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

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

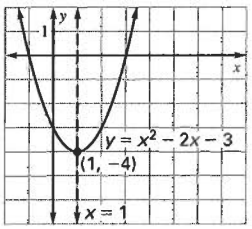
91. $y = 5(x^2 + 6x + 6x + 36) - 12$

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

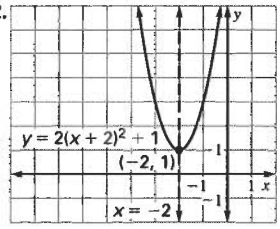
$y = 5x^2 + 60x + 168$

Quiz 1 (p. 270)

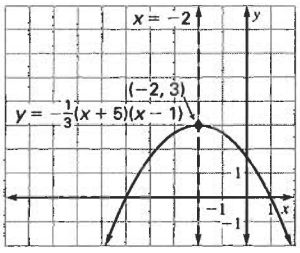
1.



2.



3.



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. $10 = 1.35s^2$

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

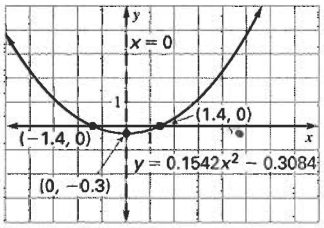
Math and History (p. 270)

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

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

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

$y = 0.1542x^2 - 0.3084$



3. $0 = (2\pi^2 f^2 x^2 - \pi^2 f^2 R^2)$

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

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

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

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

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

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. $2x^2 = -16$

$x^2 = -8$

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

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

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

7. $7 + 3i$

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

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

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

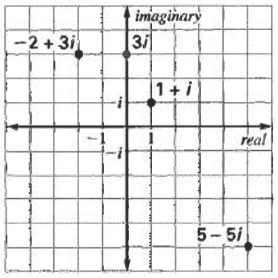
11. $\sqrt{1^2 + 1^2} = \sqrt{2}$

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

$|c| = \sqrt{2}$

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

5.4 Practice and Applications (pp. 277–280)

17. $x^2 = -4$

$x = \pm 2i$

18. $x^2 = -11$

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

19. $x^2 = -27$

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

20. $2x^2 = -50$

$x^2 = -25$

$x = \pm 5i$

21. $5x^2 = -15$

$x^2 = -3$

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

22. $-x^2 = 18$

$x^2 = -18$

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

23. $3r^2 = -3$

$r^2 = -1$

$r = \pm i$

24. $-4s^2 = 1$

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

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

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

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

$t = 2 \pm 4i$

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

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

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

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

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

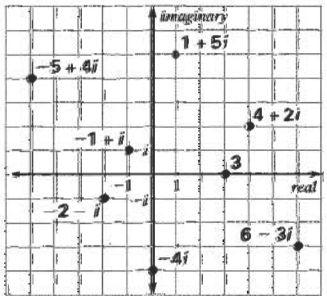
$v = -3 \pm 2i\sqrt{14}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

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

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

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

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

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

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

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

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

$z_1 = 2$ $\quad |z_1| = 2$

$z_2 = 6$ $\quad |z_2| = 6$

$z_3 = 38$ $\quad |z_3| = 38$

$z_4 = 1446$ $\quad |z_4| = 1446$

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

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

$z_0 = 0$ $\quad |z_0| = 0$

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

$z_2 = -2i$ $\quad |z_2| = 2$

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

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

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

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

$z_0 = 0$ $\quad |z_0| = 0$

$z_1 = -0.5$ $\quad |z_1| = 0.5$

$z_2 = -0.25$ $\quad |z_2| = 0.25$

$z_3 = -0.4375$ $\quad |z_3| = 0.4375$

$z_4 = -0.3086$ $\quad |z_4| = 0.3086$

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

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

$z_0 = 0$ $\quad |z_0| = 0$

$z_1 = 0.5i$ $\quad |z_1| = 0.5$

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

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

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

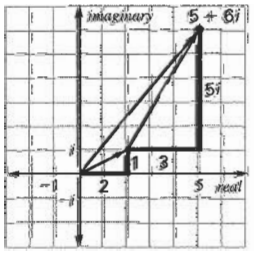
82. true

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

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

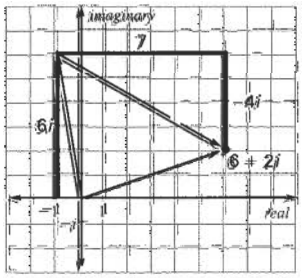
85. true

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

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. $-1 - i; \frac{1 - i}{2}$ **b.** $-3 + i; \frac{3}{10} + \frac{1}{10}i$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$(1, 2)$

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

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

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

$(-5, 7)$

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

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

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

$(4, -3)$

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

$x^2 + 8x + 15 = 0$

$(x + 3)(x + 5) = 0$

$-3, -5$

109. $x^2 + 4x + 4 - 36 = 0$

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

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

$4, -8$

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

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

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

$6, 16$

111. $(x - 5)^2 = 10$

$x - 5 = \pm\sqrt{10}$

$x = 5 \pm \sqrt{10}$

112. $(x + 7)^2 = 12$

$x + 7 = \pm 2\sqrt{3}$

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

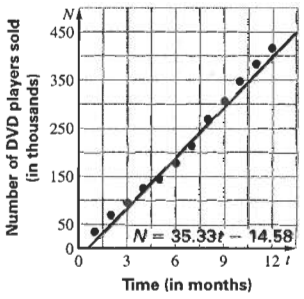
113. $3(x - 6)^2 = 21$

$(x - 6)^2 = 7$

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

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

114.



$y = 35.33x - 14.58$

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

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

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

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

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

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

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

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

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

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

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

$(-1, -6)$

22. $x(60 - 2x) = 140$

$60x - 2x^2 = 140$

$x^2 - 30x = -70$

$x^2 - 30x + 225 = -70 + 225$

$(x - 15)^2 = 155$

$x - 15 = \pm\sqrt{155}$

$x = 15 \pm \sqrt{155}$

$x \approx 27.45$ 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. $r^2 - 5r = -\frac{13}{4}$

$r^2 - 5r + \frac{25}{4} = -\frac{13}{4} + \frac{25}{4}$

$\left(r - \frac{5}{2}\right)^2 = 3$

$r - \frac{5}{2} = \pm\sqrt{3}$

$r = \frac{5 \pm 2\sqrt{3}}{2}$

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

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

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

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

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

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

$y + 7 - \frac{1}{2} = -2(x^2 + x + \frac{1}{4})$

$y = -2(x + \frac{1}{2})^2 - \frac{13}{2}$

$(-\frac{1}{2}, -\frac{13}{2})$

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

$y = \frac{2}{3}(x^2 - \frac{6}{5}x + \frac{9}{25}) - \frac{6}{25}$

$y = \frac{2}{3}(x - \frac{3}{5})^2 - \frac{6}{25};$

$(\frac{3}{5}, -\frac{6}{25})$

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. $40 = \frac{1}{2}(x + 8)x$

$80 = x^2 + 8x$

$80 + 16 = x^2 + 8x + 16$

$96 = (x + 4)^2$

$\pm 4\sqrt{6} = x + 4$

$4\sqrt{6} - 4 = x$

$x \approx 5.8$

87. $\frac{1}{2}(4x)(x + 4) = 70$

$2x^2 + 8x = 70$

$x^2 + 4x + 4 = 35 + 4$

$(x + 2)^2 = 39$

$x + 2 = \pm\sqrt{39}$

$x = -2 + \sqrt{39}$

$x \approx 4.24$

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. $d = 0.08(30)^2 + 1.1(30) = 105$ 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. $y = -0.003x^2 + 0.62x + 3$

$25 - 3 = -0.003(x^2 - 206.7x)$

$10{,}681 - 7333 = (x^2 - 206.7x + 10{,}681)$

$3348 = (x - 103.35)^2$

$\pm\sqrt{3348} = x - 103.35$

$\pm 6\sqrt{93} + 103.35 = x$

$x \approx 45.5$ ft or $x \approx 161.2$ ft

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

$l \approx 42.25$ ft or $l \approx 17.75$ ft

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

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

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

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

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

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

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

$x = -3.5 + 4.4 \approx 0.9$ 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 °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

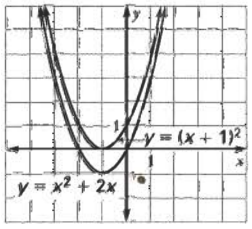
98. $y - 3 = 2(x^2 - 4x)$

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

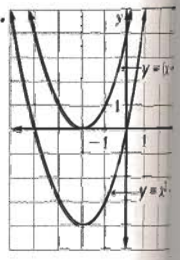
$y = 2(x - 2)^2 - 5;$

A

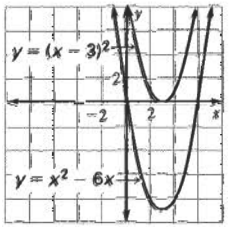
99. a.



b.



c.



100. *Sample answer:* The vertex moves up from the positi the other vertex so that the new vertex lies on the x-

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. $y + 2 = -\frac{5}{4}(x - 10)$

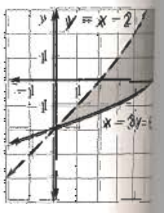
$y = -\frac{5}{4}x + \frac{47}{4}$

113.

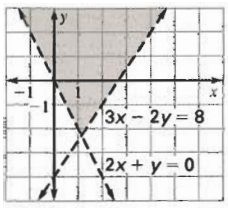
114.

115.

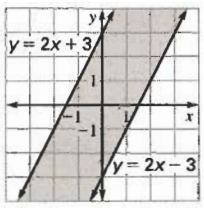
116.



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. $x = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(1)(3)}}{2} = \frac{4 \pm \sqrt{16 - 12}}{2}$

$= \frac{4 \pm \sqrt{4}}{2} = \frac{4 \pm 2}{2}$ $x = 3$ or 1

5. $x = \frac{-1 \pm \sqrt{1 + 4}}{2} = \frac{-1 \pm \sqrt{5}}{2}$

6. $x = \frac{-3 \pm \sqrt{9 - 40}}{4} = \frac{-3 \pm \sqrt{31}}{4}$

7. $x = \frac{-6 \pm \sqrt{36 + 36}}{18} = \frac{-1 \pm \sqrt{2}}{3}$

8. $x = \frac{-8 \pm \sqrt{64 - 4}}{-2} = 4 \pm \sqrt{15}$

9. $x = \frac{4 \pm \sqrt{16 - 4(4)37)}}{8} = \frac{4 \pm \sqrt{-576}}{8}$

$= \frac{4 \pm 24i}{8} = \frac{1}{2} \pm 3i$

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. $h = -16t^2 + v_0t + h_0$

$0 = -16t^2 + 21t - 6$

$t = \frac{-21 \pm \sqrt{(21)^2 - 4(-16)(-6)}}{-32}$

$t = \frac{-21 \pm \sqrt{441 - 384}}{-32}$

$t = \frac{-21 + \sqrt{57}}{-32}$

$t \approx 0.42$

0.42 sec

5.6 Practice and Applications (pp. 295–297)

17. $x = \frac{-(-5) \pm \sqrt{(-5)^2 - 4(1)(-14)}}{2(1)}$

$x = \frac{5 \pm \sqrt{25 + 56}}{2}$

$x = \frac{5 \pm 9}{2}$

$7, -2$

18. $x = \frac{-3 \pm \sqrt{3^2 - 4(1)(-2)}}{2}$

$x = \frac{-3 \pm \sqrt{9 + 8}}{2}$

$x = \frac{-3 \pm \sqrt{17}}{2}$

19. $x = \frac{2 \pm \sqrt{4 - 4(1)(-4)}}{2}$

$x = \frac{2 \pm \sqrt{4 + 16}}{2}$

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

20. $x = \frac{-10 \pm \sqrt{100 - 88}}{2}$

$x = \frac{-10 \pm \sqrt{12}}{2}$

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

21. $x = \frac{-6 \pm \sqrt{36 - 232}}{2}$

$x = \frac{-6 \pm 14i}{2}$

$x = -3 \pm 7i$

22. $x = \frac{-7 \pm \sqrt{49 - 76}}{-2}$

$x = \frac{-7 \pm 3i\sqrt{3}}{-2}$

$x = \frac{7 \pm 3i\sqrt{3}}{2}$

23. $x = \frac{-3 \pm \sqrt{9 + 20}}{10}$

$x = \frac{-3 \pm \sqrt{29}}{10}$

24. $x = \frac{11 \pm \sqrt{121 + 48}}{6}$

$x = \frac{11 \pm 13}{6}$

$4, -\frac{1}{3}$