CHAPTER 5

Think & Discuss *(p. 247)*

1. about 1900 ft

2. about 22 sec; *Sample answer:* The graph charts the lava fragment in the air from its initial point at zero until there are no longer fragments in the air at 22 sec.

Skill Review *(p. 248)*

1. $3x - 5 = 0$ 2. $4x + 24 = 12$ 3. $2x + 1 = -x + 7$

   $3x = 5$ $4x = -12$ $3x = 6$

   $x = \frac{5}{3}$ $x = -3$ $x = 2$

4.
$y = 5 - x$

5.
$3x - 2y = 12$

6.
$y = -2x$

7.
$(0, 2)$
$y = |x| + 2$

8.
$y = |x - 3|$
$(3, 0)$

9.
$(-1, -4)$
$y = -2|x + 1| - 4$
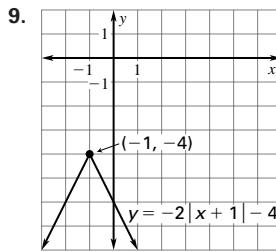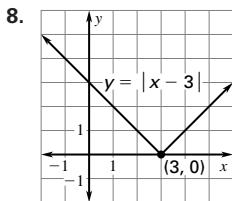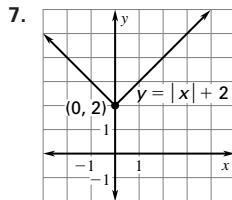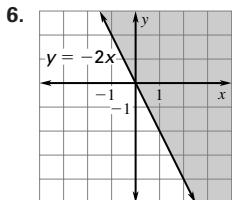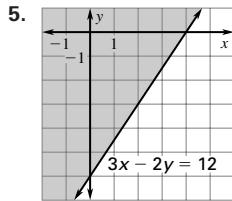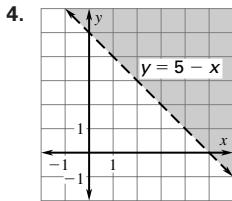
Lesson 5.1

Activity *(p. 29)*

1.

2.
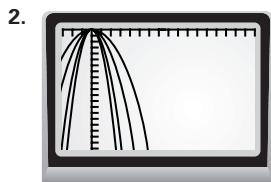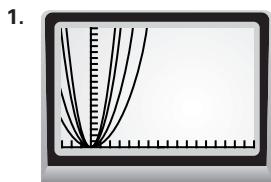
3. $(0, 0)$; $x = 0$ 4. The graph opens up if $a > 0$, the graph opens down if $a < 0$.

5.1 Guided Practice *(p. 253)*

1. parabola   2. Up; since $a = 3$ and is greater than 0, the parabola opens up.

3. intercept form

4.
$y = x^2 - 4x + 7$
$(2, 3)$
$x = 2$

5.
$y = 2(x + 1)^2 - 4$
$(-1, -4)$
$x = -1$

6.
$x = -0.5$
$(-0.5, 2.25)$
$y = -(x + 2)(x + 1)$

7.
$y = -\frac{1}{3}x^2 - 2x - 3$
$(-3, 0)$
$x = -3$

8.
$(4, 6)$
$y = -\frac{3}{5}(x - 4)^2 + 6$
$x = 4$

9.
$y = \frac{5}{2}x(x - 3)$
$(1.5, -5.625)$
$x = 1.5$
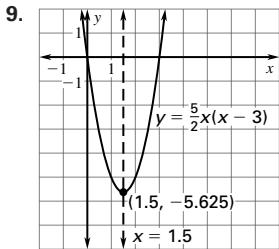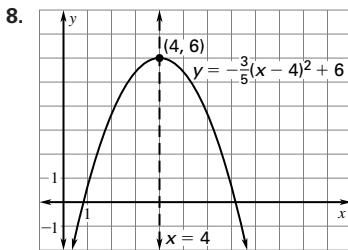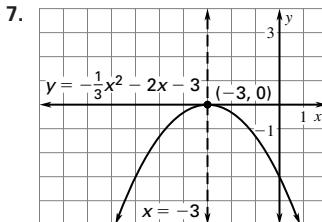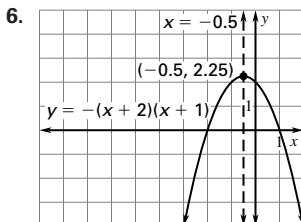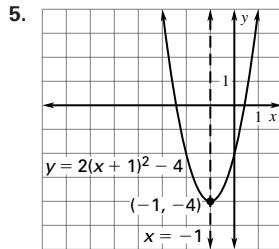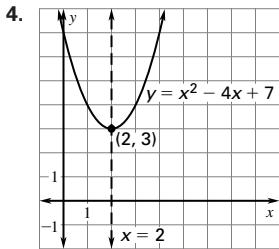
Chapter 5 *continued*

10. $y = (x + 1)(x + 2)$
$y = x^2 + 3x + 2$

11. $y = -2(x + 4)(x - 3)$
$y = -2(x^2 + x - 12)$
$y = -2x^2 - 2x + 24$

12. $y = 4(x - 1)^2 + 5$
$y = 4(x^2 - 2x + 1) + 5$
$y = 4x^2 - 8x + 9$

13. $y = -(x + 2)^2 - 7$
$y = -(x^2 + 4x + 4) - 7$
$y = -x^2 - 4x - 11$

14. $y = -\frac{1}{2}(x - 6)(x - 8)$
$y = -\frac{1}{2}(x^2 - 14x + 48)$
$y = -\frac{1}{2}x^2 + 7x - 24$

15. $y = \frac{2}{3}(x - 9)^2 - 4$
$y = \frac{2}{3}(x^2 - 18x + 81) - 4$
$y = \frac{2}{3}x^2 - 12x + 50$

16. males: $x = \dfrac{612.6}{8.58} = 71.4°\text{F}$; females: $x = \dfrac{908.9}{12.448} = 73°\text{F}$

5.1 Practice and Applications (pp. 253–255)

17. C   **18.** A   **19.** B

20.

21.

22.

23.

24.

25.

26.

27.

28.

29.

30.

31.

Chapter 5 *continued*

32.

Graph with $x = 4$, points $(2, 0)$, $(6, 0)$, $(4, -4)$, $y = (x - 2)(x - 6)$

33.

Graph with points $(1, 0)$, $(-1, 0)$, $(0, -4)$, $y = 4(x + 1)(x - 1)$, $x = 0$

34.

Graph with $x = -4$, $y = -(x + 3)(x + 5)$, $(-4, 1)$, $(-5, 0)$, $(-3, 0)$

35.

Graph with $x = -2.5$, $(-1, 0)$, $(-4, 0)$, $y = \frac{1}{3}(x + 4)(x + 1)$, $(-2.5, -0.75)$

36.

Graph with $y = -\frac{1}{2}(x - 3)(x + 2)$, $(0.5, 3.125)$, $(3, 0)$, $(-2, 0)$, $x = 0.5$

37.

Graph with $x = 1$, $(1, 3)$, $y = -3x(x - 2)$, $(0, 0)$, $(2, 0)$
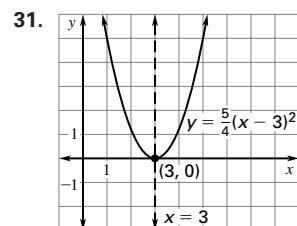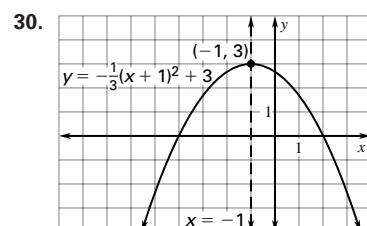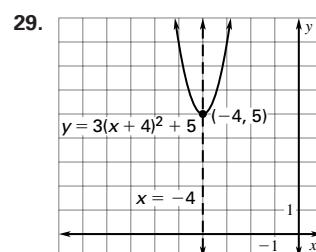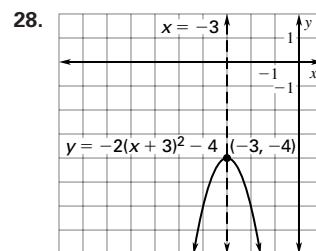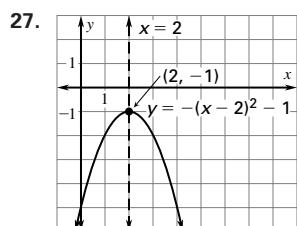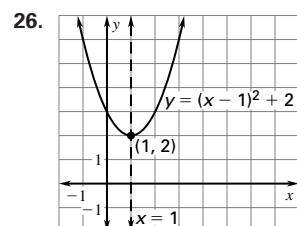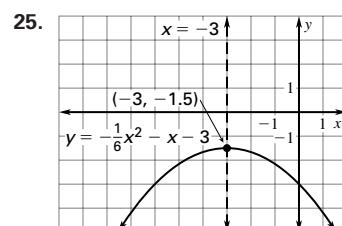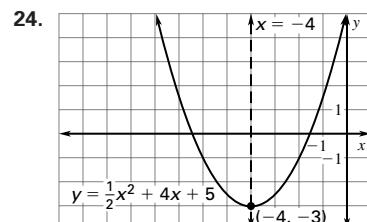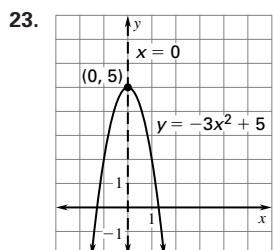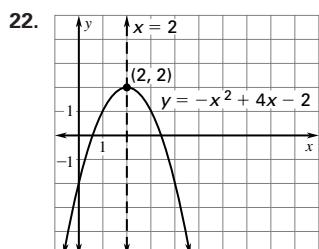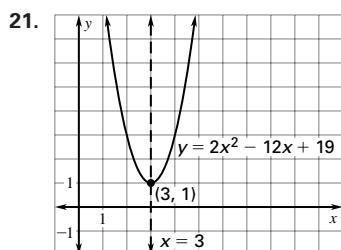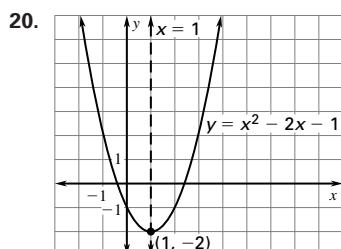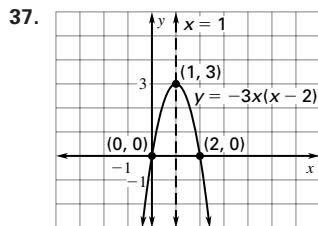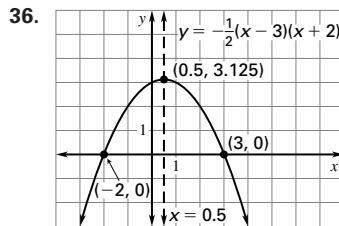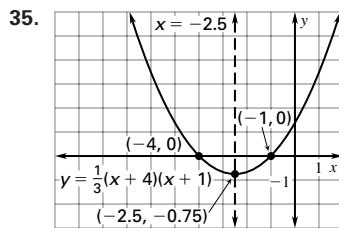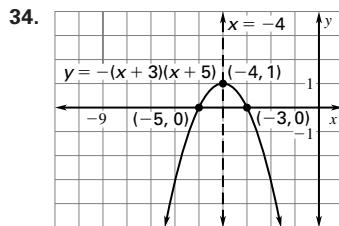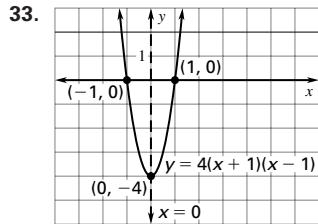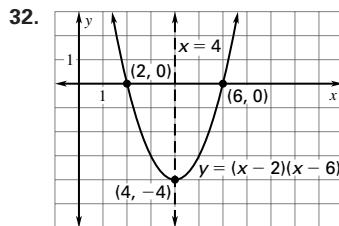
38. $y = (x + 5)(x + 2)$

$y = x^2 + 5x + 2x + 10$

$y = x^2 + 7x + 10$

39. $y = -(x + 3)(x - 4)$

$y = -(x^2 + 3x - 4x - 12)$

$y = -x^2 + x + 12$

40. $y = 2(x - 1)(x - 6)$

$y = 2(x^2 - x - 6x + 6)$

$y = 2x^2 - 14x + 12$

41. $y = -3(x - 7)(x + 4)$

$y = -3(x^2 - 7x + 4x - 28)$

$y = -3x^2 + 9x + 84$

42. $y = (5x + 8)(4x + 1)$

$y = 20x^2 + 32x + 5x + 8$

$y = 20x^2 + 37x + 8$

43. $y = (x + 3)^2 + 2$

$y = (x^2 + 6x + 9) + 2$

$y = x^2 + 6x + 11$

44. $y = -(x - 5)^2 + 11$

$y = -(x^2 - 10x + 25) + 11$

$y = -x^2 + 10x - 14$

45. $y = -6(x - 2)^2 - 9$

$y = -6(x^2 - 4x + 4) - 9$

$y = -6x^2 + 24x - 33$

46. $y = 8(x + 7)^2 - 20$

$y = 8(x^2 + 14x + 49) - 20$

$y = 8x^2 + 112x + 372$

47. $y = -(9x + 2)^2 + 4x$

$y = -(81x^2 + 36x + 4) + 4x$

$y = -81x^2 - 32x - 4$

48. $y = -\frac{7}{3}(x + 6)(x + 3)$

$y = -\frac{7}{3}(x^2 + 9x + 18)$

$y = -\frac{7}{3}x^2 - 21x - 42$

49. $y = \frac{1}{2}(8x - 1)^2 - \frac{3}{2}$

$y = \frac{1}{2}(64x^2 - 16x + 1) - \frac{3}{2}$

$y = 32x^2 - 8x - 1$

50. a.

b.
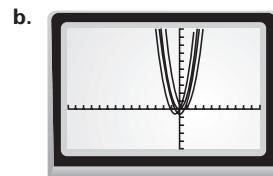
As *c* increases, the graph moves upward. The graph moves left as *b* increases.

51.
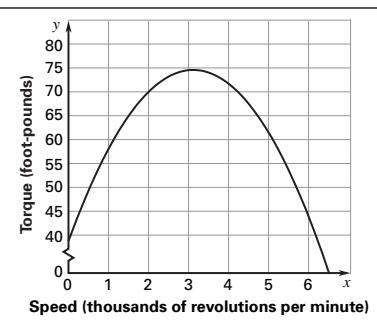
About 3093 rev per min; 74.68 foot-pounds

Chapter 5 *continued*

52. width $= 160$ ft

height $= 1.5$ ft

53.
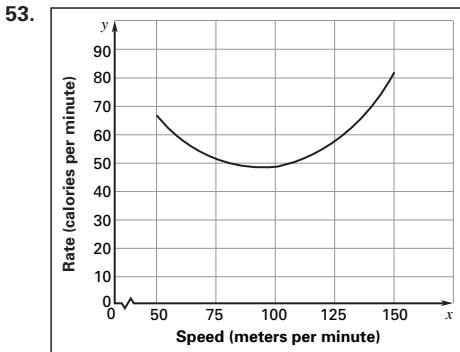
Sample answer: The energy use decreases until about 90 meters per minute and then increases.

54. width $= 6$ ft

height $= 2$ ft

55. a. $x = \dfrac{-21.4}{-1.522} \approx 14\%$

$y = -0.761(14)^2 + 21.4(14) - 94.8 \approx 56$ cm^3 per gram

b. $x = \dfrac{-17.7}{-1.304} \approx 13.6\%$

$y = -0.652(13.6)^2 + 17.7(13.6) - 76.0 \approx 44$ cm^3 per gram

c.

Volume of Popcorn
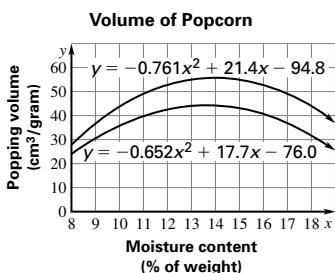
d. *Sample answer:* Hot-air popping produces a greater volume than hot-oil popping.

56. $y = a(x - h)^2 + k$ $\qquad y = a(x - p)(x - q)$

$y = a(x^2 - 2xh + h^2) + k \quad y = a(x^2 - xp - xq + pq)$

$y = ax^2 - 2axh + ah^2 + k \quad y = ax^2 - ax(p + q) + apq$

For $y = ax^2 - 2axh + ah^2 + k$, $a = a$ and $b = -2ah$.

Then $x = -\dfrac{b}{2a}$ (the x-coordinate of the vertex)

$= \dfrac{2ah}{2a} = h$. For $y = ax^2 - aqx + apq$, $a = a$ and

$b = -a(p + q)$. Then $x = -\dfrac{b}{2a}$ (then x-coordinate of the

vertex) $= -\dfrac{-a(p + q)}{2a} = \dfrac{p + q}{2}$.

5.1 Mixed Review (p. 255)

57. $x - 2 = 0$

$x = 2$

58. $2x = -5$

$x = -2.5$

59. $-4x = 28$

$x = -7$

60. $4x = -8$

$x = -2$

61. $6x = 18 - 48$

$6x = -30$

$x = -5$

62. $20x - 5 = 2x + 6$

$18x = 11$

$x = \frac{11}{18}$

63. $0.6x = 0.2x + 2.8$

$0.4x = 2.8$

$x = 7$

64. $\dfrac{35x - 24x}{40} = \dfrac{11}{2}$

$\dfrac{11x}{40} = \dfrac{11}{2}$

$x = 20$

65. $\dfrac{5x}{12} - \dfrac{x}{6} = -\dfrac{1}{4} - \dfrac{1}{2}$

$\dfrac{3x}{12} = -\dfrac{3}{4}$

$x = -3$

66.

67.

68.

69.

70.

(0, 0, 14)

$2x + 7y + 3z = 42$

(0, 6, 0)

(21, 0, 0)

71.

(0, 3, 0)

$x + 3y - 3z = 9$

(0, 0, -3)

(9, 0, 0)
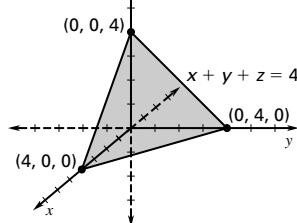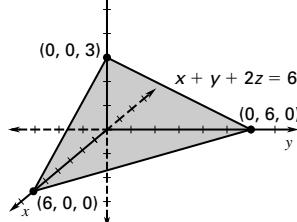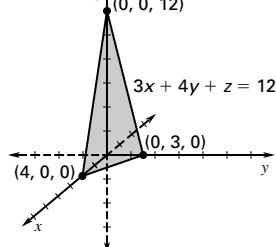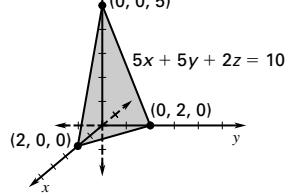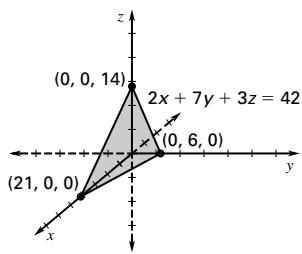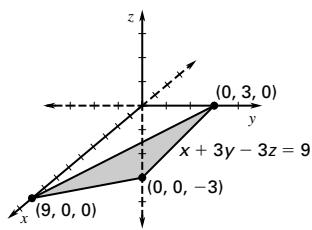
72. $A = \begin{bmatrix} 1 & 1 \\ -5 & 1 \end{bmatrix}$; $\det A = 1 + 5 = 6$

$x = \dfrac{\begin{vmatrix} 1 & 1 \\ 19 & 1 \end{vmatrix}}{6} = \dfrac{1 - 19}{6} = -3$

$y = \dfrac{\begin{vmatrix} 1 & 1 \\ -5 & 19 \end{vmatrix}}{6} = \dfrac{19 + 5}{6} = 4$

$(-3, 4)$

73. $A = \begin{bmatrix} 2 & 1 \\ 3 & -4 \end{bmatrix}$; $\det A = -8 - 3 = -11$

$x = \dfrac{\begin{vmatrix} 5 & 1 \\ 2 & -4 \end{vmatrix}}{-11} = \dfrac{-20 - 2}{-11} = 2$

$y = \dfrac{\begin{vmatrix} 2 & 5 \\ 3 & 2 \end{vmatrix}}{-11} = \dfrac{4 - 15}{-11} = 1$

$(2, 1)$

74. $A = \begin{bmatrix} 7 & -10 \\ 1 & 2 \end{bmatrix}$; $\det A = 14 + 10 = 24$

$x = \dfrac{\begin{vmatrix} -15 & -10 \\ -9 & 2 \end{vmatrix}}{24} = \dfrac{-30 - 90}{24} = -5$

$y = \dfrac{\begin{vmatrix} 7 & -15 \\ 1 & -9 \end{vmatrix}}{24} = \dfrac{-63 + 15}{24} = -2$

$(-5, -2)$

75. $A = \begin{bmatrix} 5 & 2 & 2 \\ 3 & 1 & -6 \\ -1 & -1 & -1 \end{bmatrix}$;

$\det A = (-5 + 12 - 6) - (-2 + 30 - 6) = -21$

$x = \dfrac{\begin{vmatrix} 4 & 2 & 2 \\ -4 & 1 & -6 \\ 1 & -1 & -1 \end{vmatrix}}{-21}$

$= \dfrac{(-4 - 12 + 8) - (2 + 24 + 8)}{-21} = \dfrac{-8 - 34}{-21} = 2$

$y = \dfrac{\begin{vmatrix} 5 & 4 & 2 \\ 3 & -4 & -6 \\ -1 & 1 & -1 \end{vmatrix}}{-21}$

$= \dfrac{(20 + 24 + 6) - (8 - 30 - 12)}{-21} = \dfrac{50 + 34}{-21} = -4$

$z = \dfrac{\begin{vmatrix} 5 & 2 & 4 \\ 3 & 1 & -4 \\ -1 & -1 & 1 \end{vmatrix}}{-21}$

$= \dfrac{(5 + 8 - 12) - (-4 + 20 + 6)}{-21} = \dfrac{1 - 22}{-21} = 1$

$(2, -4, 1)$

76. $A = \begin{bmatrix} 1 & 3 & 1 \\ -1 & 1 & 1 \\ 2 & -7 & 5 \end{bmatrix}$;

$\det A = (5 + 6 + 7) - (2 - 7 - 15) = 18 + 20 = 38$

$x = \dfrac{\begin{vmatrix} 5 & 3 & 1 \\ 7 & 1 & 1 \\ 28 & -7 & 5 \end{vmatrix}}{38}$

$= \dfrac{(25 + 84 - 49) - (28 - 35 + 105)}{38} = \dfrac{60 - 98}{38} = -1$

$y = \dfrac{\begin{vmatrix} 1 & 5 & 1 \\ -1 & 7 & 1 \\ 2 & 28 & 5 \end{vmatrix}}{38}$

$= \dfrac{(35 + 10 - 28) - (14 + 28 - 25)}{38} = \dfrac{17 - 17}{38} = 0$

$z = \dfrac{\begin{vmatrix} 1 & 3 & 5 \\ -1 & 1 & 7 \\ 2 & -7 & 28 \end{vmatrix}}{38}$

$= \dfrac{(28 + 42 + 35) - (10 - 49 - 84)}{38} = \dfrac{105 + 123}{38} = 6$

$(-1, 0, 6)$

Chapter 5 *continued*

77. $A = \begin{bmatrix} 2 & -3 & -9 \\ 6 & 1 & -1 \\ 9 & -2 & 4 \end{bmatrix}$;

$\det A = (8 + 27 + 108) - (-81 + 4 - 72)$

$\quad = 143 + 149 = 292$

$x = \dfrac{\begin{vmatrix} 11 & -3 & -9 \\ 45 & 1 & -1 \\ 56 & -2 & 4 \end{vmatrix}}{292}$

$\quad = \dfrac{(44 + 168 + 810) - (-504 + 22 - 540)}{292}$

$\quad = \dfrac{1022 + 1022}{292} = 7$

$y = \dfrac{\begin{vmatrix} 2 & 11 & -9 \\ 6 & 45 & -1 \\ 9 & 56 & 4 \end{vmatrix}}{292}$

$\quad = \dfrac{(360 - 99 - 3024) - (-3645 - 112 + 264)}{292}$

$\quad = \dfrac{-2763 + 3493}{292} = 2.5$

$z = \dfrac{\begin{vmatrix} 2 & -3 & 11 \\ 6 & 1 & 45 \\ 9 & -2 & 56 \end{vmatrix}}{292}$

$\quad = \dfrac{(112 - 1215 - 132) - (99 - 180 - 1008)}{292}$

$\quad = \dfrac{-1235 + 1089}{292} = \dfrac{-146}{292} = -0.5$

$(7, 2.5, -0.5)$

78. $\dfrac{22 - 7}{14} = \dfrac{15}{14} = 1\dfrac{1}{14}$ ft per hr

Lesson 5.2

5.2 Guided Practice (p. 260)

1. *Sample answer:* numbers where the value of the function is zero

2. The *x*-term is negative and its absolute value is greater than the absolute value of the constant term.

3. The student did not set the factors equal to zero.

$x^2 + 4x + 3 = 8$

$x^2 + 4x - 5 = 0$

$(x - 1)(x + 5) = 0$

$x - 1 = 0 \quad x + 5 = 0$

$\quad x = 1 \qquad x = -5$

4. $x^2 - x - 2 = (x + 1)(x - 2)$

5. $2x^2 + x - 3 = (2x + 3)(x - 1)$

6. $x^2 - 16 = (x - 4)(x + 4)$

7. $y^2 + 2y + 1 = (y + 1)(y + 1)$

8. $p^2 - 4p + 4 = (p - 2)(p - 2)$

9. $q^2 + q = q(q + 1)$

10. $x = -3 \quad x = 1$

11. $(x - 4)(x + 2) = 0$

$x - 4 = 0 \quad x + 2 = 0$

$\quad x = 4 \qquad x = -2$

12. $(3x + 1)(x + 3) = 0$

$3x = -1 \quad x = -3$

$x = -\dfrac{1}{3}$

13. $4u^2 - 1 = 0$

$(2u - 1)(2u + 1) = 0$

$2u = 1 \quad 2u = -1$

$u = \dfrac{1}{2} \quad u = -\dfrac{1}{2}$

14. $v^2 - 14v + 49 = 0$

$(v - 7)(v - 7) = 0$

$v = 7$

15. $5w^2 - 30w = 0$

$5w(w - 6) = 0$

$w = 0 \quad w = 6$

16. $y = (x - 1)(x - 5)$;

$1, 5$

17. $y = (x + 2)(x + 4)$;

$-2, -4$

18. $y = (x - 1)(x + 1)$;

$1, -1$

19. $y = (x + 5)^2$;

-5

20. $y = 2(x - 4)(x + 3)$;

$4, -3$

21. $y = (3x - 2)(x - 2)$;

$\dfrac{2}{3}, 2$

22. $(2x + 12)(2x + 8) - 96 = 96$

$4x^2 + 40x = 96$

$4(x^2 + 10x - 24) = 0$

$4(x + 12)(x - 2) = 0$

The width of the border is 2 ft.

5.2 Practice and Applications (pp. 260–263)

23. $x^2 + 5x + 4 = (x + 4)(x + 1)$

24. $x^2 + 9x + 14 = (x + 7)(x + 2)$

25. $x^2 + 13x + 40 = (x + 5)(x + 8)$

26. $x^2 - 4x + 3 = (x - 3)(x - 1)$

27. $x^2 - 8x + 12 = (x - 6)(x - 2)$

28. $x^2 - 16x + 51$ cannot be factored

29. $a^2 + 3a - 10 = (a + 5)(a - 2)$

30. $b^2 + 6b - 27 = (b + 9)(b - 3)$

31. $c^2 + 2c - 80 = (c + 10)(c - 8)$

32. $p^2 - 5p - 6 = (p - 6)(p + 1)$

33. $q^2 - 7q - 10$ cannot be factored

34. $r^2 - 14r - 72 = (r - 18)(r + 4)$

35. $2x^2 + 7x + 3 = (2x + 1)(x + 3)$

36. $3x^2 + 17x + 10 = (3x + 2)(x + 5)$

**37.** $8x^2 + 18x + 9 = (4x + 3)(2x + 3)$

38. $5x^2 - 7x + 2 = (5x - 2)(x - 1)$

Chapter 5 *continued*

39. $6x^2 - 9x + 5$ cannot be factored

40. $10x^2 - 19x + 6 = (5x - 2)(2x - 3)$

41. $3k^2 + 32k - 11 = (3k - 1)(k + 11)$

42. $11m^2 + 14m - 16 = (11m - 8)(m + 2)$

43. $18n^2 + 9n - 14 = (3n - 2)(6n + 7)$

44. $7u^2 - 4u - 3 = (7u + 3)(u - 1)$

45. $12v^2 - 25v - 7 = (3v - 7)(4v + 1)$

46. $4w^2 - 13w - 27$ cannot be factored

47. $x^2 - 25 = (x - 5)(x + 5)$

48. $x^2 + 4x + 4 = (x + 2)^2$

49. $x^2 - 6x + 9 = (x - 3)^2$

50. $4r^2 - 4r + 1 = (2r - 1)^2$

51. $9s^2 + 12s + 4 = (3s + 2)^2$

52. $16t^2 - 9 = (4t - 3)(4t + 3)$

53. $49 - 100a^2 = (7 - 10a)(7 + 10a)$

54. $25b^2 - 60b + 36 = (5b - 6)^2$

55. $81c^2 + 198c + 121 = (9c + 11)^2$

56. $5(x^2 + x - 2) = 5(x + 2)(x - 1)$

57. $2(9x^2 - 1) = 2(3x - 1)(3x + 1)$

58. $3(x^2 + 18x + 81) = 3(x + 9)^2$

59. $4(2y^2 - 7y - 15) = 4(2y + 3)(y - 5)$

60. $7(16a^2 - 24a + 9) = 7(4a - 3)^2$

61. $u(u + 7)$

62. $6t(t - 6)$

63. $-v^2 + 2v - 1 = -(v - 1)^2$

64. $2(d^2 + 6d - 8)$

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

66. $(x + 11)(x + 8) = 0$
$x = -11$ $x = -8$

67. $(5x - 3)(x - 2) = 0$
$x = \frac{3}{5}$ $x = 2$

68. $(4x - 5)(2x + 1) = 0$
$x = \frac{5}{4}$ $x = -\frac{1}{2}$

69. $(k + 12)^2 = 0$
$k = -12$

70. $(3m - 5)^2 = 0$
$m = \frac{5}{3}$

71. $(9n - 4)(9n + 4) = 0$
$n = \frac{4}{9}$ $n = -\frac{4}{9}$

72. $4a(10a + 1) = 0$
$a = 0$ $a = -\frac{1}{10}$

73. $-3(b + 5)(b - 6) = 0$
$b = -5$ $b = 6$

74. $x^2 + 9x + 20 = 0$
$(x + 4)(x + 5) = 0$
$x = -4$ $x = -5$

75. $16x^2 - 8x + 1 = 0$
$(4x - 1)^2 = 0$
$x = \frac{1}{4}$

76. $p^2 - 49 = 0$
$(p - 7)(p + 7) = 0$
$p = 7$ $p = -7$

77. $3y^2 - 5y - 8 = 0$
$(3y - 8)(y + 1) = 0$
$y = \frac{8}{3}$ $y = -1$

78. $-5q^2 + 11q - 2 = 0$
$-(5q - 1)(q - 2) = 0$
$q = \frac{1}{5}$ $q = 2$

79. $w^2 + 12w + 36 - 3w - 36 + w^2 = 0$
$$2w^2 + 9w = 0$$
$$w(2w + 9) = 0$$
$$w = 0 \quad w = -\frac{9}{2}$$

80. $y = (x - 2)(x - 1)$;
2, 1

81. $y = (x + 4)(x + 3)$;
$-4, -3$

82. $y = (x + 7)(x - 5)$;
$-7, 5$

83. $y = (x - 2)(x + 2)$;
$2, -2$

84. $y = (x + 10)^2$;
-10

85. $y = x(x - 3)$;
0, 3

86. $y = 3(x^2 - 4x - 5)$
$y = 3(x - 5)(x + 1)$;
$5, -1$

87. $y = -(x - 8)^2$;
8

88. $y = (2x - 1)(x - 4)$;
$\frac{1}{2}, 4$

89. a. $m + n = 0$
$mn = 9$

b. If $m + n = 0$, then $m = -n$. Substituting in $mn = 9$, $(-n)(n) = 9$, $-n^2 = 9$, and $n^2 = -9$. There is no such number such that $n^2 = -9$. Therefore, $x^2 + 9$ is not factorable.

90. $(4 + 2x)(5 + 2x) - 20 = 10$
$20 + 8x + 4x^2 - 20 - 10 = 0$
$4x^2 + 18x - 10 = 0$
$(2x + 10)(2x - 1) = 0$
$x = \frac{1}{2}$
0.5 ft

91. $(375 + x)(240 + x) - 90,000 = 40,500$
$x^2 + 615x - 40,500 = 0$
$(x - 60)(x + 675) = 0$
$x = 60$
60 ft

92. $x^2 + 3x = 40$
$x^2 + 3x - 40 = 0$
$(x - 5)(x + 8) = 0$
$x = 5$

93. $2x^2 + x = 105$
$2x^2 + x - 105 = 0$
$(2x + 15)(x - 7) = 0$
$x = 7$

94. $\frac{1}{2}(3x^2 - x) = 22$
$3x^2 - x - 44 = 0$
$(3x + 11)(x - 4) = 0$
$x = 4$

95. $\frac{1}{2}(6x + 2)(x) = 114$
$3x^2 + x - 114 = 0$
$(3x + 19)(x - 6) = 0$
$x = 6$

Chapter 5 *continued*

96. a. *Sample answer:* The area of the rectangle in the diagram equals the sum of the areas of its parts. The area of the rectangle also equals the product of the lengths of its sides. So, $x^2 + 5x + 6 = (x + 2)(x + 3)$.

b.
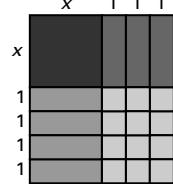
$$x^2 + 7x + 12 = (x + 3)(x + 4)$$

97.
$$1500 - (30 - 2x)(50 - 2x) = 375$$
$$1500 - (1500 - 160x + 4x^2) - 375 = 0$$
$$-4x^2 + 160x - 375 = 0$$
$$-(2x - 5)(2x - 75) = 0$$
$$x = 2.5$$

The border width is 2.5 ft.

98.
$$60x - x^2 = 800$$
$$-(x^2 - 60x + 800) = 0$$
$$-(x - 20)(x - 40) = 0$$
$$x = 20$$

20 ft by 40 ft

99. $R = (200 - 2x)(60 + x)$
$$R = -2(x - 100)(60 + x)$$
$$100, -60$$
$$\frac{100 - 60}{2} = 20$$

To maximize revenue, charge $80. Maximum revenue is $12,800.

100. $(70 + 5x)(680 - 20x) = R$
$$-100(x - 34)(x + 14) = R$$
$$34, -14$$
$$\frac{34 - 14}{2} = 10$$
$$-100(-24)(24) = R$$
$$\$57,600 = R$$

Price for each camera should be $480 and the maximum revenue is $57,600.

101. $y = -0.0196x^2 + 1.37x$
$$x = \frac{-1.37}{(2)(-0.0196)} \approx 35$$
$$y = -0.0196(35)^2 + 1.37(35)$$
$$y \approx 24$$

Big Bertha could fire a shell about 70 miles with a maximum height of about 24 miles.

102. C
$$(x - 2)(x - 2) = x^2 - 4x + 4 \neq x^2 + 4x + c$$

103. $2x^2 - 11x + 16 = x^2 - 3x$
$$x^2 - 8x + 16 = 0$$
$$(x - 4)(x - 4) = 0$$
$$x = 4 \quad \text{D}$$

104.
$$0 = 3(4)^2 + b(4) - 8$$
$$8 - 48 = 4b$$
$$-40 = 4b$$
$$-10 = b$$

B

105.
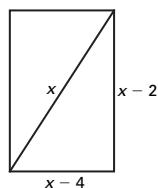
$$x^2 = (x - 4)^2 + (x - 2)^2$$
$$x^2 = x^2 - 8x + 16 + x^2 - 4x + 4$$
$$0 = x^2 - 12x + 20$$
$$0 = (x - 2)(x - 10)$$
$$x = 10$$

The door is 8 ch'ih by 6 ch'ih.

5.2 Mixed Review (p. 263)

106. $|x| = 3$
$$x = 3 \text{ or } x = -3$$

107. $|x - 2| = 6$
$$x - 2 = -6 \text{ or } x - 2 = 6$$
$$x = -4 \text{ or} \qquad x = 8$$

108. $|4x - 9| = 2$
$$4x - 9 = -2 \quad \text{or} \quad 4x - 9 = 2$$
$$4x = 7 \qquad \text{or} \qquad 4x = 11$$
$$x = 1.75 \text{ or} \qquad x = 2.75$$

109. $|-5x + 4| = 14$
$$-5x + 4 = -14 \text{ or } -5x + 4 = 14$$
$$-5x = -18 \text{ or} \qquad -5x = 10$$
$$x = 3.6 \quad \text{or} \qquad x = -2$$

110. $|7 - 3x| \neq -8$; no solution

111. $|x + 1| < 3$
$$-3 < x + 1 < 3$$
$$-4 < x < 2$$

112. $|2x - 5| \leq 1$
$$-1 \leq 2x - 5 \leq 1$$
$$4 \leq 2x \leq 6$$
$$2 \leq x \leq 3$$

Chapter 5 *continued*

113. $|x - 4| > 7$

$x - 4 < -7$ or $x - 4 > 7$

$x < -3$ or $x > 11$

114. $\left|\frac{1}{3}x + 1\right| \geq 2$

$\frac{1}{3}x + 1 \leq -2$ or $\frac{1}{3}x + 1 \geq 2$

$\frac{1}{3}x \leq -3$ or $\frac{1}{3}x \geq 1$

$x \leq -9$ or $x \geq 3$

115.

$y = x + 1$

116.

$y = -2x + 3$

117.

$y = 3x - 5$

118.

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

119.

$x + y = 4$

120.

$2x - y = 6$

121.

$3x + 4y = -12$

122.

$-5x + 3y = 15$

123.

$y = 2$

124.

$y = -3$

125.

$x = -1$

126.

$x = 4$

127.

$y = x^2 - 2$

$(0, -2)$

$x = 0$

128.

$y = 2x^2 - 5$

$(0, -5)$

$x = 0$

129.

$x = 0$

$(0, 3)$

$y = -x^2 + 3$

130.

$y = (x + 1)^2 - 4$

$(-1, -4)$

$x = -1$

131.

$x = 2$

$(2, 1)$

$y = -(x - 2)^2 + 1$

132.

$x = -3$

$(-3, 7)$

$y = -3(x + 3)^2 + 7$

133.

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

$x = 0$

134.

$x = 4$

$(4, -6)$ $y = \frac{1}{2}(x - 4)^2 - 6$

135.

$\left(1, 2\frac{2}{3}\right)$

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

$x = 1$
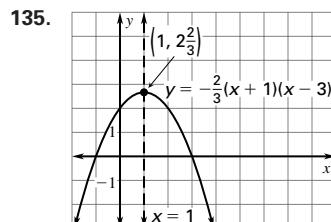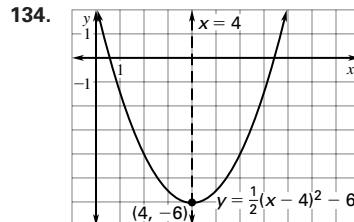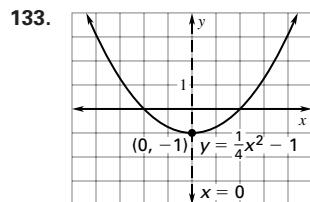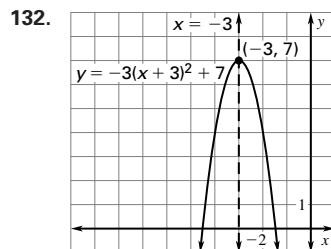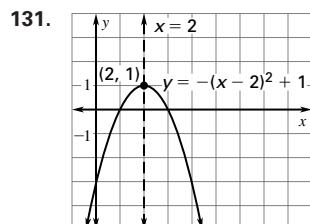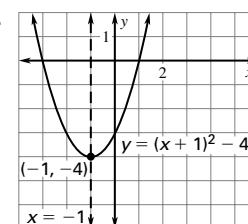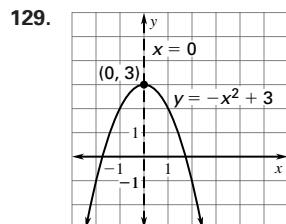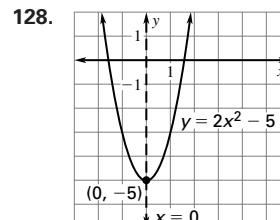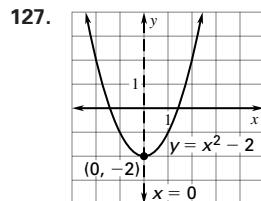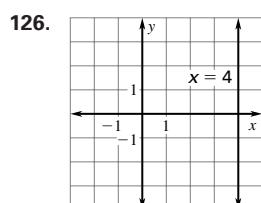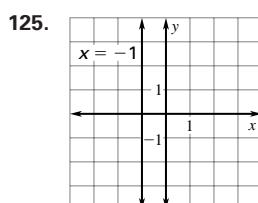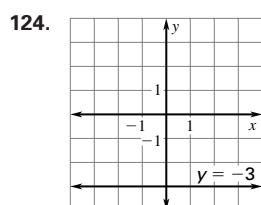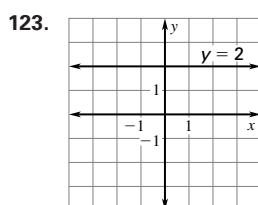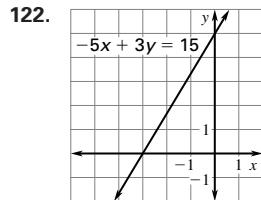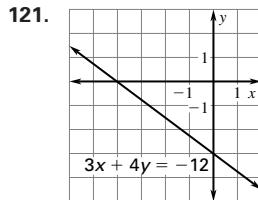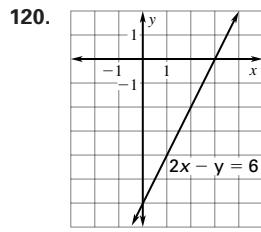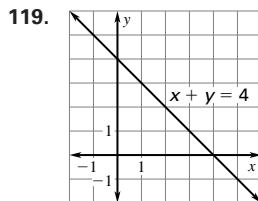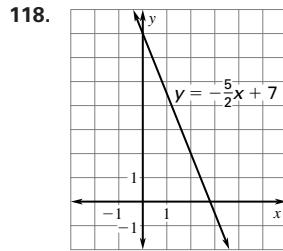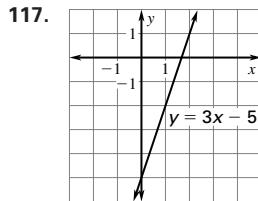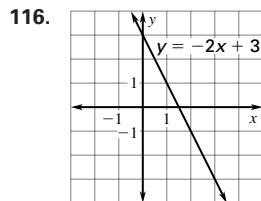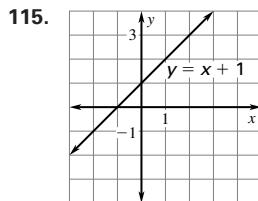
136. $x + y = 22$

$2x + 3y = 50$

$2(22 - y) + 3y = 50$

$44 - 2y + 3y = 50$

$y = 6$

You can take the bus only 6 times.

Chapter 5 *continued*

Lesson 5.3

Activity (p. 264)

1. **a.** $\sqrt{36} = 6$ **b.** $\sqrt{8} = 2\sqrt{2} \approx 2.8$

$\sqrt{4} \cdot \sqrt{9} = 6$ $\sqrt{2} \cdot \sqrt{4} = 2\sqrt{2} \approx 2.8$

c. $\sqrt{30} \approx 5.5$

$\sqrt{3} \cdot \sqrt{10} \approx 5.5$

1. a.–c. *Sample answer:* $\sqrt{ab} = \sqrt{a} \cdot \sqrt{b}$

2. **a.** $\sqrt{\dfrac{4}{9}} = \dfrac{2}{3}$ **b.** $\sqrt{\dfrac{25}{2}} \approx 3.5$

$\dfrac{\sqrt{4}}{\sqrt{9}} = \dfrac{2}{3}$ $\dfrac{\sqrt{25}}{\sqrt{2}} \approx 3.5$

c. $\sqrt{\dfrac{19}{7}} \approx 1.6$

$\dfrac{\sqrt{19}}{\sqrt{7}} \approx 1.6$

2. a.–c. *Sample answer:* $\sqrt{\dfrac{a}{b}} = \dfrac{\sqrt{a}}{\sqrt{b}}$

5.3 Guided Practice (p. 267)

1. *Sample answer:* to eliminate a radical from the denominator of a fraction

2. *Sample answer:* The product property says that the square root of a product equals the product of the square roots. The quotient property says that the square root of a quotient equals the quotient of the square roots.

3. 2; 1; 0   **4.** $\sqrt{7 \cdot 7} = 7$ **5.** $\sqrt{4 \cdot 3} = 2\sqrt{3}$

6. $\sqrt{5 \cdot 9} = 3\sqrt{5}$ **7.** $\sqrt{3} \cdot \sqrt{3 \cdot 9} = 9$

8. $\sqrt{\dfrac{16}{25}} = \dfrac{4}{5}$ **9.** $\dfrac{\sqrt{7}}{\sqrt{3 \cdot 3}} = \dfrac{\sqrt{7}}{3}$ **10.** $\dfrac{\sqrt{3}}{\sqrt{3} \cdot \sqrt{3}} = \dfrac{\sqrt{3}}{3}$

11. $\dfrac{\sqrt{5}\sqrt{2}}{\sqrt{2} \cdot \sqrt{2}} = \dfrac{\sqrt{10}}{2}$ **12.** $x^2 = 64$ **13.** $x^2 = 25$

$x = \pm 8$ $x = \pm 5$

14. $4x^2 = 16$ **15.** $x^2 = 12$

$x^2 = 4$ $x = \pm 2\sqrt{3}$

$x = \pm 2$

16. $(x - 1)^2 = 10$ **17.** $(x + 8)^2 = 28$

$x - 1 = \pm\sqrt{10}$ $x + 8 = \pm 2\sqrt{7}$

$x = \pm\sqrt{10} + 1$ $x = \pm 2\sqrt{7} - 8$

18. $h = -16t^2 + 50$

$0 = -16t^2 + 50$

$-50 = -16t^2$

$\dfrac{25}{8} = t^2$

$\sqrt{\dfrac{25}{8}} = t$

$1.8 \text{ sec} \approx t$

5.3 Practice and Applications (pp. 267–269)

19. $\sqrt{3 \cdot 3 \cdot 2} = 3\sqrt{2}$ **20.** $\sqrt{2 \cdot 2 \cdot 2 \cdot 2 \cdot 3} = 4\sqrt{3}$

21. $\sqrt{3 \cdot 3 \cdot 3} = 3\sqrt{3}$ **22.** $\sqrt{2 \cdot 2 \cdot 13} = 2\sqrt{13}$

23. $\sqrt{9 \cdot 2 \cdot 4} = 6\sqrt{2}$ **24.** $\sqrt{25 \cdot 7} = 5\sqrt{7}$

25. $\sqrt{49 \cdot 2} = 7\sqrt{2}$ **26.** $\sqrt{121 \cdot 5} = 11\sqrt{5}$

27. $2 \cdot 7 = 14$ **28.** $\sqrt{4 \cdot 2} \cdot \sqrt{2} = 4$

29. $\sqrt{3} \cdot \sqrt{3 \cdot 4} = 6$ **30.** $3\sqrt{4 \cdot 5} \cdot 6\sqrt{5} = 180$

31. $\sqrt{4 \cdot 3} \cdot \sqrt{2} = 2\sqrt{6}$ **32.** $\sqrt{2 \cdot 3} \cdot \sqrt{2 \cdot 5} = 2\sqrt{15}$

33. $4\sqrt{3} \cdot \sqrt{3 \cdot 7} = 12\sqrt{7}$

34. $\sqrt{2 \cdot 2 \cdot 2} \cdot \sqrt{2 \cdot 3} \cdot \sqrt{3} = 12$ **35.** $\dfrac{\sqrt{1}}{\sqrt{9}} = \dfrac{1}{3}$

36. $\dfrac{\sqrt{4}}{\sqrt{49}} = \dfrac{2}{7}$ **37.** $\dfrac{\sqrt{36}}{\sqrt{25}} = \dfrac{6}{5}$ **38.** $\dfrac{\sqrt{100}}{\sqrt{81}} = \dfrac{10}{9}$

39. $\dfrac{\sqrt{3}}{\sqrt{16}} = \dfrac{\sqrt{3}}{4}$ **40.** $\dfrac{\sqrt{11}}{\sqrt{64}} = \dfrac{\sqrt{11}}{8}$ **41.** $\dfrac{\sqrt{75}}{\sqrt{36}} = \dfrac{5\sqrt{3}}{6}$

42. $\dfrac{\sqrt{40}}{\sqrt{169}} = \dfrac{2\sqrt{10}}{13}$ **43.** $\dfrac{2\sqrt{3}}{\sqrt{3} \cdot \sqrt{3}} = \dfrac{2\sqrt{3}}{3}$

44. $\dfrac{5\sqrt{17}}{\sqrt{17} \cdot \sqrt{17}} = \dfrac{5\sqrt{17}}{17}$ **45.** $\dfrac{\sqrt{6} \cdot \sqrt{5}}{\sqrt{5} \cdot \sqrt{5}} = \dfrac{\sqrt{30}}{5}$

46. $\dfrac{\sqrt{144} \cdot \sqrt{11}}{\sqrt{11} \cdot \sqrt{11}} = \dfrac{12\sqrt{11}}{11}$ **47.** $\dfrac{\sqrt{7} \cdot \sqrt{2}}{\sqrt{8} \cdot \sqrt{2}} = \dfrac{\sqrt{14}}{4}$

48. $\dfrac{\sqrt{18} \cdot \sqrt{13}}{\sqrt{13} \cdot \sqrt{13}} = \dfrac{3\sqrt{26}}{13}$ **49.** $\dfrac{\sqrt{45} \cdot \sqrt{2}}{\sqrt{32} \cdot \sqrt{2}} = \dfrac{3\sqrt{10}}{8}$

50. $\dfrac{\sqrt{20}}{\sqrt{7}} = \dfrac{2\sqrt{35}}{7}$ **51.** $x^2 = 121$ **52.** $x^2 = 90$

$x = \pm 11$ $x = \pm 3\sqrt{10}$

53. $3x^2 = 108$ **54.** $2x^2 = 36$

$x^2 = 36$ $x^2 = 18$

$x = \pm 6$ $x = \pm 3\sqrt{2}$

55. $-x^2 = -75$

$x^2 = 75$

$x = \pm 5\sqrt{3}$

56. $10u^2 = 6$

$u^2 = \dfrac{6}{10}$

$u = \pm\dfrac{\sqrt{60}}{10} = \pm\dfrac{\sqrt{15}}{5}$

57. $\dfrac{v^2}{25} = 12$ **58.** $\dfrac{p^2}{8} = 10$

$v^2 = 12 \cdot 25$ $p^2 = 8 \cdot 10$

$v = \pm 10\sqrt{3}$ $p = \pm 4\sqrt{5}$

Chapter 5 *continued*

59. $\dfrac{q^2}{2} = 72$
$q^2 = 144$
$q = \pm 12$

60. $2(x^2 - 6x + 9) - 8 = 0$
$2x^2 - 12x + 18 - 8 = 0$
$2x^2 - 12x + 10 = 0$
$2(x^2 - 6x + 5) = 0$
$2(x - 1)(x - 5) = 0$
1, 5

61. $4(x^2 + 2x + 1) - 100 = 0$
$4x^2 + 8x + 4 - 100 = 0$
$4x^2 + 8x - 96 = 0$
$4(x^2 + 2x - 24) = 0$
$4(x + 6)(x - 4) = 0$
$-6, 4$

62. $-3(x + 2)^2 = -18$
$(x + 2)^2 = 6$
$x + 2 = \pm\sqrt{6}$
$x = -2 \pm \sqrt{6}$
$-2 - \sqrt{6}, -2 + \sqrt{6}$

63. $5(x - 7)^2 = 135$
$(x - 7)^2 = 27$
$x - 7 = \pm 3\sqrt{3}$
$x = 7 \pm 3\sqrt{3}$;
$7 + 3\sqrt{3}, 7 - 3\sqrt{3}$

64. $8(x + 4)^2 = 9$
$x + 4 = \pm\sqrt{\dfrac{9}{8}}$
$x = -4 \pm \dfrac{3\sqrt{2}}{4}$;
$\dfrac{3\sqrt{2}}{4} - 4, -\dfrac{3\sqrt{2}}{4} - 4$

65. $2(a - 6)^2 = 98$
$(a - 6)^2 = 49$
$a - 6 = \pm 7$
$a = 6 \pm 7$;
$13, -1$

66. $(b - 8)^2 = 28$
$b - 8 = \pm 2\sqrt{7}$
$b = 8 \pm 2\sqrt{7}$;
$8 + 2\sqrt{7}, 8 - 2\sqrt{7}$

67. $(2r - 5)^2 = 81$
$(2r - 5) = \pm 9$
$2r = 5 \pm 9$
$r = \dfrac{5 \pm 9}{2}$;
$7, -2$

68. $(s + 1)^2 - 24 = 75$
$(s + 1)^2 = 99$
$s + 1 = \pm 3\sqrt{11}$
$s = -1 \pm 3\sqrt{11}$;
$-1 + 3\sqrt{11}, -1 - 3\sqrt{11}$

69. $0 = -16t^2 + 177$
$16t^2 = 177$
$t = \dfrac{\sqrt{177}}{4}$
$t \approx 3.3$ sec

70. a. $h = -16t^2 + 20$

b.

t	0	0.1	0.2	0.3	0.4	0.5	0.6
h	20	19.84	19.36	18.56	17.44	16	14.24

t	0.7	0.8	0.9	1.0	1.1	1.2	1.3
h	12.16	9.76	7.04	4	0.64	-3.04	-7.04

t	1.4	1.5
h	-11.36	-16

$0 = -16t^2 + 20$
$16t^2 = 20$
$t^2 = \dfrac{20}{16} = \dfrac{5}{4}$
$t = \dfrac{\sqrt{5}}{2}$
$t \approx 1.1$ sec

71. Earth
$0 = -16t^2 + 200$
$16t^2 = 200$
$t = \dfrac{5\sqrt{2}}{2}$
$t \approx 3.5$ sec

Mars
$0 = -6t^2 + 200$
$6t^2 = 200$
$t = \dfrac{20\sqrt{3}}{6}$
$t \approx 5.8$ sec

Jupiter
$0 = -\dfrac{81}{2}t^2 + 200$
$81t^2 = 400$
$t = \sqrt{\dfrac{400}{81}}$
$t = \dfrac{20}{9}$
$t \approx 2.2$ sec

Neptune
$0 = -18t^2 + 200$
$18t^2 = 200$
$t = \sqrt{\dfrac{200}{18}}$
$t = \dfrac{20}{6}$
$t \approx 3.3$ sec

—CONTINUED—

Chapter 5 *continued*

71. **—CONTINUED—**

Pluto

$$0 = -\frac{2.1}{2}t^2 + 200$$

$$2.1t^2 = 400$$

$$t = \sqrt{\frac{400}{2.1}}$$

$$t = \frac{20\sqrt{2.1}}{2.1}$$

$$t \approx 13.8 \text{ sec}$$

72. $\qquad 15 = 0.019s^2$

$$\sqrt{\frac{15}{0.019}} = s$$

$$28.1 \text{ knots} \approx s$$

73. $27^2 = (4x)^2 + (3x)^2$

$$27^2 = 16x^2 + 9x^2$$

$$27^2 = 25x^2$$

$$\frac{27^2}{5^2} = x^2$$

$$\frac{27}{5} = x$$

21.6 in. by 16.2 in.

74. a. $\qquad 20 = 0.00256s^2$

$$\sqrt{\frac{20}{0.00256}} = s$$

$$88.4 \approx s$$

about 88.4 mi/h

b. $\qquad 40 = 0.00256s^2$

$$\sqrt{\frac{40}{0.00256}} = s$$

$$125 = s$$

No; *Sample answer:* When $P = 40$ lb/ft², speed is 125 mi/h which is not $2 \cdot 88.4$.

c. *Sample answer:* The wind speed value is squared in the formula and squaring increases the pressure value quickly.

75. a. $\qquad 12.5 = \left(\sqrt{25} - \frac{2\pi(2)^2\sqrt{3}}{60 \times 30}t\right)^2$

$$12.5 = \left(5 - \frac{8\pi\sqrt{3}}{1800}t\right)^2$$

$$\sqrt{12.5} = 5 - \frac{8\pi\sqrt{3}}{1800}t$$

$$6364 = 9000 - 8\pi\sqrt{3}t$$

$$-2636 = -8\pi\sqrt{3}t$$

$$\frac{-2636}{-8\pi\sqrt{3}} = t$$

$$60.6 \approx t$$

about 60.6 sec

b. $\qquad 0 = \left(\sqrt{12.5} - \frac{2\pi(2)^2\sqrt{3}t}{60 \times 30}\right)^2$

$$0 = \sqrt{12.5} - \frac{8\pi\sqrt{3}t}{1800}$$

$$-1800\sqrt{12.5} = -8\pi\sqrt{3}t$$

$$\frac{-1800\sqrt{12.5}}{-8\pi\sqrt{3}} = t$$

$$146.2 \approx t$$

about 146.2 sec

c. *Sample answer:* The water drains more slowly as the time increases.

76.

77.

78.

79.

80.

81.
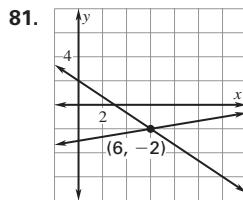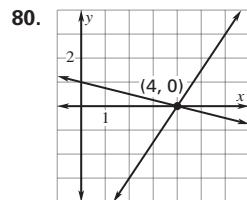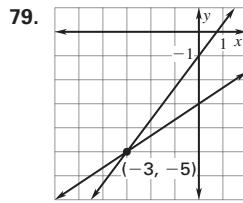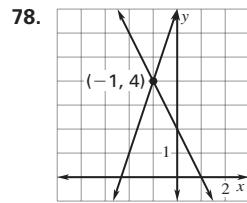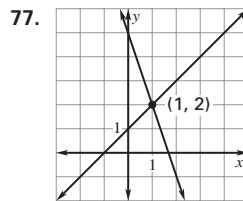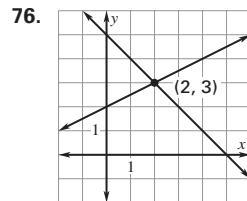
82. $\begin{bmatrix} 1 & -5 \\ 18 & 0 \end{bmatrix}$

83. $\begin{bmatrix} 13 & -1 \\ -11 & 1 \end{bmatrix}$

84. $\begin{bmatrix} 12 & -20 & 4 \\ -16 & 16 & -32 \end{bmatrix}$

85. $\begin{bmatrix} -24 & -20 \\ -40 & 18 \end{bmatrix} + \begin{bmatrix} 105 & 77 \\ 0 & -49 \end{bmatrix} = \begin{bmatrix} 81 & 57 \\ -40 & -31 \end{bmatrix}$

86. $y = x^2 + 5x - 2x - 10$

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

87. $y = x^2 - x - 8x + 8$

$y = x^2 - 9x + 8$

88. $y = 2x^2 + 7x + 8x + 28$

$y = 2x^2 + 15x + 28$

89. $y = 16x^2 + 36x - 36x - 81$

$y = 16x^2 - 81$

Chapter 5 *continued*

90. $y = x^2 - 3x - 3x + 9 + 1$

$y = x^2 - 6x + 10$

91. $y = 5(x^2 + 6x + 6x + 36) - 12$

$y = 5x^2 + 60x + 180 - 12$

$y = 5x^2 + 60x + 168$

Quiz 1 (p. 270)

1.

$y = x^2 - 2x - 3$
$(1, -4)$
$x = 1$

2.

$y = 2(x + 2)^2 + 1$
$(-2, 1)$
$x = -2$

3.

$x = -2$
$(-2, 3)$
$y = -\frac{1}{3}(x + 5)(x - 1)$
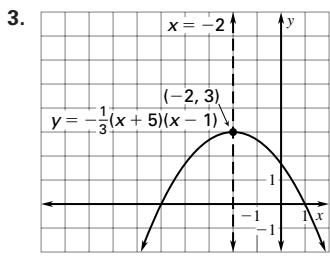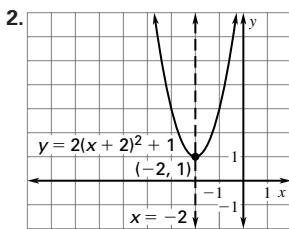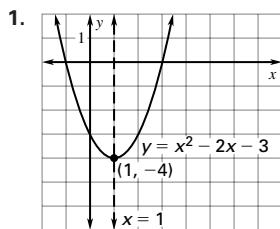
4. $(x + 3)(x - 9) = 0$

$x + 3 = 0 \qquad x - 9 = 0$

$x = -3 \qquad x = 9$

5. $(4x + 5)(x + 4) = 0$

$4x + 5 = 0 \qquad x + 4 = 0$

$x = -\frac{5}{4} \qquad x = -4$

6. $4t^2 - 4t + 1 = 0$

$(2t - 1)(2t - 1) = 0;$

$2t - 1 = 0$

$t = \frac{1}{2}$

7. $\sqrt{54} = \sqrt{9 \cdot 6} = 3\sqrt{6}$

8. $7\sqrt{2} \cdot \sqrt{2 \cdot 5} = 14\sqrt{5}$

9. $\sqrt{\frac{36}{5}} = \sqrt{\frac{36 \cdot 5}{5 \cdot 5}} = \frac{6\sqrt{5}}{5}$

10. $\frac{4}{\sqrt{4 \cdot 3}} = \frac{4\sqrt{3}}{6} = \frac{2\sqrt{3}}{3}$

11. $10 = 1.35s^2$

$\sqrt{\frac{10}{1.35}} = s \approx 2.7 \text{ mi/h}$

Math and History (p. 270)

1. $y = 0$; the x-axis lines up with the liquid's surface.

2. $y = \dfrac{\pi^2(0.5)^2}{16}x^2 - \dfrac{\pi^2(0.5)^2(2)^2}{32}$

$y = \dfrac{0.25\pi^2}{16}x^2 - \dfrac{0.25\pi^2}{8}$

$y = 0.1542x^2 - 0.3084$

$x = 0$
$(1.4, 0)$
$(-1.4, 0)$
$y = 0.1542x^2 - 0.3084$
$(0, -0.3)$
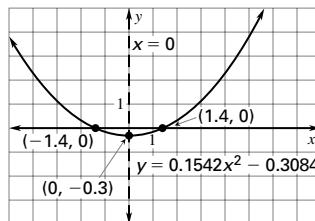
3. $0 = (2\pi^2 f^2 x^2 - \pi^2 f^2 R^2)$

$0 = \left(\sqrt{2}\pi f x + \pi f R\right)\left(\sqrt{2}\pi x f - \pi f R\right)$

$-\sqrt{2}\pi f x = \pi f R$

$x = \dfrac{\pi f R}{-\sqrt{2}\pi f} = -\dfrac{R\sqrt{2}}{2}$

$\sqrt{2}\pi f x = \pi f R$

$x = \dfrac{\pi f R}{\sqrt{2}\pi f} = \dfrac{R\sqrt{2}}{2}$

No, the x-intercepts are in terms of the radius only.

Technology Activity 5.3 (p. 271)

1. $-1.53, 1.53$

2. $-1.73, 1.73$

3. $-2.45, 2.45$

4. $-2.87, 2.87$

5. $-2.73, 0.73$

6. $-0.90, 8.90$

7. $-3.65, 1.65$

8. $-0.85, 2.35$

9. $48\pi = 6\pi r^2$

$8 = r^2$

$2.8 \text{ in.} \approx r$

Lesson 5.4

5.4 Guided Practice (p. 277)

1. $3, -7i$

2. *Sample answer:* The real part should be the same and the imaginary part should be the opposite of the given imaginary part; $-5 - 2i$.

3. *Sample answer:* distance from origin

4. $x^2 = -9$

$x = \pm 3i$

5. $2x^2 = -16$

$x^2 = -8$

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

Chapter 5 *continued*

6. $(x - 1) = \pm i\sqrt{7}$

$\quad\quad x = 1 \pm i\sqrt{7}$

7. $7 + 3i$

8. $4 + 3i + 2 - 4i = 6 - i$

9. $7 - 7i + 2i + 2 = 9 - 5i$

10. $\dfrac{3 - 4i}{1 + i} \times \dfrac{1 - i}{1 - i} = \dfrac{3 - 4 - 7i}{2} = \dfrac{-1 - 7i}{2}$

11. $\sqrt{1^2 + 1^2} = \sqrt{2}$

12. $\sqrt{0^2 + 3^2} = 3$

13. $\sqrt{(-2)^2 + 3^2} = \sqrt{4 + 9} = \sqrt{13}$

14. $\sqrt{5^2 + (-5)^2} = \sqrt{25 + 25} = 5\sqrt{2}$

15.
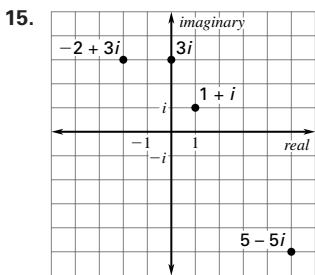
16. $|c| = \sqrt{1^2 + (-1)^2}$

$\quad\quad |c| = \sqrt{2}$

Sample answer: It does not because the absolute values become infinitely larger.

5.4 Practice and Applications (pp. 277–280)

17. $x^2 = -4$

$\quad\quad x = \pm 2i$

18. $x^2 = -11$

$\quad\quad x = \pm i\sqrt{11}$

19. $x^2 = -27$

$\quad\quad x = \pm 3i\sqrt{3}$

20. $2x^2 = -50$

$\quad\quad x^2 = -25$

$\quad\quad x = \pm 5i$

21. $5x^2 = -15$

$\quad\quad x^2 = -3$

$\quad\quad x = \pm i\sqrt{3}$

22. $-x^2 = 18$

$\quad\quad x^2 = -18$

$\quad\quad x = \pm 3i\sqrt{2}$

23. $3r^2 = -3$

$\quad\quad r^2 = -1$

$\quad\quad r = \pm i$

24. $-4s^2 = 1$

$\quad\quad s^2 = -\frac{1}{4}$

$\quad\quad s = \pm\frac{1}{2}i$

25. $(t - 2)^2 = -16$

$\quad\quad (t - 2) = \pm 4i$

$\quad\quad\quad\quad t = 2 \pm 4i$

26. $(u + 5)^2 = -20$

$\quad\quad u + 5 = \pm 2i\sqrt{5}$

$\quad\quad\quad\quad u = -5 \pm 2i\sqrt{5}$

27. $(v + 3)^2 = -56$

$\quad\quad v + 3 = \pm 2i\sqrt{14}$

$\quad\quad\quad\quad v = -3 \pm 2i\sqrt{14}$

28. $(w - 4)^2 = -\frac{1}{9}$

$\quad\quad (w - 4) = \pm\frac{1}{3}i$

$\quad\quad\quad\quad w = 4 \pm\frac{1}{3}i$

29.–36.
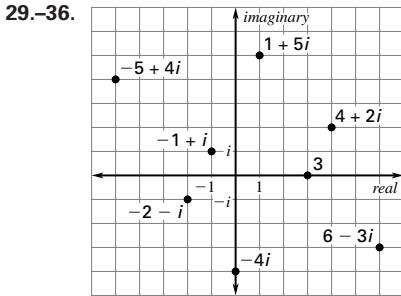
37. $(2 + 3i) + (7 + i) = 9 + 4i$

38. $(6 + 2i) + (5 - i) = 11 + i$

39. $(-4 + 7i) + (-4 - 7i) = -8$

40. $(-1 - i) + (9 - 3i) = 8 - 4i$

41. $(8 + 5i) - (1 + 2i) = 7 + 3i$

42. $(2 - 6i) - (-10 + 4i) = 12 - 10i$

43. $(-0.4 + 0.9i) - (-0.6 + i) = 0.2 - 0.1i$

44. $(25 + 15i) - (25 - 6i) = 21i$

45. $-i + (8 - 2i) - (5 - 9i) = 3 + 6i$

46. $(30 - i) - (18 + 6i) + 30i = 12 + 23i$

47. $i(3 + i) = 3i - 1 = -1 + 3i$

48. $4i(6 - i) = 24i + 4 = 4 + 24i$

49. $-40i + 70 = 70 - 40i$

50. $40 + 8i + 5i - 1 = 39 + 13i$

51. $-11 + 22i + i + 2 = -9 + 23i$

52. $18 - 12i - 81i - 54 = -36 - 93i$

53. $49 + 35i - 35i + 25 = 74$

54. $9 + 30i + 30i - 100 = -91 + 60i$

55. $225 - 120i - 120i - 64 = 161 - 240i$

56. $\dfrac{8 - 8i}{1 + 1} = 4 - 4i$

57. $\dfrac{2i - 2}{1 + 1} = i - 1 = -1 + i$

58. $\dfrac{-5 - 3i}{4i} \times \dfrac{-4i}{-4i} = \dfrac{20i - 12}{16} = \dfrac{5i}{4} - \dfrac{3}{4} = -\dfrac{3}{4} + \dfrac{5}{4}i$

59. $\dfrac{3 + i}{3 - i} \times \dfrac{3 + i}{3 + i} = \dfrac{9 + 6i - 1}{9 + 1} = \dfrac{8 + 6i}{10} = \dfrac{4}{5} + \dfrac{3}{5}i$

60. $\dfrac{2 + 5i}{5 + 2i} \times \dfrac{5 - 2i}{5 - 2i} = \dfrac{10 + 10 + 25i - 4i}{29} = \dfrac{20 + 21i}{29}$

61. $\dfrac{-7 + 6i}{9 - 4i} \times \dfrac{9 + 4i}{9 + 4i} = \dfrac{-63 + 26i - 24}{81 + 16} = -\dfrac{87}{97} + \dfrac{26}{97}i$

62. $\dfrac{\sqrt{10}}{\sqrt{10} - i} \times \dfrac{\sqrt{10} + i}{\sqrt{10} + i} = \dfrac{10 + i\sqrt{10}}{10 + 1} = \dfrac{10}{11} + \dfrac{\sqrt{10}}{11}i$

63. $\dfrac{6 - i\sqrt{2}}{6 + i\sqrt{2}} \times \dfrac{6 - i\sqrt{2}}{6 - i\sqrt{2}} = \dfrac{36 - 2 - 12i\sqrt{2}}{36 + 2}$

$\quad\quad = \dfrac{17}{19} - \dfrac{6\sqrt{2}}{19}i$

64. $\sqrt{3^2 + (-4)^2} = \sqrt{9 + 16} = \sqrt{25} = 5$

65. $\sqrt{5^2 + 12^2} = \sqrt{25 + 144} = \sqrt{169} = 13$

66. $\sqrt{(-2)^2 + (-1)^2} = \sqrt{4 + 1} = \sqrt{5}$

67. $\sqrt{(-7)^2 + (1)^2} = \sqrt{49 + 1} = \sqrt{50} = 5\sqrt{2}$

68. $\sqrt{(2)^2 + (5)^2} = \sqrt{4 + 25} = \sqrt{29}$

69. $\sqrt{(4)^2 + (-8)^2} = \sqrt{16 + 64} = \sqrt{80} = 4\sqrt{5}$

70. $\sqrt{(-9)^2 + (6)^2} = \sqrt{81 + 36} = \sqrt{117} = 3\sqrt{13}$

Chapter 5 *continued*

71. $\sqrt{(\sqrt{11})^2 + (\sqrt{5})^2} = \sqrt{11 + 5} = \sqrt{16} = 4$

72. $f(z) = z^2 + 1$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = f(1) = 1^2 + 1 = 2$ $|z_1| = \sqrt{2}$

    $z_2 = f(2) = 5 + 1 = 6$ $|z_2| = \sqrt{26}$

    $z_3 = f(5) = 25 + 1 = 26$ $|z_3| = \sqrt{626}$

    Sample answer: No, because the absolute values become infinitely large.

73. $f(z) = z^2 - 1$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = f(0) = -1$ $|z_1| = 1$

    $z_2 = f(-1) = 1 - 1 = 0$ $|z_2| = 0$

    $z_3 = f(0) = -1$ $|z_3| = 1$

    Sample answer: It does because the absolute values are equal to or less than $N = 1$.

74. $f(z) = z^2 - i$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = f(0) = -i$ $|z_1| = 1$

    $z_2 = f(-i) = 0$ $|z_2| = 0$

    $z_3 = f(0) = -i$ $|z_3| = 1$

    Sample answer: It does because the absolute values are less than $N = 2$.

75. $f(z) = z^2 - 1 - i$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = f(0) = -1 - i$ $|z_1| = \sqrt{2}$

    $z_2 = f(-1 - i) = 2i$ $|z_2| = 2$

    $z_3 = f(2i) = -4 - 1 - i$ $|z_3| = \sqrt{26}$

    Sample answer: It does not because the absolute values become infinitely large.

76. $f(z) = z^2 + 2$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = 2$ $|z_1| = 2$

    $z_2 = 6$ $|z_2| = 6$

    $z_3 = 38$ $|z_3| = 38$

    $z_4 = 1446$ $|z_4| = 1446$

    Sample answer: It does not because the absolute values become infinitely large.

77. $f(z) = z^2 - 1 + i$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = -1 + i$ $|z_1| = \sqrt{2}$

    $z_2 = -2i$ $|z_2| = 2$

    $z_3 = -5 + i$ $|z_3| = \sqrt{26}$

    $z_4 = 24 - 10i$ $|z_4| = 26$

    Sample answer: It does not because the absolute values become infinitely large.

78. $f(z) = z^2 - 0.5$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = -0.5$ $|z_1| = 0.5$

    $z_2 = -0.25$ $|z_2| = 0.25$

    $z_3 = -0.4375$ $|z_3| = 0.4375$

    $z_4 = -0.3086$ $|z_4| = 0.3086$

    Sample answer: It does because the absolute values are less than $N = 1$.

79. $f(z) = z^2 + 0.5i$

    $z_0 = 0$ $|z_0| = 0$

    $z_1 = 0.5i$ $|z_1| = 0.5$

    $z_2 = -0.25 + 0.5i$ $|z_2| = \sqrt{0.3125}$

    $z_3 = -0.1875 - 0.25i$ $|z_3| = 0.3125$

    Sample answer: It does because the absolute values are less than $N = 1$.

**80.** false; *Sample answer:* 1 is complex but not imaginary.

81. true

82. true

83. false; *Sample answer:* $(6 + 3i) + (-5 - 3i) = 1$ which is not imaginary.

84. false; *Sample answer:* Let the real number $4 = 5 + i^2$; its complex conjugate is $5 - i^2$ which is equal to 6; $4 \neq 6$.

85. true

86. a.

    $(2 + i) + (3 + 5i) = 5 + 6i$

    b.
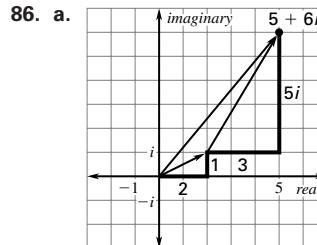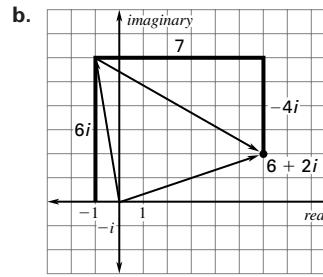
    $(-1 + 6i) + (7 - 4i) = 6 + 2i$

87. true; true   **88.** true; false   **89.** false; false

90. true; true   **91.** false; false   **92.** no

Chapter 5 *continued*

93. *Sample answer:* Algebraic: a real number can be written as $a + 0i$. Then $|z| = \sqrt{a^2 + 0^2} = \sqrt{a^2} = |a|$.
Geometric: in both definitions, the absolute value is the distance from the point to the origin.

94. a. $-1 - i; \dfrac{1 - i}{2}$ **b.** $-3 + i; \dfrac{3}{10} + \dfrac{1}{10}i$

     c. $2 - 8i; \dfrac{-2 - 8i}{68} = -\dfrac{1}{34} - \dfrac{2}{17}i$

95. a. $2 + 5i - 7i = 2 - 2i$

     b. $12 + 8i - 15i = 12 - 7i$

     c. $-2i + 8 - 6i + 4i = 8 - 4i$

96. a. $Z_1 = 3 + 4i$, $Z_2 = 6 - 2i$

     $Z = \dfrac{18 + 8 + 18i}{9 + 2i} = \dfrac{26 + 18i}{9 + 2i}$

     $Z = \dfrac{26 + 18i}{9 + 2i} \times \dfrac{9 - 2i}{9 - 2i} = \dfrac{234 + 36 + 110i}{81 + 4}$

     $Z = \dfrac{270 + 110i}{85} = \dfrac{54}{17} + \dfrac{22}{17}i$

     b. $Z_1 = 5 + 3i$, $Z_2 = 8 - 9i$

     $Z = \dfrac{40 + 27 - 21i}{13 - 6i} = \dfrac{67 - 21i}{13 - 6i}$

     $Z = \dfrac{67 - 21i}{13 - 6i} \times \dfrac{13 + 6i}{13 + 6i} = \dfrac{871 + 126 + 129i}{169 + 36}$

     $Z = \dfrac{997}{205} + \dfrac{129}{205}i$

     c. $Z_1 = 2 + 4i$, $Z_2 = 5 - 7i$

     $Z = \dfrac{10 + 28 + 6i}{7 - 3i} = \dfrac{38 + 6i}{7 - 3i}$

     $Z = \dfrac{38 + 6i}{7 - 3i} \times \dfrac{7 + 3i}{7 + 3i}$

     $Z = \dfrac{266 - 18 + 156i}{49 + 9} = \dfrac{248 + 156i}{58} = \dfrac{124}{29} + \dfrac{78}{29}i$

97. $\sqrt{25 + 16} = \sqrt{41}$ or $\sqrt{9 + 36} = \sqrt{45} = 3\sqrt{5}$ B

98. $\sqrt{36 + 64} = \sqrt{100} = 10$ or

     $\sqrt{10^2} = \sqrt{100} = 10$ C

99. $\sqrt{2^2 + (-2)^2} = \sqrt{4 + 4} = 2\sqrt{2}$ or

     $\sqrt{(\sqrt{3})^2 + (0.5)^2} = \sqrt{3 + 0.25} = \sqrt{3.25}$ A

100. a.

Power of i	i^1	i^2	i^3	i^4	i^5	i^6	i^7	i^8
Simplified form	i	-1	$-i$	1	i	-1	$-i$	1

     b. *Sample answer:* The pattern is $i, -1, -i, 1$;
     $i^9 = i$, $i^{10} = -1$, $i^{11} = -i$, $i^{12} = 1$

     c. $i^{26} = i^2 = -1$; $i^{83} = i^3 = -i$

5.4 Mixed Review (p. 280)

101. $f(3) = 4(3) - 1 = 12 - 1 = 11$

102. $f(-4) = (-4)^2 - 5(-4) + 8 = 16 + 20 + 8 = 44$

103. $f(9) = |-9 + 6| = |-3| = 3$

104. $f(-30) = 2$

105. $A = \begin{bmatrix} 3 & 1 \\ 5 & 2 \end{bmatrix}$

     $A^{-1} = \dfrac{1}{6 - 5}\begin{bmatrix} 2 & -1 \\ -5 & 3 \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ -5 & 3 \end{bmatrix}$

     $\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2 & -1 \\ -5 & 3 \end{bmatrix}\begin{bmatrix} 5 \\ 9 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$

     $(1, 2)$

106. $A = \begin{bmatrix} 1 & 1 \\ 7 & 8 \end{bmatrix}$

     $A^{-1} = \dfrac{1}{8 - 7}\begin{bmatrix} 8 & -1 \\ -7 & 1 \end{bmatrix} = \begin{bmatrix} 8 & -1 \\ -7 & 1 \end{bmatrix}$

     $\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 8 & -1 \\ -7 & 1 \end{bmatrix}\begin{bmatrix} 2 \\ 21 \end{bmatrix} = \begin{bmatrix} -5 \\ 7 \end{bmatrix}$

     $(-5, 7)$

107. $A = \begin{bmatrix} 1 & -2 \\ 3 & 4 \end{bmatrix}$

     $A^{-1} = \dfrac{1}{4 + 6}\begin{bmatrix} 4 & 2 \\ -3 & 1 \end{bmatrix} = \begin{bmatrix} \frac{2}{5} & \frac{1}{5} \\ -\frac{3}{10} & \frac{1}{10} \end{bmatrix}$

     $\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \frac{2}{5} & \frac{1}{5} \\ -\frac{3}{10} & \frac{1}{10} \end{bmatrix}\begin{bmatrix} 10 \\ 0 \end{bmatrix} = \begin{bmatrix} 4 \\ -3 \end{bmatrix}$

     $(4, -3)$

108. $(x + 4)^2 - 1 = 0$ **109.** $x^2 + 4x + 4 - 36 = 0$

     $x^2 + 8x + 15 = 0$ $x^2 + 4x - 32 = 0$

     $(x + 3)(x + 5) = 0$ $(x - 4)(x + 8) = 0$

     $-3, -5$ $4, -8$

110. $x^2 - 22x + 121 - 25 = 0$

     $x^2 - 22x + 96 = 0$

     $(x - 6)(x - 16) = 0$

     $6, 16$

111. $(x - 5)^2 = 10$ **112.** $(x + 7)^2 = 12$

     $x - 5 = \pm\sqrt{10}$ $x + 7 = \pm2\sqrt{3}$

     $x = 5 \pm \sqrt{10}$ $x = -7 \pm 2\sqrt{3}$

113. $3(x - 6)^2 = 21$

     $(x - 6)^2 = 7$

     $x - 6 = \pm\sqrt{7}$

     $x = 6 \pm \sqrt{7}$

Chapter 5 *continued*

114.

$y = 35.33x - 14.58$

Graph: *Number of DVD players sold (in thousands)* (N) vs *Time (in months)* (t); line labeled $N = 35.33t - 14.58$
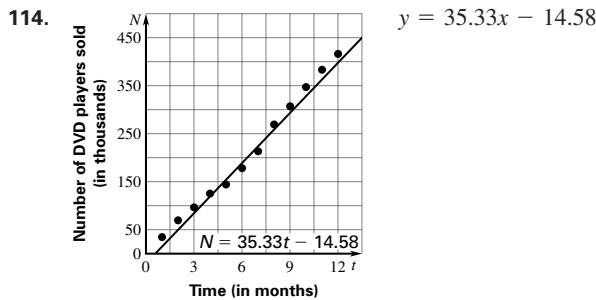
Lesson 5.5

Developing Concepts Activity 5.5 (p. 281)

1.

Expression	Number of 1-tiles needed to complete the square	Expression written as a square
$x^2 + 2x + 1$	1	$(x + 1)^2$
$x^2 + 4x + 4$	4	$(x + 2)^2$
$x^2 + 6x + 9$	9	$(x + 3)^2$
$x^2 + 8x + 16$	16	$(x + 4)^2$
$x^2 + 10x + 25$	25	$(x + 5)^2$

2. **a.** $d = \frac{1}{2}b$ **b.** $c = d^2$

   c. Find the square of half of the coefficient of the second term.

5.5 Guided Practice (p. 286)

1. *Sample answer:* Write the expression as a square of a binomial.

2. *Sample answer:* completing the square since not every quadratic equation can be solved by factoring

3. *Sample answer:* The number -9 should have been added to the left side since $-1(9) = -9$; $y = -(x + 3)^2 + 13$.

4. $1; (x + 1)^2$ **5.** $49; (x + 7)^2$

6. $9; (x - 3)^2$ **7.** $25; (x - 5)^2$

8. $\frac{25}{4}; \left(x + \frac{5}{2}\right)^2$ **9.** $\frac{169}{4}; \left(x - \frac{13}{2}\right)^2$

10. $x^2 + 4x + 1 = 0$

$x^2 + 4x + 4 = 3$

$(x + 2)^2 = 3$

$x + 2 = \pm\sqrt{3}$

$x = -2 \pm \sqrt{3}$

11. $x^2 - 2x - 4 = 0$

$(x^2 - 2x + 1) - 5 = 0$

$(x - 1)^2 = 5$

$x - 1 = \pm\sqrt{5}$

$x = 1 \pm \sqrt{5}$

12. $x^2 - 16x + 64 + 12 = 0$

$(x - 8)^2 = -12$

$x - 8 = \pm2i\sqrt{3}$

$x = 8 \pm 2i\sqrt{3}$

13. $(x^2 + 8x + 16) - 7 = 0$

$(x + 4)^2 = 7$

$x + 4 = \pm\sqrt{7}$

$x = -4 \pm \sqrt{7}$

14. $x^2 + 6x - 2 = 0$

$x^2 + 6x + 9 - 11 = 0$

$(x + 3)^2 = 11$

$x + 3 = \pm\sqrt{11}$

$x = -3 \pm \sqrt{11}$

15. $x^2 - 4x + 4 = -27$

$(x - 2)^2 = -27$

$x - 2 = \pm3i\sqrt{3}$

$x = 2 \pm 3i\sqrt{3}$

16. $y = x^2 + 12x$

$y + 36 = x^2 + 12x + 36$

$y = (x + 6)^2 - 36$;

$(-6, -36)$

17. $y - 7 = x^2 - 4x$

$y - 7 + 4 = x^2 - 4x + 4$

$y = (x - 2)^2 + 3$;

$(2, 3)$

18. $y - 31 = x^2 - 8x$

$y - 31 + 16 = x^2 - 8x + 16$

$y = (x - 4)^2 + 15$;

$(4, 15)$

19. $y - 17 = x^2 + 10x$

$y - 17 + 25 = x^2 + 10x + 25$

$y = (x + 5)^2 - 8$;

$(-5, -8)$

20. $-y - 45 = x^2 - 14x$

$-y - 45 + 49 = x^2 - 14x + 49$

$y = -(x - 7)^2 + 4$;

$(7, 4)$

21. $y + 4 = 2(x^2 + 2x)$

$y + 4 + 2 = 2(x^2 + 2x + 1)$

$y = 2(x + 1)^2 - 6$;

$(-1, -6)$

Chapter 5 *continued*

22.
$$x(60 - 2x) = 140$$
$$60x - 2x^2 = 140$$
$$x^2 - 30x = -70$$
$$x^2 - 30x + 225 = -70 + 225$$
$$(x - 15)^2 = 155$$
$$x - 15 = \pm\sqrt{155}$$
$$x = 15 \pm \sqrt{155}$$
$$x \approx 27.45 \ \text{or} \ x \approx 2.55$$
$$60 - 54.9 = 5.1$$
27.4 ft by 5.1 ft

5.5 Practice and Applications (pp. 286–289)

23. $(x + 8)^2$ **24.** $(x + 10)^2$ **25.** $(x - 12)^2$ **26.** $(x - 19)^2$

27. $(x + 0.5)^2$ **28.** $(x - 0.7)^2$ **29.** $\left(x - \frac{3}{2}\right)^2$

30. $\left(x + \frac{1}{12}\right)^2$ **31.** $\left(x - \frac{2}{9}\right)^2$ **32.** $36; (x - 6)^2$

33. $81; (x + 9)^2$ **34.** $169; (x + 13)^2$

35. $484; (x - 22)^2$

36. $\frac{81}{4}; \left(x + \frac{9}{2}\right)^2$ **37.** $\frac{121}{4}; \left(x - \frac{11}{2}\right)^2$

38. $\frac{529}{4}; \left(x - \frac{23}{2}\right)^2$ **39.** $\frac{225}{4}; \left(x + \frac{15}{2}\right)^2$

40. $0.01; (x - 0.1)^2$ **41.** $8.41; (x - 2.9)^2$

42. $0.64; (x - 0.8)^2$ **43.** $22.09; (x + 4.7)^2$

44. $\frac{1}{49}; \left(x - \frac{1}{7}\right)^2$ **45.** $\frac{25}{9}; \left(x + \frac{5}{3}\right)^2$

46. $\frac{289}{256}; \left(x + \frac{17}{16}\right)^2$

47. $x^2 + 2x + 1 = 9 + 1$
$$(x + 1)^2 = 10$$
$$x + 1 = \pm\sqrt{10}$$
$$x = -1 \pm \sqrt{10}$$

48. $x^2 - 12x + 36 = -28 + 36$
$$(x - 6)^2 = 8$$
$$x - 6 = \pm 2\sqrt{2}$$
$$x = 6 \pm 2\sqrt{2}$$

49. $x^2 + 20x + 100 = -104 + 100$
$$(x + 10)^2 = -4$$
$$x + 10 = \pm 2i$$
$$x = -10 \pm 2i$$

50. $x^2 + 3x + \frac{9}{4} = 1 + \frac{9}{4}$
$$\left(x + \frac{3}{2}\right)^2 = \frac{13}{4}$$
$$x + \frac{3}{2} = \frac{\pm\sqrt{13}}{2}$$
$$x = \frac{-3 \pm \sqrt{13}}{2}$$

51. $u^2 - 6u + 9 = 35 + 9$
$$(u - 3)^2 = 44$$
$$u - 3 = \pm 2\sqrt{11}$$
$$u = 3 \pm 2\sqrt{11}$$

52. $v^2 - 30v + 225 = -243 + 225$
$$(v - 15)^2 = -18$$
$$v - 15 = \pm 3i\sqrt{2}$$
$$v = 15 \pm 3i\sqrt{2}$$

53. $m^2 + 1.8m + 0.81 = 1.5 + 0.81$
$$(m + 0.9)^2 = 2.31$$
$$(m + 0.9) = \pm\sqrt{2.31}$$
$$m = -0.9 \pm \sqrt{2.31}$$

54. $n^2 - \frac{4}{3}n + \frac{4}{9} = \frac{14}{9} + \frac{4}{9}$
$$\left(n - \frac{2}{3}\right)^2 = 2$$
$$\left(n - \frac{2}{3}\right) = \pm\sqrt{2}$$
$$n = \frac{2}{3} \pm \sqrt{2}$$

55. $x^2 - 6x = -7$
$$x^2 - 6x + 9 = -7 + 9$$
$$(x - 3)^2 = 2$$
$$x - 3 = \pm\sqrt{2}$$
$$x = 3 \pm \sqrt{2}$$

56.
$$x^2 - 8x = -9$$
$$x^2 - 8x + 16 = -9 + 16$$
$$(x - 4)^2 = 7$$
$$x - 4 = \pm\sqrt{7}$$
$$x = 4 \pm \sqrt{7}$$

57.
$$x^2 + 14x = -50$$
$$x^2 + 14x + 49 = -50 + 49$$
$$(x + 7)^2 = -1$$
$$x + 7 = \pm i$$
$$x = -7 \pm i$$

58.
$$x^2 + 10x = -70$$
$$x^2 + 10x + 25 = -70 + 25$$
$$(x + 5)^2 = -45$$
$$x + 5 = \pm 3i\sqrt{5}$$
$$x = -5 \pm 3i\sqrt{5}$$

59.
$$r^2 - 5r = -\frac{13}{4}$$
$$r^2 - 5r + \frac{25}{4} = -\frac{13}{4} + \frac{25}{4}$$
$$\left(r - \frac{5}{2}\right)^2 = 3$$
$$r - \frac{5}{2} = \pm\sqrt{3}$$
$$r = \frac{5 \pm 2\sqrt{3}}{2}$$

Chapter 5 *continued*

60. $-2s^2 - 26s = -1$

$$s^2 + 13s + \frac{169}{4} = \frac{1}{2} + \frac{169}{4}$$

$$\left(s + \frac{13}{2}\right)^2 = \frac{171}{4}$$

$$s + \frac{13}{2} = \pm\frac{3\sqrt{19}}{2}$$

$$s = \frac{-13 \pm 3\sqrt{19}}{2}$$

61. $t^2 + t + \frac{1}{4} = -\frac{1}{2} + \frac{1}{4}$

$$\left(t + \frac{1}{2}\right)^2 = -\frac{1}{4}$$

$$t + \frac{1}{2} = \pm\frac{i}{2}$$

$$r = \frac{-1 \pm i}{2}$$

62. $w^2 - 12w = -52$

$$w^2 - 12w + 36 = -52 + 36$$

$$(w - 6)^2 = -16$$

$$(w - 6) = \pm 4i$$

$$w = 6 \pm 4i$$

63. $(x + 6)(x - 2) = 0; \quad -6, 2$

64. $x^2 - 6x + 9 = 15 + 9$

$$(x - 3)^2 = 24$$

$$x - 3 = \pm 2\sqrt{6}$$

$$x = 3 \pm 2\sqrt{6}$$

65. $9x^2 = 23$

$$x^2 = \frac{23}{9}$$

$$x = \pm\frac{\sqrt{23}}{3}$$

66. $(2x + 7)(x + 1) = 0; \quad -\frac{7}{2}, -1$

67. $3x^2 - x = -6$

$$x^2 - \frac{1}{3}x + \frac{1}{36} = -\frac{72}{36} + \frac{1}{36}$$

$$\left(x - \frac{1}{6}\right)^2 = -\frac{71}{36}$$

$$x - \frac{1}{6} = \pm\frac{i\sqrt{71}}{6}$$

$$x = \frac{1 \pm i\sqrt{71}}{6}$$

68. $(x + 8)^2 = 36$

$$x + 8 = \pm 6$$

$$x = -8 \pm 6;$$

$$-14, -2$$

69. $5k^2 + 10k = 155$

$$k^2 + 2k + 1 = 31 + 1$$

$$(k + 1)^2 = 32$$

$$k + 1 = \pm 4\sqrt{2}$$

$$k = -1 \pm 4\sqrt{2}$$

70. $25b^2 - 30b + 9 = 0$

$$(5b - 3)(5b - 3) = 0;$$

$$b = \frac{3}{5}$$

71. $p^2 - 22p = -290$

$$p^2 - 22p + 121 = -290 + 121$$

$$(p - 11)^2 = -169$$

$$p - 11 = \pm 13i$$

$$p = 11 \pm 13i$$

72. $5q^2 - 9q^2 = 360$

$$-4q^2 = 360$$

$$q^2 = -90$$

$$q = \pm 3i\sqrt{10}$$

73. $y - 11 = x^2 - 6x$

$$y - 11 + 9 = x^2 - 6x + 9$$

$$y = (x - 3)^2 + 2;$$

$$(3, 2)$$

74. $y + 9 = x^2 - 2x$

$$y + 9 + 1 = x^2 - 2x + 1$$

$$y = (x - 1)^2 - 10;$$

$$(1, -10)$$

75. $y - 14 = x^2 + 16x$

$$y - 14 + 64 = x^2 + 16x + 64$$

$$y = (x + 8)^2 - 50;$$

$$(-8, -50)$$

76. $y - 68 = x^2 + 26x$

$$y - 68 + 169 = x^2 + 26x + 169$$

$$y = (x + 13)^2 - 101;$$

$$(-13, -101)$$

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

$$y + 2 + \frac{9}{4} = x^2 - 3x + \frac{9}{4}$$

$$y = \left(x - \frac{3}{2}\right)^2 - \frac{17}{4};$$

$$\left(\frac{3}{2}, -\frac{17}{4}\right)$$

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

$$y + 1 + \frac{49}{4} = x^2 + 7x + \frac{49}{4}$$

$$y = \left(x + \frac{7}{2}\right)^2 - \frac{53}{4};$$

$$\left(-\frac{7}{2}, -\frac{53}{4}\right)$$

Chapter 5 *continued*

79.
$$y + 80 = -(x^2 - 20x)$$
$$y + 80 - 100 = -(x^2 - 20x + 100)$$
$$y = -(x - 10)^2 + 20;$$
$$(10, 20)$$

80.
$$y + 47 = -(x^2 + 14x)$$
$$y + 47 - 49 = -(x^2 + 14x + 49)$$
$$y = -(x + 7)^2 + 2;$$
$$(-7, 2)$$

81.
$$y - 1 = 3(x^2 - 4x)$$
$$y - 1 + 12 = 3(x^2 - 4x + 4)$$
$$y = 3(x - 2)^2 - 11;$$
$$(2, -11)$$

82.
$$y + 7 = -2(x^2 + x)$$
$$y + 7 - \tfrac{1}{2} = -2(x^2 + x + \tfrac{1}{4})$$
$$y = -2(x + \tfrac{1}{2})^2 - \tfrac{13}{2}$$
$$(-\tfrac{1}{2}, -\tfrac{13}{2})$$

83.
$$y - 3 = 1.4(x^2 + 4x)$$
$$y - 3 + 5.6 = 1.4(x^2 + 4x + 4)$$
$$y = 1.4(x + 2)^2 - 2.6;$$
$$(-2, -2.6)$$

84. $y = \tfrac{2}{3}(x^2 - \tfrac{6}{5}x)$
$$y = \tfrac{2}{3}(x^2 - \tfrac{6}{5}x + \tfrac{9}{25}) - \tfrac{6}{25}$$
$$y = \tfrac{2}{3}(x - \tfrac{3}{5})^2 - \tfrac{6}{25};$$
$$(\tfrac{3}{5}, -\tfrac{6}{25})$$

85.
$$100 = x(x + 10)$$
$$100 + 25 = x^2 + 10x + 25$$
$$125 = (x + 5)^2$$
$$\pm 5\sqrt{5} = x + 5$$
$$x = -5 + 5\sqrt{5}$$
$$x \approx 6.18$$

86.
$$40 = \tfrac{1}{2}(x + 8)x$$
$$80 = x^2 + 8x$$
$$80 + 16 = x^2 + 8x + 16$$
$$96 = (x + 4)^2$$
$$\pm 4\sqrt{6} = x + 4$$
$$4\sqrt{6} - 4 = x$$
$$x \approx 5.8$$

87. $\tfrac{1}{2}(4x)(x + 4) = 70$
$$2x^2 + 8x = 70$$
$$x^2 + 4x + 4 = 35 + 4$$
$$(x + 2)^2 = 39$$
$$x + 2 = \pm\sqrt{39}$$
$$x = -2 + \sqrt{39}$$
$$x \approx 4.24$$

88.
$$x(x - 5) = 54$$
$$x^2 - 5x + \frac{25}{4} = 54 + \frac{25}{4}$$
$$\left(x - \frac{5}{2}\right)^2 = \frac{241}{4}$$
$$x - \frac{5}{2} = \pm\frac{\sqrt{241}}{2}$$
$$x = \frac{5 + \sqrt{241}}{2}$$
$$x \approx 10.26$$

89.
$$d = 0.08(30)^2 + 1.1(30) = 105 \text{ ft}$$
$$80 = 0.08s^2 + 1.1s$$
$$s^2 + 13.75s = 1000$$
$$s^2 + 13.75s + 47.3 = 1047.3$$
$$(s + 6.875)^2 = 1047.3$$
$$s + 6.875 = \pm\sqrt{1047.3}$$
$$s = -6.875\sqrt{1047.3}$$
$$s \approx 25.5$$
about 25.5 mi/h

90.
$$0.0241(x^2 - 41.5x - 228.2) = 0$$
$$0.0241[(x^2 - 41.5x + 430.6) - 658.8] = 0$$
$$0.0241(x - 20.75)^2 = 15.9$$
$$(x - 20.75)^2 = 659.75$$
$$x - 20.75 = \pm\sqrt{659.75}$$
$$x = 20.75 + \sqrt{659.75}$$
$$x \approx 46.4$$

Her throw was about 46.4 ft.

91.
$$y = -0.003x^2 + 0.62x + 3$$
$$25 - 3 = -0.003(x^2 - 206.7x)$$
$$10,681 - 7333 = (x^2 - 206.7x + 10,681)$$
$$3348 = (x - 103.35)^2$$
$$\pm\sqrt{3348} = x - 103.35$$
$$\pm 6\sqrt{93} + 103.35 = x$$
$$x \approx 45.5 \text{ ft or } x \approx 161.2 \text{ ft}$$

Chapter 5 *continued*

92. a. $4l + 3w = 240$

$$3w = 240 - 4l$$

$$w = 80 - \frac{4l}{3}$$

b. $$1000 = 80l - \frac{4l^2}{3}$$

$$1000 = -\frac{4}{3}(l^2 - 60l)$$

$$1000 - 1200 = -\frac{4}{3}(l^2 - 60l + 900)$$

$$-200 = -\frac{4}{3}(l - 30)^2$$

$$\pm\sqrt{150} = l - 30$$

$$30 \pm \sqrt{150} = l$$

42.25 ft by 23.67 ft or 17.75 ft by 56.33 ft

$$l \approx 42.25 \text{ ft or } l \approx 17.75 \text{ ft}$$

93. $$200 = [\pi(x + 3)^2]9 - [\pi(3)^2](9 - x)$$

$$200 = 9\pi(x^2 + 6x + 9) - 9\pi(9 - x)$$

$$200 = 9\pi(x^2 + 6x + 9 - 9 + x)$$

$$200 = 9\pi(x^2 + 7x)$$

$$\frac{200}{9\pi} + \frac{49}{4} = \left(x^2 + 7x + \frac{49}{4}\right)$$

$$\frac{800 + 441\pi}{36\pi} = \left(x + \frac{7}{2}\right)^2$$

$$\pm 4.4 = x + \frac{7}{2}$$

$$x = -3.5 + 4.4 \approx 0.9 \text{ about 1 cm}$$

94. $y = -0.0267(x^2 - 30x)$

$y - 6 = -0.0267(x^2 - 30x + 225)$

$y - 6 = -0.0267(x - 15)^2$

$y = -0.0267(x - 15)^2 + 6$

vertex $(15, 6)$

The kangaroo can jump about 30 ft and 6 ft high.

95. $$q = -0.00002T^2 + 0.0203T - 1.24$$

$$-5.15 + q + 1.24 = -0.00002(T^2 - 1015T + 257{,}556.25)$$

$$q - 3.9 = -0.00002(T - 507.5)^2$$

$$q = -0.00002(T - 507.5)^2 + 3.9$$

$(507.5, 3.9)$

$507.5 \degree$F; 3.9 Btu/ft^3

96. C

97. $x^2 + 12x + 36 = -61 + 36$

$x^2 + 12x + 36 = -25$

$(x + 6)^2 = -25$

$x + 6 = \pm 5i$

$x = -6 \pm 5i$

B

98. $$y - 3 = 2(x^2 - 4x)$$

$$y - 3 + 8 = 2(x^2 - 4x + 4)$$

$$y = 2(x - 2)^2 - 5;$$

A

99. a.

$y = (x + 1)^2$
$y = x^2 + 2x$

b.

$y = (x + 2)^2$
$y = x^2 + 4x$

c.

$y = (x - 3)^2$
$y = x^2 - 6x$
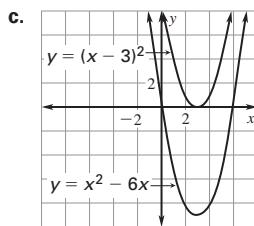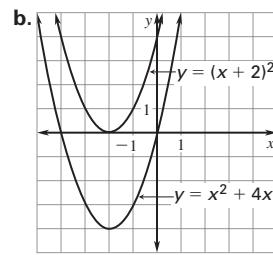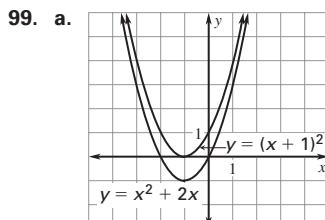
100. *Sample answer:* The vertex moves up from the position of the other vertex so that the new vertex lies on the *x*–axis.

5.5 Mixed Review (p. 289)

101. $5^2 - 4(1)(2) = 25 - 8 = 17$

102. $(-8)^2 - 4(3)(7) = 64 - 84 = -20$

103. $0^2 - 4(-5)(2.6) = (20)(2.6) = 52$

104. $4^2 - 4(11)(-1) = 16 + 44 = 60$

105. $(-24)^2 - 4(16)(9) = 576 - 576 = 0$

106. $2^2 - 4(-1.4)(-0.5) = 4 - 2.8 = 1.2$

107. $y - 1 = 2(x - 3)$

$y = 2x - 5$

108. $y + 4 = x - 2$

$y = x - 6$

109. $y - 10 = -5(x + 7)$

$y = -5x - 25$

110. $y + 8 = -3(x + 8)$

$y = -3x - 32$

111. $y - 9 = \frac{1}{3}(x - 6)$

$y = \frac{1}{3}x + 7$

112. $y + 2 = -\frac{5}{4}(x - 11)$

$y = -\frac{5}{4}x + \frac{47}{4}$

113.

114.

115.

116.

Chapter 5 *continued*

117.

118.
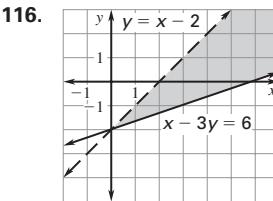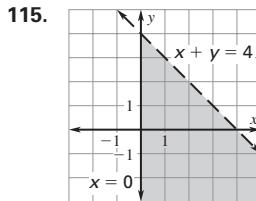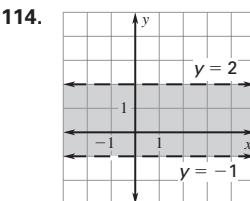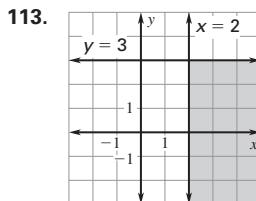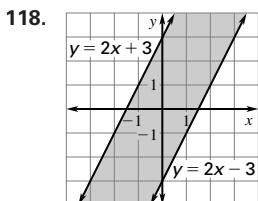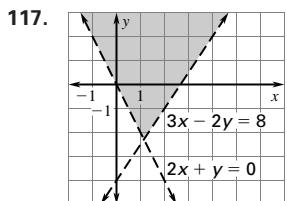
Technology Activity 5.5 (p. 290)

1. min; -4.25; 2.5

2. max; 5; 4

3. min; 4; -3

4. min; -5; -4

5. max; 8.125; -0.75

6. max; -2.125; -3.75

7. min; 2.375; 3.75

8. min; -4; -1

9. max; 8.65; 2.3

10. max at 80 cars per mile and 1997 cars per hour

Lesson 5.6

5.6 Guided Practice (p. 295)

1. the discriminant   **2.** 2 real; 1 real; 2 imaginary

3. *Sample answer:* when an object is thrown upward

4. $x = \dfrac{-(-4) \pm \sqrt{(-4)^2 - 4(1)(3)}}{2} = \dfrac{4 \pm \sqrt{16 - 12}}{2}$

$= \dfrac{4 \pm \sqrt{4}}{2} = \dfrac{4 \pm 2}{2} \qquad x = 3 \text{ or } 1$

5. $x = \dfrac{-1 \pm \sqrt{1 + 4}}{2} = \dfrac{-1 \pm \sqrt{5}}{2}$

6. $x = \dfrac{-3 \pm \sqrt{9 - 40}}{4} = \dfrac{-3 \pm \sqrt{31}}{4}$

7. $x = \dfrac{-6 \pm \sqrt{36 + 36}}{18} = \dfrac{-1 \pm \sqrt{2}}{3}$

8. $x = \dfrac{-8 \pm \sqrt{64 - 4}}{-2} = 4 \pm \sqrt{15}$

9. $x = \dfrac{4 \pm \sqrt{16 - 4(4)37}}{8} = \dfrac{4 \pm \sqrt{-576}}{8}$

$= \dfrac{4 \pm 24i}{8} = \dfrac{1}{2} \pm 3i$

10. $25 - 4(1)(2) = 25 - 8 = 17$

2 real

11. $2^2 - 4(1)(5) = 4 - 20 = -16$

2 imaginary

12. $(-4)^2 - 4(4)(1) = 16 - 16 = 0$

one real

13. $(3)^2 - 4(-2)(-7) = 9 - 56 = -47$

2 imaginary

14. $144 - 4(9)(4) = 144 - 144 = 0$

1 real

15. $(-1)^2 - 4(5)(-13) = 1 + 260 = 261$

2 real

16. $h = -16t^2 + v_0 t + h_0$

$0 = -16t^2 + 21t - 6$

$t = \dfrac{-21 \pm \sqrt{(21)^2 - 4(-16)(-6)}}{-32}$

$t = \dfrac{-21 \pm \sqrt{441 - 384}}{-32}$

$t = \dfrac{-21 + \sqrt{57}}{-32}$

$t \approx 0.42$

0.42 sec

5.6 Practice and Applications (pp. 295–297)

17. $x = \dfrac{-(-5) \pm \sqrt{(-5)^2 - 4(1)(-14)}}{2(1)}$

$x = \dfrac{5 \pm \sqrt{25 + 56}}{2}$

$x = \dfrac{5 \pm 9}{2}$

$7, -2$

18. $x = \dfrac{-3 \pm \sqrt{3^2 - 4(1)(-2)}}{2}$

$x = \dfrac{-3 \pm \sqrt{9 + 8}}{2}$

$x = \dfrac{-3 \pm \sqrt{17}}{2}$

19. $x = \dfrac{2 \pm \sqrt{4 - 4(1)(-4)}}{2}$

$x = \dfrac{2 \pm \sqrt{4 + 16}}{2}$

$x = 1 \pm \sqrt{5}$

20. $x = \dfrac{-10 \pm \sqrt{100 - 88}}{2}$

$x = \dfrac{-10 \pm \sqrt{12}}{2}$

$x = -5 \pm \sqrt{3}$

21. $x = \dfrac{-6 \pm \sqrt{36 - 232}}{2}$

$x = \dfrac{-6 \pm 14i}{2}$

$x = -3 \pm 7i$

22. $x = \dfrac{-7 \pm \sqrt{49 - 76}}{-2}$

$x = \dfrac{-7 \pm 3i\sqrt{3}}{-2}$

$x = \dfrac{7 \pm 3i\sqrt{3}}{2}$

23. $x = \dfrac{-3 \pm \sqrt{9 + 20}}{10}$

$x = \dfrac{-3 \pm \sqrt{29}}{10}$

24. $x = \dfrac{11 \pm \sqrt{121 + 48}}{6}$

$x = \dfrac{11 \pm 13}{6}$

$4, -\dfrac{1}{3}$

25. $x = \dfrac{-1 \pm \sqrt{1-8}}{4}$

$x = \dfrac{-1 \pm i\sqrt{7}}{4}$

26. $p = \dfrac{8 \pm \sqrt{64-72}}{12}$

$p = \dfrac{8 \pm 2i\sqrt{2}}{12}$

$p = \dfrac{2}{3} \pm \dfrac{i\sqrt{2}}{6}$

27. $q = \dfrac{-2 \pm \sqrt{4+252}}{-14}$

$q = \dfrac{-2 \pm 16}{-14}$

$-1, \dfrac{9}{7}$

28. $r = \dfrac{-4 \pm \sqrt{16-160}}{16}$

$r = \dfrac{-4 \pm 12i}{16}$

$r = -\dfrac{1}{4} \pm \dfrac{3}{4}i$

29. $t = \dfrac{9 \pm \sqrt{81-48}}{-8}$

$t = \dfrac{-9 \pm \sqrt{33}}{8}$

30. $u = \dfrac{12 \pm \sqrt{144-3060}}{18}$

$u = \dfrac{12 \pm 54i}{18}$

$u = \dfrac{2}{3} \pm 3i$

31. $v = \dfrac{-8 \pm \sqrt{64+40}}{20}$

$v = \dfrac{-8 \pm 2\sqrt{26}}{20}$

$v = -\dfrac{2}{5} \pm \dfrac{\sqrt{26}}{10}$

32. $x^2 + 4x + 20 = 0$

$x = \dfrac{-4 \pm \sqrt{16-80}}{2}$

$x = \dfrac{-4 \pm 8i}{2}$

$x = -2 \pm 4i$

33. $x^2 - 2x - 99 = 0$

$x = \dfrac{2 \pm \sqrt{4+396}}{2}$

$x = \dfrac{2 \pm 20}{2}$

$x = 11 \text{ or } -9$

34. $x^2 - 10x + 14 = 0$

$x = \dfrac{10 \pm \sqrt{100-56}}{2}$

$x = \dfrac{10 \pm 2\sqrt{11}}{2}$

$x = 5 \pm \sqrt{11}$

35. $x^2 - 8x + 35 = 0$

$x = \dfrac{8 \pm \sqrt{64-140}}{2}$

$x = \dfrac{8 \pm 2i\sqrt{19}}{2}$

$x = 4 \pm i\sqrt{19}$

36. $x^2 + 3x - 7 = 0$

$x = \dfrac{-3 \pm \sqrt{9+28}}{2}$

$x = \dfrac{-3 \pm \sqrt{37}}{2}$

37. $x^2 + 16x + 46 = 0$

$x = \dfrac{-16 \pm \sqrt{256-184}}{2}$

$x = \dfrac{-16 \pm 6\sqrt{2}}{2}$

$x = -8 \pm 3\sqrt{2}$

38. $3x^2 + 6x + 2 = 0$

$x = \dfrac{-6 \pm \sqrt{36-24}}{6}$

$x = \dfrac{-6 \pm 2\sqrt{3}}{6}$

$x = -1 \pm \dfrac{\sqrt{3}}{3}$

39. $8x^2 - 8x - 1 = 0$

$x = \dfrac{8 \pm \sqrt{64+32}}{16}$

$x = \dfrac{8 \pm 4\sqrt{6}}{16}$

$x = \dfrac{1}{2} \pm \dfrac{\sqrt{6}}{4}$

40. $6x^2 + 4x - 1 = 0$

$x = \dfrac{-4 \pm \sqrt{16+24}}{12}$

$x = \dfrac{-4 \pm 2\sqrt{10}}{12}$

$x = -\dfrac{1}{3} \pm \dfrac{\sqrt{10}}{6}$

41. $4x^2 - 40x + 101 = 0$

$x = \dfrac{40 \pm \sqrt{1600-1616}}{8}$

$x = \dfrac{40 \pm 4i}{8}$

$x = 5 \pm \dfrac{i}{2}$

42. $36k^2 + 24k + 5 = 0$

$k = \dfrac{-24 \pm \sqrt{576-720}}{72}$

$k = \dfrac{-24 \pm 12i}{72}$

$k = -\dfrac{1}{3} \pm \dfrac{i}{6}$

Chapter 5 *continued*

43. $9n^2 + 12n - 5 = 0$

$$n = \frac{-12 \pm \sqrt{144 + 180}}{18}$$

$$n = \frac{-12 \pm 18}{18}$$

$$n = \frac{1}{3} \text{ or } -\frac{5}{3}$$

44. $3d^2 - 10d + 1 = 0$

$$d = \frac{10 \pm \sqrt{100 - 12}}{6}$$

$$d = \frac{10 \pm 2\sqrt{22}}{6}$$

$$d = \frac{5 \pm \sqrt{22}}{3}$$

45. $3.9y^2 + 9.5y - 8.2 = 0$

$$y = \frac{-9.5 \pm \sqrt{90.25 + 127.92}}{7.8}$$

$$y = \frac{-9.5 \pm \sqrt{218.17}}{7.8}$$

46. $6(x^2 - 2) = 0$

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

47. $$x = \frac{3 \pm \sqrt{9 + 60}}{2}$$

$$x = \frac{3 \pm \sqrt{69}}{2}$$

48. $x^2 + 4x + 4 = -29 + 4$

$$(x + 2)^2 = -25$$

$$x + 2 = \pm 5i$$

$$x = -2 \pm 5i$$

49. $(x - 16)(x - 2) = 0$

$$x = 2, 16$$

50. $4\left(x^2 + 7x + \frac{49}{4}\right) = -49 + 49$

$$4\left(x + \frac{7}{2}\right)^2 = 0$$

$$x = -\frac{7}{2}$$

51. $(x + 4)^2 = -9$

$$x + 4 = \pm 3i$$

$$x = -4 \pm 3i$$

52. $-5u^2 + 10u + 5 = 0$

$$u^2 - 2u - 1 = 0$$

$$u^2 - 2u + 1 = 1 + 1$$

$$(u - 1)^2 = 2$$

$$u - 1 = \pm\sqrt{2}$$

$$u = 1 \pm \sqrt{2}$$

53. $4m^2 = 3$

$$m^2 = \frac{3}{4}$$

$$m = \pm\frac{\sqrt{3}}{2}$$

54. $-9v^2 + 36v - 31 = 0$

$$v = \frac{-36 \pm \sqrt{1296 - 1116}}{-18}$$

$$v = \frac{-36 \pm \sqrt{180}}{-18}$$

$$v = 2 \pm \frac{\sqrt{5}}{3}$$

55. $14p^2 + 19p - 3 = 0$

$$p = \frac{-19 \pm \sqrt{361 + 168}}{28}$$

$$p = \frac{-19 \pm 23}{28}$$

$$p = \frac{1}{7} \text{ or } p = -\frac{3}{2}$$

56. $16 - 40 = -24$; 2 imaginary

57. $9 + 24 = 33$; 2 real

58. $196 - 196 = 0$; 1 real

59. $100 + 60 = 160$; 2 real

60. $256 - 256 = 0$; 1 real

61. $25 - 32 = -7$; 2 imaginary

62. $0 + 84 = 84$; 2 real

63. $1 - 20 = -19$; 2 imaginary

64. $400 - 400 = 0$ 1; real

65. zero   **66.** negative   **67.** positive

68. $x^2 - 2x + c = 0$
   a. $c < 1$
   b. $c = 1$
   c. $c > 1$

69. $x^2 + 4x + c$
   a. $c < 4$
   b. $c = 4$
   c. $c > 4$

70. $x^2 + 10x + c = 0$
   a. $c < 25$
   b. $c = 25$
   c. $c > 25$

71. $x^2 - 8x + c = 0$
   a. $c < 16$
   b. $c = 16$
   c. $c > 16$

72. $x^2 + 6x + c = 0$
   a. $c < 9$
   b. $c = 9$
   c. $c > 9$

73. $x^2 - 12x + c = 0$
   a. $c < 36$
   b. $c = 36$
   c. $c > 36$

74. *Sample answer:* The initial velocity substituted into the formula can be zero.

75. $0 = -16t^2 + 5t + 92$

$$t = \frac{-5 \pm \sqrt{25 + 5888}}{-32}$$

$$t = \frac{-5 - \sqrt{5913}}{-32}$$

$$t \approx 2.56 \text{ sec}$$

Chapter 5 *continued*

76. $\frac{1}{3}(77) = 7x + (11 - x)x$

$$0 = -x^2 + 18x - \frac{77}{3}$$

$$x = \frac{-18 \pm \sqrt{324 - \frac{308}{3}}}{-2}$$

$$x = 9 \pm \frac{\sqrt{\frac{664}{3}}}{-2}$$

$$x \approx 1.56 \text{ in.}$$

77. $0 = -16t^2 - 55t + 10$

$$x = \frac{55 \pm \sqrt{3025 + 640}}{-32}$$

$$x = \frac{55 \pm \sqrt{3665}}{-32}$$

$$x \approx 0.17 \text{ sec}$$

78. $\quad l = 0.1s^2 - 3s + 22$

$$2000 = 0.1s^2 - 3s + 22$$

$$0 = 0.1s^2 - 3s - 1978$$

$$s = \frac{3 \pm \sqrt{9 + 791.2}}{0.2}$$

$$s = \frac{3 \pm \sqrt{800.2}}{0.2}$$

$$s \approx 156.4 \text{ ft/sec}$$

79. $\$60 = 0.560t^2 + 0.488t + 51$

$$0 = 0.56t^2 + 0.488t - 9$$

$$t = \frac{-0.488 \pm \sqrt{0.24 + 20.16}}{1.12}$$

$$t = \frac{-0.488 \pm \sqrt{20.4}}{1.12}$$

$$t \approx 3.6$$

in the year 1993

80. a. $v_0 = 350 \text{ ft/sec}$

$\quad h_m \approx 1914 \text{ ft}$

b. $\quad 0 = -16t^2 + 350t$

$\quad 0 = t(-16t + 350)$

$\quad 16t = 350$

$\quad t = 21.875 \text{ sec}$

81. $36 + 4 = 40 \qquad 25 + 16 = 41 \qquad$ B

82. $4k^2 - 4 = 4(k^2 - 1) \qquad 9 + 4k^2 \qquad$ B

83. $3.6 \qquad 2.7 \qquad$ A

84. a. maximum height occurs when $t = \frac{v_0}{32}$;

$$0 = -16\frac{v_0{}^2}{1024} + \frac{v_0{}^2}{32} - 160$$

$$0 = \frac{v_0{}^2}{64} - 160$$

$$(160)(64) = v_0{}^2$$

$$32\sqrt{10} \text{ ft/sec} = v_0$$

b. $t = \sqrt{10} \text{ ft/sec} \approx 3.16 \text{ sec}$

Sample answer: If $t = 2$ sec then v_0 would need to be equal to $v_0 = 32(2)^2 = 112 \text{ ft/sec.}$

5.6 Mixed Review (p. 298)

85. $3x + 6 > 12$

$\quad 3x > 6$

$\quad x > 2$

86. $16 - 7x \geq -5$

$\quad -7x \geq -21$

$\quad x \leq 3$

87. $-2x - 18 \leq 8$

$\quad -2x \leq 26$

$\quad x \geq -13$

88. $4x + 3 < -1$

$\quad 4x < -4$

$\quad x < -1$

89. $\quad 4 \leq 5x - 11 \leq 29$

$\quad 15 \leq 5x \leq 40$

$\quad 3 \leq x \leq 8$

90. $\frac{3}{2}x + 20 \leq 14 \qquad$ or $\qquad 1 > 8 - x$

$\quad \frac{3}{2}x \leq -6 \qquad$ or $\qquad -7 > -x$

$\quad x \leq -4 \qquad$ or $\qquad 7 < x$

91.

92.

93.

94.

95.

96.

Chapter 5 *continued*

97.

98.

99.

100.

101.

102.
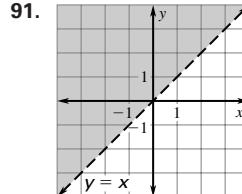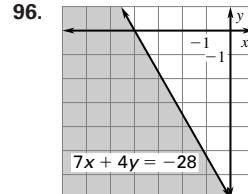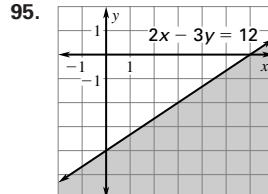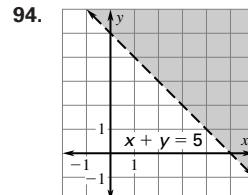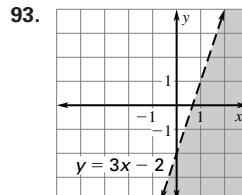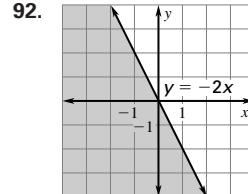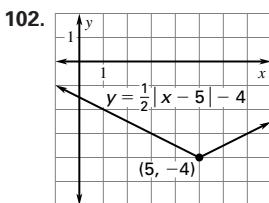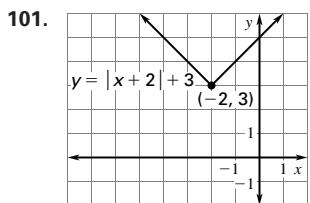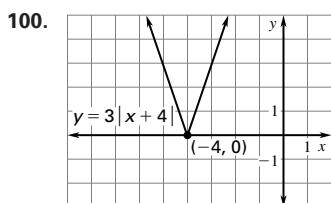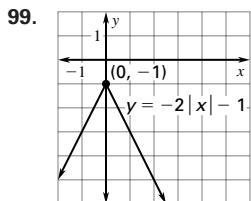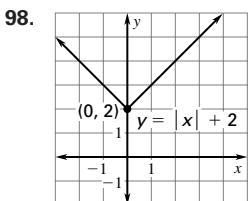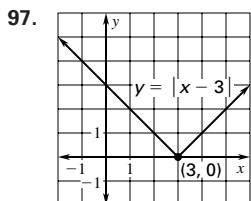
Quiz 2 (p. 298)

1. $5 + 16i$ **2.** $-4 + 10i$

3. $24 + 7 - 6i + 8i = 31 + 22i$

4. $\dfrac{1 - 3i}{5 + i} \times \dfrac{5 - i}{5 - i} = \dfrac{5 - 3 - 15i - i}{25 + 1}$

$$= \dfrac{1 - 8i}{13}$$

5.–10.
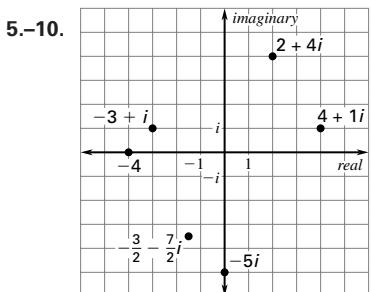
5. $\sqrt{2^2 + 4^2} = \sqrt{4 + 16} = 2\sqrt{5}$ **6.** $\sqrt{(-5)^2} = 5$

7. $\sqrt{(-3)^2 + 1^2} = \sqrt{9 + 1} = \sqrt{10}$

8. $\sqrt{4^2 + 3^2} = \sqrt{16 + 9} = 5$ **9.** $\sqrt{(-4)^2} = 4$

10. $\sqrt{\left(\dfrac{-3}{2}\right)^2 + \left(\dfrac{-7}{2}\right)^2} = \sqrt{\dfrac{9}{4} + \dfrac{49}{4}} = \dfrac{\sqrt{58}}{2}$

11. $x^2 + 8x + 16 = -14 + 16$

$$(x + 4)^2 = 2$$
$$x + 4 = \pm\sqrt{2}$$
$$x = -4 \pm \sqrt{2}$$

12. $x^2 - 2x + 1 = -17 + 1$

$$(x - 1)^2 = -16$$
$$(x - 1) = \pm 4i$$
$$x = 1 \pm 4i$$

13. $p^2 - 10p + 25 = 27$

$$(p - 5)^2 = 27$$
$$p - 5 = \pm 3\sqrt{3}$$
$$p = 5 \pm 3\sqrt{3}$$

14. $5q^2 + 20q = -19$

$$5(q^2 + 4q + 4) = -19 + 20$$
$$5(q + 2)^2 = 1$$
$$(q + 2)^2 = \dfrac{1}{5}$$
$$q + 2 = \pm\dfrac{\sqrt{5}}{5}$$
$$q = -2 \pm \dfrac{\sqrt{5}}{5}$$

15. $y - 1 = x^2 + 6x$

$$y - 1 + 9 = x^2 + 6x + 9$$
$$y = (x + 3)^2 - 8$$

16. $y - 50 = x^2 - 18x$

$$y - 50 + 81 = x^2 - 18x + 81$$
$$y = (x - 9)^2 - 31$$

17. $y + 7 = -2(x^2 - 4x)$

$$y + 7 - 8 = -2(x^2 - 4x + 4)$$
$$y = -2(x - 2)^2 + 1$$

18. $x = \dfrac{-2 \pm \sqrt{4 + 40}}{2}$

$$x = \dfrac{-2 \pm 2\sqrt{11}}{2}$$
$$x = -1 \pm \sqrt{11}$$

19. $x = \dfrac{16 \pm \sqrt{256 - 292}}{2}$

$$x = \dfrac{16 \pm 6i}{2}$$
$$x = 8 \pm 3i$$

20. $-w^2 + 3w - 4 = 0$

$$w = \frac{-3 \pm \sqrt{9 - 16}}{-2}$$

$$w = \frac{-3 \pm i\sqrt{7}}{-2}$$

$$w = \frac{3 \pm i\sqrt{7}}{2}$$

21. $25y^2 + 40y - 8 = 0$

$$y = \frac{-40 \pm \sqrt{1600 + 800}}{50}$$

$$y = \frac{-40 \pm 20\sqrt{6}}{50}$$

$$y = \frac{-4 \pm 2\sqrt{6}}{5}$$

22. $4 = -16t^2 + 15t + 3$

$0 = -16t^2 + 15t - 1$

$$t = \frac{-15 \pm \sqrt{225 - 64}}{-32}$$

$$t = \frac{-15 \pm \sqrt{161}}{-32}$$

$t \approx 0.86$

about 1 sec

Lesson 5.7

5.7 Guided Practice (p. 303)

1. *Sample answer:* one variable: $-x^2 - 5x + 7 > 0$
two variables: $-y \geq x^2 - 5x + 7$

2. *Sample answer:* $y \geq x^2$ includes points on the graph of $y = x^2$ while $y > x^2$ does not.

3. *Sample answer:* graphical: Graph $y = x^2 - 3x - 4$ using a dotted line; find the x-intercepts and determine where the graph lies above the x-axis; algebraic: factor $x^2 - 3x - 4$ and graph the critical x-values on a number line; determine where the solutions lie on the number line.

4.

5.

6.

7.

8.

9.
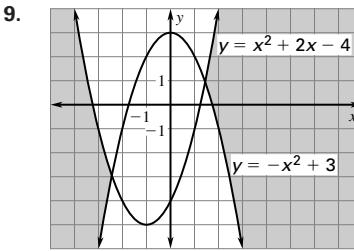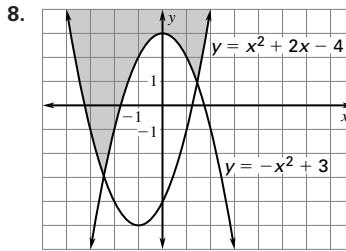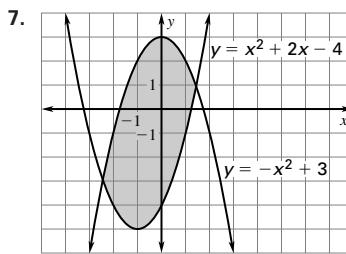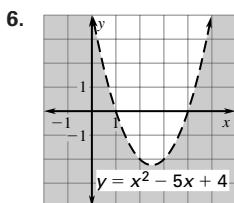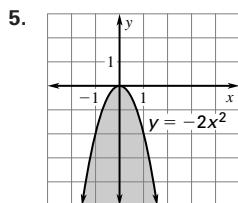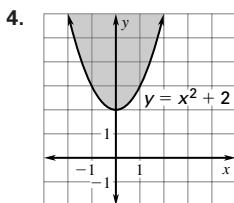
10. $x^2 - 4 < 0$

$x^2 < 4$

$-2 < x < 2$

11. $x^2 - 4 \geq 0$

$x^2 \geq 4$

$x \leq -2$ or $x \geq 2$

12. $x^2 - 4 > 3x$

$x^2 - 3x - 4 > 0$

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

$x < -1$ or $x > 4$

13. $y = -0.00211x^2 + 1.06x$

$0 = -0.00211x^2 + 1.06x - 52$

$$x = \frac{-1.06 \pm \sqrt{1.1236 - 0.4389}}{-0.00422}$$

$$x = \frac{-1.06 \pm \sqrt{0.6847}}{-0.00422}$$

$x = 55.1$ m and 447.3 m

5.7 Practice and Applications (pp. 303–305)

14. B   **15.** C   **16.** A

17.

18.

Chapter 5 *continued*

19.

$y = -x^2 + 5$

20.

$y = x^2 - 3x$

21.

$y = x^2 + 8x + 16$

22.

$y = -x^2 + x + 6$

23.

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

24.

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

25.

$y = -3x^2 + 5x - 4$

26.

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

27.

$y = \frac{4}{3}x^2 - 12x + 29$

28.

$y = 0.6x^2 + 3x + 2.4$

29.

$y = x^2 + 3$

$y = x^2$

30.

$y = -3x^2$

$y = -\frac{1}{2}x^2 - 5$

31.

$y = x^2 - 6x + 9$

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

32.

$y = x^2 - 4x + 4$

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

33.

$y = 3x^2 + 2x - 5$

$y = -2x^2 + 1$

34.

$y = 2x^2 - 9x + 8$

$y = -x^2 - 6x - 4$

35.

$y = x^2 + x - 2$

$-2 < x < 1$

36.

$y = 2x^2 - 7x + 3$

$x \le \frac{1}{2}$ or $x \ge 3$

37.

$y = -x^2 - 2x + 8$

$x \le -4$ or $x \ge 2$

38.

$y = -x^2 + x + 5$
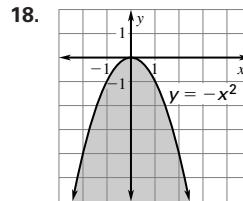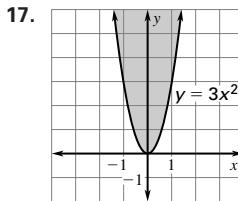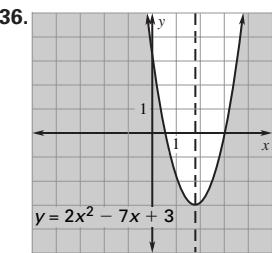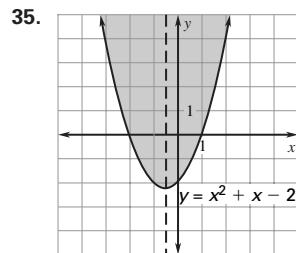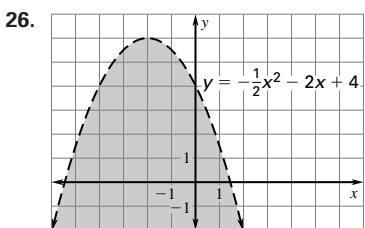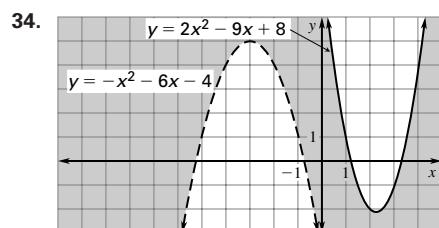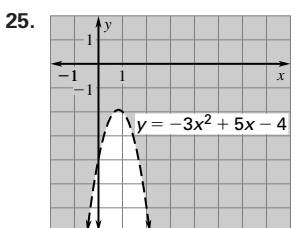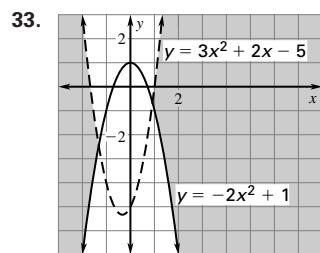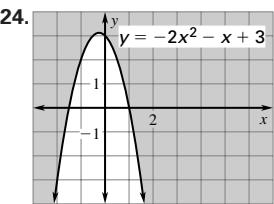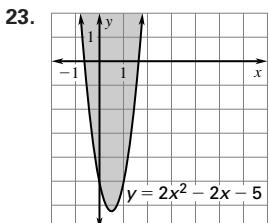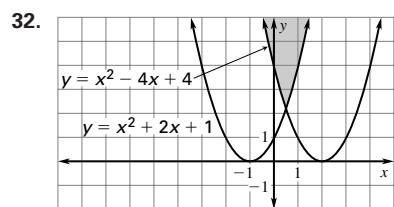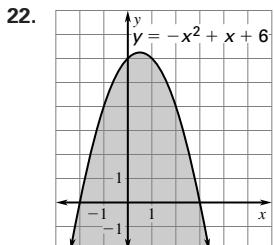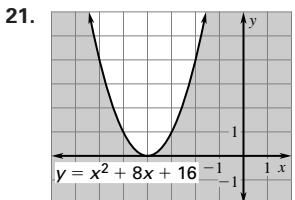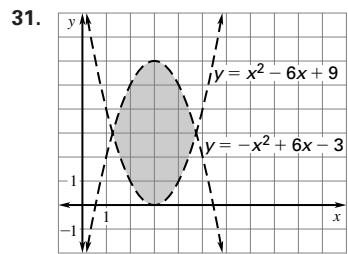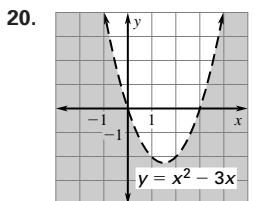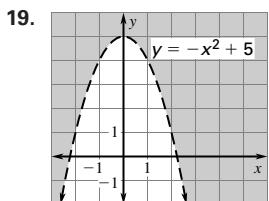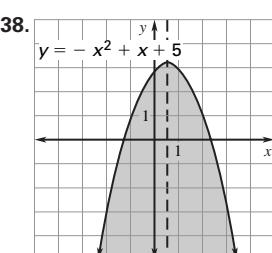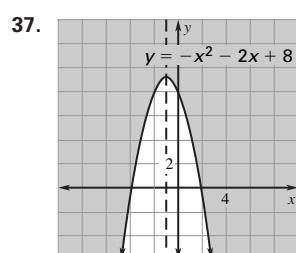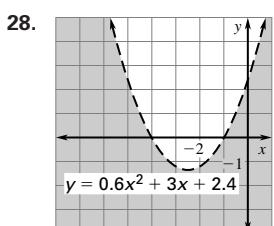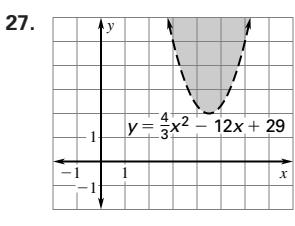
$-1.8 < x < 2.8$
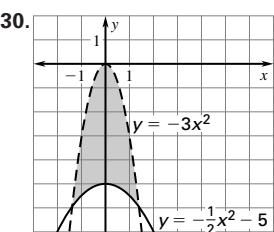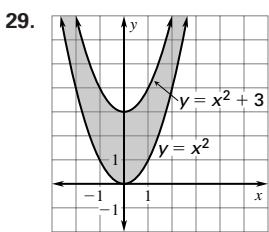
Chapter 5 *continued*

39.

$x \le -5.5$ or $x \ge -2.5$

$y = 3x^2 + 24x + 41$
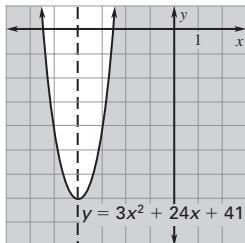
40. no real solutions

**41.** $x^2 + 3x - 18 \ge 0$

$(x - 3)(x + 6) = 0$

$x = 3$ or $x = -6$

$x \le -6$ or $x \ge 3$

42. $3x^2 - 16x + 5 \le 0$

$(3x - 1)(x - 5) = 0$

$x = 5$ or $x = \dfrac{1}{3}$

$\dfrac{1}{3} \le x \le 5$

43. $4x^2 < 25$

$x^2 = \dfrac{25}{4}$

$x = \pm\dfrac{5}{2}$

$-\dfrac{5}{2} < x < \dfrac{5}{2}$

44. $-x^2 - 12x - 32 < 0$

$-(x + 8)(x + 4) = 0$

$x = -8$ or $x = -4$

$x < -8$ or $x > -4$

45. $2x^2 - 4x - 5 > 0$

$x = \dfrac{4 \pm \sqrt{16 + 40}}{4}$

$x \approx -0.9$ or $x \approx 2.9$

$x < -0.9$ or $x > 2.9$

46. $\dfrac{1}{2}x^2 + 3x + 6 \le 0$

$x = \dfrac{-3 \pm \sqrt{9 - 12}}{1}$

no real solutions

47. Manila Rope   Wire Rope

Weight for Manila Rope

$w = 1480d^2$

Weight for Wire Rope

$w = 8000d^2$

48. no; yes

49.

Healthy Weights   121–160 lb

$w = \dfrac{19h^2}{703}$

$w = \dfrac{25h^2}{703}$
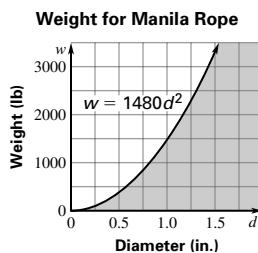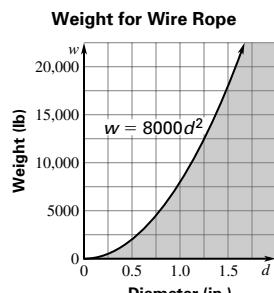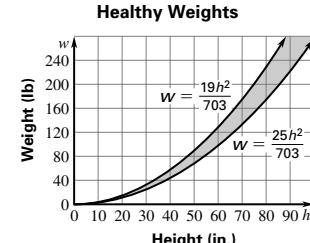
50. $0.125x^2 - 569x + 848{,}000 \ge 400{,}000$

   a. $400 \le x \le 1012.6$

 $0.125x^2 - 569x + 448{,}000 \ge 0$

   b. Decreases; there is an oversupply of timber.
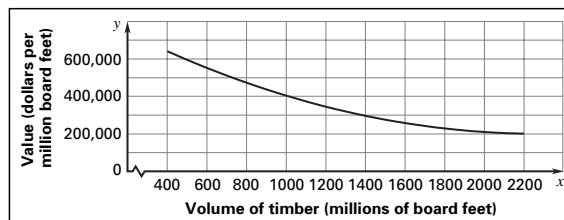

51. $-425x^2 + 42{,}500x - 761{,}000 > 250{,}000$

   $-425x^2 + 42{,}500x - 1{,}011{,}000 > 0$

   $39 < x < 61$
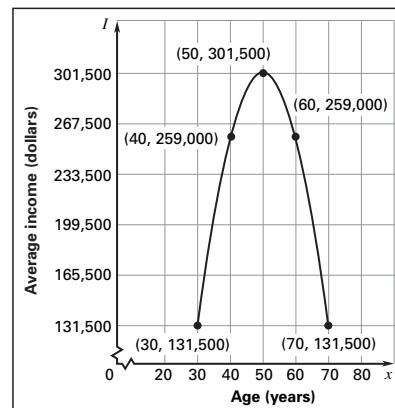
   about 39 to 61 years

52. **a.**

Reaction Times

$V(x) = 0.005x^2 - 0.23x + 22$

$A(x) = 0.0051x^2 - 0.319x + 15$
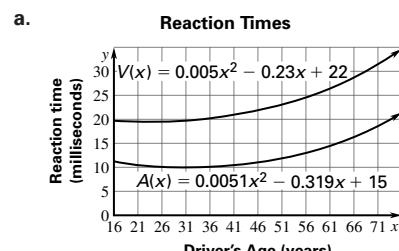
   b. *Sample answer:* $A(x)$ is always less than $V(x)$.

   c. *Sample answer:* siren; since audio stimuli reaction time is less than visual stimuli reaction time

Chapter 5 *continued*

53. a. $y \le -x(x - 4)$

$0 \le x \le 4$

$y = -2(2 - 4)$

$y = 4$

$A = \frac{2}{3}(4)(4)$

$A = \frac{32}{3}$
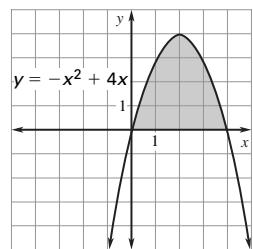
b. $y \ge (x - 5)(x + 1)$

$y \le 3$

$h = 12$

$b = 7$

$A = \frac{2}{3}(12)(7) \approx 56$

$y = -x^2 + 4x$

$y = 3$

$y = x^2 - 4x - 5$
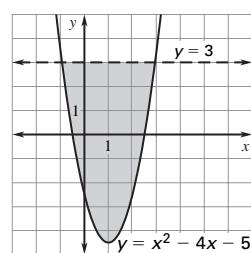
5.7 Mixed Review (p. 305)

54. $3x + y = 1$

$y = 1 - 3x$

55. $8x - 2y = 10$

$-2y = 10 - 8x$

$y = -5 + 4x$

56. $-2x + 5y = 9$

$5y = 9 + 2x$

$y = \frac{9}{5} + \frac{2}{5}x$

57. $\frac{1}{3}y = -\frac{11}{12} - \frac{1}{6}x$

$y = -\frac{11}{4} - \frac{1}{2}x$

58. $xy - x = 2$

$xy = 2 + x$

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

59. $x - 3y = 28x$

$-3y = 27x$

$y = -9x$

60. $A = \begin{bmatrix} 5 & -3 & -2 \\ -1 & 7 & -3 \\ 3 & 2 & 4 \end{bmatrix}$

det $A = (140 + 27 + 4) - (-42 - 30 + 12) = 231$

$x = \dfrac{\begin{vmatrix} -17 & -3 & -2 \\ 6 & 7 & -3 \\ 13 & 2 & 4 \end{vmatrix}}{231}$

$= \dfrac{(-476 + 117 - 24) - (-182 + 102 - 72)}{231}$

$= \dfrac{-231}{231} = -1$

$y = \dfrac{\begin{vmatrix} 5 & -17 & -2 \\ -1 & 6 & -3 \\ 3 & 13 & 4 \end{vmatrix}}{231}$

$= \dfrac{(120 + 153 + 26) - (-36 - 195 + 68)}{231} = \dfrac{462}{231} = 2$

$z = \dfrac{\begin{vmatrix} 5 & -3 & -17 \\ -1 & 7 & 6 \\ 3 & 2 & 13 \end{vmatrix}}{231}$

$= \dfrac{(455 - 54 + 34) - (-357 + 60 + 39)}{231} = \dfrac{693}{231} = 3$

$(-1, 2, 3)$

61. $A = \begin{bmatrix} 1 & -4 & 1 \\ 2 & 3 & 7 \\ -3 & 5 & -5 \end{bmatrix}$

det $A = (-15 + 84 + 10) - (-9 + 35 + 40) = 13$

$x = \dfrac{\begin{vmatrix} -14 & -4 & 1 \\ -15 & 3 & 7 \\ 29 & 5 & -5 \end{vmatrix}}{13}$

$= \dfrac{(210 - 812 - 75) - (87 - 490 - 300)}{13} = \dfrac{26}{13} = 2$

$y = \dfrac{\begin{vmatrix} 1 & -14 & 1 \\ 2 & -15 & 7 \\ -3 & 29 & -5 \end{vmatrix}}{13}$

$= \dfrac{(75 + 294 + 58) - (45 + 203 + 140)}{13} = \dfrac{39}{13} = 3$

$z = \dfrac{\begin{vmatrix} 1 & -4 & -14 \\ 2 & 3 & -15 \\ -3 & 5 & 29 \end{vmatrix}}{13}$

$= \dfrac{(87 - 180 - 140) - (126 - 75 - 232)}{13} = \dfrac{-52}{13} = -4$

$(2, 3, -4)$

62. $13 + 3i$ **63.** -6 **64.** $5 + 2i$ **65.** $6 - 5i$

66. $-6 + 48i$

67. $14 + 15 + 6i - 35i = 29 - 29i$

68. $\dfrac{1}{3 - i} \times \dfrac{3 + i}{3 + i} = \dfrac{3 + i}{10}$

69. $\dfrac{4 - 3i}{9 + 2i} \times \dfrac{9 - 2i}{9 - 2i} = \dfrac{36 - 6 - 27i - 8i}{81 + 4} = \dfrac{30 - 35i}{85}$

$= \dfrac{6}{17} - \dfrac{7i}{17}$

Lesson 5.8

Activity (p. 307)

1. $a - b + c = 2$; $9a + 3b + c = 0$

Chapter 5 *continued*

2. $A = \begin{bmatrix} 1 & -1 & 1 \\ 9 & 3 & 1 \\ 4 & -2 & 1 \end{bmatrix}$

$\det A = (3 - 4 - 18) - (12 - 2 - 9) = -20$

$a = \dfrac{\begin{vmatrix} 2 & -1 & 1 \\ 0 & 3 & 1 \\ 0 & -2 & 1 \end{vmatrix}}{-20} = \dfrac{6 + 4}{-20} = -\dfrac{1}{2}$

$b = \dfrac{\begin{vmatrix} 1 & 2 & 1 \\ 9 & 0 & 1 \\ 4 & 0 & 1 \end{vmatrix}}{-20} = \dfrac{8 - 18}{-20} = \dfrac{-10}{-20} = \dfrac{1}{2}$

$c = \dfrac{\begin{vmatrix} 1 & -1 & 2 \\ 9 & 3 & 0 \\ 4 & -2 & 0 \end{vmatrix}}{-20} = \dfrac{-36 - 24}{-20} = \dfrac{-60}{-20} = 3$

$\left(-\dfrac{1}{2}, \dfrac{1}{2}, 3\right); y = -\dfrac{1}{2}x^2 + \dfrac{1}{2}x + 3$

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

$y = -\frac{1}{2}(x^2 - x - 6)$

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

5.8 Guided Practice (p. 309)

1. best-fitting quadratic model **2.** 2; 3

3. $y = -(x - 1)^2 + 3$ **4.** $-4 = a(0 + 1)(0 - 2)$

$\qquad\qquad 2 = a$

$\qquad\qquad y = 2(x + 1)(x - 2)$

5. $A = \begin{bmatrix} 16 & -4 & 1 \\ 1 & 1 & 1 \\ 4 & -2 & 1 \end{bmatrix}$

$\det A = (16 - 16 - 2) - (4 - 32 - 4) = 30$

$a = \dfrac{\begin{vmatrix} 2 & -4 & 1 \\ 2 & 1 & 1 \\ -4 & -2 & 1 \end{vmatrix}}{30} = \dfrac{(2 + 16 - 4) - (-4 - 4 - 8)}{30}$

$= \dfrac{30}{30} = 1$

$b = \dfrac{\begin{vmatrix} 16 & 2 & 1 \\ 1 & 2 & 1 \\ 4 & -4 & 1 \end{vmatrix}}{30} = \dfrac{(32 + 8 - 4) - (8 - 64 + 2)}{30}$

$= \dfrac{90}{30} = 3$

$c = \dfrac{\begin{vmatrix} 16 & -4 & 2 \\ 1 & 1 & 2 \\ 4 & -2 & -4 \end{vmatrix}}{30}$

$= \dfrac{(-64 - 32 - 4) - (8 - 64 + 16)}{30} = \dfrac{-60}{30} = -2$

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

6. $100a + 10b + c = 165$

$36a + 6b + c = 115$

$16a + 4b + c = 154.5$

$p = 1.83t^2 - 19.55t + 172.73$

5.8 Practice and Applications (pp. 309–312)

7. $y = a(x - 2)^2 - 2$

$2 = a(-2)^2 - 2$

$4 = 4a$

$1 = a$

$y = (x - 2)^2 - 2$

8. $y = a(x + 1)^2 + 4$

$2 = a(-2 + 1)^2 + 4$

$-2 = a$

$y = -2(x + 1)^2 + 4$

9. $y = a(x - 1)^2$

$-3 = a(-1 - 1)^2$

$-3 = 4a$

$-\frac{3}{4} = a$

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

10. $y = a(x - 2)^2 - 1$

$3 = a(4 - 2)^2 - 1$

$4 = 4a$

$1 = a$

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

11. $y = a(x + 4)^2 + 6$

$9 = a(-1 + 4)^2 + 6$

$3 = 9a$

$\frac{1}{3} = a$

$y = \frac{1}{3}(x + 4)^2 + 6$

12. $y = a(x - 4)^2 + 5$

$-3 = a(8 - 4)^2 + 5$

$-8 = 16a$

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

$y = -\frac{1}{2}(x - 4)^2 + 5$

13. $y = ax^2$

$-12 = 4a$

$-3 = a$

$y = -3x^2$

14. $y = a(x - 1)^2 - 10$

$54 = a(-3 - 1)^2 - 10$

$54 = a(16) - 10$

$64 = 16a$

$4 = a$

$y = 4(x - 1)^2 - 10$

15. $y = a(x + 6)^2 - 7$

$-61 = 36a - 7$

$-54 = 36a$

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

$y = -\frac{3}{2}(x + 6)^2 - 7$

16. $y = a(x - 3)(x + 3)$

$-4 = a(1 - 3)(1 + 3)$

$-4 = a(-2)(4)$

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

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

17. $y = a(x + 2)(x - 1)$

$-6 = a(-1 + 2)(-1 - 1)$

$-6 = -2a$

$3 = a$

$y = 3(x + 2)(x - 1)$

18. $y = a(x - 0)(x - 4)$

$3 = a(3)(-1)$

$-1 = a$

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

19. $y = a(x - 1)(x - 4)$

$2 = a(3 - 1)(3 - 4)$

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

$-1 = a$

$y = -(x - 1)(x - 4)$

Chapter 5 *continued*

20. $y = a(x + 2)(x - 2)$

$8 = a(-4 + 2)(-4 - 2)$

$8 = a(-2)(-6)$

$\frac{2}{3} = a$

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

21. $y = a(x + 1)(x - 6)$

$-20 = a(1 + 1)(1 - 6)$

$-20 = a(2)(-5)$

$2 = a$

$y = 2(x + 1)(x - 6)$

22. $y = a(x + 10)(x + 8)$

$-15 = a(-7 + 10)(-7 + 8)$

$-15 = a(3)(1)$

$-5 = a$

$y = -5(x + 10)(x + 8)$

23. $y = a(x - 3)(x - 9)$

$77 = a(14 - 3)(14 - 9)$

$77 = a(11)(5)$

$\frac{7}{5} = a$

$y = \frac{7}{5}(x - 3)(x - 9)$

24. $y = a(x + 0)(x + 5)$

$18 = a(-3 + 0)(-3 + 5)$

$18 = a(-3)(2)$

$-3 = a$

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

25. $a - b + c = 2$

$c = 4$

$9a + 3b + c = -2$

$y = -x^2 + x + 4$
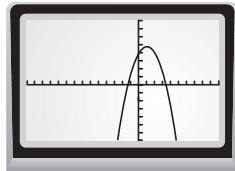
26. $4a + 2b + c = 7$

$9a + 3b + c = 2$

$25a + 5b + c = 4$

$y = 2x^2 - 15x + 29$
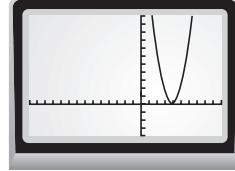
27. $25a - 5b + c = -4$

$16a - 4b + c = 0$

$c = 1$

$y = -0.75x^2 - 2.75x + 1$
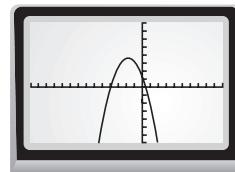
28. $a - b + c = 5$

$c = 3$

$9a + 3b + c = 9$

$y = x^2 - x + 3$
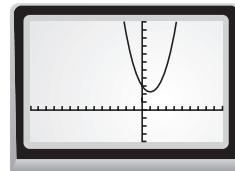
29. $a + b + c = 2$

$9a + 3b + c = 4$

$36a + 6b + c = -8$

$y = -x^2 + 5x - 2$
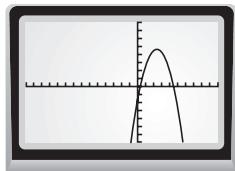
30. $4a - 2b + c = -1$

$a + b + c = 11$

$4a + 2b + c = 27$

$y = 3x^2 + 7x + 1$
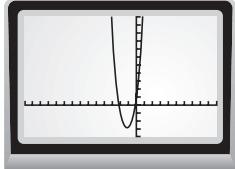
31. $16a - 4b + c = -7$

$9a - 3b + c = 3$

$9a + 3b + c = -21$

$y = -2x^2 - 4x + 9$
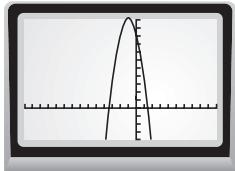
32. $9a - 3b + c = -4$

$a - b + c = 0$

$81a + 9b + c = -10$

$y = -0.25x^2 + x + 1.25$
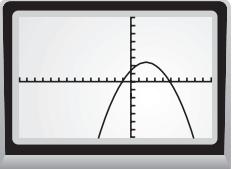
33. $36a - 6b + c = 46$

$4a + 2b + c = 14$

$16a + 4b + c = 56$

$y = 2.5x^2 + 6x - 8$
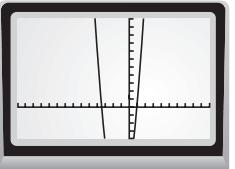
34. $h = a(s - 27)^2 + 16$

$40 = a(20 - 27)^2 + 16$

$24 = a(49)$

$\frac{24}{49} = a$

$h = \frac{24}{49}(s - 27)^2 + 16$

35. $y = a(x - 0)(x - 24)$

$0.2 = a(17)(17 - 24)$

$0.2 = -119a$

$-0.00168 = a$

$y = -0.00168(x - 0)(x - 24)$

Chapter 5 *continued*

36. $16a - 4b + c = 1.42$

$4a + 2b + c = -0.57$

$36a + 6b + c = -1.42$

$t = 0.0119s^2 - 0.3086s - 0.0005$

Change in finishing time (seconds)
Wind speed (meters per second)
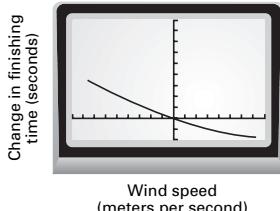
37. a. $38,025a + 195b + c = 8130$

$88,209a + 297b + c = 9680$

$160,801a + 401b + c = 9810$

$s = -0.0807p^2 + 55.229p + 330.38$

Shoulder weight (grams)
Protein intake (grams per day)
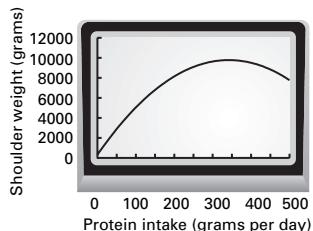
b. $38,025a + 195b + c = 239$

$116,281a + 341b + c = 334$

$182,329a + 427b + c = 373$

$k = -0.00006p^2 + 0.6257p + 125.1598$

Kidney weight (grams)
Protein intake (grams per day)
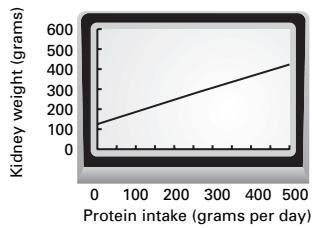
38. a. $100a + 10b + c = 61.2$

$900a + 30b + c = 130.4$

$2304a + 48b + c = 140.7$

$d = -0.0771A^2 + 6.5803A + 2.4614$

Distance (meters)
Angle (degrees)
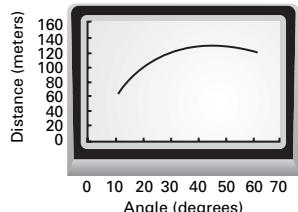
b. $100a + 10b + c = 58.3$

$900a + 30b + c = 126.9$

$2304a + 48b + c = 139.3$

$d = -0.0738A^2 + 6.4304A + 0.6928$

Distance (meters)
Angle (degrees)
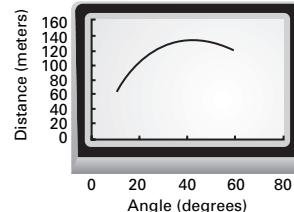
c. $100a + 10b + c = 56.1$

$900a + 30b + c = 122.8$

$2304a + 48b + c = 137.8$

$d = -0.07A^2 + 6.2284A - 0.2623$

39. a. 1.35, 1.68, 2.03, 2.37, 2.725, 3.07, 3.4; no, the ratios keep increasing as the diameter increases.

b. 0.0675, 0.0672, 0.0678, 0.0678, 0.0681, 0.0681, 0.068; the ratios are approximately equal.

c. $t \approx 0.068d^2$; about 206 min

40.

n	0	1	2	3	4	5	6
R	1	2	4	7	11	16	22

$a + b + c = 2$

$9a + 3b + c = 7$

$25a + 5b + c = 16$

$R = 0.5n^2 + 0.5n + 1$

### 5.8 Mixed Review (p. 312)

41. $(3)^2 - 4 = 9 - 4 = 5$

42. $(2)^5 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 = 32$

43. $3(-4)^3 + 10 = 3(-64) + 10 = -192 + 10 = -182$

44. $-(-1)^4 + 2(-1) + 7 = -1 - 2 + 7 = 4$

45. $x - y = 4$

$\underline{x + y = 2}$

$2x = 6$

$x = 3$

$3 - y = 4$

$-1 = y$

$(3, -1)$

46. $2x - y = 0$

$\underline{5x + 3y = 11}$

$5x + 3(2x) = 11$

$5x + 6x = 11$

$11x = 11$

$x = 1$

$y = 2(1)$

$y = 2$

$(1, 2)$

Chapter 5 *continued*

47. $3x + 2y = -2$

$\underline{4x + 7y = 19}$

$4x + 7\left(-1 - \dfrac{3x}{2}\right) = 19$

$4x - 7 - \dfrac{21x}{2} = 19$

$-\dfrac{13}{2}x = 26$

$x = -4$

$y = -1 - \dfrac{(3 \cdot -4)}{2}$

$y = -1 + 6 = 5$

$(-4, 5)$

48. $C = 1800 + 15v + 10p$

Quiz 3 (p. 312)

1.

$y = x^2 + 2$

2.

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

3.

$y = 2x^2 - 12x + 15$

4.

$y = x^2$

$y = 2x^2 - 1$

5.

$y = x^2 - 2x - 3$

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

6.

$y = x^2 + 7x + 10$

$y = -x^2 - 4x$
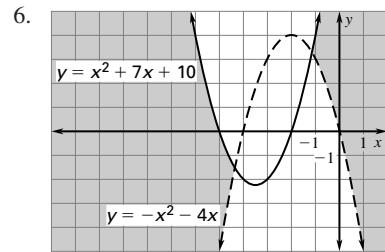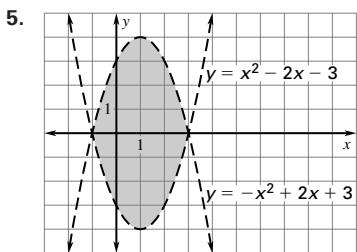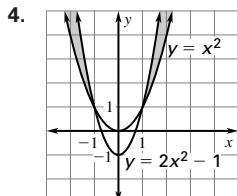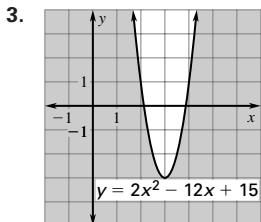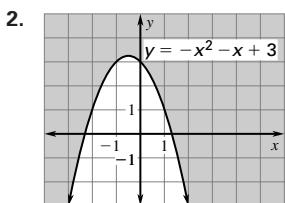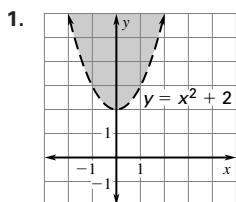
7. $y = a(x - 5)^2 - 2$

$0 = a(-1)^2 - 2$

$2 = a$

$y = 2(x - 5)^2 - 2$

8. $y = a(x + 3)(x - 1)$

$-5 = a(5)(1)$

$-1 = a$

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

9. $16a - 4b + c = 8$

$4a - 2b + c = 1$

$4a + 2b + c = 5$

$16a - 4b + c = 8$

$\underline{8a + 4b + 2c = 10}$

$24a + 3c = 18 \quad$ Eq 2

$4a - 2b + c = 1$

$\underline{4a + 2b + c = 5}$

$8a + 2c = 6 \quad$ Eq 1

$8a + 2c = 6$

$\underline{-8a - c = -6}$

$ c = 0$

$8a = 6$

$a = \frac{3}{4}$

$4\left(\frac{3}{4}\right) + 2b + 0 = 5$

$2b = 2$

$b = 1$

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

10. $0.00339N^2 + 0.00143N - 5.95 < 1000$

$0.00339(N^2 + 0.42N + 0.0441) < 1005.95 + 0.0001495$

$0.00339(N + 0.21)^2 < 1005.9502$

$(N + 0.21)^2 < 296{,}740$

$(N + 0.21) < 544.7$

$N < 544$

$0 < N < 544$

Chapter 5 Review (pp. 314–316)

1.

$y = x^2 + 4x + 7$

$(-2, 3)$

$x = -2$

2.

3.
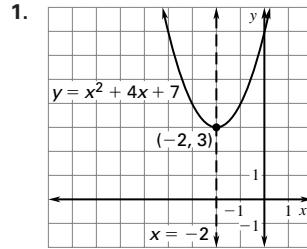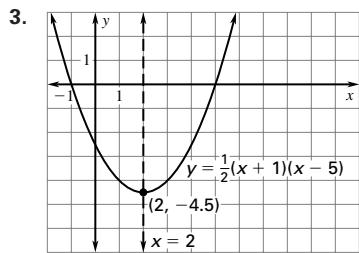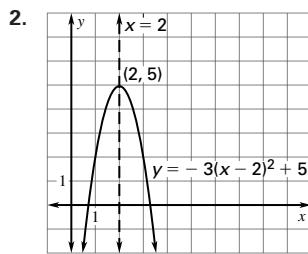
4. $x^2 + 11x + 24 = 0$

$(x + 3)(x + 8) = 0$

$x = -3$ or $x = -8$

5. $x^2 - 8x + 16 = 0$

$(x - 4)^2 = 0$

$x = 4$

6. $2x^2 + 3x + 1 = 0$

$(2x + 1)(x + 1) = 0$

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

7. $3u^2 + 4u - 15 = 0$

$(u + 3)(3u - 5) = 0$

$u = -3$ or $u = \frac{5}{3}$

8. $25v^2 - 30v + 9 = 0$

$(5v - 3)^2 = 0$

$v = \frac{3}{5}$

9. $2x^2 = 200$

$x^2 = 100$

$x = \pm 10$

10. $5x^2 = 15$

$x^2 = 3$

$x = \pm\sqrt{3}$

11. $4(t + 6)^2 = 160$

$(t + 6)^2 = 40$

$(t + 6) = \pm 2\sqrt{10}$

$t = \pm 2\sqrt{10} - 6$

12. $-(k - 1)^2 + 7 = -43$

$-(k - 1)^2 = -50$

$(k - 1)^2 = 50$

$k - 1 = \pm 5\sqrt{2}$

$k = 1 \pm 5\sqrt{2}$

13. $(7 - 2) + (-4i + 5i) = 5 + i$

14. $(2 - 6) + (11i + i) = -4 + 12i$

15. $(12 + 90) + (40i - 27i) = 102 + 13i$

16. $\dfrac{8 + i}{1 - 2i} \times \dfrac{1 + 2i}{1 + 2i} = \dfrac{(8 - 2) + (i + 16i)}{1 + 4} = \dfrac{6 + 17i}{5}$

17. $\sqrt{(6)^2 + (9)^2} = \sqrt{36 + 81} = \sqrt{117} = 3\sqrt{13}$

18. $x^2 + 4x = 3$

$x^2 + 4x + 4 = 7$

$(x + 2)^2 = 7$

$x + 2 = \pm\sqrt{7}$

$x = -2 \pm \sqrt{7}$

19. $x^2 - 10x = -26$

$x^2 - 10x + 25 = -1$

$(x - 5)^2 = -1$

$x - 5 = \pm i$

$x = 5 \pm i$

20. $2w^2 + w - 7 = 0$

$w^2 + \dfrac{1}{2}w + \dfrac{1}{16} = \dfrac{7}{2} + \dfrac{1}{16}$

$\left(w + \dfrac{1}{4}\right)^2 = \dfrac{57}{16}$

$w + \dfrac{1}{4} = \pm\dfrac{\sqrt{57}}{4}$

$w = -\dfrac{1}{4} \pm \dfrac{\sqrt{57}}{4}$

21. $y = x^2 - 8x + 17$

$y - 17 + 16 = x^2 - 8x + 16$

$y = (x - 4)^2 + 1;$

$(4, 1)$

22. $y = -x^2 - 2x - 6$

$y + 6 = -(x^2 + 2x)$

$y = -(x^2 + 2x + 1) - 5$

$y = -(x + 1)^2 - 5;$

$(-1, -5)$

23. $y = 4x^2 + 16x + 23$

$y - 23 = 4(x^2 + 4x)$

$y = 4(x^2 + 4x + 4) + 7$

$y = 4(x + 2)^2 + 7;$

$(-2, 7)$

24. $x^2 - 8x + 5 = 0$

$x = \dfrac{8 \pm \sqrt{64 - 20}}{2}$

$x = \dfrac{8 \pm \sqrt{44}}{2}$

$x = 4 \pm \sqrt{11}$

25. $9x^2 + 7x - 1 = 0$

$x = \dfrac{-7 \pm \sqrt{49 + 36}}{18}$

$x = \dfrac{-7 \pm \sqrt{85}}{18}$

26. $4v^2 + 10v + 7 = 0$

$v = \dfrac{-10 \pm \sqrt{100 - 112}}{8}$

$v = \dfrac{-10 \pm 2i\sqrt{3}}{8}$

$v = \dfrac{-5 \pm i\sqrt{3}}{4}$

Chapter 5 *continued*

27.

$y = x^2 - 4x + 4$

28.

$y = x^2 + 6x + 5$

29.

$y = -2x^2 + 3$
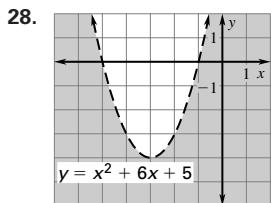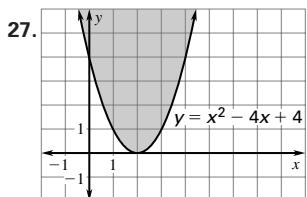
30. $x^2 - 3x - 4 \le 0$

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

$x = 4 \text{ or } x = -1$

$-1 \le x \le 4$

31. $2x^2 + 7x + 2 \ge 0$

$x = \dfrac{-7 \pm \sqrt{49 - 16}}{4}$

$x = \dfrac{-7 \pm \sqrt{33}}{4}$

$x \le \dfrac{-7 - \sqrt{33}}{4} \text{ or } x \ge \dfrac{-7 + \sqrt{33}}{4}$

32. $9x^2 > 49$

$x^2 = \frac{49}{9}$

$x = \pm\frac{7}{3}$

$x < -\frac{7}{3} \text{ or } x > \frac{7}{3}$

33. $y = a(x - 6)^2 + 1$

$5 = a(4 - 6)^2 + 1$

$4 = 4a$

$a = 1$

$y = (x - 6)^2 + 1$

34. $y = a(x + 4)(x - 3)$

$20 = a(1 + 4)(1 - 3)$

$20 = a(-10)$

$-2 = a$

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

35. $25a - 5b + c = 1$

$16a - 4b + c = -2$

$9a + 3b + c = 5$

$y = 0.5x^2 + 1.5x - 4$

Chapter 5 Test (p. 317)

1.

$x = 2$

$(2, 3)$

$y = -2x^2 + 8x - 5$

2.

$y = (x + 3)^2 + 1$

$(-3, 1)$

$x = -3$

3.

$x = 2$

$(2, 3)$ $y = -\frac{1}{3}(x + 1)(x - 5)$
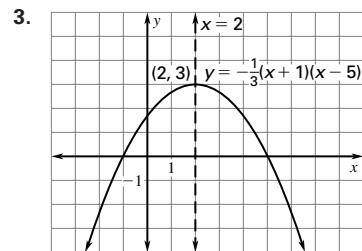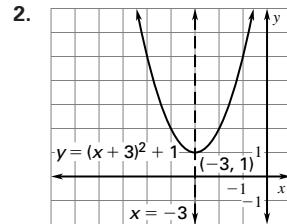
4. $y = 4(x - 3)^2 - 7$

$y + 7 = 4(x^2 - 6x + 9)$

$y + 7 = 4x^2 - 24x + 36$

$y = 4x^2 - 24x + 29$

5. $x^2 - x - 20 = (x - 5)(x + 4)$

6. $9x^2 + 6x + 1 = (3x + 1)^2$

**7.** $3u^2 - 108 = 3(u^2 - 36) = 3(u + 6)(u - 6)$

8. $y = x^2 - 10x + 16$

$y = (x - 8)(x - 2)$;

$8, 2$

9. **a.** $\sqrt{5 \cdot 5 \cdot 5 \cdot 2 \cdot 2} = 10\sqrt{5}$

b. $\sqrt{\dfrac{8}{3}} = \dfrac{\sqrt{8}\sqrt{3}}{\sqrt{3}\sqrt{3}} = \dfrac{2\sqrt{6}}{3}$

10.

11. $(3 + 1) + (i - 5i)$

$= 4 - 4i$
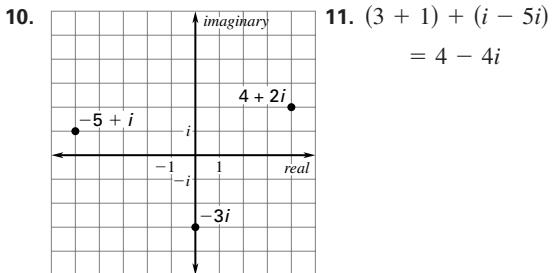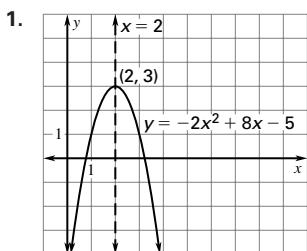
12. $(-4 - 7) + (2i + 3i) = -11 + 5i$

13. $(48 - 2) + (6i + 16i) = 46 + 22i$

14. $\dfrac{9 + 2i}{1 - 4i} \times \dfrac{1 + 4i}{1 + 4i} = \dfrac{(9 - 8) + (2i + 36i)}{1 + 16} = \dfrac{1 + 38i}{17}$

15. $f(z) = z^2 - 0.5i$

$z_0 = 0$

$z_1 = f(0) = -0.5i$

$z_2 = f(-0.5i) = -0.25 - 0.5i$

$z_3 = f(-0.25 - 0.5i) = -0.1875 - 0.5i$

$|z_0| = 0$

$|z_1| = 0.5$

$|z_2| = \sqrt{0.0625 + .25} = \sqrt{0.3125} \approx 0.56$

$|z_3| = \sqrt{(-0.1875)^2 + (-0.5)^2} \approx 0.53$

Yes, the absolute values are less than $N = 1$.

16. $c = 4$;

$(x - 2)^2$

17. $c = \frac{121}{4}$;

$\left(x + \frac{11}{2}\right)^2$

18. $c = 0.09$;

$(x - 0.3)^2$

19.

$y = x^2 + 18x - 4$

$y + 4 + 81 = x^2 + 18x + 81$

$y = (x + 9)^2 - 85$;

$(-9, -85)$

20. $7x^2 - 3 = 11$

$7x^2 = 14$

$x^2 = 2$

$x = \pm\sqrt{2}$

21. $5x^2 - 60x + 180 = 0$

$x^2 - 12x + 36 = 0$

$(x - 6)(x - 6) = 0$

$x = 6$

22. $4x^2 + 28 - 15 = 0$

$(2x + 15)(2x - 1) = 0$

$x = -\frac{15}{2}$ or $x = \frac{1}{2}$

23. $m^2 + 8m + 3 = 0$

$m = \dfrac{-8 \pm \sqrt{64 - 12}}{2}$

$m = -4 \pm \dfrac{\sqrt{52}}{2}$

$m = -4 \pm \sqrt{13}$

24. $3(p - 9)^2 = 81$

$(p - 9)^2 = 27$

$p - 9 = \pm 3\sqrt{3}$

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

25. $2t^2 - 3t + 2 = 0$

$t = \dfrac{3 \pm \sqrt{9 - 16}}{4}$

$t = \dfrac{3 \pm i\sqrt{7}}{4}$

26. $(-1)^2 - 4(7)(10)$

-279;

2 imaginary

27.

$y = x^2 + 1$

28.

$y = -x^2 + 4x + 2$

29.

$y = 2x^2 + 12x + 15$
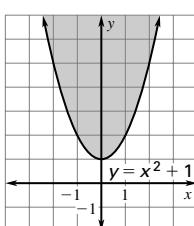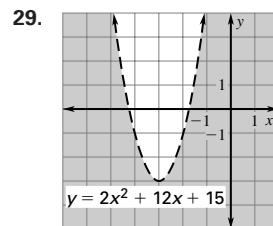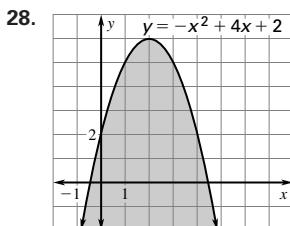
30. $-x^2 + x + 6 \geq 0$

$-(x^2 - x - 6) = 0$

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

$x = 3$ or $x = -2$

$-2 \leq x \leq 3$

31. $2x^2 - 9 > 23$

$2x^2 = 32$

$x^2 = 16$

$x = \pm 4$

$x < -4$ or $x > 4$

32. $x = \dfrac{7 \pm \sqrt{49 - 16}}{2}$

$x = \dfrac{7 \pm \sqrt{33}}{2}$

$\dfrac{7 - \sqrt{33}}{2} < x < \dfrac{7 + \sqrt{33}}{2}$

33. $y = a(x + 3)^2 + 2$

$-18 = a(-1 + 3)^2 + 2$

$-20 = 4a$

$-5 = a$

$y = -5(x + 3)^2 + 2$

34. $y = a(x - 1)(x - 8)$

$-2 = a(2 - 1)(2 - 8)$

$-2 = a(-6)$

$\frac{1}{3} = a$

$y = \frac{1}{3}(x - 1)(x - 8)$

35. $a + b + c = 7$

$16a + 4b + c = -2$

$25a + 5b + c = -1$

$y = x^2 - 8x + 14$

36. $0 = -16t^2 + 167$

$167 = 16t^2$

$\frac{167}{16} = t^2$

$t \approx 3.23$

about 3.23 sec

37. $p = 1.225a^2 - 88a + 1697.375$

Chapter 5 Standardized Test *(pp. 318–319)*

1. B

2. $4x^2 + 4x - 35 = (2x - 5)(2x + 7)$ E

3. $y = x^2 - 13x + 40$

$0 = (x - 5)(x - 8)$

5, 8

D

4. $4(x - 1)^2 = 28$

$(x - 1)^2 = 7$

$x - 1 = \pm\sqrt{7}$

$x = 1 \pm \sqrt{7}$

C

5. $(-12 + 8i)(10 - i) = (-120 + 8) + (80i + 12i)$

$= -112 + 92i$

D

6. C

Chapter 5 *continued*

7. $\sqrt{2^2 - 4(3)(-7)} = 88$

2 real solutions

A

8. $x^2 + 7x - 8 > 0$

$x^2 + 7x - 8 = 0$

$(x + 8)(x - 1) = 0$

$x = -8$ or $x = 1$

$x < -8$ or $x > 1$

B

9. D   **10.** E

11. $\sqrt{(-3)^2 + (2)^2} = \sqrt{9 + 4} = \sqrt{13} \approx 3.61$ or

$\sqrt{(1)^2 + (-4)^2} = \sqrt{1 + 17} = \sqrt{18} = 3\sqrt{2} \approx 4.24$ B

12. $49 + 96 = 145$ or $196 - 200 = -4$ A

13. a. $r = 0.334(30)^2$ **b.** $400 = 0.334s^2$

$r = 300.6$ ft $1197.6 = s^2$

$34.6 \approx s$

about 34.6 mi/h

c. $A = 24\pi r$ **d.** $A = 8.016\pi s^2$ **e.** linear; quadratic

14. a. $h = -16t^2 + 40t + 3$

b. $h - 3 = -16t^2 + 40t$

$h - 3 = -16(t^2 - 2.5t + 1.5625)$

$h - 3 = -16(t - 1.25)^2$

$h = -16(t - 1.25)^2 + 3 + 25$

$h = -16(t - 1.25)^2 + 28$

about 1.25 sec; 28 ft

c. $8 = -16(t - 1.25)^2 + 28$

$\dfrac{-20}{-16} = (t - 1.25)^2$

$\dfrac{5}{4} = (t - 1.25)^2$

$\pm\dfrac{\sqrt{5}}{2} = t - 1.25$

$1.25\dfrac{\sqrt{5}}{2} = t$

about 2.37 sec

d. $6 \le -16(t - 1.25)^2 + 28 \le 9$

$\dfrac{-22}{-16} \ge (t - 1.25)^2 \ge \dfrac{-19}{-16}$

$1.375 \ge (t - 1.25)^2 \ge 1.1875$

$1.173 \ge t - 1.25 \ge 1.090$

$2.42 \ge t \ge 2.34$

from about 2.34 sec to 2.42 sec

e. $0 = -16(0.1)^2 + (0.1)v_0 + 8$

$0 = -0.16 + 8 + 0.1v_0$

$-7.84 = 0.1v_0$

$-78.4 = v_0$

78.4 feet per sec