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

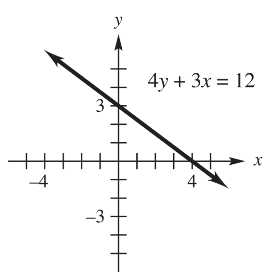
3. (1, –3) is a solution to $3x - y - 6 = 0$ because $3(1) - (-3) - 6 = 0$ is a true statement.

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.

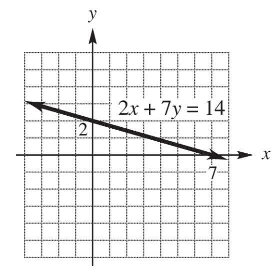
5. (3, 4) is not a solution to $(x-2)^2 + (y+2)^2 = 6$ because $(3-2)^2 + (4+2)^2 = 37,$ not 6.

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.

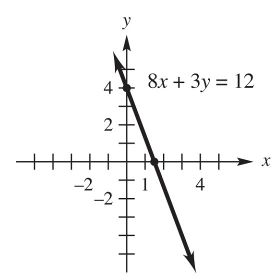
7. $4y + 3x = 12$
Find the y-intercept. If $x = 0$,
$4y = -3(0) + 12 \Rightarrow 4y = 12 \Rightarrow y = 3$
The y-intercept is 3.
Next find the x-intercept. If $y = 0$,
$4(0) + 3x = 12 \Rightarrow 3x = 12 \Rightarrow x = 4$
The x-intercept is 4.
Using these intercepts, graph the line.



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.

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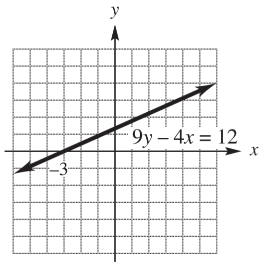
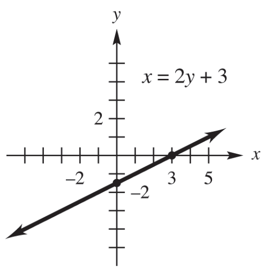
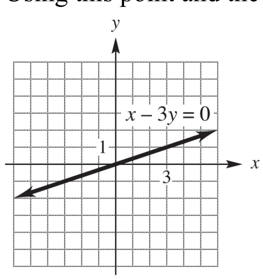
Using these intercepts, graph the line.



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.

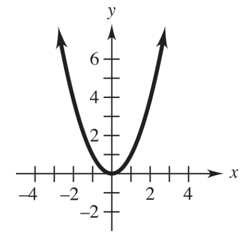
24. $y = 5x^2 + 6x + 1$
To find the x-intercepts, let $y = 0$:
$0 = 5x^2 + 6x + 1 \Rightarrow 0 = (5x+1)(x+1) \Rightarrow$
$5x + 1 = 0 \Rightarrow x = -\frac{1}{5}$ or $x + 1 = 0 \Rightarrow x = -1$
The x-intercepts are $-\frac{1}{5}$ and –1.
To find the y-intercept, let $x = 0$:
$y = 5(0)^2 + 6(0) + 1 = 1$
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.

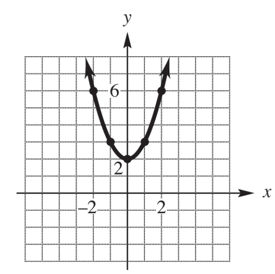
27. $y = x^2$
x-intercept: $0 = x^2 \Rightarrow x = 0$
y-intercept: $y = 0$

x	y
–2	4
–1	1
0	0
1	1
2	4



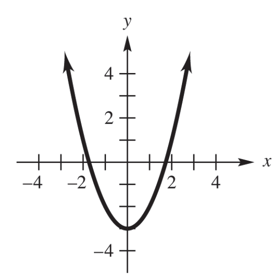
28. $y = x^2 + 2$
x-intercept: $0 = x^2 + 2 \Rightarrow x^2 = -2 \Rightarrow$
$x = \pm\sqrt{-2}$ not a real number
y-intercept: $y = 0^2 + 2 \Rightarrow y = 2$

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

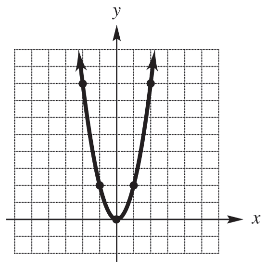
x	y
–3	6
–1	–2
0	–3
1	–2
3	6



30. $y = 2x^2$

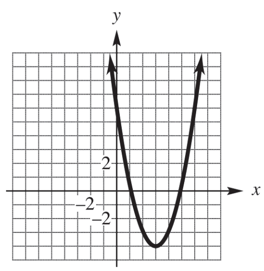
x-intercept: $0 = 2x^2 \Rightarrow x = 0$
y-intercept: $y = 2(0) = 0$

x	y
–2	8
–1	2
0	0
1	2
–2	8



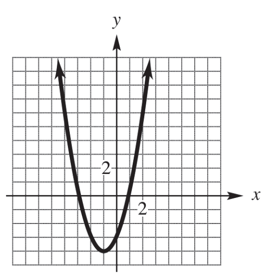
31. $y = x^2 - 6x + 5$
x-intercept:
$0 = x^2 - 6x + 5 \Rightarrow 0 = (x-1)(x-5) \Rightarrow$
$x - 1 = 0 \Rightarrow x = 1$ or $x - 5 = 0 \Rightarrow x = 5$
y-intercept: $y = (0)^2 - 6(0) + 5 = 5$

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

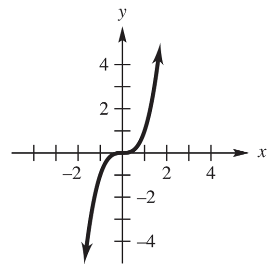
x	y
–3	0
–2	–3
–1	–4
0	–3
1	0



33. $y = x^3$

x-intercept: $0 = x^3 \Rightarrow x = 0$
y-intercept: $y = 0^3 \Rightarrow y = 0$

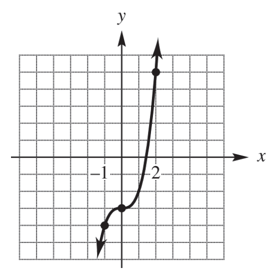
x	y
–2	–8
–1	–1
0	0
1	1
2	8



34. $y = x^3 - 3$

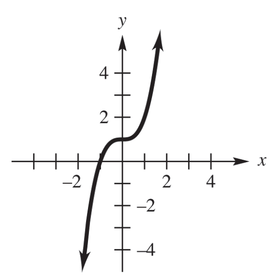
x-intercept: $0 = x^3 - 3 \Rightarrow x^3 = 3 \Rightarrow x = \sqrt[3]{3}$
y-intercept: $y = 0^3 - 3 \Rightarrow y = -3$

x	y
–2	–11
–1	–4
0	–3
1	–2
2	5



35. $y = x^3 + 1$
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

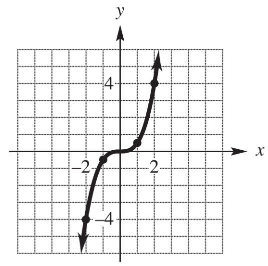


36. $y = \dfrac{x^3}{2}$

x-intercept: $0 = \dfrac{x^3}{2} \Rightarrow x = 0$

y-intercept: $y = \dfrac{0}{2} = 0$

x	y
–2	–4
–1	–1/2
0	0
1	1/2
2	4

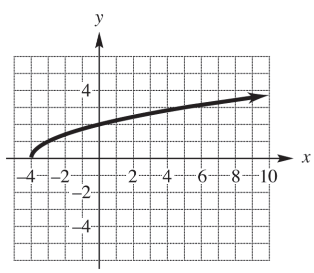


37. $y = \sqrt{x+4}$

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

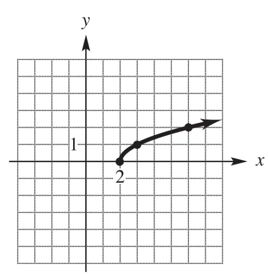


38. $y = \sqrt{x-2}$

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



39. $y = \sqrt{4-x^2}$

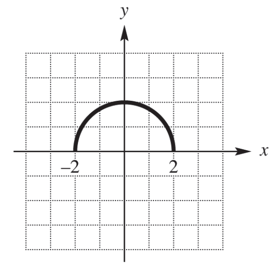
x-intercept:

$0 = \sqrt{4-x^2} \Rightarrow 0 = 4-x^2 \Rightarrow x^2 = 4 \Rightarrow$

$x = \pm\sqrt{4} = \pm 2$

y-intercept: $y = \sqrt{4} = 2$

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



40. $y = \sqrt{9-x^2}$

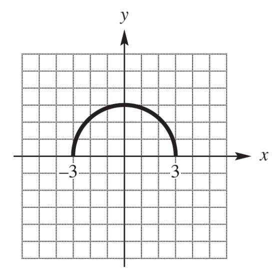
x-intercept:

$0 = \sqrt{9-x^2} \Rightarrow 0 = 9-x^2 \Rightarrow x^2 = 9 \Rightarrow$

$x = \pm\sqrt{9} = \pm 3$

y-intercept: $y = \sqrt{9-0^2} = \sqrt{9} = 3$

x	y
–3	0
–1	$2\sqrt{2} \approx 2.8$
0	3
1	$2\sqrt{2} \approx 2.8$
3	0



41. 2008; 20 million pounds

42. 2009; approximately 11 million pounds

43. 2011

44. No years

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

(b) \$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 59 pounds; chicken, about 83 pounds; pork, about 47.5 pounds

50. 2002

51. 2001

52. In 2001, annual per person beef consumption was about 66 pounds, while in 2010, annual per person beef consumption was about 59 pounds, so beef consumption decreased about 7 pounds between 2001 and 2010.

53. about \$512 billion

54. in 2005–2010

55. in 2008–2015

56. In 2015, sales are projected to be about \$590 billion, while in 2010, sales were about \$523 billion, so sales are projected to increase about \$67 billion.

57. H–P, about \$16.50; Intel, about \$21

58. H–P, about \$17.00; Intel, about \$22

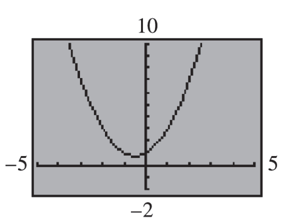
59. About \$17.25 on Day 14

60. About \$22.60 on Day 12

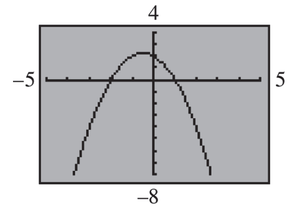
61. No

62. On day 1, the H–P share price was about \$15.00, while the H–P share price was about \$16.50 on day 21. So, the H–P share price increased by about \$1.50 for the month.

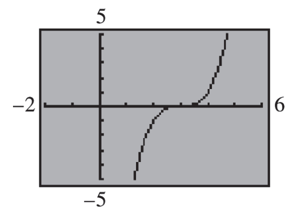
63. $y = x^2 + x + 1$



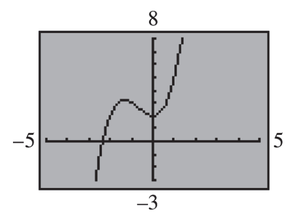
64. $y = 2 - x - x^2$



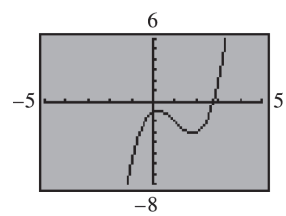
65. $y = (x - 3)^3$



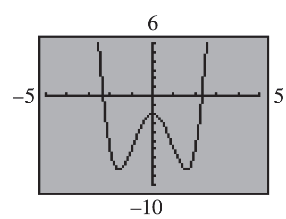
66. $y = x^3 + 2x^2 + 2$



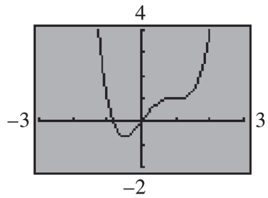
67. $y = x^3 - 3x^2 + x - 1$



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

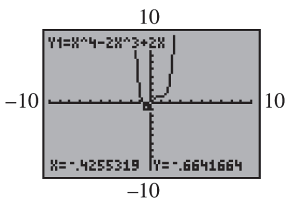


69. $y = x^4 - 2x^3 + 2x$



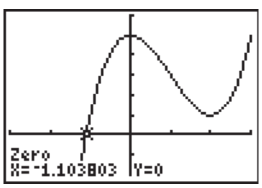
The "flat" part of the graph near $x = 1$ looks like a horizontal line segment, but it is not. The y values increase slightly as you trace along the segment from left to right.

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



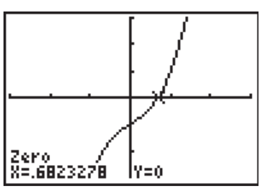
(b) The lowest point on the graph is approximately at (–.5, –.6875). Answers vary.

71. $x \approx -1.1038$



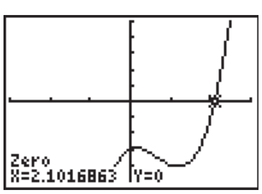
[–3, 3] by [–2, 6]

72. $x \approx .6823$



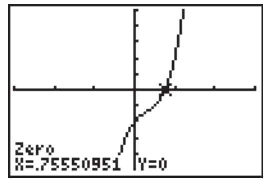
[–3, 3] by [–3, 3]

73. $x \approx 2.1017$



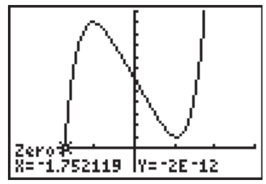
[–3, 3] by [–5, 5]

74. $x \approx .7555$



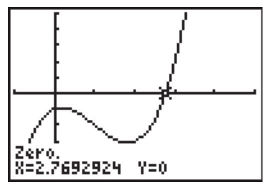
[–3, 3] by [–5, 5]

75. $x \approx -1.7521$



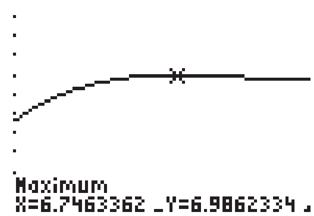
[–3, 3] by [–2, 12]

76. $x \approx 2.7693$



[–1, 53] by [–5, 5]

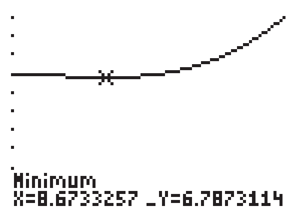
77. $y = .0556x^3 - 1.286x^2 + 9.76x - 17.4$



[4, 9] by [0, 10]

The maximum value of the total assets between 2005 and 2008 was approximately \$6.99 trillion.

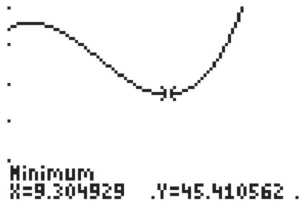
78. $y = .0556x^3 - 1.286x^2 + 9.76x - 17.4$



[7, 12] by [0, 10]

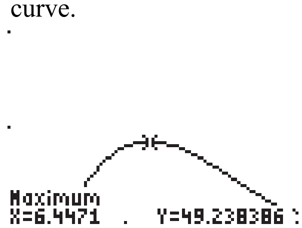
The minimum value of the total assets between 2008 and 2011 was approximately \$6.79 trillion.

79. Plot $y = .328x^3 - 7.75x^2 + 59.03x - 97.1$ on [6, 12] by [40, 50], then find the minimum of the curve.



The minimum value of the household assets between 2007 and 2011 was approximately \$45.41 trillion.

80. Plot $y = .328x^3 - 7.75x^2 + 59.03x - 97.1$ on [4, 9] by [45, 55], then find the maximum of the curve.



The maximum value of the household assets between 2005 and 2008 was approximately \$49.24 trillion.

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.
$$-9y = -6x + 16$$
$$9y = 6x - 16$$
$$y = \frac{2}{3}x - \frac{16}{9}$$
$$m = \frac{2}{3},\ b = -\frac{16}{9}.$$

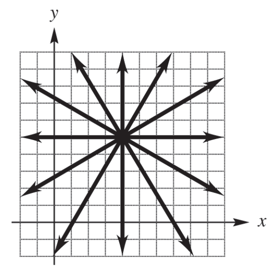
20. $4x + 2y = 0$
Rewrite in slope-intercept form.
$$2y = -4x \Rightarrow y = -2x$$
$m = -2$, $b = 0$.

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

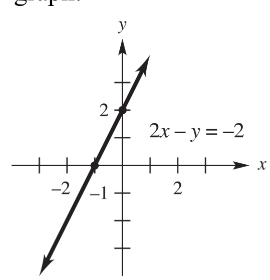
26. **(a)** $y = 3x + 2$
The slope is positive, and the y-intercept is positive. This is line D.

(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:

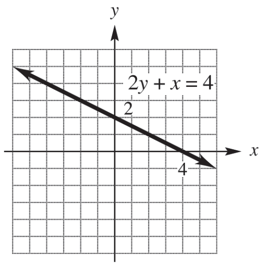


28. $2y + x = 4$

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:

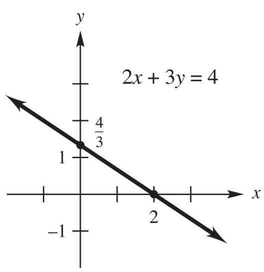


29. $2x + 3y = 4$

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. $-5x + 4y = 3$

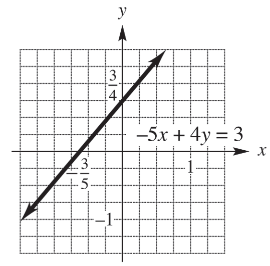
Find the x-intercept by setting $y = 0$ and solving for x:

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

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. $4x - 5y = 2$

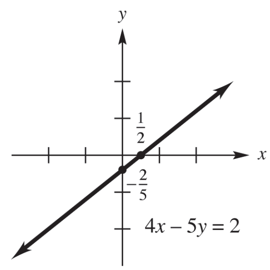
Find the x-intercept, by setting $y = 0$ and solving for x:

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

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. $3x + 2y = 8$

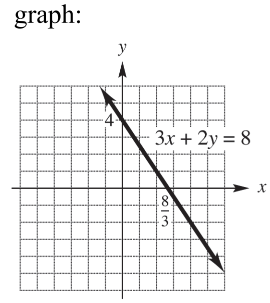
Find the x-intercept by setting $y = 0$ and solving for x:

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

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, so the correct choice is (b).

67. **a.** $x = 5$
$$y = 13.69(5) + 133.6 = 202.05$$
There were about \$202.05 billion or \$202,050,000,000 in sales from drug prescriptions in 2005.

b. $x = 10$.
$$y = 13.69(10) + 133.6 = 270.5$$
There were about \$270.5 billion or \$270,500,000,000 in sales from drug prescriptions in 2010.

c. $y = 340$
$$340 = 13.69x + 133.6$$
$$206.4 = 13.69x$$
$$15.1 \approx x$$
Sales from drug prescriptions will be about \$340 billion in the year 2015.

68. **a.** $x = 10$
$$y = 40.89(10) + 405.3 = 814.2$$
The total revenue generated from hospital care in 2010 was about \$814.2 billion or \$814,200,000,000.

b. $y = 1000$
$$1000 = 40.89x + 405.3 \Rightarrow$$
$$594.7 = 40.89x \Rightarrow x \approx 14.5$$
The total revenue generated from hospital care will be \$1 trillion in the year 2014.

69. **a.** $x = 0$

$y = -1.8(0) + 384.6 = 384.6$

There were approximately 384.6 thousand or 384,600 employees working in the motion picture and sound industries in 2000.

b. $x = 10$

$y = -1.8(10) + 384.6 = 366.6$

There were approximately 366.6 thousand or 366,600 employees working in the motion picture and sound industries in 2010.

c. $y = 350$

$350 = -1.8x + 384.6$

$-34.6 = -1.8x \Rightarrow x \approx 19.2$

This corresponds to the year 2019.
There will be approximately 350,000 employees working in the motion picture and sound industries in 2019.

70. **a.** $x = 10$.

$y = -42.1(10) + 16,288 = 15,867$

There were 15,687 golf facilities in 2010.

b. $y = 15,500$.

$15,500 = -42.1x + 16,288$

$-788 = -42.1x \Rightarrow x \approx 18.7$

This corresponds to the year 2018.
There will be 15,500 golf facilities in 2018.

71. **a.** The given data is represented by the points (5, 35.1) and (11, 29.7).

b. Find the slope.

$$m = \frac{29.7 - 35.1}{11 - 5} = \frac{-5.4}{6} = -0.9$$

$$y - y_1 = m(x - x_1)$$
$$y - 29.7 = -0.9(x - 11)$$
$$y - 29.7 = -0.9x + 9.9$$
$$y = -0.9x + 39.6$$

c. The year 2009 corresponds to $x = 9$.

$y = -0.9(9) + 39.6 = 31.5$

Total sales associated with lawn care were about \$31.5 billion in 2009.

d. $y = 25$.

$25 = -0.9x + 39.6$

$-14.6 = -0.9x \Rightarrow x \approx 16.2$

This corresponds to the year 2016. Total sales associated with lawn care will reach \$25 billion in 2016.

72. **a.** $(x_1, y_1) = (0, 16.3)$ and $(x_2, y_2) = (10, 14.9)$

Find the slope.

$$m = \frac{14.9 - 16.3}{10 - 0} = \frac{-1.4}{10} = -.14$$

Use the slope-intercept form with (0, 16.3).

$y = -.14x + 16.3$

b. Let $x = 15$.

$y = -.14(15) + 16.3 = 14.2$

According to the model, there will be 14.2 million union workers in 2015.

73. **a.** $(x_1, y_1) = (0, .4)$ and $(x_2, y_2) = (10, .75)$

Find the slope.

$$m = \frac{.75 - .4}{10 - 0} = \frac{.35}{10} = 0.035$$

The y-intercept is .4, so the equation of the line is $y = 0.035x + 0.4$.

b. The year 2014 corresponds to $x = 2014 - 2002 = 14$.

$y = 0.035(12) + 0.4 = 0.82$

In 2014, the price for chicken legs will be about \$0.82 per pound.

74. **a.** $(x_1, y_1) = (0, .6)$ and $(x_2, y_2) = (10, 1.25)$

Find the slope.

$$m = \frac{1.25 - .6}{10 - 0} = \frac{.65}{10} = 0.065$$

The y-intercept is .6, so the equation of the line is $y = 0.065x + 0.6$.

b. The year 2010 corresponds to $x = 2010 - 2002 = 8$.

$y = 0.065(8) + 0.6 = 1.12$

In 2010, the price for chicken thighs was about \$1.12 per pound

75. **a.** $(x_1, y_1) = (0, 36845)$ and $(x_2, y_2) = (10, 27200)$

Find the slope.

$$m = \frac{27,200 - 36845}{10 - 0} = -964.5$$

The y-intercept is 36,845, so the equation is $y = -964.5x + 36,845$.

b. The year 2006 corresponds to $x = 2006 - 2000 = 6$.
$y = -964.5(6) + 36{,}845 = 31058$
In 2006, there were about 31,058 federal drug arrests.

76. a. $(x_1, y_1) = (0, 1.5)$ and $(x_2, y_2) = (10, 4.5)$
Find the slope.
$m = \dfrac{4.5 - 1.5}{10 - 0} = .3$
The y-intercept is 1.5, so the equation is $y = .3x + 1.5$.

b. The year 2007 corresponds to $x = 2007 - 2000 = 7$.
$y = .3(7) + 1.5 = 3.6$
In 2007, the total amount of drugs seized was about 3.6 million pounds.

c. $5.7 = .3x + 1.5 \Rightarrow 4.2 = .3x \Rightarrow x = 14$ This corresponds to the year 2014. There will be 5.7 million pounds of drugs seized in 2014.

77. a. The slope of –.01723 indicates that on average, the 5000-meter run is being run .01723 seconds faster every year. It is negative because the times are generally decreasing as time progresses.

b. $y = -.01723(2012) + 47.61 \approx 12.94$
The model predicts that the time for the 5000-m run will be about 12.94 minutes in the 2012 Olympics.

78. a. Using data points (1980, 106.9) and (2010, 153.9), the slope is:
$m = \dfrac{153.9 - 106.9}{2010 - 1980} \approx 1.57$
Each year there is an average increase of about 1.57 million civilians.

b. $y - 153.9 = 1.57(x - 2010)$
$y - 153.9 = 1.57(2015 - 2010)$
$y - 153.9 = 7.85 \Rightarrow y = 161.75$
There will be about 161.75 million civilians in the labor force in 2015.

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.
$m = \dfrac{20 - 0}{68 - 32} = \dfrac{20}{36} = \dfrac{5}{9}$
Use the point-slope form with (32, 0).
$y - 0 = \dfrac{5}{9}(x - 32) \Rightarrow y = \dfrac{5}{9}(x - 32)$

b. Let $x = 50$.
$y = \dfrac{5}{9}(50 - 32) = \dfrac{5}{9}(18) = 10°\text{C}$
Let $x = 75$.
$y = \dfrac{5}{9}(75 - 32) = \dfrac{5}{9}(43) \approx 23.89°\text{C}$

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

a. $F = 58°\text{F}$
$C = \dfrac{5}{9}(58 - 32) = \dfrac{5}{9}(26) \approx 14.4°C$

b. $C = 50°\text{C}$
$50 = \dfrac{5}{9}(F - 32)$
$450 = 5F - 160$
$610 = 5F \Rightarrow F = 122°$

c. $C = -10°\text{C}$
$-10 = \dfrac{5}{9}(F - 32)$
$-90 = 5F - 160$
$70 = 5F \Rightarrow F = 14°$

d. $F = -20°\text{F}$
$C = \dfrac{5}{9}(-20 - 32) = \dfrac{5}{9}(-52) \approx -28.9°C$

3. F = 867°
$C = \dfrac{5}{9}(867 - 32) = \dfrac{5}{9}(835) \approx 463.89°C$

4. When are Celsius and Fahrenheit temperatures numerically equal? Set $F = C$:
$C = \dfrac{5}{9}(F - 32) = F \Rightarrow 9F = 5F - 160 \Rightarrow$
$4F = -160 \Rightarrow F = -40°$
The temperatures are numerically equal at –40°.

5. Let $(x_1, y_1) = (6, 201.6)$ and $(x_2, y_2) = (11, 224.9)$. Find the slope.

$$m = \frac{224.9 - 201.6}{11 - 6} = 4.66$$
$$y - 201.6 = 4.66(x - 6)$$
$$y - 201.6 = 4.66x - 27.96$$
$$y = 4.66x + 173.64.$$

To estimate the CPI in 2008, let $x = 8$.

$$y = 4.66(8) + 173.64 \approx 210.92$$

To estimate the CPI in 2015, let $x = 15$.

$$y = 4.66(15) + 173.64 \approx 243.54$$

6. Let $(x_1, y_1) = (1, 127.1)$ and $(x_2, y_2) = (11, 140.8)$. Find the slope.

$$m = \frac{140.8 - 127.1}{11 - 1} = \frac{13.7}{10} = 1.37$$
$$y - 127.1 = 1.37(x - 1)$$
$$y - 127.1 = 1.37x - 1.37$$
$$y = 1.37x + 125.73.$$

To estimate the number of filed returns in 2005, let $x = 2005 - 2000 = 5$.

$$y = 1.37(5) + 125.73 = 132.58$$

There were about 132.58 million examined returns in 2005.
To estimate the examined returns in 2012, let $x = 2012 - 2000 = 12$

$$y = 1.37(12) + 125.73 = 142.17$$

There were about 142.17 million examined returns in 2012

7. Let $(x_1, y_1) = (0, 6.0)$ and $(x_2, y_2) = (8, 6.5)$. Find the slope.

$$m = \frac{6.5 - 6.0}{8 - 0} = 0.0625$$

The y-intercept is 6.0, so the equation is $y = 0.0625x + 6.0$.

To estimate the number of employees working in the finance and insurance industries in 2010, let $x = 2010 - 2000 = 10$.

$$y = 0.0625(10) + 6.0 = 6.625$$

The number of employees was estimated to be 6.625 million in 2010.

8. Let $(x_1, y_1) = (0, 14.1)$ and $(x_2, y_2) = (8, 17.2)$. Find the slope.

$$m = \frac{17.2 - 14.1}{8 - 0} = 0.3875$$

The y-intercept is 14.1, so the equation is $y = 0.3875x + 14.1$.

To estimate the number of employees working in the health care and social assistance industries in 2014, let $x = 2014 - 2000 = 14$.

$$y = 0.3875(14) + 14.1 = 19.525$$

The number of employees will be about 19.525 million in 2014.

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.** $y = -143.6x + 6019$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(7, 5036)	(7,5013.8)	22.2	492.84
(8, 4847)	(8, 4870.2)	–23.2	538.24
(9, 4714)	(9, 4726.6)	–12.6	158.76
(10,4589)	(10, 4583)	6	36
(11,4447)	(11,4439.4)	7.6	57.76

(*continued next page*)

$y = -170.2x + 6250$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(7, 5036)	(7,5058.6)	–22.6	510.76
(8, 4847)	(8, 4888.4)	–41.4	1713.96
(9, 4714)	(9, 4718.2)	–4.2	17.64
(10,4589)	(10, 4548)	41	1681
(11,4447)	(11,4377.8)	69.2	4788.64

Sum of the residuals for model 1 = 0
Sum of the residuals for model 2 = 42

b. Sum of the squares of the residuals for model 1 = 1283.6
Sum of the squares of the residuals for model 2 = 8712

c. Model 1 is the better fit.

12. a. $y = 2.1x + 47$

Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(5, 53)	(5,57.5)	–4.5	20.25
(8, 67)	(8,63.8)	3.2	10.24
(11, 71)	(11,70.1)	0.9	0.81
(14, 75)	(14,76.4)	–1.4	1.96
(17, 80)	(17,82.7)	–2.7	7.29

$y = 2.8x + 44$

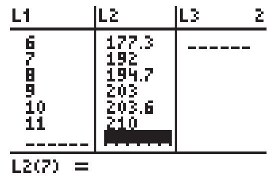
Data Point (x, y)	Model Point $(x, \hat{y})$	Residual $y - \hat{y}$	Squared Residual $(y - \hat{y})^2$
(5, 53)	(5,58)	–5	25
(8, 67)	(8,66.4)	0.6	0.36
(11, 71)	(11,74.8)	–3.8	14.44
(14, 75)	(14,83.2)	–8.2	67.24
(17, 80)	(17,91.6)	–11.6	134.56

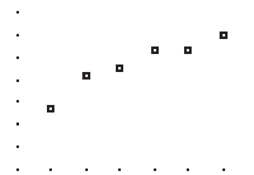
Sum of the residuals for model 1 = –4.5
Sum of the residuals for model 2 = –28

b. Sum of the squares of the residuals for model 1= 40.55.
Sum of the squares of the residuals for model 2= 241.6.

c. Model 1 is the better fit.

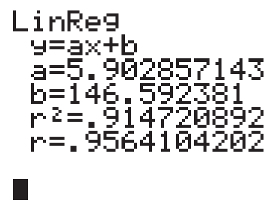
13. Plot the points.





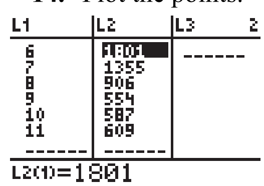
[5, 12] by [150, 220]

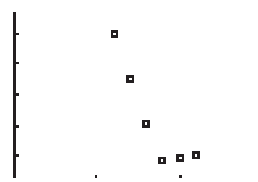
Visually, a straight line looks to be a good model for the data.



The coefficient of correlation is $r \approx .956$, which indicates that the regression line is a good fit for the data.

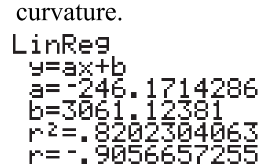
14. Plot the points.





[0, 15] by [400, 2000]

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



The coefficient of correlation is $r \approx -.906$, which indicates that the regression line is a good fit for the data, but the plot shows otherwise.

15. a. Using a graphing calculator, the regression-line model is $y = 5.90x + 146.59$.

b. The year 2015 corresponds to $x = 15$. Using the regression-line model generated by a graphing calculator, we have $y = 5.90(15) + 146.59 = 235.09$, or about \$235 billion in sales.

16. a. Using a graphing calculator, we find that the linear model is $y = -7.72x + 407.94$

b. The year 2015 corresponds to $x = 35$. Using the regression-line model generated by a graphing calculator, we have $y = -7.72(35) + 407.94 = 137.74$, or about 137 deaths per 100,000 people from heart disease.

17. a. Using a graphing calculator, the regression-line model is
$y = -3.96x + 73.98$.

b. The year 2016 corresponds to $x = 16$. Using the regression-line model generated by a graphing calculator, we have $y = -3.96(16) + 73.98 = 10.62$, or about \$10.62 billion in revenue.

18. a. Using a graphing calculator, the regression-line model is
$y = 14.9x + 2822$.

b. Using the regression-line model:
Let $x = 150$ feet squared.
$y = 14.9(150) + 2822 = 5057$
Let $x = 280$ feet squared.
$y = 14.9(280) + 2822 = 6994$
Let $x = 420$ feet squared.
$y = 14.9(420) + 2822 = 9080$
The predicted values are very close to the actual data values.

c. Using the regression-line model:
Let $x = 235$ feet squared.
$y = 14.9(235) + 2822 = 6323.5$
Adam should choose the closest value above the requirement. therefore, Adam should choose the 6500 BTU air conditioner.

19. a. Using a graphing calculator, the regression line model for estimated operating revenue (in billions of dollars) from internet publishing and broadcasting is given by $y = 2.37x - 2.02$.

b. Let $x = 12$ (2012).
$y = 2.37(12) - 2.02 = 26.42$ billion
Let $x = 14$ (2014).
$y = 2.37(14) - 2.02 = 31.16$ billion
The operating revenue was about \$26.42 billion in 2012 and will be about \$31.16 billion in 2014.

20. a. Using a graphing calculator, the regression-line model is
$y = -0.62x + 68.28$.

b. $y = -0.62(9) + 68.28 \approx 62.7$. There were about 62.7 million subscribers in 2009.

c. Let $y = 55$.
$$\begin{aligned} 55 &= -0.62x + 68.28 \\ -13.28 &= -0.62x \\ x &\approx 21.4 \end{aligned}$$
There will be 55 million subscribers in the year 2021.

d. Using a graphing calculator, the coefficient of correlation is about –.915.

21. a. Using a graphing calculator, the regression-line model is
$y = -2.318x + 55.88$.

b. $y = -2.318(6) + 55.88 \approx 41.972$. There were about 41,972 traffic fatalities in 2006.

c. Let $y = 28$.
$$\begin{aligned} 28 &= -2.318x + 55.88 \\ -27.88 &= -2.318x \\ x &\approx 12.03 \end{aligned}$$
There were 28,000 traffic fatalities in the year 2012.

d. Using a graphing calculator, the coefficient of correlation is about –.972.

22. a. Using a graphing calculator, the regression-line model for men is
$y = .215x + 52.6$.

b. Using a graphing calculator, the regression-line model for women is
$y = .144x + 65.4$.

c. $.215x + 52.6 = .144x + 65.4$

$$.071x = 12.8x$$
$$x \approx 180.3$$

According to the models, the life expectancy of men will be the same as women in the year 2080.

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). $-7 > -10$

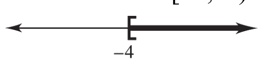
3. $-8k \le 32$

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.

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

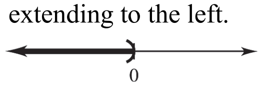
The solution is $[-9, \infty)$.

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. $6 - 6z < 0$

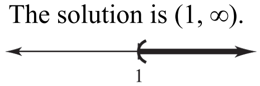
Add $6z$ to both sides.

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

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. $3x + 4 \le 14$

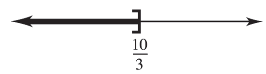
Subtract 4 from both sides.

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

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 $\frac{1}{2}$.

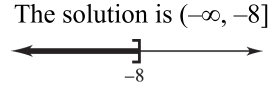
$$\frac{1}{2}(2y) < \frac{1}{2}(16) \Rightarrow y < 8$$

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

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

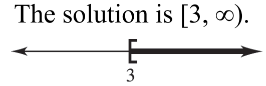
9.
$$-5 - p \ge 3$$
$$-5 + 5 - p \ge 3 + 5$$
$$-p \ge 8$$
$$(-1)(-p) \le (-1)(8)$$
$$p \le -8$$

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



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

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



11.
$$\begin{aligned} 7m-5 &< 2m+10 \\ 5m-5 &< 10 \\ 5m &< 15 \\ \frac{1}{5}(5m) &< \frac{1}{5}(15) \\ m &< 3 \end{aligned}$$

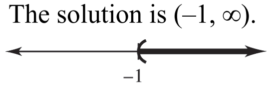
The solution is $(-\infty, 3)$.

12.
$$\begin{aligned} 6x-2 &> 4x-10 \\ 6x-2-4x &> 4x-10-4x \\ 2x-2 &> -10 \\ 2x-2+2 &> -10+2 \\ 2x &> -8 \\ \frac{1}{2}(2x) &> \frac{1}{2}(-8) \\ x &> -4 \end{aligned}$$

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

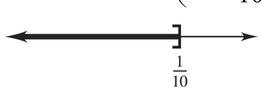
13.
$$\begin{aligned} m-(4+2m)+3 &< 2m+2 \\ m-4-2m+3 &< 2m+2 \\ -1-m &< 2m+2 \\ -m-2m &< 2+1 \\ -3m &< 3 \\ -\frac{1}{3}(-3m) &> -\frac{1}{3}(3) \\ m &> -1 \end{aligned}$$

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



14.
$$\begin{aligned} 2p-(3-p) &\le -7p-2 \\ 2p-3+p &\le -7p-2 \\ 3p-3 &\le -7p-2 \\ 10p-3 &\le -2 \\ 10p &\le 1 \\ p &\le \frac{1}{10} \end{aligned}$$

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



15.
$$\begin{aligned} -2(3y-8) &\ge 5(4y-2) \\ -6y+16 &\ge 20y-10 \\ 16+10 &\ge 20y+6y \\ 26 &\ge 26y \\ 1 &\ge y \text{ or } y \le 1 \end{aligned}$$

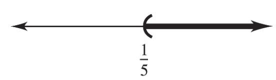
The solution is $(-\infty, 1]$.

16.
$$\begin{aligned} 5r-(r+2) &\ge 3(r-1)+6 \\ 5r-r-2 &\ge 3r-3+6 \\ 4r-2 &\ge 3r+3 \\ r-2 &\ge 3 \\ r &\ge 5 \end{aligned}$$

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

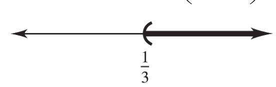
17.
$$\begin{aligned} 3p-1 &< 6p+2(p-1) \\ 3p-1 &< 6p+2p-2 \\ -1+2 &< 6p+2p-3p \\ 1 &< 5p \\ \frac{1}{5} &< p \text{ or } p > \frac{1}{5} \end{aligned}$$

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



18.
$$\begin{aligned} x+5(x+1) &> 4(2-x)+x \\ x+5x+5 &> 8-4x+x \\ 6x+5 &> 8-3x \\ 9x+5 &> 8 \\ 9x &> 3 \\ x &> \frac{1}{3} \end{aligned}$$

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).

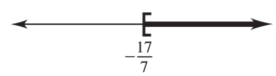
21.
$$8 \le 3r + 1 \le 16$$
$$8 - 1 \le 3r \le 16 - 1$$
$$7 \le 3r \le 15$$
$$\frac{7}{3} \le r \le 5$$
The solution is $\left[\frac{7}{3}, 5\right]$.

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 $[15, \infty)$.

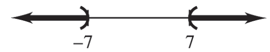
33. $C = 85x + 1000$; $R = 105x$
$$R \ge C$$
$$105x \ge 85x + 1000$$
$$20x \ge 1000$$
$$x \ge \frac{1000}{20} \Rightarrow x \ge 50$$
x must be in the interval $[50, \infty)$.

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 $[280, \infty)$.

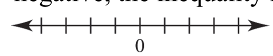
37. $|p| > 7$
$p < -7$ or $p > 7$
The solution is $(-\infty, -7)$ or $(7, \infty)$.



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

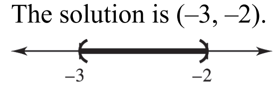
39. $|r| \le 5 \Rightarrow -5 \le r \le 5$
The solution is $[-5, 5]$.

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 $(-3, -2)$.

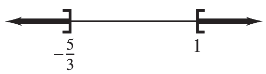


43.
$$\left|x - \frac{1}{2}\right| < 2$$
$$-2 < x - \frac{1}{2} < 2$$
$$-\frac{3}{2} < x < \frac{5}{2}$$
The solution is $\left(-\frac{3}{2}, \frac{5}{2}\right)$.

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

$$\begin{array}{lll} 3z+1 \ge 4 & \text{or} & 3z+1 \le -4 \\ 3z \ge 4-1 & & 3z \le -4-1 \\ 3z \ge 3 & & 3z \le -5 \\ z \ge 1 & & z \le -\frac{5}{3} \end{array}$$

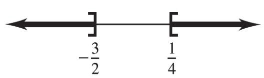
The solution is $\left(-\infty, -\frac{5}{3}\right]$ or $[1, \infty)$.



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

$$\begin{array}{lll} 8b+5 \le -7 & \text{or} & 8b+5 \ge 7 \\ 8b \le -12 & \text{or} & 8b \ge 2 \\ b \le -\frac{3}{2} & \text{or} & b \ge \frac{1}{4} \end{array}$$

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. $|R_L - 26.75| \le 1.42$
$|R_E - 38.75| \le 2.17$

a. $|R_L - 26.75| \le \pm 1.42 \Rightarrow$
$-1.42 \le R_L - 26.75 \le 1.42 \Rightarrow$
$25.33 \le R_L \le 28.17$
$|R_E - 38.75| \le 2.17 \Rightarrow$
$-2.17 \le R_E - 38.75 \le 2.17 \Rightarrow$
$36.58 \le R_E \le 40.92$

b. $225(25.33) \le T_L \le 225(28.17)$
$5699.25 \le T_L \le 6338.25$
$225(36.58) \le T_E \le 225(40.92)$
$8230.5 \le T_E \le 9207$

52. $|x - 100| > 12$

53. $35 \le B \le 43$

54. $17 \le U \le 19$

55. The six income ranges are:
$$0 < x \le 8700$$
$$8700 < x \le 35{,}350$$
$$35{,}350 < x \le 85{,}650$$
$$85{,}650 < x \le 178{,}650$$
$$178{,}650 < x \le 388{,}350$$
$$x > 388{,}350$$

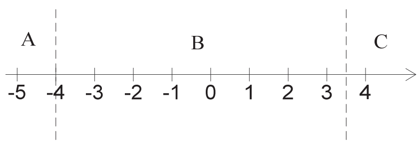
56. **a.** Let x represent the number of milligrams per liter of lead in the water.

b. 5% of .040 is .002.
$$.040 - .002 \le x \le .040 + .002$$
$$.038 \le x \le .042$$

c. Since all the samples had a lead content less than or equal to .042 mg per liter, all were less than .050 mg per liter and did meet the federal requirement.

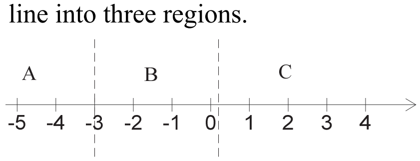
Section 2.5 Polynomial and Rational Inequalities

1. $(x+4)(2x-3) \le 0$
Solve the corresponding equation.
$(x+4)(2x-3) = 0$
$x+4=0$ or $2x-3=0$
$x=-4$ $\quad x=\dfrac{3}{2}$
Note that because the inequality symbol is "$\le$," –4 and $\dfrac{3}{2}$ are solutions of the original inequality. These numbers separate the number line into three regions.



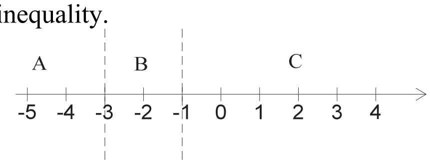
In region A, let $x = -6$:
$(-6+4)[2(-6)-3] = 30 > 0$.
In region B, let $x = 0$:
$(0+4)[2(0)-3] = -12 < 0$.
In region C, let $x = 2$:
$(2+4)[2(2)-3] = 6 > 0$.
The only region where $(x+4)(2x-3)$ is negative is region B, so the solution is $\left[-4, \dfrac{3}{2}\right]$. To graph this solution, put brackets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

2. $(5y-1)(y+3) > 0$
Solve the corresponding equation.
$(5y-1)(y+3) = 0$
$5y-1=0$ or $y+3=0$
$5y = 1$ $\quad y=-3$
$y=\dfrac{1}{5}$
Note that because the inequality symbol is "$<$", $\dfrac{1}{5}$ and -3 are not solutions of the original inequality. These numbers separate the number line into three regions.

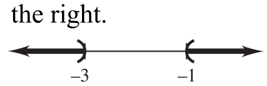


In region A, let $x = -6$:
$[5(-6)-1][-6+3] = 93 > 0$.
In region B, let $x = 0$:
$[5(0)-1][0+3] = -3 < 0$.
In region C, let $x = 2$:
$[5(2)-1][2+3] = 45 > 0$
The regions where $(5y-1)(y+3)$ is positive are regions A and C, so the solutions are $(-\infty, -3)$ and $\left(\frac{1}{5}, \infty\right)$. To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

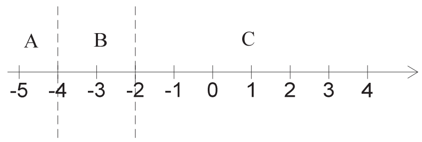
3. $r^2 + 4r > -3$
Solve the corresponding equation.
$r^2 + 4r = -3$
$r^2 + 4r + 3 = 0$
$(r+1)(r+3) = 0$
$r+1=0$ or $r+3=0$
$r=-1$ or $r=-3$
Note that because the inequality symbol is ">," –1 and –3 are not solutions of the original inequality.



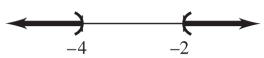
In region A, let $r = -4$:
$(-4)^2 + 4(-4) = 0 > -3$.
In region B, let $r = -2$:
$(-2)^2 + 4(-2) = -4 < -3$.
In region C, let $r = 0$:
$0^2 + 4(0) = 0 > -3$.
The solution is $(-\infty, -3)$ or $(-1, \infty)$.
To graph the solution, put a parenthesis at –3 and draw a ray extending to the left, and put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



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

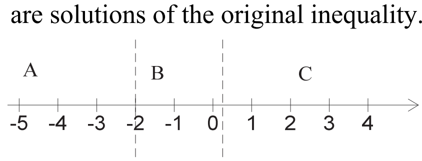


In region A, let $z = -5$:
$(-5)^2 + 6(-5) + 8 = 3 > 0$
In region B, let $z = -3$:
$(-3)^2 + 6(-3) + 8 = -1 < 0$
In region C, let $z = 0$:
$(0)^2 + 6(0) + 8 = 8 > 0$
The solution is $(-\infty, -4)$ or $(-2, \infty)$.



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

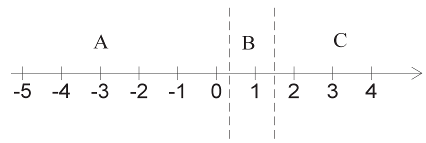
Because the inequality symbol is "≤" $\frac{1}{4}$ and –2 are solutions of the original inequality.



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.
$6p^2 - 11p + 3 = 0$
$(3p-1)(2p-3) = 0$
$3p - 1 = 0 \quad \text{or} \quad 2p - 3 = 0$
$p = \frac{1}{3} \quad \text{or} \quad p = \frac{3}{2}$

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.
$4x^2 + 3x - 1 = 0$
$(4x-1)(x+1) = 0$
$4x - 1 = 0 \quad \text{or} \quad x + 1 = 0$
$x = \frac{1}{4} \quad \text{or} \quad x = -1$

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

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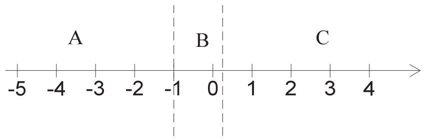


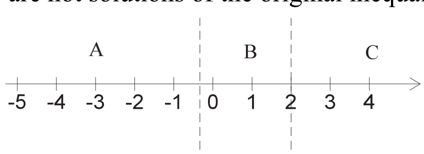
In region A, let $x = -2$:
$4(-2)^2 + 3(-2) - 1 = 9 > 0$.
In region B, let $x = 0$:
$4(0)^2 + 3(0) - 1 = -1 < 0$.
In region C, let $x = 1$:
$4(1)^2 + 3(1) - 1 = 6 > 0$.

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.

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

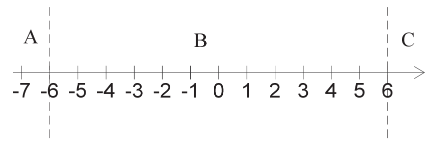
Because the inequality symbol is“>,” $-\frac{1}{3}$ and 2 are not solutions of the original inequality.



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 $x = 10$.
$3(10)^2 - 5(10) = 250 > 2$

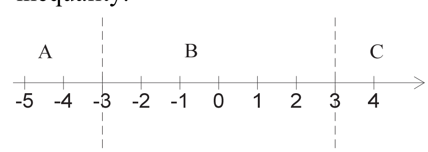
The numbers in regions A and C satisfy the inequality, so the solution is $\left(-\infty, -\frac{1}{3}\right)$ or $(2, \infty)$.

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

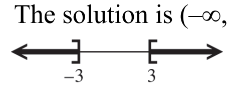


For region A, let $x = -7$: $(-7)^2 = 49 > 36$.
For region B, let $x = 0$: $0^2 = 0 < 36$.
For region C, let $x = 7$: $7^2 = 49 > 36$.
Both endpoints are included. The solution is $[-6, 6]$.

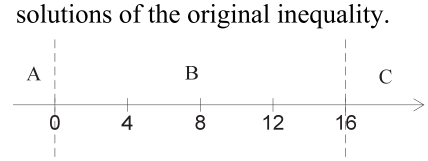
10. $y^2 \ge 9$
Solve the corresponding equation.
$y^2 = 9 \Rightarrow y = \pm 3$
Note that –3 and 3 are solutions to the original inequality.



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.



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For region A, let $p = -1$:

$(-1)^2 - 16(-1) = 17 > 0$.

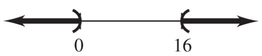
For region B, let $p = 1$:

$1^2 - 16(1) = -15 < 0$.

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.

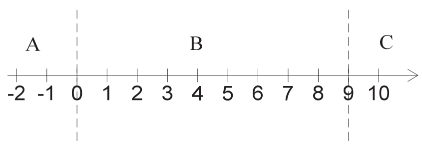
$r^2 - 9r = 0$

$r(r-9) = 0$

$r = 0 \quad \text{or} \quad r - 9 = 0$

$r = 0 \quad \text{or} \quad r = 9$

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. $x^3 - 9x \ge 0$

Solve the corresponding equation.

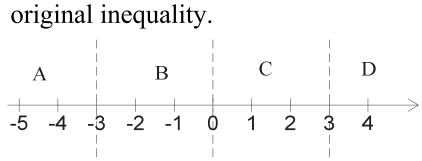
$x^3 - 9x = 0$

$x\left(x^2 - 9\right) = 0$

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

$x = 0$ 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. $p^3 - 25p \le 0$

Solve the corresponding equation.

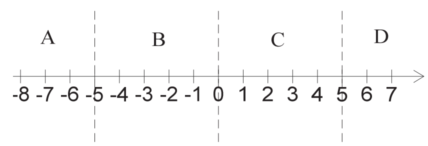
$p^3 - 25p = 0$

$p\left(p^2 - 25\right) = 0$

$p(p+5)(p-5) = 0$

$p = 0$ 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

$p^3 - 25p \le 0$.

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

$(-10)^3 - 25(-10) = -750 \le 0$

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

$(-1)^3 - 25(-1) = 24 \ge 0$

In region C, let $p = 1$.

$1^3 - 25(1) = -24 \le 0$

In region D, let $p = 10$.

$10^3 - 25(10) = 750 \ge 0$

The numbers in regions A and C satisfy the inequality, so the solution is $(-\infty, -5]$ or $[0, 5]$.

15. $(x + 7)(x + 2)(x - 2) \ge 0$

Solve the corresponding equation.

$(x + 7)(x + 2)(x - 2) = 0$

$x + 7 = 0 \quad \text{or} \quad x + 2 = 0 \quad \text{or} \quad x - 2 = 0$

$x = -7 \quad \text{or} \quad x = -2 \quad \text{or} \quad x = 2$

Note that –7, –2 and 2 are all solutions of the original inequality.

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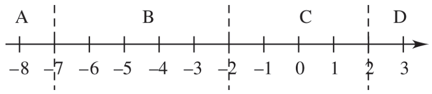
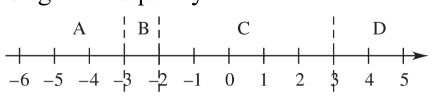


In region A, let $x = –8$:
$(–8 + 7)(–8 + 2)(–8 – 2) = –60 < 0$
In region B, let $x = –4$:
$(–4 + 7)(–4 + 2)(–4 – 2) = 36 > 0$
In region C, let $x = 0$:
$(0 + 7)(0 + 2)(0 – 2) = –28 < 0$
In region D, let $x = 3$:
$(3 + 7)(3 + 2)(3 – 2) = 50 > 0$
The solution is $[–7, –2]$ or $[2, \infty)$.

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

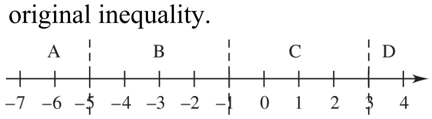
Solve the corresponding equation.
$(2x+4)(x^2-9)=0$
$(2x + 4)(x + 3)(x – 3) = 0$
$2x+4=0$ or $x+3=0$ or $x-3=0$
$x=-2$ or $x=-3$ or $x=3$
Note that –2, –3 and 3 are all solutions of the original inequality.



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 $[–2, 3]$.

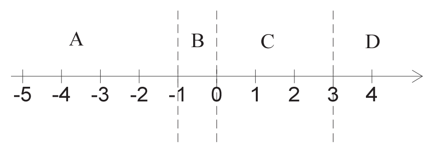
17. $(x+5)\left(x^2-2x-3\right)<0$

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.



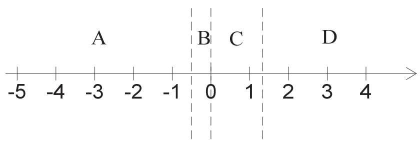
In region A, let $x = –2$:
$(-2)^3-2(-2)^2-3(-2)=-8-8+6=-10<0$
In region B, let $x=-\frac{1}{2}$:
$\left(-\frac{1}{2}\right)^3-2\left(\frac{1}{2}\right)^2-3\left(-\frac{1}{2}\right)$
$=-\frac{1}{8}-\frac{1}{2}+\frac{3}{2}=\frac{7}{8}>0$
In region C, let $x = 1$:
$1^3-2(1)^2-3(1)=1-2-3=-4<0$
In region 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.



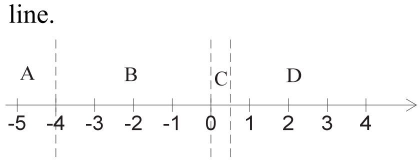
In region A, let $k = -1$:
$6(-1)^3 - 5(-1)^2 - 4(-1) = -7 < 0$
In region B, let $k = -\frac{1}{4}$:
$6\left(-\frac{1}{4}\right)^3 - 5\left(-\frac{1}{4}\right)^2 - 4\left(-\frac{1}{4}\right) = \frac{19}{32} > 0;$
In region C, let $k = 1$:
$6(1)^3 - 5(1)^2 - 4(1) = -3 < 0$
In region D, let $k = 10$:
$6(10)^3 - 5(10)^2 - 4(10) = 5460$
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 $m = -4$

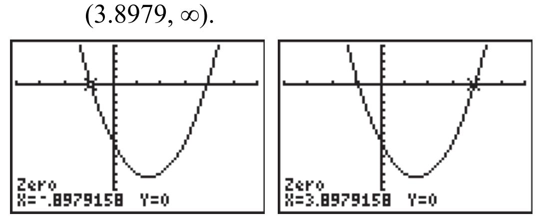
Since the inequality is ">," 0, $\frac{1}{2}$, and –4 are not solutions of the original inequality. Locate these points and regions, A, B, C, and D on a number line.



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 $\left(\frac{1}{2}, \infty\right)$.

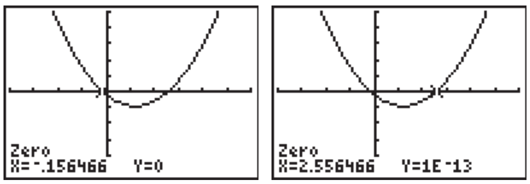
21. The inequality $p^2 < 16$ should be rewritten as $p^2 - 16 < 0$ and solved by the method shown in this section for solving quadratic inequalities. This method will lead to the correct solution (–4, 4). The student's method and solution are incorrect.

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, ∞).



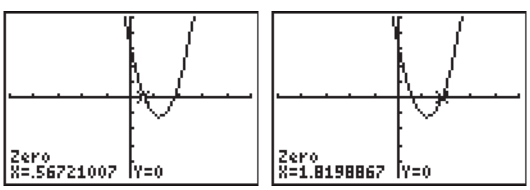
[–4, 6] by [–15,5]

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 $(-.1565, 2.5565)$.



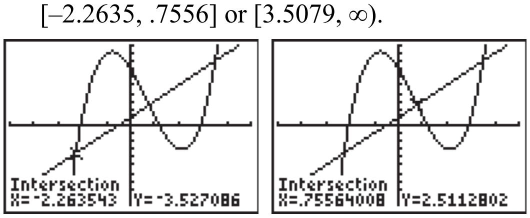
[–4, 6] by [–5,5]

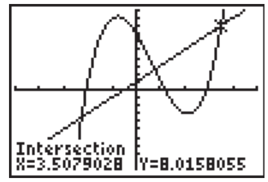
24. To solve $3.1x^2 - 7.4x + 3.2 > 0$, graph the equation $y = 3.1x^2 - 7.4x + 3.2$. Enter this equation as y_1 and use $-5 \le x \le 5$ and $-5 \le y \le 5$. On the CALC menu, use "zero" to find the x-values where the graph crosses the x-axis. These values are $x = .5672$ and $x = 1.8199$. The graph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



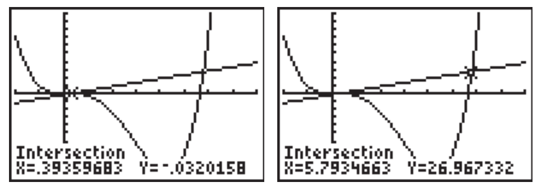
[–5, 5] by [–5, 5]

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 $[3.5079, \infty)$.

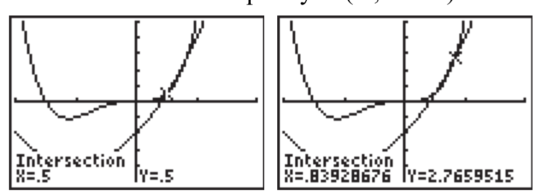




26. To solve $x^4 - 6x^3 + 2x^2 < 5x - 2$, graph $y_1 = x^4 - 6x^3 + 2x^2$ and $y_2 = 5x - 2$ in the window [–2, 8] by[–100, 100]. On the CALC menu, use "intersect" to find the x-values where the graphs intersect. These values are $x = .3936$ and $x = 5.7935$. The graph of y_1 is below the graph of y_2 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, $x = -5.783152$. 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 $(-5.78315, \infty)$.

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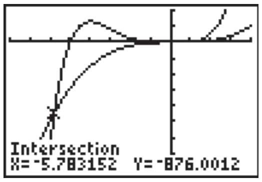
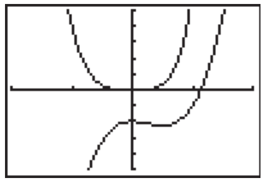


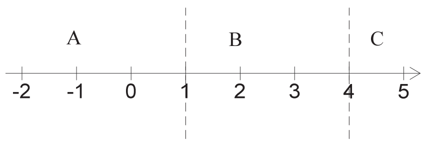


29. $\dfrac{r-4}{r-1} \ge 0$

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 $[4, \infty)$.

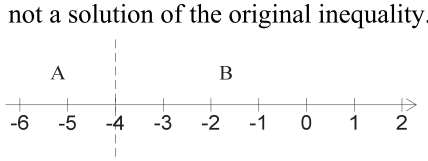
30. $\dfrac{z+6}{z+4} > 1$

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.

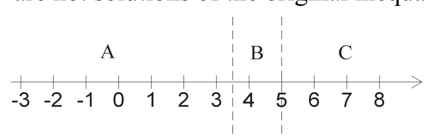
$$\frac{a-2}{a-5} = -1$$

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

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

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

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 $a = 10$:

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

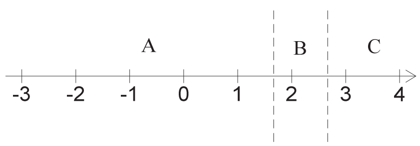
The solution is $\left(\dfrac{7}{2}, 5\right)$.

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

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 $k = \dfrac{8}{3}$. The denominator is zero when $k = \dfrac{5}{3}$. Note that $\dfrac{8}{3}$ and $\dfrac{5}{3}$ 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 $k = 3$.

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

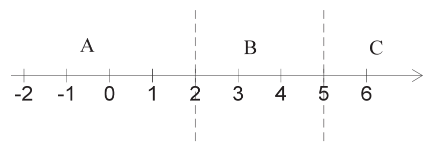
The numbers in regions A and C satisfy the inequality, so the solution is $\left(-\infty, \dfrac{5}{3}\right)$ or $\left(\dfrac{8}{3}, \infty\right)$.

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

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 $p = 0$: $\dfrac{1}{0-2} = -\dfrac{1}{2} < \dfrac{1}{3}$.

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

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

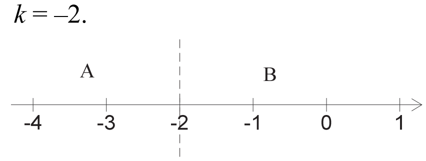
The solution is $(-\infty, 2)$ or $(5, \infty)$.

34. $\dfrac{7}{k+2} \ge \dfrac{1}{k+2}$

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 $k = -2$.



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

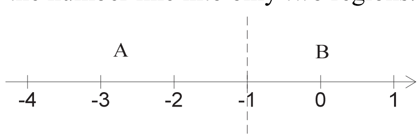
Solve the corresponding equation.

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

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

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

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.

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

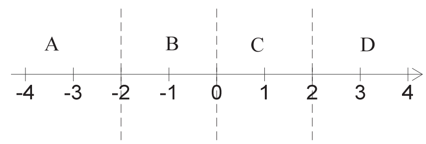
$$x^2 - 4 = 0 \quad \text{or} \quad x = 0$$

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

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

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

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.

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

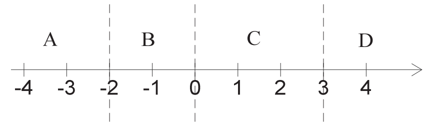
$$x^2 - x - 6 = 0 \quad \text{or} \quad x = 0$$

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

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

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

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



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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 $(0, 3)$.

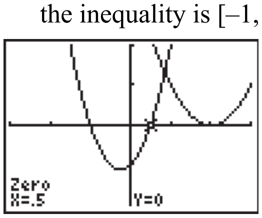
38. **a.** When $x > -4 \Rightarrow x + 4 > 0$, let $x = 0$. $0 + 4 = 4 > 0$ is positive. Therefore $x + 4$ is positive when $x > -4$.

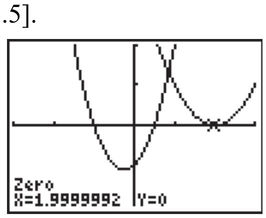
b. When $x < -4 \Rightarrow x + 4 < 0$, $x + 4$ is negative. Let $x = -5$. $-5 + 4 = -1 < 0$.

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 $[-1, .5]$.

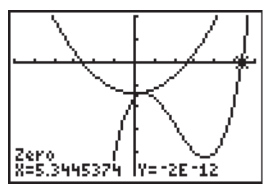


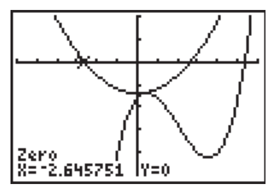


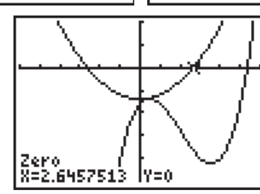
40. To solve $\frac{x^3 - 3x^2 + 5x - 29}{x^2 - 7} > 3$, rewrite the inequality with 0 on one side.

$$\frac{x^3 - 3x^2 + 5x - 29}{x^2 - 7} - 3 > 0$$
$$\frac{x^3 - 3x^2 + 5x - 29 - 3\left(x^2 - 7\right)}{x^2 - 7} > 0$$
$$\frac{x^3 - 3x^2 + 5x - 29 - 3x^2 + 21}{x^2 - 7} > 0$$
$$\frac{x^3 - 6x^2 + 5x - 8}{x^2 - 7} > 0$$

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 $(5.3445, \infty)$.





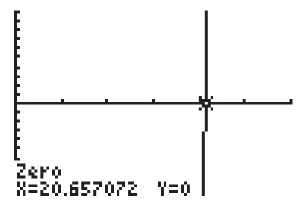


41. $P = 2x^2 - 12x - 32$
The company makes a profit when
$2x^2 - 12x - 32 > 0$.
Solve the corresponding equation.
$$2x^2 - 12x - 32 = 0$$
$$2(x^2 - 6x - 16) = 0$$
$$(x+2)(x-8) = 0 \Rightarrow x = -2 \text{ or } x = 8$$
The test regions are $A(-\infty, -2)$, $B(-2, 8)$, and $C(8, \infty)$. Region A makes 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.
$$4t^2 - 30t + 14 = 0$$
$$2(2t^2 - 15t + 7) = 0$$
$$(2t-1)(t-7) = 0 \Rightarrow t = \frac{1}{2} \text{ or } t = 7$$
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.

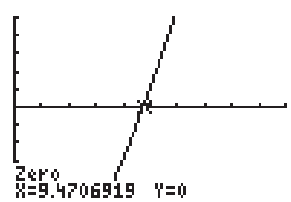
43. $P = x^2 + 300x - 18{,}000$
The complex makes a profit when
$x^2 + 300x - 18{,}000 > 0$.
Solve the corresponding equation.
$$0 = x^2 + 300x - 18{,}000$$
$$x = \frac{-300 \pm \sqrt{(300)^2 - 4(1)(-18{,}000)}}{2(1)}$$
$x \approx 51.25$ or $x \approx -351.25$
We only consider positive values of x because 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
$x^2 + 5x - 530 = 0$



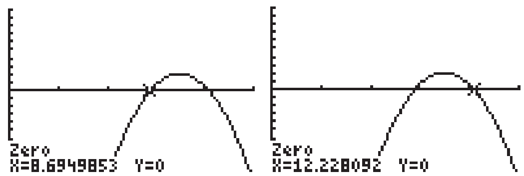
[0, 30] by [–10, 10]
The graph lies above the x-axis for $x > 20.657$. Thus, the salesman needs to make 21 pitches or more to earn a profit.

45. $.79x^2 + 5.4x + 178 > 300$
Use a graphing calculator to solve
$$.79x^2 + 5.4x + 178 = 300 \Rightarrow$$
$$.79x^2 + 5.4x - 122 = 0$$



[0, 20] by [–50, 50]
The graph lies above the x-axis for $x > 9.47$, which corresponds to the middle of 2009. Thus, there will be more than 300 million subscribers from 2010.

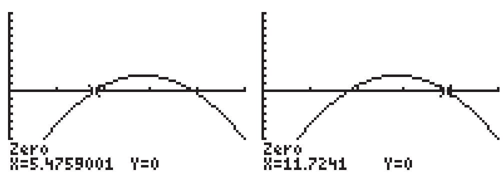
46. $-.65x^2 + 13.6x - 61.1 > 8$
Use a graphing calculator to solve
$-.65x^2 + 13.6x - 61.11 > 8$
$-.65x^2 + 13.6x - 69.11 > 0$



[0, 15] by [–10, 10]

The graph is above the x-axis for $8.69 \le x \le 12.23$. These values correspond to the years 2009 and 2012. There were greater than 8% delinquent loans in the years 2009–2012, inclusive or [2009, 2012].

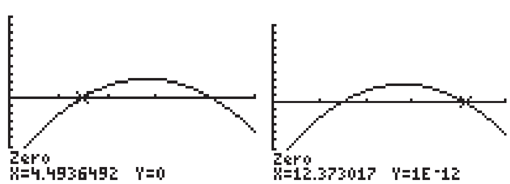
47. $-.2x^2 + 3.44x + .16 > 13$
Use a graphing calculator to solve
$-.2x^2 + 3.44x + .16 > 13$
$-.2x^2 + 3.44x - 12.84 > 0$



[0, 15] by [–10, 10]

The graph is above the x-axis for $5.48 \le x \le 11.72$. These values correspond to the years 2006 and 2011. There were greater than $13 trillion of outstanding mortgage debt in the years 2006–2011, inclusive or [2006, 2011].

48. $-.15x^2 + 2.53x + .66 > 9$
Use a graphing calculator to solve
$-.15x^2 + 2.53x + .66 > 9$
$-.15x^2 + 2.53x - 8.34 > 0$



[0, 15] by [–10, 10]

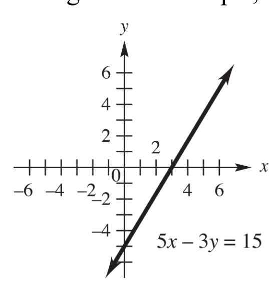
The graph is above the x-axis for $4.49 \le x \le 12.37$. These values correspond to the years 2005 and 2012. There were greater than $9 trillion of outstanding mortgage debt in the years 2005–2012, inclusive or [2005, 2012].

Chapter 2 Review Exercises

1. $y = x^2 - 2x - 5$
$(-2, 3)$:
$(-2)^2 - 2(-2) - 5 = 4 + 4 - 5 = 3$
$(0, -5)$
$(0)^2 - 2(0) - 5 = 0 - 0 - 5 = -5$
$(2, -3)$:
$(2)^2 - 2(2) - 5 = 4 - 4 - 5 = -5 \ne -3$
$(3, -2)$:
$(3)^2 - 2(3) - 5 = 9 - 6 - 5 = -2$
$(4, 3)$:
$(4)^2 - 2(4) - 5 = 16 - 8 - 5 = 3$
$(7, 2)$:
$(7)^2 - 2(7) - 5 = 49 - 14 - 5 = 30 \ne 2$
Solutions are (–2, 3), (0, –5), (3, –2), (4, 3).

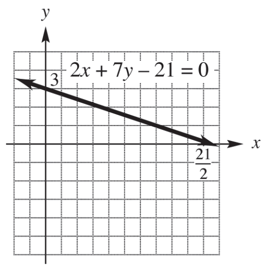
2. $x - y = 5$
$(-2, 3): -2 - 3 = -5 \ne 5$
$(0, -5): 0 - (-5) = 0 + 5 = 5$
$(2, -3): 2 - (-3) = 2 + 3 = 5$
$(3, -2): 3 - (-2) = 3 + 2 = 5$
$(4, 3): 4 - 3 = 1 \ne 5$
$(7, 2): 7 - 2 = 5$
Solutions are (0, –5), (2, –3), (3, –2), (7, 2).

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.



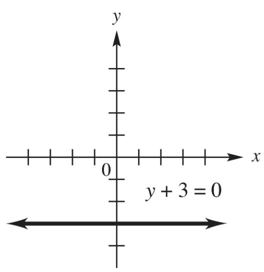
4. $2x + 7y - 21 = 0$

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.



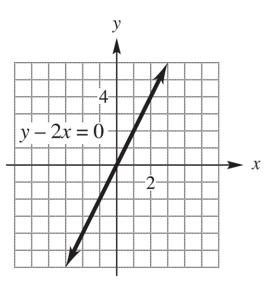
5. $y + 3 = 0$

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



6. $y - 2x = 0$

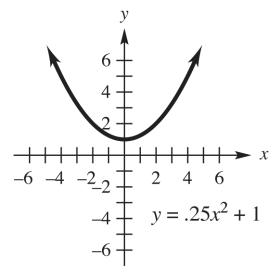
First, we find the y-intercept. If $x = 0$, $y = 0$, so the y-intercept is 0. Since the line passes through the origin, the x-intercept is also 0. We find another point on the line by arbitrarily choosing a value for x. Let $x = 2$. Then $y - 2(2) = 0$, or $y = 4$. The point with coordinates (2, 4) is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

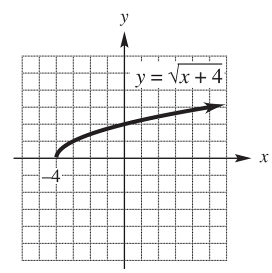
x	$.25x^2 + 1$
–4	5
–2	2
0	1
2	2
4	5



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.

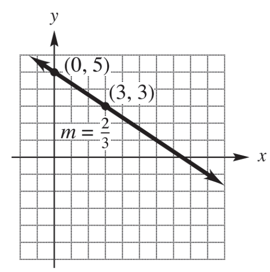
18. $x - 2 = 0$
The graph of $x - 2 = 0$ is a vertical line. Therefore, the slope is undefined.

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

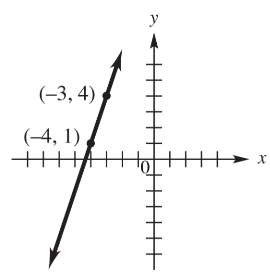
20. Parallel to $3x + 8y = 0$
First, find the slope of the given line by solving for y.
$$8y = -3x \Rightarrow y = -\frac{3}{8}x$$
The slope is the coefficient of x, $-\frac{3}{8}$. A line parallel to this line has the same slope, so the slope of the parallel line is also $-\frac{3}{8}$.

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 (5, 14.0) and (x_2, y_2) be (11, 17.3). Find the slope.

$$m = \frac{17.3 - 14.0}{11 - 5} = \frac{3.3}{6} = .55$$
$$y - 14 = .55(x - 5)$$
$$y - 14 = .55x - 2.75$$
$$y = .55x + 11.25$$

b. The slope is positive because the amount of wheat exported is increasing.

c. The year 2014 corresponds to $x = 14$.

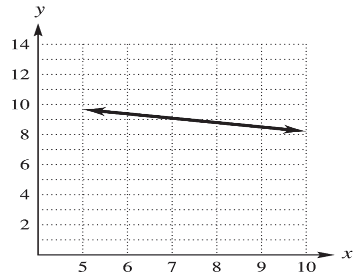
$$y = .55(14) + 11.25 = 18.95$$

If the linear trend continues, there will be 18.95 million hectoliters of fruit juice and wine exported in 2014.

34. a. Let (x_1, y_1) be (5, 9.7) and (x_2, y_2) be (10, 8.2). Find the slope.

$$m = \frac{8.2 - 9.7}{10 - 5} = \frac{-1.5}{5} \approx -.3$$
$$y - 9.7 = -.3(x - 5)$$
$$y - 9.7 = -.3x + 1.5$$
$$y = -.3x + 11.2$$

b.



c. The year 2013 corresponds to $x = 13$.
$y = -.3(13) + 11.2 = 7.3$
If the linear trend continues, there will be about 7.3 billion pounds of fish and shellfish caught in 2013.

35. a. Let (x_1, y_1) be (0, 47059) and (x_2, y_2) be (10, 66249).
Find the slope.
$$m = \frac{66{,}249 - 47{,}059}{10 - 0} = \frac{19{,}190}{10} = 1919$$
Use the y intercept (0, 47059)
$y = 1919x + 47{,}059$

b.
```
LinReg
 y=ax+b
 a=1917.383117
 b=47051.25974
 r²=.9999959607
 r=.9999979803
```
Using a graphing calculator, the least squares regression line is
$y = 1917.38x + 47{,}051.26.$

c. The year 2011 corresponds to $x = 11$. Using the two-point model, we have
$y = 1919(11) + 47{,}059 = 68{,}168.$
Using the regression model, we have
$y = 1917.38(11) + 47{,}051.26 \approx 68{,}142.44.$
The two-point model is off by \$39, while the regression model is off by \$13.44, therefore the least-squares approximation is a better estimate.

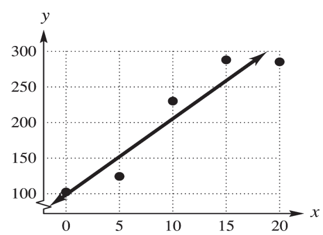
d. The year 2015 corresponds to $x = 15$.
Regression model:
$y = 1917.38(15) + 47{,}051.26 \approx 75{,}811.96$
Thus, the compensation per full-time employee in the year 2015 will be about \$75,811.96.

36. a. $900 = 17.4x + 639 \Rightarrow 261 = 17.4x \Rightarrow 15 = x$
The weekly median wages for men will earn \$900 per week in the year 2000 + 15 = 2015.

b. $900 = 17.3x + 495 \Rightarrow 405 = 17.3x \Rightarrow$
$23.4 \approx x$
The weekly median wages for women will earn \$900 per week in the year 2000 + 23 = 2023.

37. a.
```
LinReg
 y=ax+b
 a=10.72
 b=98.8
 r²=.9088769377
 r=.9533503751
```
The least-squares regression line is
$y = 10.72x + 98.8.$

b.

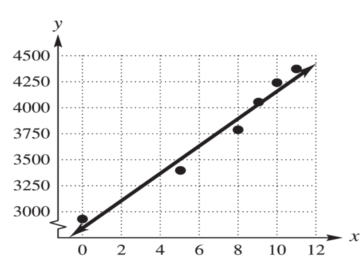


c. Yes; the line appears to fit.

d. The correlation coefficient is .953. This indicates that the line is a good fit.

38. a.
```
LinReg
 y=ax+b
 a=131.3722334
 b=2850.498994
 r²=.9760896701
 r=.9879725047
```
The least-squares regression line is
$y = 131.4x + 2850.$

b.



c. Yes; the line appears to fit.

d. The correlation coefficient is .988. 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.
$$\begin{aligned} -3 \le 4x-1 &\le 7 \\ -2 \le 4x &\le 8 \\ -\frac{1}{2} \le x &\le 2 \end{aligned}$$

The solution is $\left[-\frac{1}{2}, 2\right]$.

44.
$$\begin{aligned} 0 &\le 3-2a \le 15 \\ 0-3 &\le 3-3-2a \le 15-3 \\ -3 &\le -2a \le 12 \\ \frac{-3}{-2} &\ge \frac{-2a}{-2} \ge \frac{12}{-2} \\ \frac{3}{2} &\ge a \ge -6 \end{aligned}$$

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. $|2x-7| \ge 3$
$$\begin{aligned} 2x-7 \le -3 \quad &\text{or} \quad 2x-7 \ge 3 \\ 2x \le 4 \quad &\text{or} \quad 2x \ge 10 \\ x \le 2 \quad &\text{or} \quad x \ge 5 \end{aligned}$$
The solution is $(-\infty, 2]$ or $[5, \infty)$.

48.
$$\begin{aligned} |4m+9| &\le 16 \\ -16 \le 4m+9 &\le 16 \\ -25 \le 4m &\le 7 \\ -\frac{25}{4} \le m &\le \frac{7}{4} \end{aligned}$$

The solution is $\left[-\frac{25}{4}, \frac{7}{4}\right]$.

49.
$$\begin{aligned} |5k+2|-3 &\le 4 \\ |5k+2| &\le 7 \\ -7 \le 5k+2 &\le 7 \\ -9 \le 5k &\le 5 \\ -\frac{9}{5} \le k &\le 1 \end{aligned}$$

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. **a.** Let (x_1, y_1) be (5, 1873) and (x_2, y_2) be (10, 2250). Find the slope

$$m = \frac{2250-1873}{10-5} = \frac{377}{5} = 75.4$$

$y-1873 = 75.4(x-5)$

$y-1873 = 75.4x-377$

$y = 75.4x+1496.$

b. $75.4x+1496 > 2500 \Rightarrow 75.4x > 1004 \Rightarrow x > 13.32$

Assuming the linear trend continues, the amount of energy consumed will exceed 2500 trillion BTU's sometime during 2013 and after.

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.

$125 > 95+.2m \Rightarrow 30 > .2m \Rightarrow 150 > m$

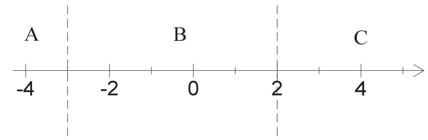
The second company is cheaper than the first company when the number of miles driven is less than 150.

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:

$3^2+3-6 = 6 > 0$.

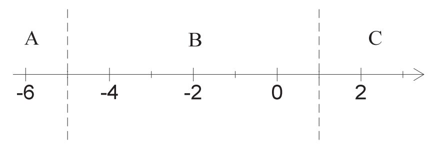
The solution is (–3, 2).

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 $(-\infty, -5]$ or $[1, \infty)$.

57. $2z^2+7z \ge 15$

Solve the corresponding equation.

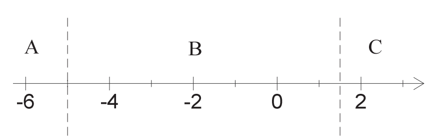
$2z^2+7z = 15$

$2z^2+7z-15 = 0$

$(2z-3)(z+5) = 0$

$z = \frac{3}{2}$ or $z = -5$

These numbers are solutions of the inequality because the inequality symbol is "≥."



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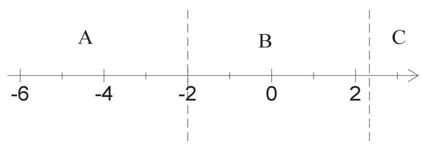
For region A, test –6:
$2(-6)^2 + 7(-6) = 30 > 15$.
For region B, test 0:
$2 \cdot 0^2 + 7 \cdot 0 = 0 < 15$.
For region C, test 2:
$2 \cdot 2^2 + 7 \cdot 2 = 22 > 15$.
The solution is $(-\infty, -5]$ or $\left[\frac{3}{2}, \infty\right)$.

58. $3k^2 \le k + 14$
Solve the corresponding equation.

$$3k^2 = k + 14$$
$$3k^2 - k - 14 = 0$$
$$(3k - 7)(k + 2) = 0$$
$$k = \frac{7}{3} \quad \text{or} \quad k = -2$$

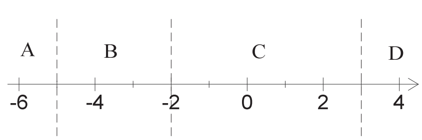


For region A, test –3:
$3(-3)^2 = 27, \ -3 + 14 = 11 \Rightarrow 27 > 11$
For region B, test 0:
$3(0)^2 = 0, \ 0 + 14 = 14 \Rightarrow 0 < 14$
For region C, test 3:
$3(3)^2 = 27, \ 3 + 14 = 17 \Rightarrow 27 > 17$
The given inequality is true in region B and at both endpoints, so the solution is $\left[-2,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

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.

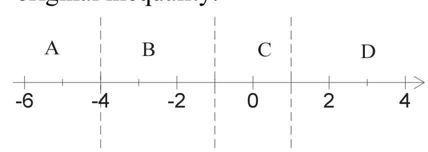


In region A, let $x = -6$:
$(-6 - 3)\left((-6)^2 + 7(-6) + 10\right)$
$= -9(36 - 42 + 10) = -9(4) = -36 < 0$
In region B, let $x = -3$:
$(-3 - 3)\left((-3)^2 + 7(-3) + 10\right)$
$= -6(9 - 21 + 10) = -6(-2) = 12 > 0$.
In region C, let $x = 0$:
$(0 - 3)\left(0^2 + 7(0) + 10\right) = -3(10) = -30 < 0$.
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. $(x + 4)\left(x^2 - 1\right) \ge 0$
Solve the corresponding equation.

$$(x + 4)\left(x^2 - 1\right) = 0$$
$$(x + 4)(x + 1)(x - 1) = 0$$
$$x + 4 = 0 \quad \text{or} \quad x + 1 = 0 \quad \text{or} \quad x - 1 = 0$$
$$x = -4 \quad \text{or} \quad x = -1 \quad \text{or} \quad x = 1$$

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



In region A, let $x = -5$:
$(-5 + 4)\left((-5)^2 - 1\right) = -1(24) = -24 \le 0$.
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. $\dfrac{m+2}{m} \le 0$

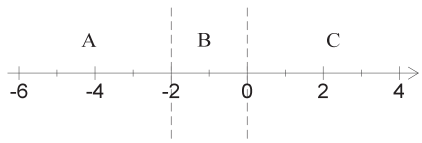
Solve the corresponding equation $\dfrac{m+2}{m} = 0.$

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:

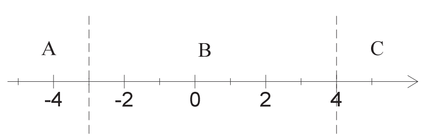
$\dfrac{1+2}{1} = 3 > 0$.

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 (–∞, –3) or (4, ∞).

63. $\dfrac{5}{p+1} > 2$

Solve the corresponding equation.

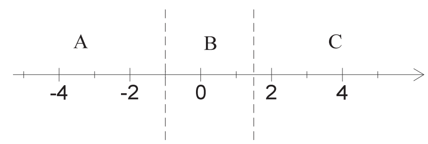
$$\frac{5}{p+1} = 2$$

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

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

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

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 $a = 2$.

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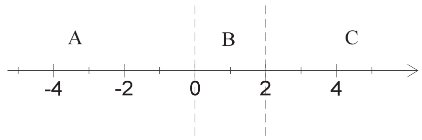


For region A, test –1:

$\frac{6}{-1-2} = -2 \geq -3$.

For region B, test 1:

$\frac{6}{1-2} = -6 \leq -3$.

For region C, test 3:

$\frac{6}{3-2} = 6 \geq -3$.

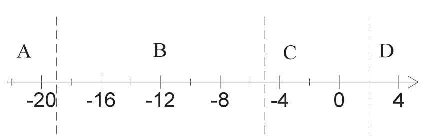
The given inequality is true in region B. The endpoint 0 is included because the inequality symbol is "≤." However, the endpoint 2 must be excluded because it makes the denominator 0. The solution is [0, 2).

65. $\frac{2}{r+5} \leq \frac{3}{r-2}$

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:

$\frac{2}{-20+5} = -\frac{2}{15} \approx -.13$ and

$\frac{3}{-20-2} = -\frac{3}{22} \approx -.14$

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 $\frac{3}{3-2} = 3$.

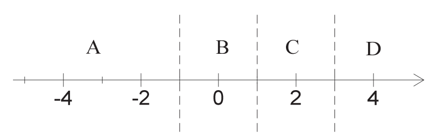
Since $\frac{1}{4} < 3$, 3 is a solution. The solution is [–19, –5) or (2, ∞).

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.

$\frac{1}{2-1} > \frac{2}{2+1} \Rightarrow 1 > \frac{2}{3}$, which is true.

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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 $(-\infty, -1)$ or $(1, 3)$.

67. $r = 340.1x^2 - 5360x + 18{,}834$

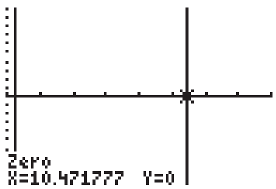
We want to determine when

$340.1x^2 - 5360x + 18{,}834 > 0$ for $6 \le x \le 12$.

Using a graphing calculator, plot

$Y_1 = 340.1x^2 - 5360x + 18{,}834$ on

[5, 13] by [–10, 10]. Then determine where the graph of Y_1 lies above the x axis.



The profit was positive in the years 2011 through 2012.

68. $r = 89.29x^2 - 1517x + 7505$

We want to determine when

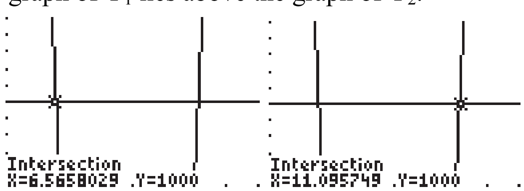
$89.29x^2 - 1577x + 7505 > 1000$ for $6 \le x \le 12$.

Using a graphing calculator, plot

$Y_1 = 89.29x^2 - 1577x + 7505$ and $Y_2 = 1000$

on

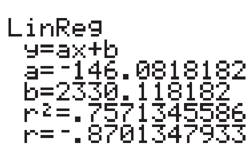
[0, 6] by [900, 1100]. Then determine where the graph of Y_1 lies above the graph of Y_2.



The net income exceeded $1000 million in 2006 and then again in 2012.

Case 2 Using Extrapolation for Prediction

1.

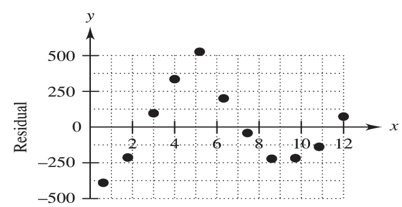


This verifies the regression equation.

2.

Year (x = 0 is 2000)	Table value	Predicted value	Residual
2	1648	2037.8	–389.8
3	1679	1891.7	–212.7
4	1842	1745.6	96.4
5	1931	1599.5	331.5
6	1979	1453.4	525.6
7	1503	1307.3	195.7
8	1120	1161.2	–41.2
9	794	1015.1	–221.1
10	652	869.0	–217.0
11	585	722.9	–137.9
12	650	576.8	73.2

3. See the table in problem 2 for residual values.



4. No; because the residuals show over fitting, under fitting, and then over fitting.

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	16.26

Then determine the least squares regression line.

```
LinReg
 y=ax+b
 a=.3429666667
 b=-20.647
 r²=.9907038368
 r=.9953410655
```

```
LinReg
 y=ax+b
 a=-3.333333E-5
 b=.003
 r²=1.006684E-6
 r=-.0010033366
```

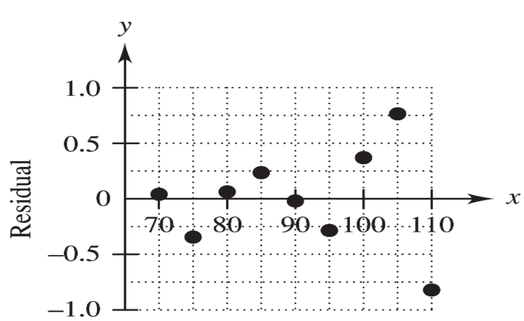
The model is verified.

6. The year 2002 corresponds to $x = 102$.
$y = .343(102) - 20.65 \approx 14.34.$
According to the model, the hourly wage in 2002 was about \$14.34, about 63¢ too low.

7. The year 1960 corresponds to $x = 60$.
$y = .343(60) - 20.65 \approx -0.07.$
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	3.36	.04
75	4.73	5.075	–.345
80	6.85	6.79	.06
85	8.74	8.505	.235
90	10.20	10.22	–.02
95	11.65	11.935	–.285
100	14.02	13.65	.37
105	16.13	15.365	.765
110	16.26	17.08	–.82



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.