Solutions for Mathematics with Applications 12th Edition by Lial

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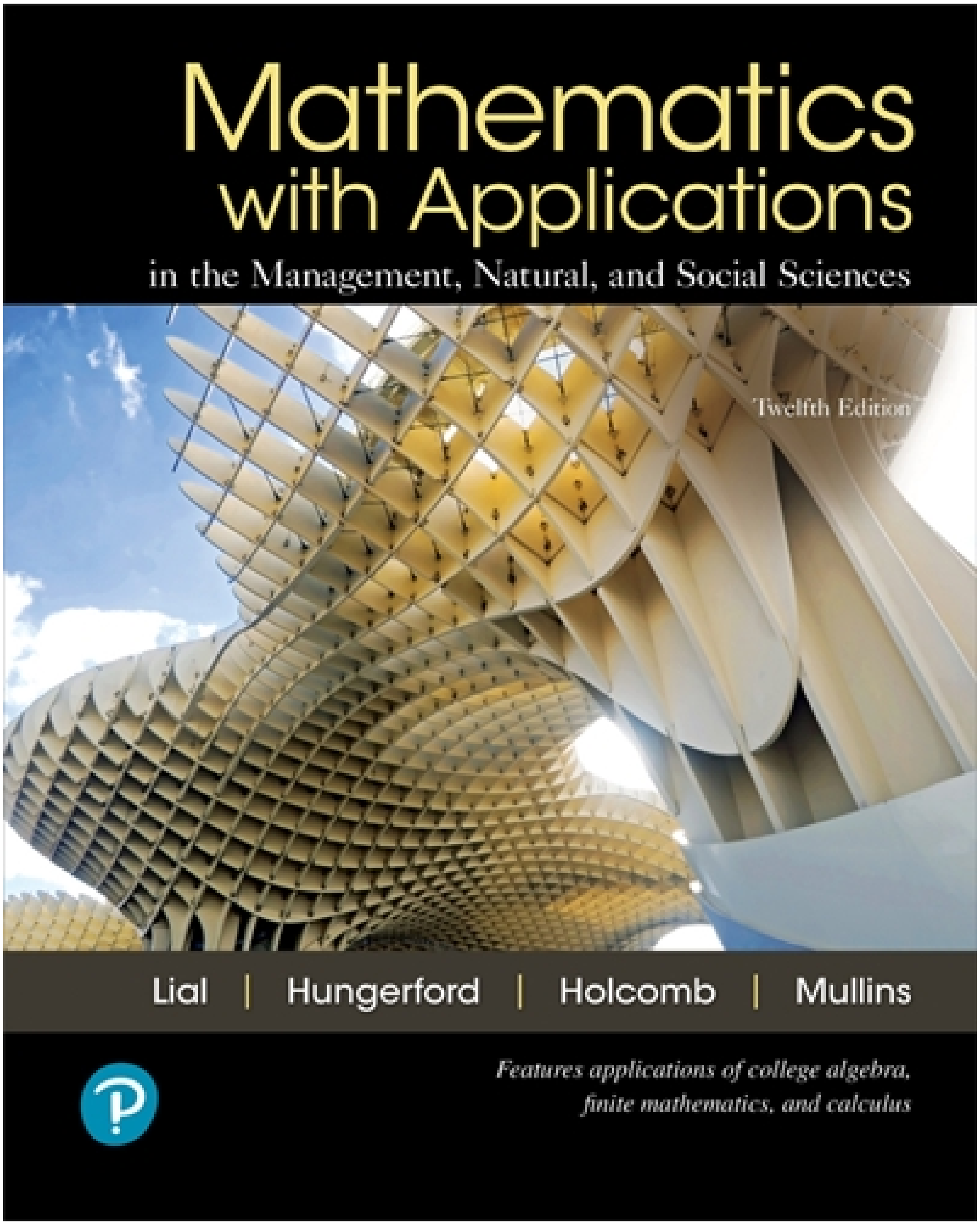


Solutions

Chapter 2 Graphs, Lines, and Inequalities

Section 2.1 Graphs, Lines, and Inequalities

1. $(1, -2)$ lies in quadrant IV
$(-2, 1)$ lies in quadrant II
$(3, 4)$ lies in quadrant I
$(-5, -6)$ lies in quadrant III

2. $(\pi, 2)$ lies in quadrant I
$\left(3, -\sqrt{2}\right)$ lies in quadrant IV
$(4, 0)$ lies in no quadrant
$(-\sqrt{3}, \sqrt{3})$ lies in quadrant II

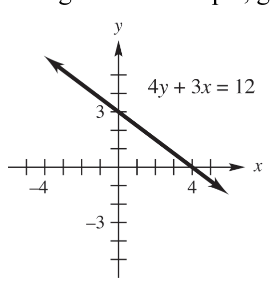
3. $(1, -3)$ is a solution to $3x - y - 6 = 0$ because $3(1) - (-3) - 6 = 0$ is a true statement.

4. $(2, -1)$ is a solution to $x^2 + y^2 - 6x + 8y = -15$ because $(2)^2 + (-1)^2 - 6(2) + 8(-1) = -15$ is a true statement.

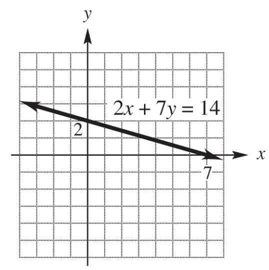
5. $(3, 4)$ is not a solution to $(x-2)^2 + (y+2)^2 = 6$ because $(3-2)^2 + (4+2)^2 = 37$, not 6.

6. $(1, -1)$ is not a solution to $\dfrac{x^2}{2} + \dfrac{y^2}{3} = -4$ because $\dfrac{1^2}{2} + \dfrac{(-1)^2}{3} = \dfrac{5}{6}$, not -4.

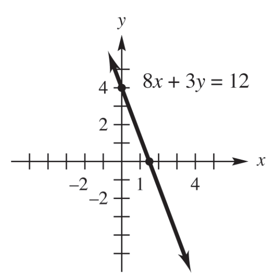
7. $4y + 3x = 12$
Find the y-intercept. If $x = 0$,
$4y = -3(0) + 12 \Rightarrow 4y = 12 \Rightarrow y = 3$
The y-intercept is 3.
Next find the x-intercept. If $y = 0$,
$4(0) + 3x = 12 \Rightarrow 3x = 12 \Rightarrow x = 4$
The x-intercept is 4.
Using these intercepts, graph the line.



8. $2x + 7y = 14$
Find the y-intercept. If $x = 0$,
$2(0) + 7y = 14 \Rightarrow 7y = 14 \Rightarrow y = 2$
The y-intercept is 2.
Next find the x-intercept. If $y = 0$,
$2x + 7(0) = 14 \Rightarrow 2x = 14 \Rightarrow x = 7$
The x-intercept is 7.
Using these intercepts, graph the line.

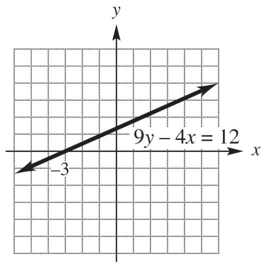


9. $8x + 3y = 12$
Find the y-intercept. If $x = 0$,
$3y = 12 \Rightarrow y = 4$
The y-intercept is 4.
Next, find the x-intercept. If $y = 0$,
$8x = 12 \Rightarrow x = \dfrac{12}{8} = \dfrac{3}{2}$
The x-intercept is $\dfrac{3}{2}$.
Using these intercepts, graph the line.

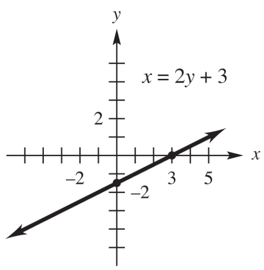


10. $9y - 4x = 12$
Find the y-intercept. If $x = 0$,
$9y - 4(0) = 12 \Rightarrow 9y = 12 \Rightarrow y = \dfrac{12}{9} = \dfrac{4}{3}$
The y-intercept is $\dfrac{4}{3}$.
Next find the x-intercept. If $y = 0$,
$9(0) - 4x = 12 \Rightarrow -4x = 12 \Rightarrow x = -3$
The x-intercept is -3.

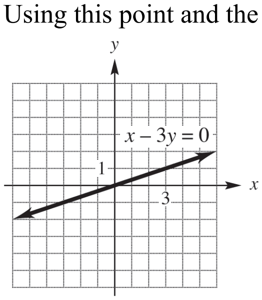
Using these intercepts, graph the line.



11. $x = 2y + 3$
Find the y-intercept. If $x = 0$,
$0 = 2y + 3 \Rightarrow 2y = -3 \Rightarrow y = -\frac{3}{2}$
The y-intercept is $-\frac{3}{2}$.
Next, find the x-intercept. If $y = 0$,
$x = 2(0) + 3 \Rightarrow x = 3$
The x-intercept is 3.
Using these intercepts, graph the line.



12. $x - 3y = 0$
Find the y-intercept. If $x = 0$,
$-3y = 0 \Rightarrow 0$
The y-intercept is 0. Since the line passes through the origin, the x-intercept is also 0. Find another point on the line by arbitrarily choosing a value for x. Let $x = 3$. Then,
$-3y = -3 \Rightarrow y = 1$
The point with coordinates (3, 1) is on the line. Using this point and the origin, graph the line.



13. The x-intercepts are where the rays cross the x-axis, –2.5 and 3. The y-intercept is where the ray crosses the y-axis, 3.

14. The x-intercept is 3; the y-intercept is 1.

15. The x-intercepts are –1 and 2. The y-intercept is –2.

16. The x-intercept is 1. There is no y-intercept.

17. $3x + 4y = 12$
To find the x-intercept, let $y = 0$:
$3x + 4(0) = 12 \Rightarrow 3x = 12 \Rightarrow x = 4$
The x-intercept is 4.
To find the y-intercept, let $x = 0$:
$3(0) + 4y = 12 \Rightarrow 4y = 12 \Rightarrow y = 3$
The y-intercept is 3.

18. $x - 2y = 5$
To find the x-intercept, let $y = 0$:
$x - 2(0) = 5 \Rightarrow x = 5$
The x-intercept is 5.
To find the y-intercept, let $x = 0$.
$0 - 2y = 5 \Rightarrow -2y = 5 \Rightarrow y = -\frac{5}{2}$
The y-intercept is $-\frac{5}{2}$.

19. $2x - 3y = 24$
To find the x-intercept, let $y = 0$:
$2x - 3(0) = 24 \Rightarrow 2x = 24 \Rightarrow x = 12$
The x-intercept is 12.
To find the y-intercept, let $x = 0$:
$2(0) - 3y = 24 \Rightarrow -3y = 24 \Rightarrow y = -8$
The y-intercept is –8.

20. $3x + y = 4$
To find the x-intercept, let $y = 0$:
$3x + 0 = 4 \Rightarrow 3x = 4 \Rightarrow x = \frac{4}{3}$
The x-intercept is $\frac{4}{3}$.
To find the y-intercept, let $x = 0$:
$3(0) + y = 4 \Rightarrow y = 4$
The y-intercept is 4.

21. $y = x^2 - 9$
To find the x-intercepts, let $y = 0$:
$0 = x^2 - 9 \Rightarrow x^2 = 9 \Rightarrow x = \pm\sqrt{9} = \pm 3$
The x-intercepts are 3 and –3.
To find the y-intercept, let $x = 0$:
$y = 0 - 9 = -9$
The y-intercept is –9.

22. $y = x^2 + 4$

To find the x-intercepts, let $y = 0$:

$0 = x^2 + 4 \Rightarrow x^2 = -4 \Rightarrow$

$x = \pm\sqrt{-4}$ not a real number

There is no x-intercept.

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

$y = 0^2 + 4 = 4$

The y-intercept is 4.

23. $y = x^2 + x - 20$

To find the x-intercepts, let $y = 0$:

$0 = x^2 + x - 20 \Rightarrow 0 = (x+5)(x-4) \Rightarrow$

$x + 5 = 0 \Rightarrow x = -5$ or $x - 4 = 0 \Rightarrow x = 4$

The x-intercepts are –5 and 4.

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

$y = 0^2 + 0 - 20 = -20$

The y-intercept is –20.

24. $y = 5x^2 + 6x + 1$

To find the x-intercepts, let $y = 0$:

$0 = 5x^2 + 6x + 1 \Rightarrow 0 = (5x+1)(x+1) \Rightarrow$

$5x + 1 = 0 \Rightarrow x = -\frac{1}{5}$ or $x + 1 = 0 \Rightarrow x = -1$

The x-intercepts are $-\frac{1}{5}$ and –1.

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

$y = 5(0)^2 + 6(0) + 1 = 1$

The y-intercept is 1.

25. $y = 2x^2 - 5x + 7$

To find the x-intercepts, let $y = 0$:

$0 = 2x^2 - 5x + 7$

This equation does not have real solutions, so there are no x-intercepts.

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

$y = 2(0)^2 - 5(0) + 7 = 7$

The y-intercept is 7.

26. $y = 3x^2 + 4x - 4$

To find the x-intercepts, let $y = 0$:

$0 = 3x^2 + 4x - 4 \Rightarrow 0 = (3x-2)(x+2) \Rightarrow$

$3x - 2 = 0 \Rightarrow x = \frac{2}{3}$ or $x + 2 = 0 \Rightarrow x = -2$

The x-intercepts are -2 and $\frac{2}{3}$.

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

$y = 3(0)^2 + 4(0) - 4 = -4$

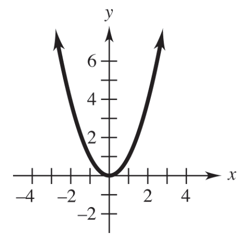
The y-intercept is –4.

27. $y = x^2$

x-intercept: $0 = x^2 \Rightarrow x = 0$

y-intercept: $y = 0$

x	y
–2	4
–1	1
0	0
1	1
2	4



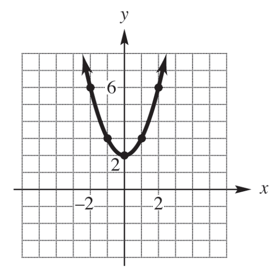
28. $y = x^2 + 2$

x-intercept: $0 = x^2 + 2 \Rightarrow x^2 = -2 \Rightarrow$

$x = \pm\sqrt{-2}$ not a real number

y-intercept: $y = 0^2 + 2 \Rightarrow y = 2$

x	y
–2	6
–1	3
0	2
1	3
2	6

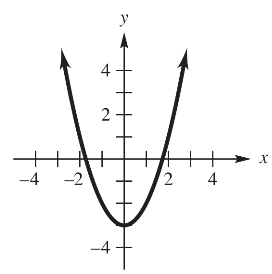


29. $y = x^2 - 3$

x-intercepts: $0 = x^2 - 3 \Rightarrow x^2 = 3 \Rightarrow x = \pm\sqrt{3}$

y-intercepts: $y = 0^2 - 3 = -3$

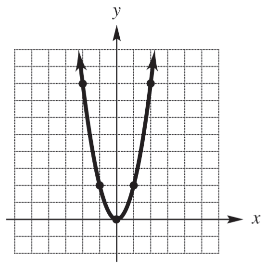
x	y
–3	6
–1	–2
0	–3
1	–2
3	6



30. $y = 2x^2$

x-intercept: $0 = 2x^2 \Rightarrow x = 0$
y-intercept: $y = 2(0) = 0$

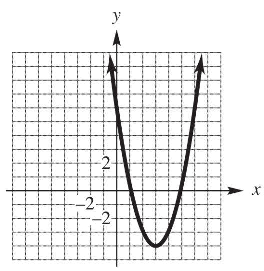
x	y
–2	8
–1	2
0	0
1	2
–2	8



31. $y = x^2 - 6x + 5$

x-intercept:
$0 = x^2 - 6x + 5 \Rightarrow 0 = (x-1)(x-5) \Rightarrow$
$x - 1 = 0 \Rightarrow x = 1$ or $x - 5 = 0 \Rightarrow x = 5$
y-intercept: $y = (0)^2 - 6(0) + 5 = 5$

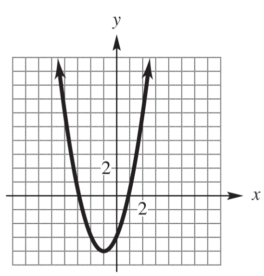
x	y
–2	21
–1	12
0	5
1	0
2	–3



32. $y = x^2 + 2x - 3$

x-intercept:
$0 = x^2 + 2x - 3 \Rightarrow 0 = (x+3)(x-1) \Rightarrow$
$x + 3 = 0 \Rightarrow x = -3$ or $x - 1 = 0 \Rightarrow x = 1$
y-intercept: $y = (0)^2 + 2(0) - 3 = -3$

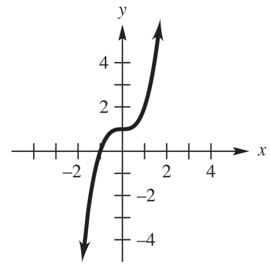
x	y
–3	0
–2	–3
–1	–4
0	–3
1	0



33. $y = x^3 + 1$

x-intercept:
$0 = x^3 + 1 \Rightarrow x^3 = -1 \Rightarrow x = \sqrt[3]{-1} = -1$
y-intercept: $y = 0^3 + 1 = 1$

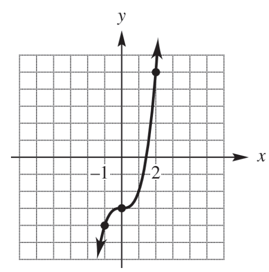
x	y
–2	–7
–1	0
0	1
1	2
2	9



34. $y = x^3 - 3$

x-intercept: $0 = x^3 - 3 \Rightarrow x^3 = 3 \Rightarrow x = \sqrt[3]{3}$
y-intercept: $y = 0^3 - 3 \Rightarrow y = -3$

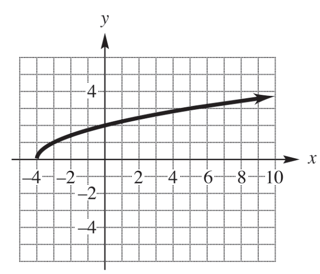
x	y
–2	–11
–1	–4
0	–3
1	–2
2	5



35. $y = \sqrt{x+4}$

x-intercept: $0 = \sqrt{x+4} \Rightarrow 0 = x + 4 \Rightarrow x = -4$
y-intercept: $y = \sqrt{0+4} = \sqrt{4} = 2$

x	y
–2	$\sqrt{2} \approx 1.4$
–1	$\sqrt{3} \approx 1.7$
0	2
2	$\sqrt{6} \approx 2.4$
5	3

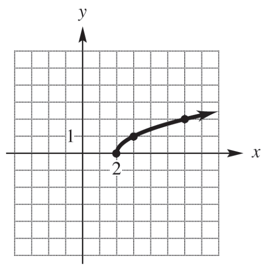


36. $y = \sqrt{x-2}$

x-intercept: $0 = \sqrt{x-2} \Rightarrow 0 = x - 2 \Rightarrow x = 2$

y-intercept: $y = \sqrt{0-2} = \sqrt{-2}$, not a real number

x	y
2	0
3	1
6	2
11	3



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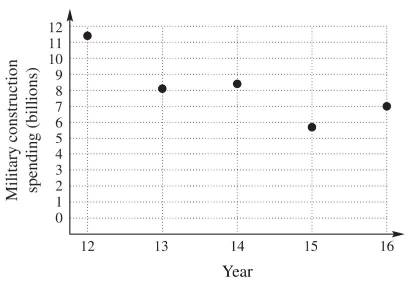

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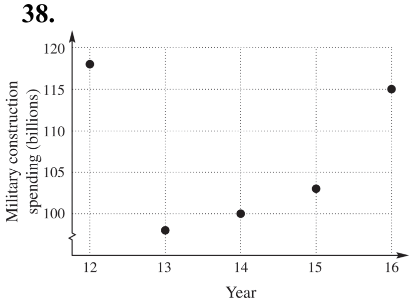

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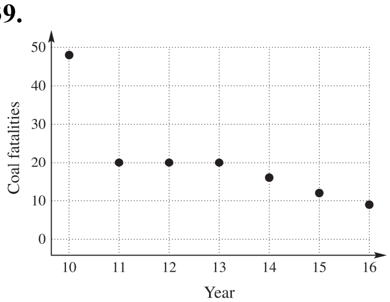
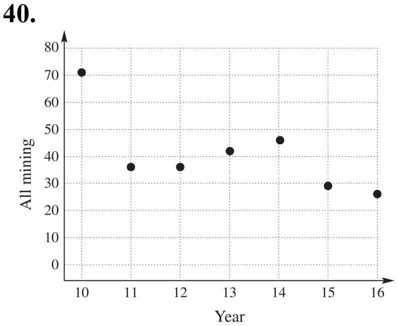


40.



41. 1999

42. 2012

43. 2011

44. 2007

45. **(a)** about $1,250,000

(b) about $1,750,000

(c) about $4,250,000

46. **(a)** about $1,000,000

(b) about $2,250,000.

(c) about $3,250,000.

47. **(a)** about $500,000

(b) about $1,000,000.

(c) about $1,500,000.

48. **(a)** about $250,000

(b) about $1,250,000

(c) about $1,500,000.

49. beef, about 57 pounds; chicken, about 81 pounds; pork, about 45 pounds

50. 2007

51. 2009

52. In 2007, annual per person beef consumption was about 75 pounds, while in 2014, annual per person beef consumption was about 64 pounds, so beef consumption decreased about 11 pounds between 2007 and 2014.

53. about $115

54. about $123

55. days 6, 12, and 14 – 21

56. days 1 – 9

57. Day 19; about \$117.50

58. Day 19; about \$129.00

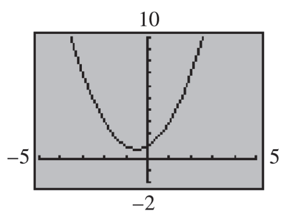
59. Day 2; about \$117.00

60. Day 2; about \$109.00

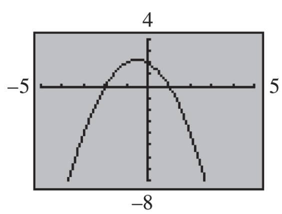
61. about \$8.50

62. about \$6.00

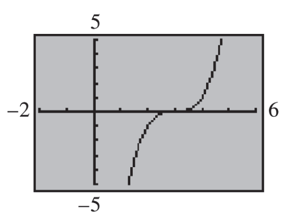
63. $y = x^2 + x + 1$



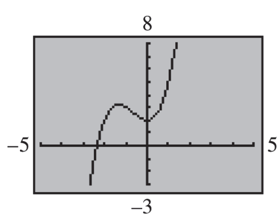
64. $y = 2 - x - x^2$



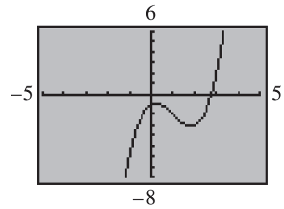
65. $y = (x-3)^3$



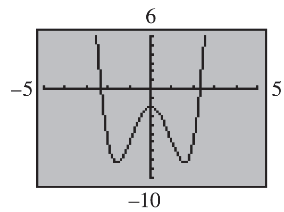
66. $y = x^3 + 2x^2 + 2$



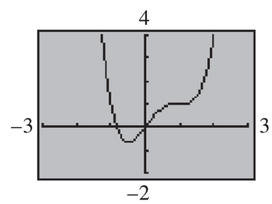
67. $y = x^3 - 3x^2 + x - 1$



68. $y = x^4 - 5x^2 - 2$

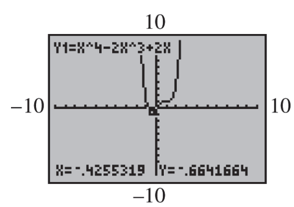


69. $y = x^4 - 2x^3 + 2x$



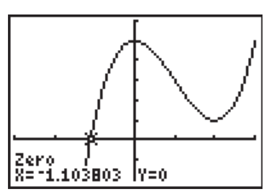
The "flat" part of the graph near $x = 1$ looks like a horizontal line segment, but it is not. The y values increase slightly as you trace along the segment from left to right.

70. **(a)** $y = x^4 - 2x^3 + 2x$



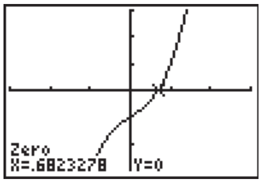
(b) The lowest point on the graph is approximately at (–.5, –.6875). Answers vary.

71. $x \approx -1.1038$



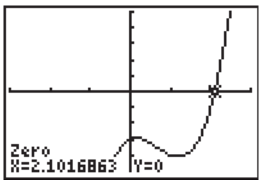
[–3, 3] by [–2, 6]

72. $x \approx .6823$



[–3, 3] by [–3, 3]

73. $x \approx 2.1017$

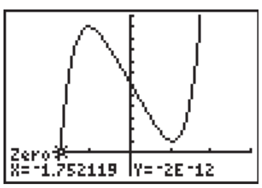


[–3, 3] by [–5, 5]

74. $x \approx .7555$

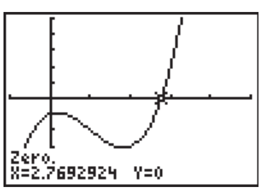
[–3, 3] by [–5, 5]

75. $x \approx -1.7521$



[–3, 3] by [–2, 12]

76. $x \approx 2.7693$



[–1, 53] by [–5, 5]

Section 2.2 Equations of Lines

1. Through (2, 5) and (0, 8)

$$\text{slope } = \frac{\Delta y}{\Delta x} = \frac{8-5}{0-2} = \frac{3}{-2} = -\frac{3}{2}$$

2. Through (9, 0) and (12, 12)

$$\text{slope } = \frac{12-0}{12-9} = \frac{12}{3} = 4$$

3. Through (–4, 14) and (3, 0)

$$\text{slope } = \frac{14-0}{-4-3} = \frac{14}{-7} = -2$$

4. Through (–5, –2) and (–4, 11)

$$\text{slope } = \frac{-2-11}{-5-(-4)} = \frac{-13}{-1} = 13$$

5. Through the origin and (–4, 10); the origin has coordinate (0, 0).

$$\text{slope } = \frac{10-0}{-4-0} = \frac{10}{-4} = -\frac{5}{2}$$

6. Through the origin, (0, 0), and (8, –2)

$$\text{slope } = \frac{-2-0}{8-0} = \frac{-2}{8} = -\frac{1}{4}$$

7. Through (–1, 4) and (–1, 6)

$$\text{slope } = \frac{6-4}{-1-(-1)} = \frac{2}{0}, \text{ not defined}$$

The slope is undefined.

8. Through (–3, 5) and (2, 5)

$$\text{slope } = \frac{5-5}{2-(-3)} = \frac{0}{5} = 0$$

9. $b = 5, m = 4$
$y = mx + b$
$y = 4x + 5$

10. $b = -3, m = -7$
$y = mx + b$
$y = -7x - 3$

11. $b = 1.5, m = -2.3$
$y = mx + b$
$y = -2.3x + 1.5$

12. $b = -4.5, m = 2.5$
$y = mx + b$
$y = 2.5x - 4.5$

13. $b = 4, \ m = -\frac{3}{4}$
$y = mx + b$
$y = -\frac{3}{4}x + 4$

14. $b = -3, \ m = \frac{4}{3}$
$y = mx + b$
$y = \frac{4}{3}x - 3$

15. $2x - y = 9$
Rewrite in slope-intercept form.
$$-y = -2x + 9$$
$$y = 2x - 9$$
$m = 2, b = -9.$

16. $x + 2y = 7$
Rewrite in slope-intercept form.
$$2y = -x + 7$$
$$y = -\frac{1}{2}x + \frac{7}{2}$$
$m = -\frac{1}{2}, b = \frac{7}{2}.$

17. $6x = 2y + 4$
Rewrite in slope-intercept form.
$2y = 6x - 4 \Rightarrow y = 3x - 2$
$m = 3, b = -2.$

18. $4x + 3y = 24$
Rewrite in slope-intercept form.
$$3y = -4x + 24$$
$$y = -\frac{4}{3}x + 8$$
$m = -\frac{4}{3}, b = 8.$

19. $6x - 9y = 16$
Write in slope-intercept form.
$$-9y = -6x + 16$$
$$9y = 6x - 16$$
$$y = \frac{2}{3}x - \frac{16}{9}$$
$m = \frac{2}{3}, b = -\frac{16}{9}.$

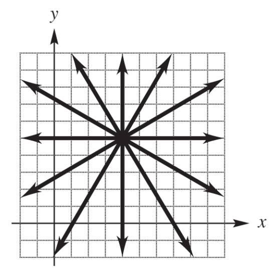
20. $4x + 2y = 0$
Rewrite in slope-intercept form.
$2y = -4x \Rightarrow y = -2x$
$m = -2, b = 0.$

21. $2x - 3y = 0$
Rewrite in slope-intercept form.
$$3y = 2x \Rightarrow y = \frac{2}{3}x$$
$m = \frac{2}{3}, b = 0.$

22. $y = 7$ can be written as
$y = 0x + 7$
$m = 0, b = 7.$

23. $x = y - 5$
Rewrite in slope-intercept form.
$y = x + 5$
$m = 1, b = 5$

24. There are many correct answers, including:



25. **(a)** Largest value of slope is at C.

(b) Smallest value of slope is at B.

(c) Largest absolute value is at B

(d) Closest to 0 is at D

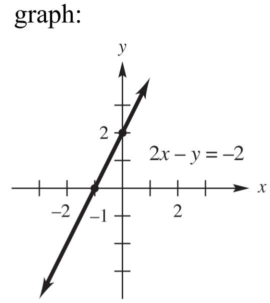
26. **(a)** $y = 3x + 2$
The slope is positive, and the y-intercept is positive. This is line D.

(b) $y = -3x + 2$
The slope is negative, and the y-intercept is positive. This is line B.

(c) $y = 3x - 2$
The slope is positive, and the y-intercept is negative. This is line A.

(d) $y = -3x - 2$
The slope is negative, and the y-intercept is negative. This is line C.

27. $2x - y = -2$
Find the x-intercept by setting $y = 0$ and solving for x: $2x - 0 = -2 \Rightarrow 2x = -2 \Rightarrow x = -1$
Find the y-intercept by setting $x = 0$ and solving for y: $2(0) - y = -2 \Rightarrow -y = -2 \Rightarrow y = 2$
Use the points (–1, 0) and (0, 2) to sketch the graph:

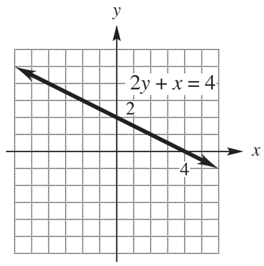


28. $2y + x = 4$

Find the x-intercept by setting $y = 0$ and solving for x: $2(0) + x = 4 \Rightarrow x = 4$

Find the y-intercept by setting $x = 0$ and solving for y: $2y + 0 = 4 \Rightarrow 2y = 4 \Rightarrow y = 2$

Use the points (4, 0) and (0, 2) to sketch the graph:

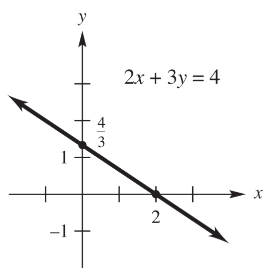


29. $2x + 3y = 4$

Find the x-intercept by setting $y = 0$ and solving for x: $2x + 3(0) = 4 \Rightarrow 2x = 4 \Rightarrow x = 2$

Find the y-intercept by setting $x = 0$ and solving for y: $2(0) + 3y = 4 \Rightarrow 3y = 4 \Rightarrow y = \frac{4}{3}$

Use the points (2, 0) and $\left(0, \frac{4}{3}\right)$ to sketch the graph:



30. $-5x + 4y = 3$

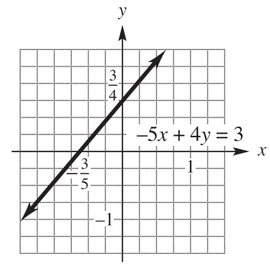
Find the x-intercept by setting $y = 0$ and solving for x:

$$-5x + 4(0) = 3 \Rightarrow -5x = 3 \Rightarrow x = -\frac{3}{5}$$

Find the y-intercept by setting $x = 0$ and solving for y:

$$-5(0) + 4y = 3 \Rightarrow 4y = 3 \Rightarrow y = \frac{3}{4}$$

Use the points $\left(-\frac{3}{5}, 0\right)$ and $\left(0, \frac{3}{4}\right)$ to sketch the graph:



31. $4x - 5y = 2$

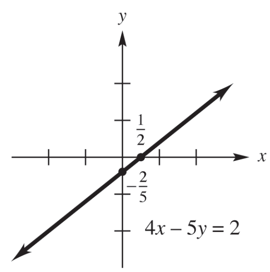
Find the x-intercept, by setting $y = 0$ and solving for x:

$$4x - 5(0) = 2 \Rightarrow 4x = 2 \Rightarrow x = \frac{1}{2}$$

Find the y-intercept by setting $x = 0$ and solving for y:

$$4(0) - 5y = 2 \Rightarrow -5y = 2 \Rightarrow y = -\frac{2}{5}$$

Use the points $\left(\frac{1}{2}, 0\right)$ and $\left(0, -\frac{2}{5}\right)$ to sketch the graph:



32. $3x + 2y = 8$

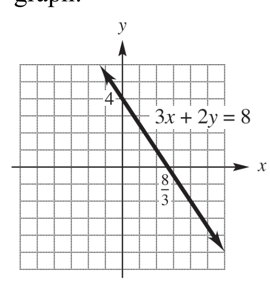
Find the x-intercept by setting $y = 0$ and solving for x:

$$3x + 2(0) = 8 \Rightarrow 3x = 8 \Rightarrow x = \frac{8}{3}$$

Find the y-intercept by setting $x = 0$ and solving for y:

$3(0) + 2y = 8 \Rightarrow 2y = 8 \Rightarrow y = 4$

Use the points $\left(\frac{8}{3}, 0\right)$ and (0, 4) to sketch the graph:



33. For $4x - 3y = 6$, solve for y.

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

For $3x + 4y = 8$, solve for y.

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

The two slopes are $\frac{4}{3}$ and $-\frac{3}{4}$. Since $\left(\frac{4}{3}\right)\left(-\frac{3}{4}\right) = -1$, the lines are perpendicular.

34. $2x - 5y = 7$ and $15y - 5 = 6x$

Solve each equation for y to find the slope.

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

$15y - 5 = 6x \Rightarrow 15y = 6x + 5 \Rightarrow$

$y = \frac{6}{15}x + \frac{5}{15} = \frac{2}{5}x + \frac{1}{3}$

The slope of each line is $\frac{2}{5}$, so the lines are parallel.

35. For $3x + 2y = 8$, solve for y.

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

For $6y = 5 - 9x$, solve for y.

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

Since the slopes are both $-\frac{3}{2}$, the lines are parallel.

36. $x - 3y = 4$ and $y = 1 - 3x$

Solve each equation for y to find the slope.

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

$y = 1 - 3x = -3x + 1$

The product of the slopes is $\left(\frac{1}{3}\right)(-3) = -1$, so the lines are perpendicular.

37. For $4x = 2y + 3$, solve for y.

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

For $2y = 2x + 3$, solve for y.

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

Since the two slopes are 2 and 1, the lines are neither parallel nor perpendicular.

38. $2x - y = 6$ and $x - 2y = 4$

Solve each equation for y to find the slope.

$2x - y = 6 \Rightarrow -y = -2x + 6 \Rightarrow y = 2x - 6$

$x - 2y = 4 \Rightarrow -2y = -x + 4 \Rightarrow y = \frac{1}{2}x - 2$

The slopes are not equal, and their product is $2\left(\frac{1}{2}\right) = 1$, not –1, so the lines are neither parallel nor perpendicular.

39. Triangle with vertices (9, 6), (–1, 2) and (1, –3).

a. Slope of side between vertices (9, 6) and (–1, 2):

$m = \frac{6-2}{9-(-1)} = \frac{4}{10} = \frac{2}{5}$

Slope of side between vertices (–1, 2) and (1, –3):

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

Slope of side between vertices (1, –3) and (9, 6):

$m = \frac{-3-6}{1-9} = \frac{-9}{-8} = \frac{9}{8}$

b. The sides with slopes $\frac{2}{5}$ and $-\frac{5}{2}$ are perpendicular, because $\frac{2}{5}\left(-\frac{5}{2}\right) = -1$. Thus, the triangle is a right triangle.

40. Quadrilateral with vertices (–5, –2), (–3, 1), (3, 0), and (1, –3):

a. Slope of side between vertices (–5, –2) and (–3, 1):

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

Slope of side between vertices (–3, 1) and (3, 0):

$m = \frac{1-0}{-3-3} = \frac{1}{-6} = -\frac{1}{6}$

Slope of side between vertices (3, 0) and (1, –3):

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

Slope of side between vertices (1, –3) and (–5, –2):

$m = \frac{-3-(-2)}{1-(-5)} = \frac{-3+2}{1+5} = -\frac{1}{6}$

b. Yes, the quadrilateral is a parallelogram because opposite sides have the same slope and are therefore parallel.

41. Use point-slope form with

$(x_1, y_1) = (-3, 2),\ m = -\frac{2}{3}$

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

42. $(x_1, y_1) = (-5, -2),\ m = \frac{4}{5}$

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-2) &= \frac{4}{5}(x - (-5)) \\ y + 2 &= \frac{4}{5}(x + 5) \\ y + 2 &= \frac{4}{5}x + 4 \\ y &= \frac{4}{5}x + 2 \end{aligned}$$

43. $(x_1, y_1) = (2, 3),\ m = 3$

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3 &= 3(x - 2) \\ y - 3 &= 3x - 6 \\ y &= 3x - 3 \end{aligned}$$

44. $(x_1, y_1) = (3, -4),\ m = -\frac{1}{4}$

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-4) &= -\frac{1}{4}(x - 3) \\ y + 4 &= -\frac{1}{4}(x - 3) \\ 4y + 16 &= -x + 3 \\ 4y &= -x - 13 \\ y &= -\frac{1}{4}x - \frac{13}{4} \end{aligned}$$

45. $(x_1, y_1) = (10, 1),\ m = 0$

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 1 &= 0(x - 10) \\ y - 1 &= 0 \Rightarrow y = 1 \end{aligned}$$

46. $(x_1, y_1) = (-3, -9),\ m = 0$

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - (-9) &= 0(x - (-3)) \\ y + 9 &= 0 \Rightarrow y = -9 \end{aligned}$$

47. Since the slope is undefined, the equation is that of a vertical line through (–2, 12).
$x = -2$

48. Since the slope is undefined, the equation is that of a vertical line through (1, 1).
$x = 1$

49. Through (–1, 1) and (2, 7)
Find the slope.

$$m = \frac{7 - 1}{2 - (-1)} = \frac{6}{3} = 2$$

Use the point-slope form with $(2, 7) = (x_1, y_1)$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 7 &= 2(x - 2) \\ y - 7 &= 2x - 4 \\ y &= 2x + 3 \end{aligned}$$

50. Through (2, 5) and (0, 6)
Find the slope.

$$m = \frac{5 - 6}{2 - 0} = \frac{-1}{2}$$

Use the point-slope form with $(0, 6) = (x_1, y_1)$.

$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 6 &= -\frac{1}{2}(x - 0) \\ y - 6 &= -\frac{1}{2}x \\ y &= -\frac{1}{2}x + 6 \end{aligned}$$

51. Through (1, 2) and (3, 9)
Find the slope.
$m = \frac{9-2}{3-1} = \frac{7}{2}$
Use the point-slope form with $(1, 2) = (x_1, y_1)$.
$y - y_1 = m(x - x_1)$
$y - 2 = \frac{7}{2}(x-1)$
$y - 2 = \frac{7}{2}x - \frac{7}{2}$
$y = \frac{7}{2}x - \frac{3}{2}$
$2y = 7x - 3$

52. Through (–1, –2) and (2, –1)
Find the slope.
$m = \frac{-2-(-1)}{-1-2} = \frac{-1}{-3} = \frac{1}{3}$
Use the point-slope form with
$(-1, -2) = (x_1, y_1)$
$y - y_1 = m(x - x_1)$
$y - (-2) = \frac{1}{3}(x - (-1))$
$y + 2 = \frac{1}{3}(x+1)$
$3y + 6 = x + 1$
$3y = x - 5$

53. Through the origin with slope 5.
$(x_1, y_1) = (0, 0)$; $m = 5$
$y - y_1 = m(x - x_1)$
$y - 0 = 5(x - 0) \Rightarrow y = 5x$

54. Through the origin and horizontal.
A horizontal line has slope 0.
$(x_1, y_1) = (0, 0)$
$y - y_1 = m(x - x_1)$
$y - 0 = 0(m - 0)$
$y = 0$

55. Through (6, 8) and vertical.
A vertical line has undefined slope.
$(x_1, y_1) = (6, 8)$
$x = 6$

56. Through (7, 9) and parallel to $y = 6$.
The line $y = 6$ has slope 0.
$(x_1, y_1) = (7, 9)$
$y - y_1 = m(x - x_1)$
$y - 9 = 0(x - 7)$
$y - 9 = 0 \Rightarrow y = 9$

57. Through (3, 4) and parallel to $4x - 2y = 5$.
Find the slope of the given line because a line parallel to the line has the same slope.
$(x_1, y_1) = (3, 4)$
$4x = 2y + 5$
$2y = 4x - 5$
$y = 2x - \frac{5}{2} \quad m = 2$
$y - y_1 = m(x - x_1)$
$y - 4 = 2(x - 3)$
$y - 4 = 2x - 6$
$y = 2x - 2$

58. Through (6, 8) and perpendicular to $y = 2x - 3$.
The slope of the given line is 2, so the slope of a line perpendicular to the given line has the slope $m = -\frac{1}{2}$.
$(x_1, y_1) = (6, 8)$
$y - y_1 = m(x - x_1)$
$y - 8 = -\frac{1}{2}(x - 6)$
$2y - 16 = -x + 6$
$2y = -x + 22$

59. x-intercept 6; y-intercept –6
Through the points (6, 0) and (0, –6).
$m = \frac{0-(-6)}{6-0} = \frac{6}{6} = 1$
$(x_1, y_1) = (6, 0)$
$y - y_1 = m(x - x_1)$
$y - 0 = 1(x - 6) \Rightarrow y = x - 6$

60. Through (–5, 2) and parallel to the line through (1, 2) and (4, 3).
The slope of the given line is
$m = \frac{2-3}{1-4} = \frac{-1}{-3} = \frac{1}{3}$, so the slope of a line parallel to the line is also $\frac{1}{3}$.

$$(x_1, y_1) = (-5, 2)$$
$$y - y_1 = m(x - x_1)$$
$$y - 2 = \frac{1}{3}(x - (-5))$$
$$3y - 6 = x + 5$$
$$3y = x + 11$$

61. Through (–1, 3) and perpendicular to the line through (0, 1) and (2, 3).
The slope of the given line is
$m_1 = \frac{1-3}{0-2} = \frac{-2}{-2} = 1$, so the slope of a line perpendicular to the line is $m_2 = \frac{-1}{1} = -1.$

$$(x_1, y_1) = (-1, 3)$$
$$y - y_1 = m(x - x_1)$$
$$y - 3 = -1(x - (-1))$$
$$y - 3 = -x - 1$$
$$y = -x + 2$$

62. y-intercept 3 and perpendicular to $2x - y + 6 = 0$.
$2x - y + 6 = 0 \Rightarrow y = 2x + 6$
The slope of this line is 2, so the slope of a line perpendicular to the line is $-\frac{1}{2}$.

$$(x_1, y_1) = (0, 3)$$
$$y - y_1 = m(x - x_1)$$
$$y - 3 = -\frac{1}{2}(x - 0)$$
$$2y - 6 = -x$$
$$2y = -x + 6$$

63. Let cost x = 15,965 and life: 12 years. Find D.
$$D = \left(\frac{1}{n}\right)x = \frac{1}{12}(15{,}965) \approx 1330.42$$
The depreciation is \$1330.42 per year.

64. Cost: \$41,762; life: 15 years
$$D = \left(\frac{1}{n}\right)x = \frac{1}{15}(41{,}762) \approx 2784.13$$
The depreciation is \$2784.13 per year.

65. Let cost x = \$201,457; life: 30 years
$$D = \left(\frac{1}{n}\right)x = \frac{1}{30}(201{,}457) \approx 6715.23$$
The depreciation is \$6715.23 per year.

66. Let x = the amount of the bonus. The manager received as a bonus .10(165,000 – x),so x = .10(165,000 – x).
Solve this equation.
$$x = 16{,}500 - .10x$$
$$1.10x = 16{,}500$$
$$x = \frac{16{,}500}{1.10} = 15{,}000$$
The bonus amounted to \$15,000.

67. $x = 10$
$$y = -3.9(10) + 27.3 = -11.7$$
There was a decrease of 11.7% for Miller Lite beer between 2007 and 2010.

68. $x = 14$
$$y = -3.9(14) + 27.3 = -27.3$$
There was a decrease of 27.3% for Miller Lite beer between 2007 and 2015.

69. $y = -32$
$$-32 = -3.9x + 27.3$$
$$-59.3 = -3.9x$$
$$15.21 \approx x$$
The first full year that there will be a decrease of 32% in Miller Lite beer shipments was 2016.

70. $y = -40$
$$-40 = -3.9x + 27.3$$
$$-67.3 = -3.9x$$
$$17.26 \approx x$$
The first full year that there will be a decrease of 40% in Miller Lite beer shipments will be 2018.

71. $x = 7$
$$y = 5.6(7) + 52 = 91.2$$
There were 91.2 million malaria cases in 2007.

72. $x = 15$
$$y = 5.6(15) + 52 = 136$$
There were 136 million malaria cases in 2015.

73. $y = 150$

$150 = 5.6x + 52$

$98 = 5.6x$

$17.5 = x$

The first full year that there will be 150 million global malaria cases will be 2018.

74. $y = 175$

$175 = 5.6x + 52$

$123 = 5.6x$

$21.96 \approx x$

The first full year that there will be 175 million global malaria cases will be 2022.

75. $y = -.0135(2016) + 40.32 \approx 13.104$

The model predicts that the time for the men's 5000-m run will be about 13.104 minutes in the 2016 Olympics. This was a difference of .044 minutes from the actual time.

76. The slope of –.0135 indicates that on average, the men's 5000-meter run is being run .0135 seconds faster every year. It is negative because the times are generally decreasing as time progresses.

77. a. $(x_1, y_1) = (11, 5)$ and $(x_2, y_2) = (15, 23)$

Find the slope.

$$m = \frac{23-5}{15-11} = \frac{18}{4} = 4.5$$

$y - 5 = 4.5(x - 11)$

$y - 5 = 4.5x - 49.5$

$y = 4.5x - 44.5$

b. The year 2013 corresponds to $x = 2013 - 2000 = 13$.

$y = 4.5(13) - 44.5 = 14$

In 2013, Michael Kors had 14% of the luxury handbag market.

c. $y = 30$

$30 = 4.5x - 44.5$

$74.5 = 4.5x$

$16.56 \approx x$

The first full year that Michael Kors will had 30% of the luxury handbag market was 2017.

78. a. $(x_1, y_1) = (5, 3.3)$ and $(x_2, y_2) = (15, 4.1)$

Find the slope.

$$m = \frac{4.1-3.3}{15-5} = \frac{.8}{10} = .08$$

$y - 3.3 = .08(x - 5)$

$y - 3.3 = .08x - .4$

$y = .08x + 2.9$

b. The year 2012 corresponds to $x = 2012 - 2000 = 12$.

$y = .08(12) + 2.9 = 3.86$

In 2012, the global cocoa bean production was 3.86 million metric tons.

c. $y = 5$

$5 = .08x + 2.9$

$2.1 = .08x$

$26.25 = x$

The first full year that global cocoa bean production will be 5 million metric tons will be 2027.

79. a. $(x_1, y_1) = (10, 3500)$ and $(x_2, y_2) = (15, 5000)$

Find the slope.

$$m = \frac{5000-3500}{15-10} = \frac{1500}{5} = 300$$

$y - 3500 = 300(x - 10)$

$y - 3500 = 300x - 3000$

$y = 300x + 500$

b. The year 2014 corresponds to $x = 2014 - 2000 = 14$.

$y = 300(14) + 500 = 4700$

In 2014, the average annual cost to employees for employer family health coverage was $4700.

c. $y = 6000$

$6000 = 300x + 500$

$5500 = 300x$

$18.33 \approx x$

The first full year that the average annual cost to employees for employer family health coverage will exceed $6000 will be 2019.

80. a. $(x_1, y_1) = (10, 10000)$ and $(x_2, y_2) = (15, 17000)$

Find the slope.

$$m = \frac{17000 - 10000}{15 - 10} = \frac{7000}{5} = 1400$$

$$y - 10000 = 1400(x - 10)$$
$$y - 10000 = 1400x - 14000$$
$$y = 1400x - 4000$$

b. The year 2012 corresponds to $x = 2012 - 2000 = 12$.

$y = 1400(12) - 4000 = 12{,}800$

In 2012, the average annual cost to employers for employer family health coverage was $12,800.

c. $y = 25{,}000$

$$25{,}000 = 1400x - 4000$$
$$29{,}000 = 1400x$$
$$20.71 \approx x$$

The first full year that the average annual cost to employers for employer family health coverage will exceed $25,000 will be 2021.

Section 2.3 Linear Models

1. a. Let (x_1, y_1) be (32, 0) and (x_2, y_2) be (68, 20).

Find the slope.

$$m = \frac{20 - 0}{68 - 32} = \frac{20}{36} = \frac{5}{9}$$

Use the point-slope form with (32, 0).

$$y - 0 = \frac{5}{9}(x - 32) \Rightarrow y = \frac{5}{9}(x - 32)$$

b. Let $x = 50$.

$$y = \frac{5}{9}(50 - 32) = \frac{5}{9}(18) = 10°\text{C}$$

Let $x = 75$.

$$y = \frac{5}{9}(75 - 32) = \frac{5}{9}(43) \approx 23.89°\text{C}$$

2. $y = \frac{5}{9}(x - 32) \Rightarrow C = \frac{5}{9}(F - 32)$

a. $F = 58°\text{F}$

$$C = \frac{5}{9}(58 - 32) = \frac{5}{9}(26) \approx 14.4°C$$

b. $C = 50°\text{C}$

$$50 = \frac{5}{9}(F - 32)$$
$$450 = 5F - 160$$
$$610 = 5F \Rightarrow F = 122°$$

c. $C = -10°\text{C}$

$$-10 = \frac{5}{9}(F - 32)$$
$$-90 = 5F - 160$$
$$70 = 5F \Rightarrow F = 14°$$

d. $F = -20°\text{F}$

$$C = \frac{5}{9}(-20 - 32) = \frac{5}{9}(-52) \approx -28.9°C$$

3. F = 867°

$$C = \frac{5}{9}(867 - 32) = \frac{5}{9}(835) \approx 463.89°C$$

4. When are Celsius and Fahrenheit temperatures numerically equal? Set $F = C$:

$$C = \frac{5}{9}(F - 32) = F \Rightarrow 9F = 5F - 160 \Rightarrow$$
$$4F = -160 \Rightarrow F = -40°$$

The temperatures are numerically equal at –40°.

5. Let $(x_1, y_1) = (11, 224.9)$ and $(x_2, y_2) = (16, 240.0)$. Find the slope.

$$m = \frac{240.0 - 224.9}{16 - 11} = 3.02$$
$$y - 224.9 = 3.02(x - 11)$$
$$y - 224.9 = 3.02x - 33.22$$
$$y = 3.02x + 191.68$$

To estimate the CPI in 2012, let $x = 12$.
$$y = 3.02(12) + 191.68 \approx 227.92$$
To estimate the CPI in 2015, let $x = 15$.
$$y = 3.02(15) + 191.68 \approx 236.98$$

6. Let $(x_1, y_1) = (5, 68.5)$ and $(x_2, y_2) = (16, 123.7)$. Find the slope.

$$m = \frac{123.7 - 68.5}{16 - 5} = \frac{55.2}{11} \approx 5.02$$
$$y - 68.5 = 5.02(x - 5)$$
$$y - 68.5 = 5.02x - 26.10$$
$$y = 5.02x + 43.4$$

To estimate the number of electronically filed returns in 2010, let $x = 2010 - 2000 = 10$.
$$y = 5.02(10) + 43.4 = 93.6$$
There were about 93.6 million electronically filed tax returns in 2010.
To estimate the number of electronically filed returns in 2015, let $x = 2015 - 2000 = 15$
$$y = 5.02(15) + 43.4 \approx 113.7$$
There were about 113.7 million electronically filed tax returns in 2015.

7. Let $(x_1, y_1) = (5, 12.3)$ and $(x_2, y_2) = (14, 13.3)$. Find the slope.

$$m = \frac{13.3 - 12.3}{14 - 5} = \frac{1}{9} \approx .11$$
$$y - 12.3 = .11(x - 5)$$
$$y - 12.3 = .11x - .55$$
$$y = .11x + 11.75$$

To estimate the number of employees working in educational services in 2012, let $x = 2012 - 2000 = 12$.
$$y = .11(12) + 11.75 = 13.08$$
The number of employees was estimated to be 13.08 million in 2012.

8. Let $(x_1, y_1) = (5, 12.1)$ and $(x_2, y_2) = (14, 13.5)$. Find the slope.

$$m = \frac{13.5 - 12.1}{14 - 5} = .16$$
$$y - 12.1 = .16(x - 5)$$
$$y - 12.1 = .16x - .78$$
$$y = .16x + 11.32$$

To estimate the number of employees working in the leisure and hospitality industries in 2013, let $x = 2013 - 2000 = 13$.
$$y = .16(13) + 11.32 = 13.4$$
The number of employees was about 13.4 million in 2013.

9. Find the slope of the line.
$$(x_1, y_1) = (50, 320)$$
$$(x_2, y_2) = (80, 440)$$
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{440 - 320}{80 - 50} = \frac{120}{30} = 4$$
Each mile per hour increase in the speed of the bat will make the ball travel 4 more feet.

10. $$y = \frac{1120 \text{ gal}}{\text{min}} \cdot \frac{60 \text{ min}}{\text{hr}} \cdot \frac{12 \text{ hr}}{\text{day}} \cdot x = 806{,}400x$$
After 30 days,
$y = 806{,}400(30) = 24{,}192{,}000$ gallons

11. a. $y = .07x + .83$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(6, .7)	(6,1.25)	–.55	.3025
(8, 1.22)	(8, 1.39)	–.17	.0289
(10, 1.53)	(10, 1.53)	0	0
(12,2.02)	(12, 1.67)	.35	.1225
(14,1.81)	(14,1.81)	0	0

$y = .2x - .38$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(6, .7)	(6,.82)	–.12	.0144
(8, 1.22)	(8, 1.22)	0	0
(10, 1.53)	(10, 1.62)	–.09	.0081
(12,2.02)	(12, 2.02)	0	0
(14,1.81)	(14,2.42)	–.61	.3721

Sum of the residuals for model 1 = –.37
Sum of the residuals for model 2 = –.82

b. Sum of the squares of the residuals for model 1 = .4539
Sum of the squares of the residuals for model 2 = .3946

c. Model 2 is the better fit.

12. a. $y = 1.35x + 2.5$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(10, 16)	(10,16)	0	0
(11, 21)	(11,17.35)	3.65	13.3225
(12, 21)	(12,18.7)	2.3	5.29
(13, 23)	(13,20.05)	2.95	8.7025
(14,21.4)	(14,21.4)	0	0

$y = 2x - 3$

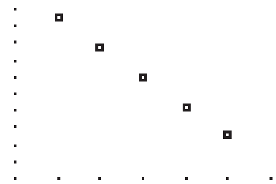
Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(10, 16)	(10,17)	–1	1
(11, 21)	(11,19)	2	4
(12, 21)	(12,21)	0	0
(13, 23)	(13,23)	0	0
(14,21.4)	(14,25)	–3.6	12.96

Sum of the residuals for equation 1 = 8.9
Sum of the residuals for equation 2 = –2.6

b. Sum of the squares of the residuals for equation 1= 27.315.
Sum of the squares of the residuals for equation 2= 17.96.

c. Equation 2 is the better fit.

13. Plot the points.



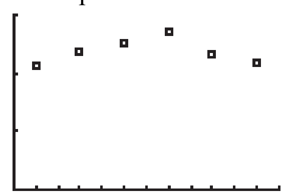
[10, 16] by [3500, 4500]

Visually, a straight line looks to be a good model for the data.

```
LinReg
 y=ax+b
 a=-170.8
 b=6320
 r²=.9998190412
 r=-.9999095165
```

The coefficient of correlation is $r \approx -.9999$, which indicates that the regression line is a good fit for the data.

14. Plot the points.



[0, 12] by [0, 3]

Visually, a straight line looks to be a poor model for the data because it shows a great deal of curvature.

```
LinReg
 y=ax+b
 a=.0038571429
 b=2.34852381
 r²=.0046227502
 r=.0679908096
```

The coefficient of correlation is $r \approx .068$, which indicates that the regression line is not a good fit for the data.

15. a. Using a graphing calculator, the regression-line model is $y = -170.8x + 6320$.

b. The year 2018 corresponds to $x = 18$. Using the regression-line model generated by a graphing calculator, we have $y = -170.8(18) + 6320 \approx 3246$, or about 3246 credit unions.

16. a. Using a graphing calculator, we find that the linear model is $y = 23.9x + 486.4$

b. Let $x = 35$. Using the regression-line model generated by a graphing calculator, we have $y = 23.9(8) + 486.4 \approx 678$, or about \$678 billion.

17. a. Using a graphing calculator, the regression-line model is
$y = .8x + 14.2$.

b. The third quarter of 2017 corresponds to $x = 11$. Using the regression-line model generated by a graphing calculator, we have $y = .8(11) + 14.2 = 23$, or about \$23 billion in revenue.

18. a. Using a graphing calculator, the regression-line model is
$y = 85.4 + .842x$.

b. Using the regression-line model:
Let $x = 42$ years-old.
$y = 85.4 + .842(42) = 120.764$
Let $x = 53$ years-old.
$y = 85.4 + .842(53) = 130.026$
Let $x = 69$ years-old.
$y = 85.4 + .842(69) = 143.498$
The predicted values are very close to the actual data values.

c. Using the regression-line model:
Let $x = 45$ years-old.
$y = 85.4 + .842(45) = 123.29$
Let $x = 70$ years-old.
$y = 85.4 + .842(70) = 144.34$
The systolic blood pressure for a 45 year-old and a 70 year-old are predicted to be 123.29 and 144.34 respectively.

19. a. Using a graphing calculator, the regression line model for amount of construction spending on highways and streets (in billions of dollars) is given by
$y = -1.829x + 98.4$.

b. Let $x = 12$ (December 2016).
$y = -1.829(12) + 98.4 \approx 76.5$ billion
The total amount of construction spending on highways and streets was about \$76.5 billion in December 2016.

20. a. Using a graphing calculator, the regression-line model is
$y = -1.49x + 75.76$.

b. $y = -1.49(13) + 75.76 \approx 56.39$. There were about 56.39 million subscribers in 2013.

c. Let $y = 50$.

$$50 = -1.49x + 75.76$$
$$-25.76 = -1.49x$$
$$x \approx 17.28$$

There will be 50 million subscribers in the year 2018.

d. Using a graphing calculator, the coefficient of correlation is about –.986.

21. a. Using a graphing calculator, the regression-line model is $y = .295x + 48$.

b. $y = .295(10) + 48 \approx 50.95$. There was about \$50.95 billion in revenue for the second quarter of 2017.

c. Let $y = 52$.

$$52 = .295x + 48$$
$$4 = .295x$$
$$x \approx 13.56$$

There will be \$52 billion in revenue during the second quarter of 2018.

d. Using a graphing calculator, the coefficient of correlation is about .795.

22. a. Using a graphing calculator, the regression-line model for men is
$y = .214x + 52.6$.

b. Using a graphing calculator, the regression-line model for women is
$y = .134x + 66.3$.

c.

$$.214x + 52.5 = .134x + 66.3$$
$$.08x = 13.8$$
$$x \approx 172.5$$

According to the models, the life expectancy of men will be the same as women in the year 2072.

Section 2.4 Linear Inequalities

1. Use brackets if you want to include the endpoint, and parentheses if you want to exclude it.

2. (c). $-7 > -10$

3. $-8k \le 32$

Multiply both sides of the inequality by $-\frac{1}{8}$.

Since this is a negative number, change the direction of the inequality symbol.

$$-\frac{1}{8}(-8k) \ge -\frac{1}{8}(32) \Rightarrow k \ge -4$$

The solution is $[-4, \infty)$.

4. $-4a \le 36$

Multiply both sides by $-\frac{1}{4}$. Change the direction of the inequality symbol.

$$-\frac{1}{4}(-4a) \ge -\frac{1}{4}(36) \Rightarrow a \ge -9$$

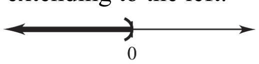
The solution is $[-9, \infty)$.

5. $-2b > 0$

Multiply both sides by $-\frac{1}{2}$.

$$-2b > 0 \Rightarrow -\frac{1}{2}(-2b) < -\frac{1}{2}(0) \Rightarrow b < 0$$

The solution is $(-\infty, 0)$. To graph this solution, put a parenthesis at 0 and draw an arrow extending to the left.



6. $6 - 6z < 0$

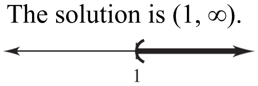
Add $6z$ to both sides.

$$6 - 6z + 6z < 0 + 6z \Rightarrow 6 < 6z$$

Multiply both sides by $\frac{1}{6}$.

$$\frac{1}{6}(6) < \frac{1}{6}(6z) \Rightarrow 1 < z \text{ or } z > 1$$

The solution is $(1, \infty)$.



7. $3x + 4 \le 14$

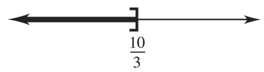
Subtract 4 from both sides.

$$3x + 4 - 4 \le 14 - 4 \Rightarrow 3x \le 10$$

Multiply each side by $\frac{1}{3}$.

$$\frac{1}{3}(3x) \le \frac{1}{3}(10) \Rightarrow x \le \frac{10}{3}$$

The solution is $\left(-\infty, \frac{10}{3}\right]$.



8. $2y - 7 < 9$

Add 7 to both sides.

$$2y - 7 + 7 < 9 + 7 \Rightarrow 2y < 16$$

Multiply both sides by $\frac{1}{2}$.

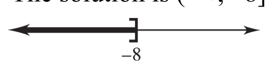
$$\frac{1}{2}(2y) < \frac{1}{2}(16) \Rightarrow y < 8$$

Solution is $(-\infty, 8)$.

For exercises 9–26, we give the solutions without additional explanation.

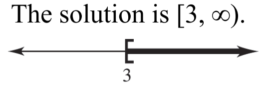
9.
$$\begin{aligned} -5 - p &\ge 3 \\ -5 + 5 - p &\ge 3 + 5 \\ -p &\ge 8 \\ (-1)(-p) &\le (-1)(8) \\ p &\le -8 \end{aligned}$$

The solution is $(-\infty, -8]$.



10.
$$\begin{aligned} 5 - 3r + (-5) &\le -4 + (-5) \\ -3r &\le -9 \\ -\frac{1}{3}(-3r) &\ge -9\left(-\frac{1}{3}\right) \\ r &\ge 3 \end{aligned}$$

The solution is $[3, \infty)$.



11. $7m - 5 < 2m + 10$

$5m - 5 < 10$

$5m < 15$

$\frac{1}{5}(5m) < \frac{1}{5}(15)$

$m < 3$

The solution is $(-\infty, 3)$.

12. $6x - 2 > 4x - 10$

$6x - 2 - 4x > 4x - 10 - 4x$

$2x - 2 > -10$

$2x - 2 + 2 > -10 + 2$

$2x > -8$

$\frac{1}{2}(2x) > \frac{1}{2}(-8)$

$x > -4$

The solution is $(-4, \infty)$.

13. $m - (4 + 2m) + 3 < 2m + 2$

$m - 4 - 2m + 3 < 2m + 2$

$-1 - m < 2m + 2$

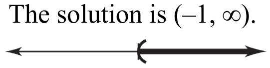
$-m - 2m < 2 + 1$

$-3m < 3$

$-\frac{1}{3}(-3m) > -\frac{1}{3}(3)$

$m > -1$

The solution is $(-1, \infty)$.



14. $2p - (3 - p) \le -7p - 2$

$2p - 3 + p \le -7p - 2$

$3p - 3 \le -7p - 2$

$10p - 3 \le -2$

$10p \le 1$

$p \le \frac{1}{10}$

The solution is $\left(-\infty, \frac{1}{10}\right]$.

15. $-2(3y - 8) \ge 5(4y - 2)$

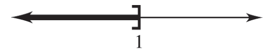
$-6y + 16 \ge 20y - 10$

$16 + 10 \ge 20y + 6y$

$26 \ge 26y$

$1 \ge y \quad \text{or} \quad y \le 1$

The solution is $(-\infty, 1]$.



16. $5r - (r + 2) \ge 3(r - 1) + 6$

$5r - r - 2 \ge 3r - 3 + 6$

$4r - 2 \ge 3r + 3$

$r - 2 \ge 3$

$r \ge 5$

The solution is $[5, \infty)$.

17. $3p - 1 < 6p + 2(p - 1)$

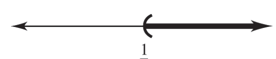
$3p - 1 < 6p + 2p - 2$

$-1 + 2 < 6p + 2p - 3p$

$1 < 5p$

$\frac{1}{5} < p \quad \text{or} \quad p > \frac{1}{5}$

The solution is $\left(\frac{1}{5}, \infty\right)$.



18. $x + 5(x + 1) > 4(2 - x) + x$

$x + 5x + 5 > 8 - 4x + x$

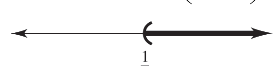
$6x + 5 > 8 - 3x$

$9x + 5 > 8$

$9x > 3$

$x > \frac{1}{3}$

The solution is $\left(\frac{1}{3}, \infty\right)$.



19. $$-7 < y - 2 < 5$$
$$-7 + 2 < y - 2 + 2 < 5 + 2$$
$$-5 < y < 7$$

The solution is (–5, 7).

20. $$-3 < m + 6 < 2$$
$$-3 + (-6) < m + 6 + (-6) < 2 + (-6)$$
$$-9 < m < -4$$

The solution is (–9, –4).

21. $$8 \le 3r + 1 \le 16$$
$$8 - 1 \le 3r \le 16 - 1$$
$$7 \le 3r \le 15$$
$$\frac{7}{3} \le r \le 5$$

The solution is $\left[\frac{7}{3}, 5\right]$.

22. $$-6 < 2p - 3 \le 5$$
$$-6 + 3 < 2p - 3 + 3 \le 5 + 3$$
$$-3 < 2p \le 8$$
$$\frac{1}{2}(-3) < \frac{1}{2}(2p) \le \frac{1}{2}(8)$$
$$-\frac{3}{2} < p \le 4$$

The solution is $\left(-\frac{3}{2}, 4\right]$.

23. $$-4 \le \frac{2k-1}{3} \le 2$$
$$-4(3) \le 3\left(\frac{2k-1}{3}\right) \le 2(3)$$
$$-12 \le 2k - 1 \le 6$$
$$-12 + 1 \le 2k \le 6 + 1$$
$$-11 \le 2k \le 7$$
$$-\frac{11}{2} \le k \le \frac{7}{2}$$

The solution is $\left[-\frac{11}{2}, \frac{7}{2}\right]$.

24. $$-1 \le \frac{5y+2}{3} \le 4$$
$$3(-1) \le 3\left(\frac{5y+2}{3}\right) \le 3(4)$$
$$-3 \le 5y + 2 \le 12$$
$$-5 \le 5y \le 10$$
$$-1 \le y \le 2$$

The solution is [–1, 2].

25. $$\frac{3}{5}(2p+3) \ge \frac{1}{10}(5p+1)$$
$$10 \cdot \frac{3}{5}(2p+3) \ge 10 \cdot \frac{1}{10}(5p+1)$$
$$6(2p+3) \ge 5p + 1$$
$$12p + 18 \ge 5p + 1$$
$$7p \ge -17$$
$$p \ge -\frac{17}{7}$$

The solution is $\left[-\frac{17}{7}, \infty\right)$.

26. $$\frac{8}{3}(z-4) \le \frac{2}{9}(3z+2)$$
$$\frac{8}{3}z - \frac{32}{3} \le \frac{2}{3}z + \frac{4}{9}$$
$$\frac{6}{3}z - \frac{32}{3} \le \frac{4}{9}$$
$$2z \le \frac{4}{9} + \frac{32}{3}$$
$$2z \le \frac{100}{9} \Rightarrow z \le \frac{50}{9}$$

The solution is $\left(-\infty, \frac{50}{9}\right]$.

27. $x \ge 2$

28. $x < -2$

29. $-3 < x \le 5$

30. $-4 \le x \le 4$

31. $C = 50x + 6000$; $R = 65x$
To at least break even, $R \ge C$.
$$65x \ge 50x + 6000$$
$$15x \ge 6000 \Rightarrow x \ge 400$$
The number of units of wire must be in the interval $[400, \infty)$.

32. Given $C = 100x + 6000$; $R = 500x$.
Since $R \ge C$,
$$500x \ge 100x + 6000 \Rightarrow 400x \ge 6000 \Rightarrow x \ge 15$$
The number of units of squash must be in the interval $[15, \infty)$.

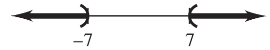
33. $C = 85x + 1000$; $R = 105x$
$$R \ge C$$
$$105x \ge 85x + 1000$$
$$20x \ge 1000$$
$$x \ge \frac{1000}{20} \Rightarrow x \ge 50$$
x must be in the interval $[50, \infty)$.

34. $C = 70x + 500$; $R = 60x$
$$R \ge C$$
$$60x \ge 70x + 500$$
$$-10x \ge 500$$
$$10x \le -500$$
$$x \le -\frac{500}{10} \Rightarrow x \le -50$$
It is impossible to break even.

35. $C = 1000x + 5000$; $R = 900x$
$$R \ge C$$
$$900x \ge 1000x + 5000$$
$$-100x \ge 5000$$
$$x \le \frac{5000}{-100} \Rightarrow x \le -50$$
It is impossible to break even.

36. $C = 25{,}000x + 21{,}700{,}000$; $R = 102{,}500x$
$$R \ge C$$
$$102{,}500x \ge 25{,}000x + 21{,}700{,}000$$
$$77{,}500x \ge 21{,}700{,}000$$
$$x \ge \frac{21{,}700{,}000}{77{,}500} \Rightarrow x \ge 280$$
x must be in the interval $[280, \infty)$.

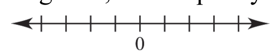
37. $|p| > 7$
$p < -7$ or $p > 7$
The solution is $(-\infty, -7)$ or $(7, \infty)$.



38. $|m| < 2 \Rightarrow -2 < m < 2$
The solution is $(-2, 2)$.

39. $|r| \le 5 \Rightarrow -5 \le r \le 5$
The solution is $[-5, 5]$.

40. $|a| < -2$
Since the absolute value of a number is never negative, the inequality has no solution.



41. $|b| > -5$
The absolute value of a number is always nonnegative. Therefore, $|b| > -5$ is always true, so the solution is the set of all real numbers.

42.
$$|2x + 5| < 1$$
$$-1 < 2x + 5 < 1$$
$$-1 - 5 < 2x < 1 - 5$$
$$-6 < 2x < -4$$
$$-3 < x < -2$$
The solution is $(-3, -2)$.

43.
$$\left|x - \frac{1}{2}\right| < 2$$
$$-2 < x - \frac{1}{2} < 2$$
$$-\frac{3}{2} < x < \frac{5}{2}$$
The solution is $\left(-\frac{3}{2}, \frac{5}{2}\right)$.

44. $|3z+1| \ge 4$

$$3z+1 \ge 4 \quad \text{or} \quad 3z+1 \le -4$$
$$3z \ge 4-1 \qquad 3z \le -4-1$$
$$3z \ge 3 \qquad 3z \le -5$$
$$z \ge 1 \qquad z \le -\frac{5}{3}$$

The solution is $\left(-\infty, -\frac{5}{3}\right]$ or $[1, \infty)$.

45. $|8b+5| \ge 7$

$$8b+5 \le -7 \quad \text{or} \quad 8b+5 \ge 7$$
$$8b \le -12 \quad \text{or} \quad 8b \ge 2$$
$$b \le -\frac{3}{2} \quad \text{or} \quad b \ge \frac{1}{4}$$

The solution is $\left(-\infty, -\frac{3}{2}\right]$ or $\left[\frac{1}{4}, \infty\right)$.

46. $\left|5x+\frac{1}{2}\right| - 2 < 5$

$$\left|5x+\frac{1}{2}\right| < 7$$
$$-7 < 5x+\frac{1}{2} < 7$$
$$-7-\frac{1}{2} < 5x < 7-\frac{1}{2}$$
$$-\frac{15}{2} < 5x < \frac{13}{2}$$
$$-\frac{15}{2}\cdot\frac{1}{5} < x < \frac{13}{2}\cdot\frac{1}{5}$$
$$-\frac{3}{2} < x < \frac{13}{10}$$

The solution is $\left(-\frac{3}{2}, \frac{13}{10}\right)$.

47. $|T-83| \le 7$

$$-7 \le T-83 \le 7$$
$$76 \le T \le 90$$

48. $|T-63| \le 27$

$$-27 \le T-63 \le 27$$
$$36 \le T \le 90$$

49. $|T-61| \le 21$

$$-21 \le T-61 \le 21$$
$$40 \le T \le 82$$

50. $|T-43| \le 22$

$$-22 \le T-43 \le 22$$
$$21 \le T \le 65$$

51. $|P-35.5| \le 3$

$$|P-35.5| \le \pm 3 \Rightarrow$$
$$-3 \le P-35.5 \le 3 \Rightarrow$$
$$32.5 \le P \le 38.5$$

52. $|x-100| > 12$

53. $35 \le B \le 43$

54. $13.1 \le U \le 15.1$

55. The seven income ranges are:

$$0 < x \le 9325$$
$$9325 < x \le 37,950$$
$$37,950 < x \le 91,900$$
$$91,900 < x \le 191,650$$
$$191,650 < x \le 416,700$$
$$416,700 < x \le 418,400$$
$$x > 418,400$$

56. The eight income ranges are:

$$0 < x \le 8450$$
$$8450 < x \le 11,650$$
$$11,650 < x \le 13,850$$
$$13,850 < x \le 21,300$$
$$21,300 < x \le 80,150$$
$$80,150 < x \le 214,000$$
$$214,000 < x \le 1,070,350$$
$$x > 1,070,350$$

Section 2.5 Polynomial and Rational Inequalities

1. $(x+4)(2x-3) \le 0$

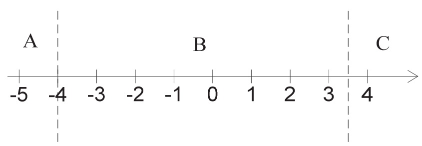
Solve the corresponding equation.

$(x+4)(2x-3) = 0$

$x+4=0 \quad \text{or} \quad 2x-3=0$

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

Note that because the inequality symbol is "≤," –4 and $\frac{3}{2}$ are solutions of the original inequality. These numbers separate the number line into three regions.



In region A, let $x = -6$:
$(-6+4)[2(-6)-3] = 30 > 0$.
In region B, let $x = 0$:
$(0+4)[2(0)-3] = -12 < 0$.
In region C, let $x = 2$:
$(2+4)[2(2)-3] = 6 > 0$.
The only region where $(x+4)(2x-3)$ is negative is region B, so the solution is $\left[-4, \frac{3}{2}\right]$. To graph this solution, put brackets at –4 and $\frac{3}{2}$ and draw a line segment between these two endpoints.

2. $(5y-1)(y+3) > 0$

Solve the corresponding equation.

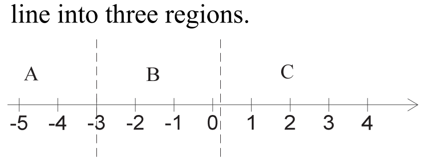
$(5y-1)(y+3) = 0$

$5y-1=0 \quad \text{or} \quad y+3=0$

$5y = 1 \qquad\qquad y=-3$

$y = \frac{1}{5}$

Note that because the inequality symbol is "<", $\frac{1}{5}$ and -3 are not solutions of the original inequality. These numbers separate the number line into three regions.



In region A, let $x = -6$:
$[5(-6)-1][-6+3] = 93 > 0$.
In region B, let $x = 0$:
$[5(0)-1][0+3] = -3 < 0$.
In region C, let $x = 2$:
$[5(2)-1][2+3] = 45 > 0$
The regions where $(5y-1)(y+3)$ is positive are regions A and C, so the solutions are $(-\infty, -3)$ and $\left(\frac{1}{5}, \infty\right)$. To graph this solution, put parentheses at –3 and $\frac{1}{5}$ and draw rays as shown below.

3. $r^2 + 4r > -3$

Solve the corresponding equation.

$r^2 + 4r = -3$

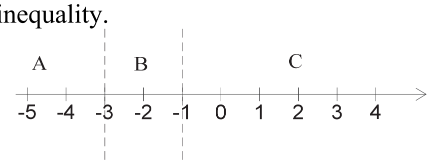
$r^2 + 4r + 3 = 0$

$(r+1)(r+3) = 0$

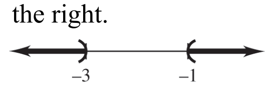
$r+1=0 \quad \text{or} \quad r+3=0$

$r=-1 \quad \text{or} \quad r=-3$

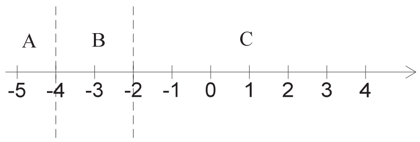
Note that because the inequality symbol is ">," –1 and –3 are not solutions of the original inequality.



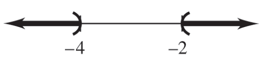
In region A, let $r = -4$:
$(-4)^2 + 4(-4) = 0 > -3$.
In region B, let $r = -2$:
$(-2)^2 + 4(-2) = -4 < -3$.
In region C, let $r = 0$:
$0^2 + 4(0) = 0 > -3$.
The solution is $(-\infty, -3)$ or $(-1, \infty)$.
To graph the solution, put a parenthesis at –3 and draw a ray extending to the left, and put a parenthesis at -1 and draw a ray extending to the right.



4. $z^2 + 6z > -8$
Solve the corresponding equation.
$z^2 + 6z = -8 \Rightarrow z^2 + 6z + 8 = 0$
$(z+2)(z+4) = 0$
$z + 2 = 0$ or $z + 4 = 0$
$z = -2$ or $z = -4$
Because the inequality symbol is ">", -2 and -4 are not solutions of the original inequality.

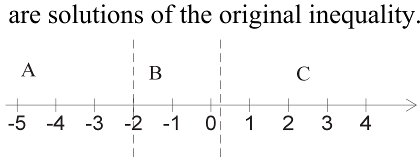


In region A, let $z = -5$:
$(-5)^2 + 6(-5) + 8 = 3 > 0$
In region B, let $z = -3$:
$(-3)^2 + 6(-3) + 8 = -1 < 0$
In region C, let $z = 0$:
$(0)^2 + 6(0) + 8 = 8 > 0$
The solution is $(-\infty, -4)$ or $(-2, \infty)$.



5. $4m^2 + 7m - 2 \le 0$
Solve the corresponding equation.
$4m^2 + 7m - 2 = 0$
$(4m-1)(m+2) = 0$
$4m - 1 = 0$ or $m + 2 = 0$
$m = \frac{1}{4}$ or $m = -2$

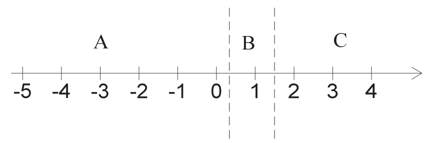
Because the inequality symbol is "≤" $\frac{1}{4}$ and -2 are solutions of the original inequality.



In region A, let $m = -3$:
$4(-3)^2 + 7(-3) - 2 = 13 > 0$.
In region B, let $m = 0$:
$4(0)^2 + 7(0) - 2 = -2 < 0$.
In region C, let $m = 1$:
$4(1)^2 + 7(1) - 2 = 9 > 0$.
The solution is $\left[-2, \frac{1}{4}\right]$.

6. $6p^2 - 11p + 3 \le 0$
Solve the corresponding equation.
$6p^2 - 11p + 3 = 0$
$(3p-1)(2p-3) = 0$
$3p - 1 = 0$ or $2p - 3 = 0$
$p = \frac{1}{3}$ or $p = \frac{3}{2}$

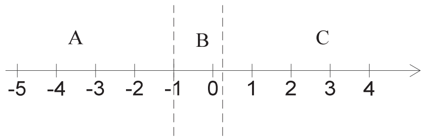
Because the inequality symbol is "≤," $\frac{1}{3}$ and $\frac{3}{2}$ are solutions of the original inequality. These points divide a number line into three regions.



In region A, let $p = 0$.
$6(0)^2 - 11(0) + 3 = 3 > 0$
In region B, let $p = 1$.
$6(1)^2 - 11(1) + 3 = -2 < 0$
In region C, let $p = 10$.
$6(10)^2 - 11(10) + 3 = 493 > 0$
The numbers in regions A and C do not satisfy the inequality, so the solution is $\left[\frac{1}{3}, \frac{3}{2}\right]$.

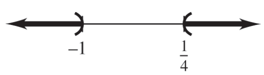
7. $4x^2 + 3x - 1 > 0$
Solve the corresponding equation.
$4x^2 + 3x - 1 = 0$
$(4x-1)(x+1) = 0$
$4x - 1 = 0$ or $x + 1 = 0$
$x = \frac{1}{4}$ or $x = -1$

Note that $\frac{1}{4}$ and -1 are not solutions of the original inequality.



In region A, let $x = -2$:
$4(-2)^2 + 3(-2) - 1 = 9 > 0$.
In region B, let $x = 0$:
$4(0)^2 + 3(0) - 1 = -1 < 0$.
In region C, let $x = 1$:
$4(1)^2 + 3(1) - 1 = 6 > 0$.

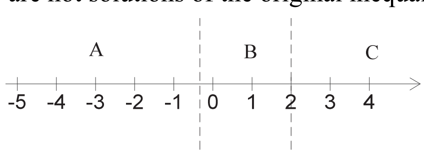
The solution is $(-\infty, -1)$ or $\left(\frac{1}{4}, \infty\right)$.



8. $3x^2 - 5x > 2 \Rightarrow 3x^2 - 5x - 2 > 0$
Solve the corresponding equation.

$$3x^2 - 5x - 2 = 0$$
$$(3x+1)(x-2) = 0$$
$$3x + 1 = 0 \quad \text{or} \quad x - 2 = 0$$
$$x = -\frac{1}{3} \quad \text{or} \quad x = 2$$

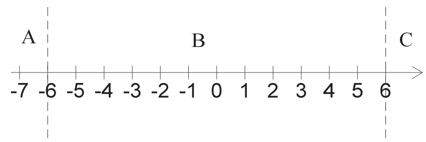
Because the inequality symbol is ">," $-\frac{1}{3}$ and 2 are not solutions of the original inequality.



In region A, let $x = -1$.
$3(-1)^2 - 5(-1) = 8 > 2$
In region B, let $x = 0$.
$3(0)^2 - 5(0) = 0 < 2$
In region C, let $x = 10$.
$3(10)^2 - 5(10) = 250 > 2$

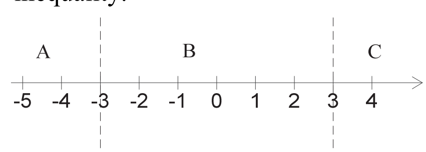
The numbers in regions A and C satisfy the inequality, so the solution is $\left(-\infty, -\frac{1}{3}\right)$ or $(2, \infty)$.

9. $x^2 \le 36$
Solve the corresponding equation.
$x^2 = 36 \Rightarrow x = \pm 6$

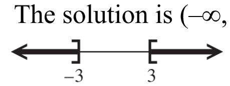


For region A, let $x = -7$: $(-7)^2 = 49 > 36$.
For region B, let $x = 0$: $0^2 = 0 < 36$.
For region C, let $x = 7$: $7^2 = 49 > 36$.
Both endpoints are included. The solution is $[-6, 6]$.

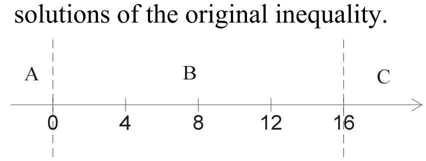
10. $y^2 \ge 9$
Solve the corresponding equation.
$y^2 = 9 \Rightarrow y = \pm 3$
Note that –3 and 3 are solutions to the original inequality.



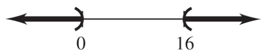
In region A, let $y = -4$:
$(-4)^2 = 16 > 9$
In region B, let $y = 0$:
$0^2 = 0 < 9$
In region C, let $y = 4$:
$(4)^2 = 16 > 9$
The solution is $(-\infty, -3]$ or $[3, \infty)$.



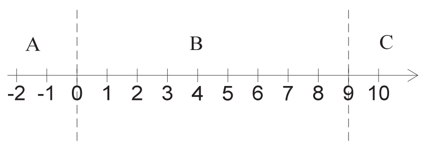
11. $p^2 - 16p > 0$
Solve the corresponding equation.
$p^2 - 16p = 0 \Rightarrow p(p - 16) = 0 \Rightarrow$
$p = 0$ or $p = 16$
Since the inequality is ">", 0 and 16 are not solutions of the original inequality.



For region A, let $p = -1$:
$(-1)^2 - 16(-1) = 17 > 0$.
For region B, let $p = 1$:
$1^2 - 16(1) = -15 < 0$.
For region C, let $p = 17$:
$17^2 - 16(17) = 17 > 0$.
The solution is $(-\infty, 0)$ or $(16, \infty)$.

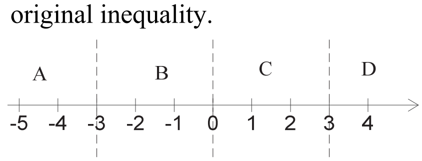


12. $r^2 - 9r < 0$
Solve the corresponding equation.
$r^2 - 9r = 0$
$r(r-9) = 0$
$r = 0$ or $r - 9 = 0$
$r = 0$ or $r = 9$
Note that 0 and 9 are not solutions to the original inequality.



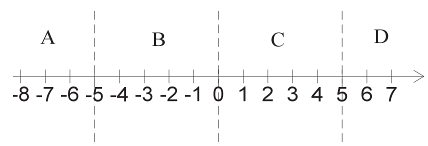
In region A, let $r = -1$:
$(-1)^2 - 9(-1) = 1 + 9 = 10 > 0$
In region B, let $r = 1$:
$(1)^2 - 9(1) = 1 - 9 = -8 < 0$
In region C, let $r = 10$:
$(10)^2 - 9(10) = 100 - 90 = 10 > 0$
The solution is (0, 9).

13. $x^3 - 9x \geq 0$
Solve the corresponding equation.
$x^3 - 9x = 0$
$x\left(x^2 - 9\right) = 0$
$x(x+3)(x-3) = 0$
$x = 0$ or $x = -3$ or $x = 3$
Note that 0, –3, and 3 are all solutions of the original inequality.



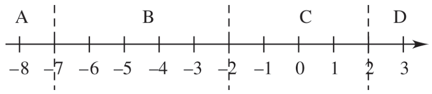
In region A, let $x = -4$:
$(-4)^3 - 9(-4) = -28 < 0$.
In region B, let $x = -1$:
$(-1)^3 - 9(-1) = 8 > 0$.
In region C, let $x = 1$:
$(1)^3 - 9(1) = -8 < 0$
In region D, let $x = 4$:
$4^3 - 9(4) = 28 > 0$.
The solution is [–3, 0] or $[3, \infty)$.

14. $p^3 - 25p \leq 0$
Solve the corresponding equation.
$p^3 - 25p = 0$
$p\left(p^2 - 25\right) = 0$
$p(p+5)(p-5) = 0$
$p = 0$ or $p = -5$ or $p = 5$
Because the inequality is "≤," 0, –5, and 5 are solutions of the original inequality. Locate these points and regions A, B, C, and D on a number line.



Test a number from each region in $p^3 - 25p \leq 0$.
In region A, let $p = -10$.
$(-10)^3 - 25(-10) = -750 \leq 0$
In region B, let $p = -1$.
$(-1)^3 - 25(-1) = 24 \geq 0$
In region C, let $p = 1$.
$1^3 - 25(1) = -24 \leq 0$
In region D, let $p = 10$.
$10^3 - 25(10) = 750 \geq 0$
The numbers in regions A and C satisfy the inequality, so the solution is $(-\infty, -5]$ or [0, 5].

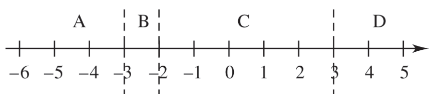
15. $(x+7)(x+2)(x-2) \geq 0$
Solve the corresponding equation.
$(x+7)(x+2)(x-2) = 0$
$x + 7 = 0$ or $x + 2 = 0$ or $x - 2 = 0$
$x = -7$ or $x = -2$ or $x = 2$
Note that –7, –2 and 2 are all solutions of the original inequality.



In region A, let $x = -8$:
$(-8 + 7)(-8 + 2)(-8 - 2) = -60 < 0$
In region B, let $x = -4$:
$(-4 + 7)(-4 + 2)(-4 - 2) = 36 > 0$
In region C, let $x = 0$:
$(0 + 7)(0 + 2)(0 - 2) = -28 < 0$
In region D, let $x = 3$:
$(3 + 7)(3 + 2)(3 - 2) = 50 > 0$
The solution is $[-7, -2]$ or $[2, \infty)$.

16. $(2x+4)\left(x^2-9\right) \le 0$

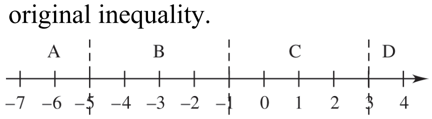
Solve the corresponding equation.
$(2x+4)(x^2-9) = 0$
$(2x+4)(x+3)(x-3) = 0$
$2x+4=0$ or $x+3=0$ or $x-3=0$
$x=-2$ or $x=-3$ or $x=3$
Note that –2, –3 and 3 are all solutions of the original inequality.



In region A, let $x = -5$:
$\left[2(-5)+4\right]\left[(-5)^2-9\right] = (-6)(16) = -96 < 0$
In region B, let $x = -2.5$:
$\left[2(-2.5)+4\right]\left[(-2.5)^2-9\right] = -1(-2.75)$
$= 2.75 > 0$
In region C, let $x = 0$:
$\left[2(0)+4\right]\left[(0)^2-9\right] = (4)(-9) = -36 < 0$
In region D, let $x = 4$:
$\left[2(4)+4\right]\left[(4)^2-9\right] = (12)(7) = 84 > 0$
The solution is $(-\infty, -3]$ or $[-2, 3]$.

17. $(x+5)\left(x^2-2x-3\right) < 0$

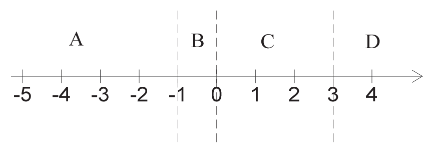
Solve the corresponding equation.
$(x+5)\left(x^2-2x-3\right) = 0$
$(x+5)(x+1)(x-3) = 0$
$x+5=0$ or $x+1=0$ or $x-3=0$
$x=-5$ or $x=-1$ or $x=3$
Note that –5, –1 and 3 are not solutions of the original inequality.



In region A, let $x = -6$:
$(-6+5)\left[(-6)^2-2(-6)-3\right] = (-1)(45)$
$= -45 < 0$
In region B, let $x = -2$:
$(-2+5)\left[(-2)^2-2(-2)-3\right] = 3(5) = 15 > 0$
In region C, let $x = 0$:
$(0+5)\left[(0)^2-2(0)-3\right] = 5(-3) = -15 < 0$
In region D, let $x = 4$:
$(4+5)\left[(4)^2-2(4)-3\right] = 9(5) = 45 > 0$
The solution is $(-\infty, -5)$ or $(-1, 3)$.

18. $x^3-2x^2-3x \le 0$

Solve the corresponding equation.
$x^3-2x^2-3x = 0$
$x\left(x^2-2x-3\right) = 0$
$x(x+1)(x-3) = 0$
$x = -1$ or $x = 0$ or $x = 3$
Note that –1, 0 and 3 are solutions of the original inequality.



In region A, let $x = -2$:
$(-2)^3-2(-2)^2-3(-2) = -8-8+6 = -10 < 0$
In region B, let $x = -\frac{1}{2}$:
$\left(-\frac{1}{2}\right)^3 - 2\left(\frac{1}{2}\right)^2 - 3\left(-\frac{1}{2}\right)$
$= -\frac{1}{8} - \frac{1}{2} + \frac{3}{2} = \frac{7}{8} > 0$
In region C, let $x = 1$:
$1^3-2(1)^2-3(1) = 1-2-3 = -4 < 0$
In region D, let $x = 4$:
$4^3-2(4)^2-3(4) = 64-32-12 = 20 > 0$
The solution is $[-\infty, -1]$ or $[0, 3]$

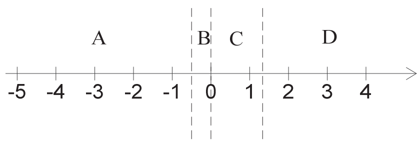
19. $6k^3 - 5k^2 < 4k \Rightarrow 6k^3 - 5k^2 - 4k < 0$

Solve the corresponding equation.

$$6k^3 - 5k^2 - 4k = 0$$
$$k\left(6k^2 - 5k - 4\right) = 0$$
$$k(3k-4)(2k+1) = 0$$

k = 0 or $k = \frac{4}{3}$ or $k = -\frac{1}{2}$

Note that 0, $\frac{4}{3}$, and $-\frac{1}{2}$ are not solutions of the original inequality.



In region A, let $k = -1$:

$6(-1)^3 - 5(-1)^2 - 4(-1) = -7 < 0$

In region B, let $k = -\frac{1}{4}$:

$6\left(-\frac{1}{4}\right)^3 - 5\left(-\frac{1}{4}\right)^2 - 4\left(-\frac{1}{4}\right) = \frac{19}{32} > 0;$

In region C, let $k = 1$:

$6(1)^3 - 5(1)^2 - 4(1) = -3 < 0$

In region D, let $k = 10$:

$6(10)^3 - 5(10)^2 - 4(10) = 5460$

The given inequality is true in regions A and C.

The solution is $\left(-\infty, -\frac{1}{2}\right)$ or $\left(0, \frac{4}{3}\right)$.

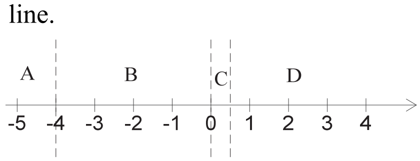
20. $2m^3 + 7m^2 > 4m \Rightarrow 2m^3 + 7m^2 - 4m > 0$

Solve the corresponding equation.

$$2m^3 + 7m^2 - 4m = 0$$
$$m\left(2m^2 + 7m - 4\right) = 0$$
$$m(2m-1)(m+4) = 0$$

$m = 0$ or $m = \frac{1}{2}$ or $m = -4$

Since the inequality is ">," 0, $\frac{1}{2}$, and –4 are not solutions of the original inequality. Locate these points and regions, A, B, C, and D on a number line.



In region A, let $m = -10$.

$2(-10)^3 + 7(-10)^2 - 4(-10) = -1260 < 0$

In region B, let $m = -1$.

$2(-1)^3 + 7(-1)^2 - 4(-1) = 9 > 0$

In region C, let $m = \frac{1}{4}$.

$2\left(\frac{1}{4}\right)^3 + 7\left(\frac{1}{4}\right)^2 - 4\left(\frac{1}{4}\right) = -\frac{17}{32} < 0$

In region D, let $m = 1$.

$2(1)^3 + 7(1)^2 - 4(1) = 5 > 0$

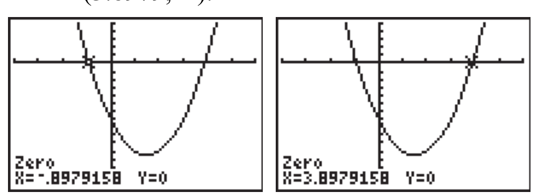
The numbers in regions B and D satisfy the inequality, so the solution is (–4, 0) or $\left(\frac{1}{2}, \infty\right)$.

21. The inequality $p^2 < 16$ should be rewritten as $p^2 - 16 < 0$ and solved by the method shown in this section for solving quadratic inequalities. This method will lead to the correct solution (–4, 4). The student's method and solution are incorrect.

22. To solve $6x + 7 < 2x^2$, write the inequality as $2x^2 - 6x - 7 > 0$.

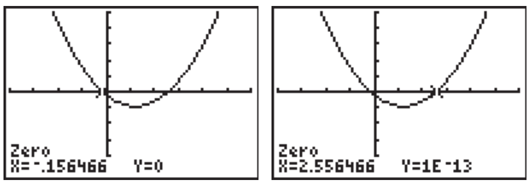
Graph the equation $y = 2x^2 - 6x - 7$.

Enter this equation as y_1 and use $-4 < x < 4$ and $-15 < y < 5$. On the CALC menu, use "zero" to find the *x*-values where the graph crosses the *x*-axis. These values are $x = -0.8979$ and $x = 3.8979$. The graph is above the *x*-axis to the left of – 0.8979 and to the right of 3.8979. The solution of the inequality is (–∞,–0.8979) or (3.8979, ∞).



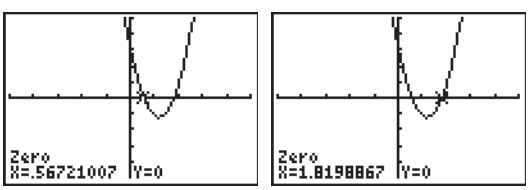
[–4, 6] by [–15,5]

23. To solve $.5x^2 - 1.2x < .2$,write the inequality as $.5x^2 - 1.2x - .2 < 0$. Graph the equation $y = .5x^2 - 1.2x - .2$. Enter this equation as y_1 and use $-4 \le x \le 6$ and $-5 \le y \le 5$. On the CALC menu, use "zero" to find the x-values where the graph crosses the x-axis. These values are $x = -.1565$ and $x = 2.5565$. The graph is below the x-axis between these two values. The solution of the inequality is $(-.1565, 2.5565)$.



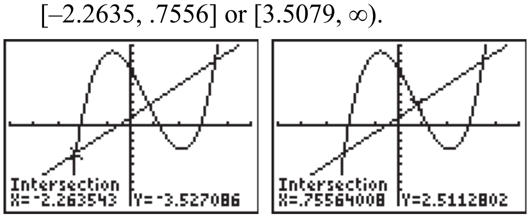
[–4, 6] by [–5,5]

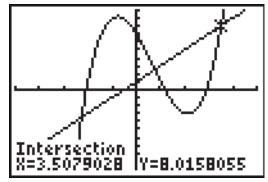
24. To solve $3.1x^2 - 7.4x + 3.2 > 0$, graph the equation $y = 3.1x^2 - 7.4x + 3.2$. Enter this equation as y_1 and use $-5 \le x \le 5$ and $-5 \le y \le 5$. On the CALC menu, use "zero" to find the x-values where the graph crosses the x-axis. These values are $x = .5672$ and $x = 1.8199$. The graph is above the x-axis to the left of .5672 and to the right of 1.8199. The solution of the inequality is $(-\infty, .5672)$ or $(1.8199, \infty)$.



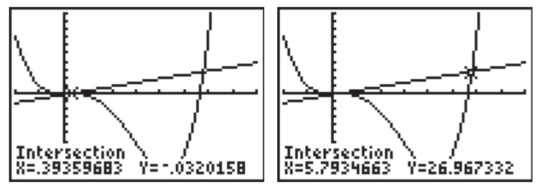
[–5, 5] by [–5, 5]

25. To solve $x^3 - 2x^2 - 5x + 7 \ge 2x + 1$, graph $y_1 = x^3 - 2x^2 - 5x + 7$ and $y_2 = 2x + 1$ in the window [–5, 5] by[–10, 10]. On the CALC menu, use "intersect" to find the x-values where the graphs intersect. These values are $x = -2.2635$, $x = .7556$ and $x = 3.5079$. The graph of y_1 is above the graph of y_2 for $[-2.2635, .7556]$ or $[3.5079, \infty)$.

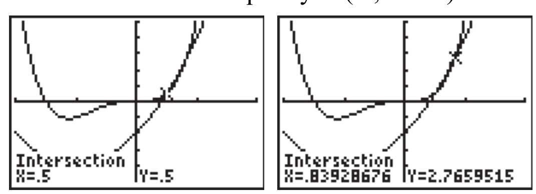




26. To solve $x^4 - 6x^3 + 2x^2 < 5x - 2$, graph $y_1 = x^4 - 6x^3 + 2x^2$ and $y_2 = 5x - 2$ in the window [–2, 8] by[–100, 100]. On the CALC menu, use "intersect" to find the x-values where the graphs intersect. These values are $x = .3936$ and $x = 5.7935$. The graph of y_1 is below the graph of y_2 for (.3936, 5.7935), so the solution is (.3936, 5.7935).



27. To solve $2x^4 + 3x^3 < 2x^2 + 4x - 2$, graph $y_1 = 2x^4 + 3x^3$ and $y_2 = 2x^2 + 4x - 2$ in the window [–2, 2] by[–5, 5]. On the CALC menu, use "intersect" to find the x-values where the graphs intersect. These values are $x = .5$ and $x = .8393$. The graph of y_1 is below the graph of y_2 to the right of .5 and to the left of .8393. The solution of the inequality is (.5, .8393).



28. To solve $x^5 + 5x^4 > 4x^3 - 3x^2 - 2$, graph $y_1 = x^5 + 5x^4$ and $y_2 = 4x^3 - 3x^2 - 2$ in the window [–8, 4] by[–1600, 400]. There is clearly one intersection near $x = -6$. On the CALC menu, use "intersect" to find this value, $x = -5.78323$. Next, change the window to [–2, 2] by [–5, 5] to examine the behavior of the graphs near the origin. From this view, it is clear that the graphs do not intersect, and y_1 is below the graph of y_2 The graph of y_1 is above the graph of y_2 for $(-5.78323, \infty)$.

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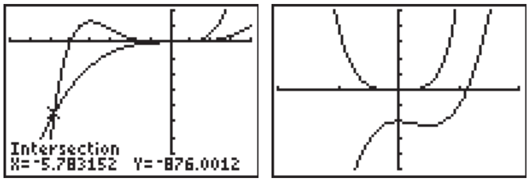
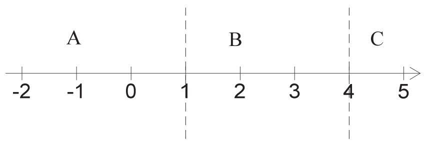


29. $\dfrac{r-4}{r-1} \ge 0$

Solve the corresponding equation.

$\dfrac{r-4}{r-1} = 0$

The quotient can change sign only when the numerator is 0 or the denominator is 0. The numerator is 0 when $r = 4$. The denominator is 0 when $r = 1$. Note that 4 is a solution of the original inequality, but 1 is not.



In region A, let $r = 0$:

$\dfrac{0-4}{0-1} = 4 > 0$.

In region B, let $r = 2$:

$\dfrac{2-4}{2-1} = -2 < 0$.

In region C, let $r = 5$:

$\dfrac{5-3}{5-1} = \dfrac{1}{4} > 0$.

The given inequality is true in regions A and C, so the solution is $(-\infty, 1)$ or $[4, \infty)$.

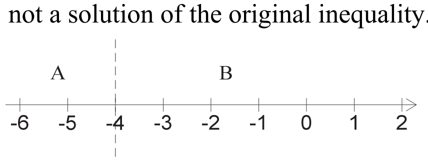
30. $\dfrac{z+6}{z+4} > 1$

Solve the corresponding equation is $\dfrac{z+6}{z+4} = 1$.

$\dfrac{z+6}{z+4} = 1 \Rightarrow \dfrac{z+6}{z+4} - 1 = 0 \Rightarrow$

$\dfrac{z+6}{z+4} - \dfrac{z+4}{z+4} = 0 \Rightarrow \dfrac{2}{z+4} = 0$

Therefore, the function has no solutions. The denominator is zero when $z = -4$. Note that -4 is not a solution of the original inequality.



Test a number from each region in the original inequality.

In region A, let $z = -6$.

$\dfrac{-6+6}{-6+4} = 0 < 1$

In region B, let $z = 0$.

$\dfrac{0+6}{0+4} = \dfrac{3}{2} > 1$

The numbers in region B satisfy the inequality, so the solution is $(-4, \infty)$.

31. $\dfrac{a-2}{a-5} < -1$

Solve the corresponding equation.

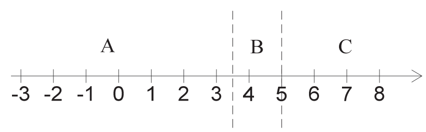
$$\dfrac{a-2}{a-5} = -1$$

$$\dfrac{a-2}{a-5} + 1 = 0$$

$$\dfrac{a-2}{a-5} + \dfrac{a-5}{a-5} = 0$$

$$\dfrac{2a-7}{a-5} = 0$$

The numerator is 0 when $a = \dfrac{7}{2}$. The denominator is 0 when $a = 5$. Note that $\dfrac{7}{2}$ and 5 are not solutions of the original inequality.



In region A, let $a = 0$:

$\dfrac{0-2}{0-5} = \dfrac{2}{5} > -1$.

In region B, let $a = 4$:

$\dfrac{4-2}{4-5} = \dfrac{2}{-1} = -2 < -1$.

In region C, let $a = 10$:

$\dfrac{10-2}{10-5} = \dfrac{8}{5} > -1$.

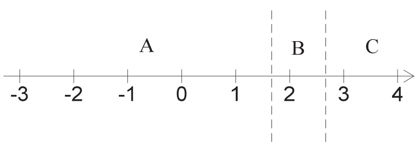
The solution is $\left(\dfrac{7}{2}, 5\right)$.

32. $\frac{1}{3k-5} < \frac{1}{3}$

Solve the corresponding equation

$$\frac{1}{3k-5} = \frac{1}{3}$$
$$\frac{1}{3k-5} - \frac{1}{3} = 0$$
$$\frac{3 \cdot 1}{3(3k-5)} - \frac{1(3k-5)}{3(3k-5)} = 0$$
$$\frac{3-(3k-5)}{3(3k-5)} = 0$$
$$\frac{3-3k+5}{3(3k-5)} = 0$$
$$\frac{8-3k}{3(3k-5)} = 0$$

The numerator is zero when $k = \frac{8}{3}$. The denominator is zero when $k = \frac{5}{3}$. Note that $\frac{8}{3}$ and $\frac{5}{3}$ are not solutions of the original inequality.



Test a number from each region in the original inequality.

In region A, let $k = 0$.

$$\frac{1}{3(0)-5} = -\frac{1}{5} < \frac{1}{3}$$

In region B, let $k = 2$.

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

In region C, let $k = 3$.

$$\frac{1}{3(3)-5} = \frac{1}{4} < \frac{1}{3}$$

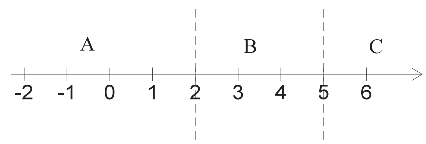
The numbers in regions A and C satisfy the inequality, so the solution is $\left(-\infty, \frac{5}{3}\right)$ or $\left(\frac{8}{3}, \infty\right)$.

33. $\frac{1}{p-2} < \frac{1}{3}$

Solve the corresponding equation.

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

The numerator is 0 when $p = 5$. The denominator is 0 when $p = 2$. Note that 2 and 5 are not solutions of the original inequality.



In region A, let $p = 0$: $\frac{1}{0-2} = -\frac{1}{2} < \frac{1}{3}$.

In region B, let $p = 3$: $\frac{1}{3-2} = 1 > \frac{1}{3}$.

In region C, let $p = 6$: $\frac{1}{6-2} = \frac{1}{4} < \frac{1}{3}$.

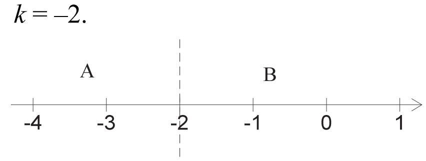
The solution is $(-\infty, 2)$ or $(5, \infty)$.

34. $\frac{7}{k+2} \geq \frac{1}{k+2}$

Solve the corresponding equation.

$$\frac{7}{k+2} = \frac{1}{k+2}$$
$$\frac{7}{k+2} - \frac{1}{k+2} = 0$$
$$\frac{6}{k+2} = 0$$

Therefore, the numerator is never zero, but the denominator is zero when $k + 2 = 0$ or $k = -2$, but the inequality is undefined when $k = -2$.



Test a number from each region in the original inequality.
For region A, let $k = -3$.

$\frac{7}{-3+2} = -7$ and $\frac{1}{-3+2} = -1$

Since $-7 \le -1$, -3 is not a solution of the inequality.
For region B, let $k = 0$.

$\frac{7}{0+2} = \frac{7}{2}$ and $\frac{1}{0+2} = \frac{1}{2}$

Since $\frac{7}{2} \ge \frac{1}{2}$, 0 is a solution of the inequality.

The numbers from region B satisfy the inequality, so the solution is $(-2, \infty)$.

35. $\frac{5}{p+1} > \frac{12}{p+1}$

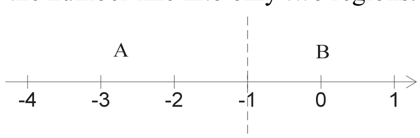
Solve the corresponding equation.

$$\frac{5}{p+1} = \frac{12}{p+1}$$

$$\frac{5}{p+1} - \frac{12}{p+1} = 0$$

$$\frac{-7}{p+1} = 0$$

The numerator is never 0. The denominator is 0 when $p = -1$. Therefore, in this case, we separate the number line into only two regions.



In region A, let $p = -2$:

$$\frac{5}{-2+1} = -5$$

$$\frac{12}{-2+1} = -12$$

$$-5 > -12$$

In region B, let $p = 0$:

$$\frac{5}{0+1} = 5$$

$$\frac{12}{0+1} = 12$$

$$12 > 5$$

Therefore, the given inequality is true in region A. The only endpoint, –1, is not included because the symbol is ">." Therefore, the solution is $(-\infty, -1)$.

36. $\frac{x^2 - 4}{x} > 0$

Solve the corresponding equation.

$$\frac{x^2 - 4}{x} = 0$$

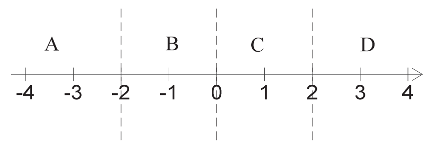
$$x^2 - 4 = 0 \quad \text{or} \quad x = 0$$

$$(x-2)(x+2) = 0 \quad \text{or} \quad x = 0$$

$$x - 2 = 0 \quad \text{or} \quad x + 2 = 0 \quad \text{or} \quad x = 0$$

$$x = 2 \quad \text{or} \quad x = -2 \quad \text{or} \quad x = 0$$

Note that –2, 0 and 2 are not solutions of the original inequality.



In region A, let $x = -3$,

$\frac{(-3)^2 - 4}{-3} = \frac{9-4}{-3} = \frac{-5}{3} < 0$.

In region B, let $x = -1$:

$\frac{(-1)^2 - 4}{-1} = \frac{1-4}{-1} = 3 > 0$.

In region C, let $x = 1$:

$\frac{1^2 - 4}{1} = \frac{-3}{1} = -3 < 0$.

In region D, let $x = 3$:

$\frac{3^2 - 4}{3} = \frac{9-4}{3} = \frac{5}{3} > 0$.

The solution is $(-2, 0)$ or $(2, \infty)$.

37. $\frac{x^2 - x - 6}{x} < 0$

Solve the corresponding equation.

$$\frac{x^2 - x - 6}{x} = 0$$

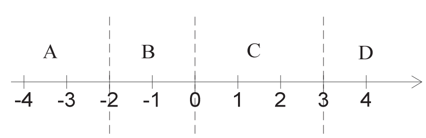
$$x^2 - x - 6 = 0 \quad \text{or} \quad x = 0$$

$$(x-3)(x+2) = 0 \quad \text{or} \quad x = 0$$

$$x - 3 = 0 \quad \text{or} \quad x + 2 = 0 \quad \text{or} \quad x = 0$$

$$x = 3 \quad \text{or} \quad x = -2 \quad \text{or} \quad x = 0$$

Note that –2, 0 and 3 are not solutions of the original inequality.



In region A, let $x = -3$:

$\frac{(-3)^2 - (-3) - 6}{-3} = \frac{9 + 3 - 6}{-3} = \frac{6}{-3} = -2 < 0$.

In region B, let $x = -1$:

$\frac{(-1)^2 - (-1) - 6}{-1} = \frac{1 + 1 - 6}{-1} = \frac{-4}{-1} = 4 > 0$

In region C, let $x = 1$:

$\frac{1^2 - 1 - 6}{1} = -6 < 0$.

In region D, let $x = 4$:

$\frac{4^2 - 4 - 6}{4} = \frac{16 - 10}{4} = \frac{6}{4} = \frac{3}{2} > 0$.

The solution is $(-\infty, -2)$ or $(0, 3)$.

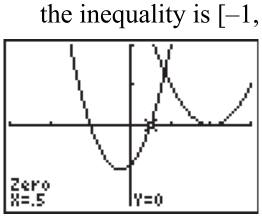
38. **a.** When $x > -4 \Rightarrow x + 4 > 0$, let $x = 0$. $0 + 4 = 4 > 0$ is positive. Therefore $x + 4$ is positive when $x > -4$.

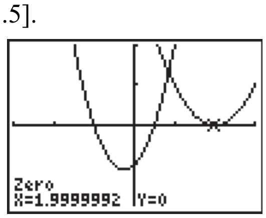
b. When $x < -4 \Rightarrow x + 4 < 0$, $x + 4$ is negative. Let $x = -5$. $-5 + 4 = -1 < 0$.

c. When $x > -4$, the quantity $x + 4$ is positive, so you don't change the direction of the inequality. When $x < -4$, $x + 4$ is negative, so you must change the direction of the inequality sign.

d. Answers vary, but you must consider two separate cases ($x > -4$ and $x < -4$) and solve the inequality in each case.

39. To solve $\frac{2x^2 + x - 1}{x^2 - 4x + 4} \le 0$, break the inequality into two inequalities $2x^2 + x - 1 \le 0$ and $x^2 - 4x + 4 \le 0$. Graph the equations $y = 2x^2 + x - 1$ and $y = x^2 - 4x + 4$. Enter these equations as y_1 and y_2, and use $-3 < x < 3$ and $-2 < y < 2$. On the CALC menu, use "zero" to find the x-values where the graphs cross the x-axis. These values for y_1 are $x = -1$ and $x = .5$. The graph of y_1 is below the x-axis to the right of -1 and to the left of .5. The graph of y_2 is never below the x-axis. The solution of the inequality is $[-1, .5]$.





40. To solve $\frac{x^3 - 3x^2 + 5x - 29}{x^2 - 7} > 3$, rewrite the inequality with 0 on one side.

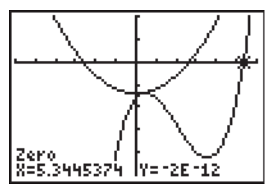
$$\frac{x^3 - 3x^2 + 5x - 29}{x^2 - 7} - 3 > 0$$

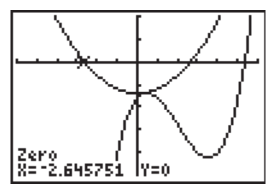
$$\frac{x^3 - 3x^2 + 5x - 29 - 3\left(x^2 - 7\right)}{x^2 - 7} > 0$$

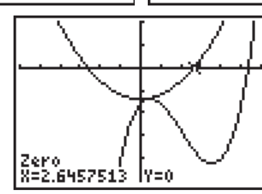
$$\frac{x^3 - 3x^2 + 5x - 29 - 3x^2 + 21}{x^2 - 7} > 0$$

$$\frac{x^3 - 6x^2 + 5x - 8}{x^2 - 7} > 0$$

Now break the inequality into two inequalities: $x^3 - 6x^2 + 5x - 8 > 0$ and $x^2 - 7 > 0$. Graph the equations $y = x^3 - 6x^2 + 5x - 8$ and $y = x^2 - 7$. Enter these equations as y_1 and y_2, and use $-6 < x < 6$ and $-25 < y < 10$. On the CALC menu, use "zero" or "root" to find the x-values where the graphs cross the x-axis. The value for y_1 is $x = 5.3445$. The graph of y_1 is above the x-axis to the right of 5.3445. The values for y_2 are $x = -2.6458$ and $x = 2.6458$. The graph of y_2 is above the x-axis to the left of -2.6458 and to the right of 2.6458. The solution of the inequality is $\left(-\sqrt{7}, \sqrt{7}\right)$ or $(5.3445, \infty)$.







41. $P = 2x^2 - 12x - 32$

The company makes a profit when

$2x^2 - 12x - 32 > 0$.

Solve the corresponding equation.

$$2x^2 - 12x - 32 = 0$$
$$2\left(x^2 - 6x - 16\right) = 0$$
$$(x+2)(x-8) = 0 \Rightarrow x = -2 \text{ or } x = 8$$

The test regions are $A(-\infty, -2)$, $B(-2, 8)$, and $C(8, \infty)$. Region A makes no sense in this context, so we ignore this. Test a number from regions B and C in the original inequality.

For region B, let $x = 0$.

$2(0)^2 - 12(0) - 32 = -32 < 0$

For region C, let $x = 10$.

$2(10)^2 - 12(10) - 32 = 48 > 0$

The numbers in region C satisfy the inequality. The company makes a profit when the amount spent on advertising in hundreds of thousands of dollars is in the interval $(8, \infty)$.

42. $P = 4t^2 - 30t + 14$

We want to find the values of t for which $P > 0$, that is, we must solve the inequality

$4t^2 - 30t + 14 > 0$.

Solve the corresponding equation.

$$4t^2 - 30t + 14 = 0$$
$$2\left(2t^2 - 15t + 7\right) = 0$$
$$(2t-1)(t-7) = 0 \Rightarrow t = \frac{1}{2} \text{ or } t = 7$$

We only consider positive values of t because t represents time (in months). The test regions are $A\left(0, \frac{1}{2}\right)$, $B\left(\frac{1}{2}, 7\right)$, and $C(7, \infty)$.

In region A, let $t = \frac{1}{4}$.:

$$4\left(\frac{1}{4}\right)^2 - 30\left(\frac{1}{4}\right) + 14 = \frac{27}{4} > 0.$$

In region B, let $t = 3$:

$4(3)^2 - 30(3) + 14 = -40 < 0.$

In region C, let $t = 10$:

$4(10)^2 - 30(10) + 14 = 114 > 0..$

The solution is $\left(0, \frac{1}{2}\right)$ or $(7, \infty)$.

The investor makes a profit between $t = 0$ and $t = \frac{1}{2}$ month and after 7 months.

43. $P = x^2 + 300x - 18{,}000$

The complex makes a profit when

$x^2 + 300x - 18{,}000 > 0$.

Solve the corresponding equation.

$$0 = x^2 + 300x - 18{,}000$$
$$x = \frac{-300 \pm \sqrt{(300)^2 - 4(1)(-18{,}000)}}{2(1)}$$

$x \approx 51.25$ or $x \approx -351.25$

We only consider positive values of x because x represents the number of apartments rented.

The test regions are $A(0, 52)$ and $B(52, 200)$.

In region A, let $x = 1$:

$(1)^2 + 300(1) - 18{,}000 = -17{,}699 < 0$.

In region B, let $x = 100$:

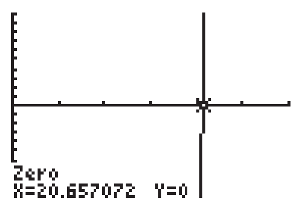
$(100)^2 + 300(100) - 18{,}000 = 22{,}000 > 0$.

The complex makes a profit when the number of units rented is between 52 and 200, inclusive, or when x is in the interval [52, 200].

44. $x^2 + 5x - 530 > 0$

Use a graphing calculator to solve

$x^2 + 5x - 530 = 0$



[0, 30] by [–10, 10]

The graph lies above the x-axis for $x > 20.657$. Thus, the salesman needs to make 21 pitches or more to earn a profit.

Chapter 2 Review Exercises

1. $y = x^2 - 2x - 5$

$(-2, 3)$:

$(-2)^2 - 2(-2) - 5 = 4 + 4 - 5 = 3$

$(0, -5)$

$(0)^2 - 2(0) - 5 = 0 - 0 - 5 = -5$

$(2, -3)$:

$(2)^2 - 2(2) - 5 = 4 - 4 - 5 = -5 \neq -3$

$(3, -2)$:

$(3)^2 - 2(3) - 5 = 9 - 6 - 5 = -2$

$(4, 3)$:

$(4)^2 - 2(4) - 5 = 16 - 8 - 5 = 3$

$(7, 2)$:

$(7)^2 - 2(7) - 5 = 49 - 14 - 5 = 30 \neq 2$

Solutions are (–2, 3), (0, –5), (3, –2), (4, 3).

2. $x - y = 5$

$(-2, 3): -2 - 3 = -5 \neq 5$

$(0, -5): 0 - (-5) = 0 + 5 = 5$

$(2, -3): 2 - (-3) = 2 + 3 = 5$

$(3, -2): 3 - (-2) = 3 + 2 = 5$

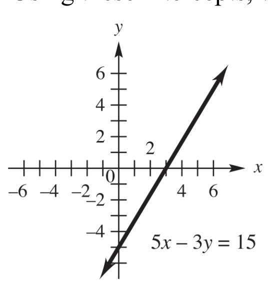
$(4, 3): 4 - 3 = 1 \neq 5$

$(7, 2): 7 - 2 = 5$

Solutions are (0, –5), (2, –3), (3, –2), (7, 2).

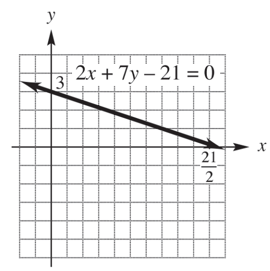
3. $5x - 3y = 15$

First, we find the y-intercept. If $x = 0$, $y = -5$, so the y-intercept is –5. Next we find the x-intercept. If $y = 0$, $x = 3$, so the x-intercept is 3. Using these intercepts, we graph the line.



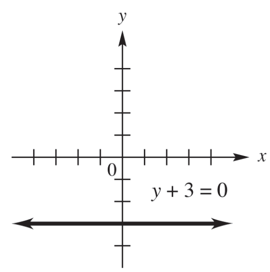
4. $2x + 7y - 21 = 0$

First we find the y-intercept. If $x = 0$, $y = 3$, so the y-intercept is 3. Next we find the x-intercept. If $y = 0$, $x = \frac{21}{2}$, so the x-intercept is $\frac{21}{2}$. Using these intercepts, we graph the line.



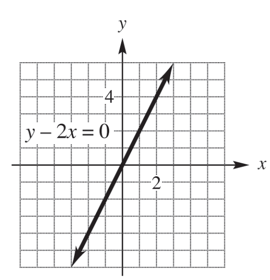
5. $y + 3 = 0$

The equation may be rewritten as $y = -3$. The graph of $y = -3$ is a horizontal line with y-intercept of –3.



6. $y - 2x = 0$

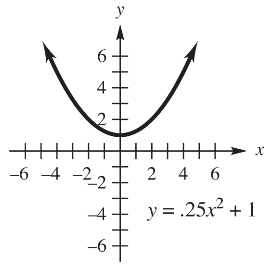
First, we find the y-intercept. If $x = 0$, $y = 0$, so the y-intercept is 0. Since the line passes through the origin, the x-intercept is also 0. We find another point on the line by arbitrarily choosing a value for x. Let $x = 2$. Then $y - 2(2) = 0$, or $y = 4$. The point with coordinates (2, 4) is on the line. Using this point and the origin, we graph the line.



7. $y = .25x^2 + 1$

First we find the y-intercept. If $x = 0$, $y = .25(0)^2 + 1 = 1$, so the y-intercept is 1. Next we find the x-intercepts. If $y = 0$, $0 = .25x^2 + 1 \Rightarrow .25x^2 = -1 \Rightarrow x = \sqrt{-4}$, not a real number. There are no x-intercepts.
Make a table of points and plot them.

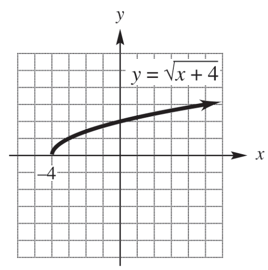
x	$.25x^2 + 1$
–4	5
–2	2
0	1
2	2
4	5



8. $y = \sqrt{x+4}$

Make a table of points and plot them.

x	$\sqrt{x+4}$
–4	0
–3	1
0	2
5	3



9. **a.** The temperature was over 55° from about 11:30 a.m. to about 7:30 p.m.

b. The temperature was below 40° from midnight until about 5 a.m., and after about 10:30 p.m.

10. At noon in Bratenahl the temperature was about 57°. The temperature in Greenville is 57° when the temperature in Bratenahl is 50°, or at about 10:30 a.m. and 8:30 p.m.

11. Answers vary. A possible answer is "rise over run".

12. Through (–1, 3) and (2, 6)

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{6-3}{2-(-1)} = \frac{3}{3} = 1$$

13. Through (4, –5) and (1, 4)

$$\text{slope} = \frac{-5-4}{4-1} = \frac{-9}{3} = -3$$

14. Through (8, –3) and the origin
The coordinates of the origin are (0, 0).

$$\text{slope} = \frac{-3-0}{8-0} = -\frac{3}{8}$$

15. Through (8, 2) and (0, 4)

$$\text{slope} = \frac{4-2}{0-8} = \frac{2}{-8} = -\frac{1}{4}$$

In exercises 16 and 17, we give the solution by rewriting the equation in slope-intercept form. Alternatively, the solution can be obtained by determining two points on the line and then using the definition of slope.

16. $3x + 5y = 25$
First we solve for y.

$$5y = -3x + 25 \Rightarrow y = -\frac{3}{5}x + 5$$

When the equation is written in slope-intercept form, the coefficient of x gives the slope. The slope is $-\frac{3}{5}$.

17. $6x - 2y = 7$
First we solve for y.

$$6x - 2y = 7 \Rightarrow 6x - 7 = 2y \Rightarrow 3x - \frac{7}{2} = y$$

The coefficient of x gives the slope, so the slope is 3.

18. $x - 2 = 0$
The graph of $x - 2 = 0$ is a vertical line. Therefore, the slope is undefined.

19. $y = -4$
The graph of $y = -4$ is a horizontal line. Therefore, the slope is 0.

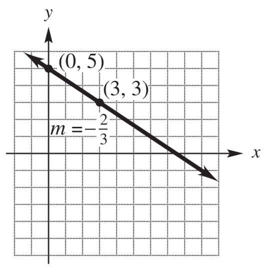
20. Parallel to $3x + 8y = 0$
First, find the slope of the given line by solving for y.

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

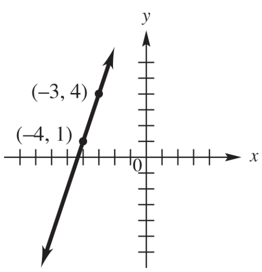
The slope is the coefficient of x, $-\frac{3}{8}$. A line parallel to this line has the same slope, so the slope of the parallel line is also $-\frac{3}{8}$.

21. Perpendicular to $x = 3y$
First, find the slope of the given line by solving for y: $y = \frac{1}{3}x$
The slope of this line is the coefficient of x, $\frac{1}{3}$.
The slope of a line perpendicular to this line is the negative reciprocal of this slope, so the slope of the perpendicular line is –3.

22. Through (0, 5) with $m = -\frac{2}{3}$
Since $m = -\frac{2}{3} = \frac{-2}{3}$, we start at the point with coordinates (0, 5) and move 2 units down and 3 units to the right to obtain a second point on the line. Using these two points, we graph the line.



23. Through (–4, 1) with m = 3
Since $m = 3 = \frac{3}{1}$, we start at the point with coordinates (–4, 1) and move 3 units up and 1 unit to the right to obtain a second point on the line. Using these two points, we graph the line.



24. Answers vary. One example is:
You need two points; one point and the slope; the y-intercept and the slope.

25. Through (5, –1), slope $\frac{2}{3}$
Use the point slope form with $x_1 = 5,\ y_1 = -1$, and $m = \frac{2}{3}$.

$$y - y_1 = m(x - x_1)$$
$$y - (-1) = \frac{2}{3}(x - 5)$$
$$y + 1 = \frac{2}{3}x - \frac{10}{3}$$

Multiplying by 3 gives

$$3y + 3 = 2x - 10$$
$$3y = 2x - 13$$

26. Through (8, 0), $m = -\frac{1}{4}$

$$y - 0 = -\frac{1}{4}(x - 8)$$
$$4y = -1(x - 8)$$
$$4y = -x + 8$$

27. Through (5, –2) and (1, 3)

$$m = \frac{3 - (-2)}{1 - 5} = \frac{5}{-4} = -\frac{5}{4}$$
$$y - 3 = -\frac{5}{4}(x - 1)$$
$$4(y - 3) = -5(x - 1)$$
$$4y - 12 = -5x + 5$$
$$4y = -5x + 17$$

28. (2, –3) and (–3, 4)

$$m = \frac{-3 - 4}{2 - (-3)} = -\frac{7}{5}$$
$$y - (-3) = -\frac{7}{5}(x - 2)$$
$$5(y + 3) = -7(x - 2)$$
$$5y + 15 = -7x + 14$$
$$5y = -7x - 1$$

29. Undefined slope, through (–1, 4)
This is a vertical line. Its equation is $x = -1$.

30. Slope 0, (–2, 5)
This is a horizontal line. Its equation is $y = 5$.

31. x-intercept –3, y-intercept 5
Use the points (–3, 0) and (0, 5).

$$m = \frac{5-0}{0-(-3)} = \frac{5}{3}$$
$$y = \frac{5}{3}x + 5$$
$$3y = 3(\tfrac{5}{3}x+5)$$
$$3y = 5x + 15$$

32. x-intercept 3, y-intercept 2.
Use the points $(3, 0)$ and $(0, 2)$.

$$m = \frac{2-0}{0-3} = -\frac{2}{3}$$
$$y = -\frac{2}{3}x + 2$$
$$3y = 3\left(-\frac{2}{3}x + 2\right)$$
$$3y = -2x + 6$$
$$2x + 3y = 6$$

The answer is (d).

33. a. Let (x_1, y_1) be (10, .8) and (x_2, y_2) be (15, 1.2). Find the slope.

$$m = \frac{1.2-.8}{15-10} = \frac{.4}{5} = .08$$
$$y - .8 = .08(x-10)$$
$$y - .8 = .08x - .8$$
$$y = .08x$$

b. The slope is positive because the total owed on federal student loans is increasing.

c. The year 2017 corresponds to $x = 17$.
$$y = .08(17) = 1.36$$
If the linear trend continued, there was \$1.36 trillion owed on federal student loans in 2017.

34. a. Let (x_1, y_1) be (11, 175) and (x_2, y_2) be (16, 337). Find the slope.

$$m = \frac{337-175}{16-11} = \frac{162}{5} = 32.4$$
$$y - 175 = 32.4(x-11)$$
$$y - 175 = 32.4x - 356.4$$
$$y = 32.4x - 181.4$$

b. The slope is positive because the number of bunts per plate appearance is increasing.

c. The year 2017 corresponds to $x = 17$.
$$y = 32.4(17) - 181.4 = 369.4$$
If the linear trend continued, there was 1 bunt for every 369.4 plate appearances in 2017.

35. a. Let (x_1, y_1) be (5, 46326) and (x_2, y_2) be (10, 49276).
Find the slope.

$$m = \frac{49,276-46,326}{10-5} = \frac{2,950}{5} = 590$$
$$y - 46,326 = 590(x-5)$$
$$y - 46,326 = 590x - 2,950$$
$$y = 590x + 43,376$$

b. Using a graphing calculator, the least squares regression line is
$$y = 964.6x + 40,833.$$

c. The year 2015 corresponds to $x = 15$. Using the two-point model, we have
$$y = 590(15) + 43,376 = 52,226.$$
Using the regression model, we have
$$y = 964.6(15) + 40,833 = 55,302.$$
The two-point model is off by \$4,290, while the regression model is off by \$1,214, therefore the least-squares approximation is a better estimate.

d. The year 2018 corresponds to $x = 18$.
Regression model:
$$y = 964.6(18) + 40,833 \approx 58,196$$
Thus, the median household income in the year 2018 will be about \$58,196.

36. a. Let (x_1, y_1) be (8, 299.6) and (x_2, y_2) be (13, 334.5).
Find the slope.

$$m = \frac{334.5-299.6}{13-8} = \frac{34.9}{5} = 6.98$$
$$y - 299.6 = 6.98(x-8)$$
$$y - 299.6 = 6.98x - 55.84$$
$$y = 6.98x + 243.76$$

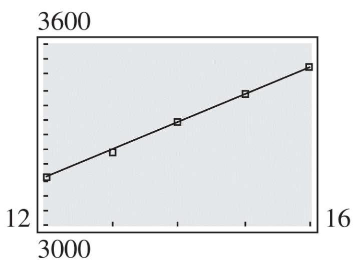
b. Using a graphing calculator, the least squares regression line is
$$y = 9.52x + 213.3.$$

c. The year 2014 corresponds to $x = 14$. Using the two-point model, we have
$y = 6.98(14) + 243.76 \approx \$341$ billion.
Using the regression model, we have
$y = 9.52(14) + 213.3 \approx \$347$ billion.
The two-point model is off by \$17.4, while the regression model is off by \$11.4, therefore the least-squares approximation is a better estimate.

d. The year 2019 corresponds to $x = 19$.
Regression model:
$y = 9.52(19) + 213.3 \approx 394$
Thus, the total amount in charitable giving in the year 2019 will be about \$394 billion.

37. a. The least-squares regression line is $y = 93.1x + 2034.8$.

b.

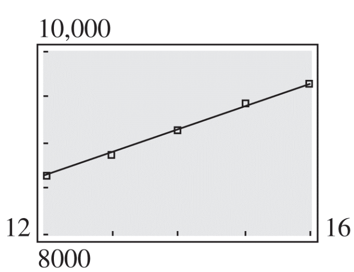


c. Yes; the line appears to fit.

d. The correlation coefficient is .9993. This indicates that the line is a good fit.

38. a. The least-squares regression line is $y = 254.3x + 5589$.

b.



c. Yes; the line appears to fit.

d. The correlation coefficient is .9996. This indicates that the line is a good fit.

39.
$$\begin{aligned}
-6x + 3 &< 2x \\
-6x + 6x + 3 &< 2x + 6x \\
3 &< 8x \\
\frac{3}{8} &< \frac{8x}{8} \\
\frac{3}{8} &< x \text{ or } x > \frac{3}{8}
\end{aligned}$$
The solution is $\left(\frac{3}{8}, \infty\right)$.

40.
$$\begin{aligned}
12z &\ge 5z - 7 \\
12z - 5z &\ge 5z - 5z - 7 \\
7z &\ge -7 \\
\frac{7z}{7} &\ge \frac{-7}{7} \\
z &\ge -1
\end{aligned}$$
The solution is $[-1, \infty)$.

41.
$$\begin{aligned}
2(3 - 2m) &\ge 8m + 3 \\
6 - 4m &\ge 8m + 3 \\
6 - 4m - 8m &\ge 8m - 8m + 3 \\
6 - 12m &\ge 3 \\
6 - 6 - 12m &\ge 3 - 6 \\
-12m &\ge -3 \\
\frac{-12m}{-12} &\le \frac{-3}{-12} \\
m &\le \frac{1}{4}
\end{aligned}$$
The solution is $\left(-\infty, \frac{1}{4}\right]$.

42.
$$\begin{aligned}
6p - 5 &> -(2p + 3) \\
6p - 5 &> -2p - 3 \\
8p - 5 &> -3 \\
8p &> 2 \\
\frac{8p}{8} &> \frac{2}{8} \\
p &> \frac{1}{4}
\end{aligned}$$
The solution is $\left(\frac{1}{4}, \infty\right)$.

43. $-3 \le 4x - 1 \le 7$
$-2 \le 4x \le 8$
$-\frac{1}{2} \le x \le 2$
The solution is $\left[-\frac{1}{2}, 2\right]$.

44. $0 \le 3 - 2a \le 15$
$0 - 3 \le 3 - 3 - 2a \le 15 - 3$
$-3 \le -2a \le 12$
$\frac{-3}{-2} \ge \frac{-2a}{-2} \ge \frac{12}{-2}$
$\frac{3}{2} \ge a \ge -6$
The solution is $\left[-6, \frac{3}{2}\right]$.

45. $|b| \le 8 \Rightarrow -8 \le b \le 8$
The solution is $[-8, 8]$.

46. $|a| > 7 \Rightarrow a < -7$ or $a > 7$
The solution is $(-\infty, -7)$ or $(7, \infty)$.

47. $|2x - 7| \ge 3$
$2x - 7 \le -3$ or $2x - 7 \ge 3$
$2x \le 4$ or $2x \ge 10$
$x \le 2$ or $x \ge 5$
The solution is $(-\infty, 2]$ or $[5, \infty)$.

48. $|4m + 9| \le 16$
$-16 \le 4m + 9 \le 16$
$-25 \le 4m \le 7$
$-\frac{25}{4} \le m \le \frac{7}{4}$
The solution is $\left[-\frac{25}{4}, \frac{7}{4}\right]$.

49. $|5k + 2| - 3 \le 4$
$|5k + 2| \le 7$
$-7 \le 5k + 2 \le 7$
$-9 \le 5k \le 5$
$-\frac{9}{5} \le k \le 1$
The solution is $\left[-\frac{9}{5}, 1\right]$.

50. $|3z - 5| + 2 \ge 10$
$|3x - 5| \ge 8$
$3z - 5 \le -8$ or $3z - 5 \ge 8$
$3z \le -3$ or $3z \ge 13$
$z \le -1$ or $z \ge \frac{13}{3}$
The solution is $(-\infty, -1]$ or $\left[\frac{13}{3}, \infty\right)$.

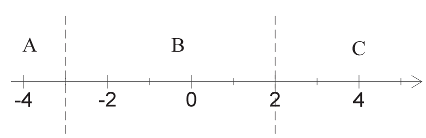
51. The inequalities that represent the weight of pumpkin that he will not use are $x < 2$ or $x > 10$. This is equivalent to the following inequalities:
$x - 6 < 2 - 6$ or $x - 6 > 10 - 6$
$x - 6 < -4$ or $x - 6 > 4$
$|x - 6| > 4$
Choose answer option (d).

52. Let x = the price of the snow thrower
$|x - 600| \le 55$

53. $45 + 8x \le 65$
$8x \le 20$
$x \le 2.5$
Due to the fact that cell phone companies sell data by the whole gigabyte, the first plan is cheaper if you use less than or equal to 2 gigabytes.

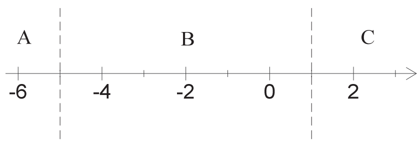
54. Let m = number of miles driven. The rate for the second rental company is $95 + .2m$. We want to determine when the second company is cheaper than the first.
$125 > 95 + .2m \Rightarrow 30 > .2m \Rightarrow 150 > m$
The second company is cheaper than the first company when the number of miles driven is less than 150.

55. $r^2 + r - 6 < 0$
Solve the corresponding equation.
$r^2 + r - 6 = 0 \Rightarrow (r + 3)(r - 2) = 0 \Rightarrow$
$r = -3$ or $r = 2$



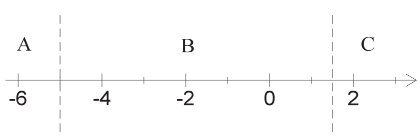
For region A, test –4:
$(-4)^2 + (-4) - 6 = 6 > 0$.
For region B, test 0:
$0^2 + 0 - 6 = -6 < 0$.
For region C, test 3:
$3^2 + 3 - 6 = 6 > 0$.
The solution is (–3, 2).

56. $y^2 + 4y - 5 \ge 0$
Solve the corresponding equation.
$y^2 + 4y - 5 = 0 \Rightarrow (y+5)(y-1) = 0$
$y = -5$ or $y = 1$



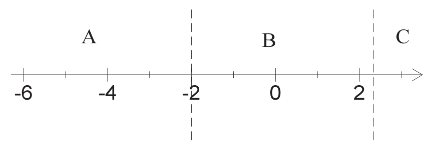
For region A, test –6:
$(-6)^2 + 4(-6) - 5 = 7 > 0$.
For region B, test 0:
$0^2 + 4(0) - 5 = -5 < 0$.
For region C, test 2:
$2^2 + 4(2) - 5 = 7 > 0$.
Both endpoints are included because the inequality symbol is "≥." The solution is (–∞, –5] or [1, ∞).

57. $2z^2 + 7z \ge 15$
Solve the corresponding equation.
$$2z^2 + 7z = 15$$
$$2z^2 + 7z - 15 = 0$$
$$(2z - 3)(z + 5) = 0$$
$$z = \frac{3}{2} \text{ or } z = -5$$
These numbers are solutions of the inequality because the inequality symbol is "≥."



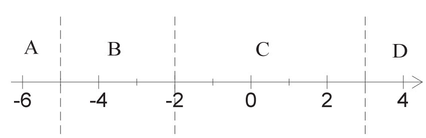
For region A, test –6:
$2(-6)^2 + 7(-6) = 30 > 15$.
For region B, test 0:
$2 \cdot 0^2 + 7 \cdot 0 = 0 < 15$.
For region C, test 2:
$2 \cdot 2^2 + 7 \cdot 2 = 22 > 15$.
The solution is (–∞, –5] or $\left[\frac{3}{2}, \infty\right)$.

58. $3k^2 \le k + 14$
Solve the corresponding equation.
$$3k^2 = k + 14$$
$$3k^2 - k - 14 = 0$$
$$(3k - 7)(k + 2) = 0$$
$$k = \frac{7}{3} \text{ or } k = -2$$



For region A, test –3:
$3(-3)^2 = 27,\ -3 + 14 = 11 \Rightarrow 27 > 11$
For region B, test 0:
$3(0)^2 = 0,\ 0 + 14 = 14 \Rightarrow 0 < 14$
For region C, test 3:
$3(3)^2 = 27,\ 3 + 14 = 17 \Rightarrow 27 > 17$
The given inequality is true in region B and at both endpoints, so the solution is $\left[-2, \frac{7}{3}\right]$.

59. $(x-3)\left(x^2 + 7x + 10\right) \le 0$
Solve the corresponding equation.
$$(x-3)\left(x^2 + 7x + 10\right) = 0$$
$$(x-3)(x+2)(x+5) = 0$$
$$x - 3 = 0 \quad \text{or} \quad x + 2 = 0 \quad \text{or} \quad x + 5 = 0$$
$$x = 3 \quad \text{or} \quad x = -2 \quad \text{or} \quad x = -5$$
Note that –5, –2, and 3 are solutions of the original inequality.



In region A, let $x = -6$:

$(-6-3)\left((-6)^2+7(-6)+10\right)$

$= -9(36-42+10) = -9(4) = -36 < 0$

In region B, let $x = -3$:

$(-3-3)\left((-3)^2+7(-3)+10\right)$

$= -6(9-21+10) = -6(-2) = 12 > 0.$

In region C, let $x = 0$:

$(0-3)\left(0^2+7(0)+10\right) = -3(10) = -30 < 0$.

In region D, let $x = 4$:

$(4-3)\left(4^2+7(4)+10\right)$

$= 1(16+28+10) = 54 > 0$.

The solution is $(-\infty, -5]$ or $[-2, 3]$.

60. $(x+4)\left(x^2-1\right) \geq 0$

Solve the corresponding equation.

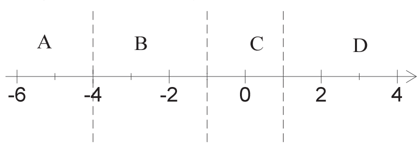
$$(x+4)\left(x^2-1\right) = 0$$

$(x+4)(x+1)(x-1) = 0$

$x+4=0$ or $x+1=0$ or $x-1=0$

$x=-4$ or $x=-1$ or $x=1$

Note that –4, –1, and 1 are solutions of the original inequality.



In region A, let $x = -5$:

$(-5+4)\left((-5)^2-1\right) = -1(24) = -24 \leq 0$.

In region B, let $x = -2$:

$(-2+4)\left((-2)^2-1\right) = 2(3) = 6 > 0$.

In region C, let $x = 0$:

$(0+4)\left(0^2-1\right) = 4(-1) = -4 < 0$.

In region D, let $x = 2$:

$(2+4)\left(2^2-1\right) = 6(3) = 18 > 0$.

The solution is $[-4, -1]$ or $[1, \infty)$.

61. $\dfrac{m+2}{m} \leq 0$

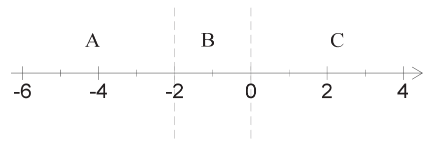
Solve the corresponding equation $\dfrac{m+2}{m} = 0.$

The quotient changes sign when

$m+2=0$ or $m=0$

$m=-2$ or $m=0$

–2 is a solution of the inequality, but the inequality is undefined when $m = 0$, so the endpoint 0 must be excluded.



For region A, test –3:

$\dfrac{-3+2}{-3} = \dfrac{1}{3} > 0$.

For region B, test –1:

$\dfrac{-1+2}{-1} = -1 < 0$.

For region C, test 1:

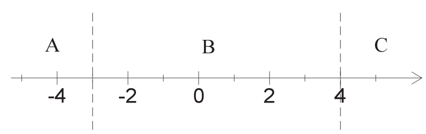
$\dfrac{1+2}{1} = 3 > 0$.

The solution is $[-2, 0)$.

62. $\dfrac{q-4}{q+3} > 0$

Solve the corresponding equation $\dfrac{q-4}{q+3} = 0.$

The numerator is 0 when $q = 4$. The denominator is 0 when $q = -3$.



For region A, test –4:

$\dfrac{-4-4}{-4+3} = \dfrac{-8}{-1} = 8 > 0$.

For region B, test 0:

$\dfrac{0-4}{0+3} = -\dfrac{4}{3} < 0$.

For region C, test 5:

$\dfrac{5-4}{5+3} = \dfrac{1}{8} > 0$.

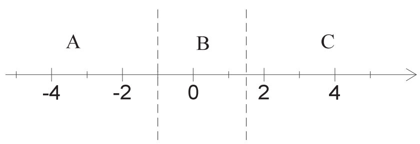
The inequality is true in regions A and C, and both endpoints are excluded. Therefore, the solution is $(-\infty, -3)$ or $(4, \infty)$.

63. $\dfrac{5}{p+1} > 2$

Solve the corresponding equation.

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

The numerator is 0 when $p = \frac{3}{2}$. The denominator is 0 when $p = -1$.
Neither of these numbers is a solution of the inequality.



In region A, test –2:

$\dfrac{5}{-2+1} = -5 < 2$.

In region B, test 0:

$\dfrac{5}{0+1} = 5 > 2$.

In region C, test 2:

$\dfrac{5}{2+1} = \dfrac{5}{3} < 2$.

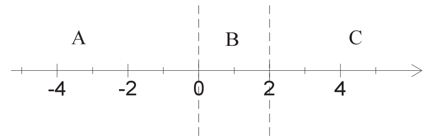
The solution is $\left(-1, \dfrac{3}{2}\right)$.

64. $\dfrac{6}{a-2} \le -3$

Solve the corresponding equation.

$$\frac{6}{a-2} = -3$$
$$\frac{6}{a-2} + 3 = 0$$
$$\frac{6+3(a-2)}{a-2} = 0$$
$$\frac{3a}{a-2} = 0$$

The numerator is 0 when $a = 0$. The denominator is 0 when $a = 2$.



For region A, test –1:

$\dfrac{6}{-1-2} = -2 \ge -3$.

For region B, test 1:

$\dfrac{6}{1-2} = -6 \le -3$.

For region C, test 3:

$\dfrac{6}{3-2} = 6 \ge -3$.

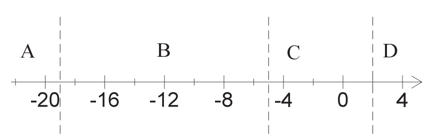
The given inequality is true in region B. The endpoint 0 is included because the inequality symbol is "≤." However, the endpoint 2 must be excluded because it makes the denominator 0. The solution is [0, 2).

65. $\dfrac{2}{r+5} \le \dfrac{3}{r-2}$

Write the corresponding equation and then set one side equal to zero.

$$\frac{2}{r+5} = \frac{3}{r-2}$$
$$\frac{2}{r+5} - \frac{3}{r-2} = 0$$
$$\frac{2(r-2)-3(r+5)}{(r+5)(r-2)} = 0$$
$$\frac{2r-4-3r-15}{(r+5)(r-2)} = 0$$
$$\frac{-r-19}{(r+5)(r-2)} = 0$$

The numerator is 0 when $r = -19$. The denominator is 0 when $r = -5$ or $r = 2$.
–19 is a solution of the inequality, but the inequality is undefined when r = –5 or r = 2.



For region A, test –20:

$\dfrac{2}{-20+5} = -\dfrac{2}{15} \approx -.13$ and

$\dfrac{3}{-20-2} = -\dfrac{3}{22} \approx -.14$

Since –.13 > –.14, –20 is not a solution of the inequality.
For region B, test –6:

$\frac{2}{-6+5}=-2$ and $\frac{3}{-6-2}=-\frac{3}{8}$.

Since $-2<-\frac{3}{8}$, –6 is a solution.

For region C, test 0: $\frac{2}{0+5}=\frac{2}{5}$ and $\frac{3}{0-2}=-\frac{3}{2}$.

Since $\frac{2}{5}>-\frac{3}{2}$, 0 is not a solution.

For region D, test 3: $\frac{2}{3+5}=\frac{1}{4}$ and $\frac{3}{3-2}=3$.

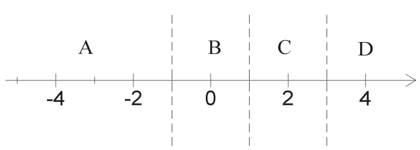
Since $\frac{1}{4}<3$, 3 is a solution. The solution is [–19, –5) or (2, ∞).

66. $\frac{1}{z-1}>\frac{2}{z+1}$

Write the corresponding equation and then set one side equal to zero.

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

The numerator is 0 when $z = 3$. The denominator is 0 when $z = 1$ and when $z = –1$. These three numbers, –1, 1, and 3, separate the number line into four regions.



For region A, test –3.

$\frac{1}{-3-1}>\frac{2}{-3+1}\Rightarrow-\frac{1}{4}>-1,$ which is true.

For region B, test 0.

$\frac{1}{0-1}>\frac{2}{0+1}\Rightarrow-1>2,$ which is false.

For region C, test 2.

$\frac{1}{2-1}>\frac{2}{2+1}\Rightarrow1>\frac{2}{3},$ which is true.

For region D, test 4.

$\frac{1}{4-1}>\frac{2}{4+1}\Rightarrow\frac{1}{3}>\frac{2}{5},$ which is false.

Thus, the solution is (–∞, –1) or (1, 3).

Case 2 Using Extrapolation for Prediction

1.

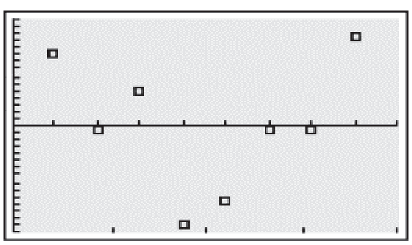
```
LinReg
 y=ax+b
 a=-.765952381
 b=82.32928571
 r²=.0399034604
 r=-.1997585053
```

This verifies the regression equation.

2.

Quarter	Table value	Predicted value	Residual
1	91.77	81.83	9.94
2	80.03	80.76	–.73
3	84.82	79.99	4.83
4	65.36	79.22	–13.86
5	67.96	78.45	–10.49
6	76.54	77.68	–1.11
7	75.81	76.91	–1.10
8	88.77	76.14	12.63

3. See the table in problem 2 for residual values.



4. No; because the residuals have a nonlinear U-shape.

5. Since $x = 0$ corresponds to the year 1900, enter the following data into a computing device.

x	y
70	3.40
75	4.73
80	6.85
85	8.74
90	10.20
95	11.65
100	14.02
105	16.13
110	19.06
115	21.03

Then determine the least squares regression line.

```
LinReg
 y=ax+b
 a=.3911151515
 b=-24.59715152
 r²=.9918612299
 r=.9959223011
```

The model is verified.

6. The year 2012 corresponds to $x = 112$.

$y = .3911(112) - 24.6 \approx 19.20.$

According to the model, the hourly wage in 2012 was about \$19.20, about \$4.23 too high.

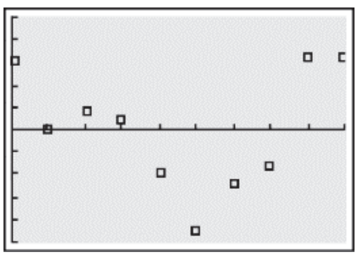
7. The year 1960 corresponds to $x = 60$.

$y = .3911(60) - 24.6 \approx -1.134.$

The model gives the hourly wage as a negative amount, which is clearly not appropriate.

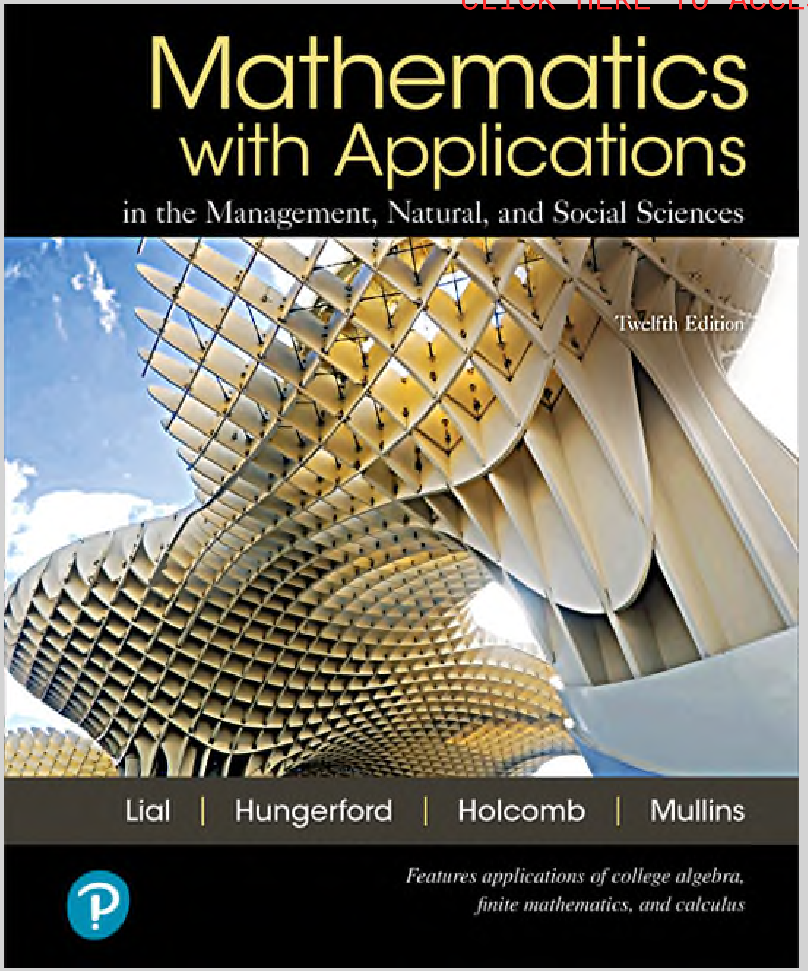
8.

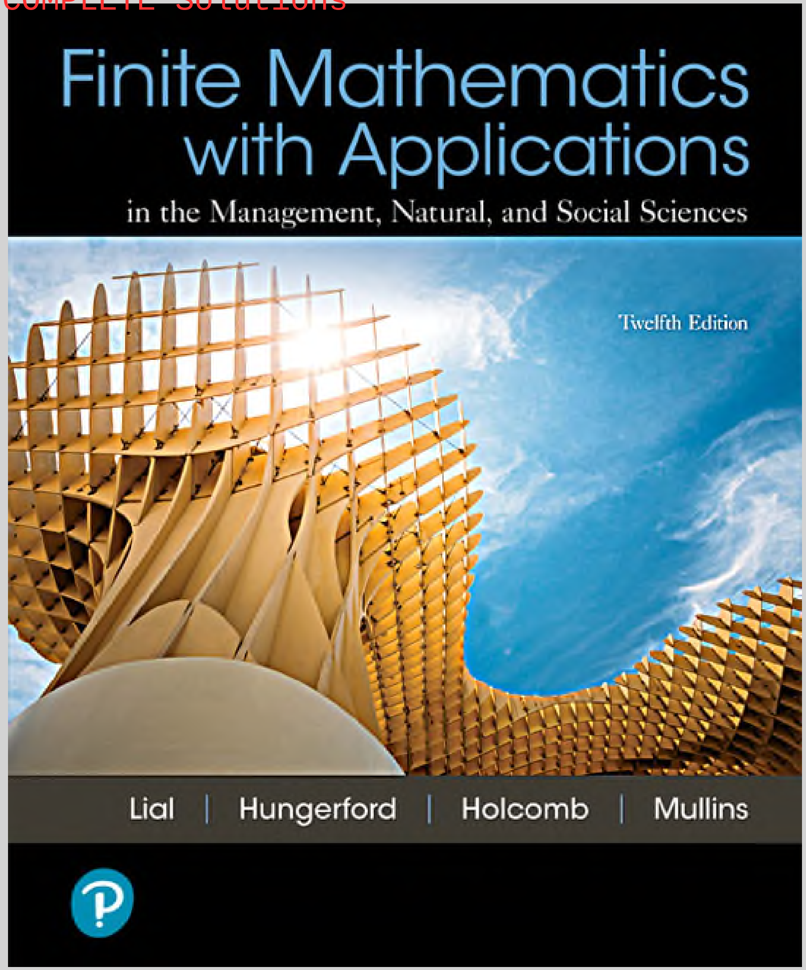
Year ($x = 0$ is 1900)	Table value	Predicted value	Residual
70	3.40	2.78	.62
75	4.73	4.73	0
80	6.85	6.69	.16
85	8.74	8.64	.10
90	10.20	10.60	–.40
95	11.65	12.56	–.91
100	14.02	14.51	–.49
105	16.13	16.47	.34
110	19.06	18.42	.64
115	21.03	20.38	.65



9. You'll get 0 slope and 0 intercept, because the residual represents the vertical distance from the data point to the regression line. Since r is very close to 1, the data points lie very close to the regression line.

```
LinReg
 y=ax+b
 a=.0040848485
 b=-.3068484848
 r²=.0135199307
 r=.116275237
```





Lial/Hungerford/Holcomb/Mullins:

Mathematics with Applications 12e

Finite Mathematics with Applications 12e

Chapter 2

Graphs, Lines and Inequalities

Section 2.1

Graphs

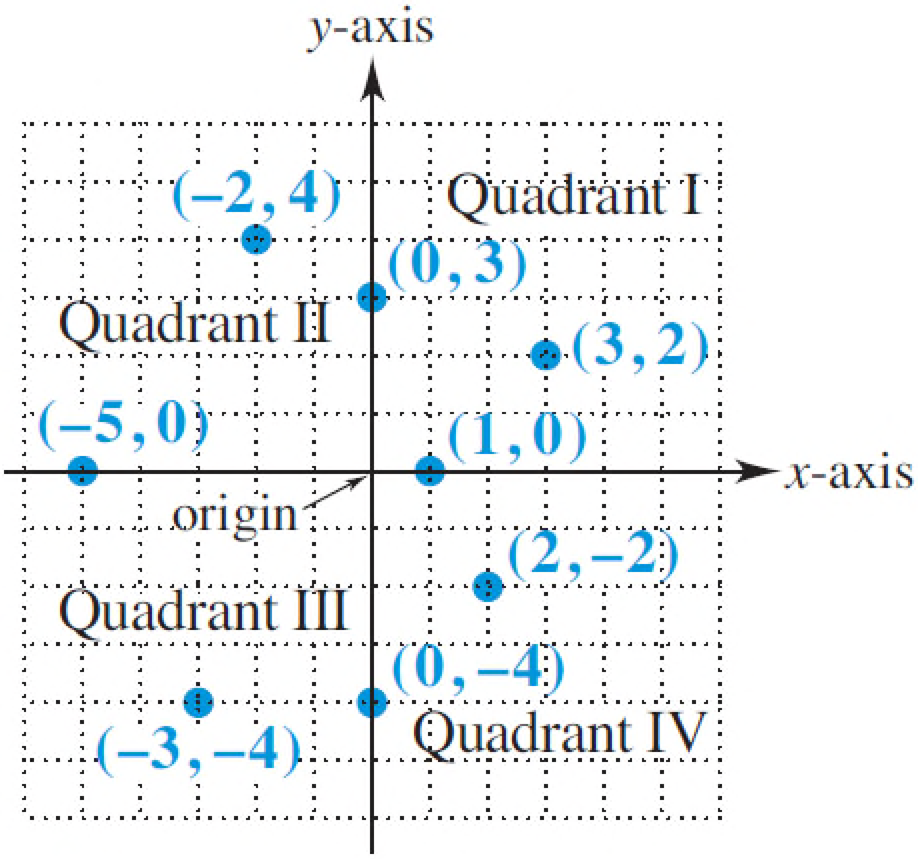

y-axis
(–2, 4)
Quadrant I
(0, 3)
Quadrant II
(3, 2)
(–5, 0)
(1, 0)
x-axis
origin
(2, –2)
Quadrant III
(0, –4)
Quadrant IV
(–3, –4)

Figure 2.1

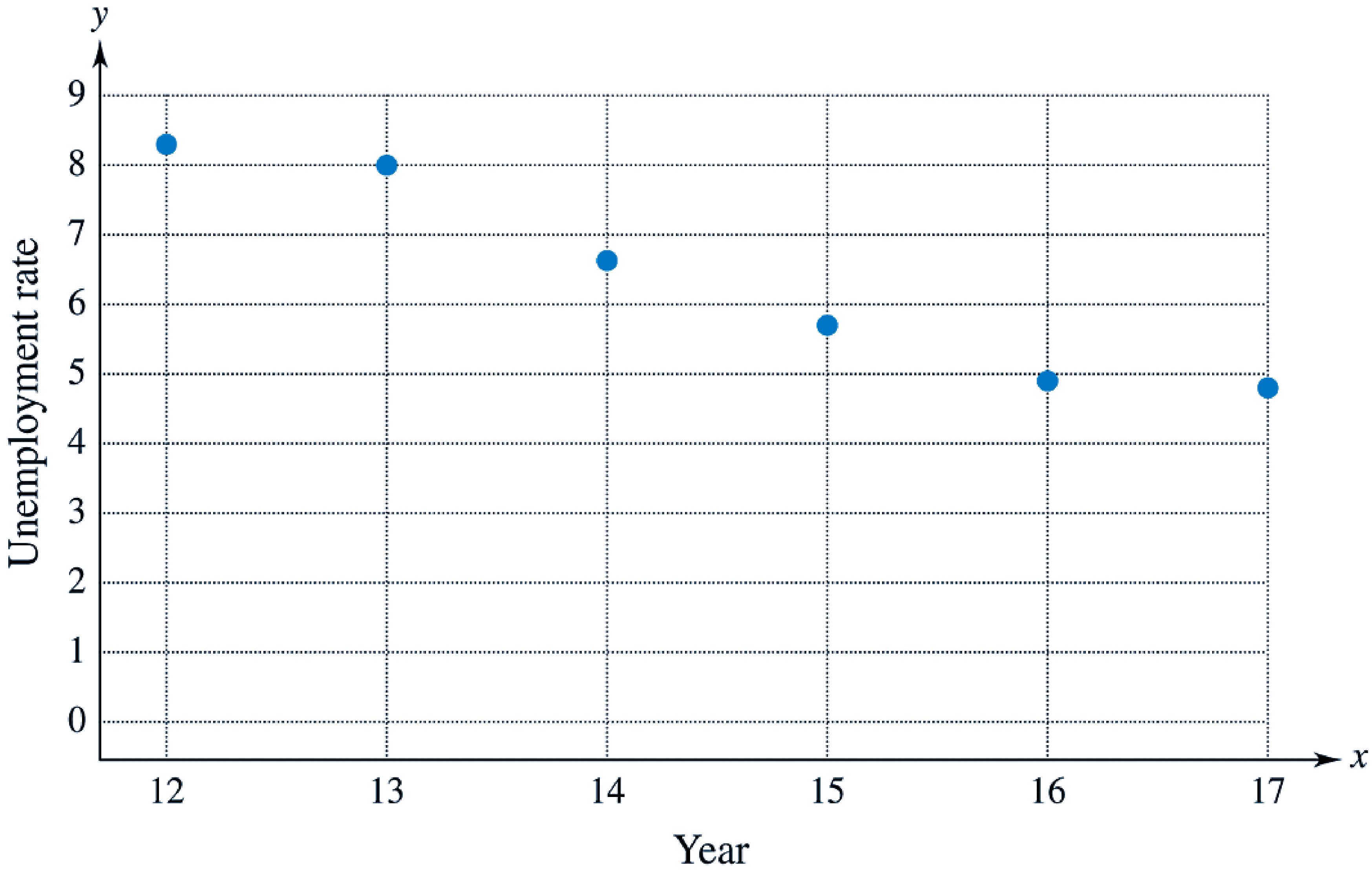


Figure 2.2

Example: Sketch the graph of $y = -2x + 5$.

Solution:

Since we cannot plot infinitely many points, we construct a table of *y*-values for a reasonable number of *x*-values, plot the corresponding points, and make an “educated guess” about the rest.

x	$-2x + 5$
-1	7
0	5
2	1
4	-3
5	-5

The table above shows a few *x*-values and *y*-values.

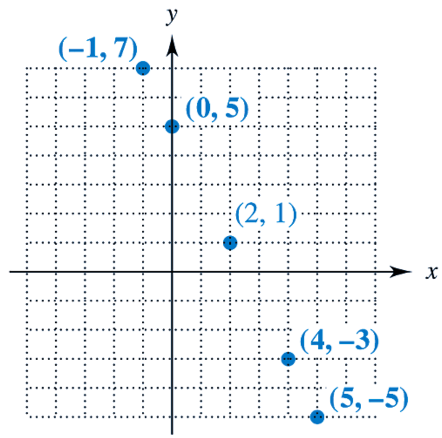


Figure 2.3a

The graph above shows the points on the coordinate plane. The points indicate that the graph should be a straight line.

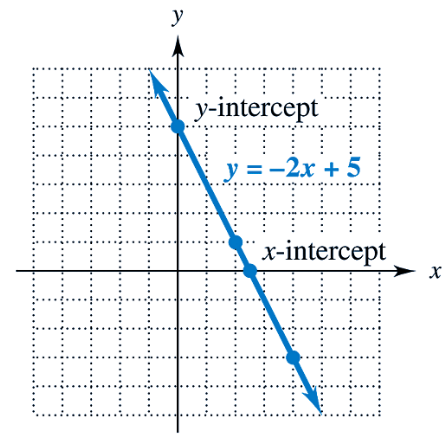


Figure 2.3b

Sketch the line that connects the points.

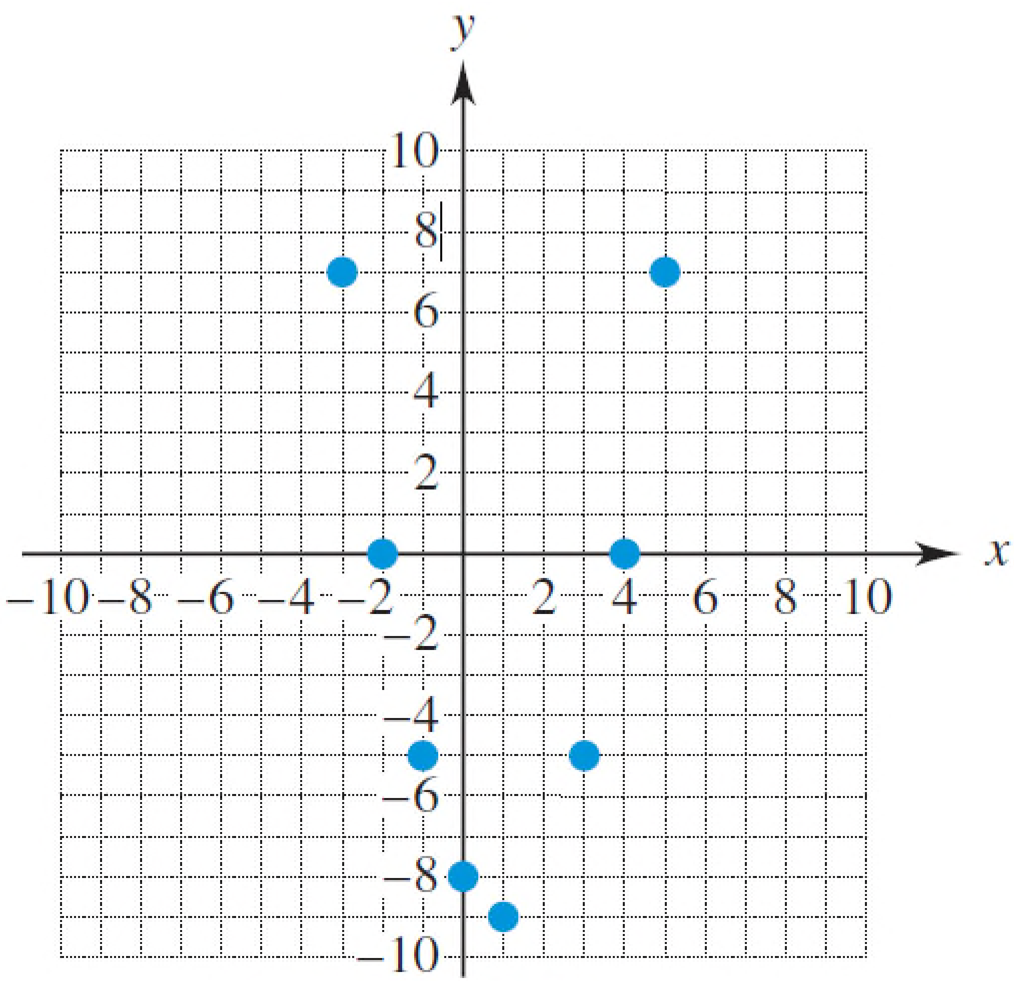


Figure 2.4

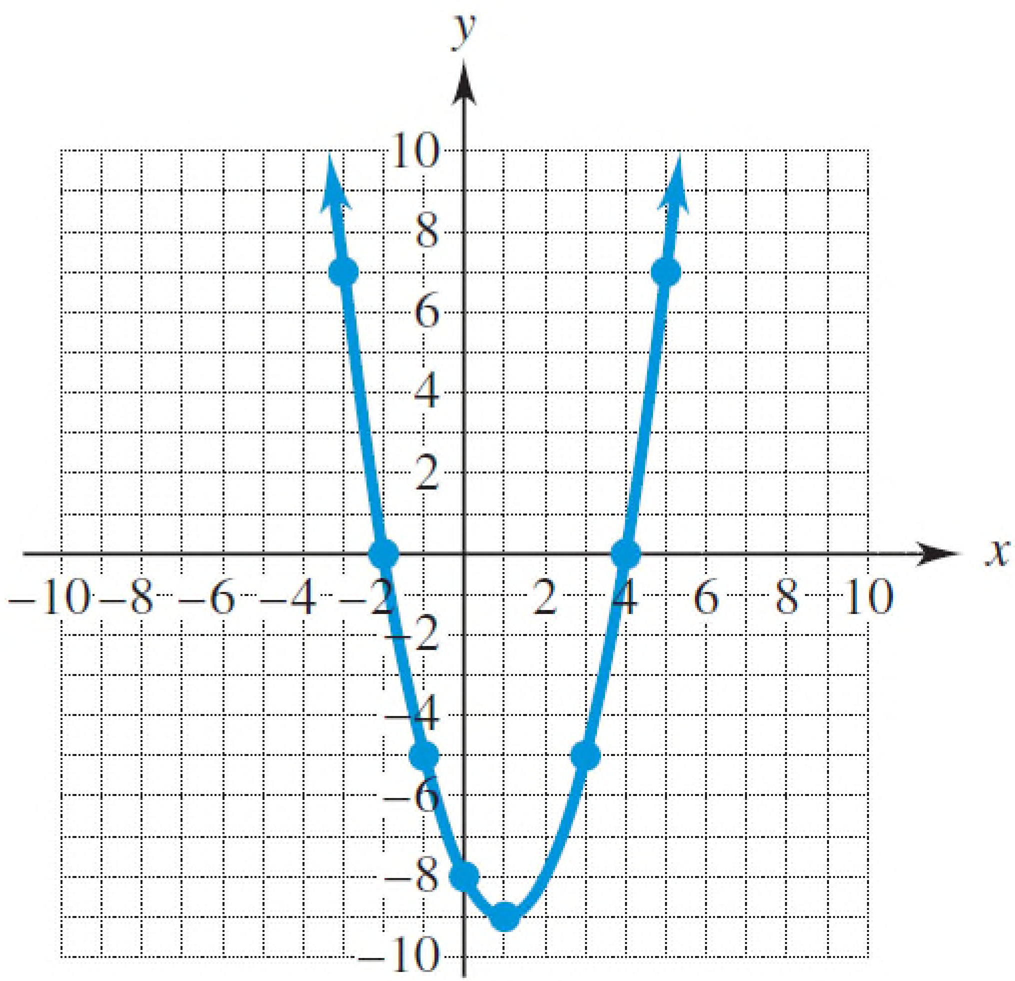


Figure 2.5

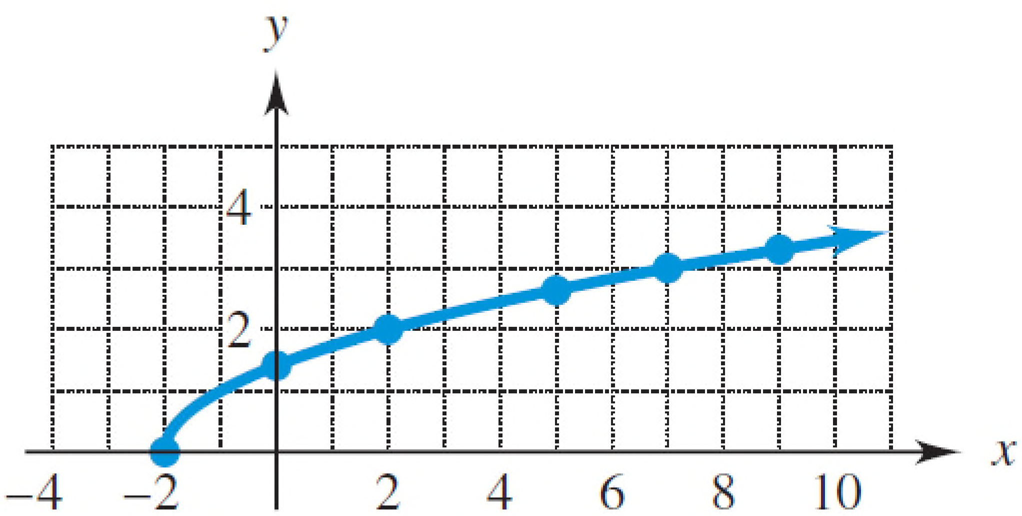


Figure 2.6

Intercepts and Equations

The real solutions of a one-variable equation of the form

$$\textbf{expression in } x = 0$$

are the x-intercepts of the graph of

$$y = \textbf{same expression in } x.$$

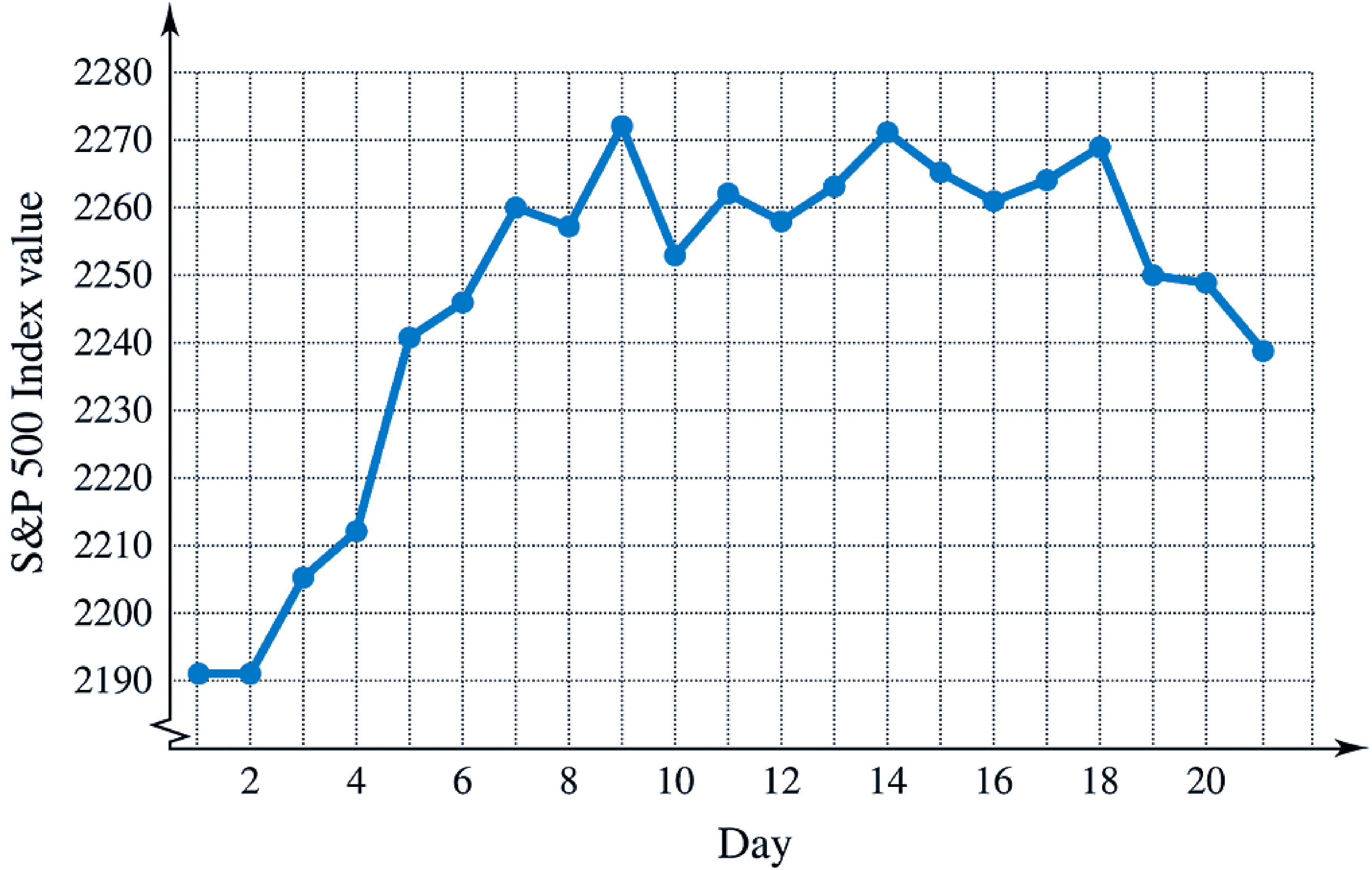

S&P 500 Index value
2280
2270
2260
2250
2240
2230
2220
2210
2200
2190
2
4
6
8
10
12
14
16
18
20
Day

Figure 2.7

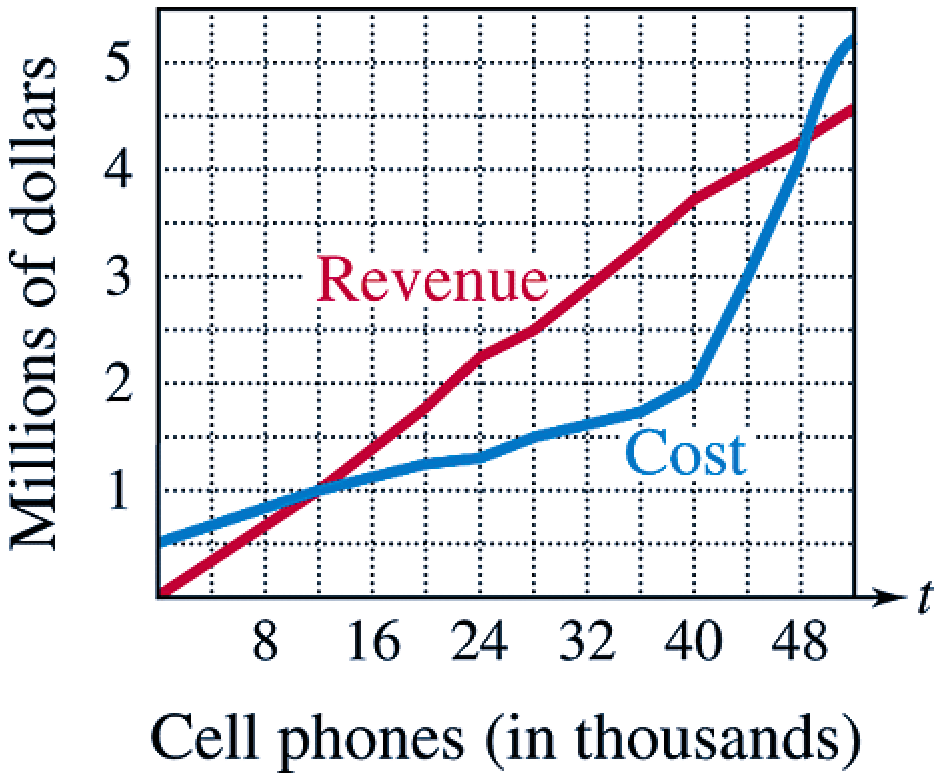

Millions of dollars
5
4
3
2
1
Revenue
Cost
8
16
24
32
40
48
t
Cell phones (in thousands)

Figure 2.8

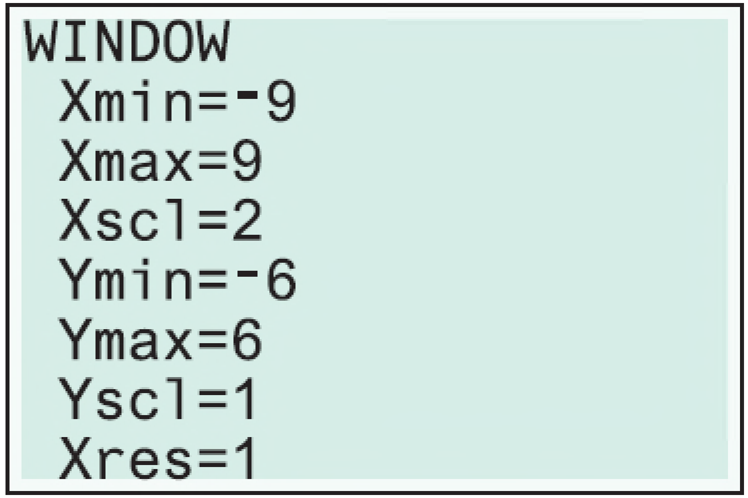


Figure 2.9

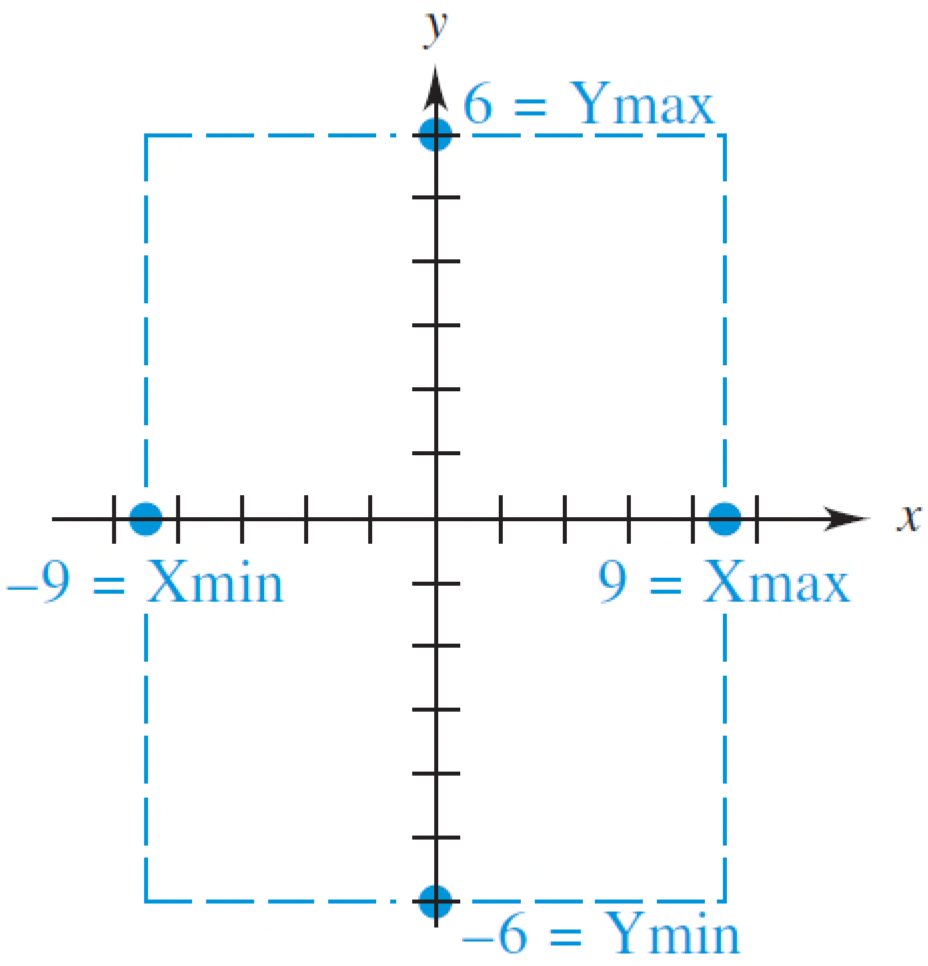


Figure 2.10

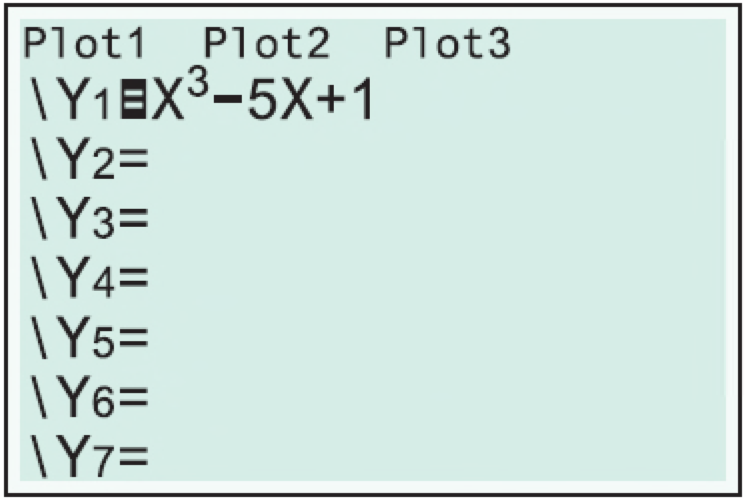


Figure 2.11

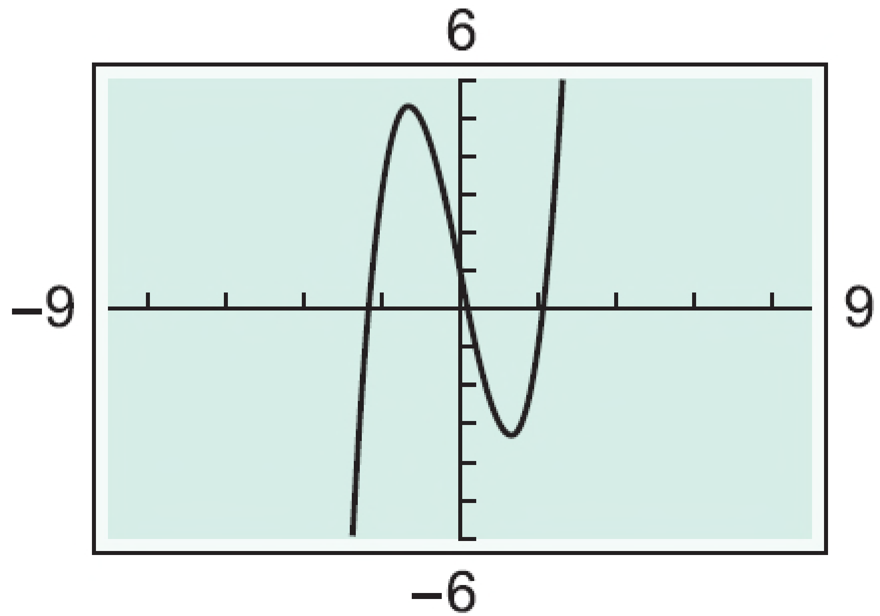


Figure 2.12

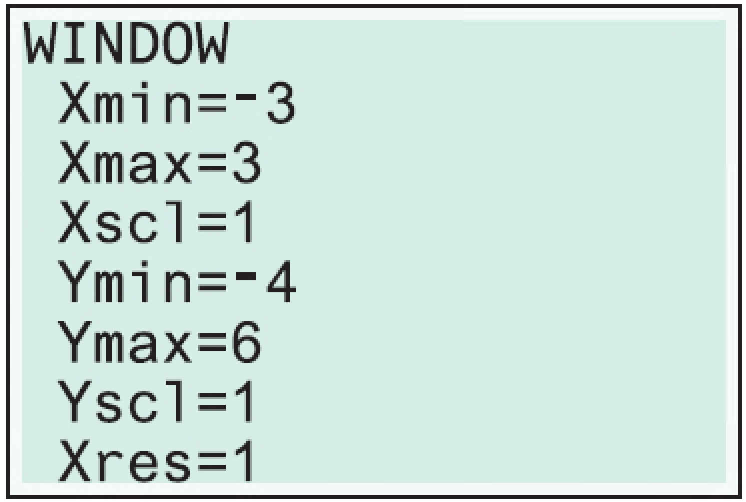


Figure 2.13

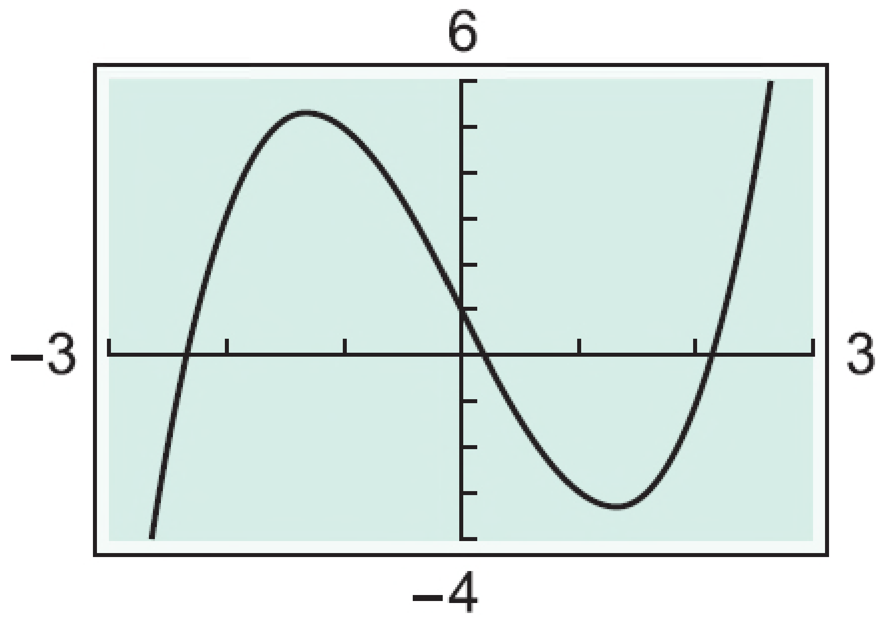


Figure 2.14

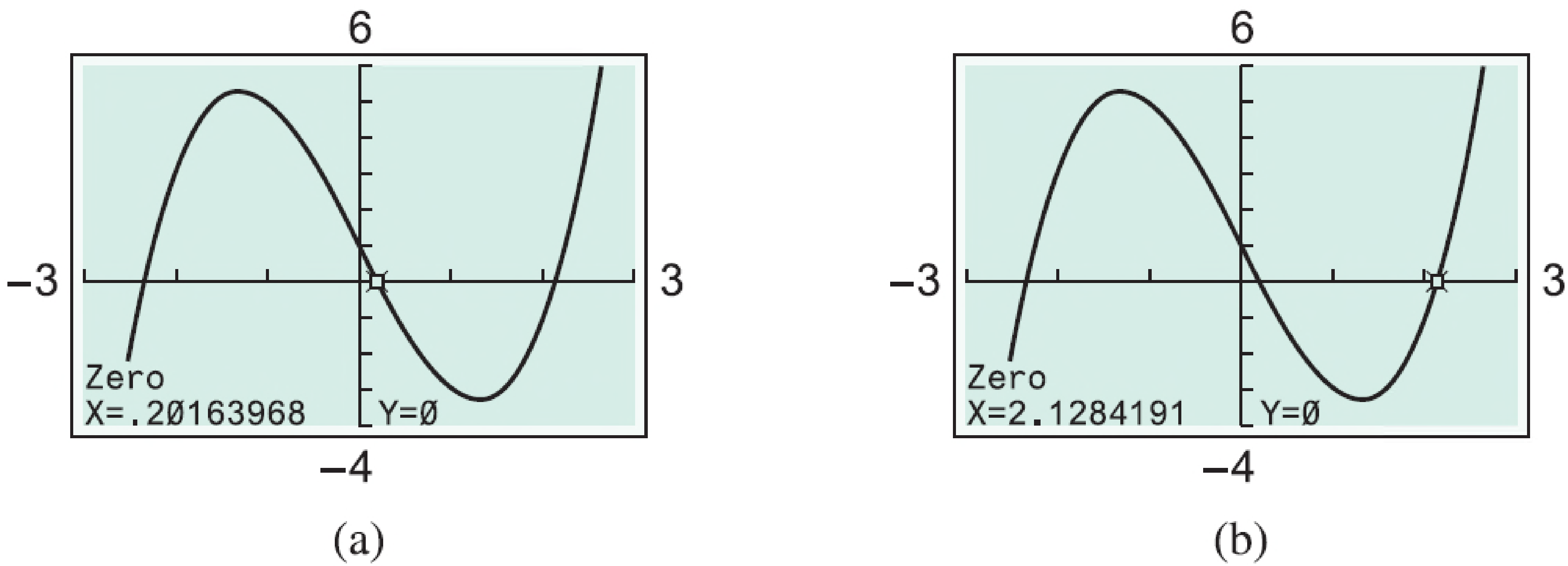


Figure 2.15

Section 2.2

Equations of Lines

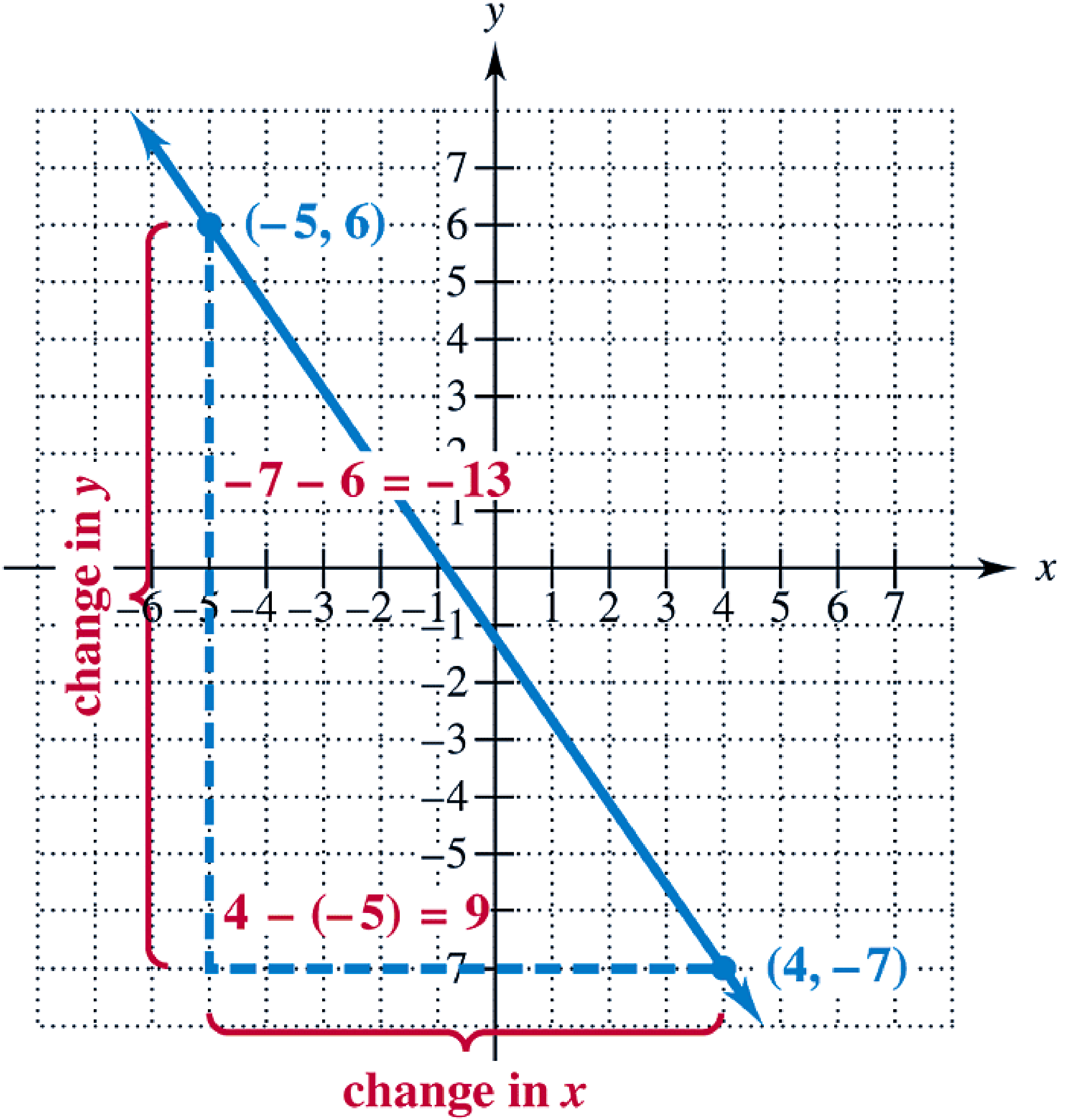


Figure 2.16

The **slope** of the line through the two points (x_1, y_1) and (x_2, y_2), where $x_1 \neq x_2$, is defined as the quotient of the change in y and the change in x:

$$\textbf{slope} = \frac{\textbf{change in } y}{\textbf{change in } x} = \frac{y_2 - y_1}{x_2 - x_1}.$$

Example: Find the slope of the line through the points (–6, 8) and (5, 4).

Solution: Let $(x_1, y_1) = (-6, 8)$ and $(x_2, y_2) = (5, 4)$. Use the definition of slope as follows:

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4-8}{5-(-6)} = \frac{-4}{11} = -\frac{4}{11}.$$

The slope can also be found by letting $(x_1, y_1) = (5, 4)$ and $(x_2, y_2) = (-6, 8)$. In that case,

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8-4}{-6-5} = \frac{4}{-11} = -\frac{4}{11},$$

which is the same answer.

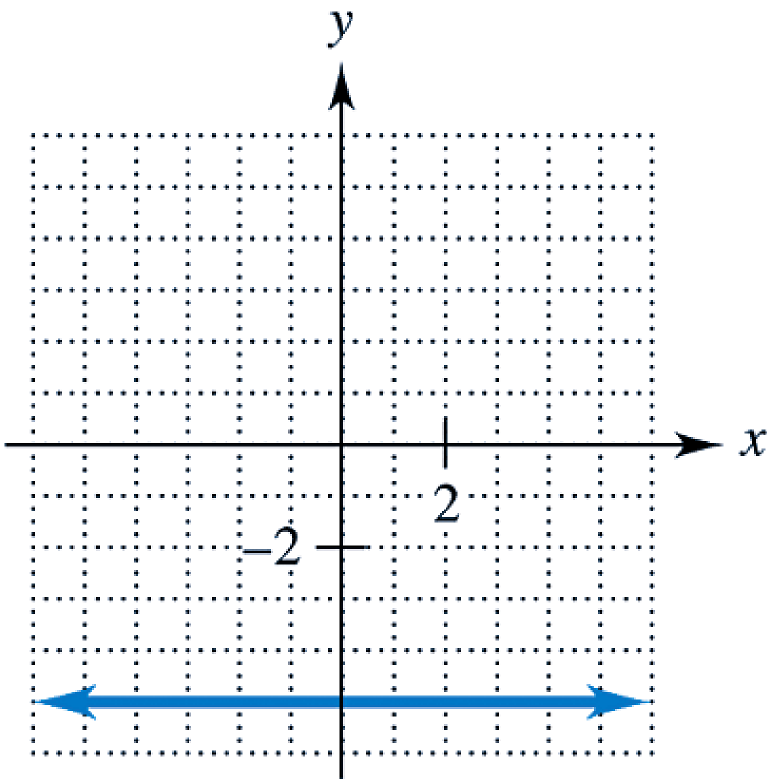


Figure 2.17

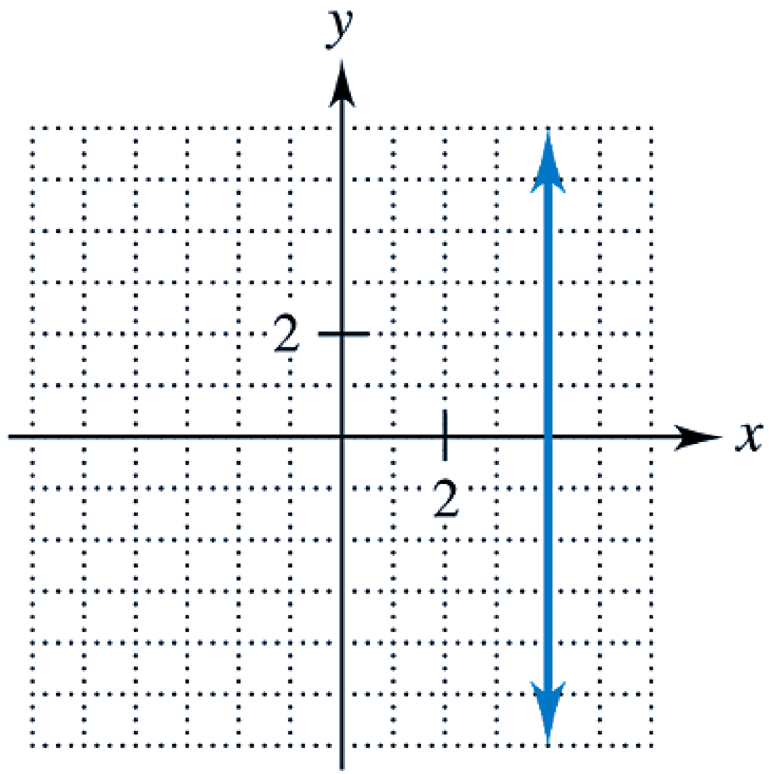


Figure 2.18

The slope of every horizontal line is 0.

The slope of every vertical line is undefined.

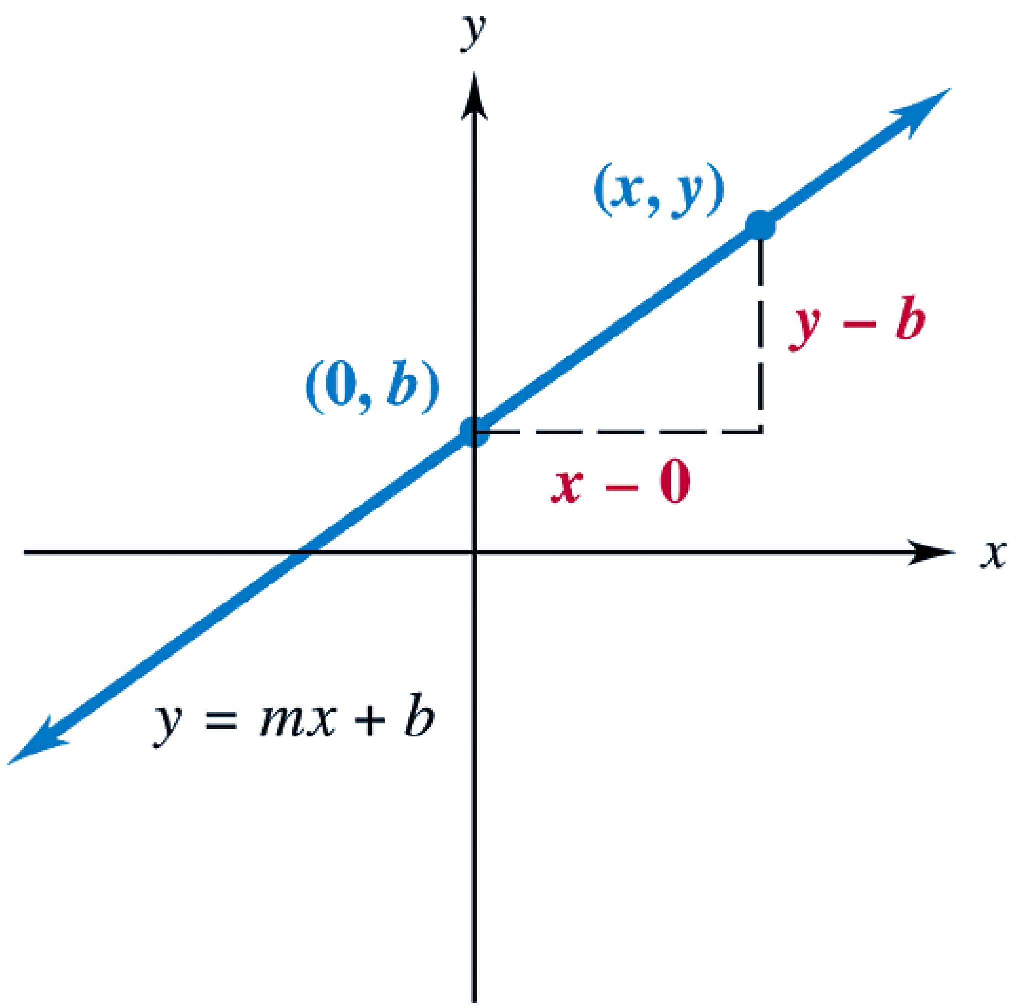


Figure 2.19

Slope–Intercept Form

If a line has slope m and y-intercept b, then it is the graph of the equation

$$y = mx + b.$$

This equation is called the **slope–intercept form** of the equation of the line.

If k is a constant, then the graph of the equation $y = k$ is the horizontal line with y-intercept k.

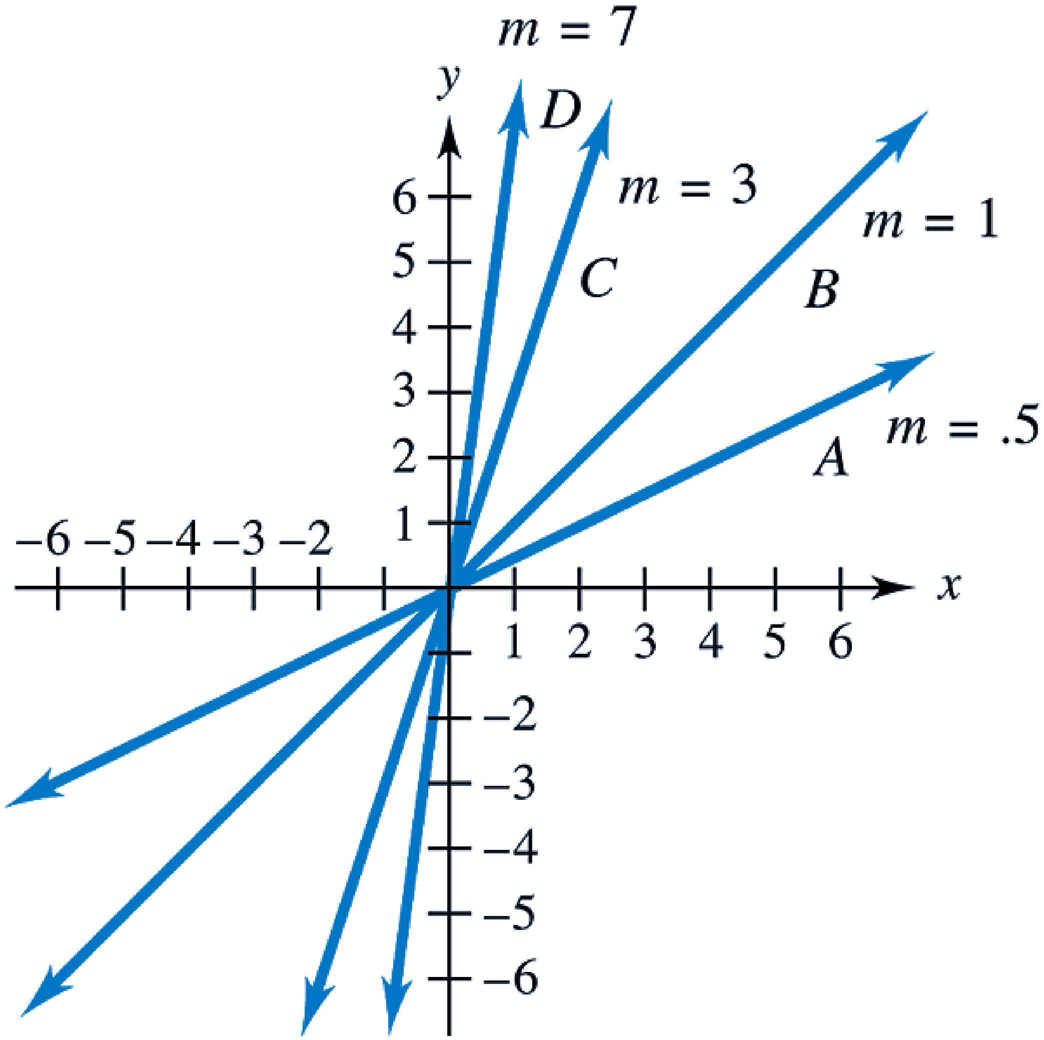


Figure 2.20a

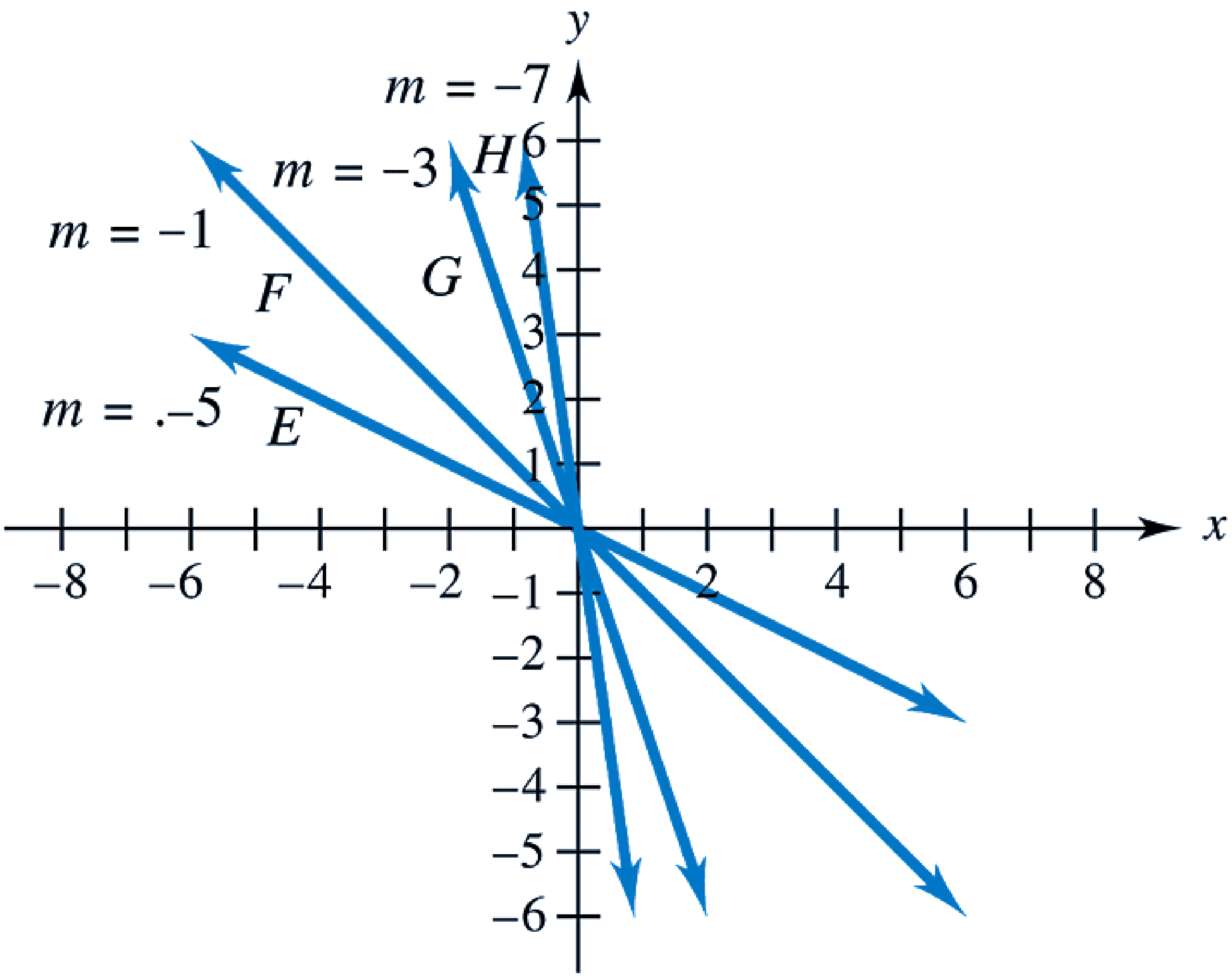


Figure 2.20b

Direction of Line (moving from left to right)	**Slope**
Upward	**Positive** (larger for steeper lines)
Horizontal	**0**
Downward	**Negative** (larger in absolute value for steeper lines)
Vertical	**Undefined**

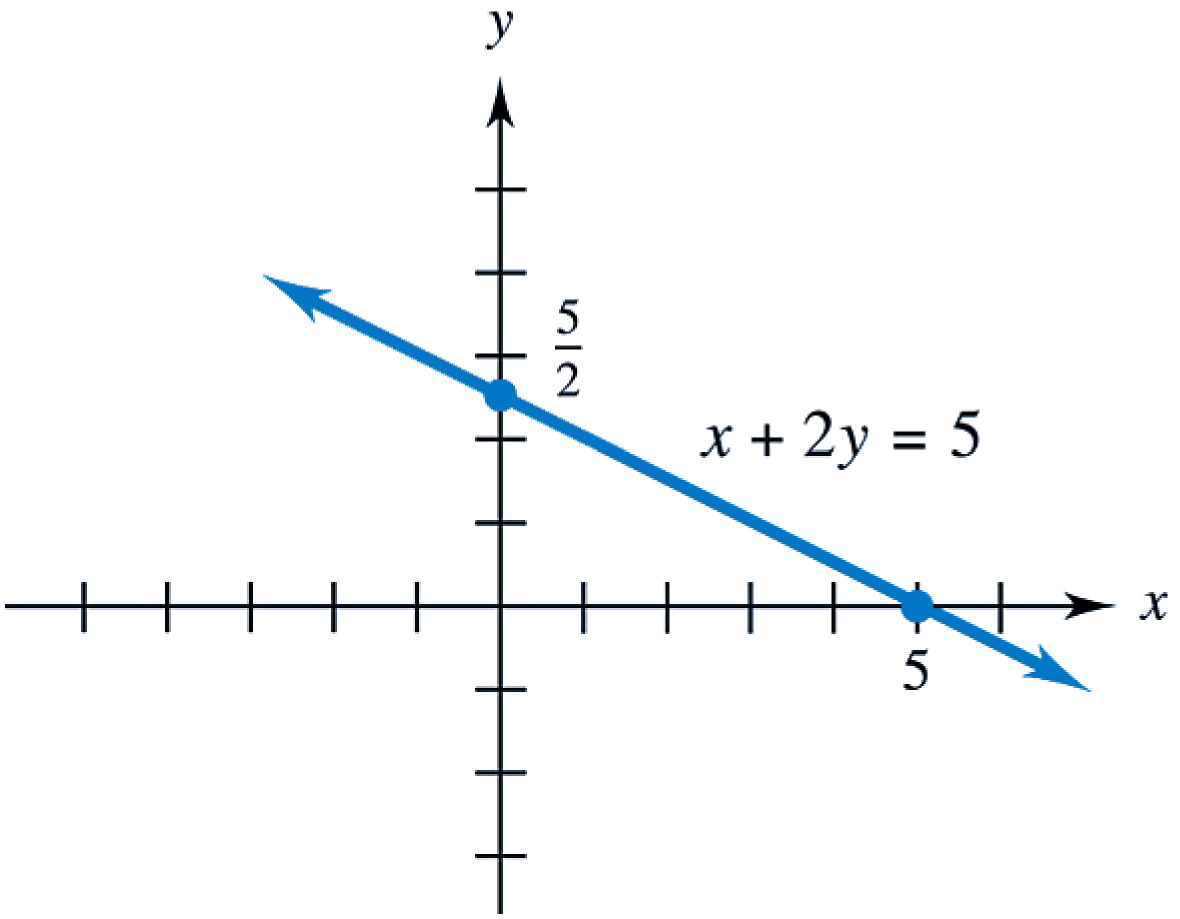


Figure 2.21

Two nonvertical lines are **parallel** whenever they have the same slope.

Two nonvertical lines are **perpendicular** whenever the product of their slopes is -1.

Note: An equivalent definition for **perpendicular lines** is nonvertical lines whose slopes are negative reciprocals of one another.

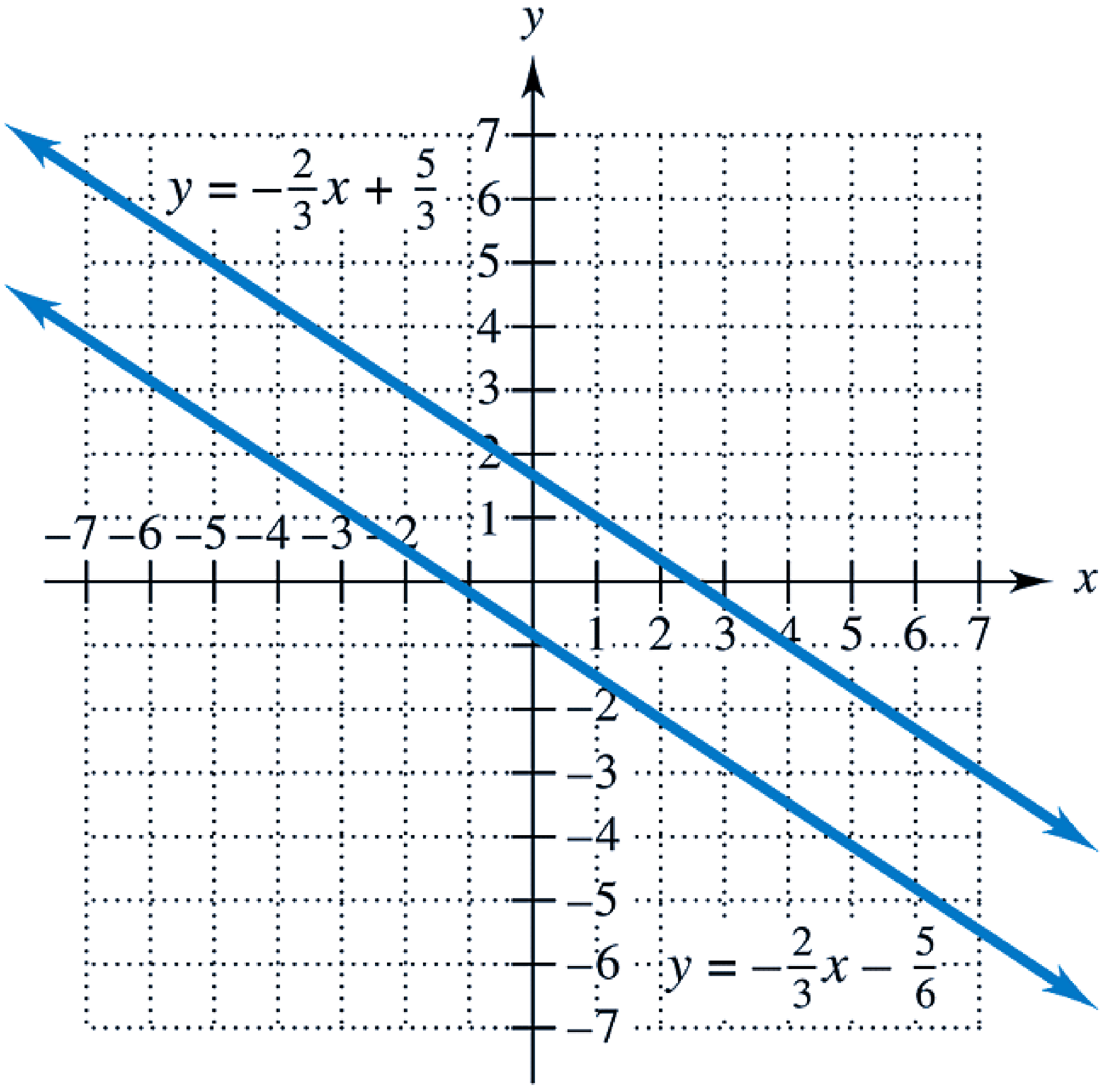

y
x
$y = -\frac{2}{3}x + \frac{5}{3}$
$y = -\frac{2}{3}x - \frac{5}{6}$
7
6
5
4
3
2
1
−7 −6 −5 −4 −3 −2
1 2 3 4 5 6 7
−2
−3
−4
−5
−6
−7

Figure 2.22(a)

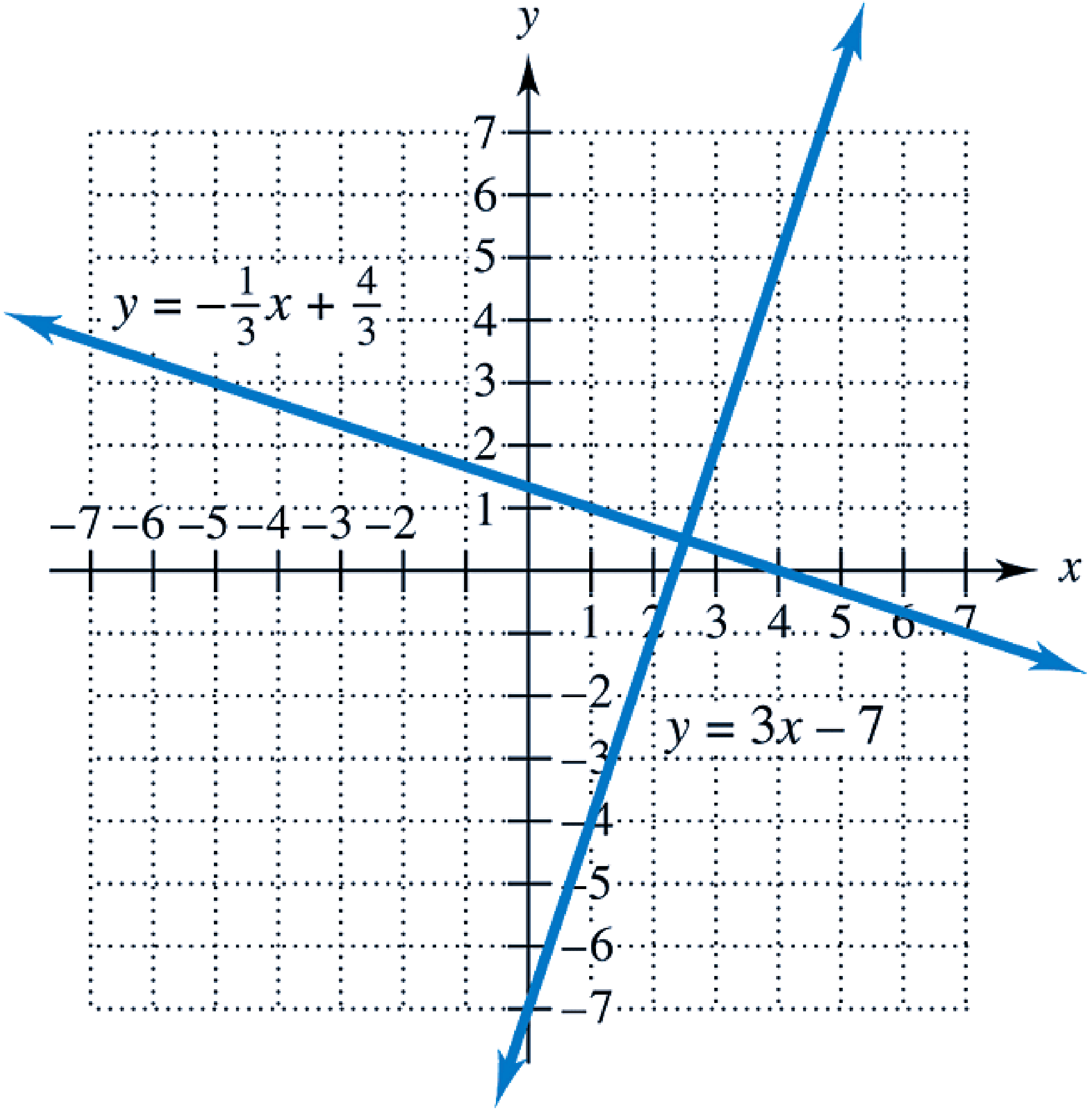


Figure 2.22(b)

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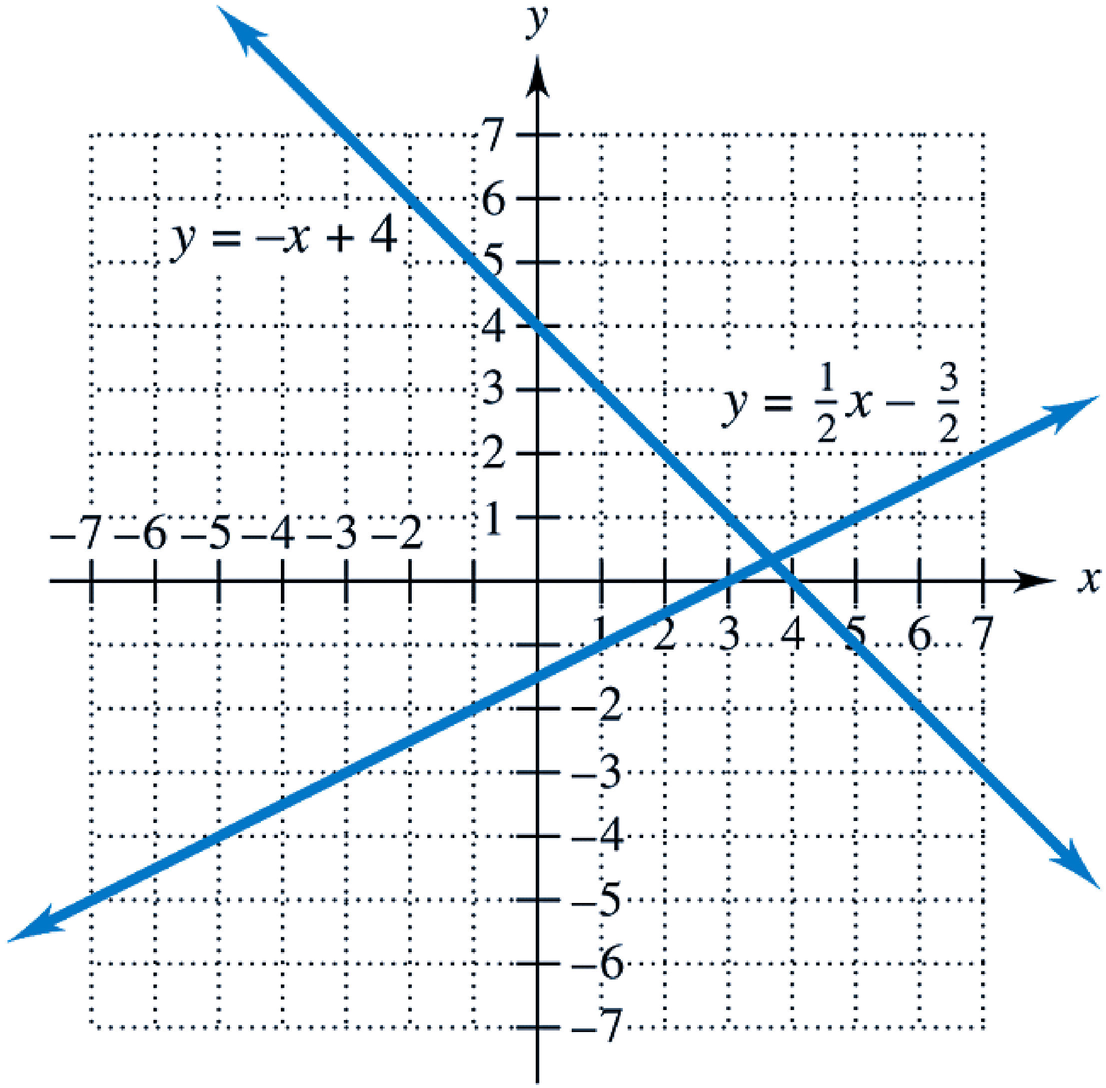

Figure 2.22(c)

Point–Slope Form

If a line has slope m and passes through the point (x_1, y_1), then

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

is the **point–slope form** of the equation of the line.

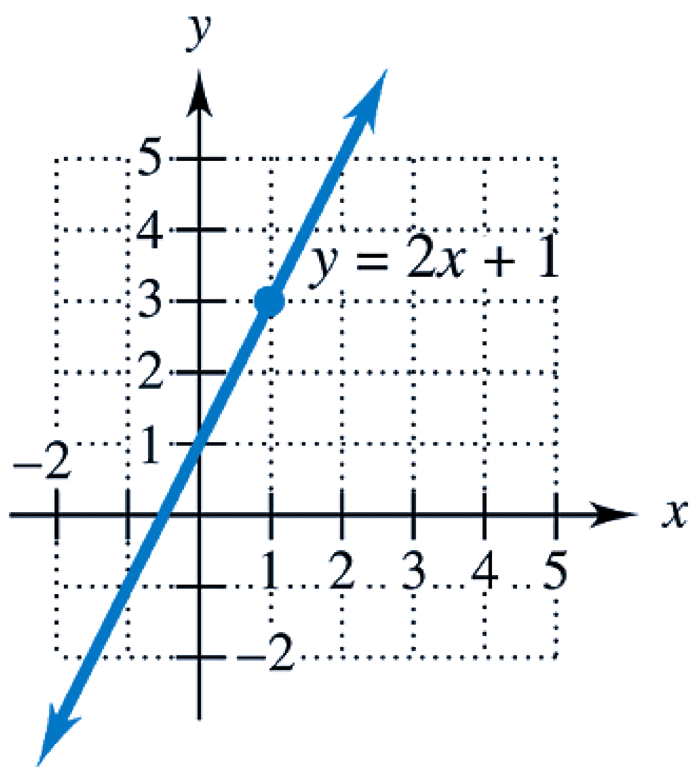

Figure 2.23

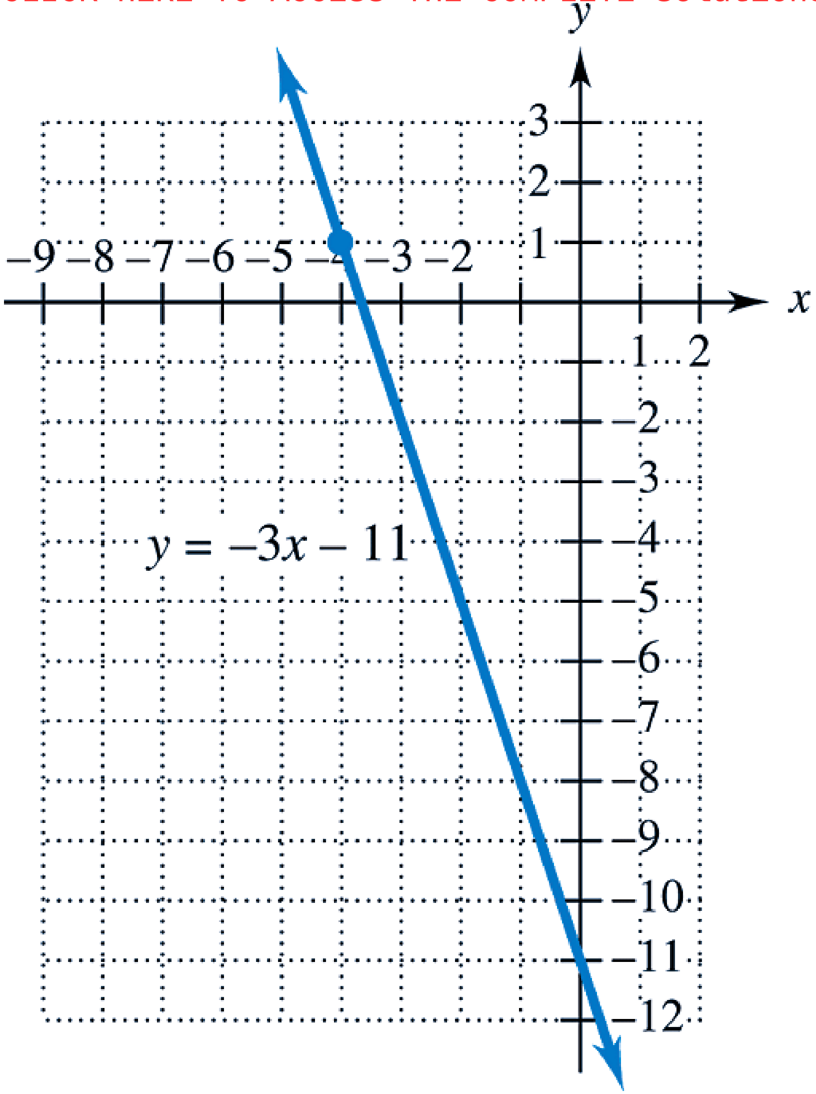

Figure 2.24

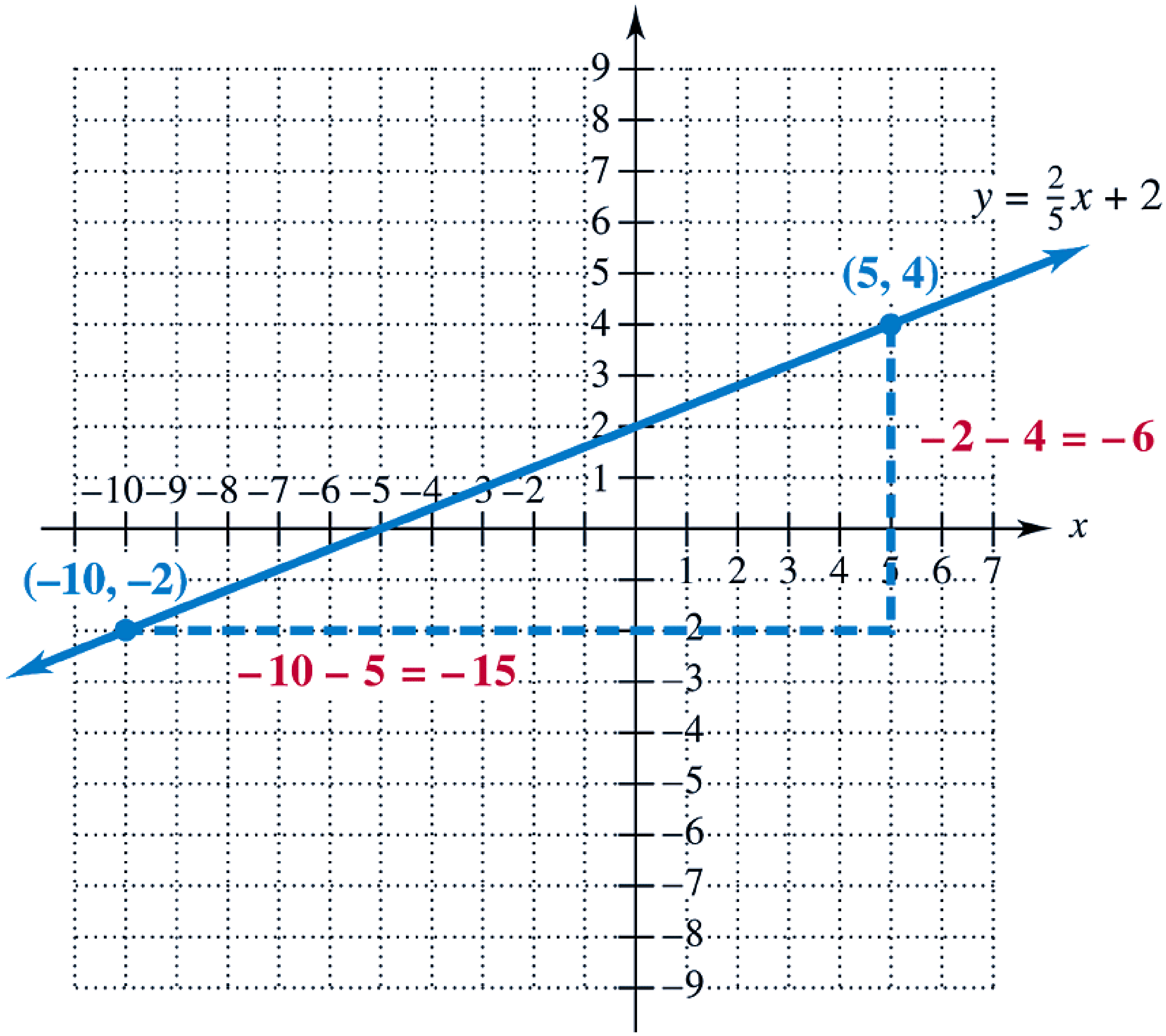

Figure 2.25

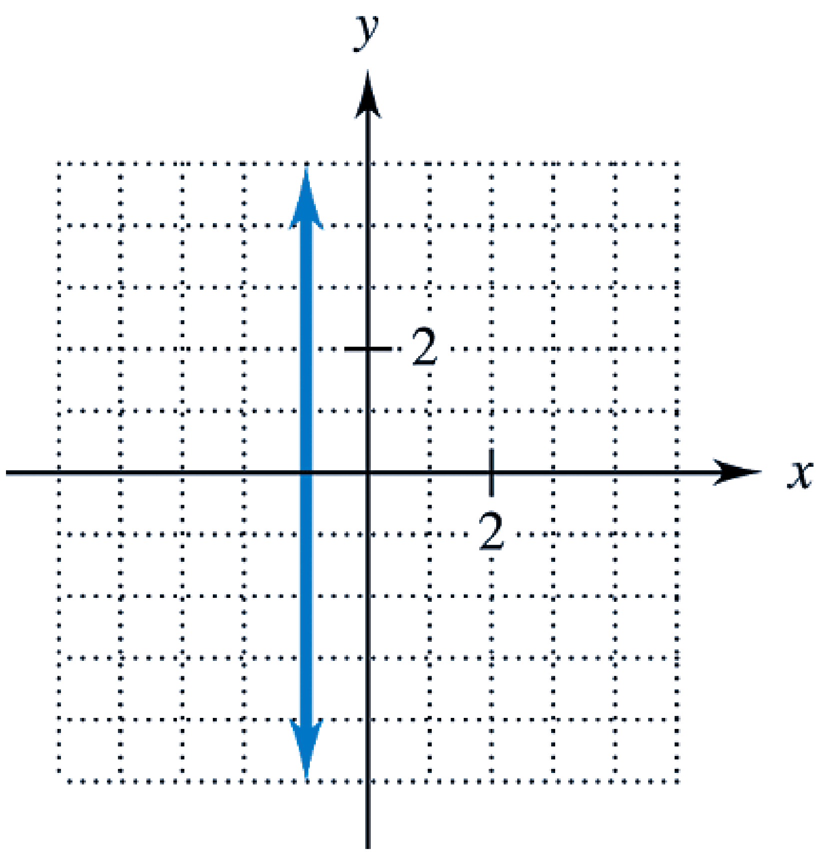

Figure 2.26

If k is a constant, then the graph of the equation $x = k$ is the vertical line with x-intercept k.

Equation	Description
$x = k$	**Vertical line,** x-intercept k, no y-intercept (unless $x = 0$), undefined slope
$y = k$	**Horizontal line,** y-intercept k, no x-intercept (unless $y = 0$), slope 0
$y = mx + b$	**Slope–intercept form,** slope m, y-intercept b
$y - y_1 = m(x - x_1)$	**Point–slope form,** slope m, the line passes through (x_1, y_1)
$ax + by = c$	**General form.** If $a \neq 0$ and $b \neq 0$, the line has x-intercept c/a, y-intercept c/b, and slope $-a/b$.

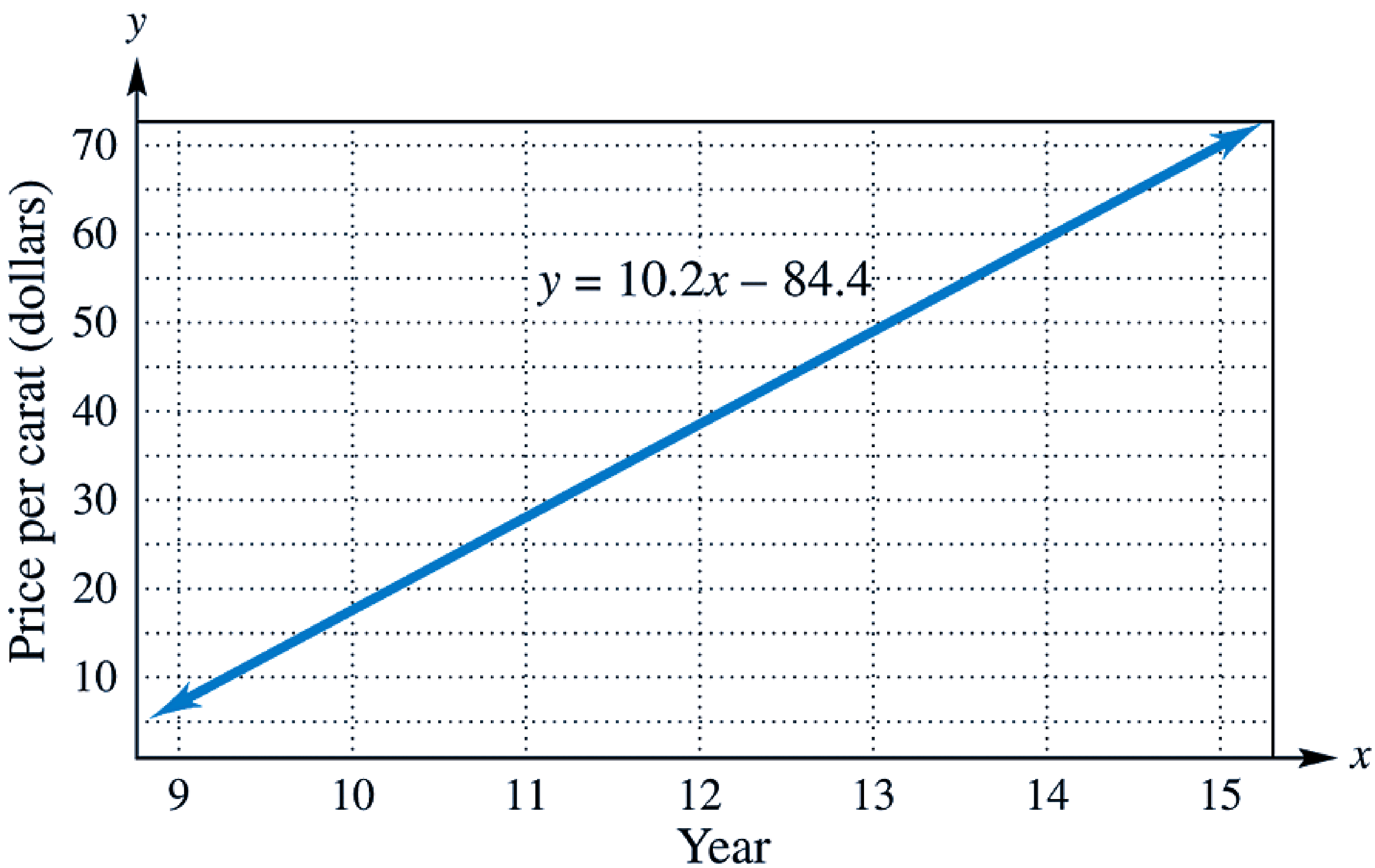
y
70
60
50
40
30
20
10
Price per carat (dollars)
y = 10.2x – 84.4
9
10
11
12
13
14
15
x
Year

Figure 2.27

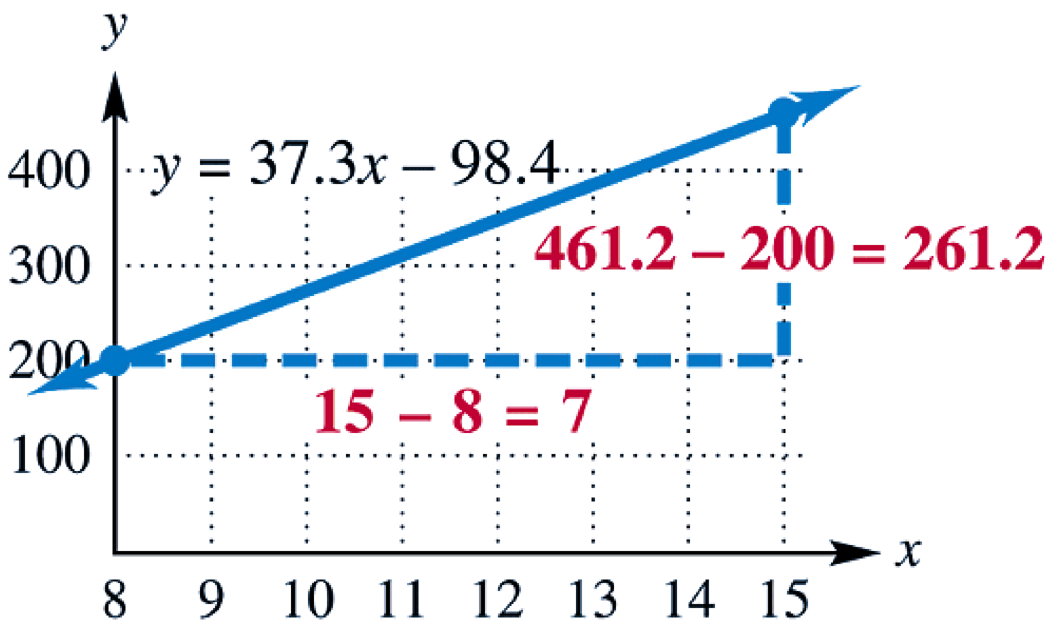
y
x
400
300
200
100
8
9
10
11
12
13
14
15
y = 37.3x – 98.4
461.2 – 200 = 261.2
15 – 8 = 7

Figure 2.28

Section 2.3

Linear Models

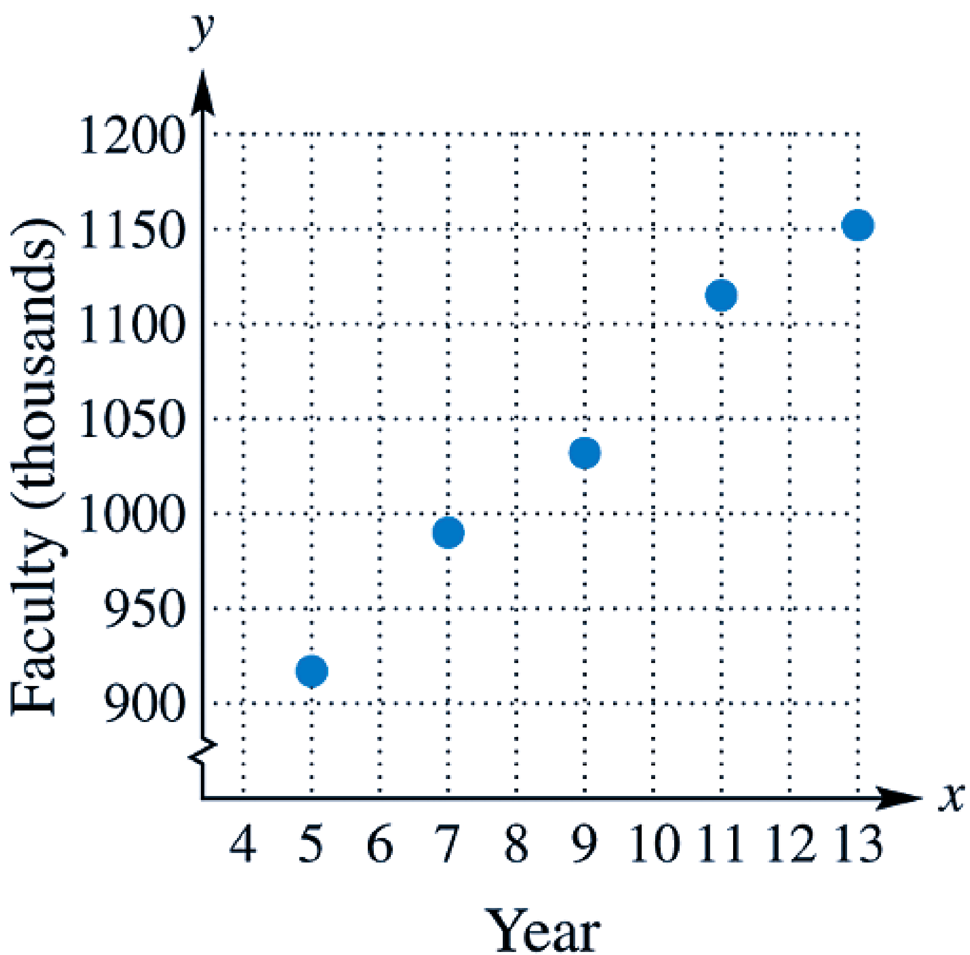
y
1200
1150
1100
1050
1000
950
900
Faculty (thousands)
x
4 5 6 7 8 9 10 11 12 13
Year

Figure 2.29

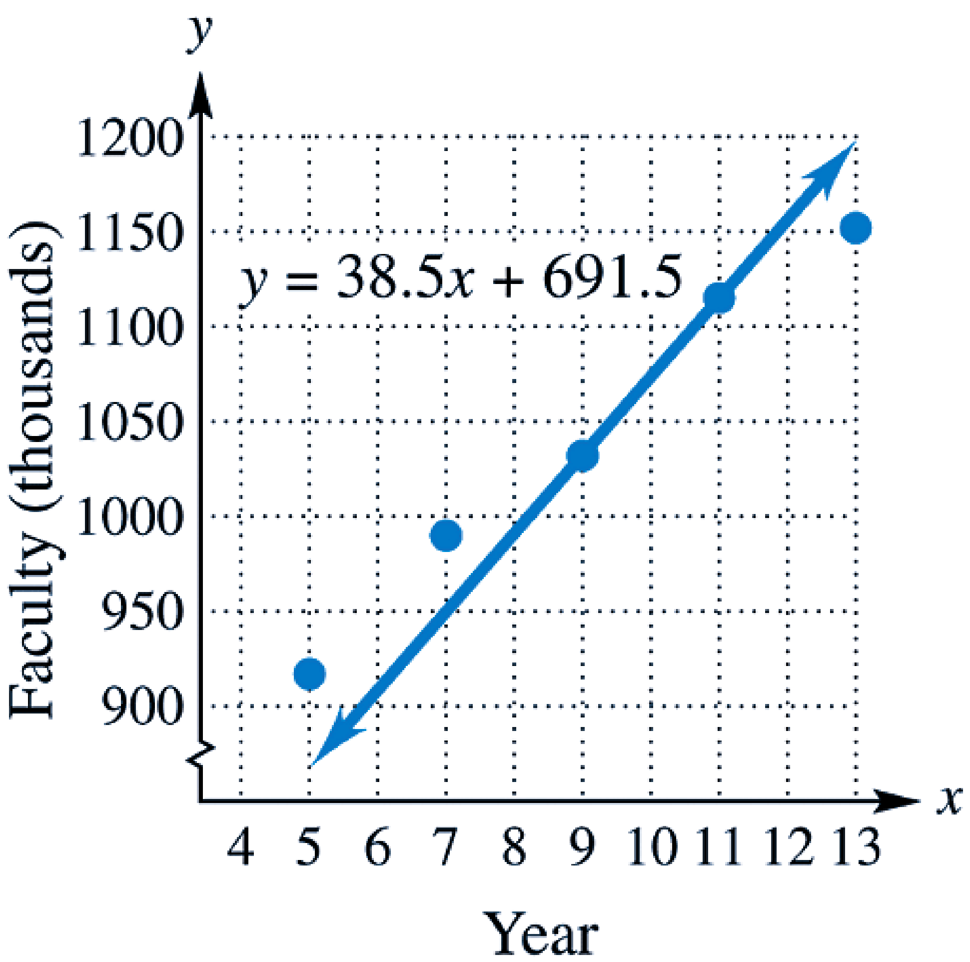
y
1200
1150
1100
1050
1000
950
900
Faculty (thousands)
y = 38.5x + 691.5
x
4 5 6 7 8 9 10 11 12 13
Year

Figure 2.30

CLICK HERE TO ACCESS THE COMPLETE Solutions

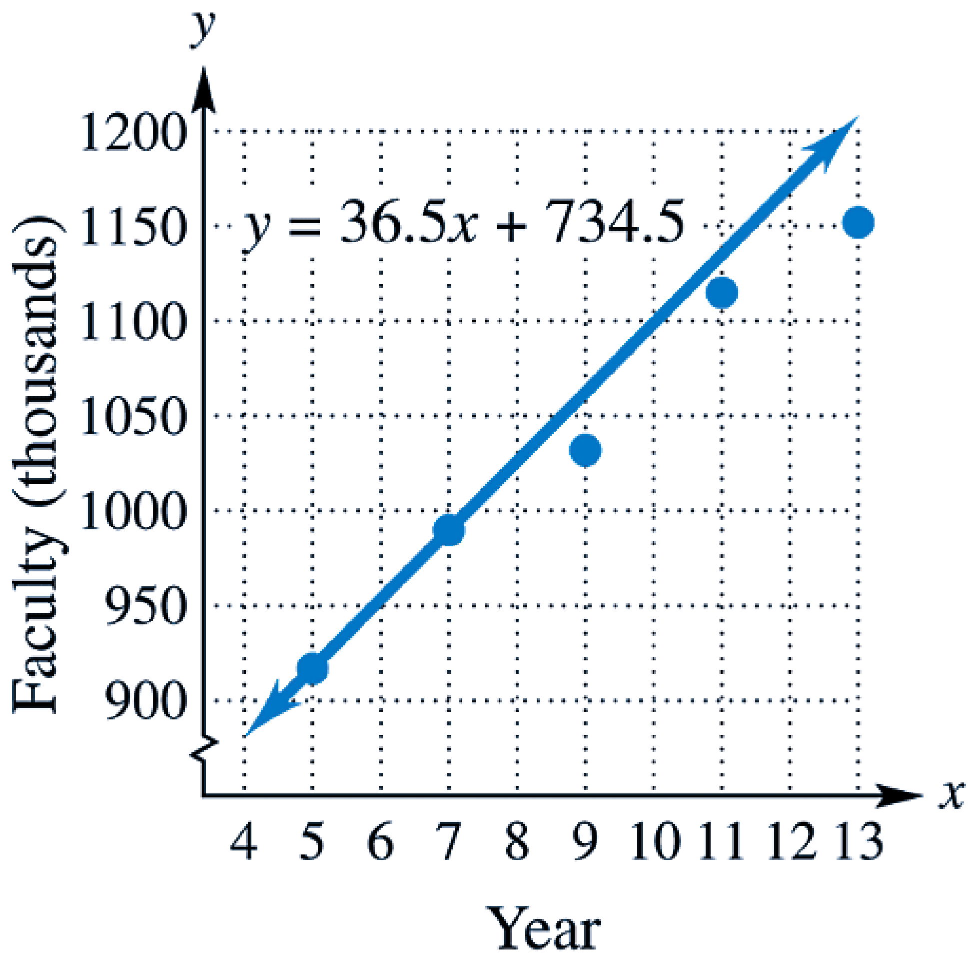

Figure 2.31

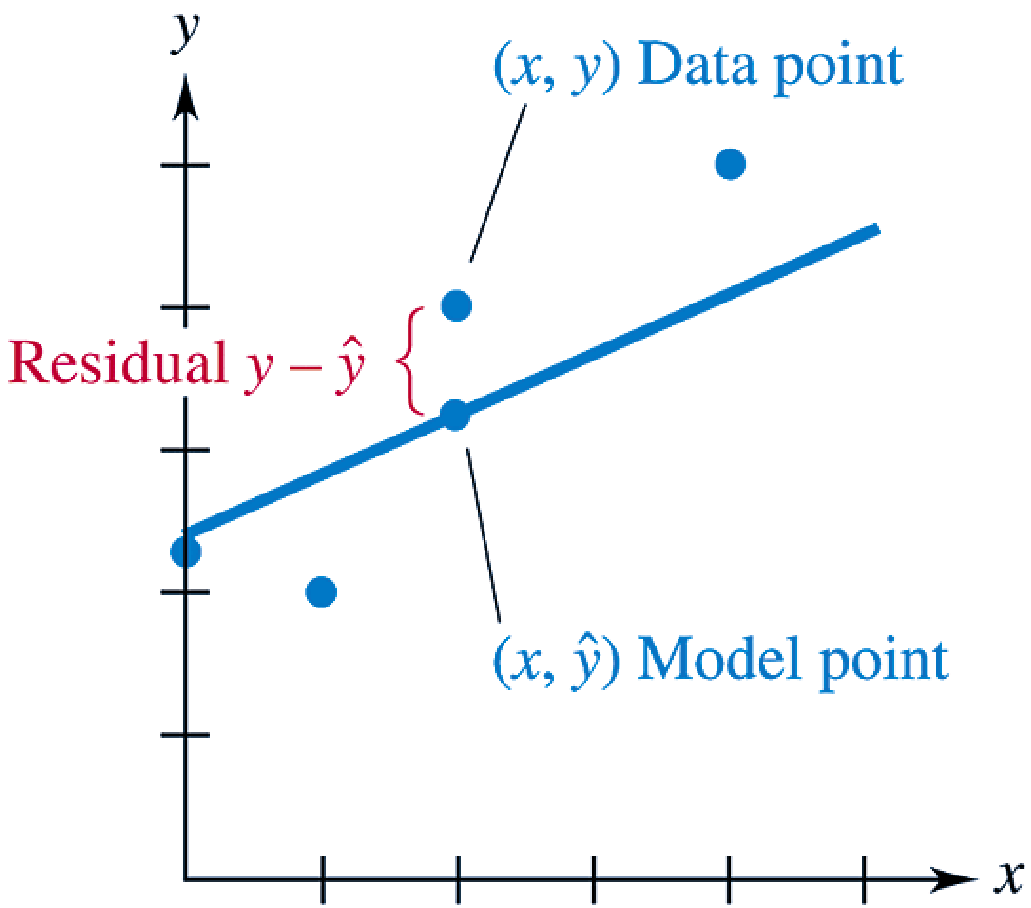

Figure 2.32

Example:

Full-Time Faculty Two linear models for the number of full-time faculty at four-year colleges and universities were constructed in Example 1:

$$y = 38.5x + 691.5 \text{ and } y = 36.5 + 734.5.$$

For each model, determine the five residuals, square of each residual, and the sum of the squares of the residuals.

Solution:

The information for the first model is summarized in the following table:

$$y = 38.5x + 691.5$$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(5, 917)	(5, 884)	33	1089
(7, 990)	(7, 961)	29	841
(9, 1038)	(9, 1038)	0	0
(11, 1115)	(11, 1115)	0	0
(13, 1152)	(13, 1192)	−40	1600
			Sum = 3530

Example:

Full-Time Faculty Two linear models for the number of full-time faculty at four-year colleges and universities were constructed in Example 1:

$$y = 38.5x + 691.5 \text{ and } y = 36.5 + 734.5.$$

Solution:

The information for the second model is summarized in the following table:

$$y = 36.5 + 734.5$$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(5, 917)	(5, 917)	0	0
(7, 990)	(7, 990)	0	0
(9, 1038)	(9, 1063)	−25	625
(11, 1115)	(11, 1136)	−21	441
(13, 1152)	(13, 1209)	−57	3249
			Sum = 4315

According to this measure of the error, the line $y = 38.5x + 691.5$ is a better fit for the data because the sum of the squares of its residuals is smaller than the sum of the squares of the residuals for $y = 36.5x + 734.5.$

For any set of data points, there is one, and only one, line for which the sum of the squares of the residuals is as small as possible.

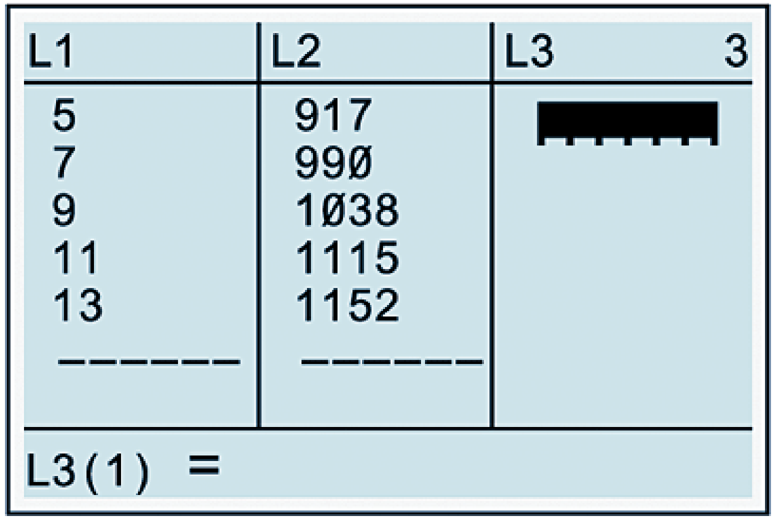

Figure 2.33

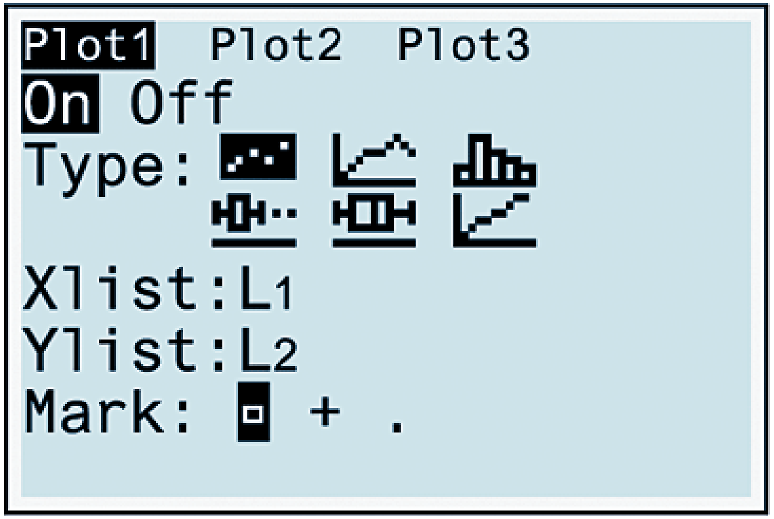

Figure 2.34

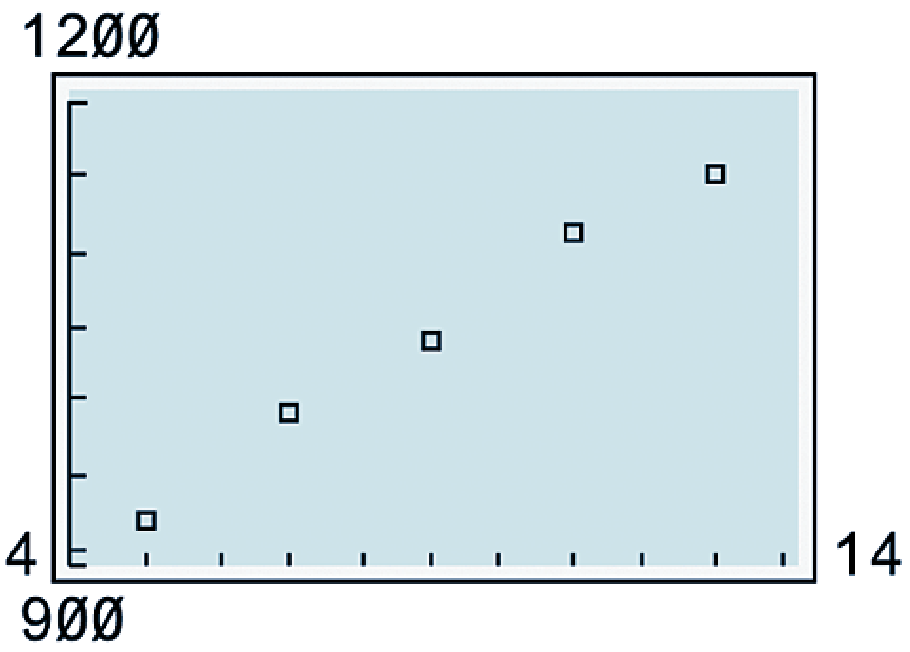

Figure 2.35

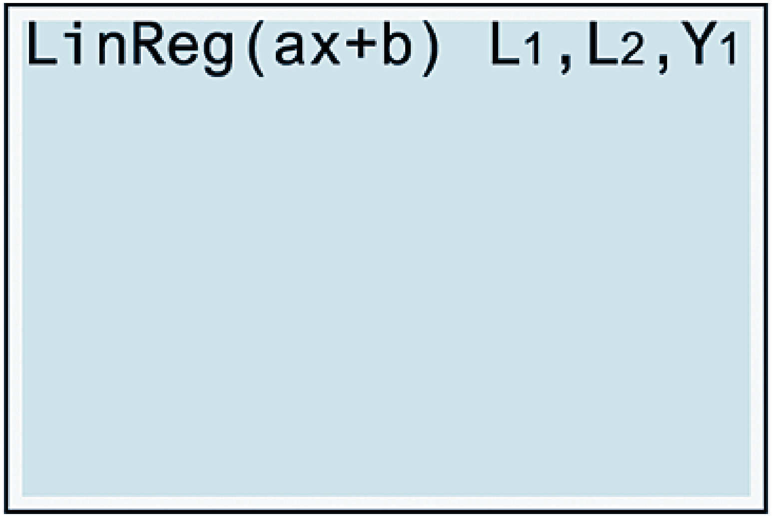

Figure 2.36

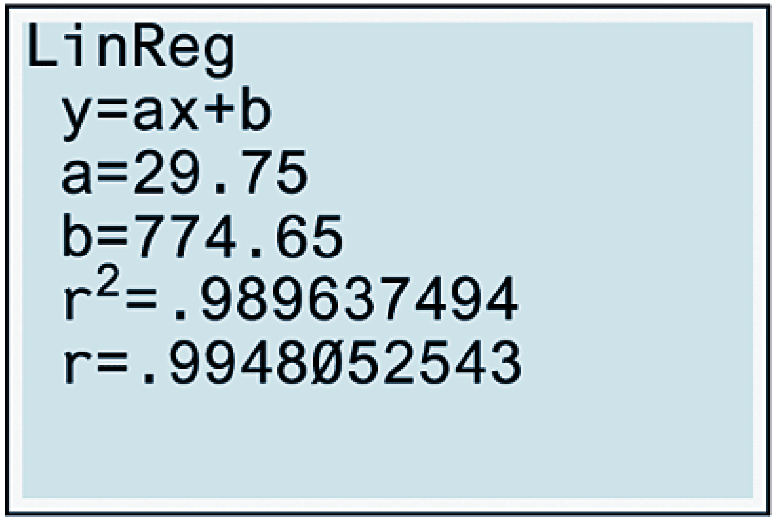

Figure 2.37

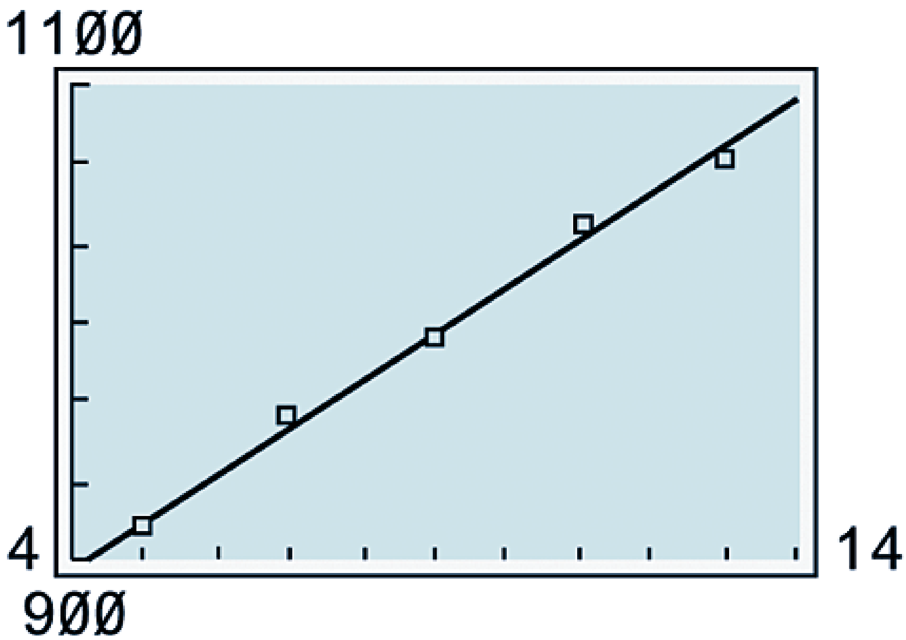

Figure 2.38

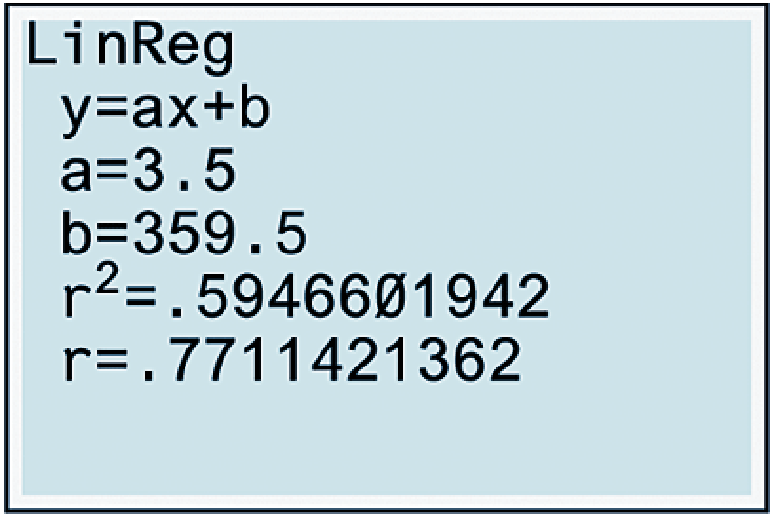

Figure 2.39

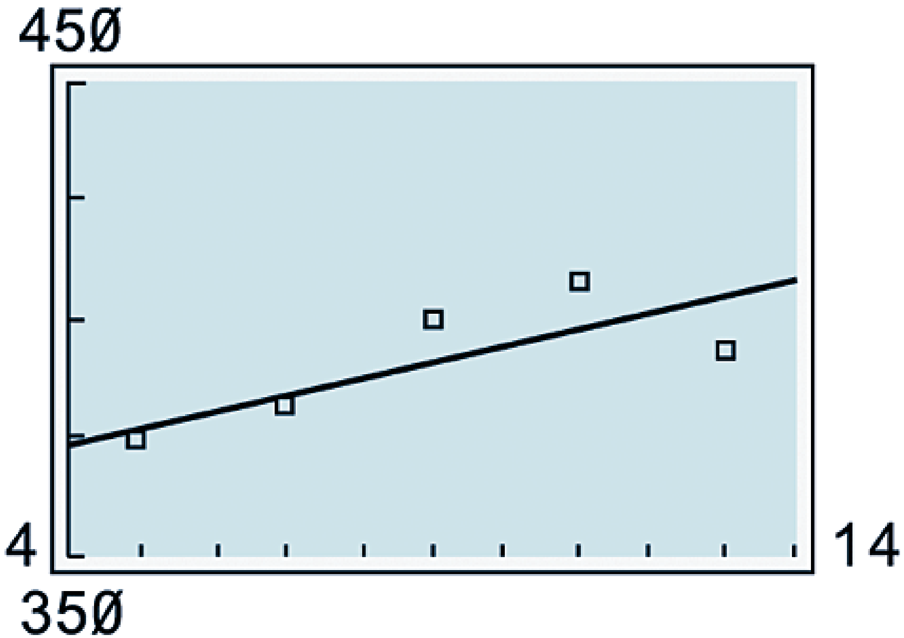

Figure 2.40

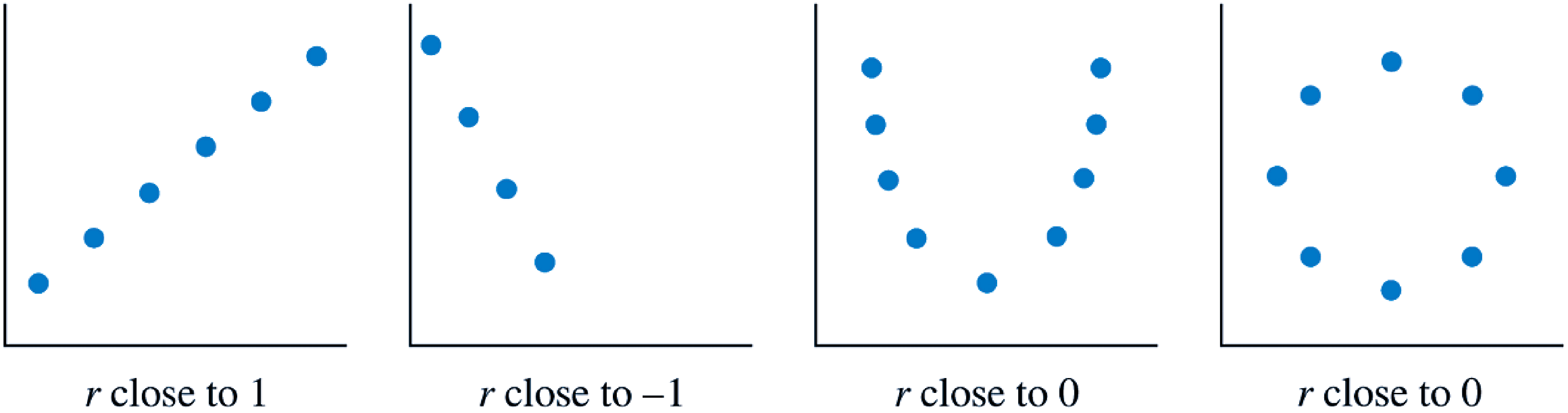

Figure 2.41

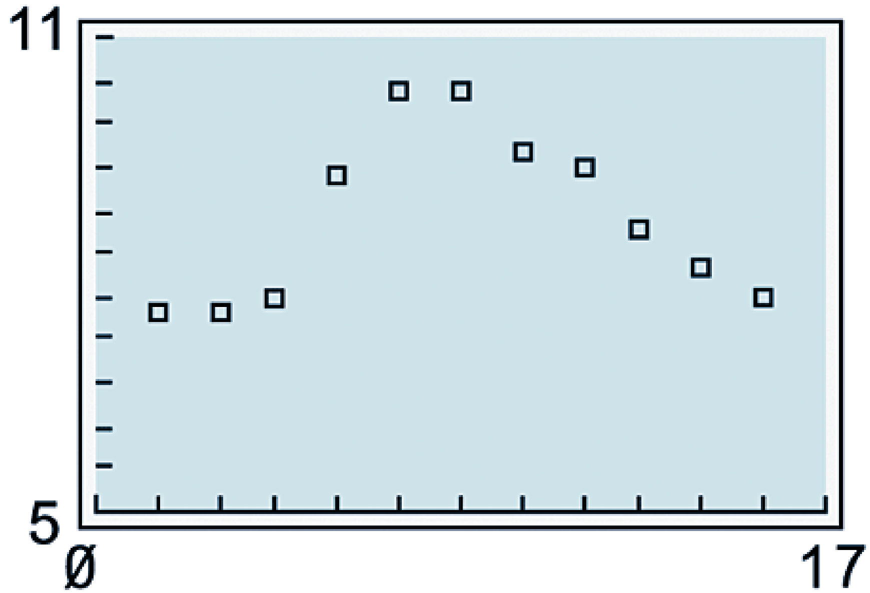

Figure 2.42

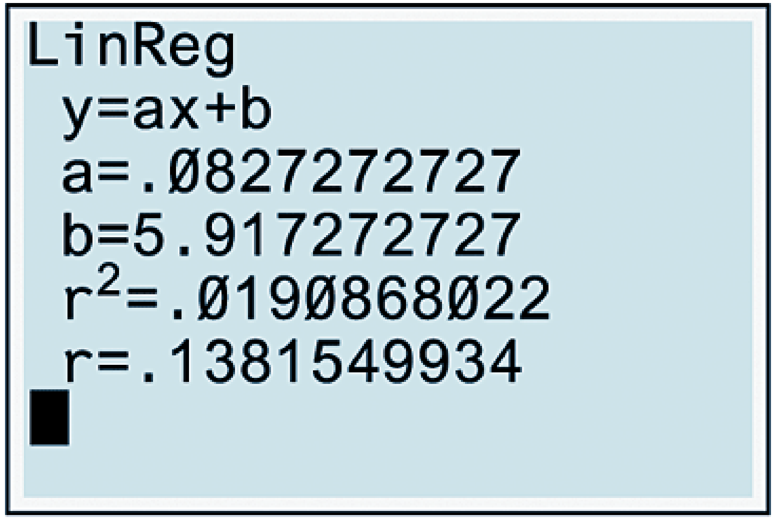
LinReg
y=ax+b
a=.Ø827272727
b=5.917272727
r²=.Ø19Ø868Ø22
r=.1381549934

Figure 2.43

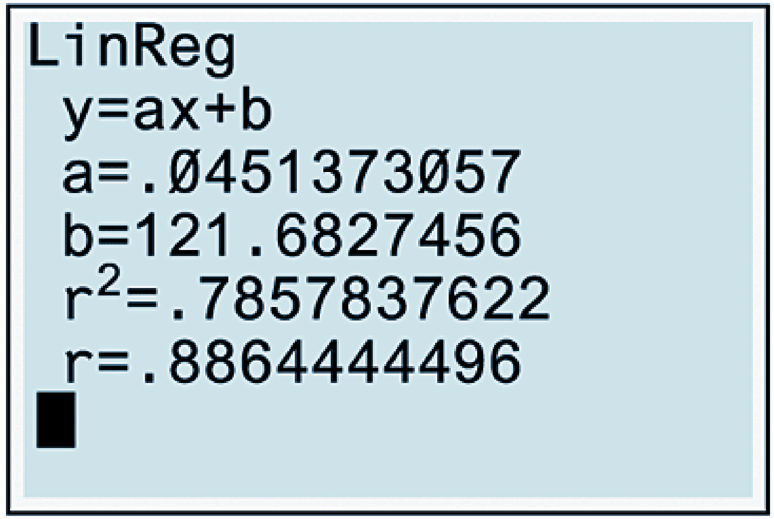
LinReg
y=ax+b
a=.0451373057
b=121.6827456
r²=.7857837622
r=.8864444496

Figure 2.44

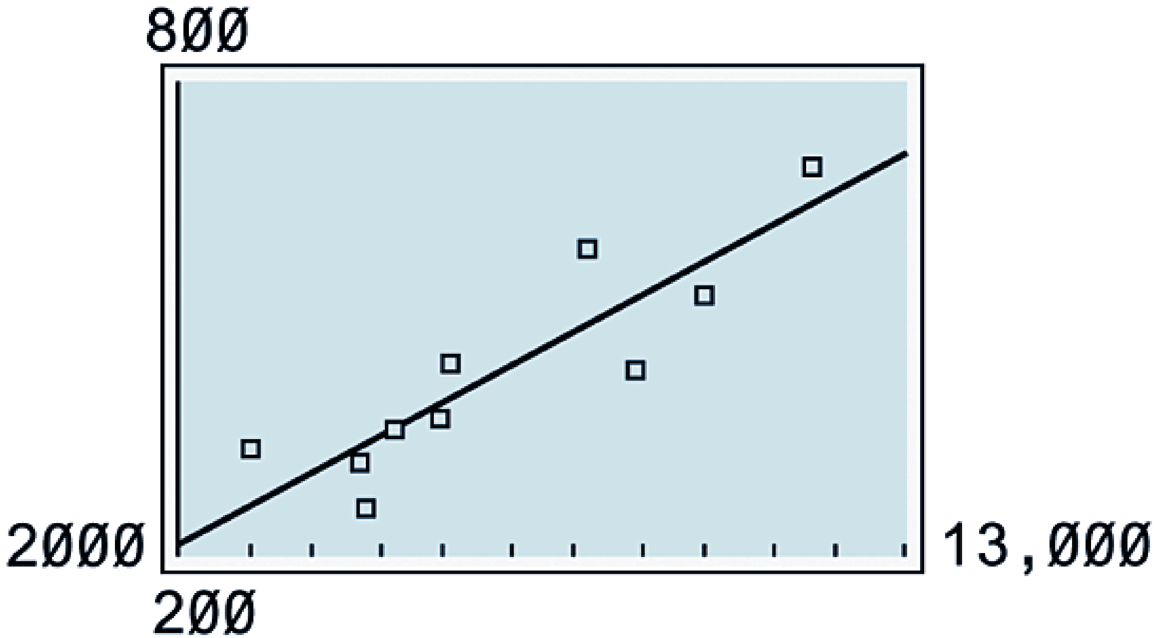

Figure 2.45

Section 2.4

Linear Inequalities

Properties of Inequality

For real numbers a, b, and c,

(a) if $a < b$, then $a + c < b + c$;

(b) if $a < b$, and if $c > 0$, then $ac < bc$;

(c) if $a < b$, and if $c < 0$, then $ac > bc$.

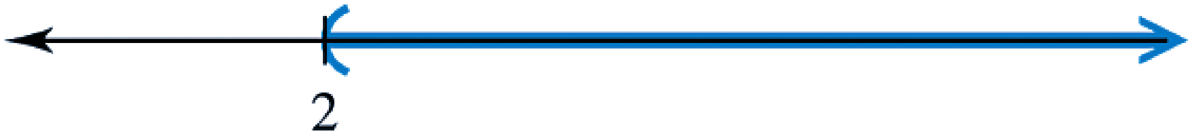

Figure 2.46

Example: Solve $4 - 3x \le 7 + 2x.$

Solution: Add -4 to both sides.

$$4 - 3x + (-4) \le 7 + 2x + (-4)$$
$$-3x \le 3 + 2x$$

Add $-2x$ to both sides (remember that adding to both sides never changes the direction of the inequality symbol).

$$-3x + (-2x) \le 3 + 2x + (-2x)$$
$$-5x \le 3$$

To finish solving the inequality, multiply both sides by $-\frac{1}{5}$. Since $-\frac{1}{5}$ is negative, change the direction of the inequality symbol:

$$-\frac{1}{5}(-5x) \ge -\frac{1}{5}(3)$$
$$x \ge -\frac{3}{5}.$$

The solution set, $\left[-\frac{3}{5}, \infty\right)$, is graphed below. The bracket in Figure 2.47 indicates that $-\frac{3}{5}$ is included in the solution.

Figure 2.47

Figure 2.48

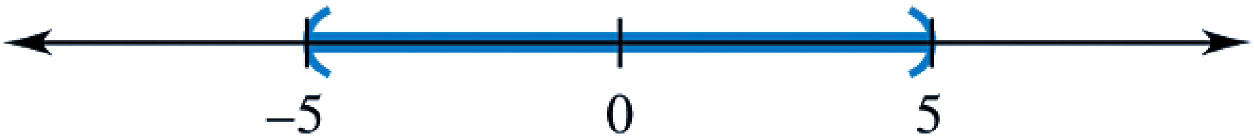

Figure 2.49

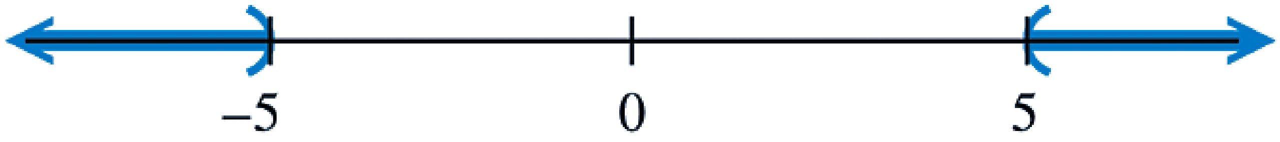

Figure 2.50

Assume that a and b are real numbers and that b is positive.

1. Solve $|a| < b$ by solving $-b < a < b$.
2. Solve $|a| > b$ by solving $a < -b$ or $a > b$.

CLICK HERE TO ACCESS THE COMPLETE Solutions

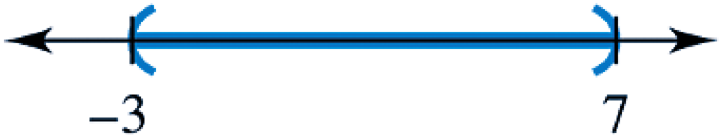

Figure 2.51

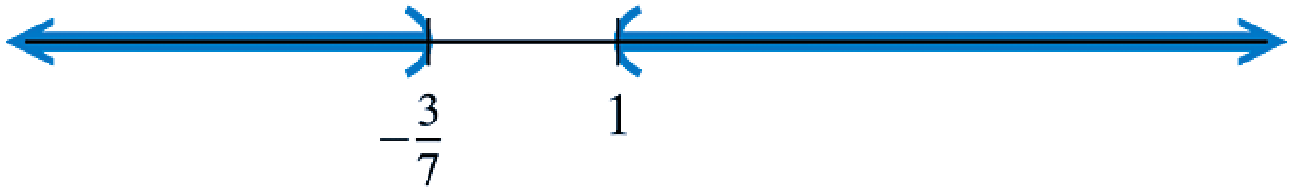

Figure 2.52

Section 2.5

Polynomial and Rational Inequalities

Example:

Use the graph of $y = x^3 - 5x^2 + 2x + 8$ in Figure 2.53 to solve each of the given equalities

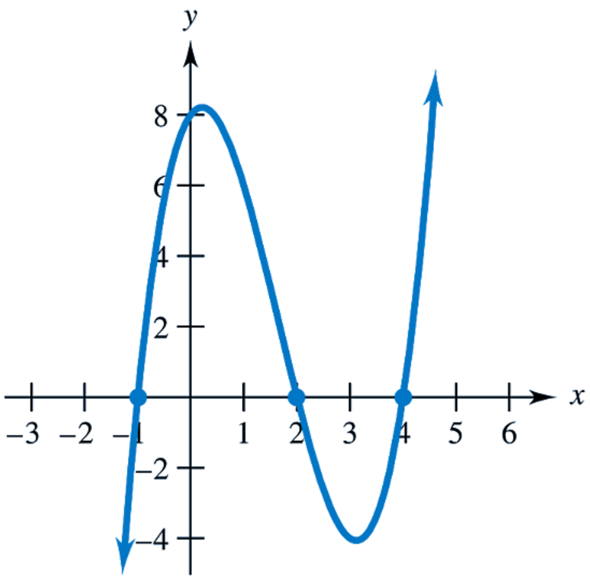

Figure 2.53

$$(a)\ x^3 - 5x^2 + 2x + 8 > 0.$$

Solution:

Each point on the graph has coordinates of the form $(x, x^3 - 5x^2 + 2x + 8)$. The number *x* is a solution of the inequality exactly when the second coordinate of this point is positive—that is, when the point lies *above* the *x*-axis.

So to solve the inequality, we need only find the first coordinates of points on the graph that are above *x*-axis.

The graph is above the *x*-axis when $-1 < x < 2$ and when $x > 4$.

Therefore, the solutions of the inequality are all numbers *x* in the interval $(-1, 2)$ or the interval $(4, \infty)$.

Example: Use the graph of $y = x^3 - 5x^2 + 2x + 8$ in Figure 2.53 to solve each of the given equalities

(b) $x^3 - 5x^2 + 2x + 8 < 0.$

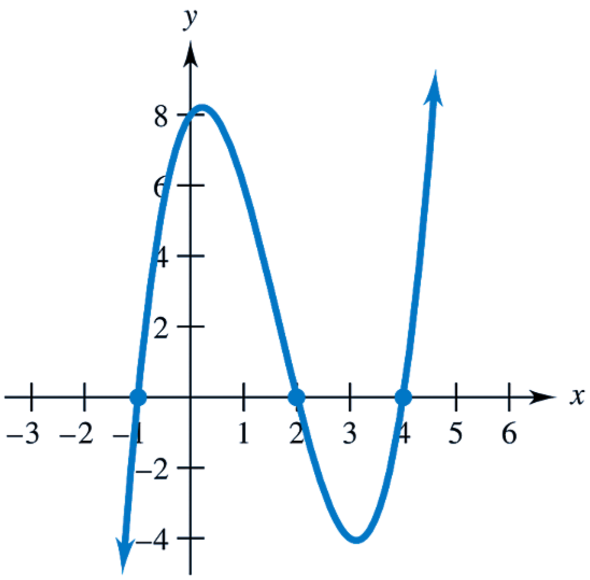

Figure 2.53

Solution: The number x is a solution of the inequality exactly when the second coordinate of the point $(x, x^3 - 5x^2 + 2x + 8)$ on the graph is negative—that is, when the point lies below the x-axis.

Figure 2.53 shows that the graph is below the *x*-axis when $x < -1$ and when $2 < x < 4$. Hence, the solutions are all numbers x in the interval $(-\infty, -1)$. or the interval $(2, 4)$.

Steps for Solving an Inequality Involving a Polynomial

1. Rewrite the inequality so that all the terms are on the left side and 0 is on the right side.
2. Find the x-intercepts by setting $y = 0$ and solving for x.
3. Divide the x-axis (number line) into regions using the solutions found in Step 2.
4. Test a point in each region by choosing a value for x and substituting it into the equation for y.
5. Determine which regions satisfy the original inequality and graph the solution.

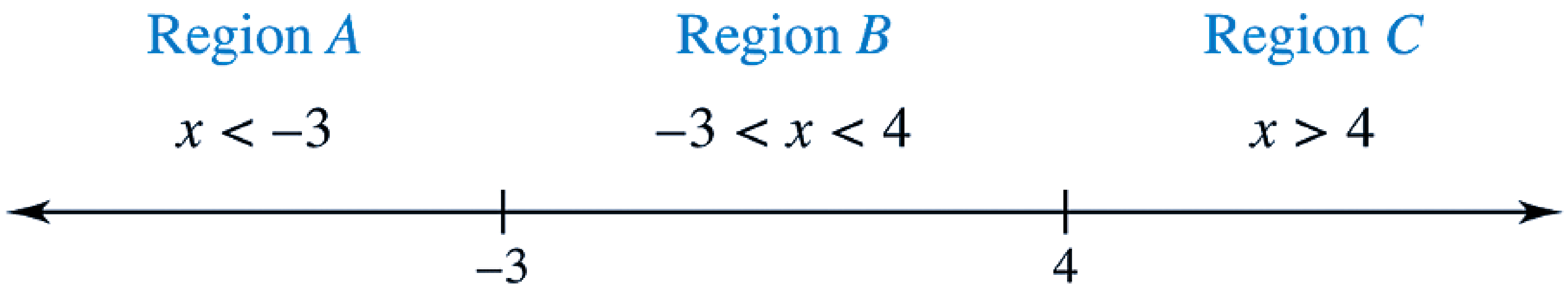

Figure 2.54

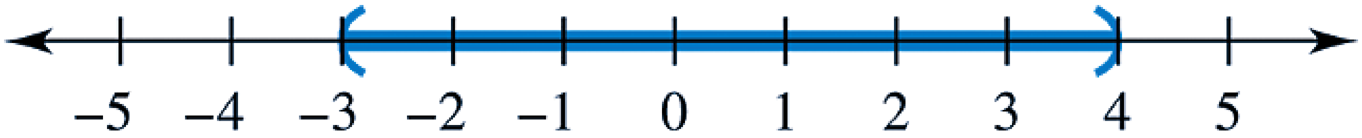

Figure 2.55

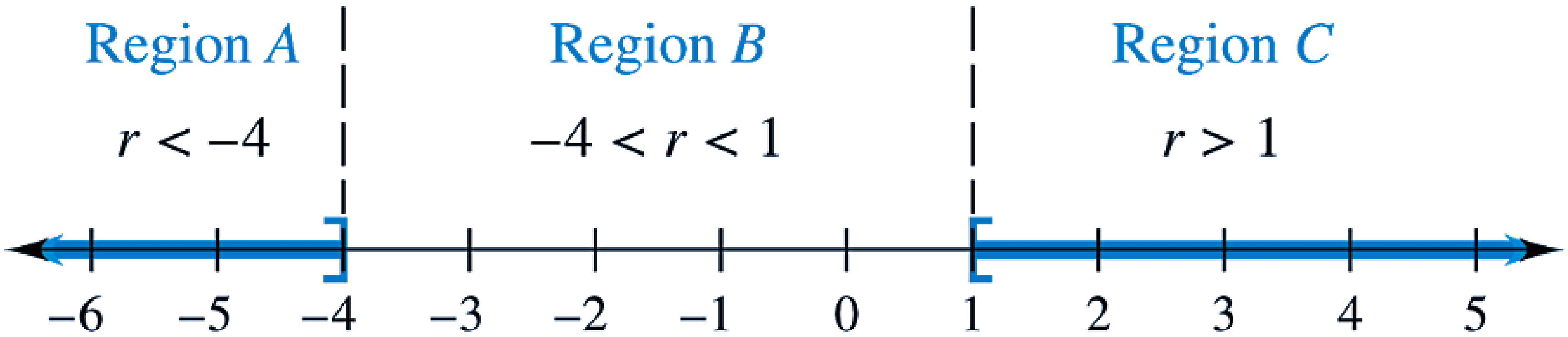

Figure 2.56

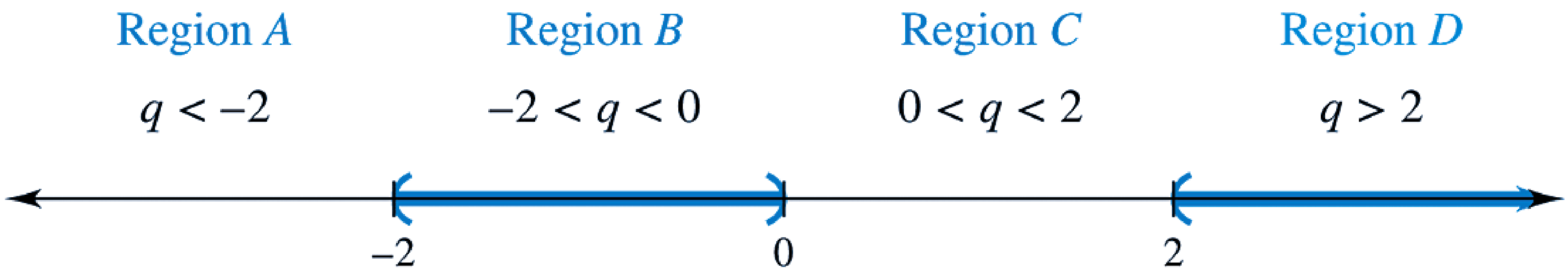

Figure 2.57

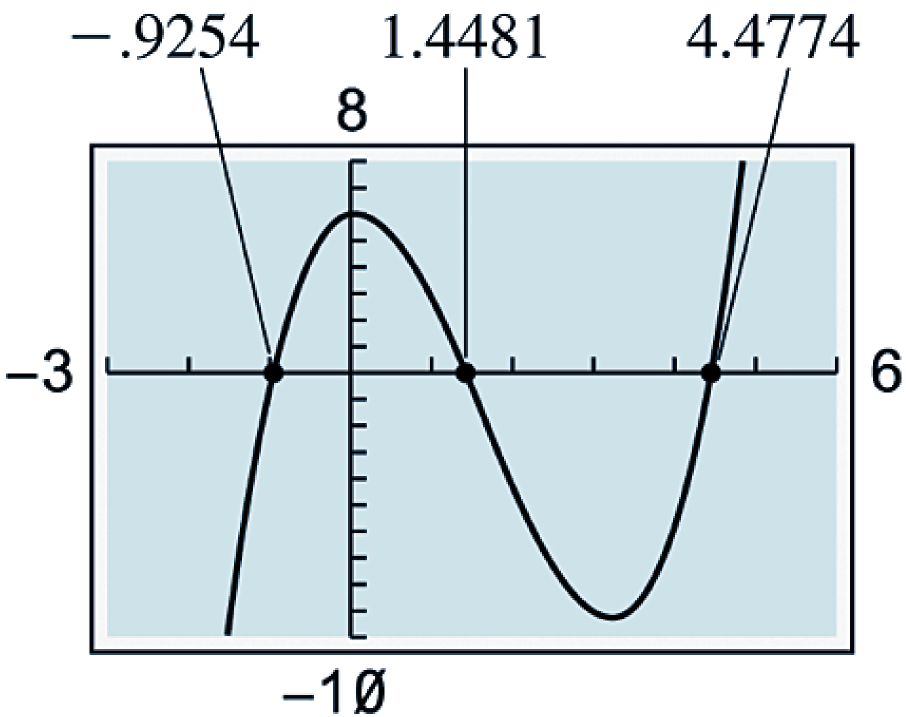

Figure 2.58

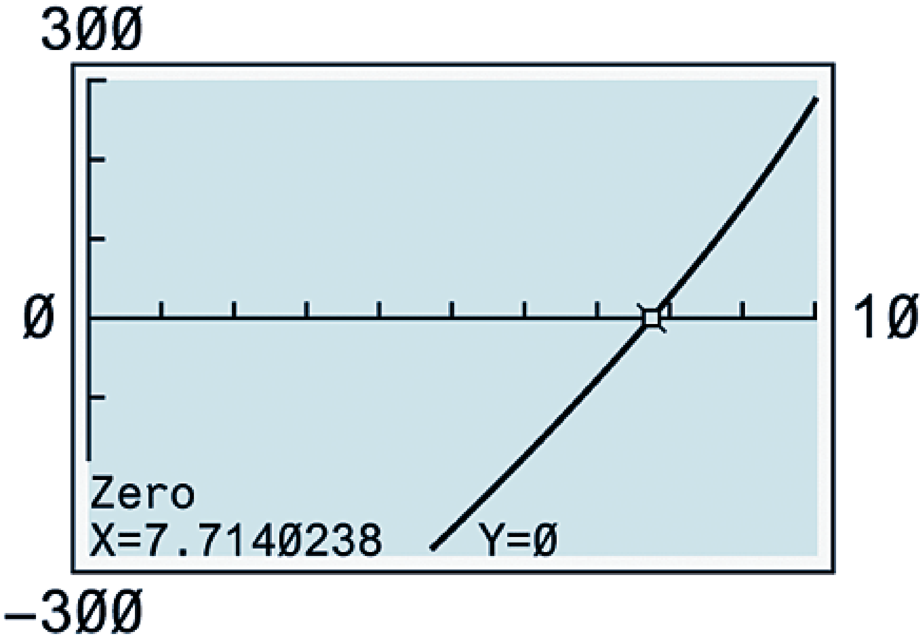

Figure 2.59

Steps for Solving Inequalities Involving Rational Expressions

1. Rewrite the inequality so that all the terms are on the left side and the 0 is on the right side.
2. Write the left side as a single fraction.
3. Set the numerator and the denominator equal to 0 and solve for x.
4. Divide the x-axis (number line) into regions using the solutions found in Step 3.
5. Test a point in each region by choosing a value for x and substituting it into the equation for y.
6. Determine which regions satisfy the original inequality and graph the solution.

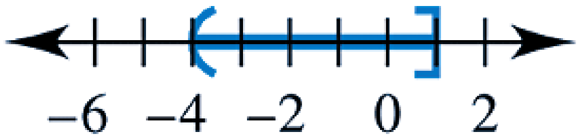

Figure 2.60

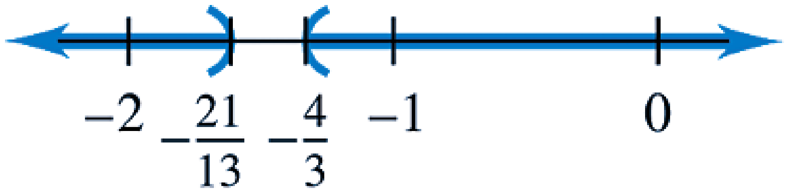

Figure 2.61

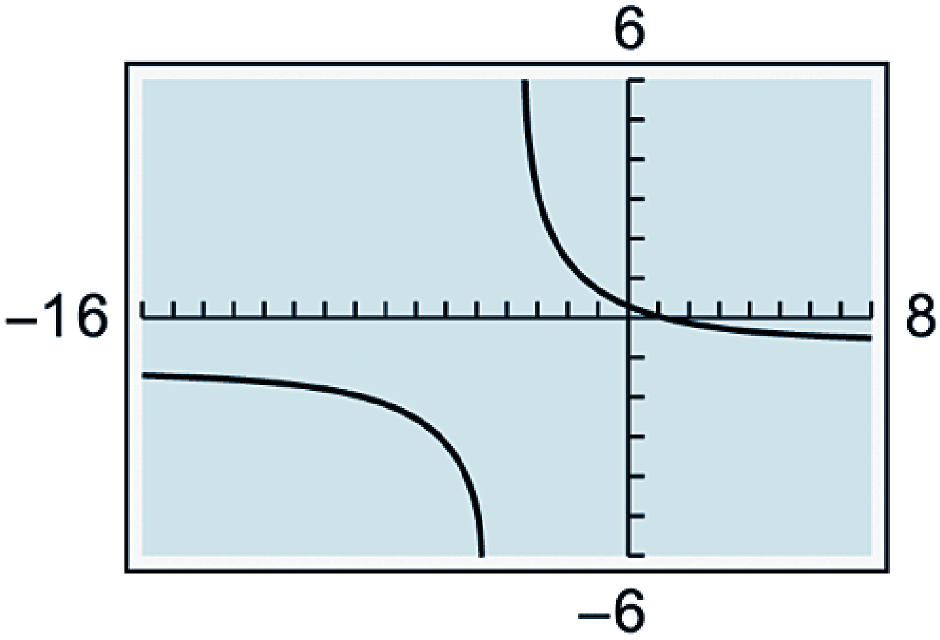

Figure 2.62