^2 + y^2 = 2$

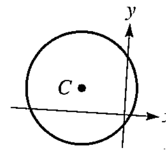
25. $(0, 3), r = 2$ 27. $(-1, 5), r = \frac{9}{2}$



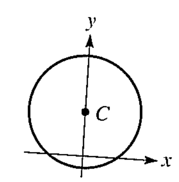


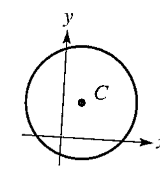
29. $(1, 0), r = 3$ 31. $(-2.1, 1.3), r = 3.1$





33. $(0, 2), r = \frac{5}{2}$ 35. $(1, 2), r = \frac{1}{2}\sqrt{22}$

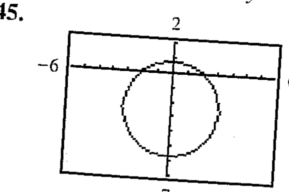




37. Symmetric to both axes and origin

39. Symmetric to y-axis 41. (7, 0), (−1, 0)

43. $3x^2 + 3y^2 + 4x + 8y - 20 = 0$, circle

45. 

47. (a) Semicircle
(b) Semicircle
(c) Yes, there is only one value of y for each x in the domain.

49. Outside