77. (a)

x	10	20	30	40	50	60	70	80	90	100
y	107.3	26.6	11.6	6.4	3.9	2.6	1.8	1.3	0.96	0.71

(b) From the table, $x \approx 45$ when $y = 4.8$.
Algebraically,

$$\frac{10{,}770}{x^2} - 0.37 = 4.8$$

$$\frac{10{,}770}{x^2} = 5.17$$

$$10{,}770 = 5.17x^2$$

$$2083.17 = x^2$$

$$x = 45.6 \text{ mils}$$

(c) When $x = 85.5$, $y = 1.10$ ohms.

(d) As the diameter increases, the resistance decreases.

79. False. The line $x = 0$ has an infinite number of x-intercepts.

81. Answers will vary.

Section P.3 Lines in the Plane

You should know the following important facts about lines.

- The graph of $y = mx + b$ is a straight line. It is called a linear equation.
- The slope of the line through (x_1, y_1) and (x_2, y_2) is

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

- (a) If $m > 0$, the line rises from left to right.
  (b) If $m = 0$, the line is horizontal.
  (c) If $m < 0$, the line falls from left to right.
  (d) If m is undefined, the line is vertical.
- Equations of Lines
  (a) Slope-Intercept: $y = mx + b$
  (b) Point-Slope: $y - y_1 = m(x - x_1)$
  (c) Two-Point: $y - y_1 = \dfrac{y_2 - y_1}{x_2 - x_1}(x - x_1)$
  (d) General: $Ax + By + C = 0$
  (e) Vertical: $x = a$
  (f) Horizontal: $y = b$
- Given two distinct nonvertical lines

  $$L_1: y = m_1x + b_1 \quad \text{and} \quad L_2: y = m_2x + b_2$$

  (a) L_1 is parallel to L_2 if and only if $m_1 = m_2$ and $b_1 \neq b_2$.
  (b) L_1 is perpendicular to L_2 if and only if $m_1 = -1/m_2$.

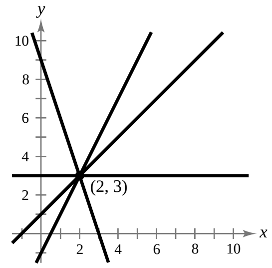
Solutions to Odd-Numbered Exercises

1. (a) $m = \frac{2}{3}$. Since the slope is positive, the line rises. Matches L_2.

(b) m is undefined. The line is vertical. Matches L_3.

(c) $m = -2$. The line falls. Matches L_1.

3.

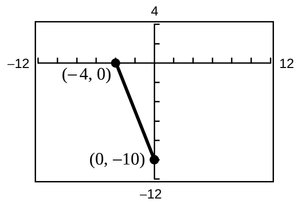


5. Slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{3}{2}$

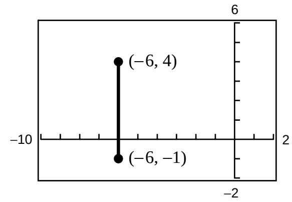
7. Slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{0}{1} = 0$

9. Slope $= \dfrac{\text{rise}}{\text{run}} = \dfrac{-8}{2} = -4$

11. slope $= \dfrac{0-(-10)}{-4-0} = \dfrac{10}{-4} = -\dfrac{5}{2}$



13.



Slope is undefined.

15. Since $m = 0$, y does not change. Three points are $(0, 1)$, $(3, 1)$, and $(-1, 1)$.

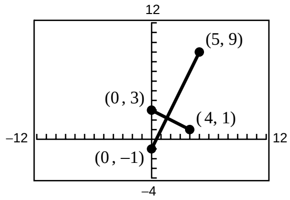
17. Since $m = 2$, y increases 2 for every unit increase in x. Three points are $(-4, 6)$, $(-3, 8)$, $(-2, 10)$.

19. Since $m = \frac{1}{2}$, y increases 1 for every increase of 2 in x. Three points are $(9, -1)$, $(11, 0)$, $(13, 1)$.

21. $m_{L_1} = \dfrac{9+1}{5-0} = 2$

$m_{L_2} = \dfrac{1-3}{4-0} = -\dfrac{1}{2} = -\dfrac{1}{m_{L_1}}$

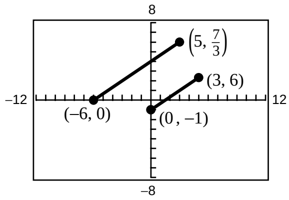
L_1 and L_2 are perpendicular.



23. $m_{L_1} = \dfrac{0-6}{-6-3} = \dfrac{2}{3}$

$m_{L_2} = \dfrac{\frac{7}{3}+1}{5-0} = \dfrac{2}{3} = m_{L_1}$

L_1 and L_2 are parallel.



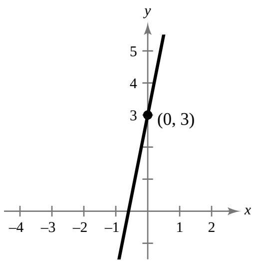
25. $5x - y + 3 = 0$

$y = 5x + 3$

(a) Slope: $m = 5$

y-intercept: $(0, 3)$

(b)



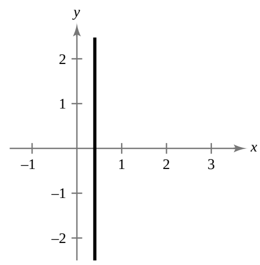
27. $5x - 2 = 0$

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

(a) Slope: undefined

No y-intercept

(b)



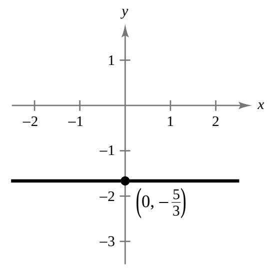
29. $3y + 5 = 0$

(a) $y = -\frac{5}{3}$

Slope: $m = 0$

y-intercept: $\left(0, -\frac{5}{3}\right)$

(b)



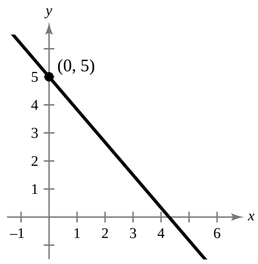
31. $7x + 6y - 30 = 0$

$y = -\frac{7}{6}x + 5$

(a) Slope: $m = -\frac{7}{6}$

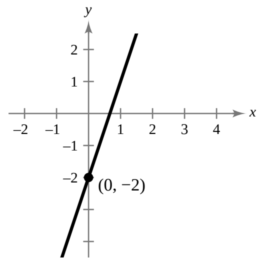
y-intercept: $(0, 5)$

(b)



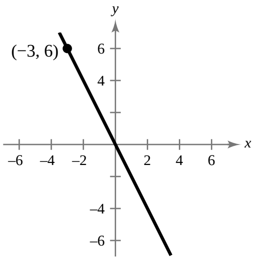
33. $y + 2 = 3(x - 0)$

$y = 3x - 2 \implies 3x - y - 2 = 0$



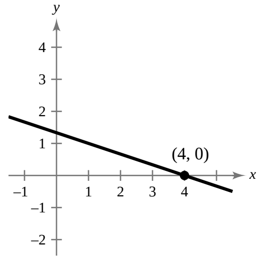
35. $y - 6 = -2(x + 3)$

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



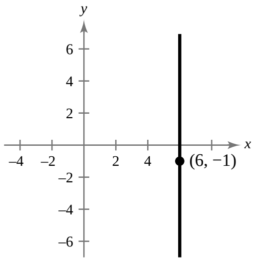
37. $y - 0 = -\frac{1}{3}(x - 4)$

$y = -\frac{1}{3}x + \frac{4}{3} \implies x + 3y - 4 = 0$



39. $x = 6$

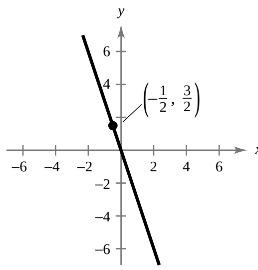
$x - 6 = 0$



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

$y = -3x$

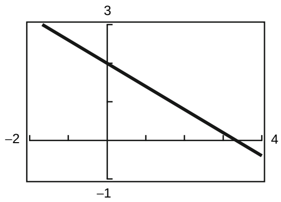
$3x + y = 0$



43. $y + 1 = \dfrac{5 + 1}{-5 - 5}(x - 5)$

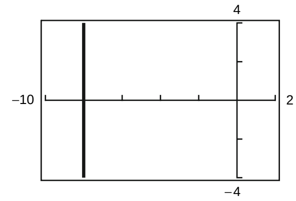
$$y = -\frac{3}{5}(x - 5) - 1$$

$$y = -\frac{3}{5}x + 2 \implies 3x + 5y - 10 = 0$$



45. Since both points have $x = -8$, the slope is undefined.

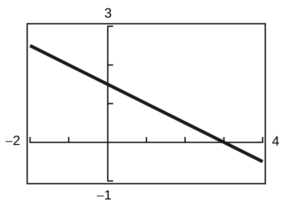
$$x = -8 \implies x + 8 = 0$$



47. $y - \dfrac{1}{2} = \dfrac{\frac{5}{4} - \frac{1}{2}}{\frac{1}{2} - 2}(x - 2)$

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

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

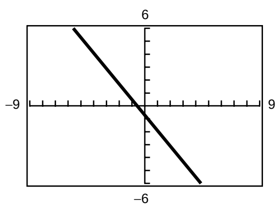


49. $y + \frac{3}{5} = \dfrac{-\frac{9}{5} + \frac{3}{5}}{\frac{9}{10} + \frac{1}{10}}\left(x + \frac{1}{10}\right)$

$$y + \tfrac{3}{5} = -\tfrac{6}{5}\left(x + \tfrac{1}{10}\right)$$

$$y = -\tfrac{6}{5}x - \tfrac{18}{25}$$

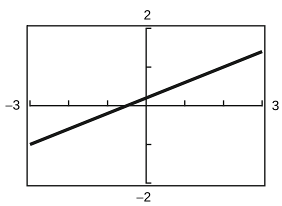
$$30x + 25y + 18 = 0$$



51. $y - 0.6 = \dfrac{-0.6 - 0.6}{-2 - 1}(x - 1)$

$$y = 0.4(x - 1) + 0.6$$

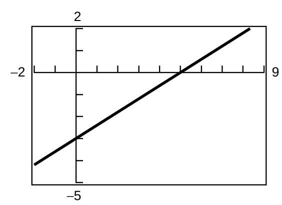
$$y = 0.4x + 0.2 \implies 2x - 5y + 1 = 0$$



53. $\dfrac{x}{5} + \dfrac{y}{-3} = 1$

$$-3x + 5y + 15 = 0$$

$a = 5$ and $b = -3$ are the x- and y-intercepts.



55. $\dfrac{x}{2} + \dfrac{y}{3} = 1$

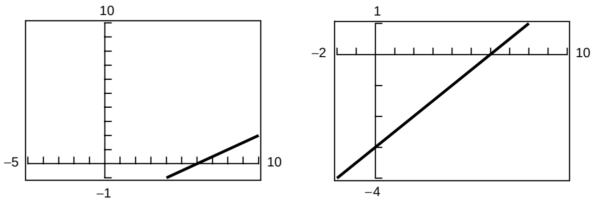
$$3x + 2y - 6 = 0$$

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

$$-6x - \tfrac{3}{2}y = 1$$

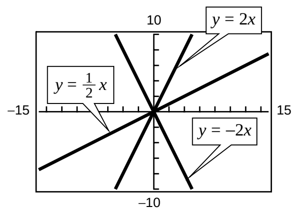
$$12x + 3y + 2 = 0$$

59. $y = 0.5x - 3$



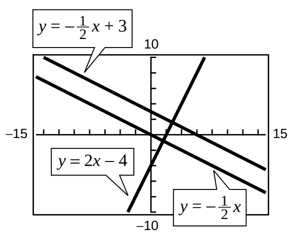
The second setting shows the x and y intercepts more clearly.

61. (a) $y = 2x$ (b) $y = -2x$ (c) $y = \frac{1}{2}x$



(b) and (c) are perpendicular.

63. (a) $y = -\frac{1}{2}x$ (b) $y = -\frac{1}{2}x + 3$ (c) $y = 2x - 4$



(a) and (b) are parallel.

(c) is perpendicular to (a) and (b).

65. $4x - 2y = 3$

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

Slope: $m = 2$

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

$$y = 2x - 3 \quad \Longrightarrow \quad 2x - y - 3 = 0$$

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

$$y = -\frac{1}{2}x + 2 \quad \Longrightarrow \quad x + 2y - 4 = 0$$

67. $3x + 4y = 7$

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

slope: $m = -\frac{3}{4}$

(a) $y - \frac{7}{8} = -\frac{3}{4}\left(x + \frac{2}{3}\right)$

$y = -\frac{3}{4}x + \frac{3}{8}$

$6x + 8y - 3 = 0$

(b) $y - \frac{7}{8} = \frac{4}{3}\left(x + \frac{2}{3}\right)$

$y = \frac{4}{3}x + \frac{127}{72}$

$96x - 72y + 127 = 0$

69. $x - y = 4$

$y = x - 4$

slope: $m = 1$

(a) $y - 6.8 = 1(x - 2.5)$

$y = x + 4.3$

$10x - 10y + 43 = 0$

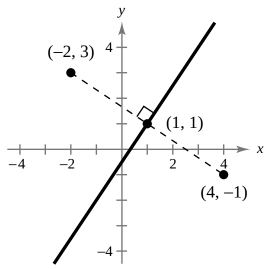
(b) $y - 6.8 = -1(x - 2.5)$

$y = -x + 9.3$

$10x + 10y - 93 = 0$

71. Set the distance between $(4, -1)$ and (x, y) equal to the distance between $(-2, 3)$ and (x, y).

$$\sqrt{(x-4)^2 + [y-(-1)]^2} = \sqrt{[x-(-2)]^2 + (y-3)^2}$$
$$(x-4)^2 + (y+1)^2 = (x+2)^2 + (y-3)^2$$
$$x^2 - 8x + 16 + y^2 + 2y + 1 = x^2 + 4x + 4 + y^2 - 6y + 9$$
$$-8x + 2y + 17 = 4x - 6y + 13$$
$$0 = 12x - 8y - 4$$
$$0 = 4(3x - 2y - 1)$$
$$0 = 3x - 2y - 1$$



This line is the perpendicular bisector of the line segment connecting $(4, -1)$ and $(-2, 3)$.

73. (a) $m = 135$. The sales are increasing 135 units per year.

(b) $m = 0$. There is no change in sales.

(c) $m = -40$. The sales are decreasing 40 units per year.

75. (a)

Years	Slope
1988–1989	$0.87 - 0.98 = -0.11$
1989–1990	$1.04 - 0.87 = 0.17$
1990–1991	$1.26 - 1.04 = 0.22$
1991–1992	$1.38 - 1.26 = 0.12$
1992–1993	$1.47 - 1.38 = 0.09$
1993–1994	$1.58 - 1.47 = 0.11$
1994–1995	$1.74 - 1.58 = 0.16$
1995–1996	$1.48 - 1.74 = -0.26$
1996–1997	$1.70 - 1.48 = 0.22$
1997–1998	$1.35 - 1.70 = -0.35$

Greatest increase: 1990–1991 and 1996–1997

Greatest decrease: 1997–1998

(b) $(1, 0.98), (11, 1.35)$: $y - 0.98 = \dfrac{1.35 - 0.98}{11 - 1}(x -$

$$y = 0.037(x - 1) + 0.98$$
$$y = 0.037x + 0.943$$

(c) Between 1988 and 1998, the earnings per share increased at a rate of \$0.037 per year.

(d) For 2001, $y = 0.037(2001) - 72.576 = 1.461$, wh is a reasonable prediction.

77. $\text{Slope} = \dfrac{\text{Rise}}{\text{Run}}$

$$-\frac{12}{100} = -\frac{2000}{y}$$
$$-12y = -200{,}000$$
$$y = 16{,}666\tfrac{2}{3} \text{ feet} \approx 3.16 \text{ miles}$$

79. $(1, 2540)$ $\quad m = 125$

$$V - 2540 = 125(t - 1)$$
$$V - 2540 = 125t - 125$$
$$V = 125t + 2415$$

81. $(1, 20400)$ $\quad m = -2000$

$$V - 20400 = -2000(t - 1)$$
$$V - 20400 = -2000t + 2000$$
$$V = -2000t + 22400$$

83. The slope is $m = -10$. This represents the decrease in the amount of the loan each week. Matches graph (b).

85. The slope is $m = 0.25$. This represents the increase in travel cost for each mile driven. Matches graph (a).

87. Using the points (0, 32) and (100, 212), we have

$$m = \frac{212 - 32}{100 - 0} = \frac{180}{100} = \frac{9}{5}$$
$$F - 32 = \frac{9}{5}(C - 0)$$
$$F = \frac{9}{5}C + 32.$$

89. Using the points (1998, 28500) and (2000, 32900) we have

$$m = \frac{32900 - 28500}{2000 - 1998} = \frac{4400}{2} = 2200$$
$$S - 28500 = 2200(t - 1998)$$
$$S = 2200t - 4{,}367{,}100$$

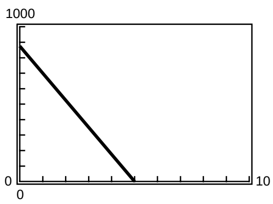
When $t = 2003$, $S = 2200(2003) - 4{,}367{,}100 = 39{,}500$

91. (a) Using the points (0, 875) and (5, 0), where the first coordinate represents the year t and the second coordinate represents the value V, we have

$$m = \frac{0 - 875}{5 - 0} = -175$$
$$V = -175t + 875, \quad 0 \le t \le 5.$$

t	0	1	2	3	4	5
V	875	700	525	350	175	0

(b)



(c) $t = 0$: $V = -175(0) + 875 = 875$

$t = 1$: $V = -175(1) + 875 = 700$

$t = 2$: $V = -175(2) + 875 = 525$

$t = 3$: $V = -175(3) + 875 = 350$

$t = 4$: $V = -175(4) + 875 = 175$

$t = 5$: $V = -175(5) + 875 = 0$

93. (a) $C = 36{,}500 + 5.25t + 11.50t$
$= 16.75t + 36{,}500$

(b) $R = 27t$

(c) $P = R - C$
$= 27t - (16.75t + 36{,}500)$
$= 10.25t - 36{,}500$

(d) $0 = 10.25t - 36{,}500$
$36{,}500 = 10.25t$
$t \approx 3561$ hours